

National Crane NBT60

Service Manual





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

NBT60 Cranes

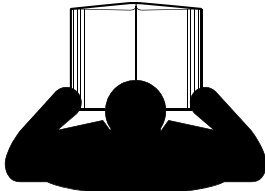

This Manual is Divided into the following Sections:

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

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.

	<h2> DANGER</h2> <p>An untrained operator subjects himself and others to death or serious injury. Do not operate this crane unless:</p> <ul style="list-style-type: none">• You are trained in the safe operation of this crane. Manitowoc is not responsible for qualifying personnel.• You read, understand, and follow the safety and operating recommendations contained in the crane manufacturer's manuals and load charts, your employer's work rules, and applicable government regulations.• You are sure that all safety signs, guards, and other safety features are in place and in proper condition.• The Operator Manual and Load Chart are in the holder provided on crane.
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**SECTION 1
INTRODUCTION**

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GENERAL

This manual has been compiled to assist you in properly operating and maintaining your Model NBT60 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 Operators Manual. Before moving a vehicle equipped with a crane, information relating to transporting the vehicle must be read and observed.

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

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

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

National Crane and our Distributor Network want to ensure your satisfaction with our products and customer support. Your local distributor is the best equipped and most knowledgeable to assist you for parts, service, and warranty issues. They have the facilities, parts, factory trained

personnel, and the information to assist you in a timely manner. We request that you first contact them for assistance. If you feel you need factory assistance, please ask the distributor’s service management to coordinate the contact on your behalf.

Supplemental Information

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

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

Safety Information

A Safety Compact Disc (CD) which includes sections on Operation, Safety and Maintenance for National Crane operators and owners is supplied when the crane is purchased new. Additional copies are available from your local distributor.

Basic Nomenclature

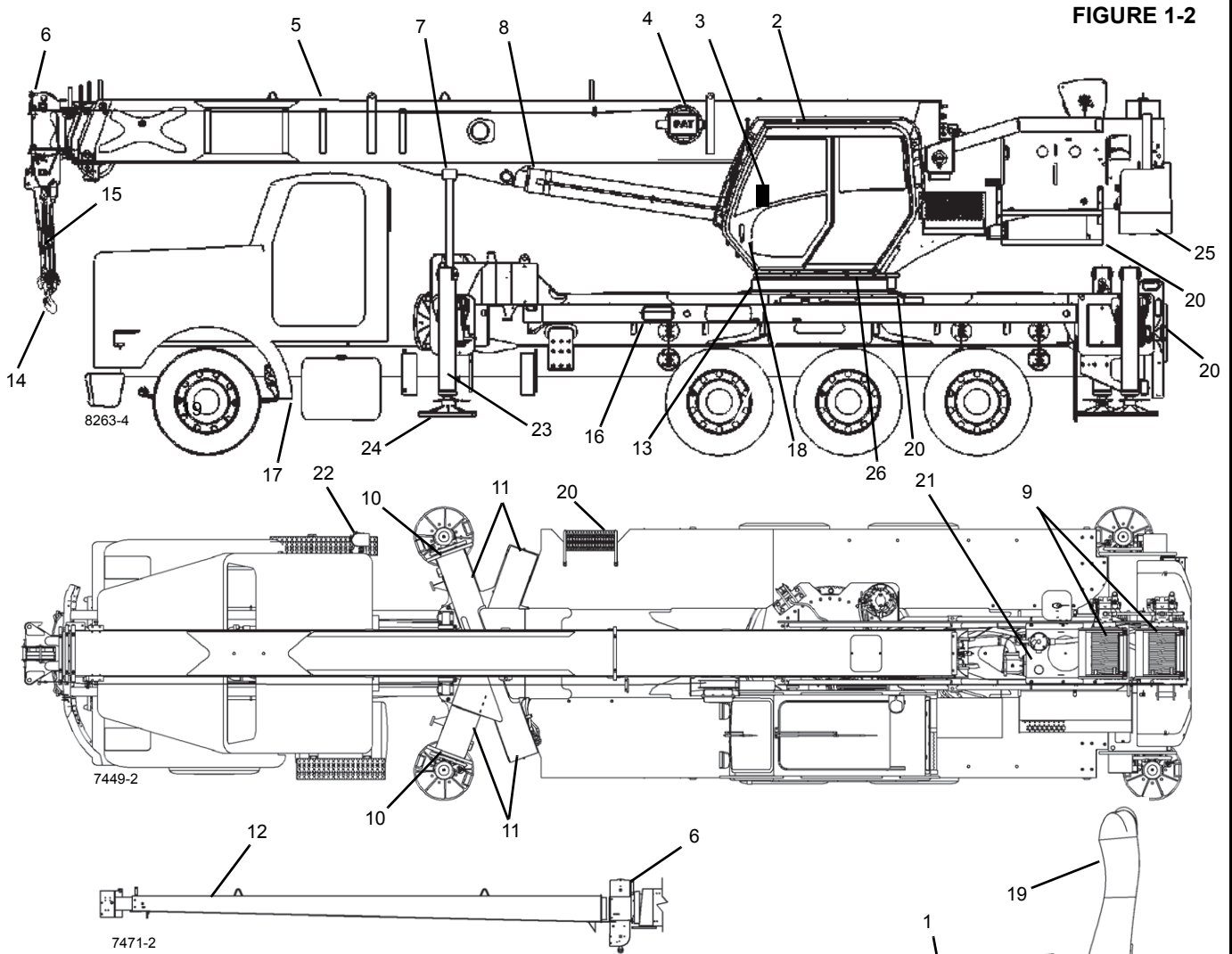
The nomenclature used to describe parts of a National Crane are described in Figure 1-2. This nomenclature is used throughout this manual.



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FIGURE 1-1

FIGURE 1-2



Item	Component
1	Cab Crane Controls
2	Cab-Tilt
3	RCL, Display Screen
4	Rated Capacity Limiter (RCL) Reel
5	Boom
6	Boom Nose
7	Boom Rest
8	Lift Cylinder
9	Main (front) and Auxiliary Hoist (rear)
10	Outrigger Beam
11	Outrigger Box
12	Jib
13	Turret
14	Hook Block
15	Hoist Cable, Wire Rope

Item	Component
16	Ground Outrigger Control
17	Hydraulic Pump
18	Cab Outrigger Control
19	Cab Seat
20	Access Steps
21	Hydraulic Tank
22	Battery Box
23	Outrigger Jack
24	Outrigger Float
25	Counterweight
26	Cab Tilt Cylinder

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.

Bearings

Antifriction Bearings

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

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

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

Preload

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

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

Sleeve Bearings

Do not install sleeve bearings with a hammer. Use a press and be sure to apply the pressure directly in line with the bore. If it is necessary to drive on a bearing, use a bearing

driver or a bar with a smooth flat end. If a sleeve bearing has an oil hole, align it with the oil hole in the mating part.

Gaskets

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

Hydraulic Systems



DANGER

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

Visual Inspection

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

Valves and Manifolds

Inspect valves and manifolds for leaking ports or sections.

Hoses and Fittings

Inspect all hoses and fittings for the following:

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

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

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

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

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

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

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

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

Electrical

Batteries

Clean the batteries with a solution of baking soda and water. Rinse with clear water and dry. Clean the battery terminals

with fine sandpaper and coat the terminals dielectric grease. Do not use a non-dielectric grease.

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

CAUTION

Disconnect batteries prior to working on the electrical system.

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

Connectors, Harnesses, Wires, and Connectors

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

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

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

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

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

Climate Zone Classification

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

Fatigue of Welded Structures

Highly stressed welded structures are subject to cracking (fatigue) when repeatedly subjected to varying stresses caused by twisting, shock, bending, and overloads. Inspect equipment periodically for weld fatigue. The frequency of inspections depends on the age of the equipment, the severity of the application, and the experience of the operators and the maintenance personnel. The following are known high stress areas and should be inspected as part of a preventive maintenance program:

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

The above is provided only as a guide and your inspection plan should not be limited to the areas listed. A visual inspection of the entire crane is recommended.

Loctite®



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

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

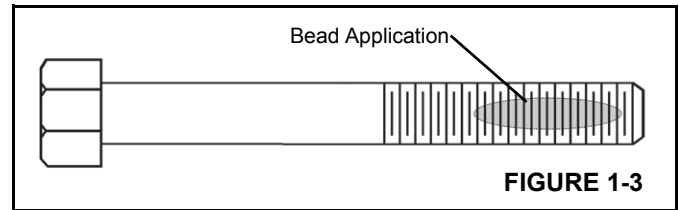
Application of Medium Strength Loctite®

NOTE: The fastener can be re-used and the adhesive can be re-applied over cured adhesive residue.

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

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

Adhesive/Sealant Application



1. Apply a bead several threads wide in the approximate area of threaded contact (Figure 1-3).
2. In a blind hole application, apply several drops of adhesive in the bottom of the hole so that the adhesive is forced up when the capscrew is installed.
3. After installation, fixturing occurs within thirty (30) minutes.
4. The time required to achieve full strength is 24 hours.

Fasteners and Torque Values

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

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

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

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

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

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

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

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

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

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

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

Torque Wrenches

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

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

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

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

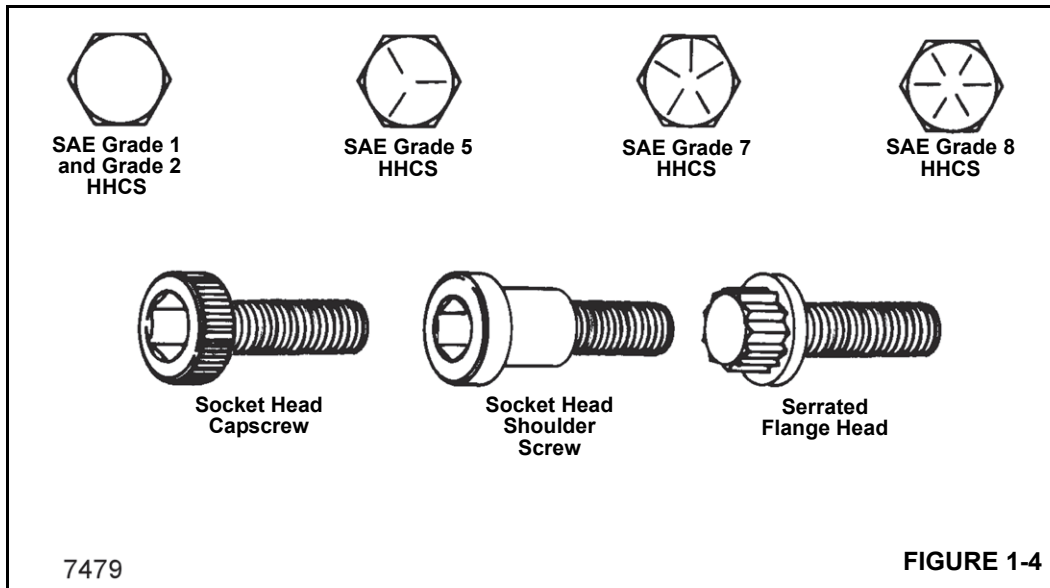
- Torque wrenches must be those specified and forces must be applied at the handle grip. The use of handle extensions will change applied torque to the bolt.
- All handles must be parallel to the step wrench during final tightening. Multiplier reaction bars may be misaligned no more than 30 degrees without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

To convert pounds-foot (lb-ft) of torque to newton meters (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.



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FIGURE 1-4

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28	5	10	9.5	9
	8	14.5	14	13.5
5/16-24	5	21	20	19
	8	26	25	24
3/8-24	5	36	35	34
	8	53	51	49
7/16-20	5	57	55	53
	8	85	82	79
1/2-20	5	88	84.5	81
	8	125	120	115
9/16-18	5	126	121	116
	8	177	170	163
5/8-18	5	182	174.5	167
	8	250	240	230
3/4-16	5	312	299.5	287
	8	425	409	393
7/8-14	5	458	439.5	421
	8	672	646	620
1-12	5	658	632	606
	8	1009	970	931
1-14	5	670	644.5	619
	8	945	908.5	872
1 1/8-12	5	882	848	814
	8	1500	1440	1380
1 1/4-12	5	1251	1203	1155
	8	2092	2008.5	1925
1 3/8-12	5	1704	1638	1572
	8	2833	2719	2605
1 1/2-12	5	2288	2196.5	2105
	8	3640	3500	3360

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

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	8.8	3.1	2.9	2.8
	10.9	4.5	4.3	4.1
	12.9	5.4	5.2	4.9
M5x0.8	8.8	6.5	6.2	5.9
	10.9	9.2	8.9	8.5
	12.9	11	10.5	10
M6x1	8.8	11	10.5	10
	10.9	16	15	14
	12.9	19	18	17
M8x1.25	8.8	27	26	25
	10.9	38	36.5	35
	12.9	45	43.5	42
M10x1.5	8.8	53	51	49
	10.9	75	72	69
	12.9	89	86	83
M12x1.75	8.8	93	89	85
	10.9	130	125	120
	12.9	156	150	144
M14x2	8.8	148	142	136
	10.9	212	203.5	195
	12.9	248	238	228
M16x2	8.8	230	221	212
	10.9	322	310	298
	12.9	387	372	357
M18x2.5	8.8	319	306.5	294
	10.9	455	436.5	418
	12.9	532	511	490
M20x2.5	8.8	447	430	413
	10.9	629	605	581
	12.9	756	727	698
M22x2.5	8.8	608	585	562
	10.9	856	823	790
	12.9	1029	989	949
M24x3	8.8	774	744	714
	10.9	1089	1047	1005
	12.9	1306	1256	1206

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M27x3	8.8	1134	1090	1046
	10.9	1591	1530	1469
	12.9	1910	1836.5	1763
M30x3.5	8.8	1538	1479	1420
	10.9	2163	2080	1997
	12.9	2595	2495	2395
M36x4	8.8	2681	2578.5	2476
	10.9	3964	3812	3660
	12.9	4639	4461	4283

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

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

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

Table 1-13: Weld Stud Torque Values

NOTE:

Weld Studs

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

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

SPECIAL BOOM INSPECTION

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

National Crane recommends that boom extension cables be replaced every seven (7) years.

HOIST CABLE INSPECTION AND MAINTENANCE

Hoist Rope

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

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

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

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

WARNING

Worn or Damaged Equipment Hazard!

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

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

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

Keeping Records

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

data which can be used to determine when a hoist rope should be replaced.

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

WIRE ROPE

General

The following information includes inspection, replacement, and maintenance guidelines for wire rope as established by ANSI/ASME B30.5, federal regulations, and National Manitowoc 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 objective of rope lubrication is to reduce internal friction and to prevent corrosion. New lubricant needs be added throughout the life of the rope. It is important that lubricant applied needs to be compatible with the original lubricant.

Consult the rope manufacturer for proper lubricant. The lubricant applied shall be of the type which does not hinder visual inspection. Those sections of rope which are located over sheaves or otherwise hidden during inspection require special attention when lubricating rope.

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

- Be free from acids and alkalis and should have sufficient adhesive strength to remain on the ropes.
- Be of a viscosity capable of penetrating the interstices between wires and strands.

- Not be soluble in the medium surrounding it under the actual operating conditions (i.e. water).
- Have a high film strength.
- Resist oxidation.

Remove dirt from the rope before applying lubrication. Use a stiff wire brush and solvent, compressed air, or live steam to clean the rope. Lubricate the rope immediately after cleaning. Methods of lubrication are bath, dripping, pouring, swabbing, painting, or pressure spray (Figure 1-5). 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.

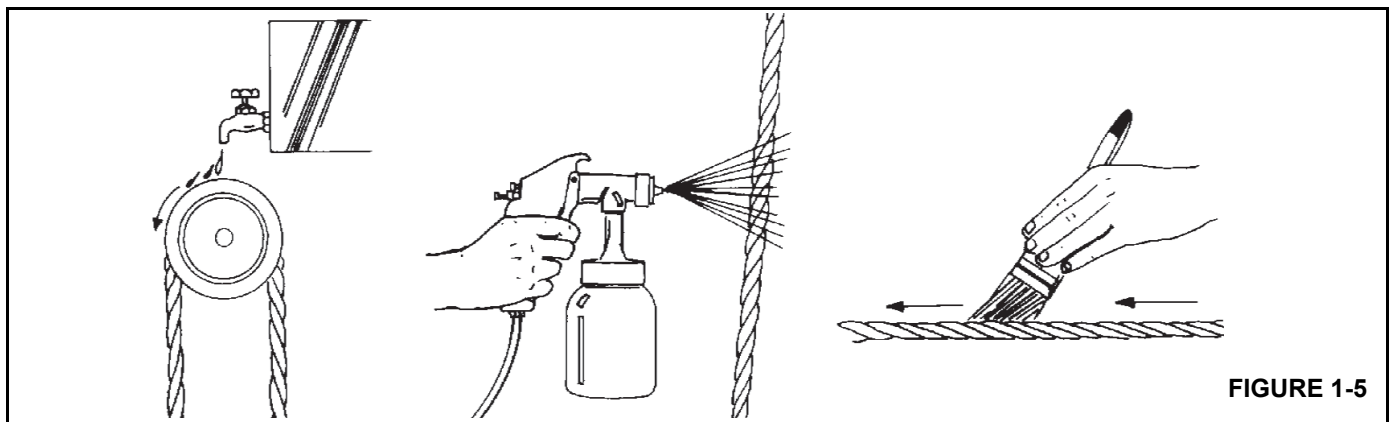


FIGURE 1-5

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 (example. 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.
- General corrosion.
- Broken or cut strands.

Yearly Inspection

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

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

Boom Extension and Retraction Cables

Periodic Inspection

It is recommended that inspection of all boom extension and retraction cables be performed in conjunction with boom lubrication or quarterly. This inspection shall cover all visible areas of the extension and retraction cables of an assembled boom.

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

This inspection shall cover the entire length of the extension and retraction cables of a disassembled boom prior to reassembly. Use this inspection to monitor degradation and identify damage that requires wire rope replacement or

equipment repair. Inspect the rope using the following guidelines for:

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

Wire Rope Replacement (All Wire Rope)

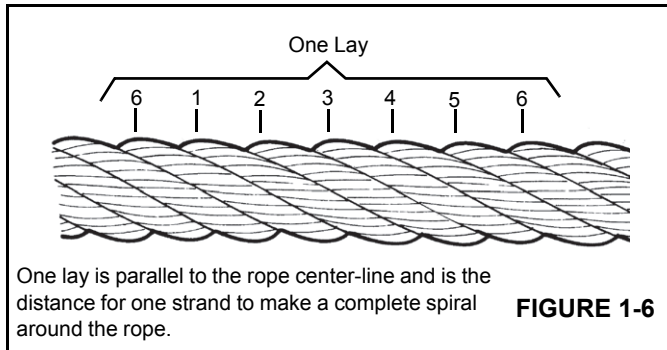
If the hoist cable needs to be replaced, care should be taken in selecting a suitable replacement cable. The cable strength requirements are shown on the crane load chart. The types of cable are optional with 6 x 25 and Dyform being the most common. A high strength, rotation resistant cable is preferred and is furnished as standard by National Crane. This cable eliminates single part line load spin and prolongs cable life. It also eliminates load block spin up when multi-part reeving is used.

Standard
16 mm (.625 in) Dia. Wire cable: Dyform 34LR Nominal Breaking Strength: 251 kN (56,420 lb)
Optional
16 mm (.625 in) Dia. Wire cable: 6X25 I WRC Nominal Breaking Strength: 200 kN (45,000 lb)

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

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

- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay (Figure 1-6).



- Wear of one-third the original diameter of outside individual wires.
- Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of heat damage.
- Reductions from nominal diameter of more than 5%:
 - .4 mm (0.0156 in) for rope diameters to 8 mm (0.313 in)
 - .8 mm (0.031 in) for rope diameters 9.5 mm (0.375 in) to 12.7 mm (0.50 in)
 - 1.2 mm (0.047 in) for rope diameters 14.3 mm (0.561 in) to 19.1 mm (0.75 in)
 - 1.6 mm (0.063 in) for rope diameters 22.2 mm (0.875 in) to 28.6 mm (1.12 in).
- One outer wire broken at its point of contact with the core of the rope which has worked its way out of, and protrudes or loops out from the rope structure.
- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
- Manitowoc recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the complete set of extension cables.

- Manitowoc recommends that boom extension cables be replaced every seven (7) years.

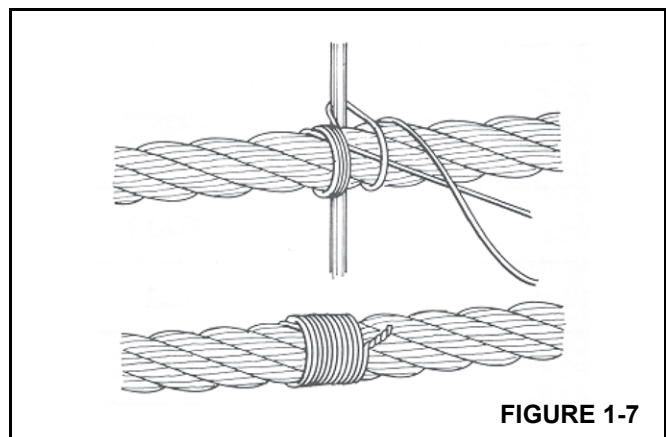
Seizing Wire Rope

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

Method 1

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

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



Method 2

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

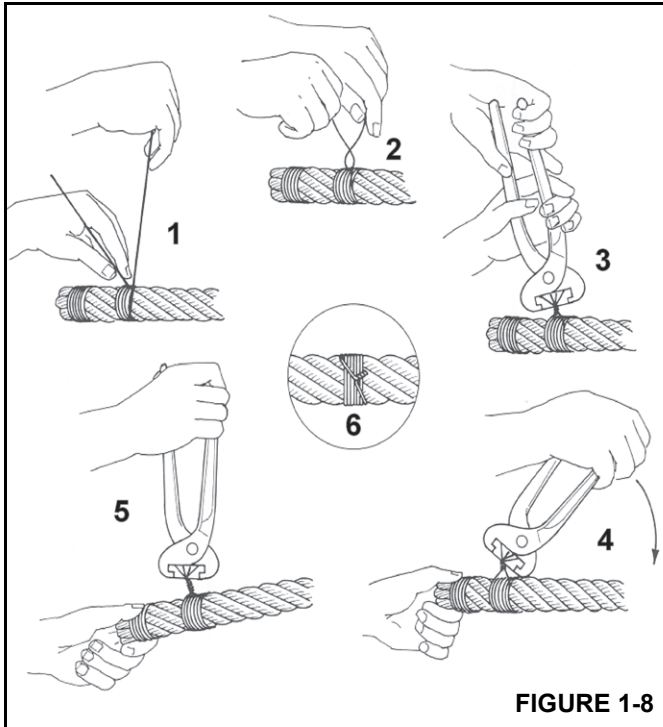
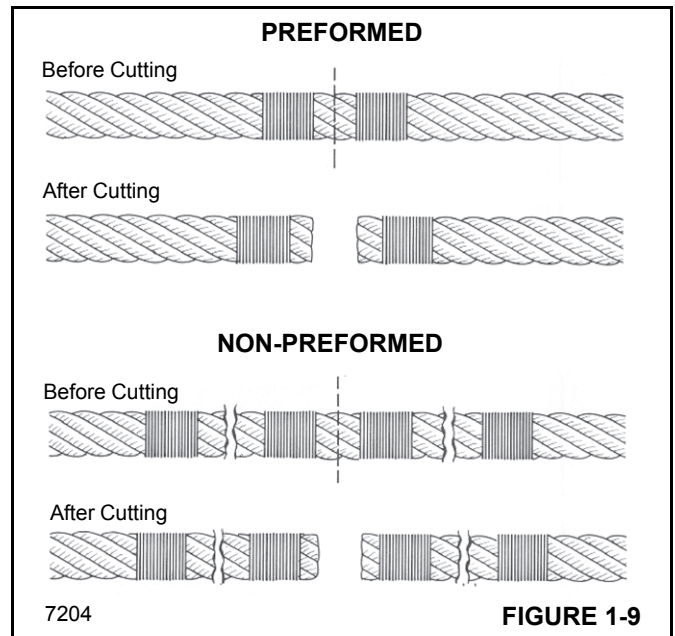


FIGURE 1-8

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



Synthetic Hoist Rope

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

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SECTION 2 HYDRAULIC SYSTEM

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DESCRIPTION

This section describes the hydraulic system, the components which make up the hydraulic system, and the components dependent upon the hydraulic system for their operation. This includes descriptions of the supply pressure and return circuit, pumps, valves, and cylinders. Detailed descriptions and operation of individual hydraulic circuits are discussed within their individual sections as applicable. A chart titled HYDRAULIC SYMBOLS on page 2-3 contains all hydraulic symbols used in the hydraulic schematics contained in this manual.

MAINTENANCE

Hydraulic Oil Recommendations

For the hydraulic oil specifications, refer to Section 8-LUBRICATION.

Draining and Flushing

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



1. Remove the reservoir drain plug. Allow about three minutes after hydraulic oil stops flowing from the drain port for the side walls to drain.
2. Clean and install the reservoir plug and fill the reservoir with a 50/50 mixture of fuel oil and clean hydraulic oil.
3. Cycle the crane through all functions several times. Then return the crane to its stowed position and shut down the engine.
4. Remove the reservoir drain plug and drain the reservoir. Clean and install the drain plug and fill the reservoir with clean hydraulic oil.
10. Disconnect the return lines from a pair of outrigger jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat step 10 and step 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 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 step 7 and step 8 for the remaining outriggers.

CAUTION


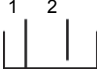
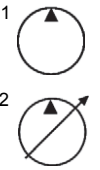
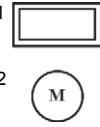
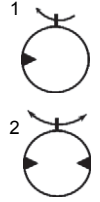
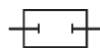





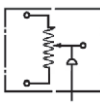
When draining the outrigger cylinders, always operate either both front or both rear cylinders together to prevent twisting the crane.


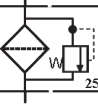








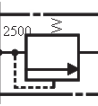
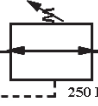

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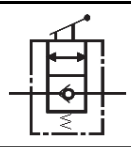
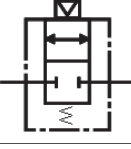
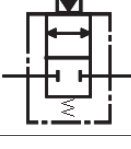
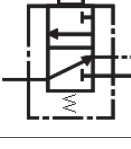
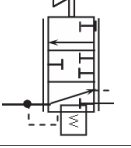
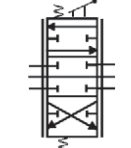
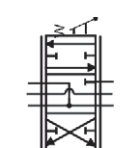
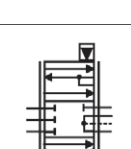
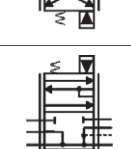
Hydraulic oils must be of the same specifications or discoloration (milky) may occur.


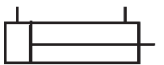
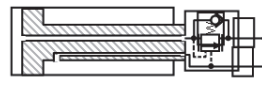
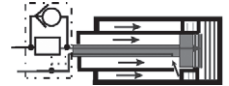

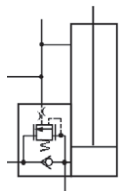
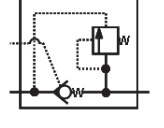
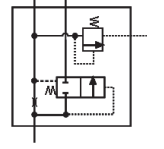
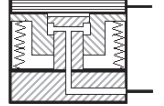
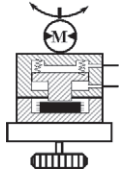
When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Working reservoir capacity (capacity to full mark) is 386.3 liters (102 U.S. gallons). Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted. Fill the reservoir to the full mark on the reservoir sight gauge, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

HYDRAULIC SYMBOLS

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

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

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

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

Removing Air from Hydraulic System

Air entering the hydraulic oil is normally removed by baffles in the hydraulic reservoir. If a component has been replaced, the reservoir oil level is too low, or a leak develops in the suction line to the pump, air can enter the system. Air can cause noisy operation of the swing and hoist hydraulic motors. Check the level of the hydraulic reservoir first if noisy operation occurs. Inspect for leaks in the suction lines leading to the pumps.

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

- Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to .138 - .276 bar (2 - 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.
- This action should return any entrapped air to the reservoir where it can be removed by the internal baffles.

DANGER

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

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

DANGER

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

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

DANGER

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

- 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.

Parts Replacement

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

Directional Control Valve (DCV)

The DCV controls the hoist, swing, lift cylinder, telescope cylinder and options when installed. The valve is located inside the turntable.

Inspection

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

Valve Leakage

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

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

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

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

Binding Spools

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

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

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

Visual Inspection of Hoses and Fittings

CAUTION

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

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:
 - a. Leaks at hose fitting or in hose

- b. Damaged, cut, or abraded cover
- c. Exposed reinforcement
- d. Kinked, crushed, flattened, or twisted hose
- e. Hard, stiff, heat cracked, or charred hose
- f. Blistered, soft, degraded, or loose cover
- g. Cracked, damaged, or badly corroded fittings
- h. Fitting slippage on hose
- i. Other signs of significant deterioration

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

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

If any of these conditions exist, address them appropriately.

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

Table 2-1

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

SUPPLY PRESSURE AND RETURN CIRCUIT

Description

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

Hydraulic Reservoir and Filter

The reservoir, (Figure 2-1) is attached to the inside of the turret and has a capacity of 386.1 liters (102 U.S. gallons) to the full mark. The all-steel reservoir has a breather-filter, a return line filter, suction filter, shutoff valve and anti-start safety switch to avoid accidental start up when valve is closed. Internal baffles help cool the hydraulic oil and prevent foaming.

Hydraulic oil flows through the suction line of the reservoir to the swivel. Return lines for the cooler, pump and hoist (Figure 2-1) 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 10 micron filter (19, (Figure 2-2)) is located on the top, inside the hydraulic reservoir to help protect the pump from contamination and a 250 micron suction strainer with internal shut off is connected to the main suction line in the front of reservoir.

The breather/filler cap 4, (Figure 2-1) on the top of the reservoir is for filling the reservoir. The filler cap includes a strainer for catching contaminants and gaskets to prevent leaking. The breather cap, (vent) which is part of the filler cap, allows air to enter or leave the reservoir. The breather must be kept clean to prevent damage to the reservoir.

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

A thermometer is located on the back of the reservoir to monitor temperature of the hydraulic oil.

The large access cover 5, (Figure 2-1) on the top of the reservoir provides access for cleaning. The cover is secured to the top of the reservoir with a single capscrew and has a gasket to prevent leaking. The access hole can also be used to fill the reservoir after it has been completely drained at plug 11, (Figure 2-1).

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

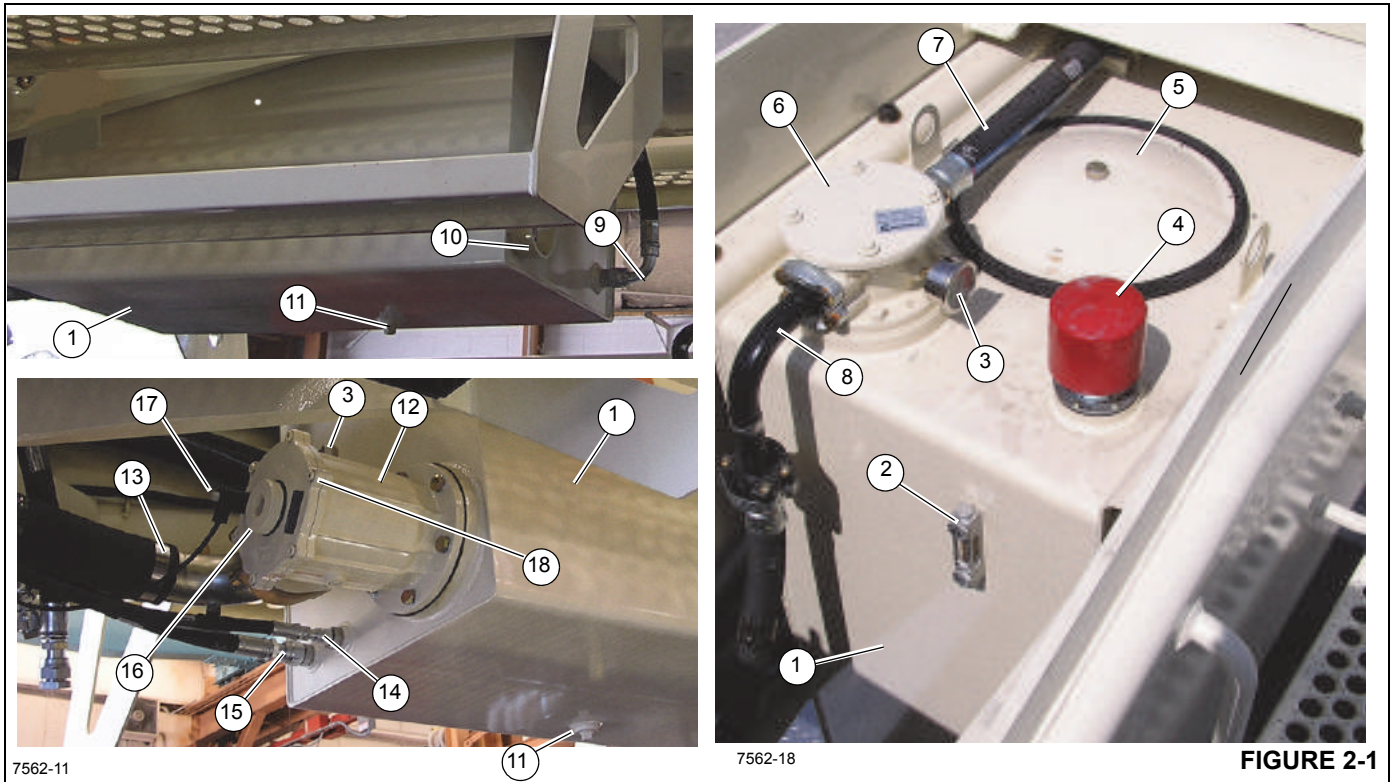


FIGURE 2-1

(Figure 2-1) Item List

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

Maintenance

Pump Distribution

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

Troubleshooting

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

Troubleshooting Chart

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Excessive Noise and/or Vibration	Check fluid level in reservoir.	Insufficient hydraulic fluid causes cavitation.	Fill the reservoir to proper level.
	Check for air in system.	Air in system causes noisy, erratic control.	Purge air and tighten fittings. Check inlet for leaks.
	Check pump inlet pressure/vacuum.	Improper inlet conditions cause erratic behavior and low output flow.	Correct pump inlet pressure / vacuum conditions.
	Inspect shaft couplings.	A loose or incorrect shaft coupling causes excessive noise and/or vibration.	Repair or replace coupling and ensure that correct coupling is used.
	Check shaft alignment.	Misaligned shafts create excessive noise and/or vibration.	Correct shaft misalignment.
	Hydraulic fluid viscosity above acceptable limits.	Hydraulic fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operating, or use fluid with the appropriate viscosity grade for expected operating temperatures.
Actuator Response is Sluggish	Check external system relief valve setting.	Low external relief valve setting slows down system.	Adjust external relief valve setting following manufacturer's recommendations. External relief setting must be above pressure compensator setting to operate properly.
	Check pressure compensator and load sense control setting.	Low pressure compensator setting prevents the pump from achieving full stroke. Low load sense setting limits output flow.	Adjust pressure compensator and load sense setting.
	Check load sense control signal pressures.	Incorrect load sense signal will not allow pump to operate correctly.	Inspect system to ensure that proper load sense signal is transmitted to pump.
	Internal system leaks.	Worn internal parts don't allow the pump to operate properly.	Refer to Authorized Service Center for required repair.
	Hydraulic fluid viscosity above acceptable limits.	Hydraulic fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operation or use fluid with the appropriate viscosity grade for expected operating temperatures.
	Check external system valving.	Malfunctioning valving may not allow system to respond properly.	Repair or replace system valving as required.
	Check pump case pressure.	High case pressure causes the system to be sluggish.	Correct case drain line restrictions.
	Check pump inlet pressure/vacuum.	High inlet vacuum causes low output flow.	Correct inlet pressure conditions.



Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
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. Verify proper size of reservoir.
	Inspect heat exchanger. Check air flow and input air temperature for the heat exchanger.	Insufficient air flow, high input air temperature, or undersized heat exchanges will not meet cooling demands of the system.	Clean, repair, or replace heat exchanger as required. Verify proper size of heat exchanger.
	Check external system relief valve setting.	Fluid passing through relief valve adds heat to system.	Adjust external system relief valve setting following manufacturer's recommendations. External relief valve setting must be above pressure compensator setting for proper operation.
	Check pump inlet pressure/vacuum.	High inlet vacuum adds heat to system.	Correct inlet pressure/vacuum conditions.
Low Pump Output Flow	Check fluid level in reservoir.	Insufficient hydraulic fluid will limit output flow and cause internal damage to pump.	Fill the reservoir to proper level.
	Hydraulic fluid viscosity above acceptable limits.	Fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operating, or use fluid with the appropriate viscosity grade for expected operating temperatures.
	Check external system relief valve setting.	External relief valve set below pressure compensator setting causes low output flow.	Adjust external relief valve following manufacturer's recommendation. External relief valve setting must be above pressure compensator setting to operate properly.
	Check pressure compensator and load sense control setting.	Low pressure compensator setting prevents the pump from achieving full stroke.	Adjust pressure compensator and load sense setting.
	Check pump inlet pressure/vacuum.	High inlet vacuum causes low output flow.	Correct inlet pressure conditions.
	Check input speed.	Low input speeds decrease flow.	Adjust input speed.
	Check pump rotation.	Incorrect rotational configuration causes low flow.	Use pump with appropriate rotational configuration.

Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Pressure or Flow Instability	Check for air in system.	Air in system causes erratic operation.	Activate pressure compensator allowing system to bleed air. Check inlet line for leaks and eliminate source of air ingress.
	Check control spools.	Sticking control spools cause erratic operation.	Inspect spools for free movement in bore. Clean or replace.
	Check load sense setting.	Low load sense setting may cause instability.	Adjust load sense setting to proper level.
	Check load sense signal line.	Blocked load sense signal line interferes with proper load sense operation.	Remove blockage.
	Check external relief valve and pressure compensator setting.	Insufficient pressure differential between pressure compensator setting and external relief valve.	Adjust external relief valve or pressure compensator control settings to appropriate level. Relief valve setting must be above pressure compensator setting to operate properly.
	Check external relief valve.	Chattering external relief valve may cause unstable feedback to pump control.	Adjust or replace relief valve.
System Pressure not Reaching Pressure Compensator Setting	Check pressure compensator control setting.	System pressure will not rise above pressure compensator setting.	Adjust pressure compensator to appropriate setting.
	Check external relief valve.	External relief valve setting below pressure compensator setting presets pressure compensation.	Adjust external relief valve according to manufacturer's recommendations. External relief valve must be set above pressure compensator setting to operate properly.
	Inspect pressure compensator control spring.	Broken, damaged, or missing spring will cause erratic operation.	Replace the spring as required.
	Inspect pressure compensator spool for wear.	Wear of pressure compensator spool causes internal leakage in the control.	Replace the spool as required.
	Inspect pressure compensator spool for proper orientation.	Improper orientation results in poor operation.	Correct orientation of spool.
	Check pressure compensator control for contamination.	Contamination may interfere with movement of the pressure compensator spool.	Clean pressure compensator control components, take appropriate action to eliminate contamination.



Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
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.

Hydraulic Filter Replacement

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

The hydraulic oil filter-suction (Figure 2-1) is located on the front of the reservoir and contains a replaceable filter element.

1. The filter can be changed without emptying the reservoir by closing the shutoff valve. The shutoff valve is controlled by the hand wheel on the filter cover. Closing the valve will activate the anti-start safety switch preventing start-up and prompting a warning to be displayed on cab console monitor.

CAUTION

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

Element Removal



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

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

CAUTION

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

2. Wipe any dirt from the filter head.
3. Place a container under the filter to catch spilled oil.
4. Remove (6) screws and remove the filter cover and seal.
5. Remove the used filter.
6. Install new filter element and new seal.
7. Re-install filter cover and screws.
8. Open filter shutoff valve to provide oil flow to hydraulic system by turning hand wheel clockwise.

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

9. Properly discard the used filter and oil.

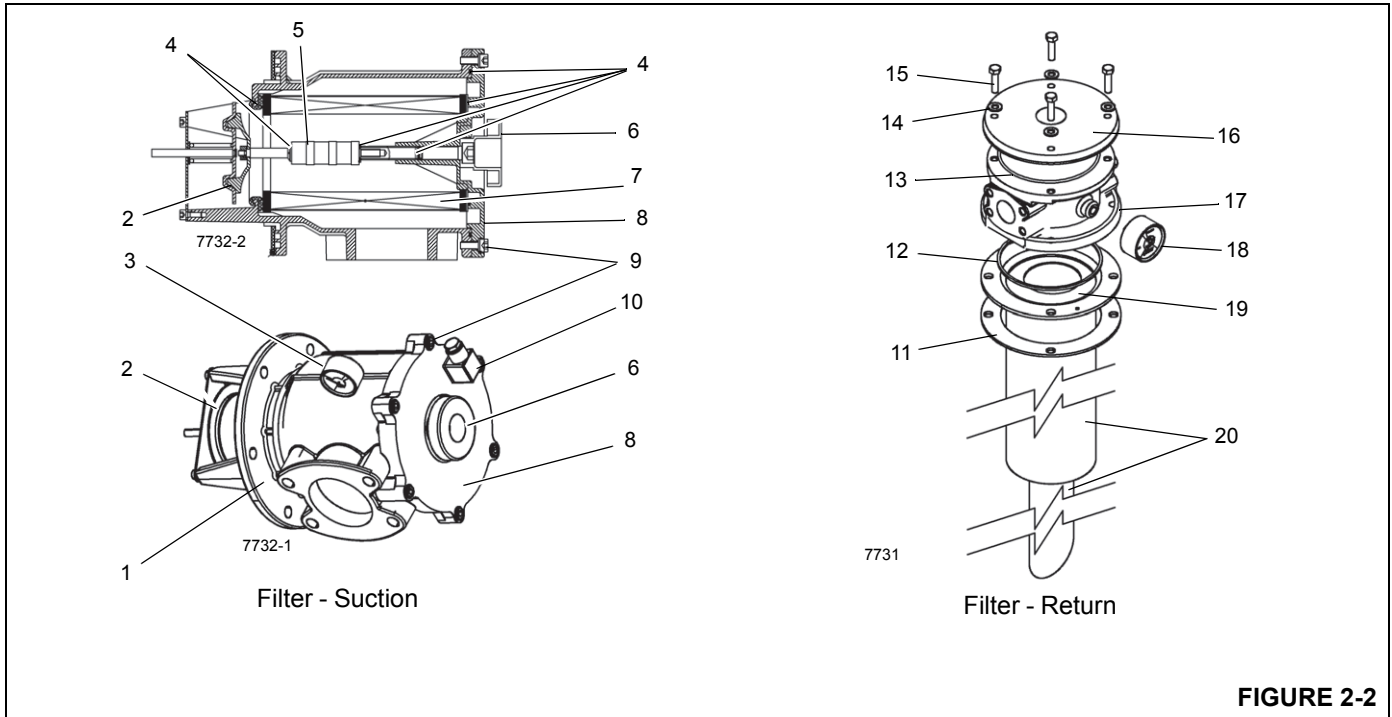


FIGURE 2-2

Figure2-2 Item List

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

HYDRAULIC OIL COOLER

Description

The hydraulic oil cooler is installed at the rear of the turret frame (Figure 2-3). The oil cooler return circuit is in parallel with the reservoir return circuit and a 206 kPa (30 psi) integral check valve regulates flow through the oil cooler. When the hydraulic oil is cold, most of the return oil goes directly to the tank. As the oil warms up and becomes thinner, more oil goes through the cooler.

A temperature switch located in the cooling core energizes the fan relay when the oil temperature reaches 48.8° C (120° F).

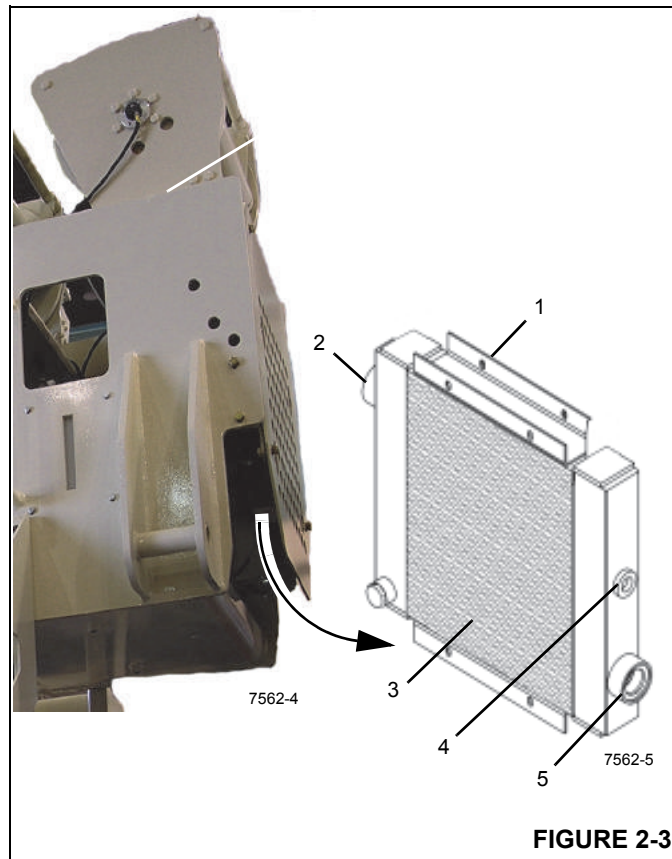


FIGURE 2-3

(Figure 2-3) Item List

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

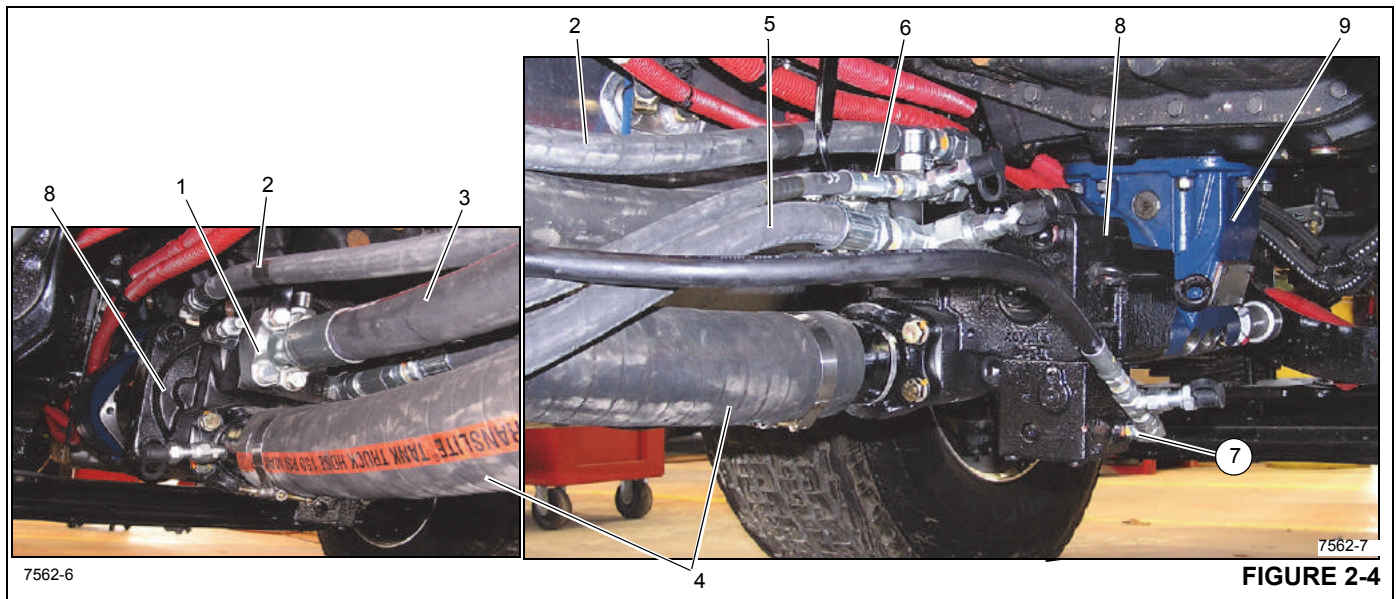
Oil Cooler Service and Maintenance

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

Frequent inspection 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 PUMP



(Figure 2-4) Item List

Item	Description	To
1	Pump Manifold	
2	Hose, 3/4" ID	Swivel Port 1, Case Drain
3	Hose 1-1/4" ID	Swivel Port 4, DC Valve
4	Hose, 3" ID	Swivel, Hydraulic Tank
5	Hose Assembly 3/4" ID	Front O/R, Port P
6	Hose, 3/8" ID	Front O/R, Port T
7	Hose, 3/8" ID	Front O/R, Port LS
8	Piston Pump	Mounted to Truck PTO
9	Power Take Off (PTO)	On truck Engine

Description

The hydraulic system pressure is supplied from an axial piston pump mounted on the truck power take off (PTO) (Figure 2-4). The hydraulic pump requires a PTO rating of 156.5 kw (210 hp) @ 2200 rpm.

The axial piston hydraulic pump (1, (Figure 2-5)) converts input torque into hydraulic power. Rotational force is transmitted through a 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

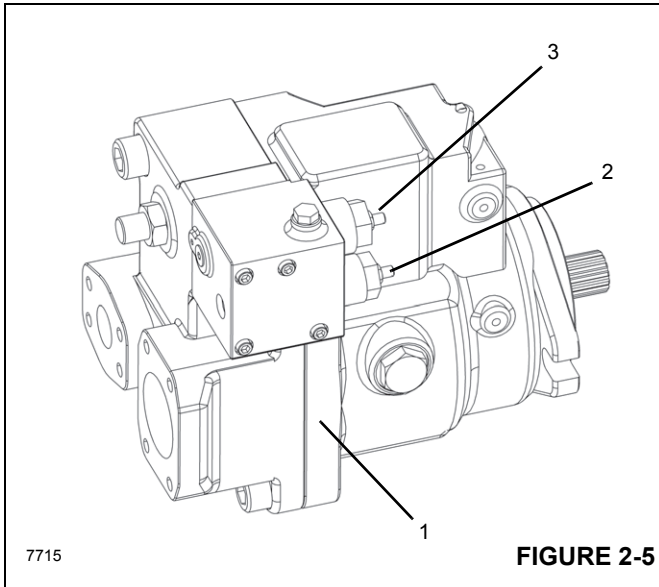
The Load Sense (LS) standby control (2), (Figure 2-5) matches pump flow with system demand. The LS control senses the flow demand of the system as a pressure drop across an External Control Valve (ECV). As the ECV opens and closes, the pressure delta across the valve changes. Opening the ECV decreases 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). The DCV directs fluid to the hydraulic components in the system. The speed of the hydraulic components in the system depends on the volume of fluid being provided by the pump. The operating pressure varies depending on the hydraulic component load, but is limited to:

- An adjustable maximum setting by the pressure compensator (PC) [3], (Figure 2-5) 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.



Removal

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

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

Installation

1. Lubricate the splines on the pump and PTO drive shaft coupling with heavy lithium grease.
2. Line up the splines on the PTO drive shaft coupling with the pump drive shaft and slide the pump drive shaft into the coupling.

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

A. Pump Startup Procedure

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

1. Connect the pump to the PTO. Ensure pump is properly aligned to the PTO shaft.
2. Fill the reservoir with hydraulic fluid.
3. Turn the shut-off valve on the inlet line from the pump to the reservoir clockwise until the handwheel is fully open in order to achieve maximum oil flow. Check the line for properly tightened fittings, and be sure the line is free of restrictions and air leaks.

CAUTION

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

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

4. Fill the pump housing with hydraulic fluid. Pour the oil directly into the upper most case drain port (Figure 2-4).
5. Fill the inlet line from the pump to the reservoir.
6. Check the suction line for properly tightened fittings and be certain it is free of any restrictions. Check for potential air leaks.
7. Inspect the case drainline for leaks or restrictions.
8. Install a gauge at the pump pressure gauge port (GP1) on the Directional Control Valve (DCV) (Figure 2-6).
9. Start the engine and engage the PTO while monitoring the gauge and idle the engine about 2 to 3 minutes until the gauge registers pressure. Do not operate any hydraulic levers.

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

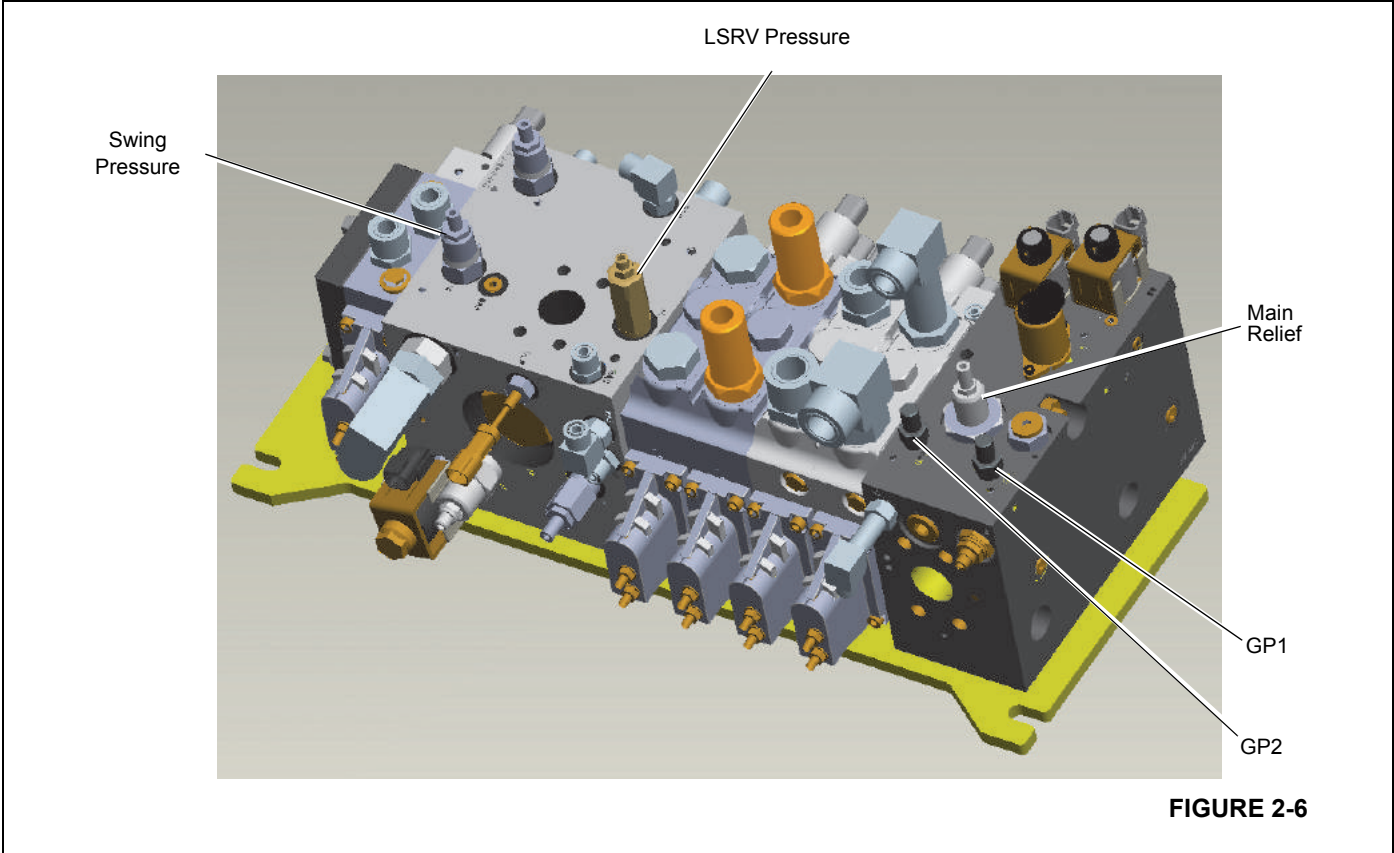


FIGURE 2-6

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

- 10. Operate the system under a light load for 5 to 10 minutes.
- 11. Check/adjust pump margin pressure; see *B. Pump Margin Pressure Setting*, page 2-18.

- 12. Check/adjust main relief valve pressure; see *C. Main Relief Pressure Setting*, page 2-18.
- 13. Check/adjust maximum pump pressure; see *Setting Main Relief Pressure*, page 2-19.
- 14. Remove pressure gauge, check hydraulic oil level in reservoir and fill if needed.

Table 2-2

Pump Margin Pressure (psi) [Read @ GP2]	Main Relief Pressure (psi) [Read @ GP1]	Max. Pump Pressure (psi) [Read @ GP1]	Load Sense Relief Valve Pressure (psi) [Read @ GP2]
25 bar ± 1.7 (363 psi ± 25) Gauge reading = 52.6 bar ± 1.7 (763 psi ± 25)	345 bar -0+3.4 (5000 psi -0 + 50)	338 bar -0+3.4 (4900 psi -0 +50)	322 bar -0+3.4 (4663 psi -0 +50)

B. Pump Margin Pressure Setting

Use (Table 2-3) to verify nominal setting and allowable tolerance.

To check the margin pressure, there are two pressures that will be set as the crane's swing circuit requires 28 bar (400 psi) of back pressure all the time. This means that when a gauge is installed in the load sense port (GP2 in Figure 2-6), the pressure will read the relief that is present in the swing circuit. Therefore the swing back pressure must be verified first,

Gauge reading for Margin Pressure = Pump Margin
25 bar (363 psi) + Swing Back-Pressure 28 bar
(400 psi) = 53 bar (763 psi) [Table 2-2].

Swing Back-Pressure Setting

1. Install a gauge at the pump pressure gauge port (GP2) on the DCV (Figure 2-6).
2. Idle engine with PTO engaged and do not operate any functions.
3. Verify swing pressure is 28 bar -0+3.4 (400 psi -0 + 50).
4. If swing pressure is not correct, adjust Main Relief (Figure 2-7) as follows: Loosen 1/2 in locknut and use 4 mm Allen wrench to adjust setting. Turning clockwise increases the setting. Each turn gains 11 bar (153 psi). Be sure to tighten the locknut to 17.7 Nm (4 lb-ft) to secure the setting.

Pump Margin Pressure Setting

1. Install a gauge at the pump pressure gauge port (GP1) on the DCV (Figure 2-6).
2. Idle engine with PTO engaged and do not operate any functions.

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

3. Adjust the LS adjusting screw (Figure 2-7) on the pump until the Pump Margin Pressure setting is correct.

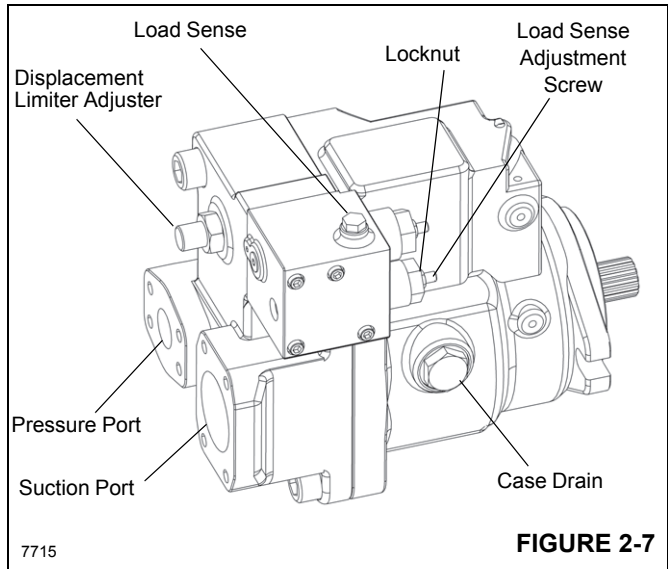


FIGURE 2-7

C. Main Relief Pressure Setting

Use (Table 2-3) to verify nominal setting and allowable tolerance.

In order to set the maximum pump pressure, the load sense relief valve (LSRV) setting must be raised to a value higher than the desired setting of the maximum pump pressure. To do this, raise the LSRV setting (Figure 2-6) by loosening the locknut (1/2 in. hex) and turning the adjustment hex (4 mm) clockwise until bottomed out. This should result in a setting of approximately 345 bar (5000 psi).

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

Method #1: Leave the main hoist up/down hoses connected to the motor and cap the main hoist brake line at the hoist down block on the hoist with a #4 JIC Cap. Using this method, activate the hoist down function to develop maximum pressure (Figure 2-8).

Method #2: Disconnect and cap the main hoist up/down hoses. Refer to (Figure 2-8). Using this method, activate the hoist up or hoist down function to develop maximum pressure.

4. Start the engine and idle with PTO engaged. Activate hoist joystick. Refer to table for correct Maximum Pump Pressure reading (Table 2-2). The pressure reading at GP1 should be the value of the Maximum Pump Pressure as this is now the lowest pressure in the system.
5. Install a 414 bar (6000 psi) minimum gauge in the pump gauge port GP1 (Figure 2-6).

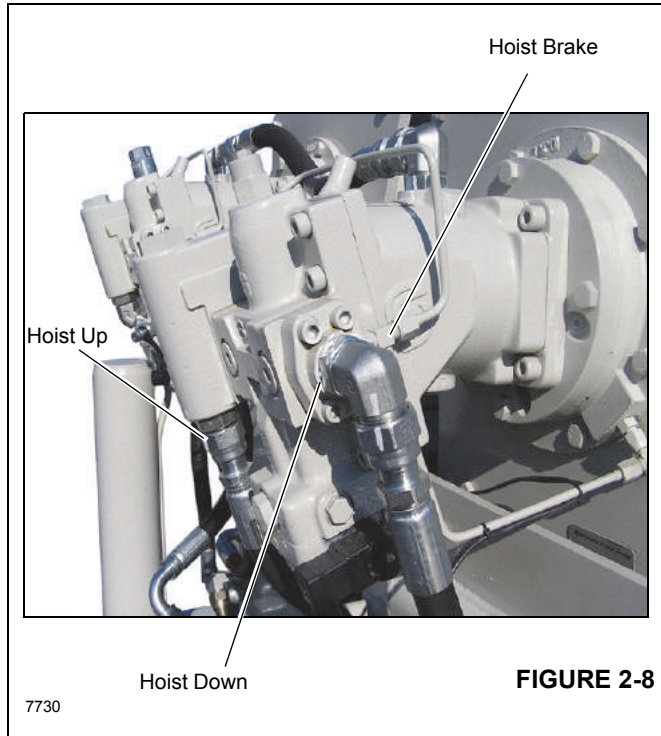


FIGURE 2-8

Setting Main Relief Pressure

1. Idle machine with PTO engaged. Use method #1 or #2 above and hold the joystick. The pressure reading at GP1 should be the value of the Maximum Pump Pressure (Table 2-2) as this is now the lowest pressure in the system.

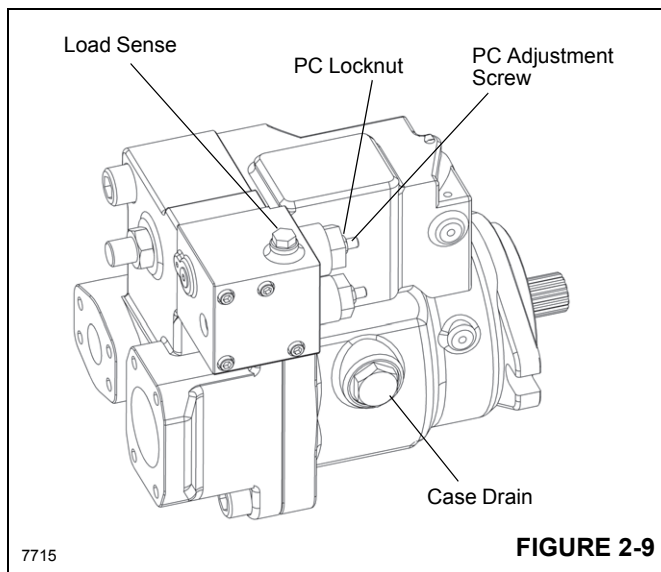


FIGURE 2-9

2. If the pressure reading is below the Maximum Pump Pressure setting, raise the pump pressure compensating (PC) adjusting screw as shown in

(Figure 2-9). Loosen M8 locknut and use a 4mm allen wrench to adjust the setting. Turning clockwise increases the setting and each turn gains 100 bar (1450 psi).

3. Increase the pressure compensator (PC) setting until 345 bar (5000 psi) is reached on the gauge. There should be an audible hiss at the main relief and the return line back to the hydraulic tank should feel as if there is a large oil flow to tank. This means that the main relief setting has been reached.
4. If the 345 bar (5000 psi) setting cannot be reached on the gauge, the main relief valve setting must be increased (reference Figure 2-6). This can be adjusted by loosening the 3/4 in. locknut and using a 3/16 in. allen wrench to adjust the setting. Turning clockwise increases the setting and each turn gains 91 bar (1315 psi). Be sure to retighten the 3/4 in. locknut to 8 Nm (6 lb-ft) when setting is correct.
5. Once the desired main relief setting is reached, the pump pressure compensator (PC) setting must be returned to the value from Table 2-2. See "D. Setting Maximum Pump Pressure."

D. Setting Maximum Pump Pressure

Once the desired main relief setting is reached, the pump pressure compensator (PC) setting must be returned to 338 bar (4900 psi).

1. Install 414 bar (6000 psi) gauge at the pump pressure gauge port (GP1) on the DCV (Figure 2-6).

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

Method #1: Leave the main hoist up/down hoses connected to the motor and cap the main hoist brake line at the hoist down block on the hoist with a #4 JIC Cap (Figure 2-8). Using this method, activate the hoist down function to develop maximum pressure.

Method #2: Disconnect and cap the main hoist up/down hoses (Figure 2-8). Using this method, activate the hoist up or hoist down function to develop maximum pressure.

2. Start the engine and activate hoist joystick. Adjust pressure compensator (PC) Adjusting Valve (Figure 2-9) counter clockwise to attain correct pressure. Refer to Table 2-2 for correct Maximum Pump Pressure reading.
3. Reset the LSRV setting to the value shown in (Table 2-2). See Load Sense Relief Valve Pressure Setting.

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

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

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

Method #1: Leave the main hoist up/down hoses connected to the motor and cap the main hoist brake line at the hoist down block on the hoist with a #4 JIC Cap. See (Figure 2-8). Using this method, activate the hoist down function to develop pressure.

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

To Set the LSRV Pressure

1. Install a 345 bar (5000 psi) gauge at the pump pressure gauge port (GP2) on the DCV (Figure 2-6).
2. Idle engine with PTO engaged. Use method #1 or # 2 above and hold the joystick. Verify LSRV pressure is at correct setting (Table 2-2).
3. If the LSRV pressure is not correct, Adjust the LSRV adjusting screw as shown in (Figure 2-6).

HYDRAULIC SYSTEM SETUP PROCEDURE

Table 2-3 Pressure Settings

Hydraulic Circuit	Pressure bar (PSI)	Tolerance bar (PSI)	1: Gauge Port Label (GPX) 2: Location
Hoist Holding Valve	322 (4663)	-0/+3 (-0/+50)	GP2 @ Directional Control Valve Load Sense Relief Valve
Hoist Thermal Relief	276 (4000)		Hoist
Boom Lift Up	280 (4061)	-3./+48 (-50/+700)	GP1 @ boom lift cylinder manifold Non-adjustable
Boom Lift Down	140 (2031)	-3/+23 (-50/+330)	GP2 @ boom lift cylinder manifold Non-adjustable
Telescope - Retract	140 (2031)	-3/+23 (-50/+330)	None Directional Control Valve Non-adjustable
Telescope - Extend	175 (2538)	-3/+23 (-50/+330)	None Directional Control Valve Non-adjustable
Telescope - Thermal Relief	314 (4550)		Telescope Cylinder
Outrigger Circuit	207 (3000)	-0/+3 (-0/+50)	Relief Valve On Pump
Swing Circuit Clockwise	207 (3000)	-3./+3 (-50/+50)	GPA @ Swing Manifold Directional Control Valve, Adjustable LSRV Valve
Swing Circuit Counter Clockwise	207 (3000)	-3./+3 (-50/+50)	GPB @ Swing Manifold Directional Control Valve, Adjustable LSRV Valve
Swing Backpressure	28 (400)	-0/+3 (-0/+50)	GP1 @ Directional Control Valve Swing Backpressure Relief Valve
Pilot Supply	21 (300)	-0/+3 (-0/+50)	GP5 @ Directional Control Valve Pilot Relief Valve
Swing Brake Release	21 (300)	-0/+3 (-0/+50)	GP4 @ Directional Control Valve Pilot Relief Valve
Swing Brake Apply	26 (375)	-0/+3 (-0/+50)	GP3 @ Directional Control Valve None - Solenoid Controlled (Current, mA)
Air Conditioning- S/S Cab	100 (1450)	-0/+3 (-0/+50)	ACG @ Directional Control Valve A/C - Relief Valve
Gearbox Coolant	4 (60)	-0/+2 (-0/+25)	None Coolant Reducing Valve
Outrigger - Extend	207 (3000)	-0/+3 (-0/+50)	GPB @ Front O/R Manifold Pump Manifold Relief Valve



Hydraulic Circuit	Pressure bar (PSI)	Tolerance bar (PSI)	1: Gauge Port Label (GPX) 2: Location
Outrigger - Retract	127.6 (1850)	-0/+14 (-0/+200)	GPA @ Front O/R Manifold Pump Manifold Relief Valve
Front Jack Extend (Optional)	34 (500)		Port Block on Front Jack
Front Jack Retract (Optional)	79.2 (1150)		Port Block on Front Jack
Counterweight Removal Cylinder(s)	79.2 (1150)	-0/+3 (-0/+50)	None Counterweight Manifold Inlet
Main Relief (DCV)	345 (5000)	-0/+3 (-0/+50)	GP1 @ Directional Control Valve
Load Sense Relief	322 (4663)	-0/+3 (-0/+50)	GP2 @ Directional Control Valve
Lift Thermal Relief	359 (5200)		Lift Cylinder Holding Valve
Cab Tilt	180 (2000)	-7/+7 (-100/+100)	GP2 @ Directional Control Valve Cab Tilt valve

Table 2-4

A. Getting Started

1. Before checking any pressure for the work functions, the following settings must be set/verified:
 - a. Pump Margin Pressure (Standby)
 - b. Pump Max Pressure (Pmax)
 - c. Load Sense Relief Valve Pressure (LSRV)
 - d. Reference the "Pump Startup Procedure" page 2-16 for how to set and verify these settings
2. Valve sections that have relief valves installed (called "shock valves" by the manufacturer) have a fixed adjustment and can not be changed, shimmed, etc.
3. If the shock valve is suspected of being incorrect, it can be inspected using a 13 mm socket to remove the outer casing that retains the shock valve assembly.
 - a. For the Boom, Tele and Hoist sections reference (Figure 2-10). These sections have shock valves on each side of the valve section - directly opposite of each other, with shock valves facing horizontally.
 - b. For the Swing function, reference (Figure 2-11) of the generic valve section cutaway. There are shock valves on each side of the valve section located adjacent to each workport (vertical).
4. The setting of the shock valve in "bar" is stamped on each assembly and can be seen when removed.

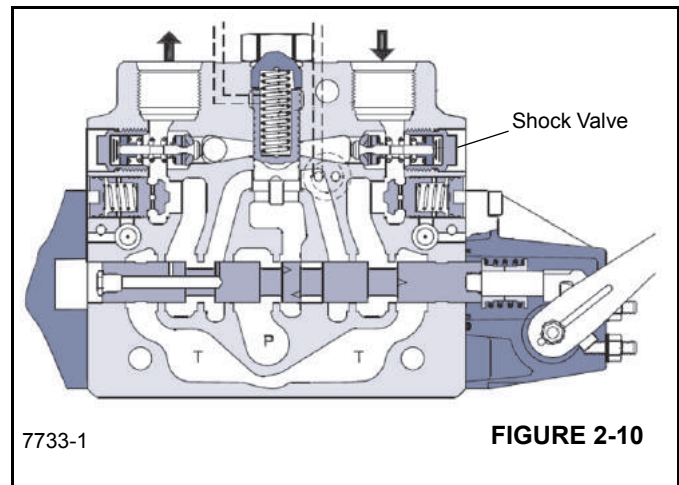


FIGURE 2-10

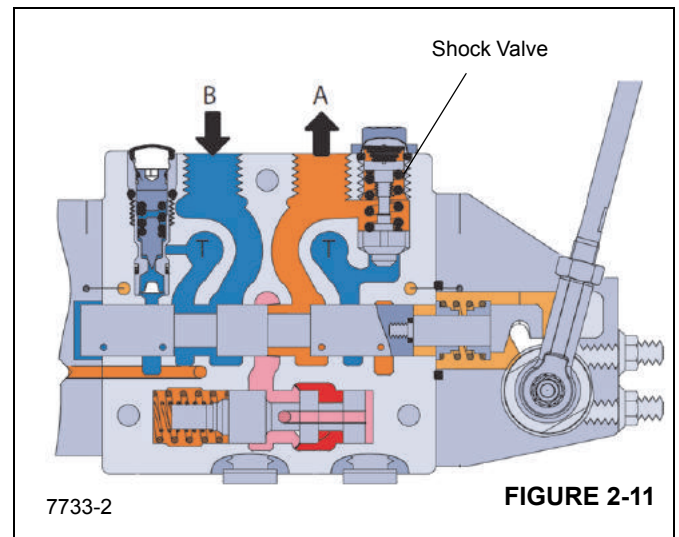


FIGURE 2-11

B. Hoists

- These functions are limited by the maximum load sense relief valve (LSRV) setting.
- Reference the “Pump Startup Procedure” page 2-16 for how to set and verify these settings

C. Boom Up

- Boom Up has a single shock valve in the valve section that has a fixed adjustment of 280 bar (4061 psi) as shown in (Figure 2-12).
- This can not be changed, shimmed, etc. Reference comments in Section A (page 2-22) about checking this setting on the physical shock valve assembly.
- In order to check this setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the extend hose at the cylinder connection.
 - b. Bottom out lift cylinder (full extension) or actuate the function with plugged hoses if no cylinder is present.
 - c. Move joystick to full shift and monitor pressure reading at gauge.
 - d. Use (Table 2-3) to verify nominal setting and allowable tolerance.
 - e. Uninstall gauge and re-torque all connections.

D. Boom Down

- Boom Down has a single shock valve in the valve section that has a fixed adjustment of 140 bar (2031 psi) as shown in (Figure 2-12).
- This can not be changed, shimmed, etc. Reference comments in Section A (page 2-22) about checking this setting on the physical shock valve assembly.
- In order to check this setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the retract hose at the cylinder connection.
 - b. Bottom out lift cylinder (full retraction) or actuate the function with plugged hoses if no cylinder is present.
 - c. Move joystick to full shift and monitor pressure reading at gauge.
 - d. Use (Table 2-3) to verify nominal setting and allowable tolerance.

- e. Uninstall gauge and re-torque all connections.

E. Telescope Extend

- The Telescope Extend function has dual shock valves in the valve section that each have a fixed adjustment of 175 bar (2538 psi) as shown in (Figure 2-12).
- This can not be changed, shimmed, etc. Reference comments in Section A (page 2-22) about checking this setting on the physical shock valve assembly
- In order to check this setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the extend hose at the cylinder connection.
 - b. Bottom out telescope cylinder (full extension) or actuate the function with plugged hoses if no cylinder is present.
 - c. Move joystick to full shift and monitor pressure reading at gauge.
 - d. Use (Table 2-3) to verify nominal setting and allowable tolerance. Uninstall gauge and re-torque all connections.

F. Telescope Retract

- The Telescope Retract function has dual shock valves in the valve section that each have a fixed adjustment of 140 bar (2031 psi) as shown in (Figure 2-12).
- This can not be changed, shimmed, etc. Reference comments in Section A (page 2-22) about checking this setting on the physical shock valve assembly
- In order to check this setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the retract hose at the cylinder connection.
 - b. Bottom out telescope cylinder (full retraction) or actuate the function with plugged hoses if no cylinder is present.
 - c. Move joystick to full shift and monitor pressure reading at gauge.
 - d. Use (Table 2-3) to verify nominal setting and allowable tolerance.
 - e. Uninstall gauge and re-torque all connections.

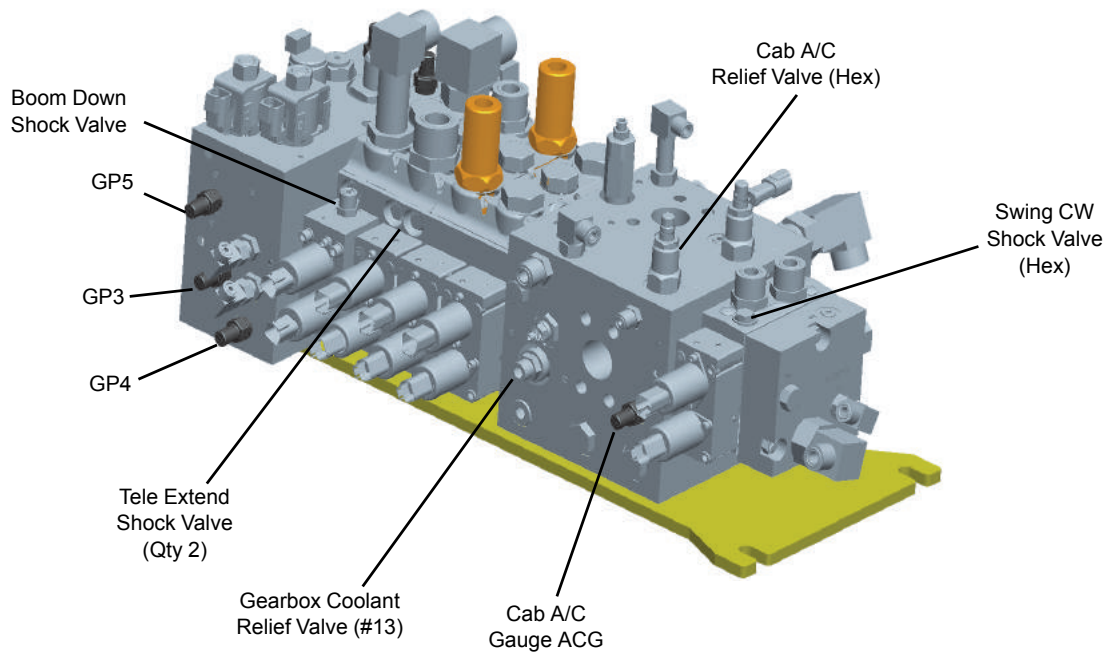
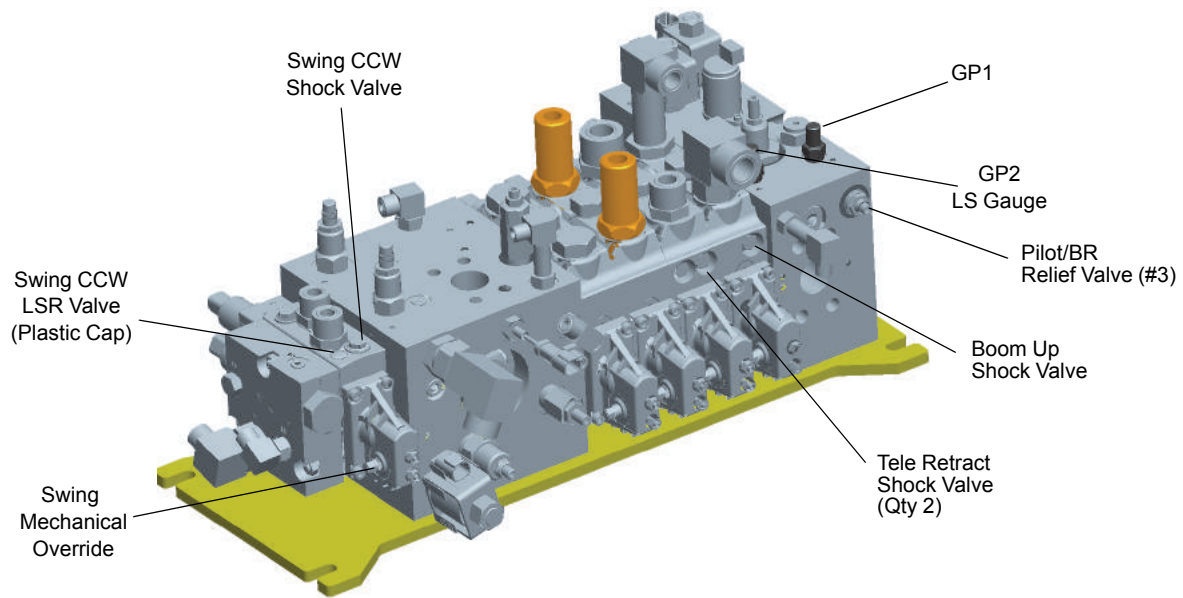


FIGURE 2-12

G. Swing Clockwise/Counter Clockwise

- Swing clockwise/counter clockwise each have a single shock valve in the valve section that has a fixed adjustment of 210 bar (3045 psi) as shown in (Figure 2-12). This can not be changed, shimmed, etc. Reference comments in Section A about checking this setting on the physical shock valve assembly if suspect.
- The swing setting should be set by the load sense relief valve (LSRV) for each direction as it is adjustable up to the shock valve setting mentioned above. These LSRV's are located under the rounded black plastic plugs located on each side of the section adjacent to the shock valves as shown in (Figure 2-11) and (Figure 2-12).
- In order to set the swing settings:
 - a. Install a 345 bar (5000 psi) minimum gauge in the GA or GB gauge port on the hydraulic motor manifold (Figure 2-13).

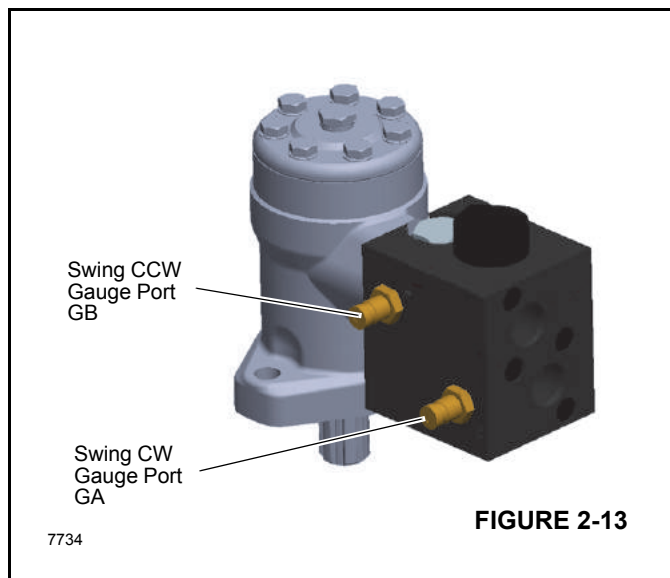


FIGURE 2-13

- b. Method #1: Using mechanical override

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

Actuate the swing clockwise or counter clockwise with the swing brake released (with Brake Release solenoid unplugged - Wire #50).
- d. Move joystick/override to full shift and monitor pressure reading at gauge.
- e. Use (Table 2-3) to verify nominal setting and allowable tolerance for LSRV valve(s).

- f. Uninstall gauge and re-torque all connections.

H. Swing Backpressure

1. This backpressure should have been set at pump startup.
2. Reference the "Pump Startup Procedure" (page 2-16) for how to set and verify this setting.

I. Cab A/C

1. The Cab A/C circuit has a single relief valve in the directional control valve mid-inlet manifold with a setting of 100 bar (1450 psi) as shown in (Figure 2-12).
2. This can be adjusted by loosening the $\frac{3}{4}$ in. locknut and using a $\frac{1}{4}$ in. allen wrench to adjust the setting. Clockwise rotation increases the setting and each turn gains 40 bar (573 psi). Be sure to retighten the $\frac{3}{4}$ in. locknut to 5 N·m (4 lb-ft) when setting is correct.
3. In order to check this setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the A/C gauge port on the control valve mid-inlet manifold (Figure 2-12).
 - b. Install a plug in the A/C pressure hose at the compressor box located behind the crane cab.
 - c. Turn Cab A/C ON using the cab control knob and monitor pressure reading at gauge.
 - d. Use Table 2-3 to verify nominal setting and allowable tolerance.
 - e. Uninstall gauge and re-torque all connections.

J. Pilot Supply

(Shared Relief with Swing Brake Release)

1. The Pilot Supply circuit has a single relief valve in the directional control valve inlet manifold with a setting of 21 bar (300 PSI) as shown in (Figure 2-12).
2. This can be adjusted by loosening the $\frac{11}{16}$ in. locknut and using a $\frac{3}{16}$ in. allen wrench to adjust the setting. Be sure to retighten the $\frac{11}{16}$ in. locknut to 5.4 Nm (4 lb-ft) when setting is correct.
3. In order to check this setting:
 - a. Install a 69 bar (1000 psi) minimum gauge in the GP5 gauge port on the control valve inlet manifold (Figure 2-12).
 - b. Turn Crane Power Switch ON using the cab control switch and monitor pressure reading at gauge

Use Table 2-3 to verify nominal setting and allowable tolerance.

 - c. Uninstall gauge and re-torque all connections.

K. Swing Brake Release

(Shared Relief with Pilot Supply)

1. The Swing Brake Release circuit has a single relief valve in the directional control valve inlet manifold with a setting of 21 bar (300 psi) as shown in (Figure 2-12).
2. This can be adjusted by loosening the 11/16 in. locknut and using a 3/16 in. allen wrench to adjust the setting. Be sure to retighten the 11/16 in. locknut to 5 N·m (4 lb-ft) when setting is correct.
3. In order to check this setting:
 - a. Install a 69 bar (1000 psi) minimum gauge in the GP4 gauge port on the control valve inlet manifold (Figure 2-12).
 - b. Turn Crane Power Switch and Swing Brake Release switch ON using the cab control switches and monitor pressure reading at gauge.
 - c. Use Table 2-3 to verify nominal setting and allowable tolerance.
 - d. Uninstall gauge and re-torque all connections.

L. Swing Brake Apply

1. The Swing Brake Apply circuit is controlled through a proportional solenoid valve shown in (Figure 2-12) and can not be adjusted.
2. In order to check this setting:
 - a. Install a 69 bar (1000 psi) minimum gauge in the GP3 gauge port on the control valve inlet manifold. See (Figure 2-12).
 - b. Turn Crane Power Switch and Swing Brake Release switch ON using the cab control switches. Fully depress the swing brake pedal on cab floor and monitor pressure reading at gauge.
 - c. Use (Table 2-3) to verify nominal setting and allowable tolerance.
 - d. If above or below tolerance, the amount of current (mA) available to this proportional valve may need to be adjusted. Reference “Crane Software Configuration” specification for instructions on adjusting and checking this current, contact Manitowoc crane care.
 - e. Uninstall gauge and re-torque all connections.

M. Gear Box Coolant

1. The Gearbox Coolant circuit has a single reducing valve in the directional control valve mid-inlet manifold with a

setting of 60 psi (4 bar) as shown in (Figure 2-12) (Gearbox Coolant Relief Valve #13).

2. This can be adjusted by loosening the 3/4 in. locknut and using a 5/16” allen wrench to adjust the setting. clockwise rotation increases the setting and each turn gains 29 bar (420 psi). Be sure to retighten the 3/4 in. locknut to 5 N·m (4 lb-ft) when setting is correct.
3. In order to check this setting:
 - a. Install a 69 bar (1000 psi) minimum gauge in the gearbox coolant hose at the swing gearbox with the hose removed from the gearbox port.
 - b. With the hydraulic system operating, monitor pressure reading at gauge.
 - c. Use Table 2-3 to verify nominal setting and allowable tolerance.
 - d. Uninstall gauge and re-torque all connections.

N. Outrigger Extend and Retract

1. The outrigger circuit has a single relief valve in the pump manifold with a setting of 207 bar (3000 psi) as shown in (Figure 2-14).

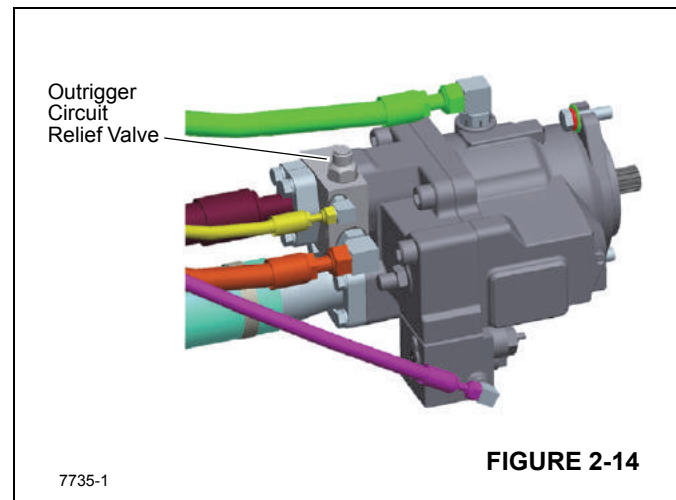


FIGURE 2-14

2. This can be adjusted by first removing the adjustment cover plug using a 5/16 in. allen wrench and using a 3/16 in. allen wrench to adjust the setting. Clockwise rotation increases the setting and each turn gains 61 bar (884 psi). Be sure to retighten the adjustment cover to 5 N·m (4 lb-ft) when setting is correct.
3. In order to check setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the GB gauge port on the front outrigger manifold. See (Figure 2-15).
 - b. Turn Crane Power Switch ON using the cab control switch. Fully extend an outrigger beam or jack and

continue to hold function switch while monitoring pressure reading at gauge.

- c. Use (Table 2-3) to verify nominal setting and allowable tolerance.
- d. Uninstall gauge and re-torque all connections.

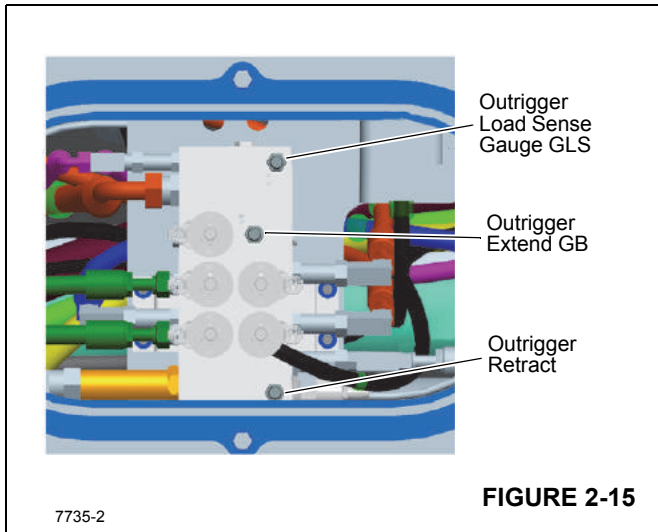


FIGURE 2-15

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O. Counterweight Removal Cylinders

- 1. The Counterweight Cylinder circuit has a single reducing valve in the counterweight removal manifold with a setting of 79 bar (1150 psi) as shown in (Figure 2-16).

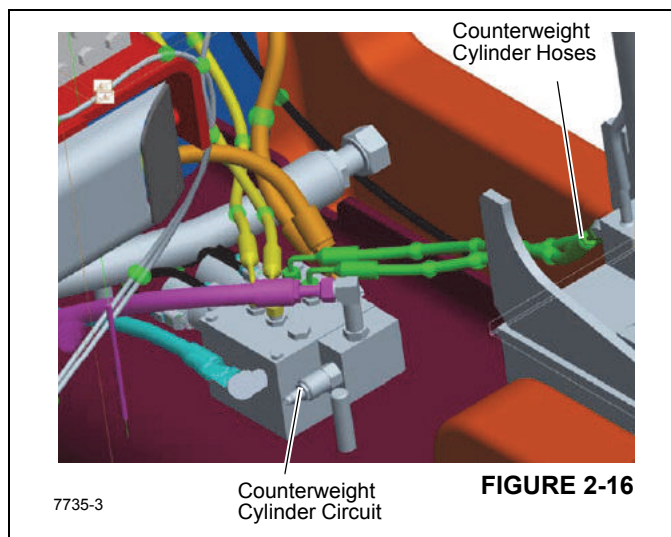


FIGURE 2-16

7735-3

- 2. This can be adjusted by loosening the 3/4" locknut and using a 1/4" allen wrench to adjust the setting. clockwise rotation increases the setting and each turn gains 25.8 bar (375 psi). Be sure to retighten the 3/4" locknut to 5 N·m (6 lb-ft) when setting is correct.

- 3. In order to check this setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the GP2 gauge port on the directional control valve (Figure 2-12).
 - b. Fully retract (or extend) one of the counterweight removal cylinders and hold button.
 - c. Use Table 2-3 to verify nominal setting and allowable tolerance.
 - d. Uninstall gauge and re-torque all connections.

P. Tilt Cab Cylinder

- 1. The Cab Tilt Cylinder circuit has a single reducing valve in the cab tilt manifold with a setting of 138 bar (2000 psi) as shown in (Figure 2-17).

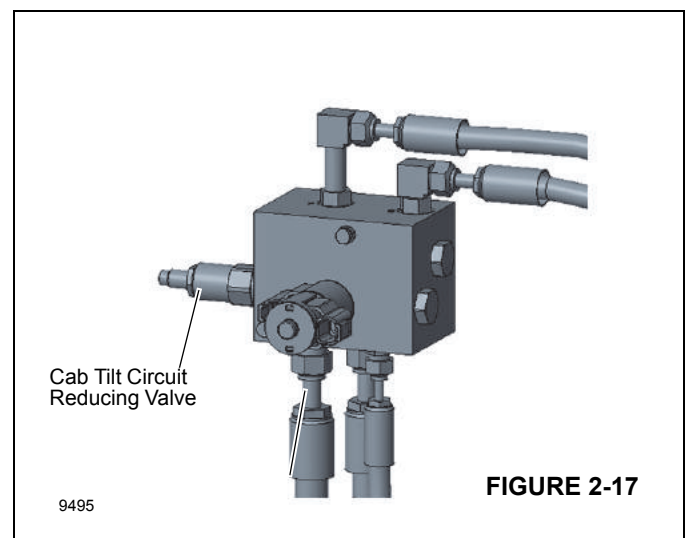


FIGURE 2-17

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- 2. This can be adjusted by loosening the 3/4" locknut and using a 1/4" allen wrench to adjust the setting. Clockwise rotation increases the setting and each turn gains 7.5 bar (110 psi). Be sure to retighten the 3/4" locknut to 5 N·m (6 lb-ft) when setting is correct.
- 3. In order to check this setting:
 - a. Install a 345 bar (5000 psi) minimum gauge in the GP2 gauge port on the directional control valve (Figure 2-12).
 - b. Fully retract the cab tilt cylinder (lower cab) and hold switch.
 - c. Use Table 2-3 to verify nominal setting and allowable tolerance.
 - d. Uninstall gauge and re-torque all connections.

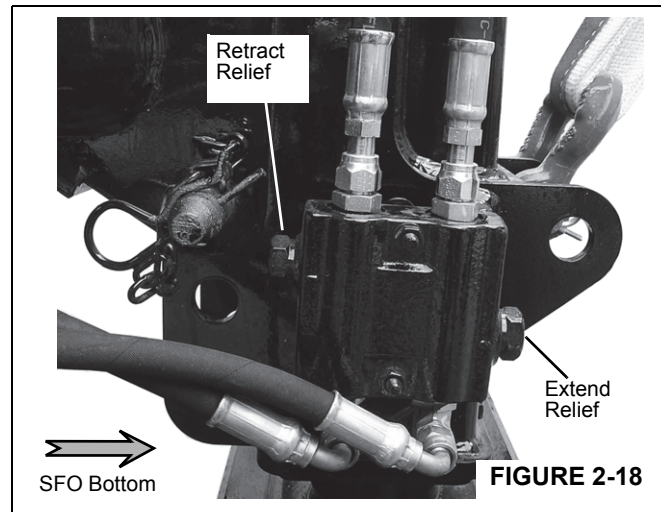
Single Front Outrigger (SFO) - Optional

1. Disconnect the single front outrigger (SFO) extend and retract lines (Figure 2-18). Cap the retract line and install a gauge in the extend line.

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

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

8. Shutdown the engine, remove the gauge and cap, and reconnect the SFO hydraulic lines.



VALVES

General

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

valves, the circuit they are used in, and their physical location, refer to Table 2-5. The description of each valve given here is for the valve itself. For information on how each valve functions in the individual circuits, refer to the description and operation procedures of that circuit.

Table 2-5 Directional Control Valve

Valve Name	Circuit Used In	Physical Location
Directional Control Valve (DCV)	Boom Lift, Telescope, Hoist(s) and Swing	Mounted inside the turret.
Electric Control Valves	Boom Lift, Telescope, Hoist(s) and Swing	Mounted to DCV inside the turret
Holding Valves	Boom Lift, and Telescope	Port block on cylinder, hoist, outrigger
Hoist Motor Counter Balance Valve	Hoist	On hoist motor
Front Outrigger Selector and Control Manifold	Outrigger	Inside T-box frame (front)
Rear Outrigger Control Manifold	Outrigger	Inside T-box frame (rear)
Pilot Operated Check valve	Outriggers	Port block of each jack cylinder (4)
Swing Speed Flow Valves	Swing	On swing motor
High Speed Hoist Control Solenoid	Hoist	On hoist motor
Single Front Outrigger (SFO) jack relief valve (optional)	Outrigger	On single front jack (SFO)

The Directional Control Valve (DCV) [1] (Figure 2-19) is located inside the turret frame.

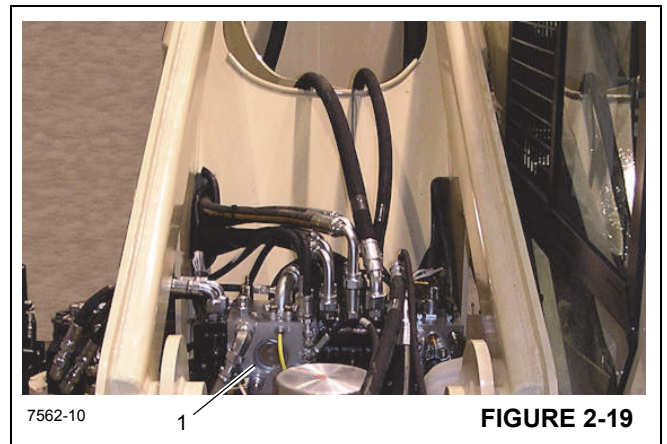
Cab controls and radio remotes control the crane functions through solenoid controlled proportional valves that are integral to the DCV and control pilot pressure to the main function valves on the DCV.

When the crane function power switch is turned on, the pilot pressure enable solenoid on the DCV (Figure 2-20) is energized.

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

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

The ports and valves used on the directional control valve are identified in (Figure 2-20).



Directional Control Valve (DCV)

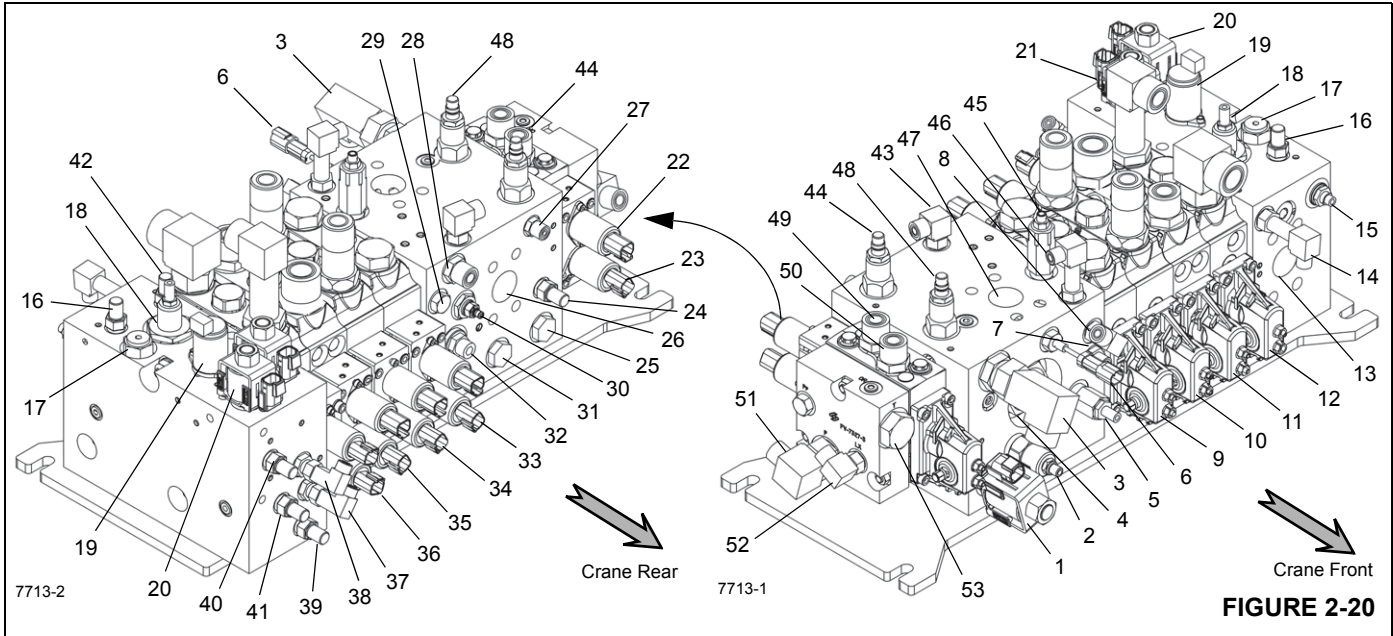


FIGURE 2-20

Item	Description
1	A/C Enable Solenoid Valve
2	FDCB-LAN 120.6 bar (1750 psi)@36.3 lpm(8 gpm)
3	Lower Return Check Valve
4	Oil Cooler Check Valve
5	Swing - Anti-Cav Supercharge Valve
6	Resistive Temperature Device (RTD)
7	Lift Cylinder - HV Drain
8	Gearbox Coolant Drain
9	Auxiliary Hoist B-port section (with manual override)
10	Main Hoist B-port section (with manual override)
11	Telescope B-port section (with manual override)
12	Boom B-port section (with manual override)
13	Port P
14	LS Port (Load Sense)
15	Reducing/Relieving Valve, 20.64 bar (300 psi) @ deadhead
16	GP1 Port Pump Inlet
17	Pilot Supply Filter
18	Main Relief Valve 344.7 bar (5000 psi) @ 22.7 lpm(5 gpm)
19	Brake Apply Valve
20	Pilot Supply Valve
21	Brake Release Valve
22	Swing Solenoid A
23	Swing Solenoid B
24	ACG Port - A/C Gauge
25	ACP Port - A/C Pressure
26	BYPASS Port - Cooler Bypass

Item	Description
27	MCD Port - Motor Case Drain
28	DR1 Port - Reservoir Drain
29	DR2 Port - A/C Case Drain
30	Gearbox Coolant Flow 4.13 bar(60 psi)@4.5 lpm(1gpm)
31	ACR Port - A/C Return
32	Gearbox Coolant Supply 4.13 bar(60 psi)@4.5 lpm(1gpm)
33	Auxiliary Hoist Solenoid B
34	Main Hoist Solenoid B
35	Telescope Solenoid B
36	Boom Solenoid B
37	BA Port - Apply Brake
38	BR Port - Brake Release
39	GP4 Brake Release
40	GP5 Port - Pilot Supply
41	GP3 Port - Brake Supply
42	GP2 Port - (Load Sense)
43	SGC Port - Swing Gearbox Coolant Supply
44	A/C Relief Valve 99.97 bar (1450 psi) @ 36.3 lpm(8 gpm)
45	Load Sense Relief 321.5 bar (4663 psi) @ 113 lpm(25 gpm)
46	SAC Port - Swing Anti-Cavitation
47	CLR Port - Cooler Supply
48	GP1 Swing Back Pressure Check Valve 27.57 bar (400 psi)
49	Swing A Workport
50	Swing B Workport
51	Counterweight Removal Pressure Port
52	LX Port Counterweight Removal, (Load Sense)
53	T Port Tank (Not used)

Removal

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

Installation

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

Functional Check

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

OUTRIGGER MANIFOLDS

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

HOLDING VALVES

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

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

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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 system and supplies power for all crane functions. The wire harness is routed through the truck frame and contains the wiring interface between the truck and the crane.

JUMP STARTING THE CRANE

Do not attempt to jump start the crane.

CAUTION

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

All crane models, particularly those produced since 2000, have multiple computer systems (crane control, RCL, engine & transmission control) that are highly susceptible to voltage/ amperage surges in the electrical system.

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger

of appropriate voltage level or replace the batteries with fully charged batteries.

Charging

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

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

WELDING PRECAUTIONS

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

- Disconnect truck battery cables (positive and negative)
- Attach welding ground lead as close as possible to area to be welded.

MAINTENANCE

General

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

DANGER

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

DIAGNOSTIC

Crane information/warnings, (I/O screens and error codes) are displayed on the diagnostic menu screen on crane operator console (Figure 3-1). To get to the diagnostic menu screen, turn on the crane ignition switch and follow the prompts on the screens. The crane control system will display up to 20 active faults or errors in the crane and RCL control system(s). The faults numbers are displayed only when a fault occurs and clears when the fault is corrected. The three digit numbers correspond to a specific fault for a specific module, connector and pin.

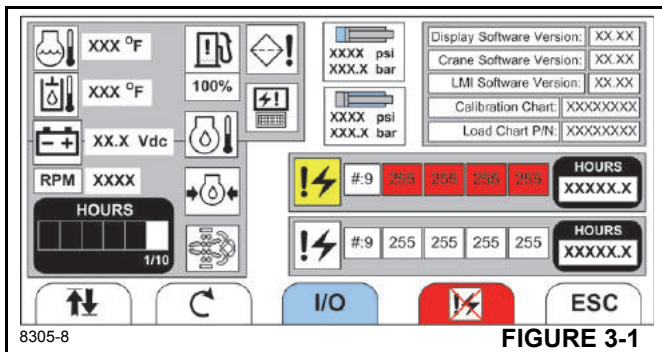


FIGURE 3-1

- 1 - # Block - Indicates the number of the active fault already in the control system, use the arrow keys to scroll. Numbers are 1 through 20, with maximum of 20 faults.
- 2 - Device Number
- 3 - Group Number
- 4 - Index
- 5 - Error Number

Logged Fault Box (B) - Logged faults are not currently active, use the up/down arrows to scroll through the codes.

The crane control system will display up to 20 of the most recent logged faults or errors in the crane and RCL control system(s). The up/down arrows can be used to scroll through the active faults. This series of three-digit numbers correspond to a specific fault for a specific module, connector and pin. To clear the logged fault codes, the button with the fault code icon and red button can be depressed.

General Troubleshooting

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

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

Troubleshooting the Electrical Swivel

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

Connector Troubleshooting

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

Because the pins and sockets are crimped to the wires, it is not possible to remove them. Using the proper extraction tool, remove the pin(s) or socket(s) from the plug or receptacle. Cut the wire as close to the pin or socket as possible. After cutting the pin or socket off, the wire will most likely be too short. Using a wire that is too short will allow pressure to be applied to the pin or socket and wire where

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

Ignition Switch

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

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

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

- Both of the outrigger control emergency stops (ESTOPS) must be off
- The ESTOP in the crane cab must be off
- The truck Ignition Switch must be turned to off
- The PTO switch must be on
- The hydraulic suction valve at the filter must be closed.

RATED CAPACITY LIMITER (RCL) SYSTEM DESCRIPTION

The Rated Capacity Limiter (RCL) monitors crane operation and alerts the operator of stability or structural limits based on the load chart. The crane functions that worsen the condition (hoist up, boom down, telescope out) are disabled. A RCL override key switch is located behind the operator's seat. Turn the key switch ON to override the RCL.

RCL and Anti-two Block (A2B) System Description

The anti-two-block system (A2B) is part of the RCL system that helps prevent damage to the hoist cable by sensing when the 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 boom until the A2B weight is suspended freely. The A2B system is incorporated into the crane RCL system.



WARNING

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

The boom A2B cable (1), Figure 3-2 runs from the A2B reel outside the boom to the A2B switch assembly (3). The A2B switch assembly cable is attached to the anti-two block weight.

To replace the A2B cable:

- Retract the boom.
- Run the cable through the cable thimbles on the side of the boom.
- Secure the A2B cable to the boom tip.

The CAN bus cable (5) runs from the bottom of the reel to the rear of the boom, then down through the turret to the main electrical harness.

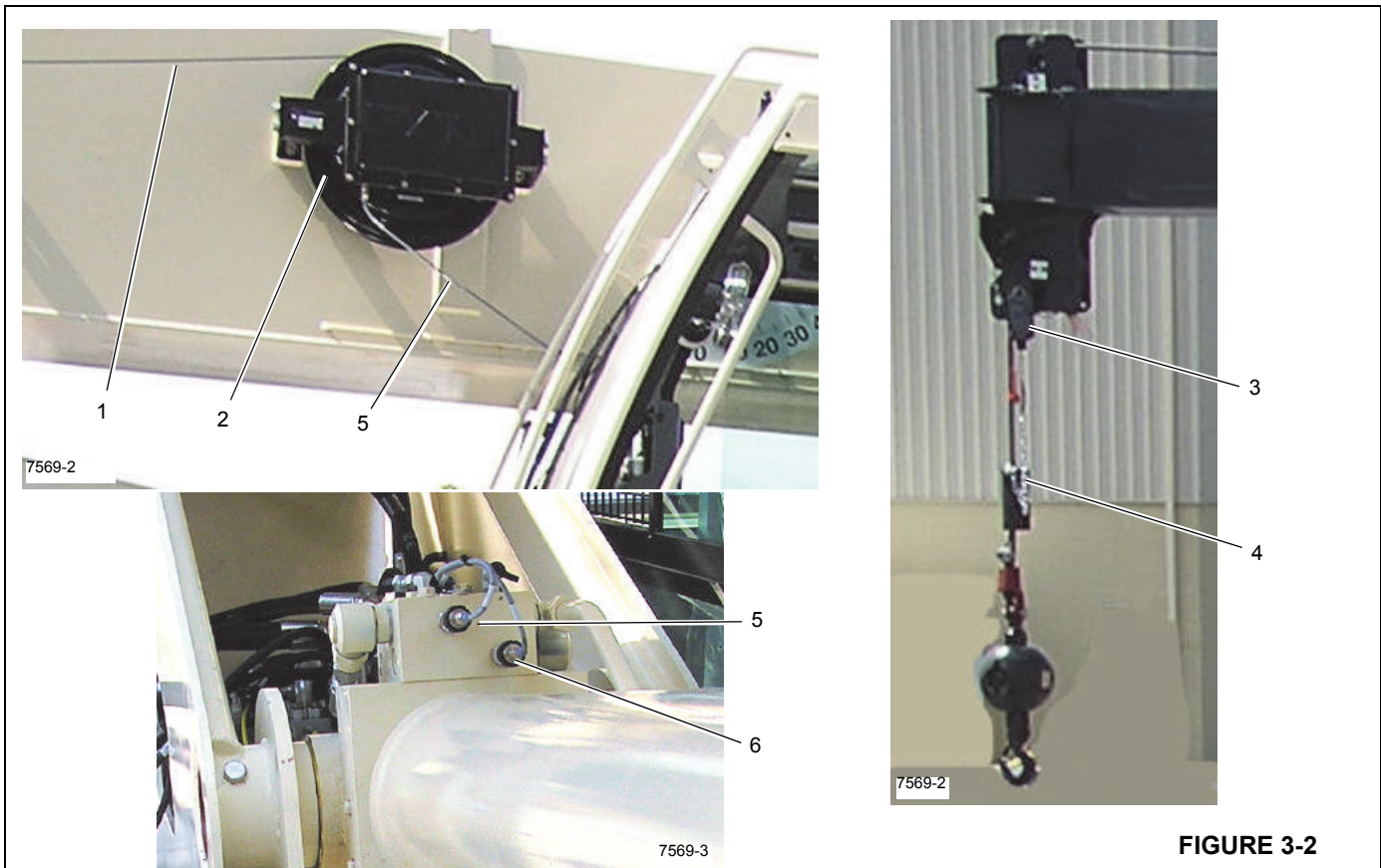


FIGURE 3-2

RCL Communication Overview

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

Each device on the CAN network is capable of digital communications. This enables many devices to communicate quickly over a single twisted pair of wires. Each device on the CAN bus sends and/or receives messages on the network in a predefined format called a protocol. A device is called a node and one of the nodes is defined as the control module.

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 1 meter.

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.

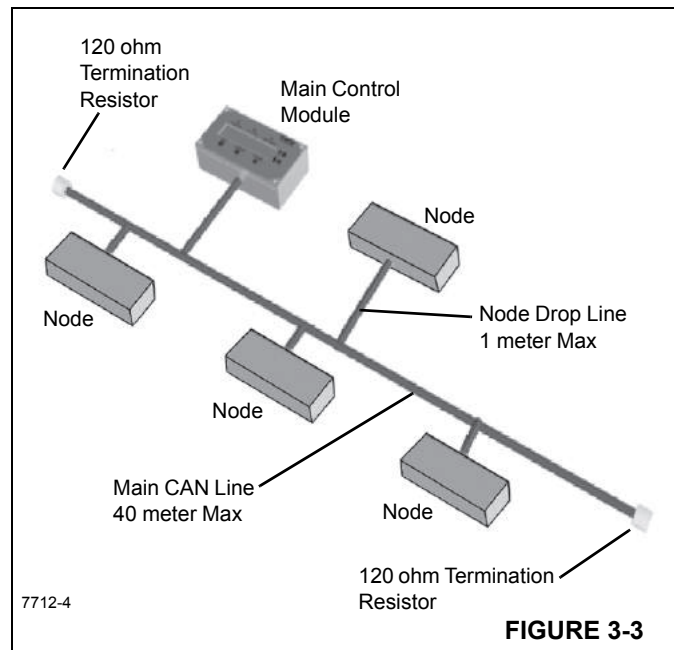


FIGURE 3-3

Advantages to a CAN bus system are:

- Reliability

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

Tooling For Troubleshooting

To effectively troubleshoot the electrical system, you need a Windows-based personal computer, HED service software (Orchestra, HED Display Programmer, Application Configurator), CAN-Link service software, and a USB connection UL2725 cable (Part No. 80060307).

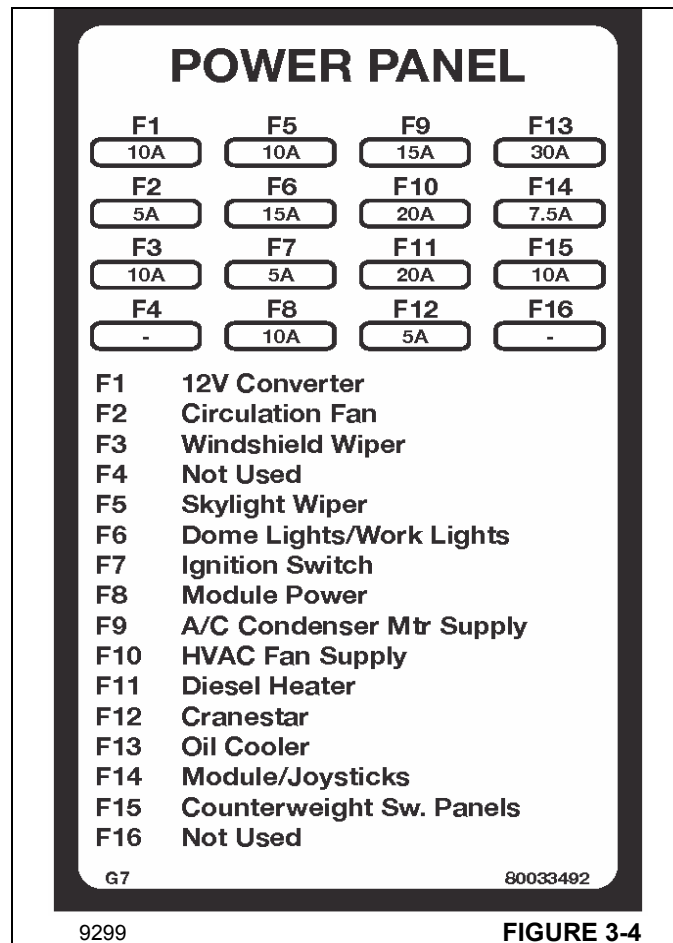
Manitowoc Crane Care recommends you have as part of your service tool kit inventory the Orchestra (CAN-Link) service tool kit for the NBT60. The software will allow you to see in real time the status of all inputs or outputs signals on the system, and it will allow you to detect any errors on input or output. The Orchestra (CAN-Link) service software and hardware are available through Crane Care to those service technicians who have successfully completed the Orchestra level training course. The PC1 connector (8), Figure 3-5 is for troubleshooting by authorized OEM technicians only.

CAB MODULE, FUSE, RELAY PANEL

The cab and superstructure fuse/relay access panel (1), Figure 3-5 is located behind the operator’s seat. Remove the two thumbscrews (24) securing the access panel to gain access to the fuse blocks, relays, cab control module, interface connectors and the cab RCL module.

The fuse panel (2), (Figure 3-5) contains the fuses that protect the circuits as indicated in Figure 3-4.

The cab control modules and RCL module are not serviceable; contact Manitowoc Crane Care Customer Service with any service or repair questions about the modules.



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FIGURE 3-4

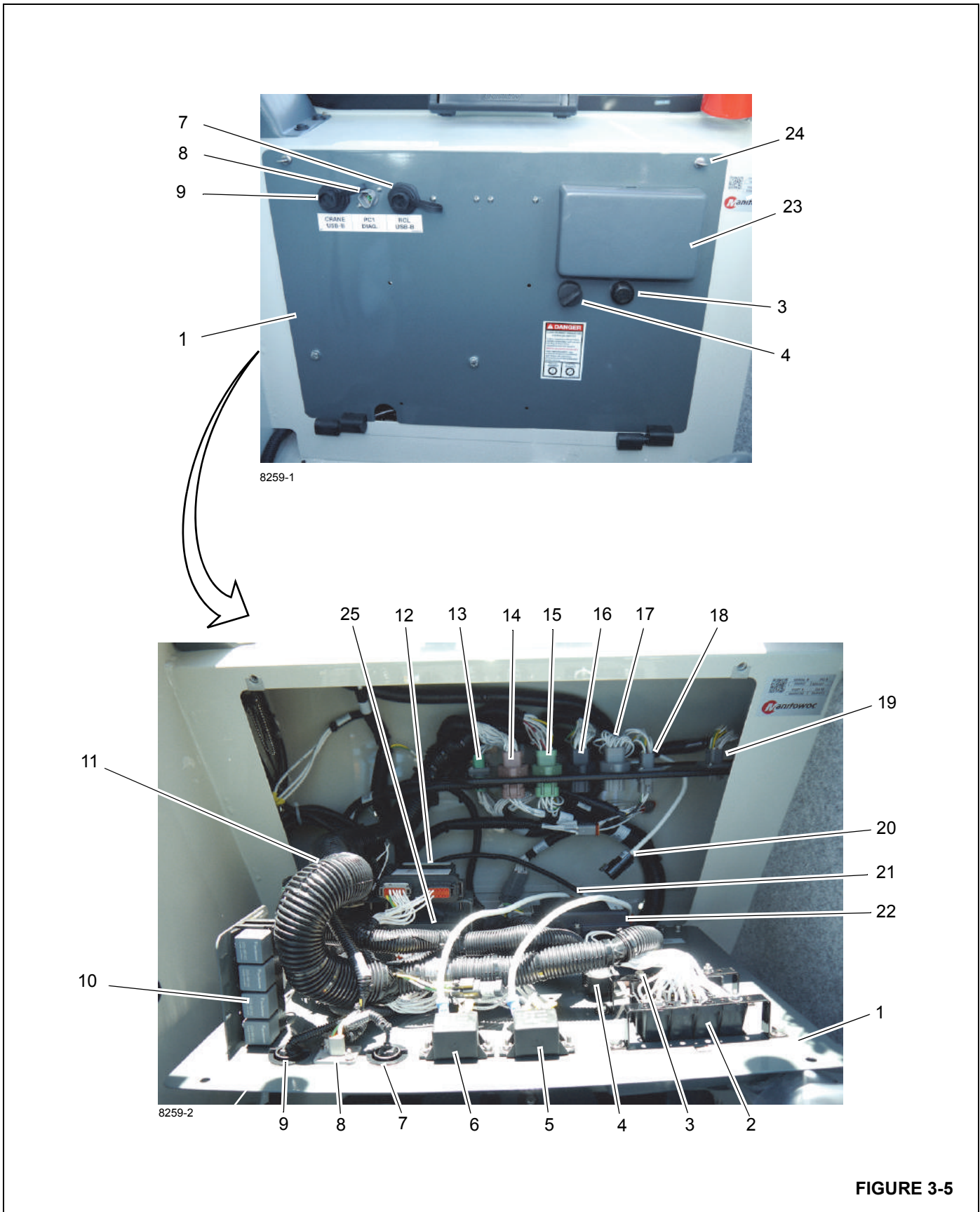


FIGURE 3-5

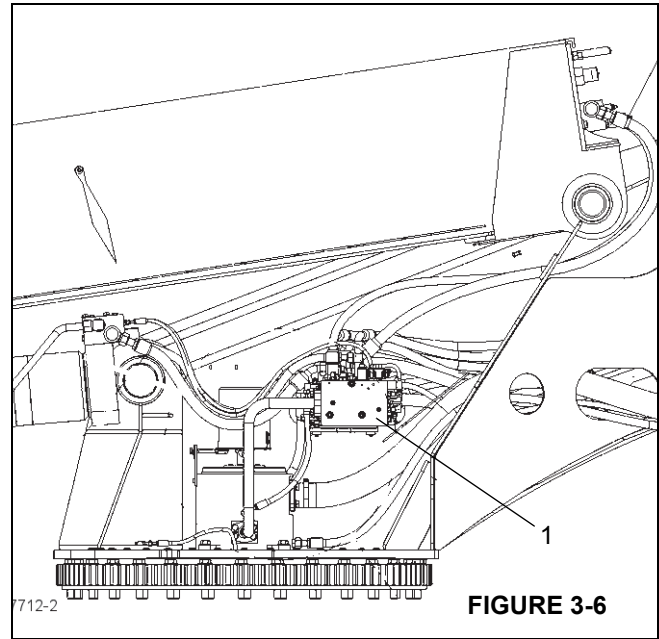
Figure 3-5 Item List

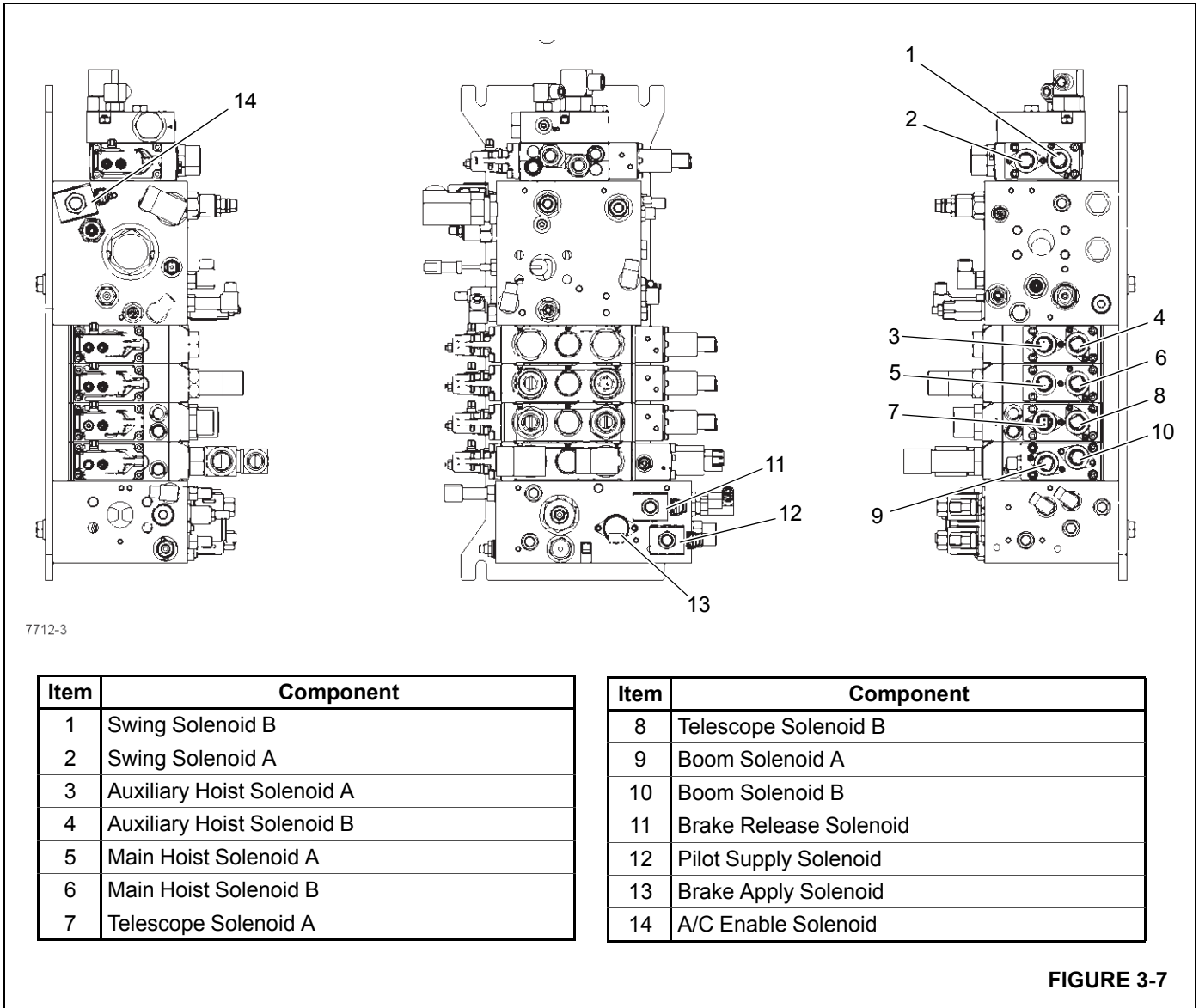
Item	Component
1	Access Panel
2	Fuse and Relay
3	Buzzer Alarm
4	RCL Master Key Switch
5	#1 ACC Relay R-1
6	#2 ACC Relay R-2
7	RCL USB-B Connector
8	PC1 Connector
9	Crane USB-B Connector
10	Relays
11	Cab Module #2 (Behind)
12	Cab Module #1

Item	Component
13	Cab - C
14	Cab - B Harness (Brown)
15	Cab - A Harness (Green)
16	S/S Harness B (Black)
17	S/S Harness A (Gray)
18	Seat Harness (Gray)
19	Swivel Harness (Gray)
20	Swivel Harness
21	Seat Harness
22	RCL Module
23	Fuse/Relay Cover
24	Thumb Screw
25	Server Module

DIRECTIONAL CONTROL VALVE

All crane functions are controlled by the directional control valve (1, Figure 3-6) located in the turret. The solenoid valves are identified in Figure 3-7.





DIRECTIONAL CONTROL VALVE (DCV) SOLENOIDS

The solenoids on the directional control valve are used to control the mode of operation of the associated valve.

OUTRIGGER MANIFOLDS

There are two outrigger manifolds located on the crane t-box frame. The front outrigger manifold is mounted in the center of the crane frame between the cab and front outrigger box (Figure 3-8).

The rear outrigger manifold is mounted in the center of the crane frame between the rear of the superstructure cab and rear outrigger box. (Figure 3-9).

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

NOTE: The front and rear outrigger modules (Figure 3-8 and Figure 3-9) are not serviceable; contact Manitowoc Crane Care Customer Service with any service or repair questions about the module.

Front Outrigger Manifold

The solenoids on the front outrigger manifold (Figure 3-8) control the selection of the front outrigger components, the optional single front outrigger (SFO) (if equipped) and the extend and retract functions of front outrigger components.

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

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

- The single front outrigger (SFO) solenoid (4) (if equipped) extends or retracts the SFO when energized. Any time the retract button on the outrigger control is depressed, the SFO is the first to retract.
- The extend solenoid (12) controls the extend functions for all outrigger components.
- The retract solenoid (1) controls the retract functions for all outrigger components.

- Solenoids (2), (3) and (10) (11) control the front outrigger components. See Figure 3-8 for solenoid identification.
- The lower front module #1 and module #2 are mounted to stack (7) and are connected to the lower frame main wiring harness (8) providing outrigger function data to the front outrigger manifold.

If disconnecting the main wiring harness (8) from the lower front module #1 and module #2, note the position of the gray and black connectors; these connectors must be reconnected in the same position.

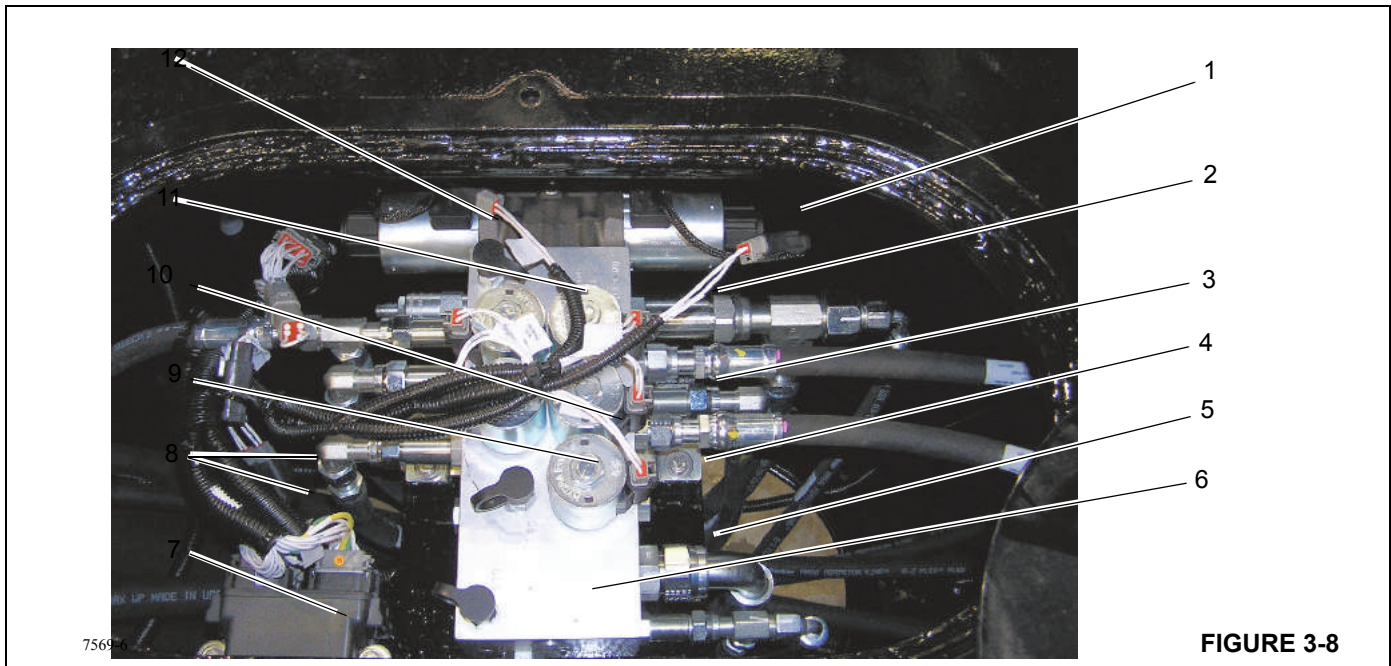


FIGURE 3-8

Figure 3-8 Item List

Item	Description	Item	Description
1	Solenoid O/R Retract	7	Lower Front Module Stack (2 modules)
2	Solenoid, Right Front Jack Cylinder	8	Frame Main Wiring Harness
3	Solenoid Right Front O/R Beam	9	O/R Extend Gauge Port (GB)
4	Solenoid, Single Front Outrigger (optional)	10	Solenoid, Left Front O/R Beam
5	Outrigger Manifold	11	Solenoid, Left Front O/R Jack Cylinder
6	O/R Load Sense Gauge Port (GLS)	12	Solenoid O/R Extend

Rear Outrigger Manifold

The solenoids on the rear outrigger manifold control the rear outrigger functions. See Figure 3-9 for solenoid identification.

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

- The lower rear modules #1 and #2 (6) are connected to the lower frame main wiring harness (5) and provide outrigger functional data to the main server module.

If disconnecting the main wiring harness (5) from the modules on the stack (6), note the position of the gray and black connectors; these connectors must be reconnected in the same position.

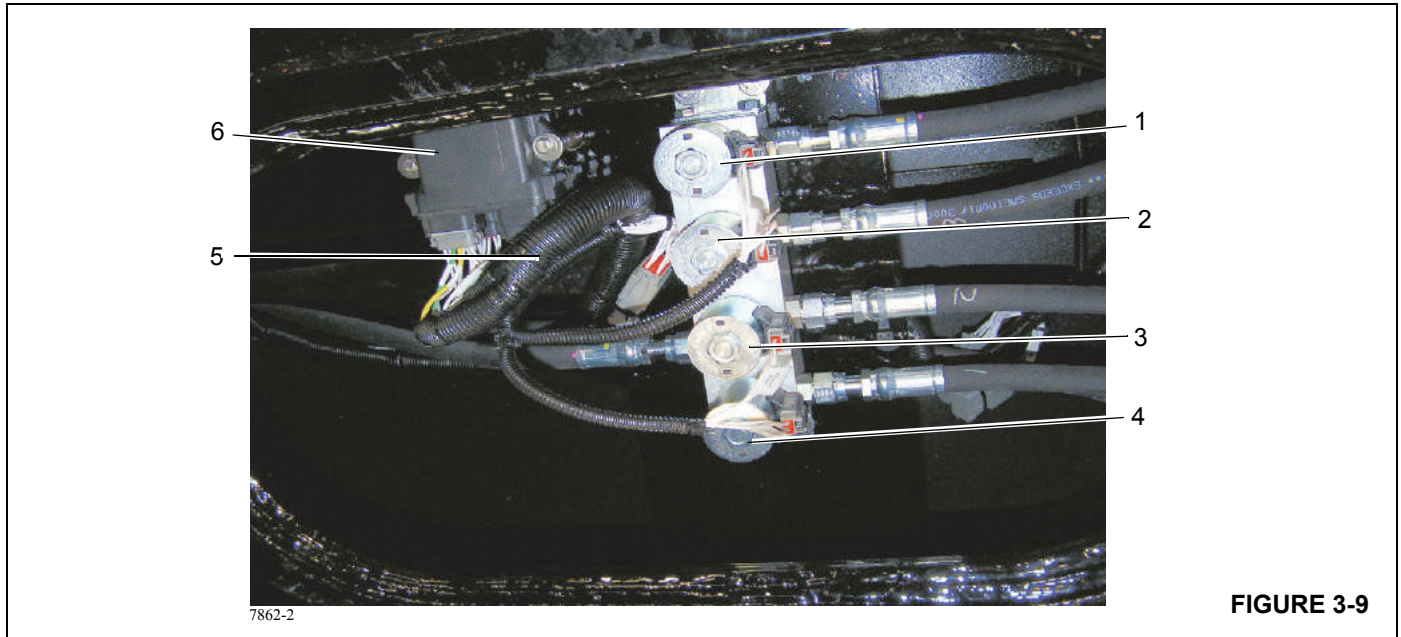


FIGURE 3-9

Figure 3-9 Item List

Item	Solenoid
1	Left Rear Jack Cylinder Solenoid
2	Beam Solenoid
3	Right Rear Beam Solenoid
4	Right Jack Cylinder Solenoid
5	Lower Frame Main Wiring Harness
6	Lower Rear Module Stack (2 Modules)

HYDRAULIC OIL COOLER

The hydraulic oil cooler is mounted in rear of the turret. The oil cooler circulates air over the cooling core when the hydraulic oil in the cooling core reaches 48.8° C (120° F).

Not all return flow is routed through the oil cooler. A 2 bar (30 psi) 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
- Temperature Sensor

The temperature sensor is located in the cooling core and energizes the fan relay when the hydraulic oil reaches 48.8° C (120° F). If the fan is not running and the oil temperature warning is displayed on the RCL screen, check the fan temperature sensor and fan motor.

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SECTION 4 BOOM MAINTENANCE

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THEORY OF OPERATION

A two-stage, rod fed, double-acting cylinder is attached to and supports the 1st, 2nd and 3rd boom sections.

The 3/4/5 extend cables (Figure 4-1) attach to the base of the Tele 2 section, are reeved around sheaves at the tip of the Tele 3 section and attach to the base of the Tele 4 section and support the Tele 4 section.

The 5/4/3 retract cables (Figure 4-1) are attached to the base of the Tele 4 section, are reeved around sheaves at the base of the Tele 3 section and attach to the tip of the Tele 2 section.

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

the base of the Tele 2 section and attach to the tip of the Tele 1 section.

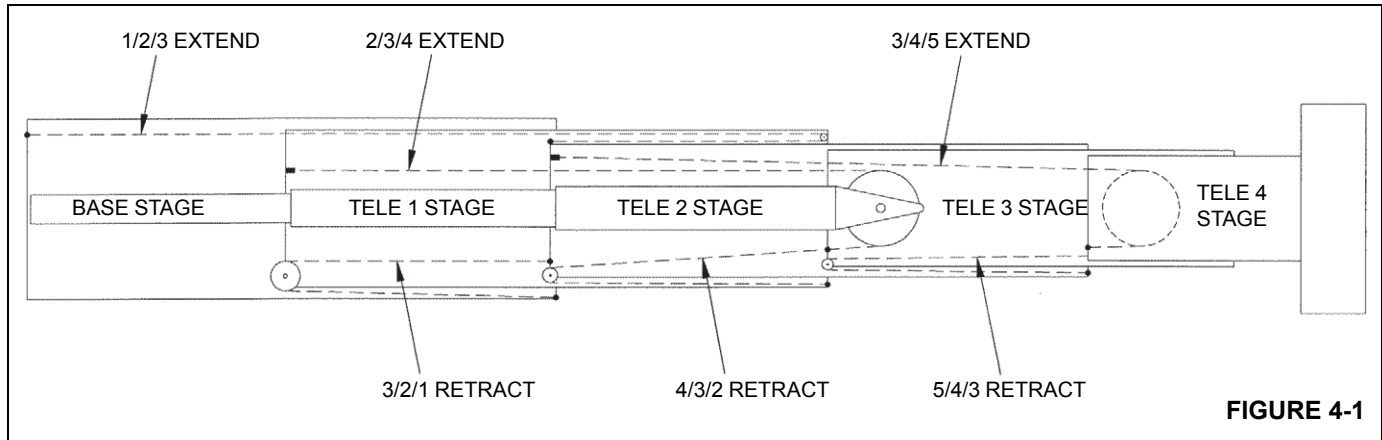
The 1/2/3 extend cables (Figure 4-1) attach to the base of the Base section, are reeved around sheaves at the tip of the Tele 1 section and attach to the base of the Tele 2 section.

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

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

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

The 5/4/3 retract cables (Figure 4-1) directly oppose the 3/4/5 extend cables to ensure that the Tele 3 and Tele 4 sections extend and retract equally at all times.



Reference Figure 4-1, Figure 4-2, Figure 4-4, and Figure 4-5 for Boom Removal, Disassembly, Assembly and Cable Tensioning.

MAINTENANCE

SPECIAL BOOM INSPECTION

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

National Crane recommends that boom extension cables be replaced every seven (7) years.

Boom Removal

CAUTION

Sling webbing is recommended to lift boom and tele sections. Chains are not recommended. A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during removal of any section or sections.

NOTE: The boom may be disassembled with the base section left on the crane if repair of the base section is not necessary.

NOTE: The boom weighs approximately 6,812 kg (15,017 lb). Removal of the swingaway jib boom will simplify boom removal; therefore, the above weight is for the boom without the swingaway jib boom extension attached.

For Boom weight see *Specifications*, page 9-62 of this manual.

1. Extend and set machine outriggers and (SFO) - optional front jack, if installed. Boom must be completely retracted and stowed in boom rest over the front of truck.

2. If equipped, remove the jib boom extension according to procedures outlined in the Set-Up Section of the Operator's Manual.



CAUTION

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

3. Remove the hook block or downhaul weight and wind all wire rope onto the hoist drum and stow wedge socket.

NOTE: Keep slight tension on loadline to avoid bird caging of loadline on hoist drum.

4. Elevate the boom slightly to allow for the withdrawal of the lift cylinder rod end from the lift cylinder attach fitting on the bottom of the boom.



WARNING

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

5. Attach a lifting device to the boom that provides for equal weight distribution.

6. Disconnect any electrical wiring from the boom.

7. Tag and disconnect the hydraulic lines to the telescope cylinder. Cap/plug all openings.



WARNING

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

8. Block the lift cylinder.

9. Remove the capscrew and locknut securing the upper lift cylinder shaft to the side of the attachment fitting on the boom.
10. Remove the upper lift cylinder shaft.
11. Activate the hydraulic system and retract the lift cylinder rod enough to clear the attachment fitting. For removal of the lift cylinder from the crane, refer to "Lift Cylinder Removal" on page 34.

NOTE: Shut down the crane before proceeding.

12. Take up the slack on the boom lifting device.
13. Remove the capscrew, washer and nut that passes through the end of the pin that secures the boom pivot pin in place, then remove the pin. Remove the grease fitting from each end of the boom pivot shaft, then remove the boom pivot shaft.
14. Raise the boom clear of the crane and lower to ground level. Set cribbing under base section and level boom for disassembly

Boom Disassembly

For the following assembly procedure, reference Figure 4-4 for all item number call outs.

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

Steps 1 through 3 apply to a boom that is to be disassembled with the 1st section and the jib (if equipped) left on the crane.

1. Extend and set the outriggers and optional single front outrigger (SFO) - if equipped.
2. Place boom in a horizontal position.
3. Remove the access cover plate (34) from the top of boom. Retract the boom until the upper wear pads can be accessed and relieve tension on the adjusting cam plates and remove wear pads to allow boom sections to slide freely during disassembly.

Tele 1 Section Disassembly

1. Completely retract boom before removal of Tele 1 section (2) from base section (1).
2. Tag and disconnect the hydraulic lines to the telescope cylinder. Cap all lines and openings.
3. Loosen and remove two pins (28) and attaching hardware which anchor the 1st stage extend cylinder rod to the base of the Base section.
4. Mark the location of the nuts (27), and washer (26) which secure the synchro 1/2/3 extend cables (49) to the rear of the base section (1). Remove cable protector (155), nuts and washers from synchro cables at rear of

the base section. Leave the cable ends draped inside the boom.

5. Tag and remove cable guides (21), plates and attaching hardware from the top of the sections and store in a secure place.
6. Attach a sling to the tip of the Tele 1 section (2) and pull the Tele 1 section (with the Tele 2, Tele 3 and Tele 4 sections) out approximately 12 in to allow access to the top rear wear pads through the access opening on the top of boom. Remove adjusting cam plate (41), bolt (42), flatwasher (23) wear pad plate (40) and wear pads (39) from the sections being removed if not removed in preliminary boom disassembly steps.
7. Loosen socket setscrew (15), remove and tag side wear pads (11), plate (12), adjusting plate (13), bracket (14) and attaching hardware (16,17,18) and top plate (20), wear pad (22) and hardware from tip of base section (1).
8. Tag and remove cable protectors (156) and loosen adjusting nuts (10), remove four capscrews (9) which retain the 3/2/1 retract cable (52) anchors (8) to the bottom tip of the base section (1). Elevate tip of boom assembly and remove wear pads (7) from bottom tip of base section. Pull the retract cable anchors (8) out at tip of Base section and keep retract cables (52) taut while pulling Tele 1 section (with Tele 2, Tele 3, and Tele 4 sections) out of Base section. Take care not to pinch or crush retract cables while lifting or supporting Tele 1 section. Support the base end of the Tele 1 section as it exits the Base section.
9. Place Tele 1 section (with Tele 2, Tele 3, and Tele 4 sections) on a suitable horizontal surface. Store 3/2/1 retract cables (52), which are now free, in an area where they will not be damaged during further boom disassembly. Tag and remove wear pads (55, 56, 43, 44), shims and hardware from base of Tele 1 section if replacing wear pads.
10. Tag and remove retract cable (52) retaining capscrew (91) and lockwasher (24) from each side of the bottom base of the Tele 2 section (3).
11. Tag and remove capscrews (33) and lockwashers (17) which retain 3/2/1 retract sheave pins. Remove the retract sheave shafts (51). Note the placement of thrust washers (53) on pin and tag and remove retract sheaves (50), thrust washers (53), and guards (54) at the base of the Tele 1 section.

Tele 2 Section Disassembly

1. Tag and remove adjusting nut (62) and washer (61) on 2/3/4 extend cables (139) at rear of Tele 1 section (2). Note the location and cable sequence for reassembly. Remove capscrew (67), washer (17), keeper plate (66), cable anchor (59) and capscrew (60) from the end of the extend cables (139) at base of Tele 1.

2. Remove cylinder trunnion attaching bolts (65) and washer (26) from base of Tele 1 (2) section. Trunnion (64) will remain on cylinder until later in disassembly.
3. Attach a sling to the tip of Tele 2 (3) section and pull (with the Tele 3, and Tele 4 section) out approximately 305 mm (12 in). Pull the sheave anchor assembly (46) with 1/2/3 extend synchro cables (49) forward from between top tip of Tele 1 section and let the sheave case and cables rest on the top of the Tele 2 section where they will not be damaged during further boom disassembly. Remove and tag upper cable guide (21), wear pad (22) and hardware (25,24,23) and plate (57) and hardware.
4. Tag and remove bracket (154), side wear pads (86) and shims and hardware from front tip of Tele 1 section.
5. Tag and remove cable protectors (156) and loosen adjusting nuts (10), remove four capscrews (9) which retain the 4/3/2 retract cable (82) anchors plate (38) to the bottom tip of the Tele 1 section (2).
6. Elevate tip of boom assembly and remove wear pads (7) from bottom tip of Tele 1 section.
7. Pull the retract cable anchors (38) out at tip of Tele 1 section and keep retract cables (82) taut while pulling Tele 2 section (with, Tele 3, and Tele 4 sections) out of Tele 1 section. Take care not to pinch or crush retract cables while lifting or supporting Tele 2 section. Support the base end of the Tele 2 section as it exits the Tele 1 section.
8. Place Tele 2 section (with Tele 3, and Tele 4 sections) on a suitable horizontal surface.
9. Remove the 1/2/3 extend cable (49) from top of Tele 2 section. Remove capscrew (78) and washer (77) from top base of Tele 2. Remove end of cable from attaching pin at top of base of section. Push the two sheaves (47) and pin (48) forward from sheave anchor (46) and remove the 1/2/3 extend cable sheave case at the tip of the Tele 2 section. The cable loops may now be pulled out of the sheave case and the 1/2/3 extend cable is free. Smooth out any burrs which may be present on the flat ends of the pins (48) to eliminate sheave bearing damage and remove pins from sheaves (47).
10. Mark the location of the adjusting nuts (62) which secure the 3/4/5 extend cables at base of Tele 2 section. Loosen and remove adjusting nuts and washer (61) from the 3/4/5 extend cable (106). Place cables in an area where they will not be damaged during further boom disassembly.
11. Tag and remove wear pads (55 and 43), shims and hardware from outer side of base of Tele 2 section if replacing wear pads.
12. Tag and remove cable protectors (156) and loosen adjusting nuts (10), remove capscrews (69) which retain the 5/4/3 retract cable (118) anchors plate (68) to the bottom tip of the Tele 2 section (3).
13. Tag and remove cable retaining capscrew (91) and (24) and remove 3/2/1 retract cable (52) from base of Tele 2.
14. Loosen and remove capscrews (90), washers (89) which anchor the extend cylinder at the center base of the Tele 2 section. Anchor the Tele 2 section so it will not move and attach a sling to the base of the extend cylinder and pull the extend cylinder out of the base of Tele 2 section approximately 305 mm (12 in.) keeping 2/3/4 extend cables taut.
15. Rotate the cylinder 90 degrees by putting a pry bar in the head and turning or by attaching a sling to the head of the cylinder in such a manner that the rod can be rotated allowing the cylinder to be removed from the section.
16. Raise and support the extend cylinder approximately 127 mm (5 in.) to allow access to internal components at base end of Tele 2 section.
17. Tag and remove capscrew (33), washer (17), shaft (51), bushing (83), thrust washer (53), sheave (79), guard (80) and note the placement of components.
18. Tag and remove bracket (154), side wear pads (86), shims and hardware from the front tip of Tele 2 section. Remove cable guide (73), wear pad (74 and 72) from upper tip of Tele 2. Elevate tip of boom and remove inner wear pad (7) from tip of Tele 2 section.

Tele 3 Section Disassembly

1. Attach a sling to the tip of Tele 3 (4) section and pull along with Tele 4 section, out of Tele 2 section. Take care not to pinch or crush cables while lifting or supporting Tele 3 section. Support the base end of the Tele 3 section as it exits the Tele 2 section.
2. Place Tele 3 section (with Tele 3 section) on a suitable horizontal surface.
3. Remove cylinder wear pad (117) and hardware (19, 16 and 17) from inner base of Tele 3.
4. Remove retract cable (118) by loosen locking nut (111) and tagging and removing retaining capscrew (174) and roller (110) from each side of the bottom base of the Tele 3 section (4). Remove capscrews (112) which retain 4/3/2 retract cables (82) from base of Tele 3.
5. Remove outer wear pad (55), shim (81) and capscrew (9) retaining the 2/3/4 extend cable pin (93). Note the placement of the extend cables (139) and thrust washers (53) on pin and tag and remove sheaves (92), thrust washers (53), and bushings (94) at the base of the Tele 3 section.

Tele 4 Section Disassembly

1. Attach a sling to the tip of Tele 4 (5) section and pull Tele 4 section out of Tele 3 section approximately 152mm (6 ft). Remove upper cable guide (73), wear pads (107,108) plate (109) and hardware.
2. Remove side wear pad (113), shims and hardware from tip of Tele 3.
3. Loosen adjusting setscrew (15) at wear pad (116)
4. Remove capscrew (104) attaching the sheave pin (103) from 3/4/5 extend sheave pins (103) and remove 3/4/5 extend sheave pins while removing 3/4/5 extend sheaves (100) taking care not to pinch or crush extend cables.
5. Raise tip of Tele 4 section and remove wear pad (99) from inside tip of Tele 3 section.
6. Pull Tele 4 section (with, Tele cylinder) out of Tele 3 section. Take care not to pinch or crush extend cables while lifting or supporting Tele 4 section. Support the base end of the Tele 4 section as it exits the Tele 3 section.
7. Place Tele 4 section (with Tele cylinder) on a suitable horizontal surface.
8. Remove wear pad (135) and hardware attaching the 3/4/5 extend cable (106) to the base of Tele 4 section. Remove 3/4/5 extend cables from the anchor plates at the bottom base of the Tele 4 section and store in an area where they will not be damaged during further boom disassembly.
9. Remove wear pads from the bottom tip of the Tele section.
10. Tag and remove loadline sheaves if desired, by removing two capscrews, two lockwashers and the keeper (128) from the sheave pins and lightly tapping the pin while removing sheaves and spacers until all sheaves are removed from boom tip.
11. Attach a sling to the tele cylinder and remove the tele cylinder from the boom, keeping the 2/3/4 extend cables taut to prevent damage to cables.
12. Remove 2/3/4 extend cables from tip of tele cylinder (139) by removing lower plate (150), lower wear pad (145) threaded rods (141), upper wear pad (143) and hardware.
13. Remove sheaves (138) from tip of the extend cylinder, if desired by removing two capscrews (149) and the keeper plate (148) from the shaft and lightly tapping the shaft while removing the sheaves (138) and spacers (140).

Additional Maintenance, Disassembled Boom

1. Clean all 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 installed bearing diameter is 0.38 mm (0.015 in) larger than pin diameter, bearing must be replaced. Any cut or gouge which causes the bearing liner to lose strands is cause for bearing replacement.
4. Clean and inspect all cable assemblies according to wire rope inspection procedures in this section. Pay particular attention to any wire breakage at the end connections. Replace cable assemblies as required. Lubricate all cable assemblies as required. Lubricate all cable assemblies before reinstalling them in boom.
5. Inspect all sheave pins for nicks, gouges or pitting due to rust in the bearing surface area. Replace if any damage is evident.
6. Inspect all grease fittings and grease paths in pins to ensure proper grease flow. Clean and replace as required.
7. Inspect all wear pads for gouges or uneven wear on surface area. Replace if any damage is evident. Replace all lubricating plugs in all wear pads.

Boom Assembly**CAUTION**

Sling webbing is recommended to lift boom and tele sections. Chains are not recommended. A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during assembly of any section or sections.

NOTE: The boom weighs approximately 6,812 kg (15,017 lb). The above weight is for the boom without the swingaway jib attached.

For Boom weight see Specifications in Section 9 of this manual.

**CAUTION**

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

**WARNING**

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

Attach a lifting device to the boom that provides for equal weight distribution.

Reassemble parts following tagged procedure during the disassembly instructions. Follow the assembly procedure and reference Figure 4-4 for all item number call outs.

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

Apply medium strength thread locking adhesive to all hardware. See "Loctite ®" on page 1-7.

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

Tighten according to torque specifications. See "Fasteners and Torque Values" on page 1-7.

Clean and pre-lube inside of all boom sections before assembly. Apply multipurpose grease to all wear surfaces. See *Lubrication*, page 8-1

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

Tele Cylinder Assembly

1. Install sheaves in tip of the tele cylinder (6), by installing shaft (147) from the left side with slot facing toward the front of cylinder, followed by a spacer (140), two sheaves (138) and spacer (140). Attach keeper plates (148) with two capscrews (149) and install grease fittings (105) on both sides of shaft and apply multipurpose grease. See *Lubrication*, page 8-1.
2. Label and position 2/3/4 extend cables (139) evenly divided around tele cylinder sheaves so they do not get crossed by securing cables along cylinder using temporary strapping or tape (which will be removed later during assembly process).
3. Install upper wear pads (143) with capscrews (152), attach threaded rod (141) top secure with capscrew (151) and position lower wear pad (145) and threaded rod (141) and secure with capscrews (151 and 152). Install plate (150) with capscrew (149) to bottom tip of tele cylinder. Apply multipurpose grease to all wear surfaces. See *Lubrication*, page 8-1.
4. Turn cylinder trunnion mounting and port block on rod to a vertical position of 90 ° to allow the cylinder to slide between the entry points in base end of boom sections during assembly.

NOTE: The orientation of plugged fitting on port block is facing toward the top when assembled.

Tele 4 Section Assembly

Assemble and install sheaves (124) and bearings (123) as an assemble into the boom nose sheave case.

Sheaves (124) that are placed next to the sheave case side plates must be installed with the grease fitting (105) facing the side plate to allow for greasing.

Center sheave's (124) grease fitting (105) may face either side.

1. Top sheaves (124) are to be installed from the left hand side of the boom nose by first inserting shaft (127) in sheave case, followed by two spacers (125), one spacer (126), two spacers (122), sheave (124) one spacer (127), spacer (126), spacer (122), sheave (124), spacer (122) spacer (125) toward the right hand side. Install keepers (128) washers (24) and capscrews (129) on both sides.
2. Lower sheaves (124) are to be installed from the left hand side of the boom nose by first inserting shaft (127) in sheave case, followed by spacer (122), link (134), spacer (126), spacer (122), sheave (124) spacer (122), sheave (124), two spacers (122) sheave (124) spacer (122) sheave (124), spacer (122), spacer (125) toward sheave case. Install keepers (128), washers (24) and capscrews (129) on both sides of sheave case.
3. Insert button end of 5/4/3 retract cable (118) firmly engaged into inner anchor mount at base of Tele 4 (5) with cables facing the rear and secure in place with capscrew (131). Store retract cables in an area where they will not be damaged during further boom assembly.
4. Install wear pad (121) with capscrews (87) to bottom base end of Tele 4 (5).
5. Insert button end of 3/4/5 extend cable (106) firmly engaged into outer anchor mount at base of Tele 4 (5) with cables facing forward. Install wear pads (135) and shims (81,56) with capscrews (9). Shim and adjust wear pads accordingly or as pads were originally removed and tagged. Refer to "Boom Calibration" on page 24. Stow extend cables in an area where they will not be damaged during further boom assembly.
6. Attach a sling to the tele cylinder (6) and insert sheave end of tele cylinder into base end of Tele 4 section (5), keeping the 2/3/4 extend cables taut to prevent damage to cables, leaving approximately 1 meters (3 ft) extending out of rear of boom. Take care not to cross cables and keep all cables clear of pinch points created by slings and bottom pads.
7. Insert a temporary (wooden) block (which will be removed later during assembly process), to support the cylinder during boom assembly. Temporarily coil and

stow the retract cables inside rear of Tele 4 boom to prevent damage to cables.

8. Install wear pad (43) and shim (44) with capscrews (25), lockwasher (24) and flatwasher (23) to bottom base end of Tele 3 (4). Install side wear pad (55), shims (81) and capscrews (9). Shim and adjust wear pads accordingly or as pads were originally removed and tagged. Refer to "Boom Calibration" on page 24. Apply multipurpose grease to all wear surfaces. See *Lubrication*, page 8-1.

NOTE: Assembly tip: Apply spray adhesive or tape to aid in holding wear pad and shims together during installation.

Tele 3 Section Assembly

1. Attach a sling to Tele 4 (5) section and insert approximately half-way into Tele 3 (4) section. Guide and pull threaded end of 3/4/5 extend cable (106) inside the tip end of Tele 3 (4) forming a loop in the cable with the threaded end toward the top of loop to wrap around the extend sheave (100). Refer to Figure 4-4.
2. Raise the tip of Tele 4 (5) section and insert lower wear pad (99) in inner pad pockets at tip of Tele 3 section. Apply multipurpose grease to all wear surfaces. See *Lubrication*, page 8-1. Lower tip of boom.
3. Install wear plugs (102) and bushing (101) in sheave (100) and insert sheave assembly in the loop of 3/4/5 extend cable. Install 3 wear plugs (102) in end of each sheave pin (103), install pin (103) securing with 10 capscrews (104) on each side of the tip of Tele 3 section. Apply multipurpose grease to exterior of all wear plugs and all wear surfaces. See *Lubrication*, page 8-1.

NOTE: Do not apply any grease to sheave bushings (101) or pin (103) bushing contact points. The bushings are permanently lubricated and failure could result from contamination.

4. Pull extend cables taut around sheave assembly and install wear pads (113), shims (114,115) with capscrews (9).
5. Apply grease and install upper adjustable wear pad (116), plate (12), adjusting plate (13), adjusting setscrew (15), and secure with washers (16,17) and 6 capscrews (18) to tip of Tele 3. Install bracket (70) to left side adjusting plate using (2 each) of capscrews (19) and washers (16 and 17) into the forward mounting holes. Evenly adjust wear pads on each side. Refer to "Boom Calibration" on page 24.
6. Install plates (109) to inside upper tip of Tele 3 (4) section, securing into rear mounting holes with capscrews (164), washers (23 and 24). Install outer wear pad (107), cable guide (73) and wear pad (108) to outside forward mounting holes securing with capscrews (75) and washers (23 and 24).

7. Route 4/3/2 single retract cables (118) through lower openings at bottom base of Tele 3 (4) section and route towards tip of boom between bottom of Tele 4 and Tele 3 sections booms.
8. Install plate (68), nut (10) on threaded end of 4/3/2 retract cable at tip of Tele 3 section securing with capscrews (69).

NOTE: This step will prevent cables from sliding past sections during assembly.

9. Slide Tele 3 (4) and Tele 4 (5) sections together until top rear wear pad mounting is accessible through the access opening on top of boom. Install wear pad (119) and wear pad plates (120) securing with capscrews (87). Install cam plate (130) securing with capscrews (87) and center the section by turning adjusting cam to adjust wear pads accordingly or as pads were originally removed and tagged. Refer to "Boom Calibration" on page 24.
10. Attach a sling to the tele cylinder (6) and raise and remove temporary block supporting tele cylinder at base of boom. Refer to Figure 4-2. Insert shaft (93) in base of Tele 3, spacer (94), thrust washer (53) and loop 4/3/2 retract cable (118) over single groove retract sheave (92) and install thrust washer (53). Align trunnion ends of tele cylinder 2/3/4 extend cables (139) and lightly tap shaft through trunnion ends, installing thrust washer (53), loop cable (118) over next single groove retract sheave (92), and install thrust washer (53) spacer (94). Install wear pads (55), shims (81) and capscrews (9) to retain ends of shaft assembly. Refer to "Boom Calibration" on page 24. Install grease fittings (105) in both ends of shaft (93) and lube. Apply multipurpose grease to exterior of all wear pads and all wear surfaces. See *Lubrication*, page 8-1.
11. Install cable retaining rollers (110) over retract sheaves (92) by inserting capscrews (174) into roller and adjusting locking nut (111) until the roller is centered with sheaves (92).
12. Attach wear pad (96) with retaining lip facing up and in toward cylinder. Inserting the mounting hardware (97, 23, 24, 98) in the upper hole first. Position 3/4/5 extend cable (106) inside cutout lip on the wear pad and swing wear pad up into position. Install hardware in lower mounting hole and tighten securely.
13. Install lower wear pad (43) and shims (44) with hardware (23, 24, 25) to bottom of base of Tele 3 (4) section as pads were originally removed and tagged. Refer to "Boom Calibration" on page 24. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.
14. Install cylinder supporting wear pad (117) with capscrew (19) and washers (16, 17) inside base of Tele 3 and reposition temporary support block.

NOTE: Use caution while lowering cylinder to prevent damage to cable retaining rollers (110).

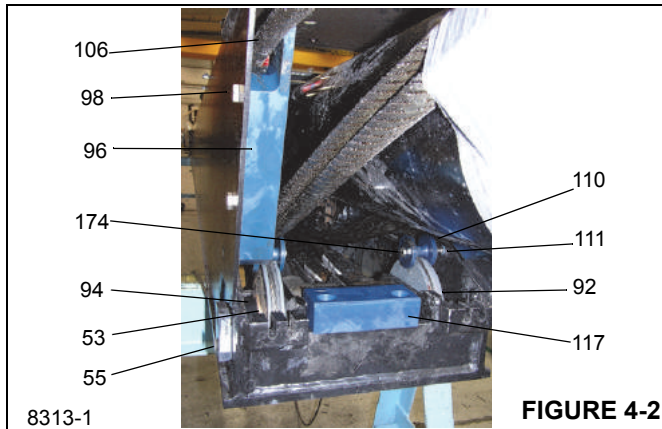


FIGURE 4-2

Tele 2 Section Assembly

Do not slide sections completely together. Place a temporary block between tips of sections to separate approximately 38 cm (15 in) See Figure 4-3.

NOTE: Use caution while lowering cylinder to prevent damage to cable retaining rollers (110).

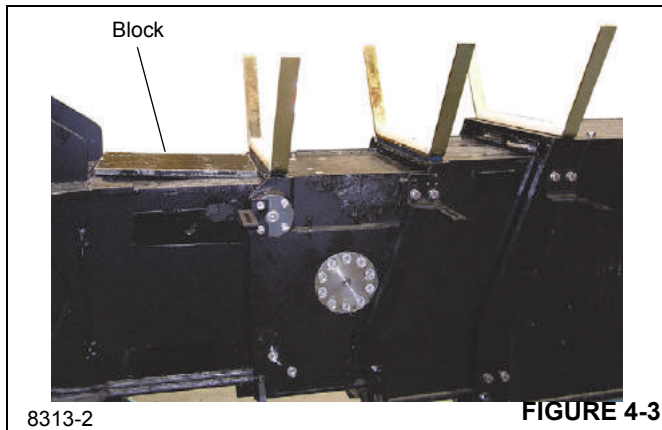


FIGURE 4-3

1. Apply grease to wear surfaces and hang trunnion plate (88) on forward cylinder mounting lug before inserting Tele 3 section into Tele 2 (3) section.
2. Attach a sling to Tele 3 (4) section and insert approximately half-way into Tele 2 (3) section. Take care not to cross cables and keep all cables clear of pinch points created by slings and bottom pads. Refer to Figure 4-4.
3. Raise the tip of Tele 3 (4) section and insert lower wear pads (7) in pad pockets at tip of Tele 2 section. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.

4. Install (4) side wear pads (86), shims (84, 85) with capscrews (173) or as pads were originally removed and tagged. Refer to "Boom Calibration" on page 24. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.

NOTE: Assembly tip: Apply spray adhesive or tape to wear pads and shims to aid in holding together during installation.

5. Insert 2 each capscrews (97), washers (23,24) in lower bracket (154) holes at left side-upper wear pad.
 6. Install plate (71), shim (165) to the inside, and wear pad (72) cable guide (73) and wear pad (74) securing with capscrews (7) and washer (23) to the outside tip of Tele 2 (3) section.
 7. Slide sections together until top rear wear pad mounting is accessible through the access opening on top of boom. Install wear pads (39), wear pad plate (40) and cam plate (41) with capscrews (95) and flatwashers (23). Center the section and turn adjusting cam plate to adjust wear pads according to the calibration instructions in this section. Refer to "Boom Calibration" on page 24.
 8. Route the (2) 4/3/2 retract cables (82) through openings in the base end of Tele 2 (3) and attach anchor ends of cables in mounting sockets at base of Tele 2 and secure with capscrews (91) and lockwashers (24).
 9. Insert shafts (51) in mounting lugs, bushing (83), thrust washer (53), two groove sheave (79), thrust washer (53) and guard (80). Secure with capscrew (33) and lockwasher (17). Install grease fitting (58) and apply multipurpose grease.
 10. Install side wear pads (55), shims (81) with capscrews (9). Install outer lower wear pad (43), spacer (44) with mounting hardware (25, 24, 23) as pads were originally removed and tagged. Refer to "Boom Calibration" on page 24. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.
- NOTE:** Assembly tip: Apply spray adhesive or tape to wear pads and shims to aid in holding together during installation.
11. Remove temporary block and attach cylinder mounting trunnion plates (88) with capscrews (90) and washers (89) to base of Tele 2.
 12. Rotate cylinder shaft until trunnion is horizontal and the small plugged fitting on port block is facing up. Cylinder should extend out of Tele 2 section approximately 38 cm (12 in).
 13. Insert threaded end of 3/4/5 extend cables (106) through anchor holes in upper base end of Tele 2 (3) and install washers (61) and nuts (62). Adjust slack from cables

and tighten locking nuts. Refer to “Boom Cable Tensioning” on page 19.

14. Insert anchor capscrews (60) and the cylinder 2/3/4 extend cables (139) in cable anchors (59) in the sequence as labeled. Install keeper plate (66) with capscrew (67) and washer (17).

NOTE: Use caution not to cross cables, failure will occur.

Tele 1 Section Assembly

1. Apply grease to wear surfaces and hang trunnion plate (64) on rear cylinder mounting lug before inserting Tele 2 (3) section into Tele 1 (2) section.
2. Attach synchro cables (49) with hardware (78, 77) to mounting anchors at the top base end of Tele 2 (3). Route cable on top of boom and loop cables through sheave anchor (46) at the tip of boom. Insert pins (48) in sheave (47), insert sheave assembly in slot of sheave anchor (46) and install grease fittings (63) in pin (48) and apply multipurpose grease to grease fittings. Position anchor assembly to prevent damage to cables during assembly with threaded ends routed to rear of boom.
3. Attach a sling to Tele 2 (3) section and insert into Tele 1 (2) section while guiding 4/3/2 retract cables. Take care not to cross cables and keep all cables clear of pinch points created by slings and bottom pads. Refer to Figure 4-4.
4. Raise the tip of Tele 2 section and insert lower wear pads (7) in pad pockets at lower tip of Tele 1 section. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.
5. Install four side wear pads (86), shims (84, 85) with hardware (153, 23, 24) to tip of Tele 1 as pads were originally removed and tagged. Refer to “Boom Calibration” on page 24. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.

NOTE: Assembly tip: Apply spray adhesive or tape to wear pads and shims to aid in holding together during installation.

6. Insert two capscrews (25), washers (23, 24) in upper bracket (154) holes at left side-upper wear pad.
7. Install 4/3/2 retract cables plate (38) and nuts (10) with capscrew (9) to lower tip of Tele 1.
8. Install plates (57) between tip of sections securing with hardware (25, 24, 23) in rear mounting holes. Install cable guide (21) and wear pad (22) and secure with hardware (25, 24, 23) in forward mounting holes.
9. Slide sections together until top rear wear pad mounting is accessible through the access opening on top of boom. Install top wear pads (76), wear pad plates (40), cam plates (41) with hardware (169, 23) to rear of Tele 2

section. Center the section and turn adjusting cam plate to adjust wear pads according to the calibration instructions. Refer to “Boom Calibration” on page 24. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.

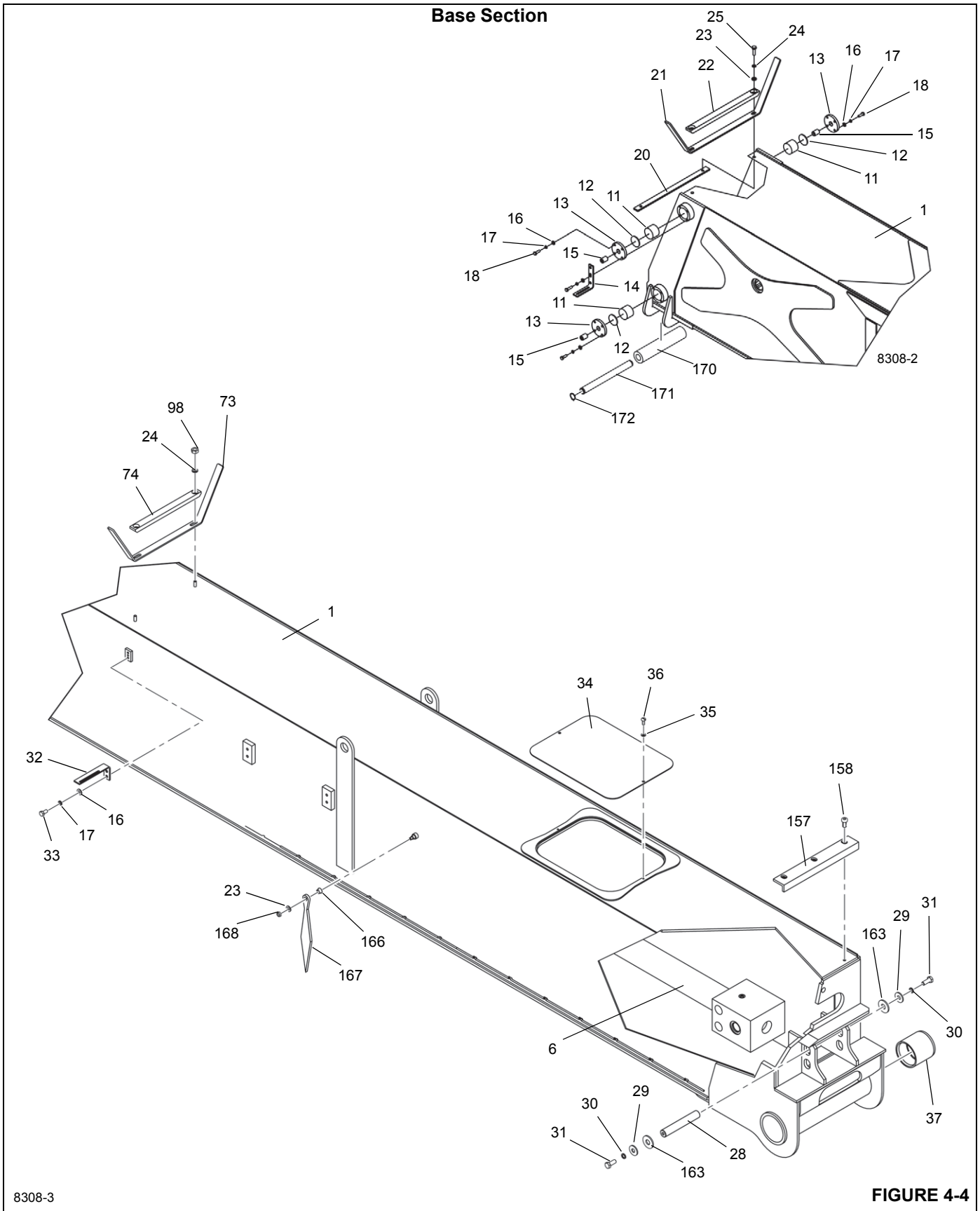
10. Guide synchro cable sheave assembly (47) into tip of Tele 1 section as sections are slid together.
11. Guide anchor capscrews (60) securing 2/3/4 extend cables anchor (59) into anchoring holes at the base end of Tele 1 and securing with two washers (61), four cable adjusting nuts (62). Refer to “Boom Cable Tensioning” on page 19.
12. Align cylinder trunnion (64) and install capscrews (65) and washers (26).
13. Attach three 3/2/1 retract cables (52) to anchor points with capscrews (91) and lockwashers (24) at the base of Tele 2.
14. Route 3/2/1 retract cables (52) and insert the plates (8) and nuts (10) on threaded ends of cables for tip of Tele 1 to keep cable taut during assembly.
15. Install 3/2/1 retract cable shafts (51), two thrust washer (53), three groove sheaves (50). Loop 3/2/1 retract cables (52) around sheaves and install one thrust washer (53) and guard (54) to base of Tele 1. Secure shafts with capscrews (33) and washers (17). Install grease fittings (58) and apply multipurpose grease. See *Lubrication*, page 8-1.
16. Install wear pads (55) and shims (56) with capscrew (9) and wear pad (43), shims (44) securing with hardware (25, 24, 23) to lower base of Tele 1 or as pads were originally removed and tagged. Refer to “Boom Calibration” on page 24. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.

NOTE: Assembly tip: Apply spray adhesive or tape to aid in holding wear pad and shims together during installation.

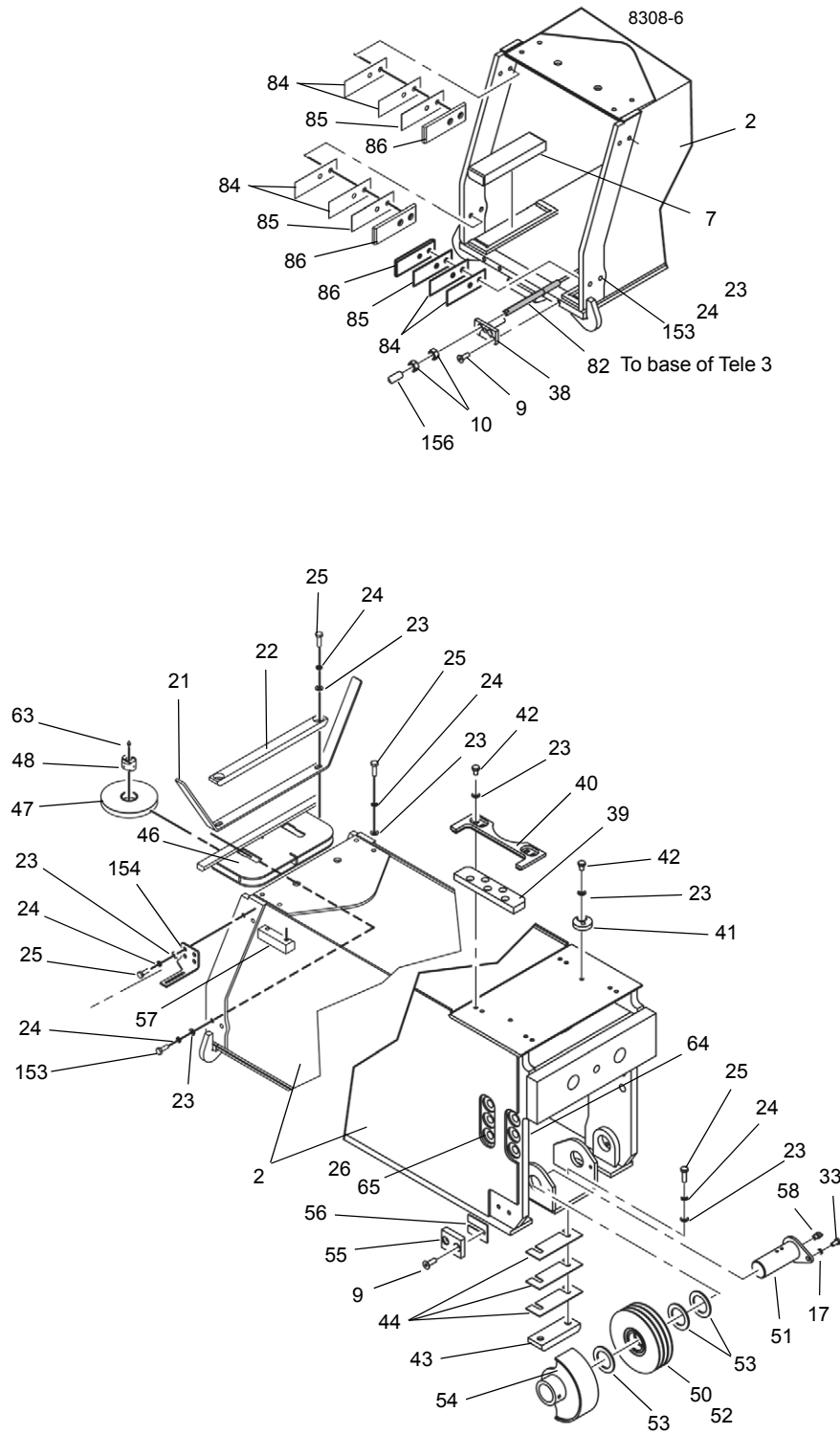
Base Section Assembly

1. Attach a sling to Tele 1 (2) section and insert into base (1) section while guiding 3/2/1 retract cables (52) to prevent crossing and damage. Refer to Figure 4-4.
2. Raise the tip of Tele 1 section and insert lower wear pads (7) in pad pockets at lower tip of base section. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.
3. Install four side wear pads (11), plate (12), adjusting plate (13), setscrew (15) with hardware (16, 17, 18) to tip of base. Mount bracket (14) into rear holes of the upper-left side wear pad mounting holes. Refer to “Boom Calibration” on page 24. Apply multipurpose grease to

- all wear pads and all wear surfaces. See *Lubrication*, page 8-1.
4. Attach threaded ends of cables 3/2/1 retract cables plates (8) and nuts (10) with capscrews (9) to the lower tip of base section.
 5. Insert plate (20) between tip of base section and Tele 1 section and install cable guide (21) and wear pad (22) with hardware (25, 24, 23).
 6. Slide sections together until top rear wear pad mounting is accessible through the access opening on top of boom. Install top wear pads (39), wear pad plates (40), cam plates (41) with hardware (42, 23) to rear of Tele 1 section. Center the section and turn adjusting cam to adjust wear pads according to the calibration instructions. Refer to "Boom Calibration" on page 24. Apply multipurpose grease to all wear pads and all wear surfaces. See *Lubrication*, page 8-1.
 7. Slide boom sections together and insert threaded end of synchro cable (49) in rear of base section and install washers (26), and adjusting nuts (27). Refer to "Boom Cable Tensioning" on page 19.
 8. Align cylinder port block with mounting anchor at rear of base section and install pins (28) with flatwashers (163), flatwashers (29), lockwashers (30) and capscrews (31).
 9. Install cable guide (73) and wear pad (74) with washer, (24) and nut (98) to mounting studs top center of base section.
 10. Install bracket (32) with hardware (16, 17, 33) and elevation pendulum (167) with hardware (168, 23, 166) to side of base section.
 11. Install upper wear pad (157) with capscrew (158) to top rear of base section.
 12. Install roller (170) with shaft (171) with retainer (172) at bottom tip of base section. Inspect boom pivot bushing (37) and replace if necessary before installing boom.
 13. Align all boom sections and adjust wear pads and adjust cable tensions. Refer to "Boom Calibration" on page 24 and Refer to "Boom Cable Tensioning" on page 19. Install thread protectors to all threaded cable ends.
 14. Install boom access cover plate (34) with screw (36) and flatwasher (35) to top of base section.



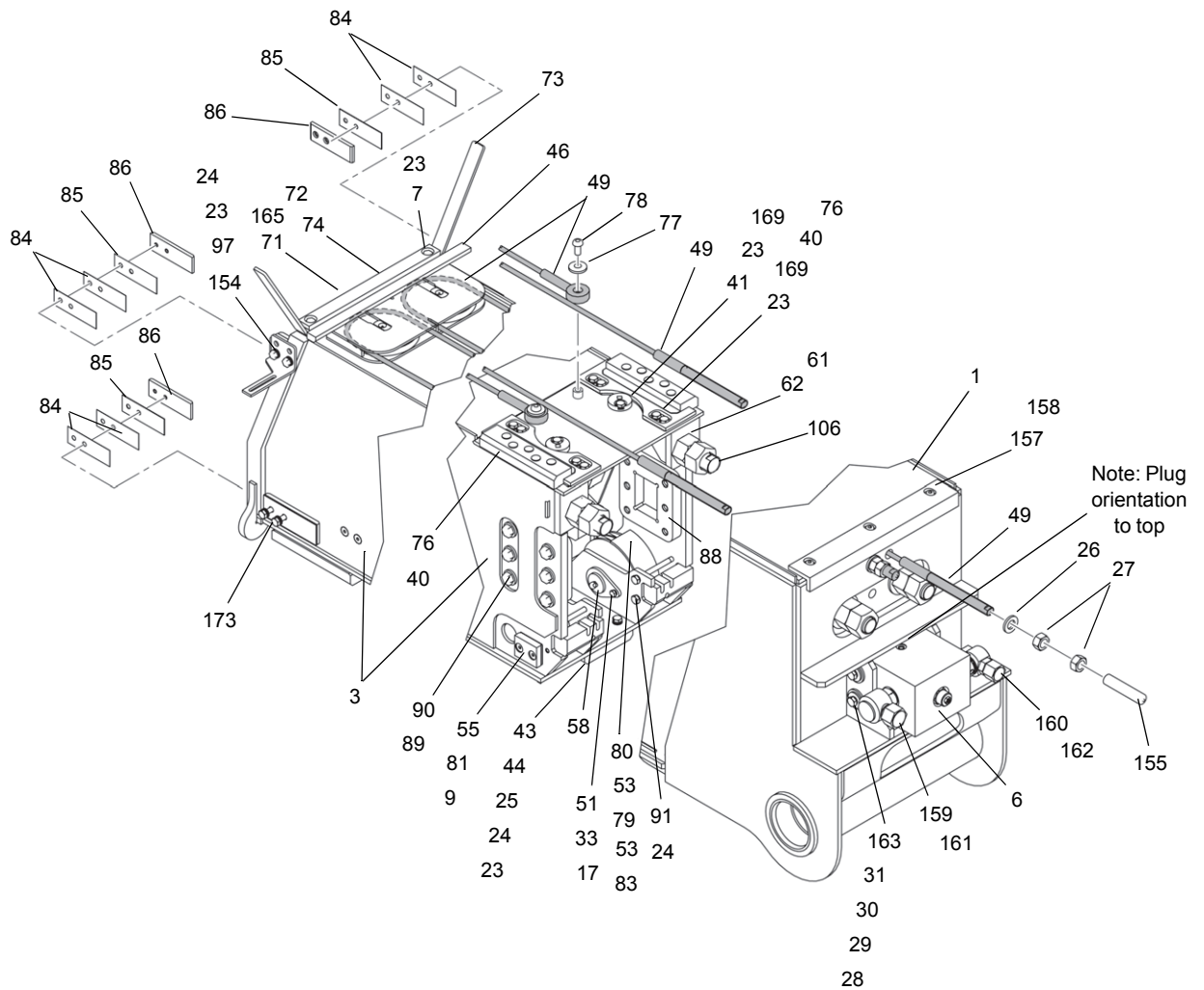
Tele 1 Section



8308-4

FIGURE 4-4 continued

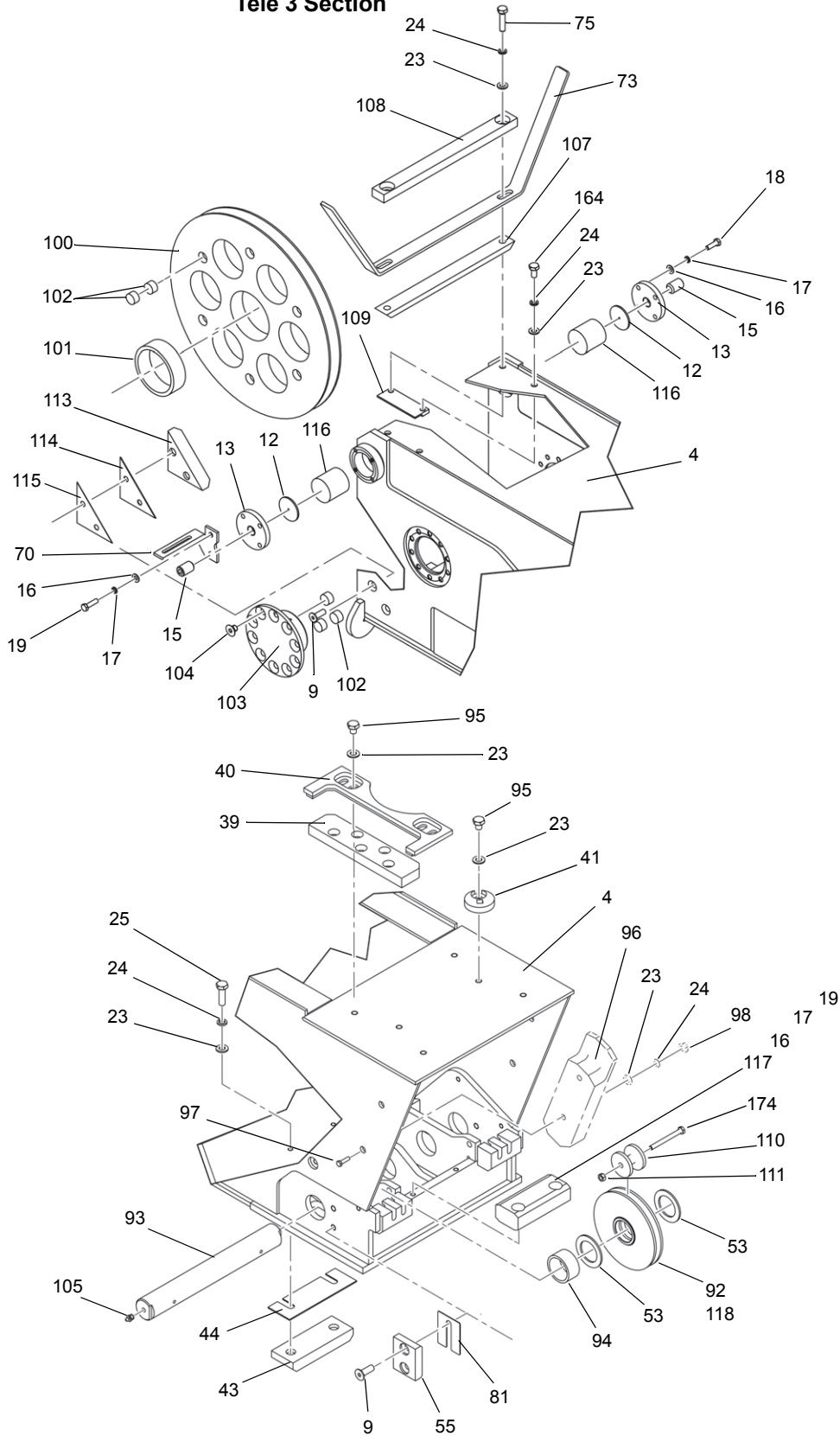
Tele 2 Section



8308-4

FIGURE 4-4 continued

Tele 3 Section



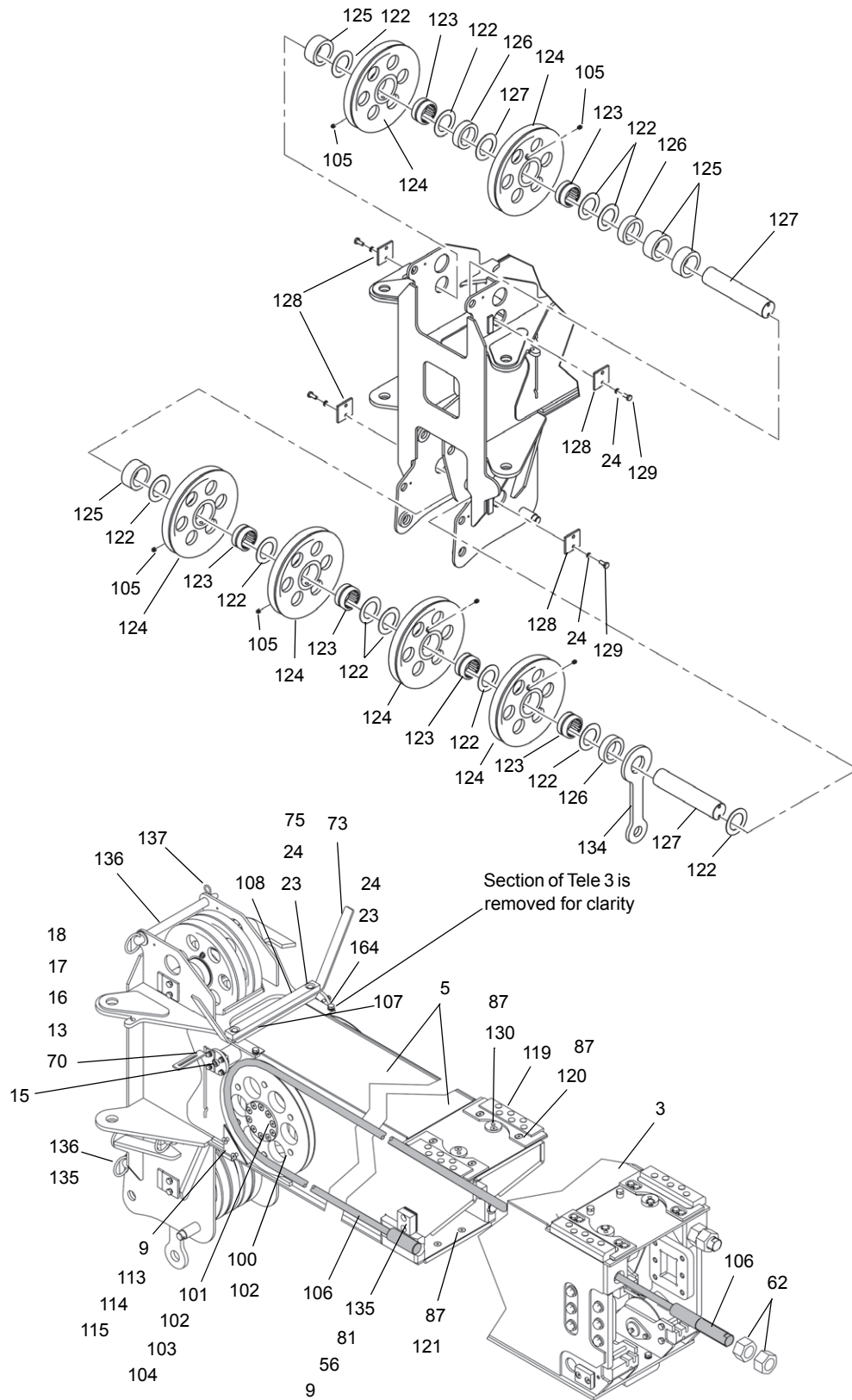
8308-7

8308-8

FIGURE 4-4 continued

Tele 4 Section

8308-9



8308-1

FIGURE 4-4 continued

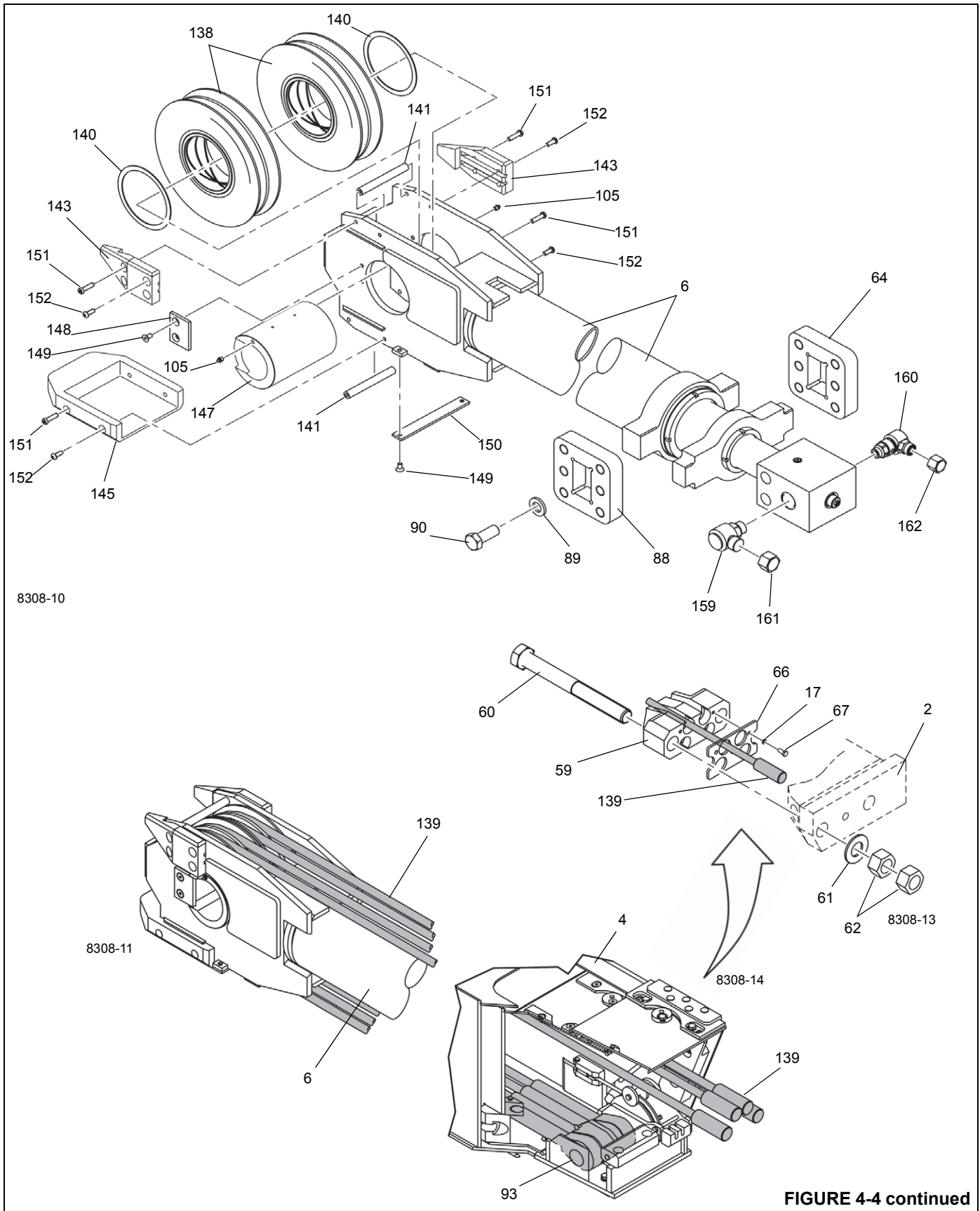


FIGURE 4-4 continued

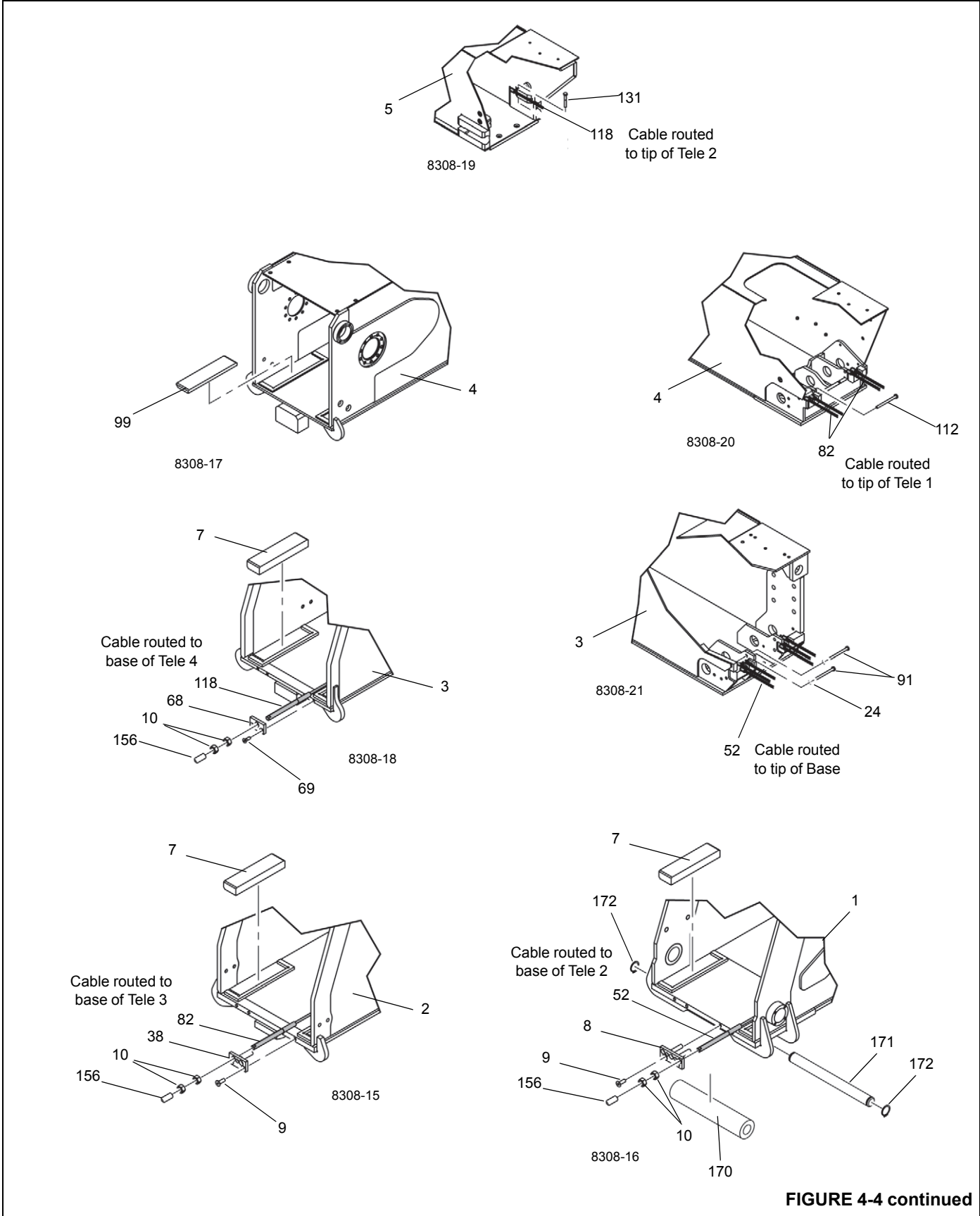


Table 4-1

Item	Description
1	Base Section
2	Tele 1 Section
3	Tele 2 Section
4	Tele 3 Section
5	Tele 4 Section
6	Tele Cylinder
7	Wear Pad
8	Plate
9	Flat Head Capscrew M10x30
10	Hex Nut M16
11	Wear Pad
12	Plate
13	Adjusting Plate
14	Bracket
15	Socket Setscrew M20
16	Flat Washer 8
17	Lock Washer 8
18	Hex Head Capscrew M8x25
19	Hex Head Capscrew M8x30
20	Plate
21	Cable Guide
22	Wear Pad
23	Flat Washer 10
24	Lock Washer 10
25	Hex Head Capscrew M10x35
26	Flat Washer
27	Hex Nut M20
28	Pin
29	Flat Washer
30	Lock Washer 12
31	Hex Head Capscrew M12x30
32	Mounting Angle
33	Hex Head Capscrew M8x16
34	Plate
35	Flat Washer 6
36	Screw M6
37	Bushing
38	Plate
39	Wear Pad
40	Wear Pad Plate
41	Cam Plate
42	Hex Head Capscrew M10x16
43	Wear Pad
44	Spacer
46	Sheave Anchor
47	Sheave
48	Pin
49	Synchro Cable

Item	Description
50	Sheave - 3 groove
51	Shaft
52	Retract Cable
53	Thrust Washer
54	Guard
55	Wear Pad
56	2mm Side Pad
57	Plate
58	90 Deg Grease Fitting
59	Anchor
60	Hex Head Capscrew
61	Flat Washer
62	Hex Nut
63	Grease Fitting
64	Trunnion
65	Hex Head Capscrew M20x50
66	Keeper Plate
67	Hex Head Capscrew M8x20
68	Plate
69	Flat Head Capscrew M8x25
70	Bracket
71	Plate
72	Wear Pad
73	Cable Guide
74	Wear Pad
75	Hex Head Capscrew M10x45
76	Wear Pad
77	Fender Washer
78	Button Head Capscrew 5
79	Sheave - 2 groove
80	Guard
81	1mm Side Pad Shim
82	Retract Cable
83	Bushing
84	Shim
85	Shim
86	Wear Pad
87	Flat Head Capscrew M10x16
88	Trunnion Plate
89	Flat Washer
90	Hex Head Capscrew M16x45
91	Hex Head Capscrew M10x120
92	Sheave - one groove
93	Shaft
94	Spacer
95	Hex Head Capscrew M10x12
96	Wear Pad
97	Hex Head Capscrew M10x40
98	Hex Nut M10

Item	Description
99	Wear Pad
100	Sheave
101	Bushing
102	Wear Plug
103	Sheave Pin
104	Flat Head Capscrew M8x14
105	Grease Fitting
106	Extend Cable
107	Wear Pad
108	Wear Pad
109	Plate
110	Roller
111	Hex Nut M8
112	Hex Head Capscrew M8x85
113	Wear Pad
114	Shim
115	Shim
116	Wear Pad
117	Wear Pad
118	Retract Cable
119	Wear Pad
120	Upper Plate
121	Wear Pad
122	Spacer
123	Bearing
124	Sheave
125	Spacer
126	Spacer
127	Shaft
128	Keeper
129	Hex Head Capscrew M10x25
130	Cam Plate
131	Hex Head Capscrew M6x16
134	Link
135	Wear Pad
136	Lock Pin
137	Hitch Pin
138	Sheave
139	Extend Cable
140	Spacer-154mm
141	Threaded Rod
143	Wear Pad
145	Wear Pad
147	Shaft
148	Keeper Plate
149	Flat Head Capscrew M10x20
150	Plate
151	Button Head Capscrew
152	Button Head Capscrew

Item	Description
153	Hex Head Capscrew M10x30
154	Bracket
155	Cable Protector
156	Cable Protector
157	External Wear Pad
158	Socket Head Capscrew- M10
159	Adapter, Swivel
160	360 Deg Swivel
161	Cap
162	Cap
163	Flat Washer
164	Hex Head Capscrew M10x20
165	Shim
166	Bearing
167	Pendulum
168	Hex Lock Nut
169	Hex Head Capscrew M10x14
170	Roller
171	Pin
172	Retaining Ring
173	Socket Hd Capscrew M10x16
174	Hex Head Capscrew M8x70
200	Wear Pad Kit

BOOM CABLE TENSIONING

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

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

A single stage cylinder will control first extendable section.

A dual stage cylinder will control second extendable section.

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

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

Five Section Cable Tensioning

Tensioning Setup Procedure

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 4-5.
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.

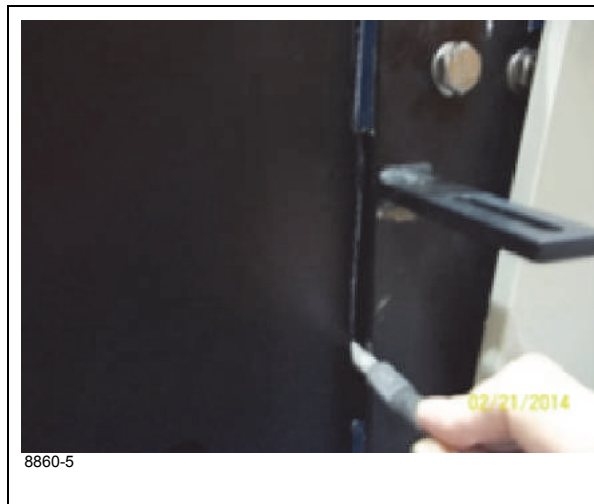


FIGURE 4-5

Cable Tension Sequence

Five section boom with two stage cylinder.

Cable tensioning (See Figure 4-6) to be in the following order:

1. 321 retract cables
2. 123 extend (synchronizing) cables.
3. 234 extend cables
4. 432 retract cables.
5. 345 extend cables
6. 543 retract cables.

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.

Three section boom with one stage cylinder.

Cable tensioning to be in the following order:

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

5 - Section Boom w/ 2 Stage Cylinder Cable Positioning

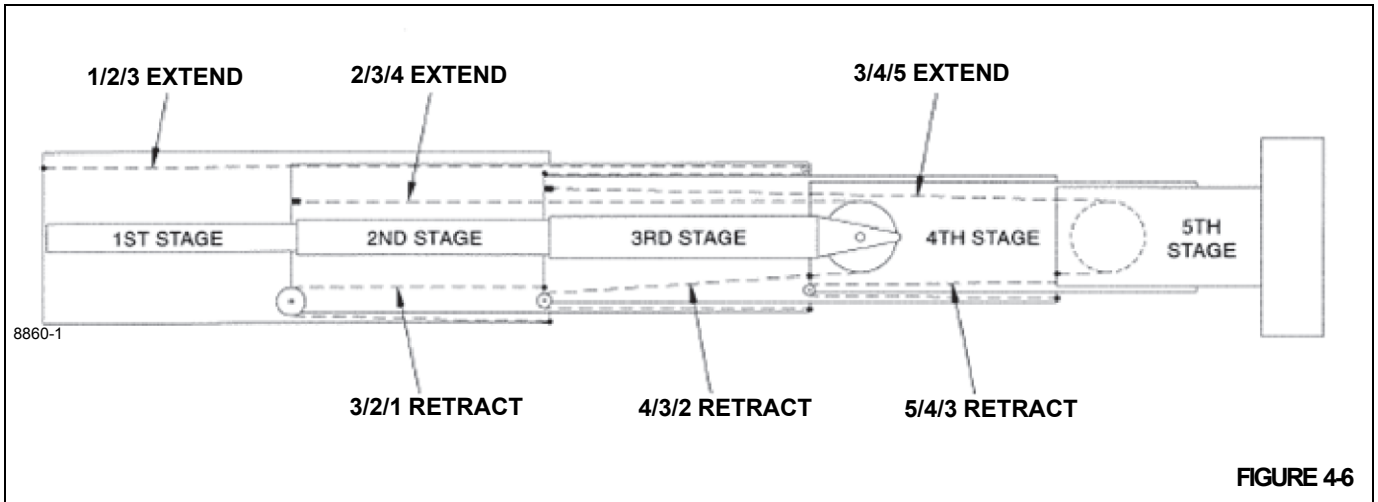


FIGURE 4-6

Cable Tightening Sequence 5 Section Boom with Two Stage Extend Cylinder

Boom must be in horizontal position when adjusting cable tension (See Figure 4-6.) Retract boom fully ensuring sections are bottomed out on section stops and do not spring back. (Reference Tensioning Setup Procedure)

321 and 123 cable balancing

Extension

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

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

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

The second section should have moved out.

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

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

Retraction

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

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

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

The third section should have moved out.

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

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

234 and 432 cable balancing

Extension

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

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

2. Tighten the **234** extend cable located at the back top of the second section the difference in the extension gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the extension gaps.

The fourth section should have moved out.

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

Retraction

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

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

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

The fourth section should have moved in.

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

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

345 and 543 cable balancing

Extension

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

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

2. Tighten the **345** extend cable located at the back top of the third section the difference in the extension gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the extension gaps.

The fifth section should move outward.

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

Retraction

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

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

2. Tighten the **543** retract cable located at the front bottom of the third section the difference in the retraction gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the retraction gaps.

The fifth section should have moved in.

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

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

Cable Retention

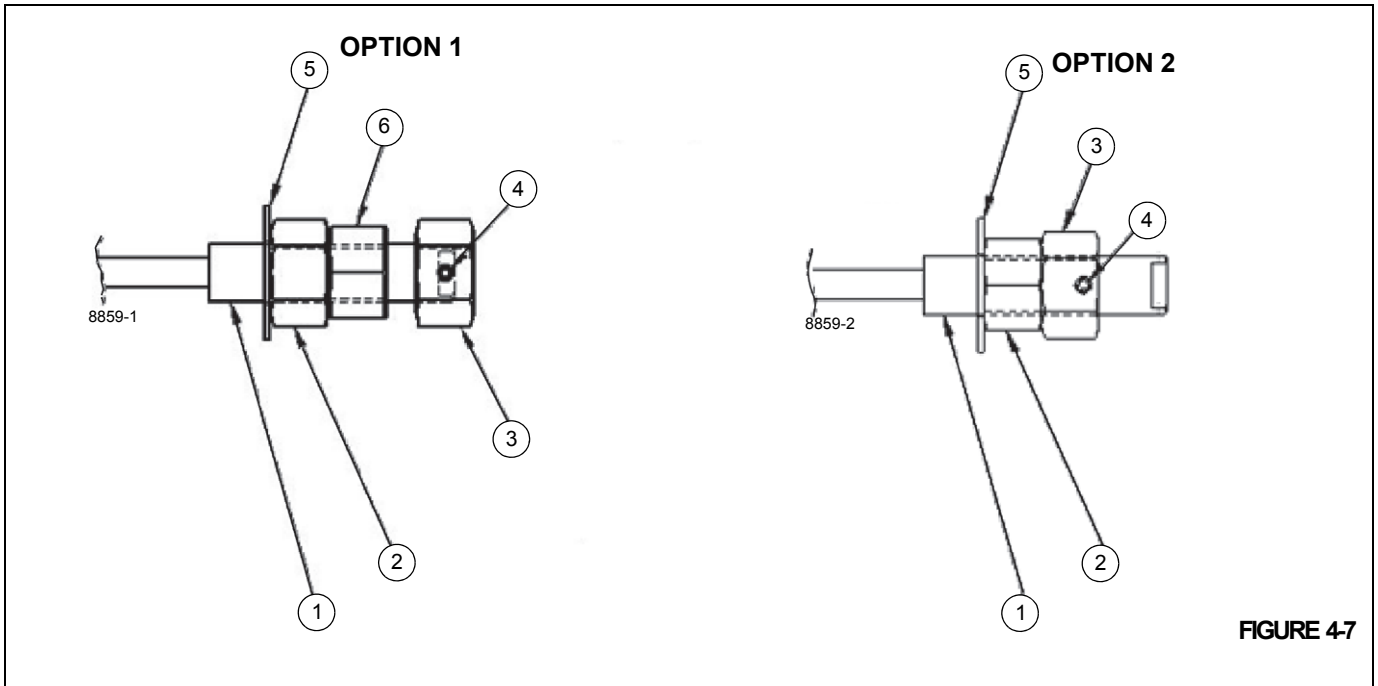


FIGURE 4-7

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 4-7) 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 4-7).

TORQUE VALUES for Second Nut:

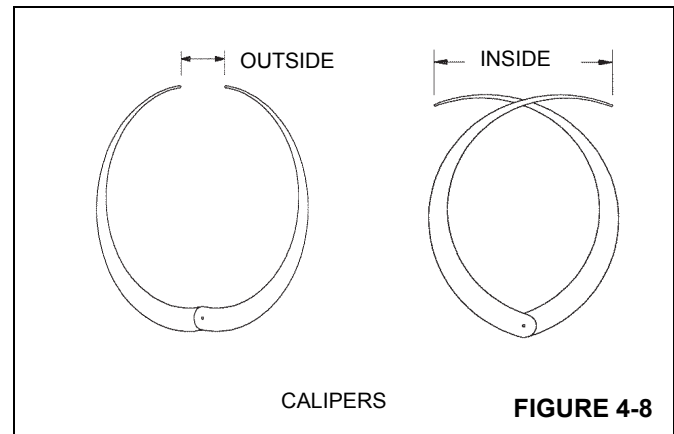
Inch Series with Coarse Threads (UNC)

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

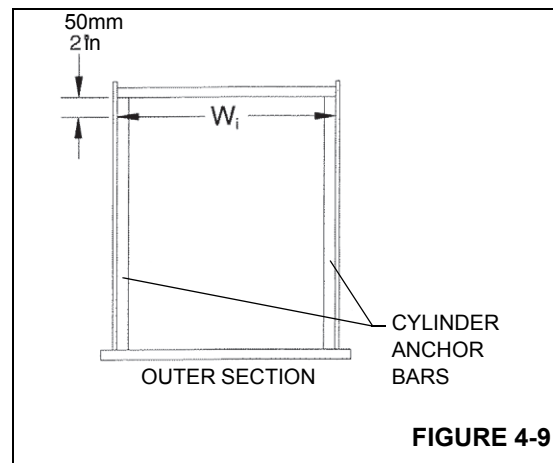
Cable end Thread Size	Minimum Nut Property Class	Nut Type	TORQUE Nm
M16x2	5	Hex Jam (THIN)	26
M20x2.5	5	Hex Jam (THIN)	66

BOOM CALIBRATION



Top, Rear Wear Pads

1. With a pair of inside/outside calipers, measure the inside width of the outer section (W_i) within 50 mm (2 in) of the top plate at the front and back of the boom and record the smallest measurement. If the section has cylinder anchor bars, take a measurement directly in front of those bars.



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

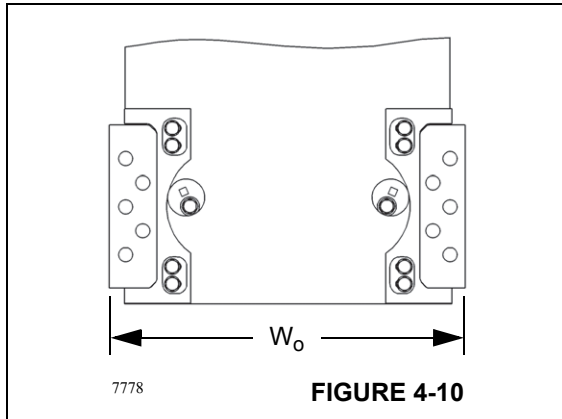


FIGURE 4-10

Inner Side Pads

1. With a pair of inside/outside calipers, measure the inside width of the outer section (W_i) at the front and back of the boom within 76 mm (3 in) of the bottom plate and record the smallest measurement. If the section has cylinder anchor bars, take a measurement directly in front of these bars.

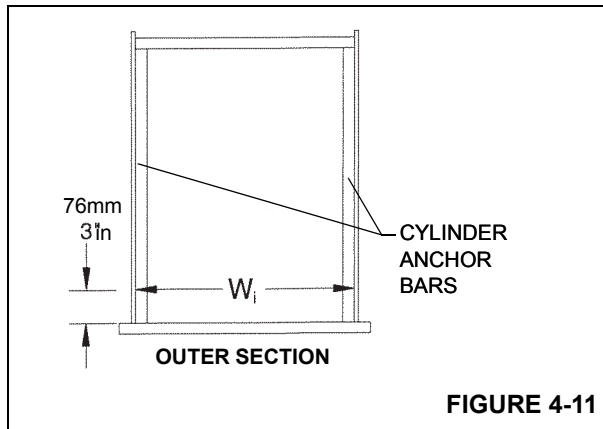


FIGURE 4-11

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

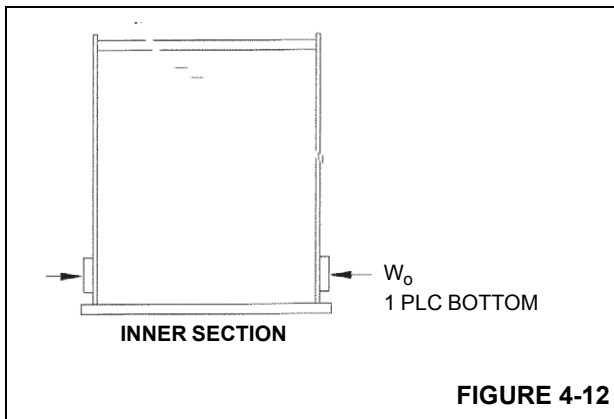


FIGURE 4-12

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

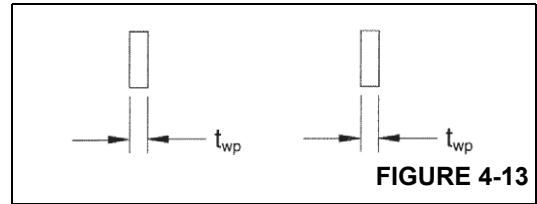


FIGURE 4-13

4. Subtract the outside width (W_o) of the inner section and the thickness of the two pads (t_{wp}) from the inside width of the outer section (W_i). Add shims as required (each shim is 0.76 mm (0.03 in) to tighten the pads so that there is 0.00 - 1.5 mm (0.00 - 0.06) clearance between the inner boom rear lower wear pads and the most narrow part of the outer boom when shims are installed.

Bottom Rear Pads

1. With a tape measure, measure the inside height of the outer section (H_i) at the front and back of the boom and record the smallest measurement. If the section has cylinder anchor bars, take a measurement directly in front of these bars.

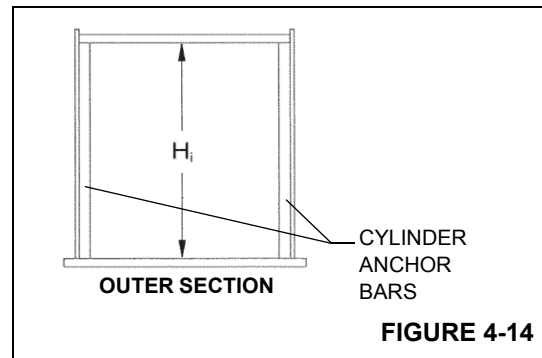


FIGURE 4-14

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

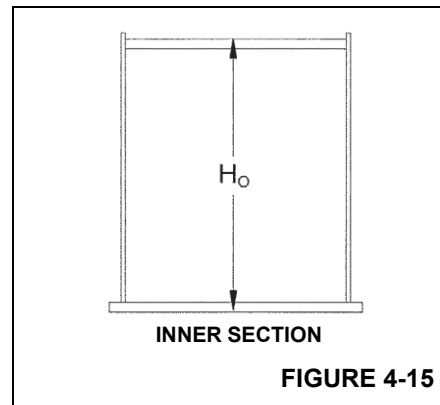
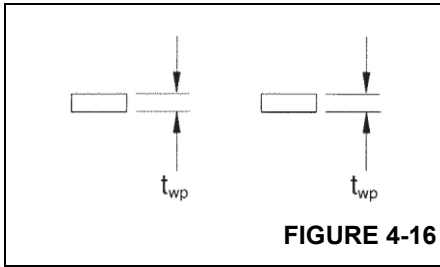


FIGURE 4-15

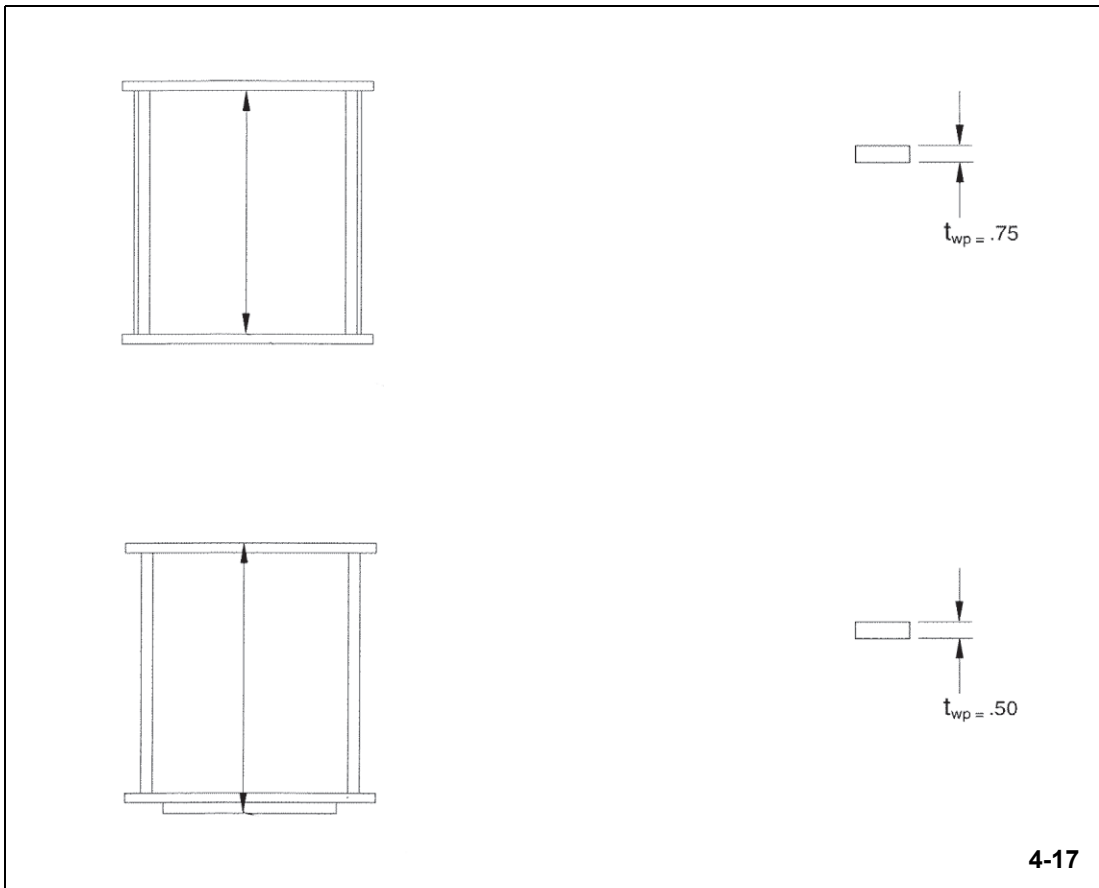
3. Measure the thickness of the top wear pads and record (t_{wp}).

4



4. Subtract the largest outside height (H_o) of the inner section and the thickness of the top pad and lower pad (t_{wp}) from the inside height of the outer section (H_i). Add shims as required [each shim is 1.5 (0.06) thick] to tighten the pads so that there is 1.5 mm - 3.4 mm (0.06 - 0.12) clearance between the widest part of the inner boom and the most narrow part of the outer boom when shims and pads are installed.

EXAMPLE



H_i	=	19.38
$-H_o$	=	-17.88
$-t_{wp}$	=	-0.75
$-t_{wp}$	=	<u>-0.50</u>
Clearance	=	0.25
Bottom shims	=	<u>-0.19</u>
Final Clearance	=	0.06

MULTI-STAGE EXTEND CYLINDER

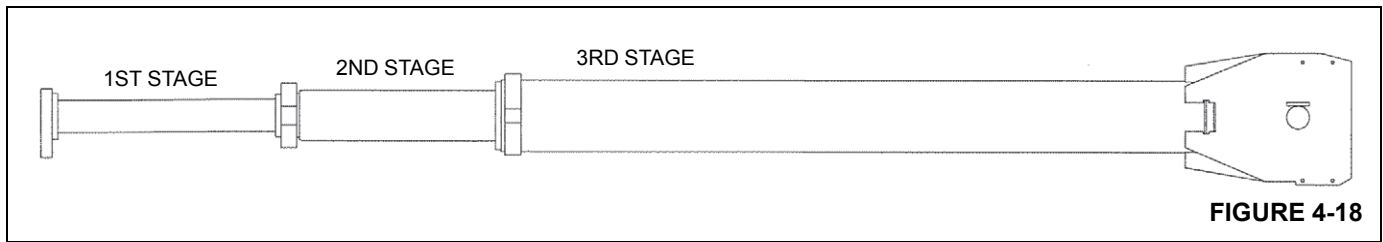


FIGURE 4-18

Cylinder Disassembly

1. After cylinder has been disassembled from boom, place on supports and place drain pan under holding valve.
2. Using hydraulic power (porta power or crane circuit) extend cylinder sections approximately 61 cm (24 in). If stages do not move equally, retain the moving stage to allow for equal extension of cylinder. Remove the holding valve from the 1st stage butt plate and drain oil.
3. Using the proper size spanner wrench (listed on the cylinder parts page break down), loosen the packing gland and completely unscrew from the 3rd stage barrel assembly.
4. Remove the 2nd/1st stage cylinder assembly from the 3rd stage barrel assembly and place on supports. Caution must be exercised in the support and removal of 2nd/1st stage cylinder assembly as damage to the chrome surface will necessitate replacement.
5. Using the proper size spanner wrench (listed on the cylinder parts page break down), loosen the packing gland and completely unscrew from the 2nd stage cylinder assembly.
6. Remove the 1st stage cylinder assembly from the 2nd stage cylinder assembly and place on supports. Caution must be exercised in the support and removal of the 1st stage cylinder assembly as damage to the chrome surfaces will necessitate replacement.
7. Using a 3/16 in allen wrench, remove the locking setscrews from the 1st stage cylinder shaft piston and from the 2nd stage cylinder shaft piston. Using the proper size spanner wrench, loosen and completely unscrew pistons from the 1st and 2nd stage cylinder shaft assemblies. Remove stop tubes from the 1st and 2nd stage cylinder shaft assemblies.
8. Wipe and inspect all cylinder internal and external surfaces for damage. Wipe and inspect all threaded components for damage to threads.
9. Inspect wear pads on the 3rd stage barrel sheave case assembly. Replace as required.
10. Ensure that the O-ring seal area of the packing gland bores on both the 2nd stage cylinder assembly and the 3rd stage barrel assembly are smooth and free of nicks

and lubricate to eliminate damage to the packing gland O-ring during reassembly.

Cylinder Reassembly

1. Replace cylinder packing parts as required on 1st stage cylinder assembly. Refer to parts pages for replacement packing kit part number. Warming the U-cup seals in 140°F oil will allow for easier assembly.
2. Reinstall packing gland and stop tube onto 1st stage cylinder shaft assembly.
3. Install O-ring and backup rings on inner diameter of 1st stage piston and thread onto 1st stage cylinder shaft assembly until snug making certain piston counterbore is seated over shaft assembly properly. Take care not to damage the O-ring while installing piston. Using the proper size spanner wrench tighten piston onto 1st stage cylinder shaft assembly to 814 N·m (600 lb-ft).
4. Install setscrew into piston using Loctite® according to Loctite® recommendations and torque to 11 N·m (8 lb-ft). Loctite® and install second set-screw on top of first setscrew and torque to 11 N·m (8 lb-ft.)
5. Replace cylinder packing parts as required on 2nd stage cylinder assembly. Refer to parts pages for replacement packing kit part number.
6. Reinstall packing gland and stop tube onto 2nd stage cylinder shaft assembly.
7. Install O-ring and backup rings on inner diameter of 2nd stage piston and thread onto 2nd stage cylinder shaft assembly until snug making certain piston counterbore is seated over shaft assembly properly. Take care not to damage the O-ring while installing piston. Using the proper size spanner wrench, tighten piston onto 2nd stage cylinder shaft assembly to 814 N·m (600 lb-ft).
8. Install setscrew into piston using Loctite® according to Loctite® recommendations and torque to 8 lb-ft. Loctite® and install second set-screw on top of first setscrew and torque to 11 N·m (8 lb-ft).
9. Reinstall 2nd stage cylinder assembly with piston stop tube and packing gland into 3rd stage barrel assembly to within 61 cm (24 in) of fully assembled. Carefully start packing gland into 3rd stage barrel and tighten to within

1/4 in of snug. Using the proper size spanner wrench, torque the packing gland to 814 N·m (600 lb-ft).

10. Apply a 3/16 in wide band of Loctite® 518 to outer threads of packing gland and complete installation.
11. Reinstall 1st stage shaft assembly with piston, stop tube and packing gland into 2nd stage cylinder assembly to within 609 mm (24 in) of fully assembled. Carefully start packing gland into 2nd stage and tighten to within 6 mm (.25 in) of snug.
12. Apply a 4 mm (3/16 in) wide band of Loctite® 518 to outer threads of packing gland and complete installation. Using the proper size spanner wrench, torque the packing gland to 814 N·m (600 lb-ft.).
13. Install holding valve onto 1st stage shaft butt plate. Cycle test cylinder to ensure leak proof operation. Apply oil to the 1st stage shaft assembly through the holding valve. Support the 2nd and the 3rd stages as they extend and retract.

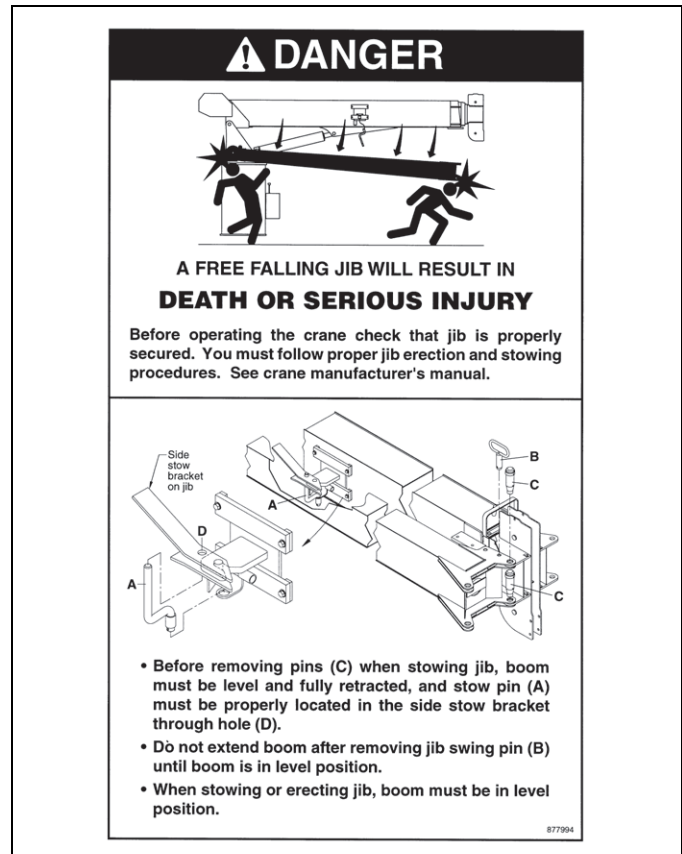
JIB BOOM

Jib Stowage Bracket Adjustment

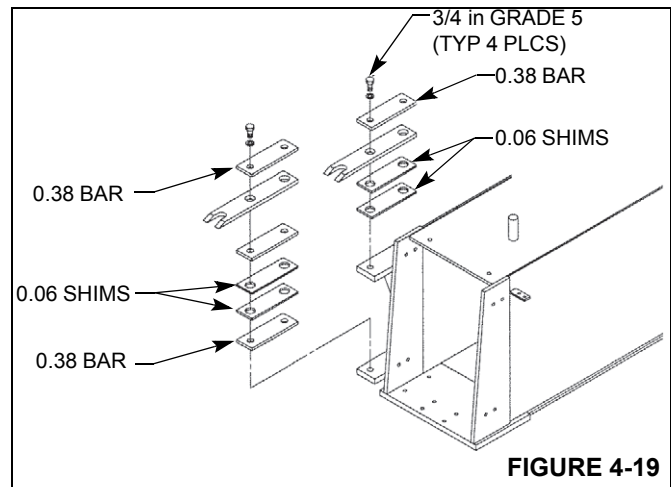
It is extremely important for the safety of the crane operator and all others working near the crane that the jib boom extension be properly secured to the jib stowage bracket (Figure 4-22) or to the boom nose of the main boom.

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

Before beginning this procedure read and understand the following DANGER decal. Also review and understand the Operator's Manual Set-Up section 4 for jib safety, stowing and deployment instructions.



1. Loosely bolt the two ear assemblies with shims and bars as shown in Figure 4-19 to the side of the first boom section.



2. Loosely bolt the hook assembly to the side of the first boom section, Figure 4-20.

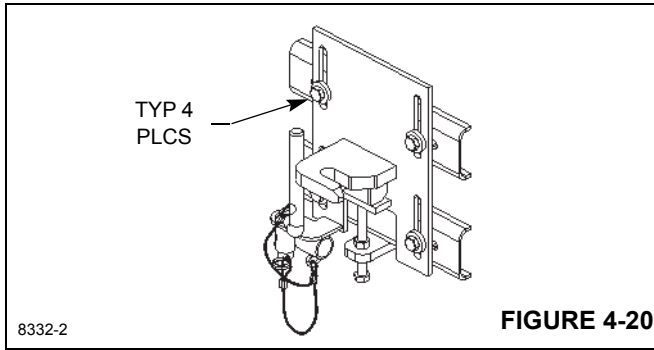


FIGURE 4-20

3. Extend the boom approximately one foot.
4. Using an overhead hoist, lift the jib assembly and align and pin the jib to the boom sheave head, Figure 4-21.

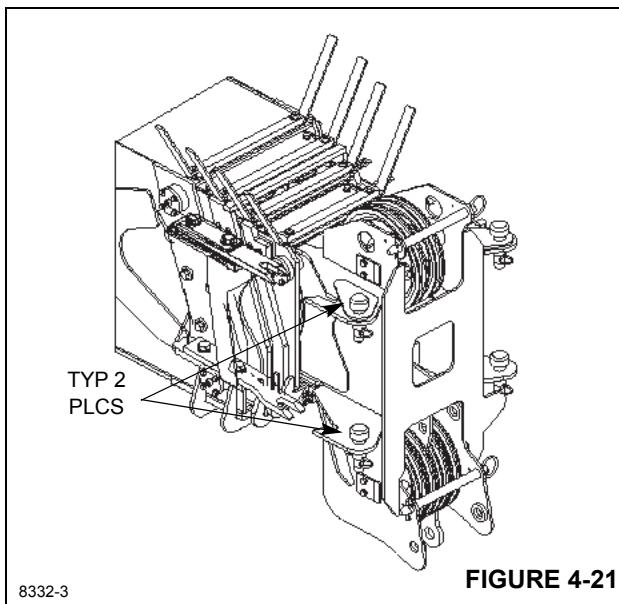


FIGURE 4-21

5. With jib pinned to the sheave head, swing the jib parallel to the boom and secure to the jib stowage bracket Figure 4-22.

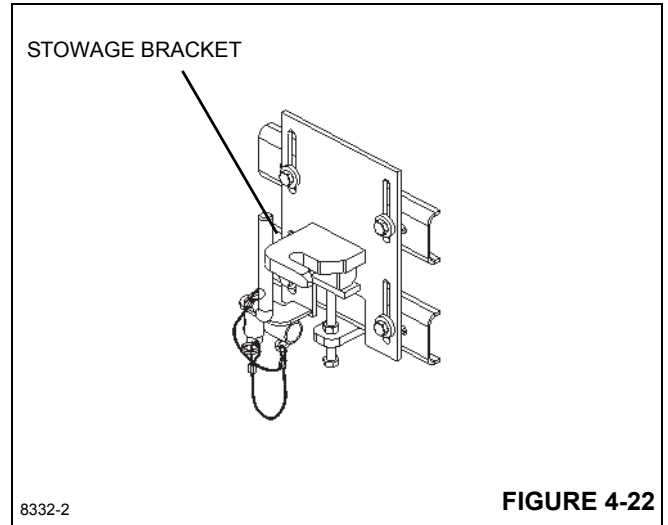


FIGURE 4-22

6. Slowly retract the boom until the jib ears are within 0.50 in (13 mm) of the ear assemblies on the first boom section. Observe the vertical alignment of the jib ears and ear assemblies and add or remove shims until the jib is supported by the jib ears. The jib will typically rest only on the upper support, Figure 4-23.

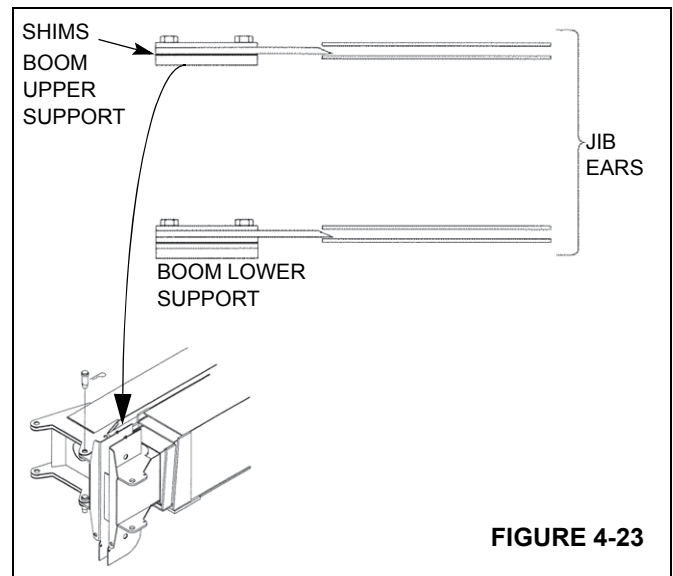


FIGURE 4-23

7. Observe the horizontal alignment of the slot in the ear assemblies and the stow pin in the jib. Horizontal adjustment of the stow ears is provided by oversize bolt holes in the stow ear. Move the ears in or out to achieve proper alignment. Position the top ear so it holds the top of the jib in toward the boom and the bottom ear so that it holds the bottom of the jib away from the bottom of the boom, see Figure 4-24.

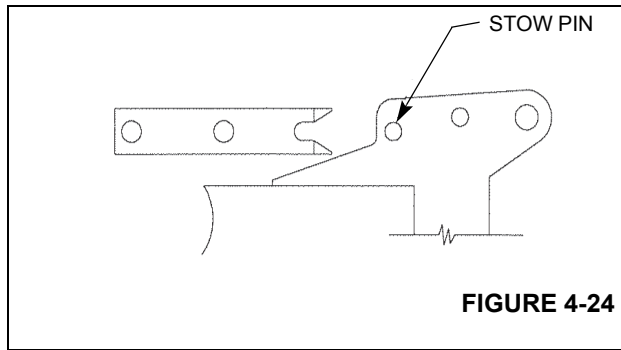


FIGURE 4-24

8. Retract the boom slowly. Observe the stow hook and lock assembly alignment as the boom is retracted, Figure 4-25.

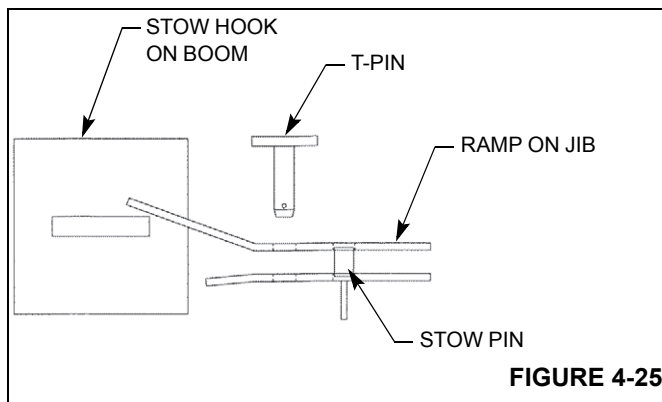


FIGURE 4-25

CAUTION

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

9. When the boom is fully retracted, the jib stow pins must be bottomed out securely in the ear assemblies. Refer to (Figure 4-26).

If the stow pins are not aligned properly, the hook assembly and front bars will have to be positioned as shown so the jib cannot slide forward or backward as the boom is elevated.

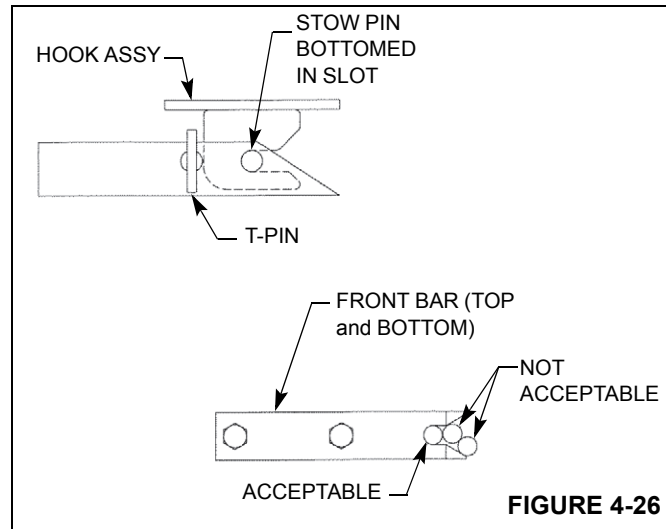


FIGURE 4-26

10. Try to remove the jib pins. If the pins are too tight, the stow hook assembly or front bars will have to be adjusted.
11. Torque all fasteners to their specified torque value. See "Fasteners and Torque Values" on page 1-7. Install stow pin in lock assembly and remove the jib pins.
12. Extend and retract boom to insure proper alignment of jib pins.
13. Install jib pins and remove the stow pins.
14. Extend and retract the boom and jib to ensure proper alignment of jib stow brackets.
15. Install jib stow pins and remove jib pins. Always save shims to allow future adjustment of jib stow if required.

Jib Jack Service and Maintenance

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

Remove the jack (1) from the jib boom (2) by removing three bolts and flatwashers (3). Refer to (Figure 4-27)

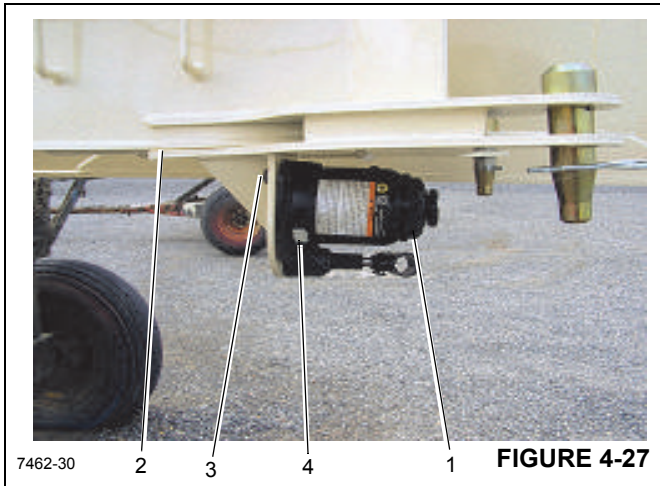


FIGURE 4-27

Adding Oil

1. With saddle fully lowered and piston depressed, set jack in its upright level position and remove oil filler plug. (4, Figure 4-27).
2. Fill until oil is level with filler plug hole.

Changing Oil

1. For best performance and longest life, replace the complete oil supply at least once a year.
2. To drain the oil, remove the filler plug (4, Figure 4-27).
3. Lay the jack on its side and allow the oil to run out into suitable drain pan. The oil will run slowly because air must enter as oil drains out.
4. Be careful to prevent dirt or foreign matter from entering the system.
5. Replace with proper oil as described above.

Lubrication

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

Rust Prevention

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

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



Troubleshooting

Symptom	Possible Cause(s)	Corrective Action
Will not lift load	<ol style="list-style-type: none"> 1. No oil in system 2. Release valve not closed 	<ol style="list-style-type: none"> 1. Add oil to reservoir tank through oil filler hole 2. Turn handle clockwise tightly
Will lift load only part way	Oil level low	Add oil to reservoir tank through oil filler hole
Will lift load but will not hold	<ol style="list-style-type: none"> 1. The following valve or valves leaking: <ol style="list-style-type: none"> a. Suction valve b. Delivery valve c. Release valve 2. Packings worn out or defective 	<ol style="list-style-type: none"> 1. Replace jack 2. Replace jack
Jack will not lower	Release valve stuck, probably dirt or foreign matter	Transfer load then replace dirty oil, flush oil reservoir with kerosene
Poor lifting	<ol style="list-style-type: none"> 1. Dirty oil 2. Air in hydraulic system 	<ol style="list-style-type: none"> 1. Change hydraulic oil 2. Purge air from system
Poor pumping action	Oil seal for pump crane worn out or defective	Replace jack

LIFT CIRCUIT

Description

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

The lift directional control valve is the closed spool type.

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

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

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

Theory of Operation

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

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

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

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

Maintenance

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

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



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

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

Lift Cylinder Removal

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



WARNING

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

NOTE: The lift cylinder weighs approximately 700 kg (1,543 lb).

3. Ensure the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.
4. Attach an adequate lifting/supporting device to the lift cylinder.
5. Remove the capscrew, lockwasher and nut securing the lift cylinder upper pivot shaft to the boom.
6. Remove the capscrew, lockwasher and nut securing the lift cylinder lower pivot shaft to the turntable.
7. Remove the upper pivot shaft and any attached thrust washers. Activate the hydraulic system and retract the lift cylinder enough to clear the upper attach point.
8. Tag and disconnect all the hydraulic lines to the cylinder. Cap or plug all openings with high pressure fittings.

9. Pull the lower lift cylinder pivot shaft and any attached thrust washers out far enough to remove the cylinder.

10. Move the lift cylinder to a clean work area.

Lift Cylinder Installation

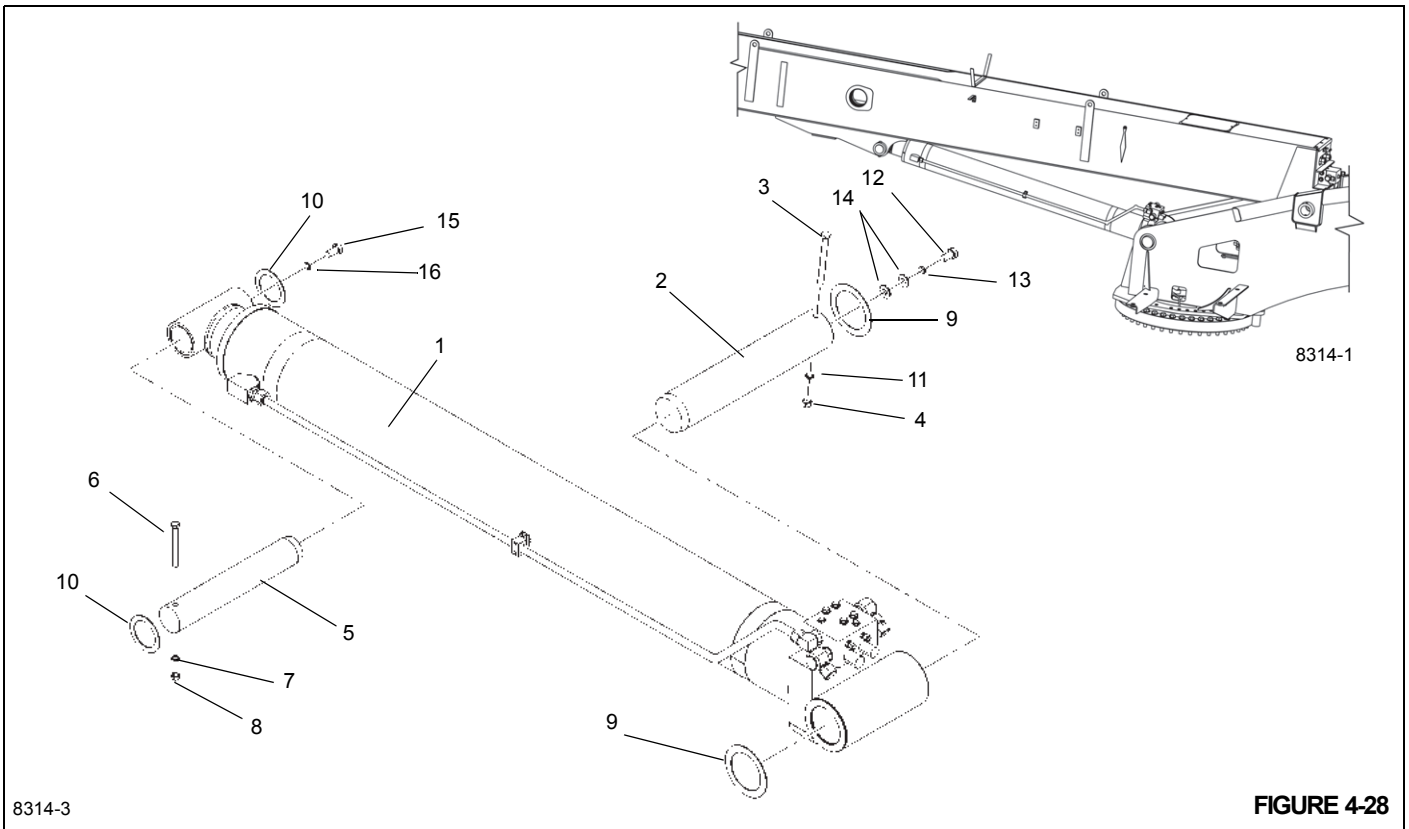
1. Attach an adequate lifting device to the lift cylinder and position the cylinder over the attach fitting on the turntable.

NOTE: The lift cylinder weighs approximately 700 kg (1,543 lb).

2. Lower the lift cylinder into the attach fittings on the turntable and align the lift cylinder bushing with the attach fitting holes.

NOTE: Install pivot shaft with tapped hole on the right side of the crane, side opposite the cab.

3. Install the lift cylinder lower pivot shaft and any attached thrust washers and secure with the capscrew and lockwasher and nut.
4. Connect the extend and retract hoses to the lift cylinder.
5. Activate the crane's hydraulic system and align the lift cylinder rod end with the attach point on the boom. Install the upper pivot shaft and any attached thrust washers through the cylinder and boom attach points. Shut down the engine.
6. Shim lift cylinder, as needed, using thrust washer(s) on each side.
7. Secure the upper pivot shaft with the capscrew and lockwasher and nut.
8. Remove the lifting and supporting devices from the boom and lift cylinder. Activate the hydraulic system and check the lift cylinder for proper operation and any leaks.
9. Lubricate the pivot shafts using grease fittings on cylinder. See *Lubrication*, page 8-1.



4

FIGURE 4-28

Item	Description
1	Cylinder
2	Shaft-Lower
3	Capscrew M18 X 190
4	Nut - M18
5	Shaft-Upper
6	Capscrew - M16 X 150
7	Lockwasher - M16
8	Nut - M16

Item	Description
9	Thrust Washer
10	Thrust Washer
11	Lockwasher
12	Capscrew - M20 X 25
13	Lockwasher - M20
14	Washer - M20
15	Capscrew -1/2 X 3/4
16	Lockwasher -1/2

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SECTION 5 HOIST AND COUNTERWEIGHT

SECTION CONTENTS

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DESCRIPTION

The NBT60 hoist is composed of motor control valve, a dual displacement hydraulic motor, multiple disc brakes, and a pair of planetary gear sets.

The multiple disc brake is spring applied and hydraulically released through a port in the brake housing. An overrunning clutch allows the hoist to be raised without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down.



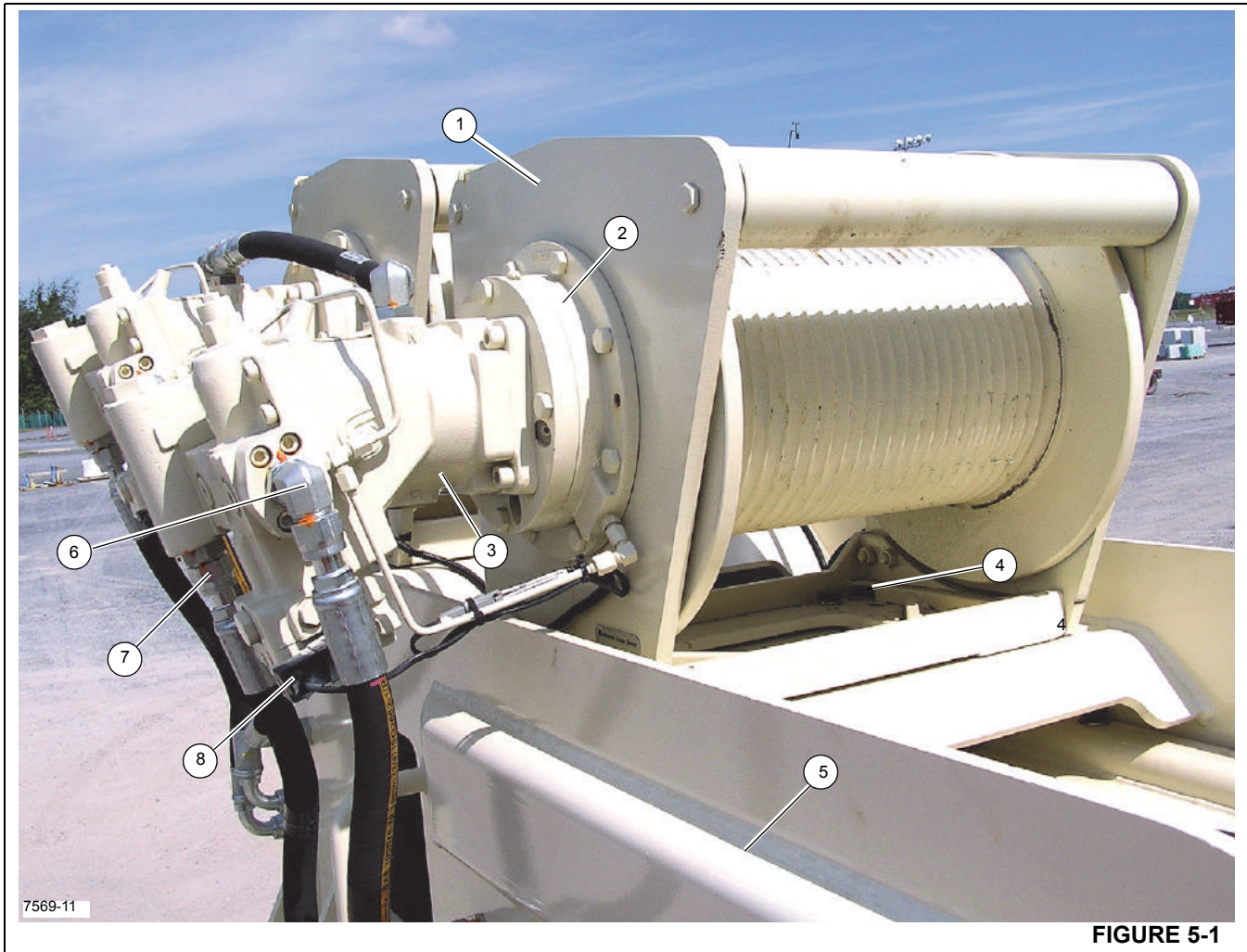


FIGURE 5-1

Figure 5-1 Item Numbers

Item	Component
1	Hoist
2	Brake
3	Motor

Item	Component
4	Mounting Bolts (8 places)
5	Turret
6	Lower Port
7	Raise Port
8	2 speed shift solenoid

Removal

DANGER

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

DANGER

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

CAUTION

The combined weight of the hoist and 137.6 m (450 ft) of wire rope is 499 kg (1100 lbs).

1. Turn Off the truck engine.
2. Remove the rotation indicator (DRI) cable (1, Figure 5-5) from the hoist drum.
3. Tag and disconnect the hoist hydraulic lines shown in Figure 5-1. Cap and plug all hoist hydraulic hose and motor openings.
4. Attach a lifting device to hoist and take up the slack.
5. Remove the mounting bolts (4), Figure 5-1 from the hoist.
6. Remove the hoist from the crane with the lifting device.

Hydraulic Hose

Inspect the hydraulic hoses for wear and damage; replace hoses or hose connectors as needed.

Hoist Installation

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

Reinstall the hydraulic hoses as per removal tags.

Warm-up Procedure

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


Run the crane at idle with the hoist control lever in neutral and allow sufficient time for the hydraulic system to warm up. Operate the hoist at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil and circulate lubricant through the planetary gear sets.

Hoist Rotation Indicator (HRI) Display System

The HRI Display consists of an LED display that indicates the direction the hoist(s) are rotating, pressure switches that monitor hydraulic pilot pressure, and a control module mounted in the cab. The HRI system also provides the operator with a touch indication of drum rotation so he will know if and at what speed the hoist drum is rotating, even under the most distracting conditions. (See "Drum Rotation Indicator" on page 5-4 DRI).

Pressure Switches

The pressure switches are located on the main control valve Figure 5-2. The switch contacts close at 75 psi (5.17 bar).



TYPICAL VIEW ONLY

8425-9

Item	Description
1	Main Hoist Down Switch
2	Auxiliary Hoist Down Switch
3	Auxiliary Hoist Up Switch
4	Main Hoist Up Switch

FIGURE 5-2

HRI Display

The HRI display is located in the console display panel. Reference the Controls and Operating procedures in Operator Manual.

HRI Control Module

The control module is located in the fuse and relay panel behind the driver's seat in the cab Figure 5-3.

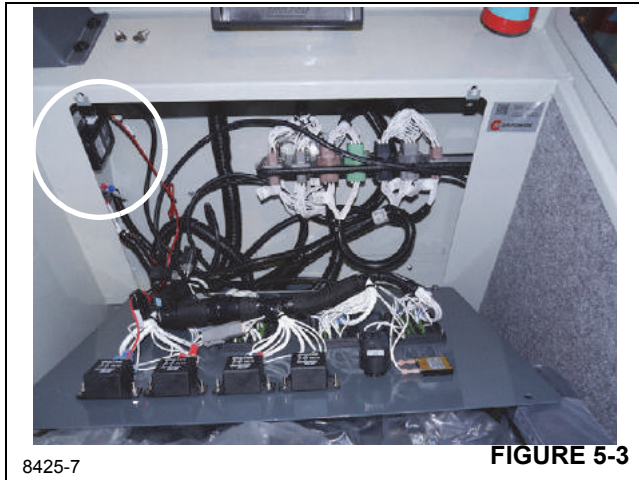
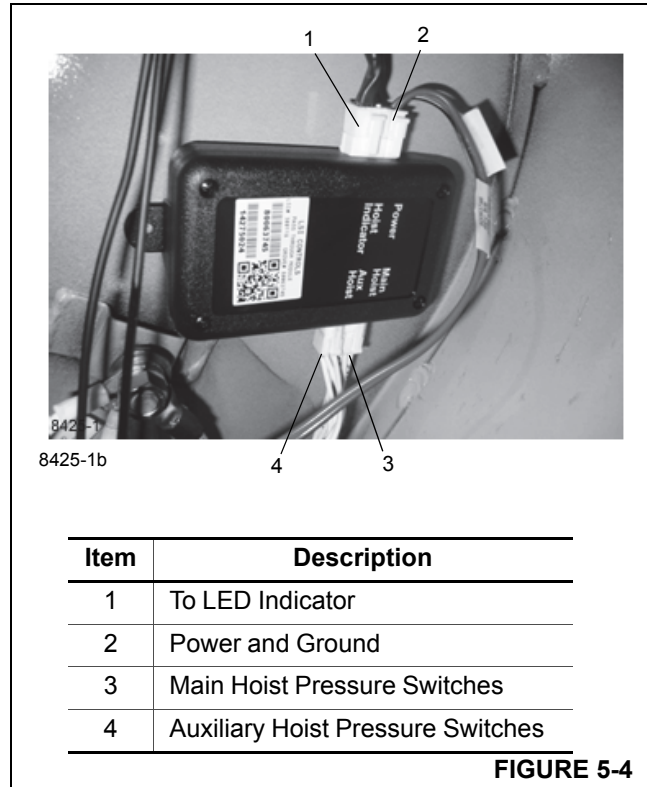


FIGURE 5-3

To replace the control module, tag and disconnect the wires from the module Figure 5-4. The module is mounted to the bulkhead using double-sided adhesive tape. To remove the module, pry it off the bulkhead. Remove any residual tape from the bulkhead. Secure the replacement module to the bulkhead with the foam tape. Connect the wires as tagged during removal.



Item	Description
1	To LED Indicator
2	Power and Ground
3	Main Hoist Pressure Switches
4	Auxiliary Hoist Pressure Switches

FIGURE 5-4

DRUM ROTATION INDICATOR

The Drum Rotation Indicator (DRI) and Minimum Wrap Indicator (MWI) are integrated into one Hoist Monitoring System (HMS) 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 seat.

The DRI transducer and integral Minimum Wrap Indicator (MWI) is programmed to notify the operator when there are three wraps of wire or synthetic rope left on the hoist drum.

The HMS is available with two systems, Series, "A" and Series "B". The HMS is available with a CAN J1939, (Series "B"), allowing the device to interface with the Rated Capacity Indicator (RCL) system.

Series "A" units can be distinguished by a single cable connection on the HMS, located on the left side of the hoist. Series "B" units have a second connection (CAN J1939) along with an integrated protection circuitry, acting as a circuit breaker, on the MWI and DRI (Thumper) outputs.

Removal

1. Loosen the collar on the connector and unplug the DRI cable (1, Figure 5-5).
2. Remove the two retaining screws (2).
3. Remove the DRI unit from the hoist.

- Loosen set screw and remove shaft assembly from MWI.

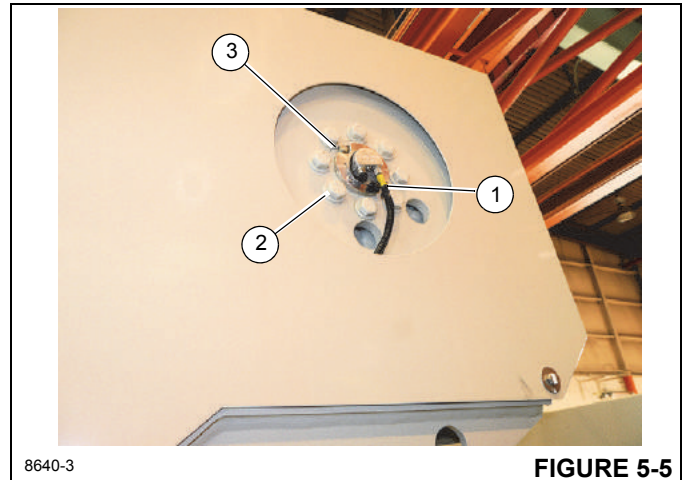


FIGURE 5-5

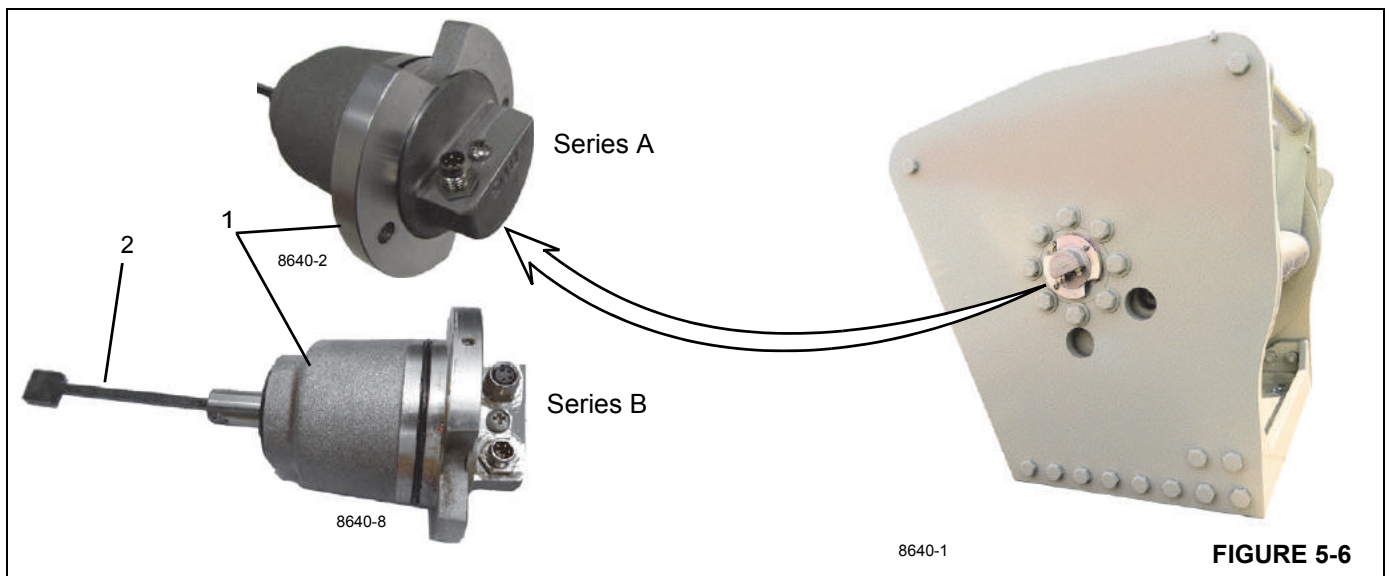


FIGURE 5-6

Installation

To install the DRI, use the following procedure:

- Install shaft assembly into MWI.
- Apply silicone sealant on the setscrew to prevent oil getting into electronics.
- Tighten setscrew.
- Insert the DRI into the drum. Rotate the DRI (1, Figure 5-6) so that the DRI shaft (2) engages the drive inside the drum.
- Push the DRI into the drum so that the notch is lined up with the breather (3, Figure 5-5).
- Secure the DRI with the retaining screws (2, Figure 5-5).
- Loosen the set screw (1, Figure 5-7) on the side of the DRI flange.
- Using the spanner wrench holes (2, Figure 5-7) rotate the DRI so that the connector (3) is pointed down.
- Tighten the set screw (1, Figure 5-7) after the DRI is positioned as desired.
- Plug in the DRI cable and tighten the collar to secure the connector.

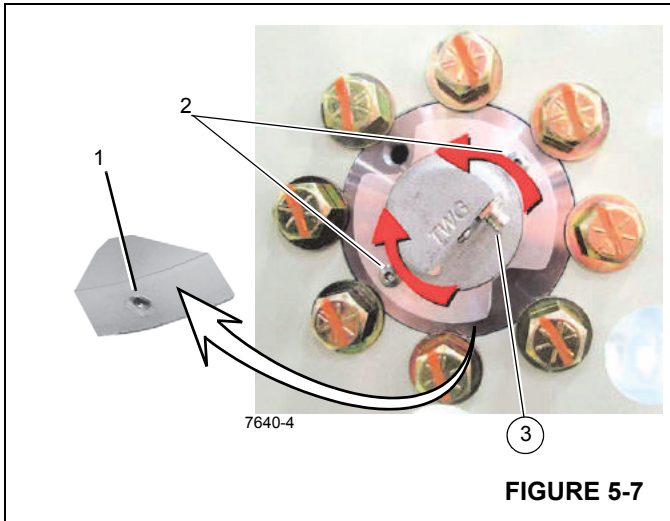


FIGURE 5-7

Programming the Minimum Wrap Indicator

The minimum wrap indicator (MWI) needs to be programmed to alert the operator when the cable is down to the third wrap of wire or synthetic hoist rope. To program the MWI you need to:

1. Run the hoist to the first set point, third wrap of wire or synthetic rope. This deactivates the alarm output.
2. Remove power from the MWI by disconnecting the DRI cable (2, Figure 5-8).
3. Remove the sealed Hoist Monitoring System (HMS) programming button cover screw (1, Figure 5-8) on the DRI.
4. Push and gently hold the programming button (3, Figure 5-8) and return power to the MWI by reconnecting the DRI cable.

NOTE: Use an Allen Wrench or other small tool with a flat, blunt end approximately 1.5mm or (1/16") in width and at least 76 mm (3") in length. Use of a pointed or sharp tool can cause faulty setting or damage to the HMS. Excess force can damage the HMS operation.

5. Hold the programming button for at least 2 seconds, but less than 15 seconds, after power is applied and release.

NOTE: Holding the button for longer than 15 seconds puts the HMS into Shipping Mode for Series A units. (See Figure 5-8). See Shipping Mode for more information.

6. Run the winch to the second set point.

NOTE: It is recommended to transition to the second layer as the second set point.

7. Gently press and hold the programming button for 1-2 seconds, then release.
 8. Replace the MWI/HMS programming screw. Tighten to 7 in-lbs.
- NOTE:** Failure to replace the programming screw (1, Figure 5-8) could effect the operation of the MWI.
9. The MWI setup routine is complete.

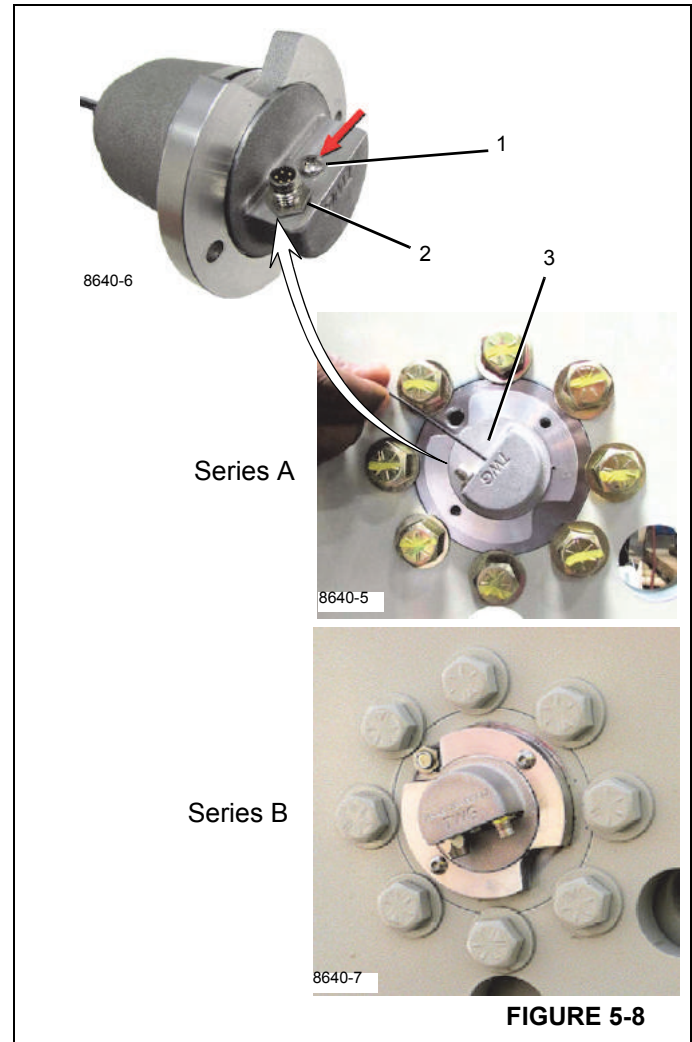


FIGURE 5-8

Shipping Mode (Series A Only)

If the programming button is held down for more than 15 seconds, the HMS will enter "Shipping Mode (Series A Only)." The HMS rapidly pulses the "Warning" output indicating the HMS is entering or exiting "Shipping Mode." While in "Shipping Mode", the HMS will pulse the "Warning" output two times with a 30 second pause.

Shipping Mode allows the OEM to set the set points on the cable before shipping to a job site. This prevents the need to recalibrate the set points when the winch is installed on the machine.

NOTE: The drum rotation indication, commonly a thumper handle, remains operational while the HMS is in shipping mode.

To use Shipping Mode:

1. Install the wire rope on the drum. Refer to the appropriate winch manual for more information.
2. See See “Programming the Minimum Wrap Indicator” on page 5-6 to set the end points.
3. Remove the programming button cover screw (1, Figure 5-8).
4. Press and gently hold the programming button for at least 15 seconds. The HMS rapidly pulses the “Warning” output to confirm the HMS has entered Shipping Mode. The set points remain saved in the HMS.

NOTE: Excess force can damage the programming button and affect MWI/HMS operation.

5. This allows the winch to rotate without the count or set points being disturbed.
6. When the winch is installed on the machine and the wire rope is installed to the same length as the original setup, press and hold the programming button for more than 15 seconds. The HMS rapidly pulses the "Warning" output to confirm the HMS is no longer in Shipping Mode.
7. The HMS is now ready for use.

TROUBLESHOOTING

For Series “A”

Check the in-line fuse used to protect the thumper line.

Series “B” Circuit Breaker Reset Instructions

Series “B”, units have integrated protection circuitry, acting as a circuit breaker on MWI and DRI outputs. If circuit breaker trips, remove power (turn OFF key switch or disconnect cable) and inspect load devices, (Thumper handles).

HOIST REPAIR

Disassembly

Refer to Figure 5-9 and the Hoist Parts List on page 5-9 to disassemble the hoist.

1. Drain the oil from the gearbox and brake sections using the instructions in the Operator’s Manual.
2. Stand the hoist on its end with the motor pointing up.

3. Disconnect the tubing (Item 22) connected to the brake housing (Item 21). Remove the motor and counterbalance valve assembly from the hoist by removing four capscrews (Item 47). See *Motor*, page 5-12 for motor and counterbalance valve disassembly.
4. Remove the brake subassembly from the hoist by removing eight capscrews (Item 9) holding the brake housing to the side plate (Item 27). Reinstall two of these capscrews into the two extra tapped holes and tighten them evenly until the brake housing comes loose from the side plate. See *Brake*, page 5-11 for brake repair.
5. Remove the side plate (Item 27) and base spacer (Item 60) by removing eleven capscrews (Items 1, 57, and 59) and two nuts (Item 58).
6. Remove the retaining ring (Item 52). Lift the ring gear (Item 25) out of the drum (Item 5). Remove the five pins (Item 51) as the ring gear is lifted out. Inspect the gear teeth in the ring gear for excessive wear and replace if necessary. Inspect the bearing (Item 28) for signs of pitting or spalling and if necessary, replace the bearing and seal (Item 7-6).
7. Remove the thrust washer (Item 6) and input sun gear (Item 8) from the input planet gear set (Item 36). Inspect for damage and replace if needed.
8. Remove the input planet gear set (Item 36) from the drum (Item 5). Inspect the gear set for damage.
9. Remove the thrust washer (Item 6) and output sun gear (Item 16). Inspect for damage and replace if needed.
10. Remove the output planet gear set (Item 4) from the cable drum. Inspect the gear set for wear and repair as needed. See *Planetary Set*, page 5-12 for disassembly and repair.
11. Remove the drum (Item 5) by lifting straight up and off of the output shaft (Item 32). Inspect the bearing (Item 28) for signs of spalling or pitting and, if necessary, replace the bearing and seal (Item 7-6).
12. Inspect the retaining ring (Item 35) on the output shaft to ensure that it is still in the groove and is not bent, and replace if necessary.
13. Inspect the shaft (Item 32) for wear or damage and, if necessary, remove it from the side plate (Item 29) by removing six capscrews (Item 9).

Assembly

Refer to Figure 5-9 and the Hoist Parts List on page 5-9 to disassemble the hoist.

1. Thoroughly clean all parts. Replace those that show wear or damage.
2. Inspect the drum (Item 5) for structural integrity and the gear teeth for excessive wear, then replace if necessary.

3. Attach the output shaft (Item 32) to the side plate (Item 29) with six capscrews (Item 9), making sure the vent (Item 30) is oriented properly. Torque to *Fasteners and Torque Values*, page 1-7 in this manual).
4. Install the retaining ring (Item 3) onto the shaft (Item 32).
5. Attach the spacer (Item 60), base (Item 56), and rod (Item 2) to the side plate (Item 29) with eleven capscrews (Items 1, 57, and 59) and two nuts (Item 58). Torque to *Fasteners and Torque Values*, page 1-7 in this manual).
6. If necessary, install a new bearing (Item 28) and oil seal (Item 7-6) into the drum.
7. Lay the unit down so that the rod (Item 2) and base (Item 56) are pointing up. Set the drum (Item 5) onto the shaft (Item 32) being careful not to damage the seal (Item 7-6), seating the drum on the bearing (Item 28).
8. Install the output planet gear set (Item 4) into the drum (Item 5), making sure it's installed correctly onto the output shaft (Item 32).
9. Put a light coating of grease on the thrust washer (Item 6) to keep it in place. Install the thrust washer into the output gear set (Item 4), and then insert the output sun gear (Item 16). The slot in the sun gear must be installed facing the output shaft.
10. Install the input planet gear set (Item 36) into the drum (Item 5), making sure it's installed correctly onto the output sun gear (Item 16).
11. Put a light coating of grease on the thrust washer (Item 6) to keep it in place. Install the thrust washer into the input gear set (Item 36), and then insert the input sun gear (Item 8).
12. Install a new O-ring (Item 7-4) and, if necessary, a new bearing (Item 28) and seal (Item 7-6) into the ring gear (Item 25). Grease the O-ring and seal and install the ring gear into the drum, making sure the pin holes are lined up.
13. Install five pins (Item 51) between the ring gear (Item 25) and the drum (Item 5). Then, install the retaining ring (Item 52) into the drum.
14. Position the spacer (Item 60) and side plate (Item 27) on top of the base (Item 56) and rod (Item 2). Attach the side plate with eleven capscrews (Items 1, 57, and 59) and two nuts (Item 58). Torque to *Fasteners and Torque Values*, page 1-7 in this manual).
15. Install the brake subassembly into the side plate (Item 27), making sure that the pilot of the brake housing aligns with the bearing (Item 28) and seal (Item 7-6) in the ring gear (Item 25) and that the holes for the motor are in the correct orientation. Also, make sure that the level and vent plugs in the cover are properly oriented. Install eight capscrews (Item 9). Torque to *Fasteners and Torque Values*, page 1-7 in this manual).
16. Install a new O-ring (Item 7-5) on the face of the motor and re-install the motor/counterbalance valve assembly. Install four capscrews (Item 9). Torque to *Fasteners and Torque Values*, page 1-7 in this manual).
17. Reconnect the tubing (Item 22) to the brake housing (Item 21).
18. Fill both the gearbox and the brake section with the proper amount and type of lubricants as recommended. See *Check Hoist Brake Oil*, page 8-8 of this manual.

Hoist Parts List

Item	Qty	Description	Item	Qty	Description
1	18	CAPSCREW	36-2	3	Planet Gear
2	2	Support rod	36-3	3	Planet Pin
3	1	Counterbalance Block	36-4	3	Retaining Ring
4	1	Gear Set	36-5	1	Plate
4-1	1	Carrier	36-6	3	Needle Bearing
4-2	3	Planet Gear	36-7	6	Fitting, Str Adapter
4-3	3	Planet Pin	37	1	Capscrew
4-4	3	Retaining Ring	38	4	Input Driver
4--5	1	Plate	39*	1	Bushing
4-6	6	Bearing	40	1	Pipe Plug
4-7	3	Spacer	42	2	Motor
4-8	6	Race	43	1	Straight Adapter
5	1	Drum	44	1	Tee Fitting
6	2	Race	45	1	90 deg Adapter
7	1	Seal Kit	46	1	90deg Adapter
8	1	Input Sun Gear	47	1	Capscrew
9	14	Capscrew	50	4	Flange
10	1	Brake Piston	51	1	Pin
11	4	Capscrew	52	5	Retaining Ring
12	1	Tubing	54	1	DRI/MWI
13	1	Brake Driver	56	1	Base
14	2	Race	57	1	Capscrew
15	2	Retaining Ring	58	4	Nut
16	1	Output Sun Gear	63	4	Screw
17	2	Bushing	64	2	Cord set
18	7	Friction Disk	65	1	Cable packer
19	8	Stator Plate	65-1	2	Bearing
20	1	Brake Cover	65-2	2	Arm
21	1	Brake Housing	65-3	1	Roller
22	1	Tubing	65-4	1	Roller
24	12	Brake Spring	65-5	2	Capscrew
25	1	Gear Insert	65-6	2	Ball Bearing
27	1	Side Plate	65-7	1	Spring, LH
28	2	Ball Bearing	65-8	1	Spring RH
29	1	Sideplate	68	1	CB Valve
30	2	Breather	76	1	Plug
31	4	Capscrew	81	1	Cord set, DRI/MWI
32	1	Output Shaft	82	1	Shaft, Drive, DRI
33	1	Plug	84	1	Roller
34	1	Clutch	85	2	Bushing
35	1	Retaining ring	86	1	Connector
36	1	Input Gear Set			
36-1	1	Carrier			

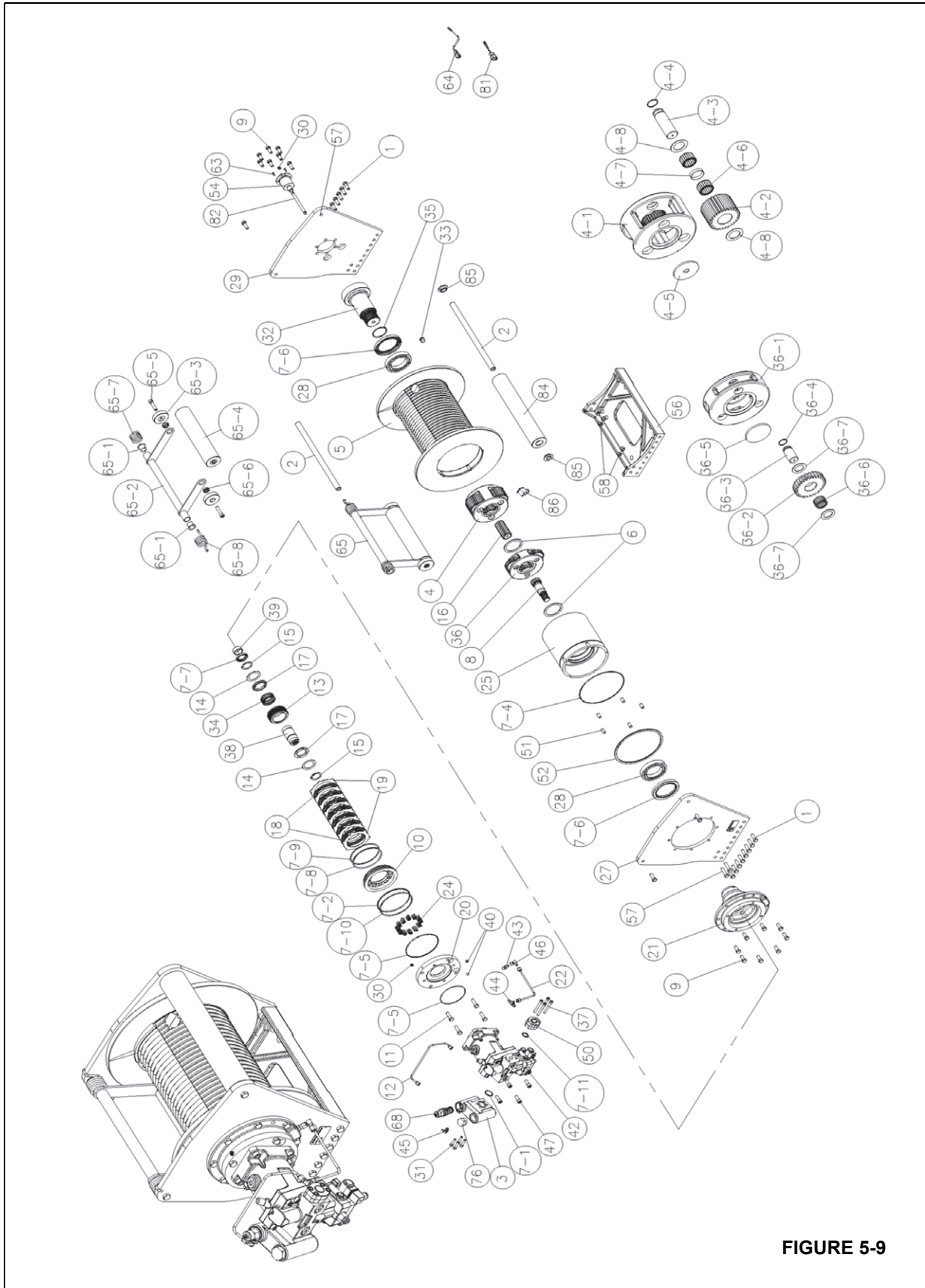


FIGURE 5-9

Brake

Refer to Figure 5-9 and the Hoist Parts List on page 5-9 for the following brake service steps.

1. Evenly remove the four capscrews (Item 11) holding the brake cover (Item 20) in place. Spring pressure will raise the cover as the capscrews are loosened. Remove the cover from the brake housing.
2. Remove the springs (Item 24) from the piston and check the free height. Each spring should measure at least 30 mm (1.2 in) with no force on them.
3. Remove the brake piston (Item 10) by installing two pieces of 3/8"-16NC all-thread in the bottom of two spring pockets. 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 a portable power unit or shop air to slowly pressurize the brake cavity until the piston is out of the bore.
4. Remove the brake driver/clutch assembly (Items 13, 14, 15, 17, 34, and 38) from the brake housing (Item 21).
5. Remove the brake driver/clutch assembly (Items 13, 14, 15, 17, 34, and 38) from the brake housing (Item 21).
6. Remove the stator plates (Item 19) and friction discs (Item 18) from the brake housing and check them for excessive wear, then replace if necessary. Additionally, check the top stator plate for scoring caused by the removal tools and polish if necessary. Friction discs should measure no less than 1.3 mm (0.055 in) thick and stator plates should measure no less than 1.6 mm (0.064 in) thick.
7. If necessary, with a hook wire or pry bar, remove the seal (Item 7-7) from the brake housing.
8. Examine the bushing (Item 39) in the brake housing for wear and if worn replace it.
9. If the brake housing (Item 21) is removed from the hoist, examine the journal on the brake housing where the seal (Item 7-6) runs for wear. If severely worn, replace the brake housing.
10. Carefully disassemble the brake driver/clutch and note the side in which the markings on the clutch (Item 34) are facing. The clutch assembly must be re-assembled with the markings facing the proper direction in order for the hoist to function properly. Inspect the surface on the input and brake drivers (Items 13 and 38) where the clutch (Item 34) runs. If there is any pitting or spalling on the drivers then both 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 (Item 7-7) into the brake housing. If the brake housing is removed from the hoist, temporarily install the input sun gear (Item 38) into the brake housing and slide the driver/clutch assembly onto the sun gear spline.
13. Install the stator plates (Item 19) and friction discs (Item 18) into the brake housing. Alternate installing the stator plates and friction discs, beginning with the stator plates. There is one more stator plate than friction disc so you will finish with a stator plate.
14. After installation, check the brake stack-up to make sure that the dimensions are within the tolerance shown in Figure 5-10. 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 O-rings and backup rings (Items 7-3, 7-7, 7-8, and 7-9) with light oil and install onto the piston (Item 10). See Figure 5-10 for proper O-ring/backup ring installation.

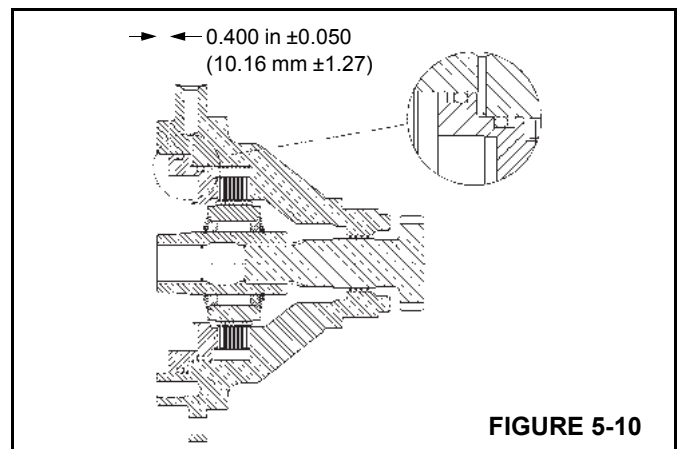


FIGURE 5-10

16. Carefully install the piston (Item 10) into the brake housing (Item 21) and gently tap it down until it is seated.
17. Install the springs (Item 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 (Item 7-3) with light oil and install it into the groove on the brake cover (Item 20).
19. Install the cover (Item 20) onto the brake housing (Item 21) and draw it down evenly, alternating between opposite capscrews. Make sure that the cover is aligned properly with the brake housing in order to correctly orient the motor and vent/drain plugs.
20. Check the brake release with a portable hydraulic pump. Full release should be obtained at 15.5 Nm (225 psi) $\pm 10\%$.

Planetary Set

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

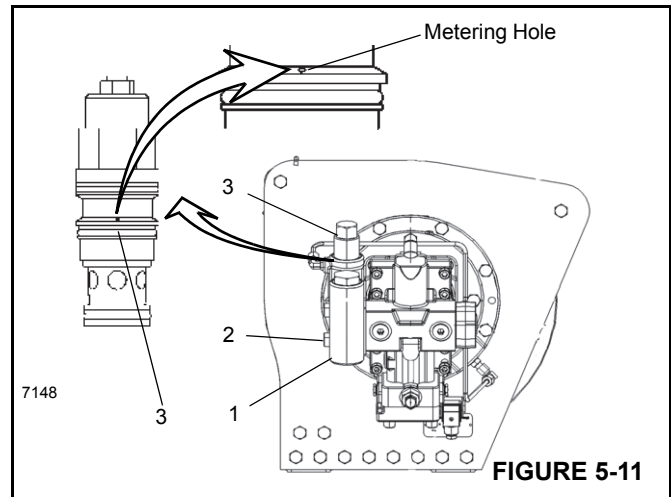
1. Remove the spiral retaining rings (4-4, 36-4) from the planet pins.
2. Remove the pins (4-3, 36-3) from the carrier by carefully tapping them out.
3. Remove the planet gears, thrust washers and bearings from the carriers.
4. Inspect the pins, bearings, and gear bores for evidence of wear and replace if necessary.
5. On output planet sets, note that two bearings (4-6) with a spacer (4-7) between them are used.
6. Before reassembly, be sure to insert the round plates into the carriers (4-5, 36-5).
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

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 (1) from the motor assembly (Figure 5-11).
2. To remove the counterbalance block (1), loosen and remove the four capscrews (2).
3. Remove the counterbalance valve (3) from the counterbalance block (1) and inspect the small metering hole located on the side of the cartridge valve to make sure it is not obstructed. 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 distributor for service.



TROUBLESHOOTING

Problem	Cause	Corrective Action
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 improperly hooked up 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 that caused the shaft seal to fail. Service the brake section and replace worn parts.

COUNTERWEIGHT CYLINDER

Removal

1. Stow the counterweight; refer to *Stowing the Counterweight* in *Section 4* of your *Operator's Manual*.
2. Fully retract the counterweight cylinder.
3. Tag and disconnect the two hydraulic hoses at the cylinder; cap and plug all openings.

NOTE: Counterweight cylinder weighs 38.5 kg (85 lb).

4. Attach an adequate lifting device and sling to the cylinder; remove the slack from the sling.
5. Remove the four capscrews securing cylinder to superstructure and remove the cylinder.

Installation

NOTE: Counterweight cylinder weighs 38.5 kg (85 lb).

1. Using an adequate lifting device and sling, lift and position the cylinder on top of the superstructure. Ensure steel hydraulic tube on side of cylinder is facing toward the superstructure.
2. Secure cylinder to superstructure with four capscrews after applying thread locking compound (Specification 6829012418) to the bolts' threads. Torque bolts; refer to *Fasteners and Torque Values*, page 1-7 for proper torque value.
3. Connect the two hydraulic hoses to cylinder as tagged during removal.
4. Extend and retract the cylinder to ensure it operates properly and there are no leaks.

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SECTION 6 SWING

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DESCRIPTION

The purpose of the swing system is to allow the crane turret to rotate atop the carrier frame. The NBT60 swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. With free swing and the swing brake switch in the OFF position, the turret swings freely after the swing control lever is released and coasts to a stop.

NOTE: When equipped with a radio remote control, the swing brake is automatically applied whenever the swing control lever is in the neutral position.

The swing system consists of a electronic remote controller, directional control valve, swing drive gearbox, swing motor, swing brake, and swing brake pedal. The maximum rotation is 2.0 rpm. The swing control lever is used to slow and stop the swing by moving the control lever to the opposite direction of the swing. The swing brake pedal is used to keep the turret parked in position.

THEORY OF OPERATION

Swing Drive

The hydraulic power for the swing drive (Figure 6-1) is supplied by the PTO driven axial piston hydraulic pump. Oil flows from the pump, through swivel port #3, to the directional control valve.

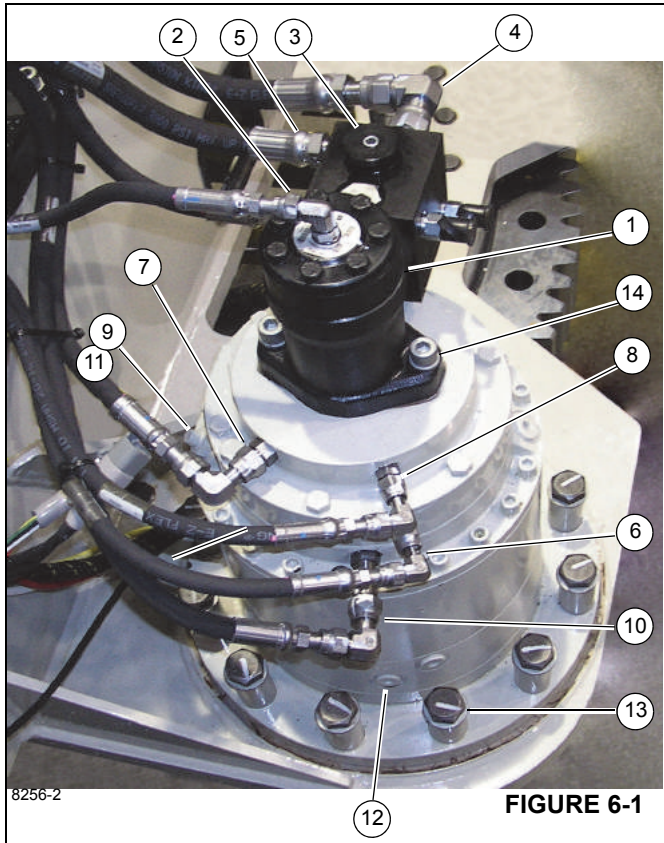
When the electronic remote control is positioned to select right or left swing, the flow through the control valve is directed to the swing motor. If the swing brake selector switch is in the OFF position, the turret rotates in the desired direction. Shifting the control to neutral allows the turret to coast to a stop. Shifting the control to the opposite directions powers the turret to a stop. Depressing the swing brake pedal holds the turret in position.

Swing Brake

Hydraulic power for the swing brake control is supplied by the directional control valve and swing brake pedal. Pressing the Swing Brake Release Switch activates a solenoid and releases the spring applied swing brake and permits the crane to swing. The swing brake is applied dynamically using the pedal on the cab floor. The brake can also be applied using the Swing Brake Control Switch. Refer to the Operator's Manual for a description of the Swing Control Switch.



Figure 6-1 Item List



Item	Description	Item	Description
1	Motor	8	Brake Apply
2	Case Drain	9	Breather
3	Adjustable Speed Valve	10	Brake Coolant In
4	Control Counter-Clockwise	11	Oil Fill/Vent
5	Control Clockwise	12	Oil Drain
6	Brake Release	13	Screw and Flatwasher, 3/4"
7	Brake Coolant Out	14	Screw and Lockwasher, 1/2"

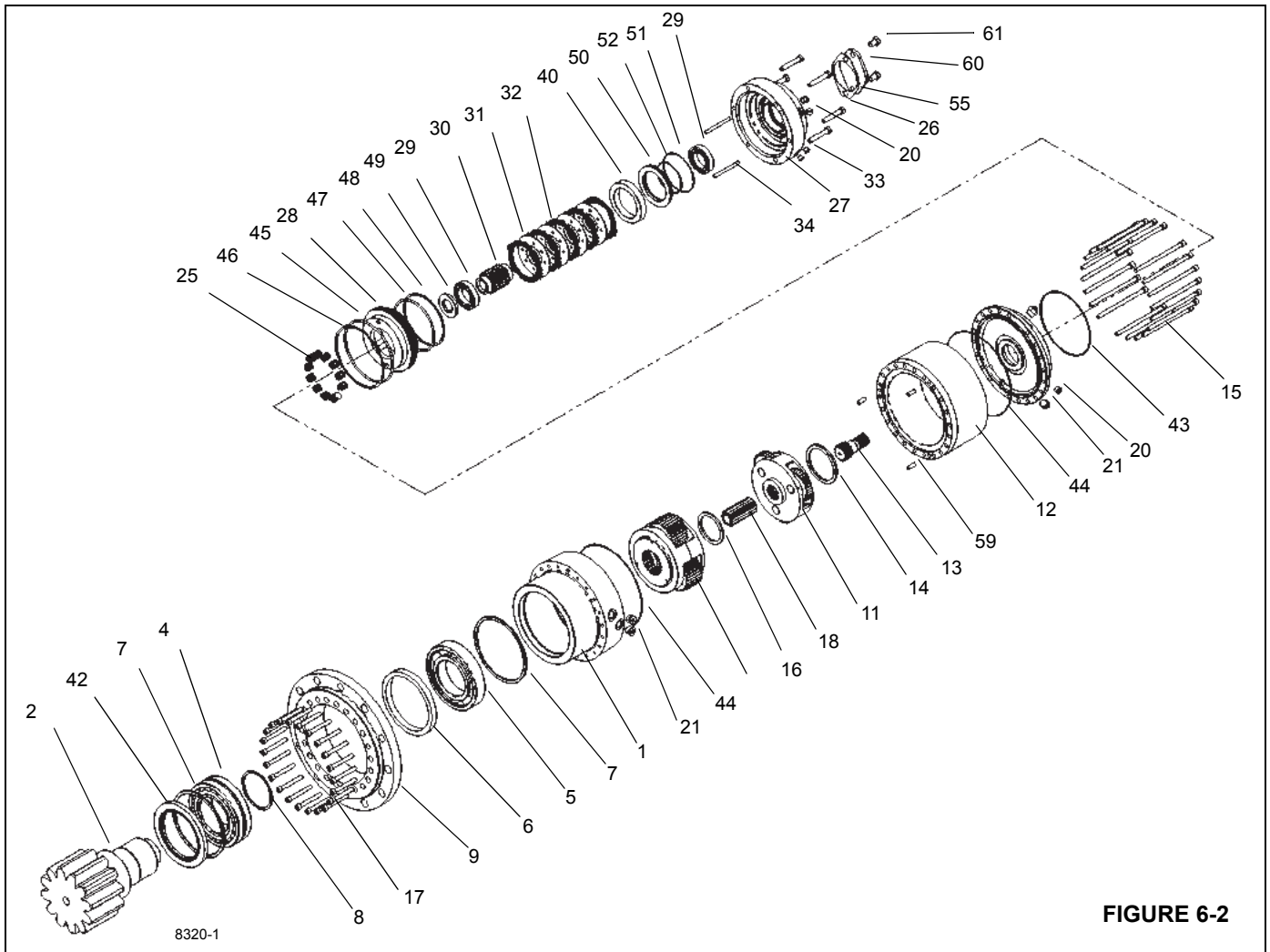


FIGURE 6-2

Item	Component
1	Housing
2	Shaft, Output
4	Bearing, Spherical
5	Bearing, Ball
6	Spacer, Bearing
7	Ring, Retaining
8	Ring, Retaining
9	Flange
10	Carrier Assembly-Secondary Ser-21T/ 6.4:1
11	Carrier Assembly-Planetary - Pri 6.4:1
12	Ring Gear
13	Gear, Sun
14	Washer-Nylon Thrust
15	Capscrew
16	Washer-Nylon Thrust
17	Capscrew
18	Gear, Sun - Sec- 15T/10P-D
19	Adapter, Brake
20	Plug, Socket Head, O-ring
21	Plug, O-ring
23	Shim
24	Breather
25	Spring
26	Capscrew - Hex Head
27	Housing, Brake
28	Piston, Brake
29	Bearing Ball
30	Shaft, Brake
31	Disc, Friction

Item	Component
32	Plate, Drive - Brake
33	Plug, O-ring
34	Pin, Dowel
36	Adapter
37	Pin, Roll
38	O-ring
40	Spacer, Brake
42	Seal
43	O-ring
44	O-ring
45	O-ring
46	Ring, Backup
47	O-ring
48	Ring, Backup
49	Seal
50	Piston, Glide-Swing
51	O-ring
52	O-ring
53	Lockwasher
54	Protector/Dust Cover
55	Gasket
56	Caplug
57	Capscrew
58	Washer
59	Pin
60	Cover
61	Capscrew, Hex Head
62	Brake Sub-Assembly

Swing Gearbox and Brake

The planetary gearbox is a hydraulically driven 2-stage planetary gearbox designed to use a motor with SAE "A" 2-capscrew mount and 1.00" 6B spline shaft. This gearbox has a total ratio of 41:1.

The gearbox is designed to utilize a hydraulic motor, driving through a multiple-disc static oil brake, into a pair of planetary gear sets to the output pinion.

The multiple-disc oil bath static park brake is spring applied and hydraulically released through a port in the brake housing. The multiple-disc service brake is hydraulically applied through a port in the brake housing.

During operation, dual counterbalance valves are used for dynamic braking to prevent the gearbox from moving faster than desired. These counterbalance/brake valves partially block the main line from the motor back to the directional control valve, allowing only a limited amount of hydraulic fluid through the motor. The counterbalance valves are generally internally modulated by sensing pressure on the supply line. Additionally, any time there is sufficient pressure to modulate the counterbalance valves; this same pressure releases the static friction/stator style park brake.

The rotation drive is a double planetary gear reducer with an integral brake. The gear reducer is designed to give long life in heavy duty applications such as crane rotation. The gearbox incorporates tapered roller bearings on the output shaft and heavy duty bearings in the planet gears.

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

The planetary gearbox is equipped with a spring applied hydraulically released static park brake and an optional integral hydraulically applied dynamic service brake. The park brake on this unit should full release by pressurizing the "BR" port to 20.6 bar (300 psi). The maximum pressure allowed into the park brake is 206 bar (3,000 psi). The service brake is applied by pressurizing the "BA" port while pressurizing the "BR" port. The maximum pressure allowed into the service brake port is 68.9 bar (1,000 psi). The service brake is cooled using a flow-thru cooling method by plumbing hydraulic oil into "BC IN" port and plumbing "BC OUT" port back to tank. The maximum pressure allowed in the brake cavity (flow thru cooling circuit) is 1.7 bar (25 psi). Excessive pressure in the flow thru cooling circuit could damage the oil seal separating the brake oil from the gearbox oil.

Oil Change

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

1000 hours or 6 months of usage. Gearbox oil is drained by removing the drain plug and vent (See *Figure 6-1*).

1. Examine the used oil for signs of significant metal deposits and then dispose of it in a proper manner.
2. Replace the drain plug.
3. Fill the swing drive with the appropriate amount and type of oil and then replace plug and vent. See *Lubrication*, page 8-1 of this manual for the recommended oil type, amount and grade for your application.

Gearbox oil level inspection is achieved by removing the gearbox fill/vent plug and visually inspecting the oil level. Maximum oil level is to be 1" below the port for this gearbox.

Disassembly and Assembly Instructions

If the rotation drive needs to be repaired, use the following procedure for disassembly. (See *Figure 6-1*)

1. Remove the gearbox from the crane by securing the boom.
2. Tag and disconnect hydraulic hoses connecting the gearbox to the crane.
3. Remove the 12 mounting capscrews.

NOTE: The weight of the rotation gearbox with integral brake and a hydraulic motor bolted on the input end of the assembly is approximately 135 kg (298 lbs).

Tools Required

- Scribe or small punch
- Oil drain pan
- Eye bolts, 1/4 in
- Retaining ring pliers
- Gear puller
- Ratchet wrench (1/2 in drive)
- 9/16 in socket (1/2 in drive)
- Soft hammer (brass or plastic)
- Press
- Drift rod 6.3 mm to 9.5 mm (1/4 to 3/8 in diameter)
- Torque wrench [1/2 in drive - approximately 135 Nm (100 ft-lb)]

Parts Required to Rebuild

- Seals
- O-rings
- Back-up rings

- Parts to replace damaged or worn parts
- Locknut (9) and lockwasher (8)

Disassembly

(See Figure 6-2 for reference numbers.)

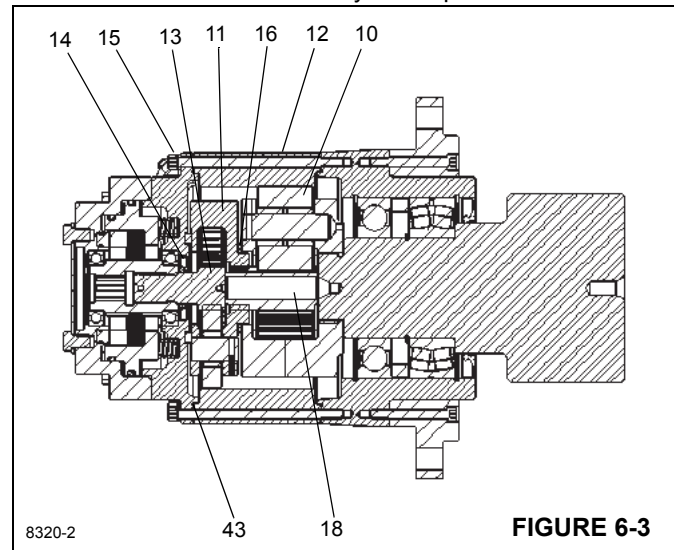
1. With a scribe or small punch make a set of marks on the brake assembly flange (27) and the top edge of the gear housing (1) to aid in reassembly.
2. Label and disconnect all hoses attached to the gearbox.
3. Remove both drain plugs (21) and drain the oil from the unit. Drainage is facilitated when the oil is warm.
4. Remove the hydraulic motor by removing the 2 capscrews in the motor flange.
5. Remove the brake assembly from the gearbox by removing the 20 capscrews (15). Refer to (Figure 6-3).

NOTE: Notice the orientation of the ports in relation to the drain and fill holes for reassembly.

If necessary, screw the hydraulic motor capscrews into the brake assembly for use as handles. Refer to *Servicing the Brake*, page 6-7 for brake service or repair.

6. Inspect the O-ring (43) for damage and replace if necessary.
7. Remove the nylon thrust washer (14) and sun gear (13) from the input planetary set (11). Inspect for wear or damage and replace if needed.
8. Remove input planet gear assembly by pulling straight up and out of the ring gear (12). See *Planetary Gear Set*, page 6-8 for disassembly and repair.
9. Remove the nylon thrust washer (16) and sun gear (18) from the output planetary gear set (10). Inspect for wear or damage and replace if needed.
10. Using the eyebolt/chain method, remove output planet gear assembly by pulling straight up and out of the ring gear (12). See *Planetary Gear Set*, page 6-8 for disassembly and repair.

11. To service the pinion gear or pinion bearings see *Servicing the Bearing and Pinion*, page 6-8 section in this manual for disassembly and repair.



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.

Assembly

(See Figure 6-2 for reference numbers.)

1. After servicing, inspecting and or repairing the Brake, Pinion Bearing and or the Planetary Gear sub-assemblies, start reassembly by positioning the Bearing/Pinion section in a pinion down orientation.
2. Install new O-ring (43) onto ring gear pilot on top of bearing housing (1).
3. Install the ring gear (12) onto the bearing housing making sure to align dowel pins with the appropriate dowel pin hole. Using a dead blow hammer tap ring gear into position.
4. Insert the output planetary gearset (10) into the ring gear making sure that it fully engages the splines on the output pinion shaft (2).
5. Install output sun gear (18) into output planet set (10).
6. Place and center nylon thrust washer (16) on top of output planet set (10).
7. With nylon washer in place install the input planet set (11) into the ring gear making sure it fully engages the teeth on the output sun gear (18).
8. Insert the input sun gear (13) into the input gear set (11). Turn sun gear by hand to ensure the gearing rotates and is not bound up.

9. Place and center nylon thrust washer (14) onto input planet set (11).
10. Lubricate and install a new O-ring (43) onto brake housing (19).
11. Check and align proper port orientation as marked during disassembly and install the brake section sub-assembly onto ring gear (12) and input sun gear (13).
12. Install the 20 ring gear capscrews (15) and washers (53), and tighten as defined in *Fasteners and Torque Values*, page 1-7.

Servicing the Brake

(See Figure 6-4 for reference numbers.)

1. Evenly remove the six capscrews (26) attaching the brake housing (27) to the brake adapter (19). Spring pressure will raise the brake housing as the capscrews are loosened. Remove the brake housing from the brake adapter.
2. Remove the piston (28) from the brake housing (27) by applying shop air to the "BR" port.

WARNING

Use caution to avoid sudden release of components when applying compressed air which could result in damage to the assembly and possible injury or death to personnel.

3. Remove the brake shaft (30), friction disc's (31), stator plates (32) and bearings (29) from brake housing (27).
4. Using a bearing puller remove the bearings (29) from the brake shaft (30).
5. Remove the friction disc's (31) and stator plates (32) from brake shaft (30) and check them for excessive wear, then replace if necessary.

NOTE: Friction discs should measure no less than 1.9 mm (0.075 in) thick and stator plates should measure no less than 1.1 mm (0.045 in) thick.

6. Remove the spacer (Item 40).
7. If equipped with a Service Brake, remove the service brake piston by applying shop air to the "BA" port.

WARNING

Use caution to avoid sudden release of components when applying compressed air which could result in damage to the crane and possible injury or death to personnel.

8. Remove and inspect all brake springs (25) and shims (23) for damage and replace if necessary.

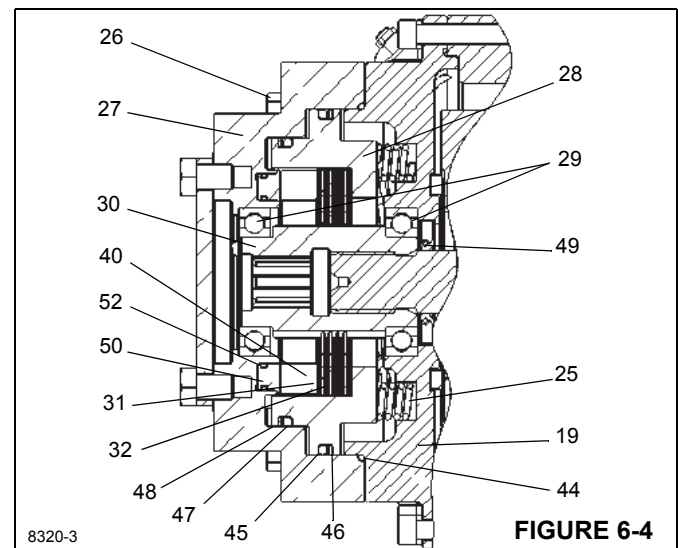
9. Press or tap the oil seal (49) out of brake adapter (19) noting the orientation of the sealing lip. Using proper tooling, carefully replace the oil seal (49).
10. If equipped, install a new O-ring (51) onto the outside diameter of the service brake piston and a new O-ring (52) into the inside diameter of the service brake piston. Lubricate the O-rings and install the piston into the brake housing (27).
11. Install a new bearing (29) into the brake adapter (19).
12. Reinstall the brake springs (25) and shims (23) into the spring pockets in brake adapter (19).
13. Tap or press the brake shaft (30) into the bearing in the brake adapter (19).

NOTE: The 6 tooth spline should be oriented to engage with the hydraulic motor.

14. Next install the O-ring (44) onto the brake adapter (19) and small O-ring (38) into counter-bored port in the brake adapter (19).

15. Install the O-ring and backup rings (45, 46, 47 and 48) onto the outside diameter of the piston.

NOTE: The rectangular backup rings should be located on the outsides of the O-rings as shown in (Figure 6-4). Lubricate the O-ring and backup rings and place the piston onto the springs centering the piston in the brake adapter.



16. Next install the friction discs (31) and stator plates (32) into the piston over the brake shaft (30).

NOTE: You will start with a friction disc and end with a friction disc.

17. Place the spacer (40) into the piston on top of the friction/stator pack.

18. Carefully place brake housing assembly onto piston making sure to orient the motor mount capscrews and all ports properly. Tap brake housing down until it makes contact with the springs.
19. Install the six capscrews (26) thru the brake housing into the brake adapter (19) and evenly tighten the capscrews to draw the brake housing down onto the springs to prevent damaging the O-ring and backup rings on piston.
20. Torque the capscrews to the proper specification. See the Torque Chart located on *Fasteners and Torque Values*, page 1-7 of this manual.

Servicing the Bearing and Pinion

1. Remove the gearbox from the vehicle by removing the capscrews in the mounting flange (9).
2. Remove the brake sub-assembly, gear sets (10 and 11), and ring gear (12) from unit by removing the twenty ring gear capscrews (15) and washers (53). Note or mark the orientation of the brake housing in relation to the gearbox oil drain port located in the bearing housing (1) for re-assembly.
3. Pry the oil seal (42) out of the bearing housing (1) and using tin snips cut the seal and remove it from the output pinion gear (2).
4. Remove the retaining ring (7) from the bearing housing (1).
5. Secure the bearing housing assembly and press the pinion gear (2), spherical bearing (4), retaining ring (8) and spacer (6) out of the bearing housing (1).
6. Remove the retaining ring (7) from bearing housing.
7. Tap or press the ball bearing (5) out of the bearing housing.
8. Clean and inspect all parts and hardware for damage or wear and replace if necessary.
9. For re-assembly of the bearing and pinion section the distance of the mounting flange to the end of the pinion must be maintained while pressing the new bearings

into the housing. For this unit the dimension is 181 mm (7.150 in). For reference see Figure 6-5.

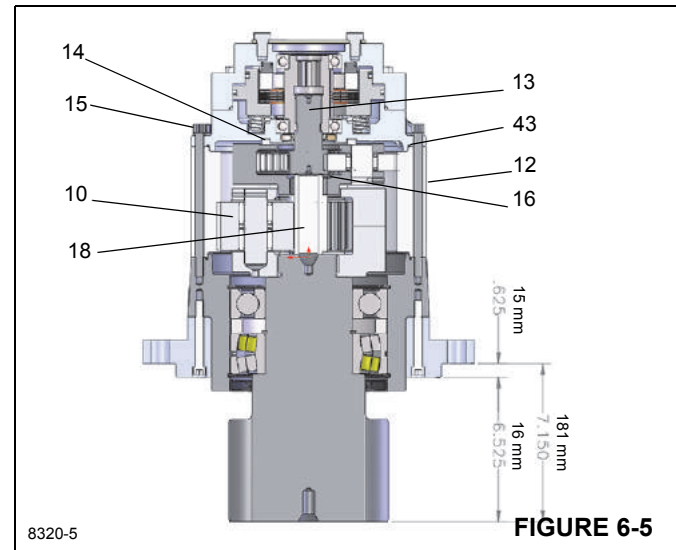


FIGURE 6-5

10. Install outboard retaining ring (7) into bearing housing.
11. Install new oil seal (42) into bearing housing (1).
12. Carefully place bearing housing assembly onto pinion shaft making sure to have the appropriate spacers in place to achieve the 181 mm (7.150 in) dimensions, shown in Figure 6-5.
13. Using appropriate press tooling, install and press the spherical roller bearing (4) into the housing.
14. Install retaining ring (8) onto pinion shaft making sure it is seated properly in groove.
15. Next insert bearing spacer (Item 6) into housing.
16. Using proper tooling press, press the ball bearing (5) into the housing.
17. Install inboard retaining ring (7) into the housing.
18. Check sub-assembly to ensure the pinion rotates freely.

Planetary Gear Set

The planetary gear sets (Items 10 and 11) are not serviceable in the field and must be replaced as a unit. Inspect for any damage or wear and replace if necessary.

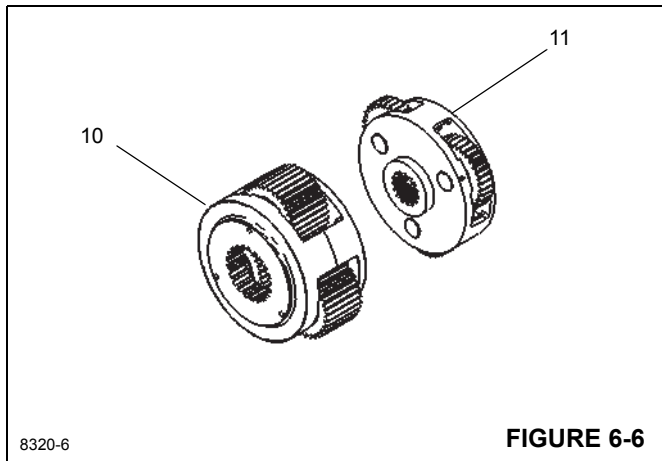


FIGURE 6-6

Troubleshooting

Symptom	Possible Cause(s)	Corrective Action
Gearbox brake will not hold	<ol style="list-style-type: none"> 1. The brake discs and or stator plates are worn 2. Broken dowel pins in brake piston 3. Mechanical failure 4. Weak or damaged brake springs 	<ol style="list-style-type: none"> 1. Check and replace, the friction discs should measure no less than 1.9 mm (0.075 in) thick and the stator plates should measure at least 1.1 mm (0.045 in) thick 2. Check and replace 3. Evaluate all parts that transmit torque to ensure structural integrity and replace any parts that show signs of damage or excessive wear 4. Check and replace, the free length of springs should be 2.5 mm (1 in)
Gearbox unable to rotate	<ol style="list-style-type: none"> 1. Motor failure 2. Gearing failure 3. Counterbalance cartridge may have a plugged metering hole 	<ol style="list-style-type: none"> 1. Remove motor and rotate both directions verify pressure rotating in both directions 2. See Servicing the Planetary Gear Set 3. Remove the counterbalance cartridge valve and inspect/clean metering holes
Oil leaks from vent	<ol style="list-style-type: none"> 1. The brake piston O-rings may have failed 2. Hydraulic motor shaft seal failure 3. Gearbox is overfilled with oil 4. Brake oil seal failure 	<ol style="list-style-type: none"> 1. Service the brake section and replace any worn or damaged parts and O-rings 2. Return to authorized distributor for service 3. Maintain proper oil amount 4. Inspect and replace oil seal

the dynamic brake piston which reapplies pressure to the brake discs.

SWING BRAKE

The brake is manufactured for two specific types of holding torque requirements. The brake has a “park” mode and is also set up to operate in a “glide-swing” mode. The brake is in the park mode until pressure is applied to one side of the piston in the brake assembly. As the pressure increases the spring force keeping the brake applied is overcome and the brake is released. Once the brake is released, the crane is free to rotate. Rotation is controlled by applying pressure on

SWING BEARING

Description

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

MAINTENANCE

General

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

Torquing Swing Bearing Bolts

General



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

Maintaining the proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the turret from the carrier. Refer to *Fasteners and Torque Values*, page 1-7 for information on the use of a torque wrench and torque values for fasteners.

CAUTION

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

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8), 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.

If it is reported by the crane operator or suspected that the crane has been overloaded beyond the capacities specified above the bold line on the cranes' capacity chart, then all swing bearing bolts must be inspected for looseness and re-torqued to specifications.

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

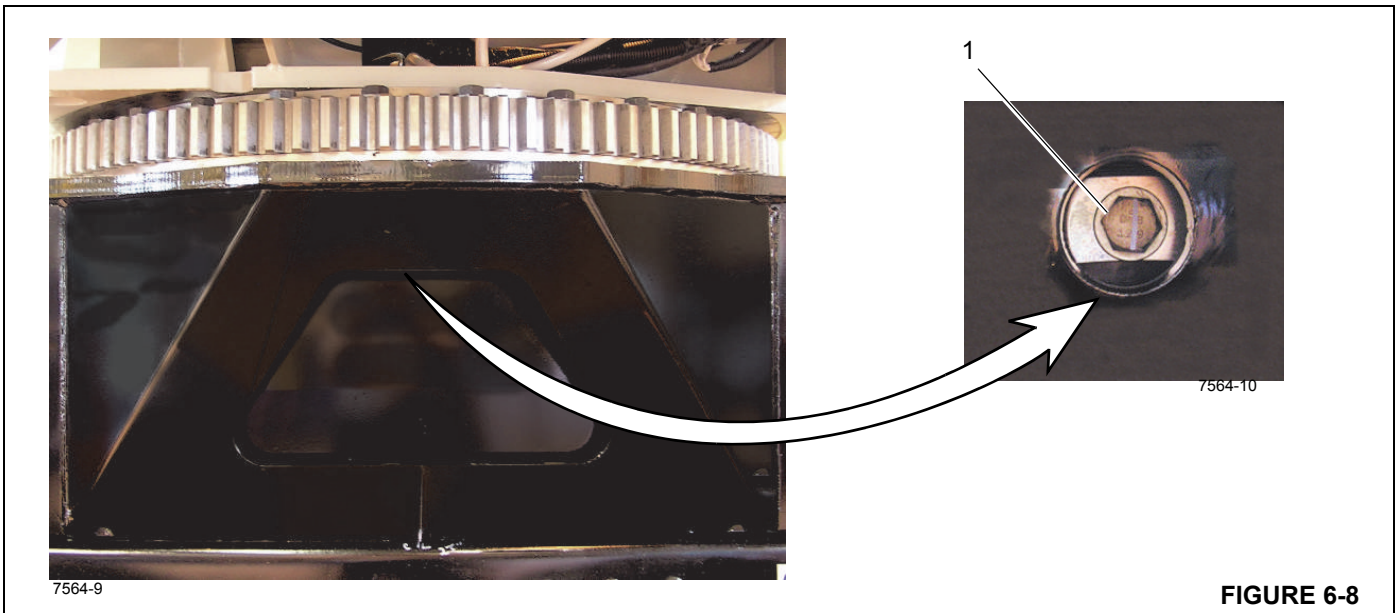
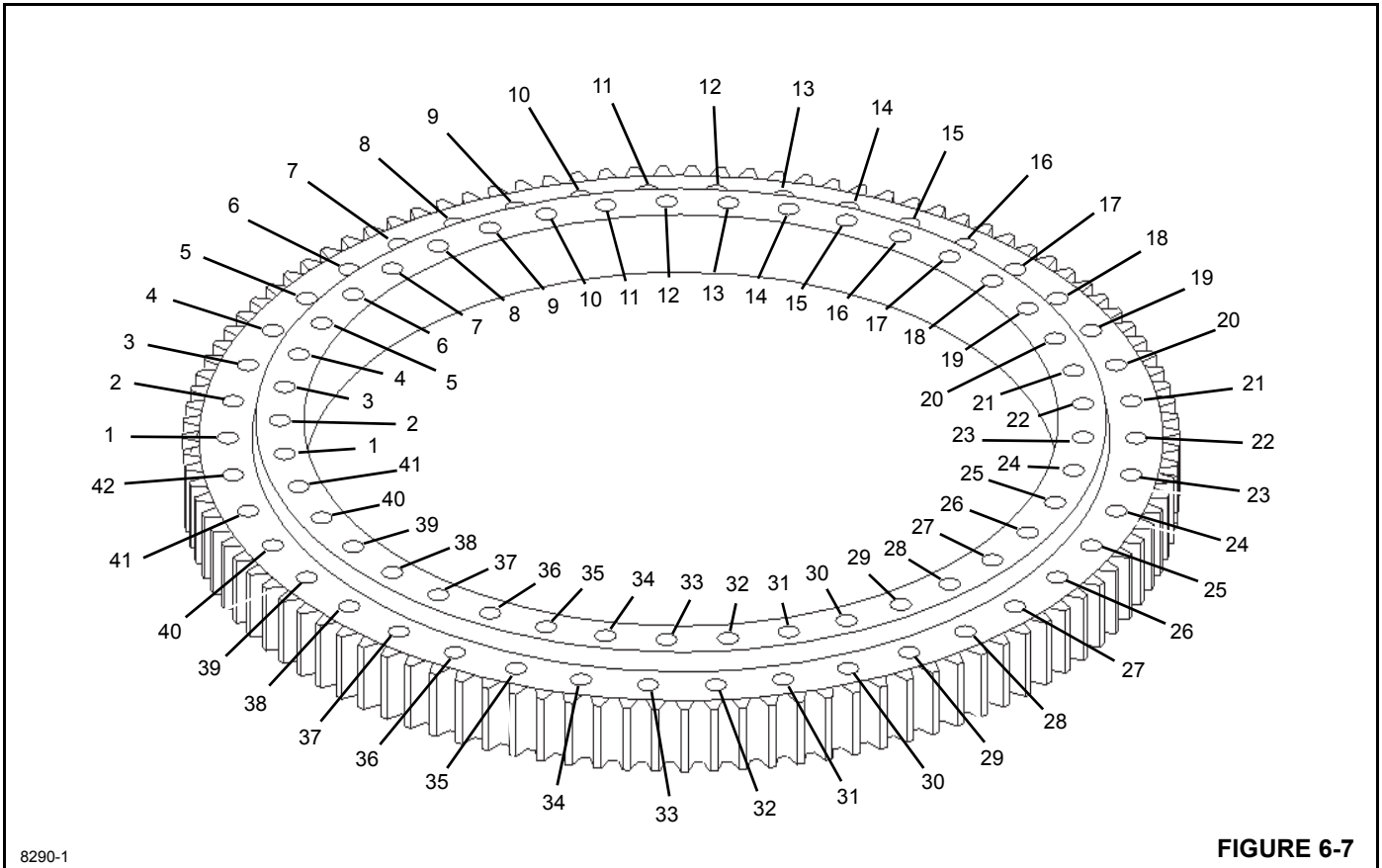
Swing Bearing Bolts

The inner race of the bearing is secured to the turret by 41 grade 8 bolts, HHCS 1.25-7 UNC x 6.5 (Figure 6-7). The outer race of the bearing is secured to the carrier frame by 42 grade 8 bolts, HHCS 1.25-7 UNC x 6.5 (Figure 6-7).

Inner Race Torquing

The inner race bolts (1, Figure 6-8) can be accessed through the access holes underneath the bed.

1. Extend and set the outriggers. Fully elevate the boom.
2. Torque eight bolts (Figure 6-7) to 80% of their specified torque value using the following sequence pattern; 1, 21, 11, 31, 6, 26, 16, and 36; refer to *Fasteners and Torque Values*, page 1-7 for proper torque value. 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 their final torque value specified. The same tools are used as in step 1.



Outer Race Torquing

The outer race bolts (1) are located on top of the bearing (Figure 6-9).

1. Extend and set the outriggers. Fully elevate the boom.

Torque eight bolts (Figure 6-7) to 80% of their specified torque value using the following sequence pattern; 1, 21, 11, 31, 6, 26, 16, and 36; refer to *Fasteners and Torque Values*, page 1-7 for proper torque value. Tools used are

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

2. Return to bolt 1 and torque all bolts sequentially in a clockwise direction to their final torque value specified. The same tools are used as in step 1.

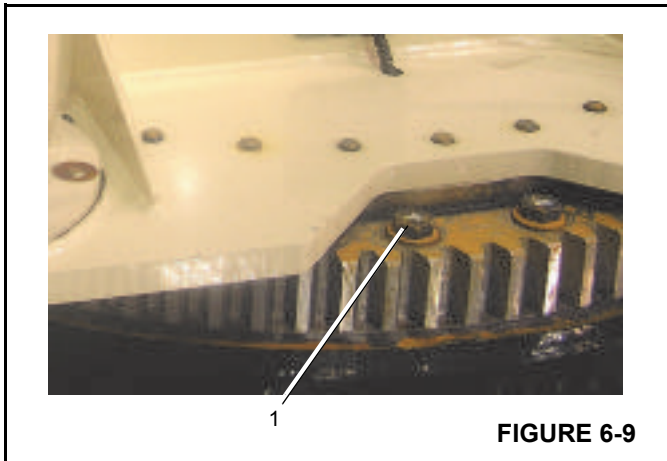


FIGURE 6-9

BEARING CLEARANCE

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

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

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

1. Place the boom over the front and set the outriggers.
2. Put a dial indicator (2, Figure 6-10) opposite the boom on the T-box frame (3).
3. Place the dial on the top of the turret bearing plate (1, Figure 6-10).
4. Power the boom down onto the boom rest.
5. Set the dial indicator at zero.
6. Raise the boom about 76 mm (3 in) above the boom rest.

7. Record the deflection indicated on the dial.
8. Repeat steps 4 through 7 three times and average the readings.
9. If the average is greater than 2.2 mm (0.090 in), replace the bearing.
10. If the average is less than 2.2 mm (0.090 in), repeat the measurement at every 45° around the total working area of the crane (Figure 6-11).
 - 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 76mm (3 in).
 - f. Record the reading on the dial indicator.
 - g. Repeat steps (d) through (f) three times.
 - h. Average the readings.
 - i. If the average is greater than 2.2 mm (0.090 in) at any position, replace the bearing.

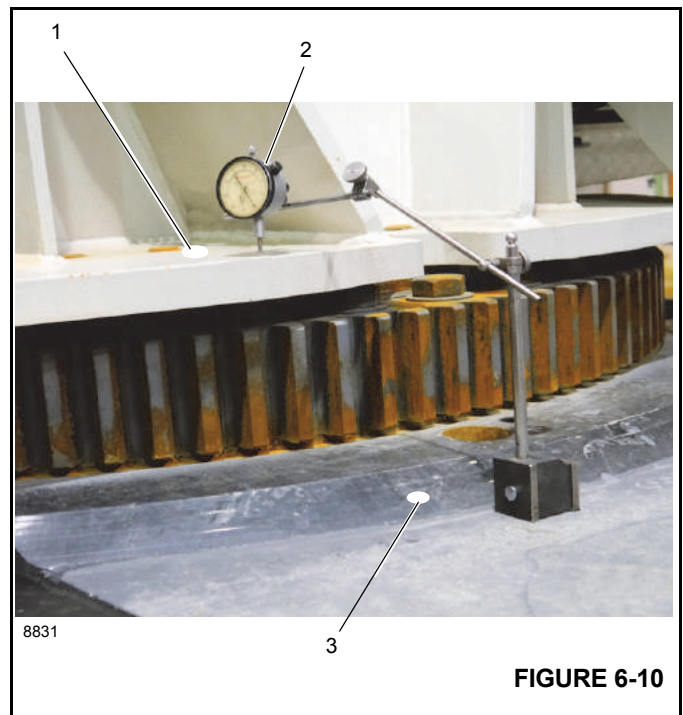


FIGURE 6-10

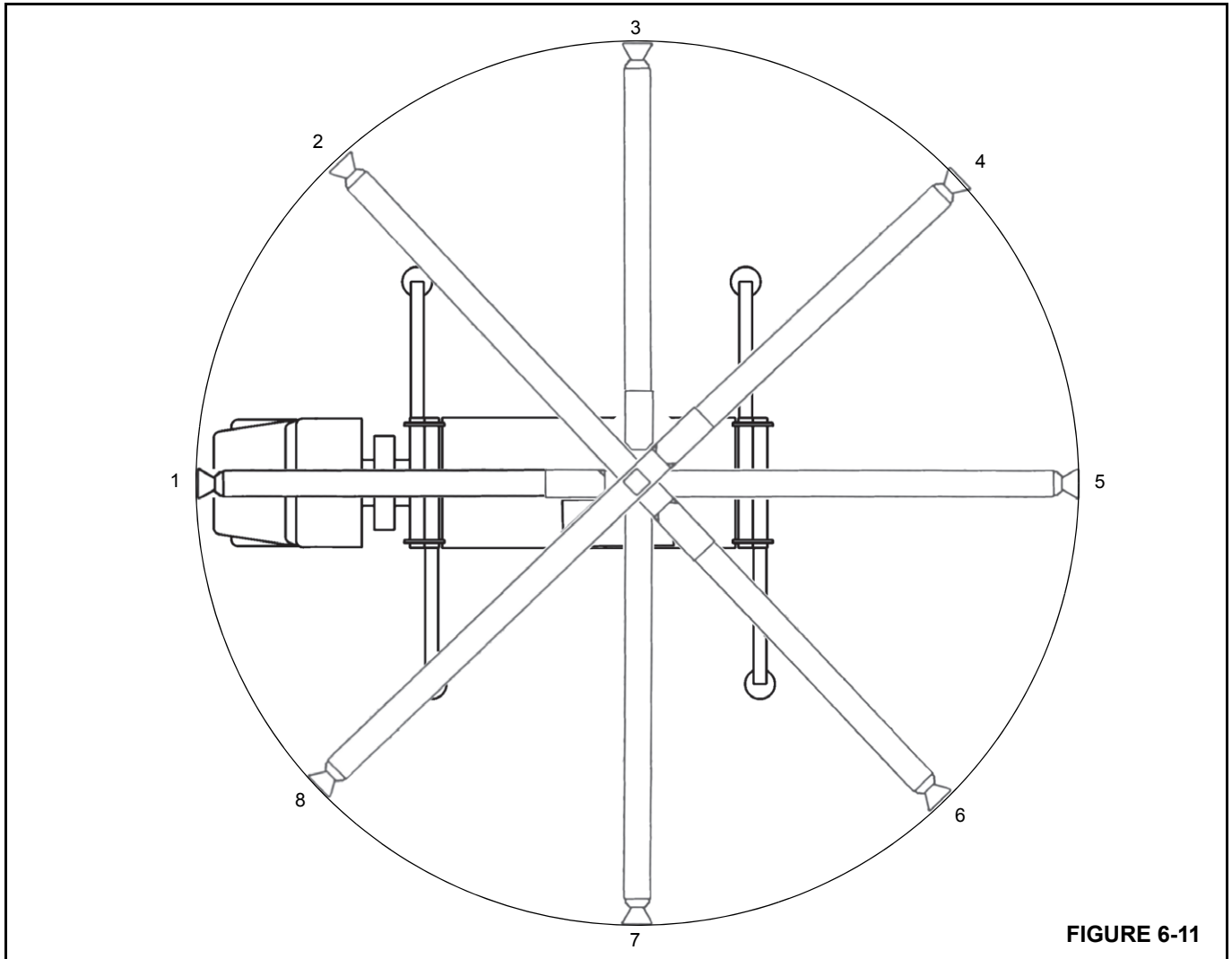


FIGURE 6-11

BEARING REPLACEMENT

Removal

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

NOTE: Do not raise the machine on the outriggers.

2. Rotate the boom to about 20° off the front position so that the boom is clear of the truck cab.

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

3. Mark the position of the swing motor. The bolts underneath the swing motor need to be removed before any other bearing bolts are removed.
4. Rotate the boom back to the front and remove the turntable bolts between the marks in step 4.
5. Slowly rotate the boom back to 20° off front position.

6. Elevate the boom slightly and shut down the engine.
7. Tag and disconnect the battery cables.
8. Remove the boom and lift cylinder following the procedures outlined in *Boom Maintenance*, page 4-1.

DANGER

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

9. Tag and disconnect all hydraulic lines from the swivel on the carrier side. Cap or plug all lines and openings.
10. Disconnect the wiring harness connectors from the carrier side of the swivel.
11. Coil the wiring harness and secure it to the swivel to prevent damage to the harness during turret removal.

NOTE: The swivel is removed with the turret.

12. Attach a suitable lifting device to the turret. Remove any slack in the sling. Do not pull up on the turret.
13. Remove the remaining bolts and washers securing the swing bearing outer race to the carrier.

⚠ DANGER

Ensure blocking material can support the turret.

14. Carefully lift the turret and set it on blocking that will not allow the turret to tilt or shift. Leave the lifting device attached.

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

15. Remove the 41 bolts from the inner race of the turret bearing.

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

NOTE: The bearing weighs about 578 kg (1274 lb).

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

Installation

⚠ DANGER

Do not reuse the swing bearing bolts. The swing bearing is torqued to the applied torque of the class 12.9 bolts. New bolts ensure proper torque and bolt strength for securing the swing bearing and turret to the carrier.

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

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 41 new bolts and washers securing the bearing to the turret. Refer to Torquing Swing Bearing Bolts.
3. Using an appropriate lifting device, align the turret over the carrier same position that it was before removal.
4. Carefully lower the turret into position on the bearing plate. Be careful not to damage the swivel assembly.
5. Install all bolts and washers that are not covered by the swing motor. Refer to Outer Race Torquing on page 6-11.
6. Install the swing drive pinion (1) Figure 6-13 so that the drive pinion gear teeth are aligned with the high point

(maximum eccentricity) teeth (2) on the turret bearing (3).

The high point or maximum eccentricity of the turret bearing is identified at the factory using three gear teeth in a row on the turret bearing as the high point. Tooth one and three are steel stamped (1) Figure 6-12 with a dash mark at the top and bottom of the gear teeth. Use these three gear teeth when installing the swing drive and checking the backlash shown in Figure 6-13.

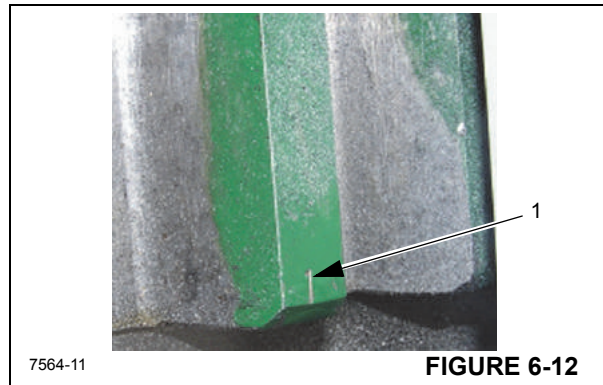


FIGURE 6-12

7. Check the backlash (4) Figure 6-13 with .203 mm (0.008 in) thick shim between the drive pinion gear teeth (5) and the high point (maximum eccentricity) gear teeth (2) on the turret bearing.

If the pinion must be moved to achieve proper backlash of .40 mm (.016 in), contact your local distributor.

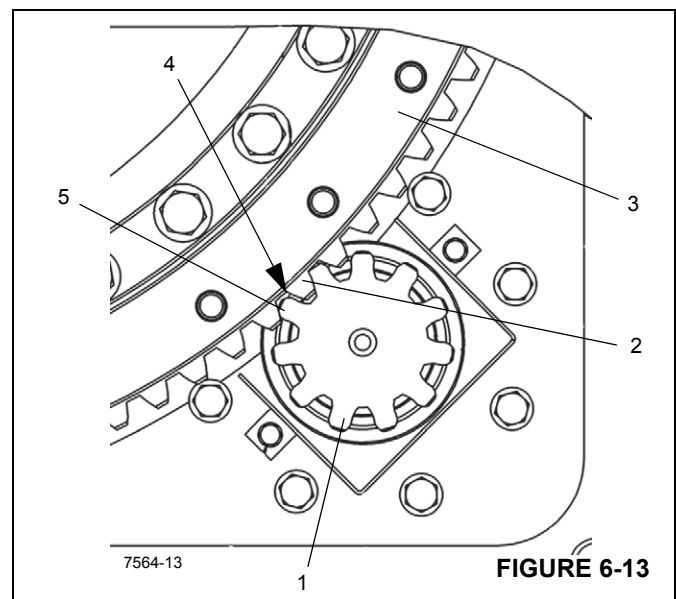


FIGURE 6-13

NOTE: If a new bearing (3) Figure 6-13 is installed, a new pinion gear (1) must also be used.

8. Plug the swivel wiring harness connectors into the carrier receptacles.
9. Reconnect the hydraulic lines as per removal tags.

10. Install the boom and lift cylinder following the procedures outlined in Section 4- BOOM.
11. Reconnect the batteries.
12. Carefully swing the turret so that the bolt holes that were covered by the swing motor are accessible.
13. Install the remaining swing bearing bolts.
14. Check the slew potentiometer in the electrical swivel for proper orientation as described below.

Testing

Activate the crane and check for proper function.

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

Slew Encoder

Adjustment

There is no mechanical adjustment for the slew encoder (Figure 6-14). Refer to the *RCL Section* of the *Operator's Manual* for calibration instructions.



FIGURE 6-14

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SECTION 7 OUTRIGGERS

SECTION CONTENTS

Description	7-1	Description	7-13
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Outrigger Controls	7-2	Description	7-14
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Description	7-9	Single Front outrigger (SFO)	
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Extension Cylinder	7-13	Maintenance	7-17

Description

The outriggers, when properly extended and set, provide a rigid four point platform which is capable of supporting the crane and its maximum load capacity. The outriggers consist of inverted jack cylinders with outrigger beams to allow for fully retracted, partial extension, and fully extended operation. An optional center front jack is available for added stabilization (if equipped). The outriggers are fully hydraulic. The front outrigger box is mounted behind the front axles while the rear outrigger box is mounted behind the rear axles. The optional front jack (if equipped) is mounted on the center of a crossmember at the front of the crane.

The beam assembly (see Figure 7-2) contains the 6.35 cm (2.5 in) bore extension cylinder and the 13.9 cm (5.50 in) jack cylinder which is mounted in a tube at the end of the beam.

The outrigger circuit consists of an integrated outrigger selector manifold, two outrigger manifold valves, four extension cylinders, four jack cylinders, a relief valve, and

(pilot operated) check valves and outrigger monitoring sensors (OMS) in each outrigger beam. The two front extension cylinders are mounted in the front outrigger beams and the two rear extension cylinders are mounted in the rear outrigger beams. The front and rear jack cylinders are mounted on their respective jack boxes; in turn the jack tubes are mounted on the end of each outrigger beam. Each jack cylinder has an integral pilot operated valve.

There are three CAN bus outrigger control panels on the crane. One control panel is located on the superstructure cab console, and one on either side of the crane decking near the front outriggers. The engine speed will be automatically increased above RPM idle when the outrigger extend or retract button is enabled.

A sight bubble level is mounted on the right side of the cab and at each control panel on the left and right sides of the crane. The sight bubble level provides the operator with a visual indication of crane level attitude.

Theory of Operation

The outriggers allow quick and easy crane set-up and includes an outrigger beam position sensing system that aids the operator in selecting the correct load chart based on the crane's outrigger footprint. Operations are controlled with an outrigger control station containing a touch pad control panel, emergency stop switch and levelling bubble.

When an outrigger extension cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. The jack cylinder applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

Outrigger Controls

Each outrigger control panel contain a touch pad and LED indicator (Figure 7-1). There are four outrigger beam and four jack selector buttons located on each outrigger control panel. Pre-selection of a button or a combination of buttons (one or more beams or jacks) may be selected within 5 seconds of pressing the next function for extending and retracting the outrigger beams and outrigger jack cylinders and also for raising and lowering the center front jack (if equipped).

Press the extend or retract button while holding the enable button to complete the operation.

NOTE: Extension beam and jack cannot be operated simultaneously. The control station can not be activated if the crane is performing another function (For example: operating the boom). The operator must be in the crane cab seat with left armrest lowered and crane power switch in the ON position for the outrigger controls to operate from the crane cab.

The LED indicators display the status of the control button being selected on the outrigger control panel. A blue LED will illuminate for 5 seconds indicating a button has been selected. A red LED will illuminate if a button selection is

unavailable. The module power LED illuminates when the control station is activated.

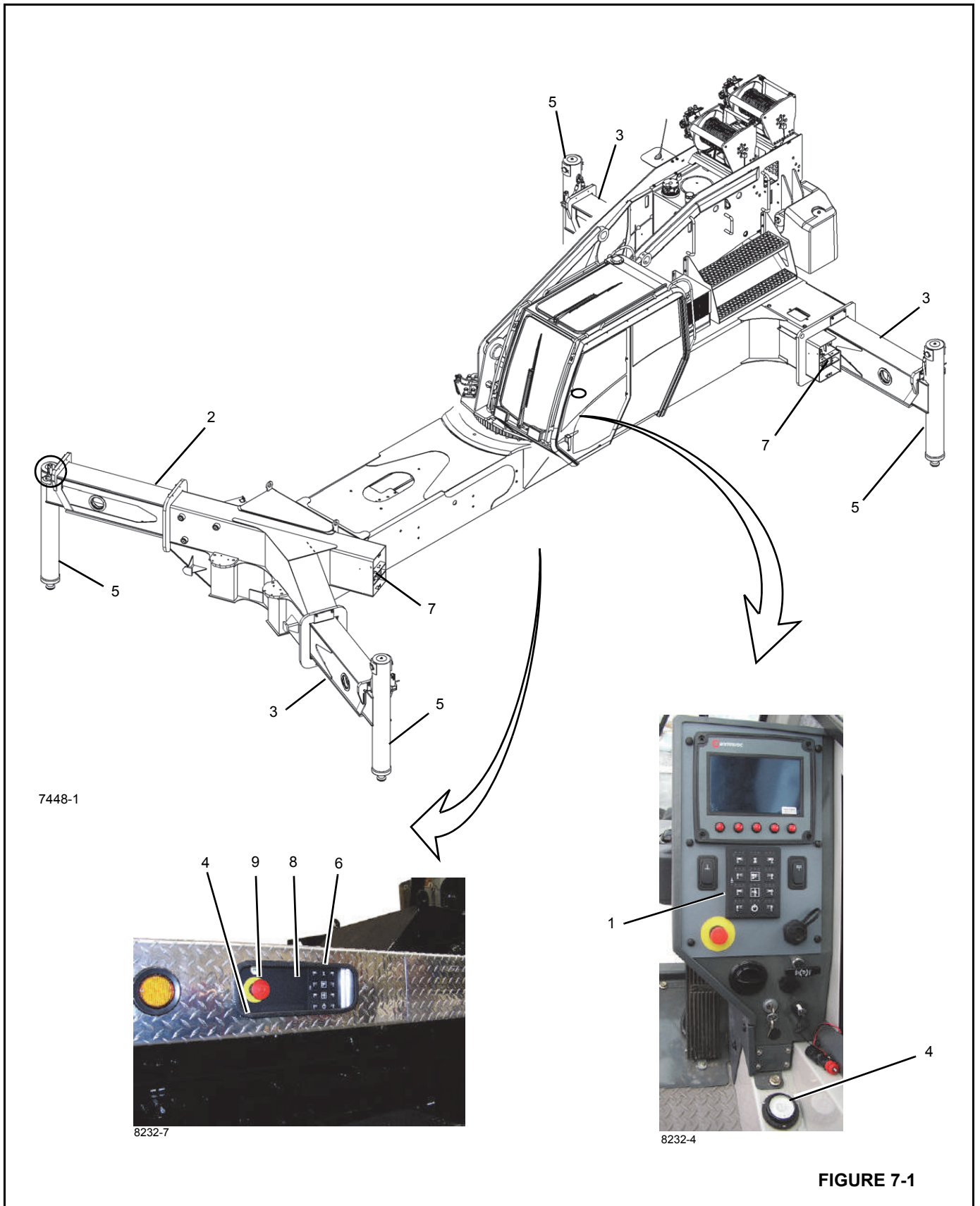
Outrigger Selector Valve

Pushing the desired selector buttons, the enable button, and either the extend or retract button, energizes the control solenoid to allow hydraulic fluid to flow through the control solenoid valve. The individual solenoid valves and moves the selected component in the desired direction. When the buttons are pushed, a signal is sent to the engine ECM to increase the engine speed above idle for operation of the outriggers.

The integrated outrigger valve spool shifts allowing flow to either the extend or retract line as applicable. If the extend button is pushed, flow continues through the open solenoid valve to the piston side of the cylinder. If the jack is to be extended, the flow first unseats the cylinder check valve then extends the cylinder. The oil from the rod end flows through the integrated outrigger valve, and then to the reservoir. When the outrigger retract button is pushed, the flow through the selector valve is directed to the rod side of the cylinder. The oil in the piston side flows through the open solenoid back to the integrated outrigger valve. If a jack cylinder is to be retracted, the pilot pressure from the pressurized retract line unseats the cylinder check valve allowing oil to flow from the piston side through the open solenoid valve to the integrated outrigger valve. The integrated outrigger valve directs the flow to the reservoir.

Single Front Outrigger (SFO) - optional

The optional front jack (if equipped) functions similar to any of the other jack cylinders. The front jack will retract when the outrigger retract button is positioned to the retract position. After operating the main outrigger control, the single front outrigger (SFO) jack must be reset before operating the crane. An inline relief valve prevents over pressurization of the center front jack cylinder as the cylinder is being extended. The valve is installed in line between the solenoid valve and the cylinder, and is set at 34.4 bar (500 psi).



Item	Description	Item	Description
1	Front Console	6	Ground Station Outrigger Controls
2	Outrigger Beam Assy-Tall	7	Outrigger Extend/Retract Cylinder
3	Outrigger Beam Assy-Short	8	Lower Control Station
4	Level Indicator	9	Emergency Stop Switch
5	Outrigger Jack		

Maintenance

Troubleshooting

Symptom	Probable Cause	Corrective Action
1. Outrigger beam extension cylinder slow or erratic.	a. Low hydraulic oil level.	a. Check for leaks. Make any needed repairs. Fill reservoir to proper level.
	b. Damaged relief valve.	b. Remove relief valve; clean or replace.
	c. Sticking solenoid valve spool.	c. Repair or replace valve spool.
	d. Improper ground to base of solenoid.	d. Ground properly.
	e. Damaged O-rings and swivel.	e. Remove swivel and replace O-rings.
	f. Directional selector button sticking.	f. Replace touch pad
	g. Collector ring dirty or glazed.	g. Clean and de-glaze collector ring.
	h. Damaged wiring to solenoid.	h. Replace wiring.
	i. Weak brush springs on collector ring.	i. Replace brush springs.
	j. Damaged extension cylinder (internal parts).	j. Remove extension cylinder and repair as necessary.
	k. Bent cylinder rods.	k. Replace piston rods and seals.
	l. Excessive material on outrigger beams.	l. Clean outrigger beams.
	m. Binding outrigger beam.	m. Repair or replace outrigger beam.
	n. Damaged outrigger valve.	n. Repair or replace valve.
	o. Damaged valve coil.	o. Replace coil.
	p. Main hydraulic pump cavitation.	p. Replace or tighten hose or fitting.
	q. Partially shifted hydraulic spool in selector valve or manifolds.	q. Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	r. Insufficient voltage for operation of solenoid valve.	r. Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring and electrical coupling collector rings.
	s. Damaged piston seals.	s. Replace all cylinder seals.
t. Worn or damaged hydraulic pump section.	t. Repair or replace pump section.	
u. Scored cylinder barrel.	u. Repair or replace extension cylinder.	



Symptom	Probable Cause	Corrective Action
Slow or erratic operation of outrigger extension cylinders. (continued)	v. Cracked or damaged piston.	v. Replace rod weld and all cylinder seals.
	w. Piston loose on piston rod	w. Replace all cylinder seals and torque piston locknut.
2. Sticking spool.	a. Dirt in the system.	a. Change oil and flush system.
	b. Distortion caused by sectional tie bolts being over-torqued.	b. Retorque sectional tie bolts.
	c. Flow in excess of valve rating.	c. Limit flow through valve to recommended values. Check pump output and cylinder ratio.
	d. Pressure in excess of valve rating.	d. Check relief valve setting or pump compensation with recommended values.
	e. Electrical failure.	e. Check wiring and solenoids.
3. External leakage.	a. Damaged O-ring or quad rings.	a. Check for chipped packing and replace.
	b. Loose sectional tie bolts.	b. Retorque sectional tie bolts.
	c. Damaged solenoid.	c. Replace damaged parts.
4. Solenoid failure.	a. No current.	a. Check power source.
	b. Damaged solenoid assembly.	b. Replace solenoid.
	c. Short in solenoid.	c. Replace coil.
	d. Loss of solenoid force.	d. Decrease time of solenoid energization, decrease cycle rate.
5. Outrigger vertical jack cylinder slow or erratic.	a. Low hydraulic oil level.	a. Check for leaks. Make any needed repairs. Fill reservoir to proper level.
	b. Damaged main relief valve.	b. Repair or replace valve.
	c. Damaged holding valve seals.	c. Replace holding valve seals.
	d. Bent cylinder rod.	d. Replace cylinder rod and seals.
	e. Bent outrigger housing.	e. Repair or replace outrigger housing.
	f. Damaged O-rings in swivel.	f. Replace O-rings.
	g. Excessive material on beams.	g. Clean outrigger beams.
	h. Sticking solenoid valve spool.	h. Repair or replace valve spool.
	i. Damaged wiring to solenoid.	i. Repair or replace wiring.
	j. Weak brush springs on collector rings.	j. Replace brush springs.
	k. Collector ring dirty or glazed.	k. Clean or deglaze collector ring.
l. Directional selector button sticking.	l. Replace touch pad.	

Symptom	Probable Cause	Corrective Action
Outrigger vertical jack cylinder slow or erratic. (continued)	m. Main hydraulic pump cavitation.	m. Replace or tighten hose and fittings.
	n. Worn or damaged hydraulic pump section.	n. Repair or replace pump section.
6. Outrigger jack cylinder retracts under load.	a. Damaged piston seals.	a. Replace all cylinder seals.
	b. Damaged holding valve seals.	b. Replace seals.
	c. Damaged holding valve.	c. Replace valve assembly.
	d. Scored cylinder barrel.	d. Repair or replace cylinder.
	e. Cracked or damaged piston.	e. Replace piston and all cylinder seals.
7. Jack cylinder extends while machine is traveling.	a. Damaged piston seals.	a. Replace all cylinder seals.
	b. Scored cylinder barrel.	b. Replace jack cylinder.
	c. Cracked or damaged piston.	c. Replace piston and seals.
	d. Piston loose on cylinder rod.	d. Replace seal and retorque.
8. Outrigger system will not activate (from stowed or extended and down position).	a. Hydraulic oil low.	a. Replenish system.
	b. Loose or broken wire to touch pad.	b. Repair or replace wiring.
	c. Clogged, broken, or loose lines or fittings.	c. Clean, tighten, or replace lines or fittings.
	d. Damaged relief valve or damaged control valve.	d. Repair or replace valve.
9. Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	a. Clogged, broken, or loose hydraulic lines or fittings.	a. Clean, tighten, or replace lines or fittings.
	b. Loose or broken wire to control touch pad or solenoid valve.	b. Repair or replace wiring.
	c. Damaged solenoid valve.	c. Repair or replace valve.
	d. Damaged control button.	d. Replace button.
	e. Damaged hydraulic cylinder.	e. Repair or replace cylinder.
	f. Damaged relief valve.	f. Repair or replace relief valve.
10. Outriggers keypads will not function.	<p>a. Connectors are not securely plugged in.</p> <p>b. The outrigger keypads are not active.</p> <p>c. Buttons are not being activated correctly</p>	<p>a. Secure the plug.</p> <p>b. Check to see what the machine state crane is in.</p> <p>c. First select the outrigger selection (either beams or jacks) then select the activate and function button (retract or extend) to function the outriggers.</p>
11. Two outriggers activate from single control button.	a. Improper wiring.	a. Troubleshoot wiring from modules
12. One/two outriggers will not stow.	a. Pressures may be too low.	a. Check pressures to ensure the right value is being sent to activate the cylinders



Symptom	Probable Cause	Corrective Action
<p>13. Individual outrigger will not set or stow.</p>	<p>a. Damaged piston seals.</p>	<p>a. Replace seals.</p>
	<p>b. Damaged check valve.</p>	<p>b. Repair or replace valve.</p>
	<p>c. Loosen or broken wire to control touch pad or solenoid valve.</p>	<p>c. Repair or replace wiring.</p>
	<p>d. Damaged solenoid valve.</p>	<p>d. Repair or replace valve.</p>
<p>14. Red LED indicator on lower control station stays illuminated.</p>	<p>a. A different control station is activated.</p>	<p>a. Activate individual control station. The red LED only stays on when there are buttons that cannot be selected. (Example: The left outrigger beam from the right side control station.)</p>
<p>15. Can not operate the outrigger extension beam on the opposite side from control station.</p>	<p>a. Control station is not activated.</p>	<p>a. Operate the control station from the same side the outrigger beam is located, or operate from the crane cab control station.</p>
<p>16. Can not operate outrigger controls from cab control station.</p>	<p>a. Control station is not activated.</p>	<p>a. Operator must sit in the cab seat, lower left arm rest controller (to activate safety features) and enable Crane Power switch on overhead console.</p>
<p>17. Can not pre-select multiple buttons simultaneously.</p>	<p>a. Delay in selection.</p> <p>b. Outrigger keypads are not configured or are improperly configured.</p>	<p>a. Make selection with-in 5 seconds of next function or select only beams or jacks. (If you select a jack after all applicable beams are selected, it deselects the beams and selects only the jack that was last selected.)</p> <p>b. Reset (if necessary) and configure outrigger keypads</p> <p>c. Correct wiring, secure diode or place diode in harness.</p>
<p>18. Crane will not start.</p>	<p>a. Emergency stop switch is activated.</p>	<p>a. Reset emergency stop switches at all control stations.</p>

OUTRIGGER BEAM

Description

The outrigger beam assembly (see Figure 7-2) consists of an outrigger beam, a 13.9 cm (5.50 in) jack cylinder, a 6.3 cm (2.5 in) outrigger extension cylinder, two outrigger monitoring sensors (OMS) and the required hoses and mounting hardware.

Theory of Operation

When the outrigger extension cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. The jack cylinder applies force to the outrigger beam vertically. This provides for lifting and stabilizing the crane for operation.

Maintenance

See Figure 7-2 for outrigger assembly breakdown.

Removal

1. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.
2. Remove the bolts, washers, and lock washers securing the shim plates to the ends of the outrigger box and mid beam.
3. From the opposite side of the outrigger housing, remove the end cover.
4. Tag and disconnect the three hydraulic hoses from the hydraulic tubes entering the outrigger box housing. Cap or plug all openings.



CAUTION

Cable is under spring tension. Do not free-release. This could result in injury and damage to the sensor.

5. Disconnect the outrigger OMS string potentiometer (quick clip) cable from the outrigger beam.
6. Disconnect electrical connection from the potentiometer.
7. Remove the pipe clamp, bolt insert, and bolt from each of the three hydraulic tubes entering the outrigger housing.
8. Tag, disconnect, and remove the three hydraulic tubes to the cylinder end of the extension cylinder. Cap or plug all openings.
9. On the side of the outrigger housing, remove the setscrews from the adjustable wear pads and back off the wear pads from the housing.

10. Remove the cotter pin and clevis pin securing the rod of the extension cylinder to the outrigger housing.
11. Attach a suitable lifting device of straps or belts to the beam. Partially pull the outrigger beam out of the outrigger box, re-adjusting the lifting attachment to maintain balance during removal to prevent the beam from tipping.

NOTE: Do not use chains to prevent nicking the bottom edges of the outrigger beam,

NOTE: The outrigger beam assembly weighs approximately 750 kg (1653 lb).

12. Position the outrigger beam on suitable blocking material.
13. If necessary, remove the wear pad from the inside bottom of the outrigger box.

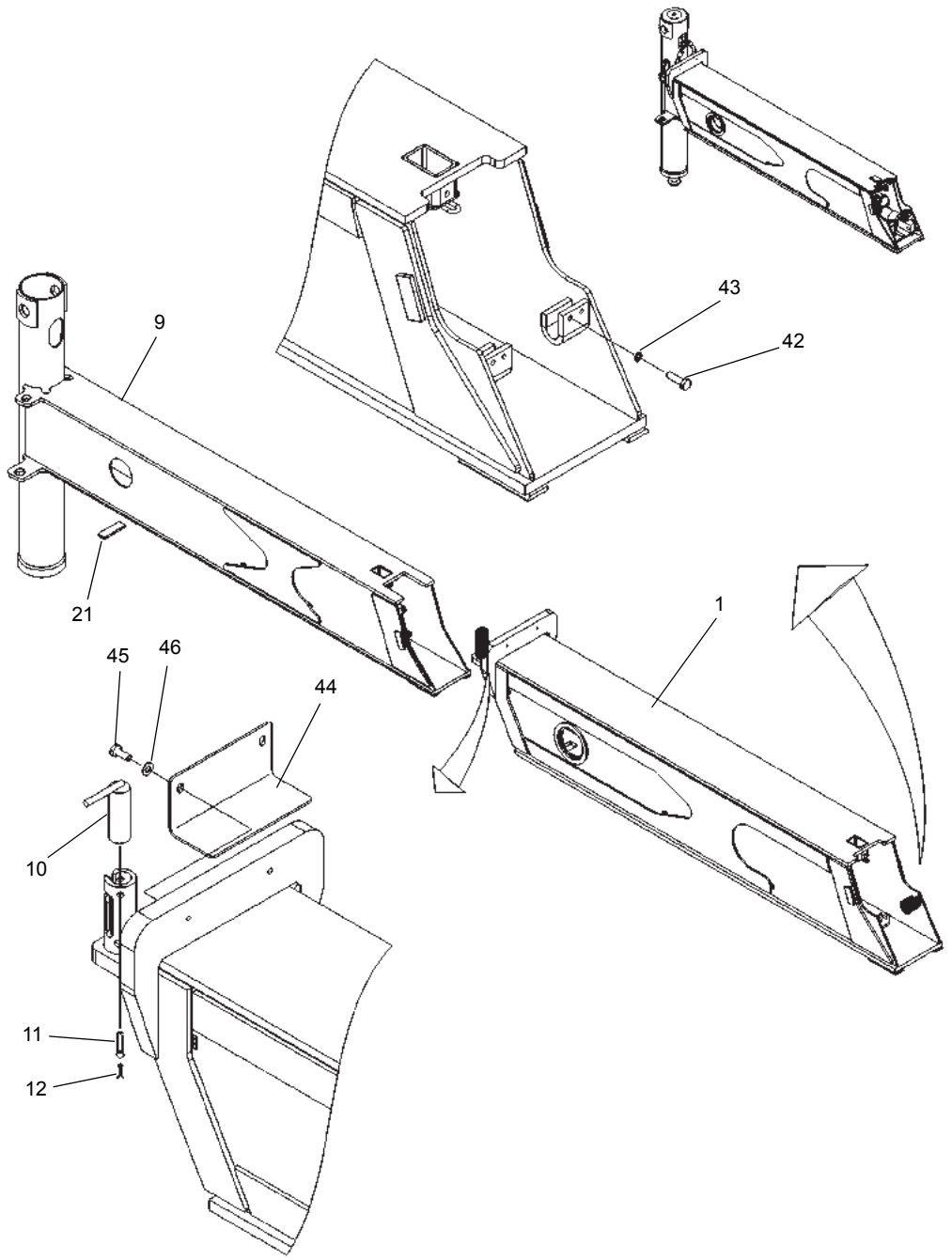
Disassembly

1. Remove the four bolts and lock washers securing the extension cylinder barrel lugs to the brackets on the mid beam.
2. Attach a suitable lifting device of straps or belts to the outrigger beam. Partially pull the outrigger beam out of the outrigger mid beam, re-adjusting the lifting attachment to prevent the beam from tipping.

NOTE: Do not use chains to prevent nicking the bottom edges of the outrigger beam,

NOTE: The outrigger beam and jack cylinder assembly weighs approximately 679 kg (1496 lb).

3. Position the outrigger beam on a suitable blocking material.
4. Remove the wear pad and wedge from the pocket in the top of the mid beam.
5. Remove the wear pad from the pocket in the bottom of the mid beam.
6. Remove the wear pad and wedge from the pocket in the top of the outrigger beam.
7. Remove the extension cylinder. Refer to Removal on page 13 in this section.
8. Remove the jack cylinder. Refer to Removal on page 17 in this section.
9. Remove the two clamps, washers, lock washers, and nuts securing each tube and hose assembly to the inside top of the outrigger beam. Remove the tube and hose assemblies.



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FIGURE 7-2

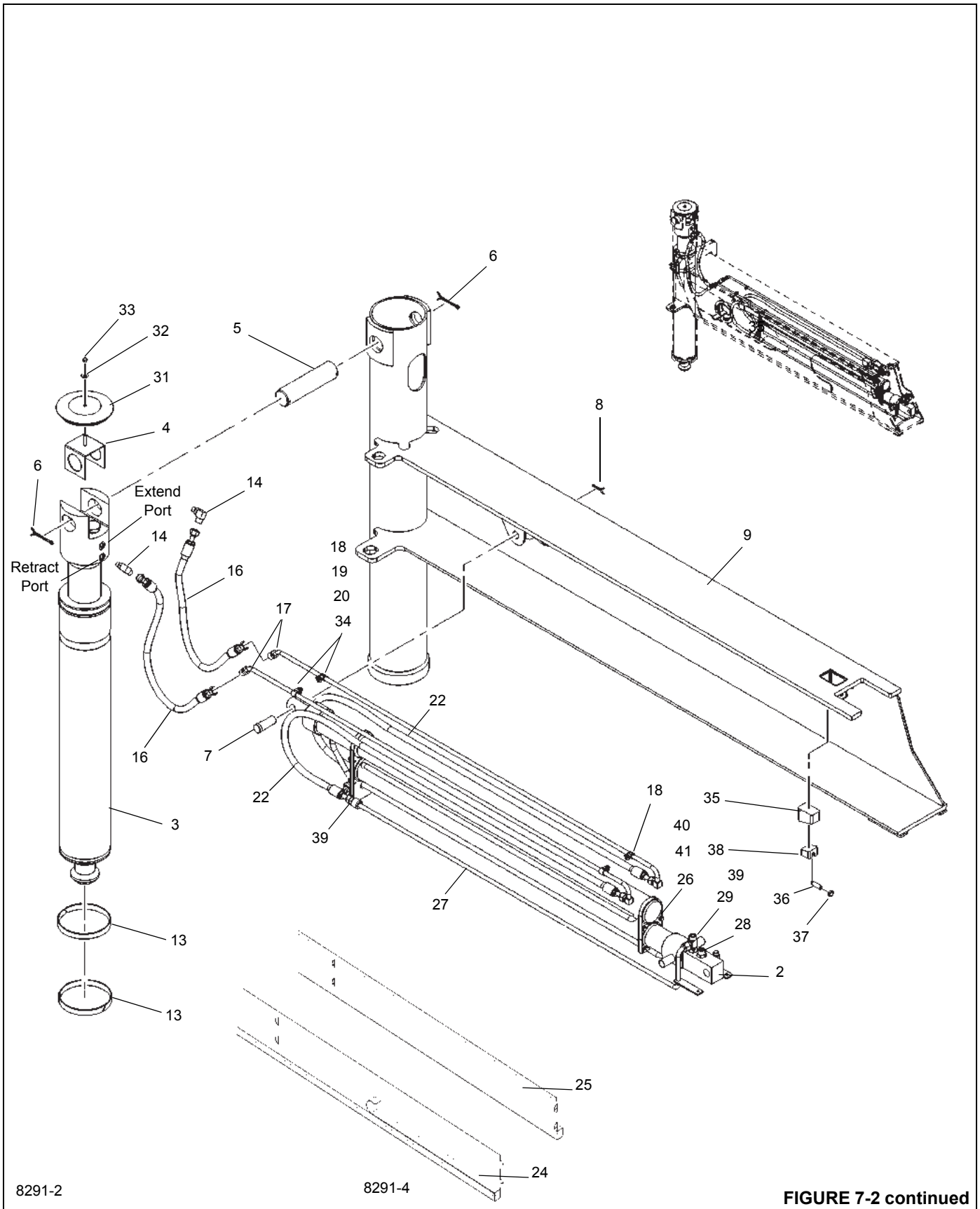


FIGURE 7-2 continued

Item	Description
1	Outrigger mid beam
2	Cylinder assembly-2.50 - outrigger beam
3	Cylinder assembly-5.50 jack
4	Cap Bracket
5	Pin
6	Cotter Pin 0.25x3" St
7	Clevis pin 1x2.5" Hard
8	Cotter pin 0.19x1.75" St
9	Outrigger beam
10	Pin
11	Clevis pin 0.31x2.13" St
12	Cotter Pin 0.09x0.75" St
13	6.50" wear ring
14	Elbow 90 degree
16	Hose -.5" Abrasion
17	Tube, outrigger jack line
18	Tubing clamp 1/2" I.D.
19	Flat washer 8 -St
20	Lock washer 8 -
21	Wear pad, outrigger (nylon)
22	Hose 133/16-16 x 1/2 ID x 76
23	Tube assembly- outrigger jack cylinder
24	Tray - left hand
25	Tray - right hand
26	Hex head capscrew 1/4-20UNC x 0.5 G5
27	Tube assembly - outrigger jack cylinder
28	Str Adapter
29	Run Tee
31	Cap - jack cylinder tube
32	Flat washer 0.38x0.90x0.06"
33	Acorn nut 5/16-18UNC SAE-2
34	Hex nut M8
35	Wear pad
36	Socket setscrew- M12x40
37	Hex jam nut M12
38	Wedge

Item	Description
39	O-ring
40	Flat washer 1/4" Narrow
41	Lock washer 1/4" Reg
42	Hex head capscrew M10x35
43	Lock washer 10
44	Shim L-Shape 4 mm
45	Hex head capscrew M10x25 mm
46	Flat washer 10 mm

Inspection

1. Inspect the hoses, couplings, and end fittings for cracks, chafing, cuts, or other damage.
2. Inspect the outrigger beams for bends, evidence of cracks, or other damage. Check the outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder or damaged hydraulic line.

Assembly

1. Route the tube and hose assemblies through the outrigger beam. Attach the tubes to the inside top of the outrigger beam using the four clamps, washers, lock washers, and nuts; do not tighten the clamps at this time.
2. Install the jack cylinder in the outrigger beam. Refer to Outrigger Jack Cylinder - Installation in this Section.
3. Install the outrigger extension cylinder in the outrigger beam. Refer to Extension Cylinder - Installation in this Section.
4. Position the wedge and wear pad in the pocket in the top of the jack beam. Coat the wear pad with grease.
5. Position the wear pad in the pocket in the bottom of the mid beam. Coat the wear pad with grease.
6. Position the wedge and wear pad in the pocket in the top of the mid beam. Coat the wear pad with grease.
7. Attach a suitable lifting device of straps or belts to the outrigger jack beam. Slide the outrigger beam into the outrigger mid beam.

NOTE: Do not use chains to prevent nicking the bottom edges of the outrigger beam,

NOTE: The outrigger beam assembly weighs approximately 236 kg (520 lb).

8. Place the extension cylinder barrel lugs in the brackets of the mid beam and secure with four bolts and lock washers.

Installation

1. Install the wear pad in the inside bottom of the outrigger housing. This will prevent the beam side plates from riding on the bottom of the box.
2. Apply grease (EP-MPG) to the bottom of the outrigger beam assembly and all wear pad contact surface.
3. Attach a suitable lifting device of straps or belts to the outrigger beam. Slide the beam into the outrigger housing and align the cylinder rod with the mounting hole.

NOTE: Do not use chains to prevent nicking the bottom edges of the outrigger beam,

NOTE: The outrigger beam assembly weighs approximately 750 kg (1653 lb).

4. Secure the cylinder rod to the housing with the clevis pin and cotter pin.
5. Connect the three hydraulic tubes to the cylinder end as tagged during removal.
6. Secure the three hydraulic tubes to the outside of the outrigger housing using the pipe clamps, bolt inserts, and bolts.
7. Connect the three hydraulic hoses to the hydraulic tubes as tagged prior to removal.

**CAUTION**

Make sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

**CAUTION**

During initial start-up and checking of the outrigger operation, each control button must be operated before operating the selector valve. If hydraulic lines are reversed to one or more cylinders, this will prevent damage to the cylinders.

**WARNING**

Cable is under spring tension. Do not free-release. This could result in injury and damage to the sensor.

8. Connect the outrigger OMS string potentiometers (quick clip) cable to the outrigger beam.
9. Connect electrical connection to the potentiometers.

10. Install the shim plates on the ends of the outrigger housing and the mid beam using the bolts, washers, and lock washers. Adjust the gap to obtain a maximum clearance of 1.5 mm (.098 in).

11. Adjust the wear pads. Refer to Wear Pad Adjustment.

12. Install the end cover.

NOTE: At installation, be sure that the outrigger jack cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

Wear Pad Adjustment

NOTE: When adjusting wear pads, refer to Figure 7-2.

1. Adjust the top wear pads until a gap of 2.0 mm (0.07 in)) is obtained at the tightest point during full extension. Install and lock setscrews against wear pads.
2. Adjust outrigger box side wear pads until a gap of 2.0 mm (0.07 in) is obtained at the tightest point during full extension. Install and lock setscrews against wear pads.

EXTENSION CYLINDER**Description**

The outrigger beam extension cylinder is a combination unit with two rods, one for extending each beam section. Each “half” of the cylinder is a double-acting type cylinder. The barrel end is attached to the mid beam. The lower rod is attached to the outrigger box and the upper rod is attached to the jack beam.

Each barrel has a 6.4 cm (2.50 in) diameter bore. Internal seals are used to prevent internal and external leakage.

Removal

1. Remove the outrigger beam. Refer to Outrigger Beam Removal on page 9 in this section.
2. Remove the cotter pin and clevis pin securing the cylinder rod to the jack beam.
3. Loosen the two clamps securing each hydraulic tube to the inside top of the jack beam. Slide the tubes out of the jack beam enough to remove the hoses from them. Tag and remove the hoses from the tubes. Cap or plug all openings.
4. Slide the extension cylinder from the jack beam being careful not to damage the two hydraulic tubes mounted to the inside top of the jack beam.

NOTE: The extension cylinder weighs approximately 70.3 kg (155 lb).

5. Disconnect the tube from the extension cylinder port.
6. Pull the tube and hose assemblies from the tube trays.

- Remove the bolts, washers, and lockwashers securing the trays to the extension cylinder and remove the trays.

Installation

NOTE: The extension cylinder weighs approximately 70.3 kg (155 lb).

- Coat the inside of the tube trays with anti-seize compound. Attach the trays to the extension cylinder with bolts, washers, and lockwashers.
- With the extension cylinder sitting with the roller down, rotate the rod end that is closest to the jack cylinder so that the centerline through the clevis pin hole is horizontal to the ground.
- Install the tube and hose assemblies in the trays.
- Insert the extension cylinder three-quarters of the way in the end of the jack beam.
- Connect the hoses to the tubes in the top of the jack beam as marked during disassembly. Ensure the top and bottom portions of the curved hoses are in vertical alignment with each other or else the hoses will be damaged during cylinder extension and retraction.
- Connect the tube to the extension cylinder port.
- Slide the tubes that are attached to the inside top of the jack beam into the jack beam until their ends are flush with the top plate of the jack beam, then tighten the four clamps.
- Secure the extension cylinder rod to the jack beam ears using the clevis pin and a cotter pin.
- Assemble the jack beam into the mid beam. Refer to Outrigger Beam Assembly on page 12 in this section.

Functional Check

- Extend and retract the outrigger.
- Observe the operation of the outrigger beam.
- Check the hydraulic connections for any evidence of leakage.

OUTRIGGER JACK CYLINDER

Description

The jack cylinders have 13.9 cm (5.50 in) diameter bores and are the double-acting type. The cylinders are pinned into tubes welded onto the end of the outrigger beams. A port block is welded to the end of the cylinder rod and a pilot-operated check valve is threaded into the port block. Internal seals are used within the cylinder to prevent internal and external leakage. A wiper ring is mounted to the front of the cylinder barrel to wipe dirt from the rod as it is retracted.

Maintenance

Removal

- Extend the outrigger beam slightly for improved access to the jack cylinder. Shut down the engine.
- Tag and disconnect the hydraulic hoses from the jack cylinder. Remove the fittings from the cylinder.
- Remove the cylinder cap.
- Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Raise the cylinder up just enough to relieve any pressure on the cylinder retaining pin.

NOTE: The outrigger jack cylinder weighs approximately 105.4 kg (232.5 lb).

- Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin.
- Remove the cap bracket from the top of the cylinder.
- Raise the jack cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.



CAUTION

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

- Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

Installation

- Apply grease to the grooves at the top of the jack cylinder and inside the bottom of the jack cylinder tube. Install a wear ring around the top of the jack cylinder and the inside of the cylinder tube. Apply grease to the wear rings.
- Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under Removal, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.

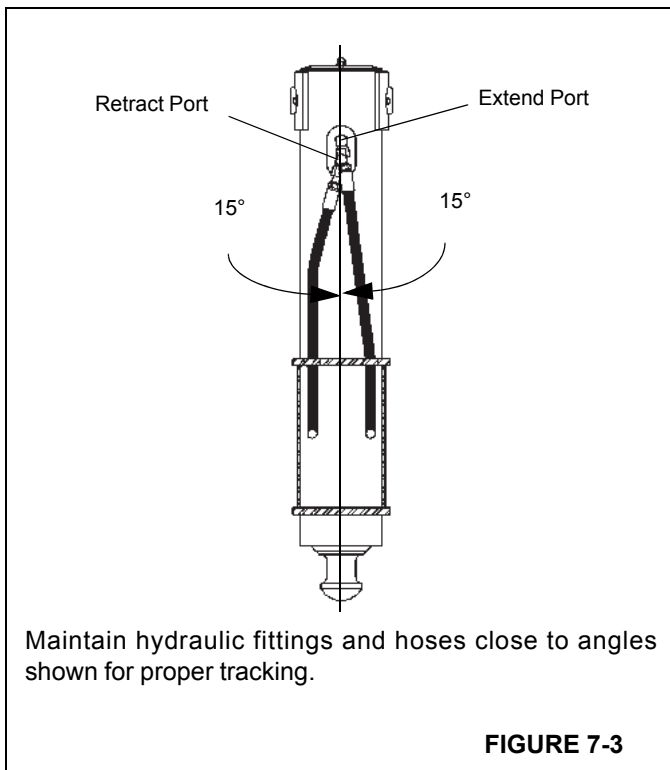
NOTE: The outrigger jack cylinder weighs approximately 105.4 kg (232.5 lb).

- Remove the retaining pin and cotter pins from the cylinder.

4. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam. Install the cap bracket on top of the cylinder. Secure the cylinder in place with the retaining pin and cotter pins.
5. Install the cylinder cap.

! CAUTION

Make sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.



6. Install the fittings in the cylinder, then connect the hydraulic hoses to the jack cylinder as marked prior to disassembly.

NOTE: Keep hydraulic fittings and hoses close to angles shown in (Figure 7-3) for proper tracking during extension and retraction.

Functional Check

1. Extend and retract the jack cylinder.
2. Check for smooth operation of the cylinder.
3. Check all hydraulic connections and hoses for evidence of leakage.

Outrigger Jack Cylinder Internal Leak Test

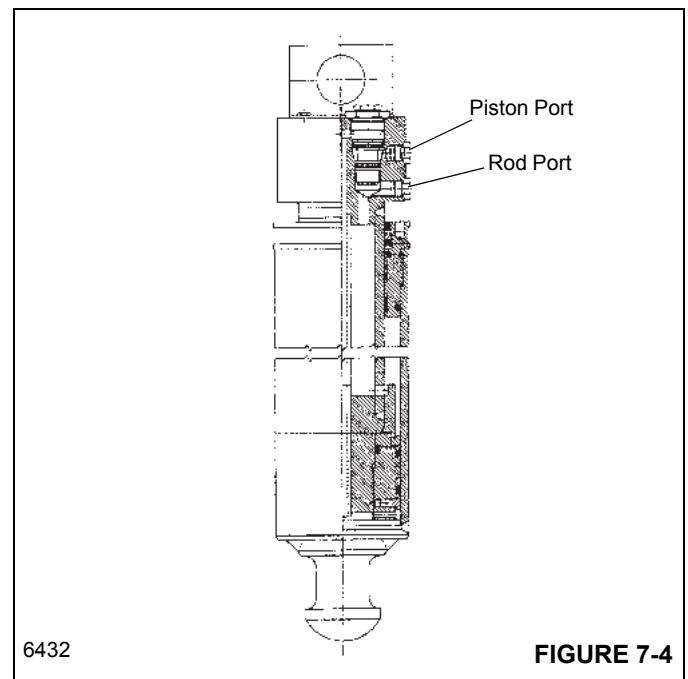
Use the following procedure to troubleshoot and diagnose an internal leak, a leaking pilot operated check valve or a thermal contraction on an outrigger jack cylinder.

! DANGER

Perform the following procedures with the crane positioned on a firm level surface with outriggers fully extended and set, and the crane in the travel position. Remove hoses from one cylinder at a time.

Checking Cylinder For Internal Piston Seal Leak

1. Fully extend and set the outriggers.



! CAUTION

When performing the following step 2, remove the hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the rod side cylinder hose from the suspected leaking jack cylinder (see Figure 7-4). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the rod side port.

Check for the following conditions:

- a. If oil stops flowing, the cylinder's internal piston seal is sealing properly.
 - b. If oil continues to flow out the rod port, the cylinder's internal piston seal is leaking.
3. After determining the condition of the cylinder's internal piston seal, leave the rod side hose disconnected and continue to test the pilot operated check valve.

Testing Pilot Operated Check Valve For Leakage

1. Fully extend and set the outriggers.



CAUTION

When performing the following step 2, remove the hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the piston side cylinder hose from the suspected leaking jack cylinder (see Figure 7-4). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the piston side port.
 - a. If oil stops flowing, the cylinder's pilot operated check valve is sealing properly.
 - b. If oil continues to flow out the piston port, the cylinder's pilot operated check valve is leaking.

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

OUTRIGGER SYSTEM VALVES

Description

There are four valve assemblies responsible for controlling the outrigger system: the pressure reducing valve, the front outrigger control manifold, the rear outrigger control manifold, and the pilot operated check valves. Trucks

equipped with an (optional) single front outrigger (SFO) jack have an additional relief valve.

NOTE: For a more detailed DESCRIPTION and MAINTENANCE of the valves, refer to VALVES in Section 2 - HYDRAULIC SYSTEM.

Pressure Reducing Valve

The pressure reducing valve is located on the pump manifold and reduces the system pressure in the outrigger circuit to 20.7 mPa (3000 psi).

Front Outrigger Control Manifold

The front outrigger control manifold is located behind the front outrigger boxes and inside the T-box frame. The manifold consists of a three position four way solenoid directional control valve that controls outrigger extend and retract functions. Additionally, five solenoid control valves on the manifold operate the front outrigger beam extension and jack cylinders as well as the (optional) single front outrigger (SFO) jack cylinder. The manifold also contains a 24.1 mPa (3500 psi) relief valve that protects the cylinders from damage due to thermal expansion.

Rear Outrigger Control Manifold

The rear outrigger control manifold is located in front of the rear outrigger boxes and inside the T-box frame. The rear manifold consists of four solenoid control valves that operate the rear outrigger extension and jack cylinders.

Pilot Operated Check Valve

A pilot operated check valve is located in each outrigger jack port block. The check valve prevents the jack cylinder from retracting if a hose fails.

Single Front Outrigger (SFO) Circuit Relief Valve (Optional)

The (optional) single front outrigger (SFO) circuit relief valve is mounted to the side of the front jack tube and prevents over pressurization of the front jack circuit when fully extended or retracted.

SINGLE FRONT OUTRIGGER (SFO) CYLINDER (OPTIONAL)

Description

The (optional) single front outrigger (SFO) jack cylinder has a 7.6 cm (3.0 in) diameter bore and is the double acting type. The cylinder is bolted to a tube which is mounted onto a special crossmember on the front end of the carrier frame. A port block is bolted to the end of the cylinder rod and a pilot operated check valve is threaded into the port block. Internal seals are used within the cylinder to prevent internal and external leakage. A wiper ring is mounted to the front of the cylinder barrel to wipe dirt from the rod as it is retracted.

Maintenance

Removal

See Figure 7-5 for cylinder breakdown.

1. Tag and disconnect the two hoses coming from the truck to the relief valve on the side of the jack cylinder support tube. Cap or plug all openings.
2. Remove the two pins securing the jack assembly to the front chassis. Remove the jack assembly.

NOTE: The front jack cylinder assembly weighs approximately 78.9 kg (174 lb).

3. Tag and disconnect the two hoses to the check valve block on top of the cylinder. Cap or plug all openings.
4. Remove the two bolts securing the check valve block to the cylinder port block. Remove the check valve block.
5. Slide the cylinder out of the cylinder support tube.

Installation

1. Apply grease (EP-MPG) to the inside of the jack cylinder support tube.
2. Slide the cylinder into the cylinder support tube.
3. Install the check valve block on the cylinder port block using the two bolts.
4. Connect the hoses to the check valve block as tagged prior to removal.
5. Install the jack assembly on the front chassis using the two pins. Ensure there is a ground clearance of 35 to 48 cm (14 to 19 in) under the jack cylinder.
6. Connect the hoses coming from the truck to the relief valve on the side of the jack cylinder support tube as tagged prior to removal.

Functional Check



Extend and set the four main outriggers before extending the single front outrigger (SFO) jack.

1. Extend and set the outriggers.
2. Extend and retract the front jack cylinder.
3. Observe for proper operation of the cylinder.
4. Check the hydraulic connections for evidence of leakage.

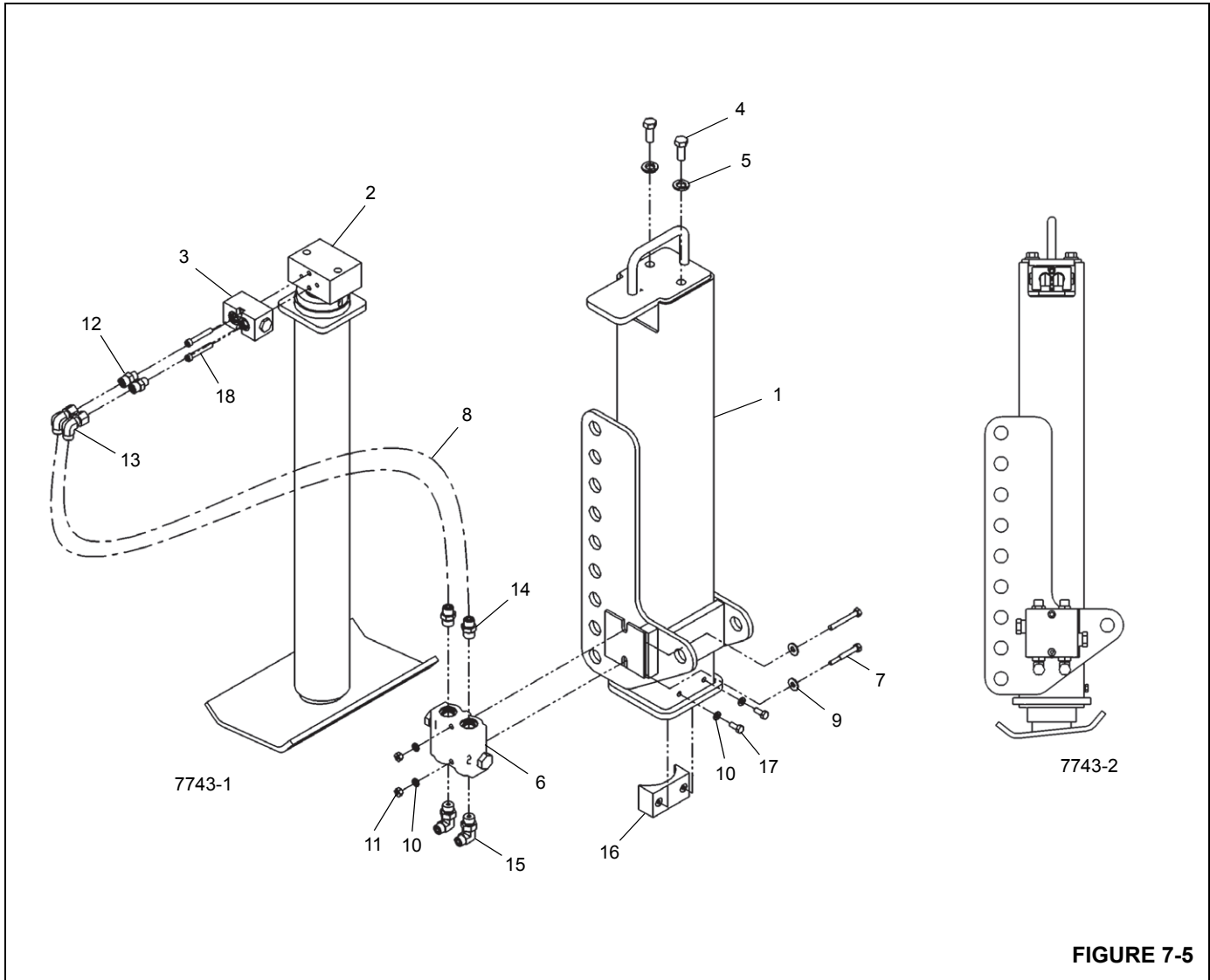


FIGURE 7-5

Item	Description
1	Single Front Outrigger Leg (Optional)
2	Cylinder Assembly
3	Check Valve
4	Hex Head Capscrew 1/2-13UNCx1.25 G5
5	Lock Washer 1/2" Reg
6	Relief Valve
7	Hex Head Capscrew 5/16-18UNCx2.5 G5
8	3/8" I.D. Hydr Hose Str B
9	Flat Washer 5/16" Wide MS

Item	Description
10	Lock Washer 5/16" Reg
11	Hex Nut 5/16-18UNC
12	Straight Thread Adapter
13	90 Deg Elbow - Male ORS Thd
14	Straight Thread Adapter
15	90 Deg Elbow
16	Wear Pad
17	Hex Head Capscrew- 5/16-18UNCx0.75 G5
18	Socket Head Capscrew 5/16-18UNC

SECTION 8 LUBRICATION

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GENERAL

Following a designated lubrication procedure is important to ensure a maximum crane life. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information. This section does not include lubrication requirements for the truck chassis. Refer to truck service manual for this information.

The service intervals specified are for normal operation where moderate temperature, humidity, and atmospheric conditions prevail. In areas of extreme conditions, the service periods and lubrication specifications should be altered to meet existing conditions. For information on extreme condition lubrication, contact your local National Crane Distributor or Manitowoc Crane Care.

Environmental Protection

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

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

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

When filling and draining crane components, observe the following:

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

Lubricants

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

Arctic Conditions Below -9°C (15°F)

In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester



hydraulic fluids, might not be compatible with hydraulic system seals and wear bands. If you are in doubt about the suitability of a specific fluid, check with your authorized National Cranes distributor or Manitowoc Crane Care.

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

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

Chassis Grease

CAUTION

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

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

CAUTION

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

Low Temperature Grease

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

Extreme Pressure Multipurpose Gear Lubricant (EPGL)

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

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

Open Gear Lubricant

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

Antifreeze/Coolant (for Cab Heater)

The standard antifreeze/coolant 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 8-1.

Standard Hydraulic Oil

Temperature Above -9° C (15° F)

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

NOTE: On units equipped with self-leveling platforms, low temperature service oils are necessary to provide proper boom functions at temperatures below -9° C (15° F).

CAUTION

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

Arctic Hydraulic Oil

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

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

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

Petroleum based fluids developed especially for low temperature service may be used with satisfactory results. However, certain fluids, such as 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 by-pass condition, the hydraulic oil must be sampled. The hydraulic tank breather should also be inspected to assure that it is not restricting air flow into and out of the reservoir.

To inspect the hydraulic oil, fill a small glass container with a sample of the reservoir oil and another glass container with fresh oil. Let the samples stand, undisturbed, for one or two hours. Then, compare the samples. If the reservoir oil is heavily contaminated with water, the sample will appear “milky” with only a small layer of transparent oil on top. If the

“milky” appearance is due to air foaming, it will dissipate and the oil should closely match the fresh oil. Remember, replacement oil must meet ISO 17/14 or better cleanliness level and must meet John Deere Standard JDM J20C. Contact your National Crane distributor or Manitowoc Crane Care if you have any questions.

LUBRICATION

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 (page 8-4) are to be used only as a guide. Actual intervals should be formulated by the operator to correspond accordingly to conditions such as continuous duty cycles and/or hazardous environments.

The following describe the lubrication points and gives the lube type, lube interval, lube amount, and application of each. Each lubrication point is numbered, and this number corresponds to the index number shown on the Lubrication Chart (Figure 8-1). Lube description and symbols are found in tables below.

Lubrication Chart

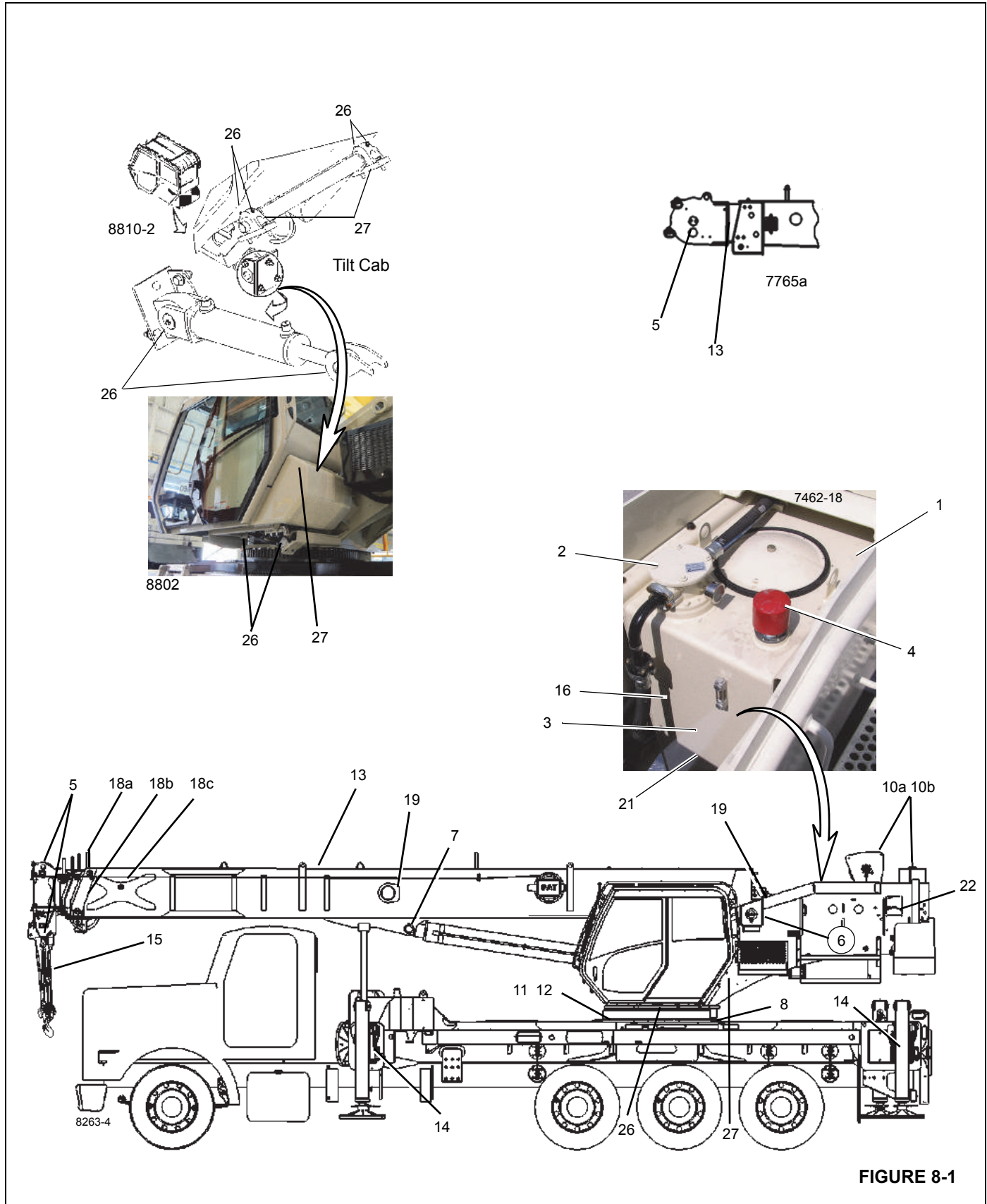


FIGURE 8-1

Symbol	Description	Manitowoc Lube Specification	
		Standard	Cold Weather -40°C (-40°F)
AFC	Antifreeze/Coolant (for Cab Heater)	6829101130	6829104212
EP-MPG	Extreme Pressure Multipurpose Grease	6829003477	6829104275
GL-5	GL-5 Gear Lubricant	6829012964	6829014058
HYDO	Hydraulic Oil	6829006444	6829006993
EP-OGL	Open Gear Lubricant, CEPLATTYN 300 Spray, NLGI Grade 1-2	6829102971	6829102971
AGMA EP-4	Extreme Pressure Gear Lubricant.	6829100213	6829103636
WRL	Wire Rope Lubricant	6829015236	6829010993
EO-20W-20	Engine Oil (Light non-EP Oil), Mil-L-46152	6829005570	-
TES 295	TES295 Compliant Fluid	-	6829101690

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

Item	Application	Recommended Lubricant	Procedure	Frequency
1	Hydraulic Oil Tank Reservoir	HYDO	Check, fill, change	Weekly, as required, Semi-Annually
2	Hydraulic Tank Oil Filter		Change or clean	After first 40 hours, Quarterly thereafter.
3	Hydraulic Tank Suction Filter (inside tank)		Change or clean	After first 40 hours, Quarterly thereafter.
4	Breather, Hydraulic Oil Reservoir		Clean	Monthly
5	Sheave Pins: boom (5 plcs), Jib (1 pl), Block (1 pl), Rooster Sheave (1 pl)	EP-MPG	Grease gun	Weekly
6	Boom Pivot Pin	EP-MPG	Grease gun	Monthly
7	Lift Cylinder Pin	EP-MPG	Grease gun	Monthly
8	Swing Bearing	EP-MPG	Grease gun	Weekly
10a	Hoist Gearbox	GL-5	Gearbox check and fill	Gearbox check and fill: As part of daily crane inspection, check the hoist for visible leaks.
10b	Hoist Brake	EO-20W-20 or TES295	Gearbox change Brake check and fill Brake change	Gearbox change: Every 1000 hours or 6 months of use. Brake check and fill: As part of daily crane inspection, check the hoist for visible leaks. Brake change: Every 1000 hours or 6 months of use.
11	Swing Drive Gearbox	GL-5	Check and Fill Change	Check and fill: As part of daily crane inspection, check the gearbox for visible leaks. Change: After the first 50 hours of use, then every 1000 operating hours or 6 months thereafter.
12	Swing Gear Teeth	EP-OGL	Spray Can	Monthly
13	Boom - Wear Pads (Inner, Side and Bottom)	LTG	See 8-7	Monthly or as required
14	Outrigger Beams - Bottom, Sides	LTG	Brush or roller spray can	Monthly or as required
15	Wire Rope (loadline)	EP-OGL	Brush or spray	Semi-Annually
16	Diffuser Strainer, Hydraulic Oil Reservoir		Clean	Semi-Annually with oil change
17	Swing Motor Pinion Gear	EP-MPG	Grease Gun	Sparingly every 50 hours
18a	Extend Sheaves: Top of 2nd Section - 103 foot and 128 foot Booms	EP-MPG	Grease Gun	Weekly
18b	Extend Sheaves: Side of 4th Section 128 Foot Boom Each Side	EP-MPG	Grease Gun	Weekly
18c	Extend Sheaves: Telescope Cylinder	EP-MPG	Grease Gun	Weekly
19	Retract Sheaves: Fully retract the boom until the retract sheave grease fittings can be accessed from the rear of the booms or extend the booms until the grease fittings are visible through the access holes at the center of boom.	EP-MPG	Grease Gun	Weekly

Item	Application	Recommended Lubricant	Procedure	Frequency
20	Extension Cables (Not Shown)	WRL	Spray or Brush	Any time boom is disassembled or 5 years
21	Hydraulic Tank - Magnetic Plug (tank bottom)		Clean	When servicing hydraulic tank, item 1
22	Cab Heater Reservoir	AFC	Check/Fill Drain and fill	Weekly, fill as required Semi-Annually
23	Hook Block Swivel Bearing	EP-MPG	Grease gun	Monthly
24	Hook Block Sheaves	EP-MPG	Grease gun	Monthly
25	Turntable Swing Lockpin	EP-MPG	Spray	Monthly
26	Cab Tilt Cylinder Pivot Pins - (If equipped with Cab Tilt)	EP-MPG	Grease gun	Every 500 hours or 3 months
27	Cab Pillow Block - (If equipped with Cab Tilt)	EP-MPG	Grease gun	Every 500 hours or 3 months

NOTE: Lubricate items more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.

Internal Cable Sheave Lubrication



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

Lubrication of the extend and retract sheaves as follows:

1. Locate the fittings as listed in the table above.
2. Lubricate the sheave pins until a small amount of grease extrudes from the pin.

Side and Bottom Boom Wear Pad 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-MPG grease.

1. Fully extend and set the outriggers.
2. Lower the boom to horizontal.
3. Extend the boom and apply grease to the sides and bottom of the Tele 2, Tele 3, Tele 4, and Tele 5 sections at contact areas with a brush or putty knife.
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.

Top Boom Wear Pad 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.
2. Lower the boom to horizontal.
3. Remove access plate at top rear of the base section.
4. Extend the boom until wear pads are centered in access opening and apply grease to all wear pads and contact surfaces at the top of all boom sections with a grease gun or a brush.
5. Raise the boom to 75°.
6. Extend and retract the boom several times until the grease is evenly spread.
7. Repeat as necessary.

Outrigger Beam Lubrication



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

Recommended lubricant is EP-3MG grease.

1. Fully extend and set the outriggers. Refer to (Figure 8-2.)
2. Apply grease to all wear pads and contact surfaces at the side and bottom of all beam sections and lower surface of the 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.



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FIGURE 8-2

Hoist Brake Oil



DANGER

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

Check Hoist Brake Oil

To check the hoist brake oil, remove the inspection plug (2, Figure 8-3) and visually inspect the oil level. The fluid should be level with 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 (2).

Drain /Add New Hoist Brake Oil

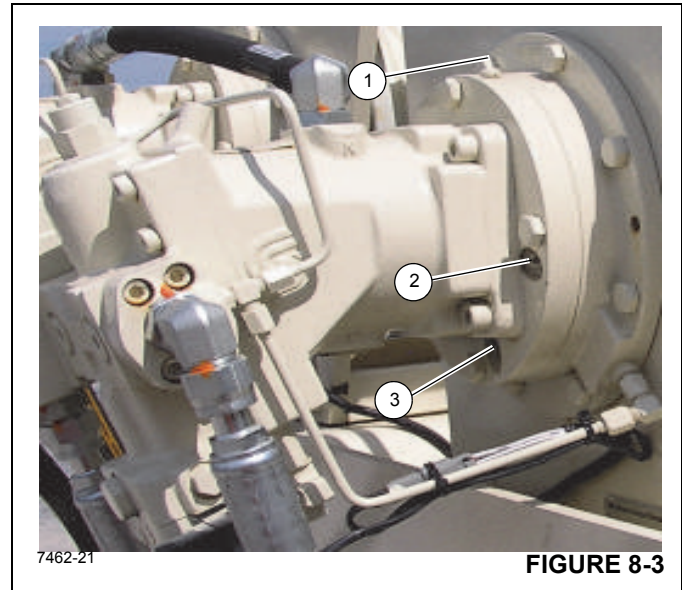
To drain and add new oil, remove the drain plug (3, Figure 8-3), inspection plug (2) and vent plug (1) and drain the hydraulic oil. Reinstall drain plug (3) and add fluid at the inspection hole (2), until oil is at the bottom level of the inspection hole. Install the inspection plug and the oil vent (1) and the inspection plug (2). See "Lubrication" on page 8-3. The hoist brake fill capacity is 0.23 liter (.25 quart).

NOTE: Hoist 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.



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FIGURE 8-3

Hoist Gearbox Oil

Check hoist gearbox oil level:

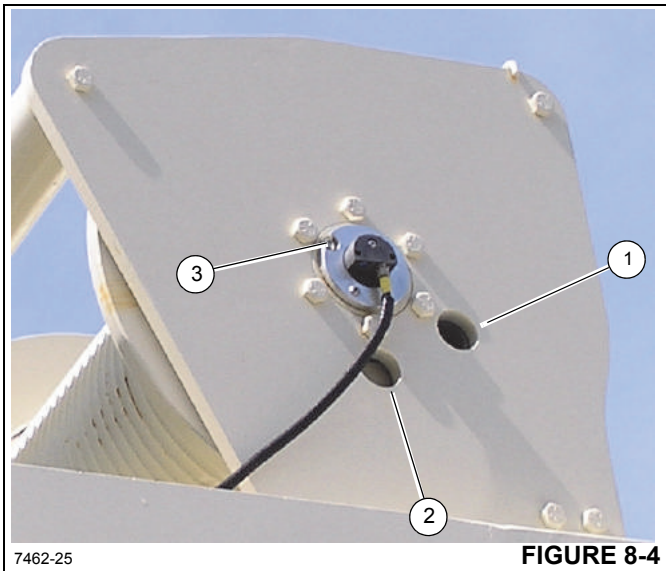
- Rotate the drum until the oil fill/level plug (1, Figure 8-4) is visible in the inspection hole.
- Remove the fill/level plug (1) and visually inspect the oil level. The oil should be level with the bottom of the inspection hole. If more oil is needed, add and reinstall fill/level plug.
- To drain and add new oil, remove the vent plug (3, Figure 8-4). Remove the drain plug (2) with a hex head socket and then screw a 1" pipe into the drain plug hole (2) to allow the oil to drain. Drain hydraulic oil. Remove the 1" drain pipe and install drain plug (2).

Fill hoist gearbox with oil:

- To fill with oil, rotate the drum so the fill/level port (1, Figure 8-4) is visible through the upper hole. Install a 1" pipe with elbow into the fill hole (1) to assist in adding oil. Remove fill/level plug with a hex socket and fill gear box with 3.3 l (3.50 qt) of gear lube oil. See "Lubrication" on page 8-3.

- Hoist gear 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.

Hoist gear 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.



Swing Gearbox and Brake Oil

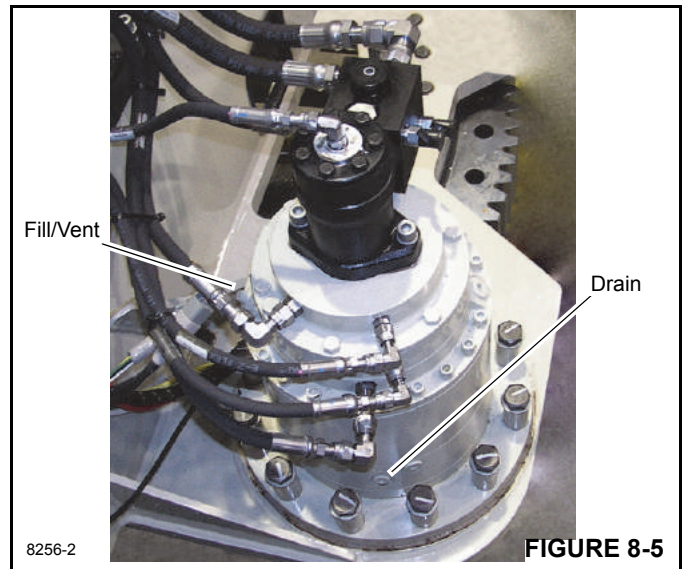
Check Swing Gearbox oil level:

The oil in the gearbox and brake sections is recommended to be changed after every 1000 hours or 6 months of usage. Gearbox oil is drained by removing the drain plug and vent (See Figure 8-5).

1. Examine the used oil for signs of significant metal deposits and then dispose of it in a proper manner.
2. Replace the drain plug.
3. Fill the swing gearbox with the appropriate amount and type of oil and then replace plug and vent. See "Lubrication" on page 8-3 of this manual.

Gearbox oil level inspection is achieved by removing the gearbox fill/vent plug and visually inspecting the oil level. Maximum oil level is to be 1" below the port for this gearbox with 3.3 l (3.50 qt) of gear lube oil.

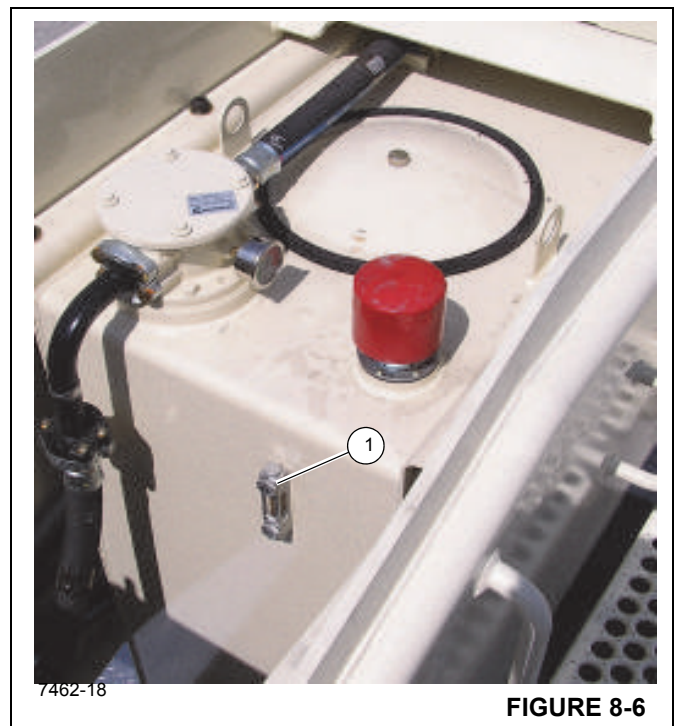
Gearbox lubricants are satisfactory for standard operation in temperatures from -23° C to 82° C (-10° F to +180° F). For operation outside this range, contact Manitowoc Crane Care for recommendations.



Hydraulic Oil Reservoir Level

The hydraulic oil reservoir has a sight gauge (1, Figure 8-6) located on the side of the reservoir. The oil in the hydraulic reservoir is sufficient when the level is between the High and Low marks on the sight gauge with the crane parked on a level surface in the transport position and the oil cold.

If the oil level is too low, add the recommended hydraulic oil until the oil level is even with the upper mark. If the oil level is high, drain oil until the oil level is even with the upper mark.



Surface Protection for Cylinder Rods

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

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

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

WIRE ROPE LUBRICATION

Wire rope is lubricated during manufacture and the lubricant applied does not last the life of the rope. The wire rope must be lubricated as part of a regularly scheduled maintenance program. The lubricant applied must be compatible with the original lubricant and not hinder visual inspection of the rope. Consult the rope manufacturer for proper lubricant. The sections of rope which are located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention.

The object of rope lubrication is to reduce internal friction and to prevent corrosion. The type and amount of lubrication applied during manufacture depends on the rope size, type, and anticipated use. This lubrication provides the finished rope with protection for a reasonable time if the rope is stored under proper conditions. When the rope is put into service, periodic applications of a suitable rope lubricant are necessary. Characteristics of a good wire rope lubricant are that it should be:

- free from acids and alkalis.
- have sufficient adhesive strength to remain on the rope.
- of a viscosity capable of penetrating the interstices between wires and strands.
- not be soluble in the medium surrounding it under the actual operating conditions (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.

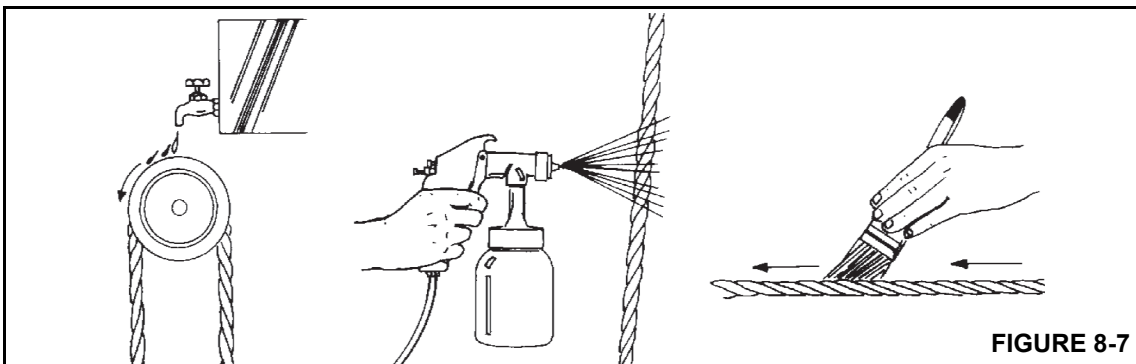


FIGURE 8-7

CARWELL® RUST INHIBITOR

Protecting Cranes From Rusting

National Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

National cranes will be treated with a rust inhibitor called Carwell® T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on National cranes that are treated with this product.

Carwell® is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29 CFR 19 10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

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

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

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

In addition to the factory-applied treatment, National crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on National cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

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

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

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

Cleaning Procedures

To help protect against corrosion of National cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleaning may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.

- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.



CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

For scratches and marks in highly visible areas:

- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to ensure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

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

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

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

- Do not apply to recently primed and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Crane must be completely dry before applying treatment.

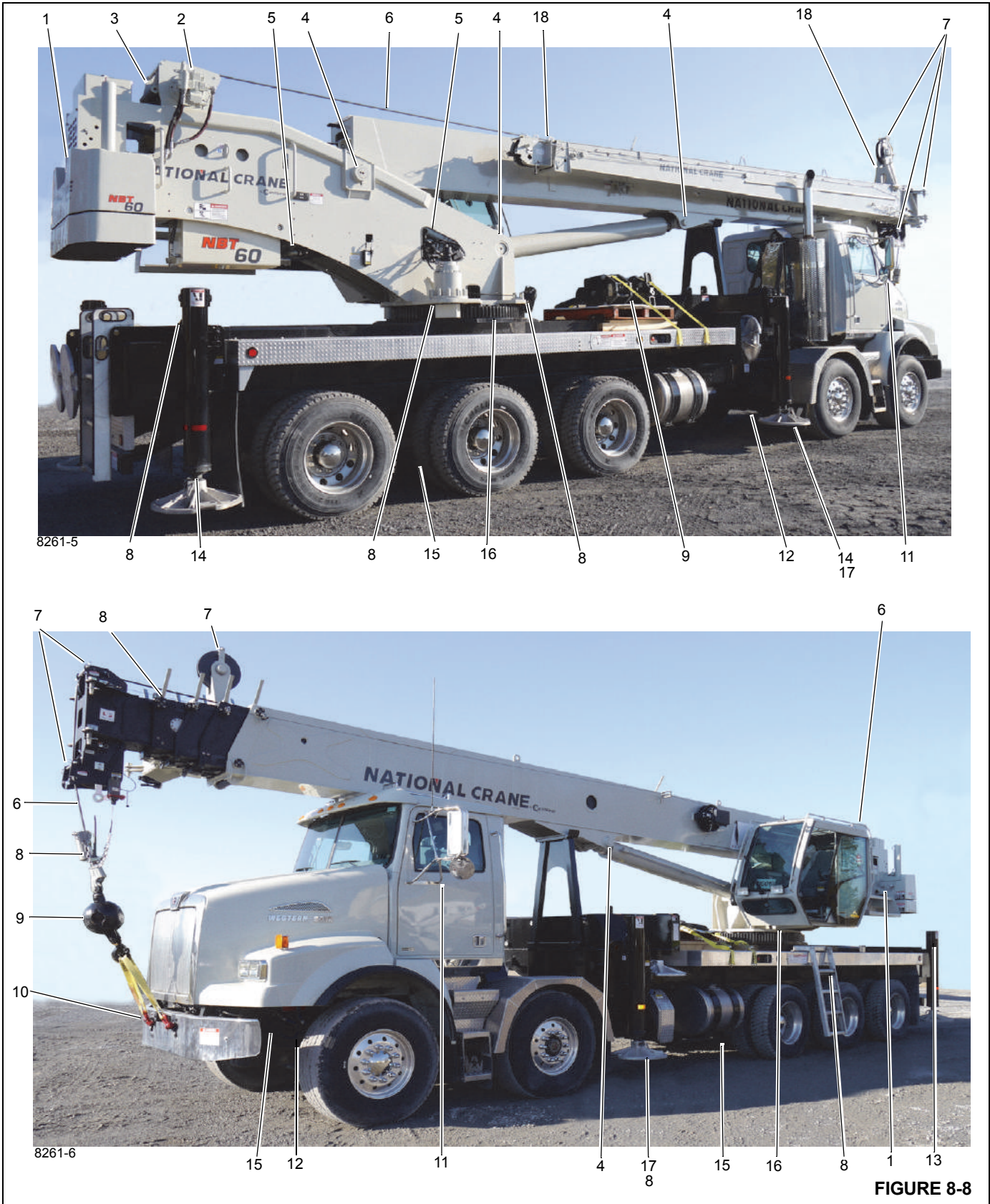
- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Crane should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the crane.
- Use of pressure pots to apply the treatment to the crane being processed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

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 8-8

- The underside of the crane will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; Valves, hose ends and fittings, swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.
- Boom applications areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.



Item	Description
1	Counterweight Pins
2	Hoist Plumbing Connections
3	Tension Spring
4	Pivot Shaft
5	Valve bank, Hose Connections inside turntable
6	Wire Rope
7	Boom Nose Pins, Clips
8	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
9	Headache Ball/Hook block

Item	Description
10	Headache Ball/Hook Block Tiedown
11	Mirror Mounting Hardware
12	Powertrain Hardware
13	O/R Hose Connections
14	O/R Pins, Clips
15	Entire underside of crane
16	Turntable Bearing Fasteners
17	Outrigger Beam Hardware
18	Boom Extension Hardware (Optional)

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SECTION 9 CRANE INSTALLATION

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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 men [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.

Verify that the number on the serial number plates on the major components match the main serial number located on the crane frame. 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

Many factors must be considered in the selection of a proper truck for a NBT60 series crane. Items which must be considered are:

1. **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.
2. **Wheelbase (WB), Cab-to-Trunnion (CT) and Bare Chassis Weight.** The wheelbase, CT and chassis weights shown meet the driving and stability requirements in all states. 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 the Mounting Configuration pages for additional information.
3. **Axle Weight Limits.** Individual states vary on the permissible loads that a three axle or a four axle truck may carry on state highways. Some states allow



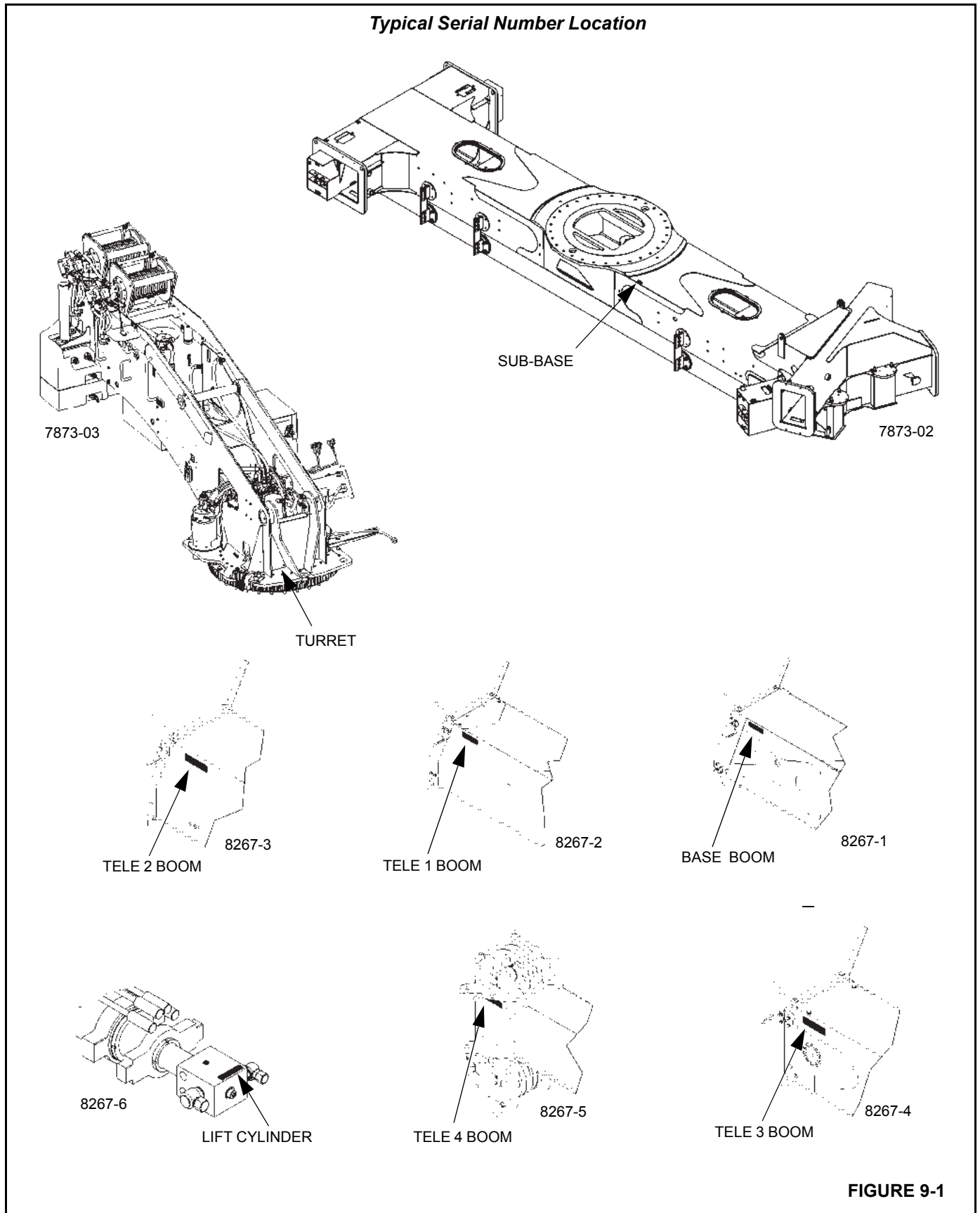
25,000 pounds on the steering axle and 55,000 pounds on a tandem/tridem axle if the crane is designated as a truck mounted crane. All states must use the Federal Bridge Law requirements for trucks operating on the Interstate highway system. While other arrangements are possible, a seven axle, 80,000 lb truck (two pusher axles, a tridem axle and a tag axle) will meet bridge laws with a front to rear axle spacing of 34 ft. These measurements are taken between the extremes of the front and the rear axles.

- 4. Truck Frame.** Try to select a truck frame that will minimize or eliminate frame reinforcement or extension of the after frame (AF). Many frames are available that have the necessary after frame (AF) section modulus (S.M.) and resistance to bending moment (RBM) so that reinforcing is not required. (If equipped) the front hydraulic jack is used for a 360° working range around the truck. The frame under the cab through the front suspension must have the minimum S.M. and RBM because reinforcing through the front suspension is often difficult because of engine, radiator mounts and steering mechanics. See "Truck Requirements" and "Frame Strength" pages for the necessary section modulus and resistance to bending moment values.

- 5. Additional Equipment.** In addition to the axle ratings, wheelbase, cab-to-axle requirements and frame, it is recommended that the truck is equipped with electronic engine control, increased cooling and a transmission with a PTO opening available with an extra heavy duty PTO. See "PTO Selection" pages. A conventional cab truck should be used for standard crane mounts.
- 6. Neutral Start Switch.** The chassis must be equipped with a switch that prevents operation of the engine starter when the transmission is in gear.
- 7. Serial Number Identification** - Figure 9-1 shows the typical locations for the Serial Number identification tags that are fastened to the main components of the crane.

Before proceeding with the installation, verify that the number on the serial number plates on the major components match the main serial number which is found on the crane frame.

If the serial numbers do not match, contact the factory before proceeding. Matching the serial number plates insures that accurate warranty information will be recorded at the factory and will aid in dispensing service bulletins and other pertinent information.



MOUNTING CONFIGURATIONS

Table 9-1 Weight and Center of Gravity (CG) Data

Weight and CG Estimates (See Notes)				
Standard NBT Configuration	Horizontal CG mm (in)	Weight with Fluids kg (lb)	Counterweight Pinned (No. Slabs)	Counterweight Stowed (No. Slabs)
NBT60128	459 (18.1)	23,065 (50,850)	2	0
NBT60128	872(34.3)	23,065 (50,850)	1	1
NBT60128	1,293(50.9)	23,065 (50,850)	0	2
NBT60128	708(27.9)	21,704 (47,850)	1	0
NBT60128	1,155(45.5)	21,704 (47,850)	0	1
NBT60128	1,068 (42.1)	19,986 (44,061)	0	0

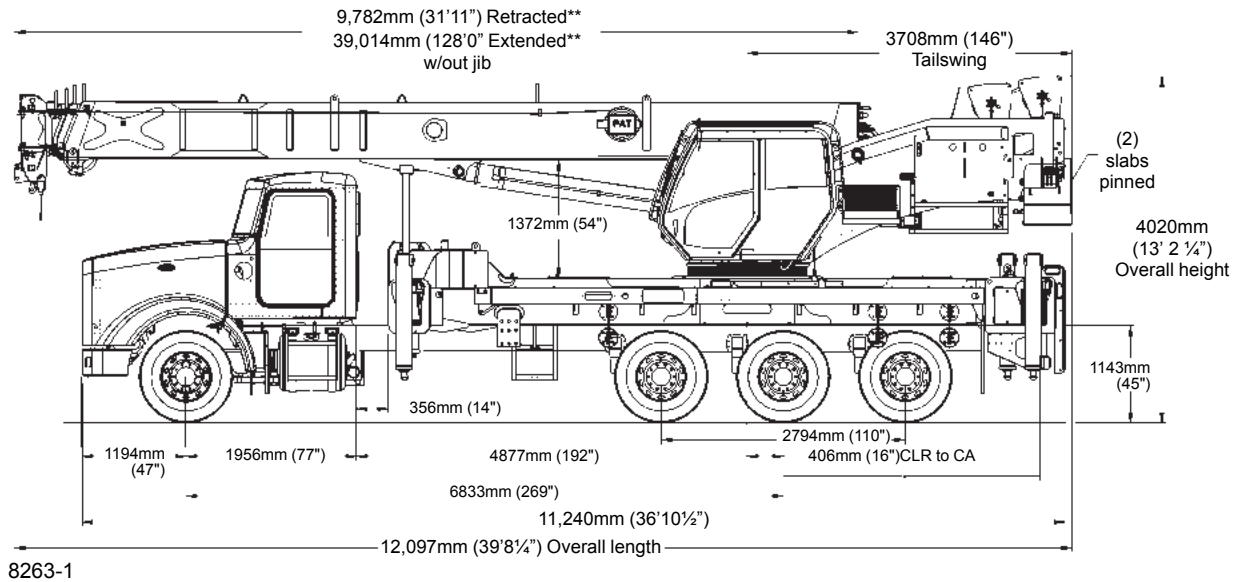
Weight and CG Estimate Notes:

1. Information is for reference only
2. Weight and CG data is applicable for a standard crane:
 - 128 ft boom
 - 2/3 part lineblock included
 - Main hoist only (auxiliary hoist IPO counterweight present)
 - STD decking with fixed access ladder
 - No boom extension equipped
 - No optional turret access step
 - No Auxiliary nose or optional hook blocks.
3. All counterweight configurations are shown in table:
 - Pinned = attached to cylinders and turret (in use)
 - Stowed = attached to torsion box (not in use)
 - "2" = Top and bottom slabs
 - "1" = Top or bottom slab only
 - "0" = No slab pinned and/or stowed

If both stowed and pinned columns are "0" the counterweight is physically removed from the crane. IPO counterweight is also assumed removed in this case (if no auxiliary hoist is equipped).

For more information contact Manitowoc Crane Care or your local National Crane distributor.

Configuration 1-NBT60128 (4-axle Minimum Truck)

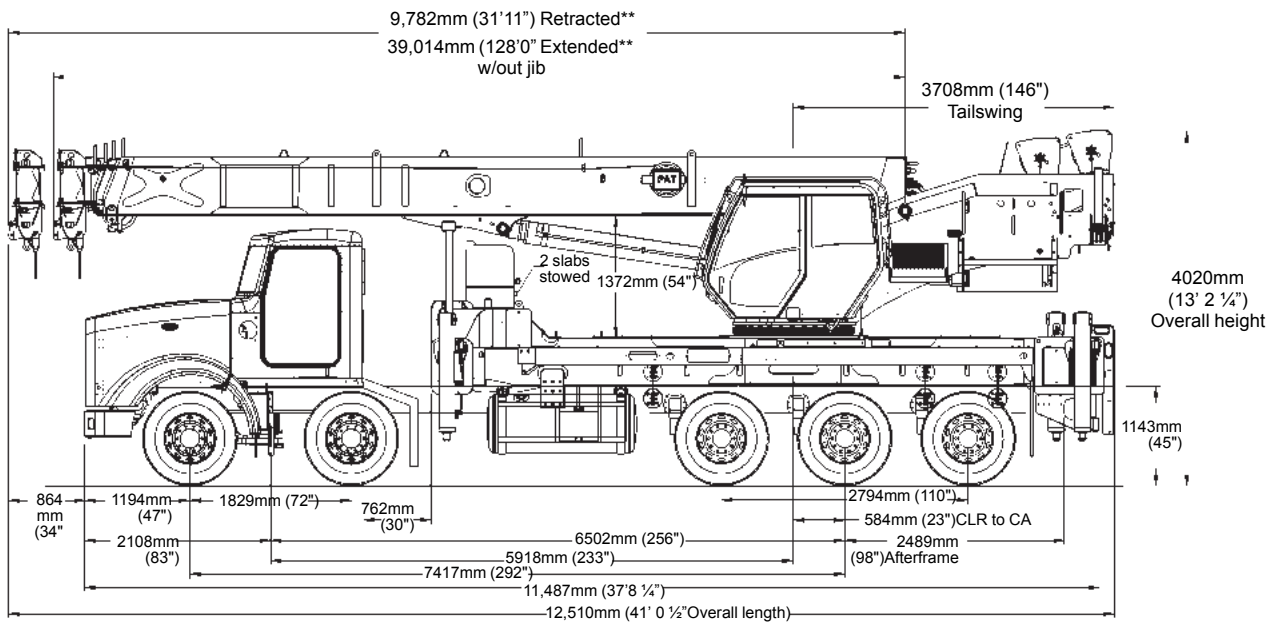


Working area	360°
Gross Axle Weight Rating, Front	9,072 kg (20,000 lb)
Gross Axle Weight Rating, Rear	29,937 kg (66,000 lb)
Gross Vehicle Weight Rating	39,009 kg (86,000 lb)
Wheelbase (WB)	683 cm (269 in)
*Note: Estimated axles scale weights prior to installation of crane assembly for 85% stability	

Cab to Axle /Cab to Trunnion	488 cm (192 in)
Frame Strength	785 MPa (110,000 PSI)
Frame Section Modulus (SM); front axle to end of After Frame (AF)	327 cm ³ (20 in ³)
Stability Weight, Front	4445 kg (9,800 lb)
Stability Weight, Rear	5,670 kg (12,500 lb)
**Note: Some overhang may be necessary to road hookblock/headache ball	

FIGURE 9-2

Configuration 2-NBT60128 (Heavy Lift Truck-Tandem/Tridem)



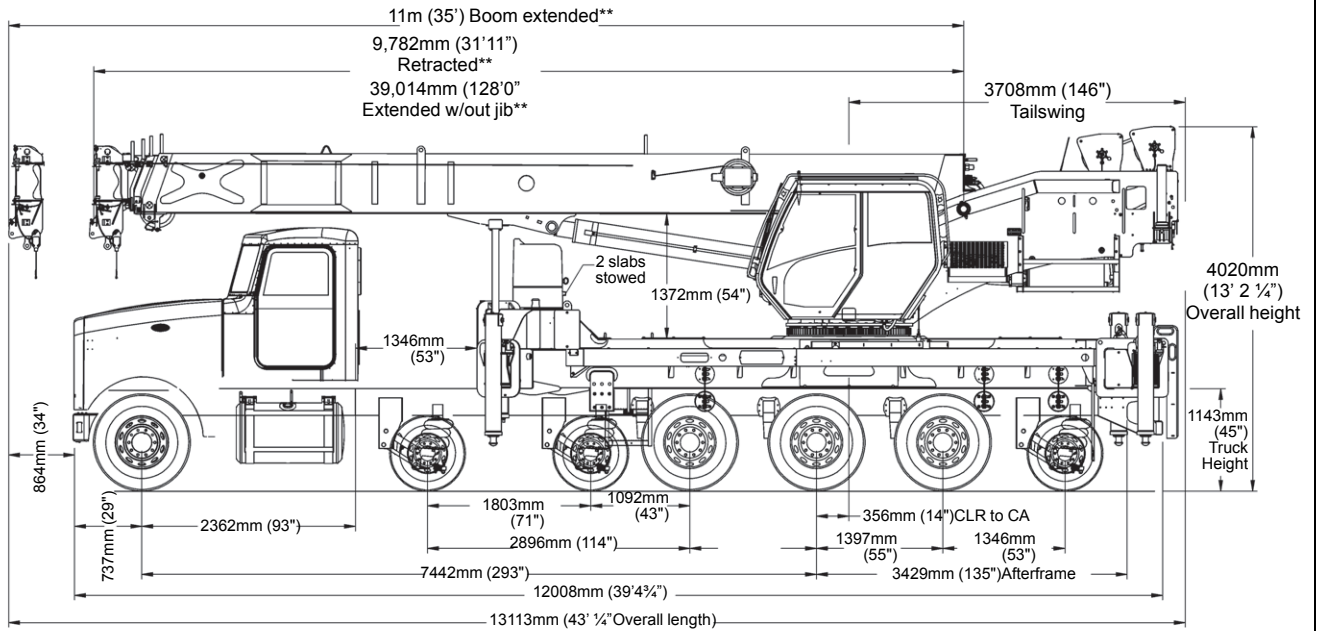
8263-2

Working area	360°
Gross Axle Weight Rating, Front	18,144 kg (40,000 lb)
Gross Axle Weight Rating, Rear	29,937 kg (66,000 lb)
Gross Vehicle Weight Rating	48,080 kg (106,000 lb)
Wheelbase (WB)	742 cm (292 in)
*Note: Estimated axles scale weights prior to installation of crane assembly for 85% stability	

Cab to Axle /Cab to Trunnion	546 cm (215 in)
Frame Strength	785 MPa (110,000 PSI)
Frame Section Modulus (SM); front axle to end of After Frame (AF)	327 cm³ (20 in³)
Stability Weight, Front	6,940 kg (15,300 lb)
Stability Weight, Rear	5,125 kg (11,300 lb)
**Note: Some overhang may be necessary to road hookblock/headache ball	

FIGURE 9-3

Configuration 3-NBT60128 (7-Axle Federal Bridge-Compliant)

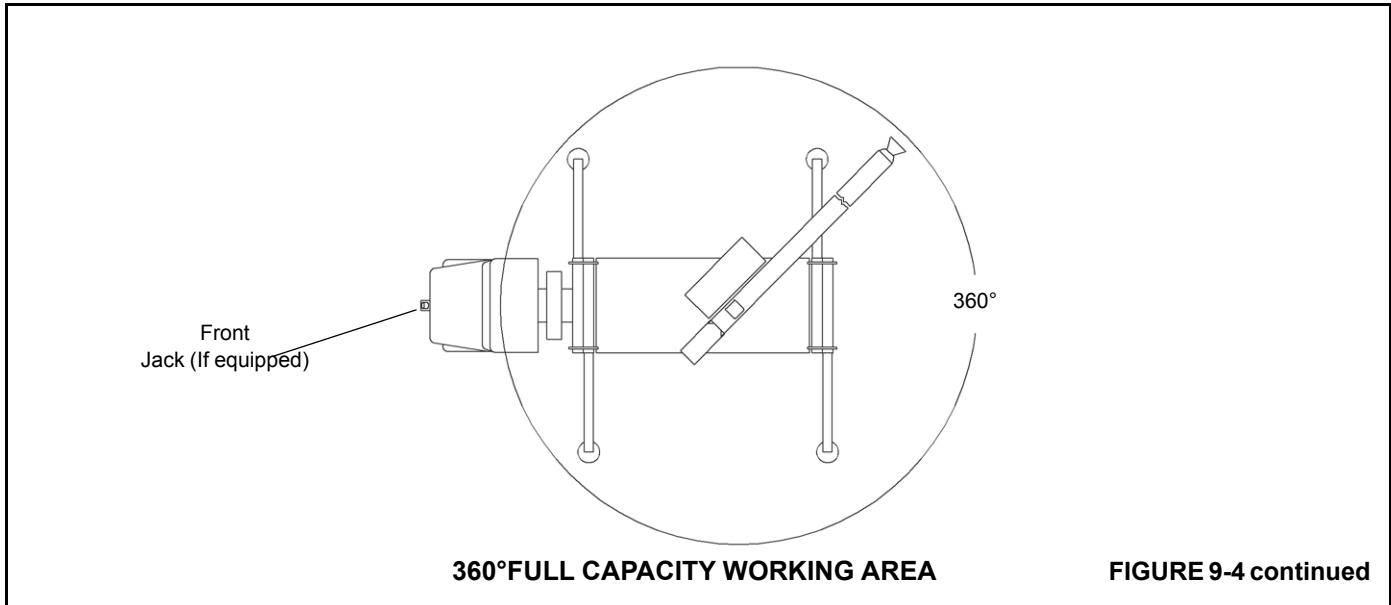


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Working area	360°
Gross Axle Weight Rating, Front	9,072 kg (20,000 lb)
Gross Axle Weight Rating, Rear	29,937 kg (66,000 lb)
Gross Vehicle Weight Rating - Pusher 1	3,629 kg (8,000 lb)
Gross Vehicle Weight Rating - Pusher 2	3,629 kg (8,000 lb)
Gross Vehicle Weight Rating, - Tag	3,629 kg (8,000 lb)
Wheelbase (WB)	744 cm (293 in)

Cab to Axle /Cab to Trunnion (CA/CT)	508 cm (200 in)
Frame Strength	785 MPa (110,000 PSI)
Frame Section Modulus (SM); front axle to end of After Frame (AF)	327 cm ³ (20 in ³)
Stability Weight, Front	5,341 kg (11,775 lb)*
Stability Weight, Rear	6,031 kg (13,295 lb)*
*Note: Estimated axles scale weights prior to installation of crane assembly for 85% stability	
**Note: Some overhang may be necessary to road hookblock/headache ball	

FIGURE 9-4



The mounting configuration shown is based on an 85% stability factor.

The complete crane must be installed on the truck in accordance with factory requirements, and a test performed to determine actual stability and counterweight requirements, since individual truck chassis vary.

If bare truck weights are not met, counterweight will be required.

A summary of mounting and truck requirements are as follows:

- Working area 360°
- Gross Axle Weight Rating (GAWR), front 9,072 kg (20,000 lb)
- Gross Axle Weight Rating (GAWR), rear 29,937 kg (66,000 lb)
- Gross Lift Axle Weight Rating (Pusher or Tag) 3,629 kg (8,000 lb) minimum
- Gross Vehicle Weight Rating 39,009 kg (86,000 lb)
- Gross Tag Axle Rating (min) 4,536 kg (10,000 lb)
- Wheelbase (WB) 683 cm (269 in)
- Cab to Centerline of tridem axle 4.88 m (192 in)

- Cab to end of frame 804 m (331 in)
- Frame Section Modulus (SM), front axle to end of after frame (AF) 327 cm³ (20 in³)

Figure 9-3 shows the 360° working area that can be achieved with the single front outrigger (SFO) - if equipped on the NBT60. See "Truck Frame Strength" on page 9-11 for truck frame strength required for mounting crane.

Gross Vehicle Weight Rating (GVWR) is dependent on all components of the vehicle (axles, tires, springs, frame, etc.) meeting manufacturers' recommendations; always specify GVWR when purchasing trucks.

Diesel engines require a variable speed governor and energize-to-run fuel solenoid for smooth crane operation; electronic fuel injection is required.

All mounting data is based on a National Series NBT60 with subbase and an 85 percent stability factor.

The complete crane must be installed in accordance with factory requirements, and a test performed to determine actual stability and counterweight requirements; contact the factory for details.

Transmission neutral safety interlock switch is required.

PTO REQUIREMENTS

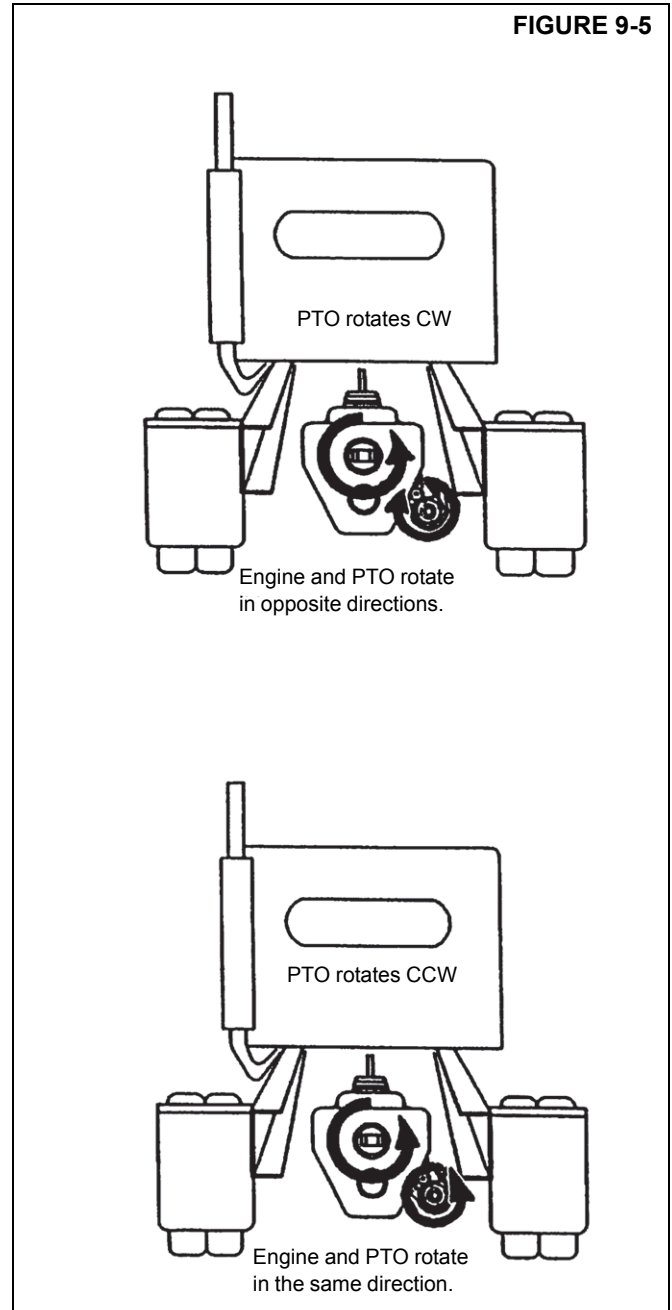
Pump Rotation

The hydraulic pump must be installed so that the pump rotates the same direction as the arrow on the pump housing. Make certain which direction the power take off output shaft rotates before selecting a clockwise (CW) or counter-clockwise (CCW) rotation hydraulic pump. Either CW or CCW rotation pumps are available and are marked clearly with a directional arrow on the pump housing.

CAUTION

Rotating the pump in the wrong direction damages the pump.

Do not confuse engine crankshaft rotation with power take off rotation. If the power take off shaft rotates opposite the engine crankshaft, it is turning in a clockwise direction when viewed from the rear of the truck. If the power take off shaft rotates the same as the engine crankshaft, it is turning in a counter clockwise direction when viewed from the rear of the truck. See Figure 9-5.



PTO Ratio

Pump shaft speed is determined by truck engine RPM and PTO ratio:

$$\text{Pump Shaft Speed} = \text{Truck Engine RPM} \times \text{PTO Ratio}$$

The following PTO ratio - engine speed combinations will provide 2,200 rpm pump shaft speed which is the recommended maximum speed for the NBT60 pump:

ENGINE SPEED (RPM)	PTO RATIO
2900	76%
2800	79%
2600	85%
2400	92%
2200	100%
2000	110%
1800	122%
1600	138%
1500	147%
1400	157%

The speeds shown above are optimum operating speeds. The engine must be operated at a speed such that the horsepower developed is adequate to pull the pumps under pressure and flow requirements.

PTO Horsepower Requirements

In order to operate the NBT60 pump at full flow and full pump pressure, a PTO capable of delivering 100 HP per 1000 RPM of shaft speed with 475 lb-ft torque rating is required. This is an extra heavy duty rated PTO and usually has an 8 bolt mount.

If it is desirable to integrally mount the pump to the PTO, most PTO's can be supplied with integral pump mounting brackets so that the standard pump may be integrally mounted. The back end of the pump must be supported because of pump weight. Use the support bars provided to do this.

The splined shaft coupling in a direct mount pump installation requires lubrication. #200S Silver Streak Special Multi-Lube (Medium) should be applied to the shaft during original installation and reapplied to the shaft or grease fitting provided on PTO housing shaft semi-annually thereafter.

TRUCK FRAME STRENGTH

In order for a truck frame to be suitable for accepting a NBT60 crane, the truck frame must have a requirement for rigidity so as not to allow excessive boom movement due to truck frame deflection when lifting over the front of the crane, and it must be strong enough to resist the loading induced by the crane so as not to permanently bend or deform. Section Modulus (S.M.) is a measurement of the area of the truck frame and determines the rigidity of the frame. Resistance to bending moment (RBM) is a measurement of strength and is determined by multiplying the section modulus of each frame rail by the yield strength of the rail material.

For a standard mount, the NBT60 requires a minimum of 3,000,000 lb-in RBM and 25 in³ S.M. from the rear of the truck frame to the front of the front outrigger boxes. The truck frame strength required from the front of the outrigger boxes to the single front outrigger (if equipped) attachment point is variable and is listed in the table below. Most truck frames have reduced section properties through the front suspension due to truck frame cut outs or because outer channel reinforcement stops short of the front suspension. In these cases it is imperative that the truck frame is measured and the section modulus is calculated and compared to the

table below to ensure adequate strength exists for front jack loading.

The distances listed in the chart below are shown in Figure 9-6.

Distance From SFO Attachment centimeters (Inches)	Section Modulus Per Rail cm ³ (in. ³)
0 - 30 cm (0 - 12 in)	44 cm ³ (2.7 in ³)
30 - 61 cm (12 - 24 in)	90 cm ³ (5.5 in ³)
61 - 91 cm (24 - 36 in)	134 cm ³ (8.2 in ³)
91 - 121 cm (36 - 48 in)	180 cm ³ (11.0 in ³)
121 - 152 cm (48 - 60 in)	224 cm ³ (13.7 in ³)
152 - 182 cm (60 - 72 in)	270 cm ³ (16.5 in ³)
182 - 213 cm (72 - 84 in)	315 cm ³ (19.2 in ³)
213 - 243 cm (84 - 96 in)	359 cm ³ (21.9 in ³)
243 - 274 cm (96 - 108 in)	405 cm ³ (24.7 in ³)
274 - 304 cm (108 - 120 in)	449 cm ³ (27.4 in ³)
304 + cm (120+ in)	492 cm ³ (30.0 in ³)

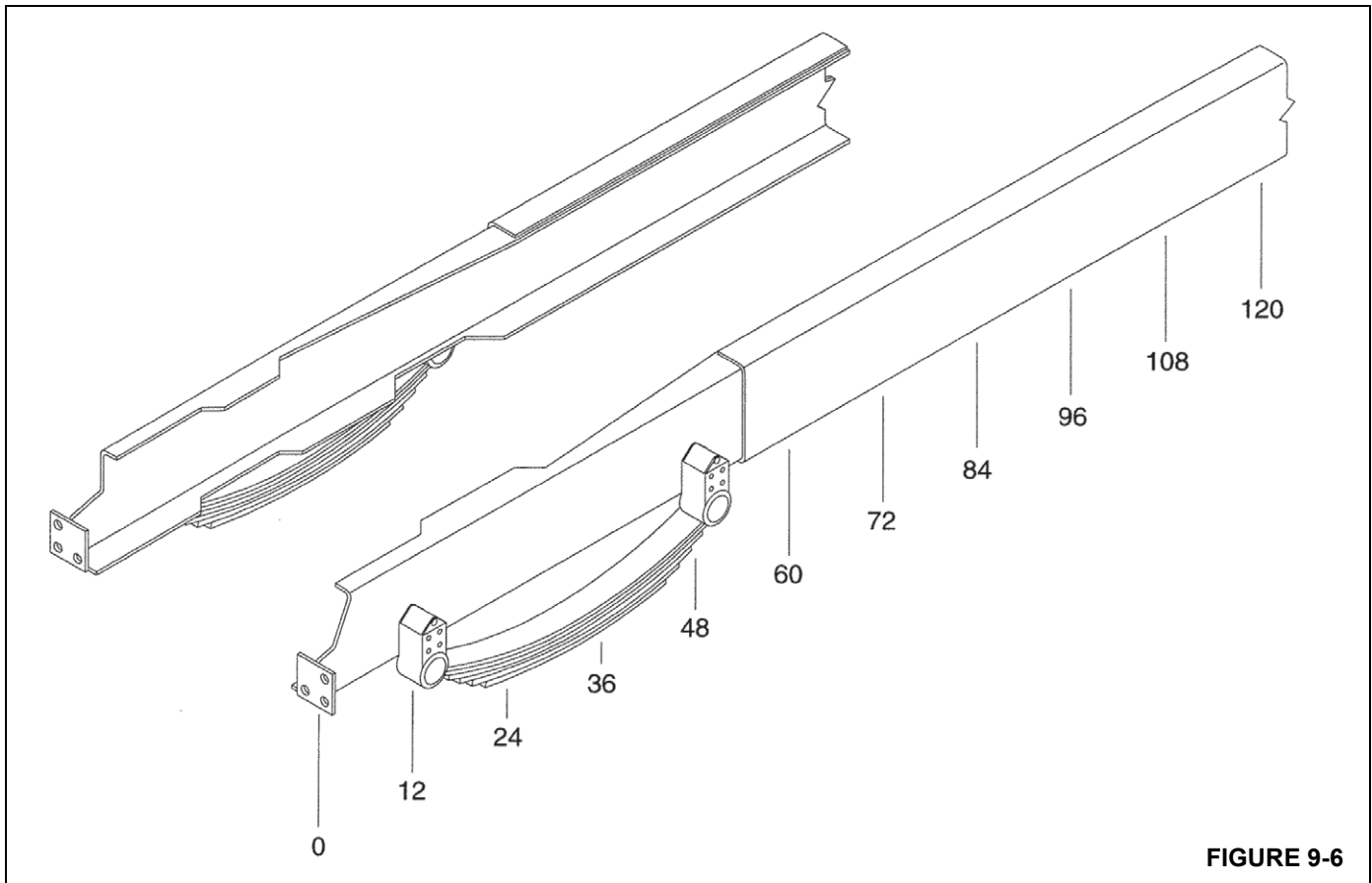


FIGURE 9-6

Section Modulus Tables

The following tables will help determine the section modulus of the truck frame. Always measure the truck frame and check the tables to be sure that any truck factory listed section modulus is correct.

- **Channel** (Table A). Table A provides the section modulus of channel frames in thicknesses of 3/16, 1/4, 5/16 and 3/8 with each grouping a flange width and web depth column. When the depth of frame channel and flange width is known, the point at which these two lines intersect is the section modulus from that particular channel.
If the section modulus of the channel does not meet the requirements, the channel should be reinforced in the most applicable method following.
- **Channel Reinforcement** (Table A). In order to provide more strength, a channel of suitable thickness can be added to the existing frame. The depth and flange width of this channel should be chosen so it fits over the existing frame. The section modulus of the needed channel is obtained from Table A and should be added to the section modulus obtained from the truck frame.

- **Angle Reinforcement** (Table B). If the truck is reinforced with an angle, refer to Table B for the data on the added strength provided by the angle. Add this to the section modulus of the channel obtained from Table A.
- **Fish Plate Reinforcement** (Table C). The frame can be strengthened by adding a fish plate of suitable thickness and depth equal to the frame. The section modulus of the fish plate can be obtained from table C and this must be added to the section modulus of the frame to obtain the total section modulus.
- **Angle Under Reinforcement** (Table D). This table lists the section modulus of an angle with the flange under the truck frame that is added to a frame with an angle reinforcement already added. Add the section modulus from Table D to the section modulus obtained from Tables A and B to determine total section modulus.

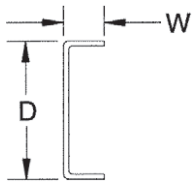
The edges of the reinforcing angles or channels are to be flush with the edges of the frame.

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)				
	2½ (64)	3 (76)	3½ (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 5/16 in (7.94 mm)				
	2½ (64)	3 (76)	3½ (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 1/4 in (6.35 mm)

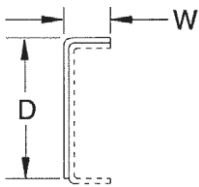
	2½ (64)	3 (76)	3½ (89)	4 (102)
8 (203)	6.9 (113)	7.8 (128)	8.8 (144)	9.7 (159)
9 (229)	8.2 (134)	9.2 (151)	10.3 (169)	11.4 (187)
10 (254)	9.5 (156)	10.7 (175)	11.9 (195)	13.1 (215)
11 (279)	11.0 (180)	12.3 (202)	13.6 (223)	14.9 (244)
12 (305)	12.5 (205)	13.9 (228)	15.3 (251)	16.8 (275)
13 (330)	14.1 (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 3/8 in (9.52 mm)

	2½ (64)	3 (76)	3½ (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)

	2¾ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	2.2 (36)	2.3 (38)	2.3 (38)	2.4 (39)
8½ (216)	2.8 (46)	2.9 (48)	3.0 (49)	3.0 (49)
9½ (241)	3.4 (56)	3.5 (57)	3.6 (59)	3.7 (61)
10½ (267)	4.1 (67)	4.3 (70)	4.4 (72)	4.5 (74)
11½ (292)	4.9 (80)	5.1 (84)	5.2 (85)	5.4 (88)
12½ (318)	5.8 (95)	6.0 (98)	6.1 (100)	6.3 (103)
13½ (343)	6.7 (110)	6.9 (113)	7.1 (116)	7.3 (120)
14½ (368)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)

THICKNESS 1/4 in (6.35 mm)

	2¾ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	2.9 (48)	3.0 (49)	3.1 (51)	3.2 (52)
8½ (216)	3.7 (61)	3.8 (62)	3.9 (64)	4.0 (66)
9½ (241)	4.5 (74)	4.7 (77)	4.8 (79)	5.0 (82)
10½ (267)	5.5 (90)	5.7 (93)	5.8 (95)	6.0 (98)
11½ (292)	6.5 (106)	6.7 (110)	6.9 (113)	7.1 (116)
12½ (318)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)
13½ (343)	8.8 (144)	9.1 (149)	9.4 (154)	9.6 (157)
14½ (368)	10.1 (166)	10.5 (172)	10.7 (175)	11.0 (180)

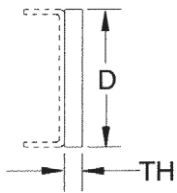
THICKNESS 5/16 in (7.94 mm)

	2¾ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	3.6 (59)	3.7 (61)	3.9 (64)	4.0 (66)
8½ (216)	4.6 (75)	4.7 (77)	4.9 (80)	5.0 (82)
9½ (241)	5.6 (92)	5.8 (95)	6.0 (98)	6.2 (102)
10½ (267)	6.8 (111)	7.1 (116)	7.3 (120)	7.5 (123)
11½ (292)	8.1 (133)	8.4 (138)	8.6 (141)	8.9 (146)
12½ (318)	9.5 (156)	9.8 (161)	10.1 (166)	10.4 (170)
13½ (343)	11.0 (180)	11.4 (187)	11.7 (192)	12.0 (197)
14½ (368)	12.6 (206)	13.0 (213)	13.4 (220)	13.7 (224)

THICKNESS 3/8 in (9.52 mm)

	2¾ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	4.3 (70)	4.5 (74)	4.6 (75)	4.8 (79)
8½ (216)	5.5 (90)	5.7 (93)	5.9 (97)	6.0 (98)
9½ (241)	6.7 (110)	7.0 (115)	7.2 (118)	7.4 (121)
10½ (267)	8.1 (133)	8.4 (138)	8.7 (143)	8.9 (146)
11½ (292)	9.7 (159)	10.0 (164)	10.3 (169)	10.6 (174)
12½ (318)	11.3 (185)	11.7 (192)	12.1 (198)	12.4 (203)
13½ (343)	13.1 (215)	13.6 (223)	14.0 (229)	14.3 (234)
14½ (368)	15.1 (247)	15.5 (254)	16.0 (262)	16.4 (269)

TABLE C

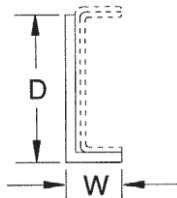


Section Modulus in³ (cm³)

	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)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	5.7 (93)	6.4 (105)	7.0 (115)	7.7 (126)
9 1/2 (241)	6.7 (110)	7.4 (121)	8.1 (133)	8.9 (146)
10 1/2 (267)	7.7 (126)	8.5 (139)	9.3 (152)	10.1 (166)
11 1/2 (292)	8.8 (144)	9.7 (159)	10.6 (174)	11.4 (187)
12 1/2 (318)	10.0 (164)	10.9 (179)	11.9 (195)	12.8 (210)
13 1/2 (343)	11.2 (184)	12.2 (200)	13.2 (216)	14.3 (234)
14 1/2 (368)	12.5 (205)	13.6 (223)	14.6 (239)	15.7 (257)
15 1/2 (394)	13.8 (226)	15.0 (246)	16.1 (264)	17.3 (284)

THICKNESS 1/4 in (6.35 mm)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	7.7 (126)	8.6 (141)	9.4 (154)	10.3 (169)
9 1/2 (241)	9.1 (149)	10.0 (164)	10.9 (179)	11.9 (195)
10 1/2 (267)	10.5 (172)	11.5 (188)	12.5 (205)	13.6 (223)
11 1/2 (292)	11.9 (195)	13.1 (215)	14.2 (233)	15.4 (252)
12 1/2 (318)	13.5 (221)	14.7 (241)	16.0 (262)	17.2 (282)
13 1/2 (343)	15.2 (249)	16.5 (270)	17.8 (292)	19.2 (315)
14 1/2 (368)	16.9 (277)	18.3 (300)	19.7 (323)	21.2 (347)
15 1/2 (394)	18.7 (306)	20.2 (331)	21.7 (356)	23.3 (382)

THICKNESS 5/16 in (7.94 mm)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	9.8 (161)	10.8 (177)	11.9 (195)	12.9 (211)
9 1/2 (241)	11.5 (188)	12.6 (206)	13.8 (226)	15.0 (246)
10 1/2 (267)	13.3 (218)	14.5 (238)	15.8 (259)	17.1 (280)
11 1/2 (292)	15.1 (247)	16.5 (271)	18.0 (295)	19.4 (318)
12 1/2 (318)	17.1 (280)	18.6 (305)	20.2 (331)	21.7 (356)
13 1/2 (343)	19.2 (315)	20.8 (341)	22.5 (369)	24.2 (397)
14 1/2 (368)	21.4 (351)	23.1 (379)	24.9 (408)	26.7 (438)
15 1/2 (394)	23.7 (388)	25.5 (418)	27.4 (449)	29.4 (482)

THICKNESS 3/8 in (9.52 mm)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	11.9 (195)	13.2 (216)	14.4 (236)	15.6 (256)
9 1/2 (241)	14.0 (229)	15.3 (251)	16.7 (274)	18.1 (297)
10 1/2 (267)	16.2 (266)	17.7 (290)	19.2 (315)	20.7 (339)
11 1/2 (292)	18.4 (302)	20.1 (329)	21.8 (357)	23.5 (385)
12 1/2 (318)	20.9 (342)	22.6 (370)	24.5 (402)	26.3 (431)
13 1/2 (343)	23.4 (384)	25.3 (415)	27.3 (447)	29.3 (480)
14 1/2 (368)	26.0 (426)	28.1 (461)	30.2 (495)	32.4 (531)
15 1/2 (394)	28.8 (472)	31.0 (508)	33.3 (546)	35.6 (583)

TRUCK PREPARATION

Plan installation completely before any work is done. Plan the location of the crane for the final front and rear axle weights and boom overhang.

Check the final weight to verify that final truck weight with crane, reinforcement, counterweight and options such as jib, etc. complies with the appropriate laws.

Welding Precautions

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

- Disconnect truck battery cables (positive and negative)
- Attach welding ground lead as close as possible to area to be welded.

Positioning Crane on Truck

The final user of the crane must be aware of all state axle and length laws in force at the time of crane mounting and position the crane on the truck accordingly. Following are items which must be considered.

- **Overall Length:** Most states have a maximum straight truck length limit of 1,219.2 cm (40 ft). Using too long a WB truck could cause the crane to exceed this limit.
- **Axle Weights:** All states allow 9,072 kg (20,000 lb) single axle weight and 19,050 kg (42,000 lb) on three axles spaced at least 243.8 cm (8 ft) apart on primary roads, however, some states restrict axle weight to less on secondary roads or at certain times throughout the year. Be aware of your state's axle laws and the roads the crane will operate on for weight restrictions due to secondary roads, bridges, winter driving conditions, etc.
- **Overhang:** The most restrictive overhang laws call for a maximum of 91.4 cm (3 ft) in front of the truck. Check on your state requirements.
- **Federal Bridge Law.** The Federal Bridge Law in effect currently states that in order to carry 26,308 kg (58,000 lb) on a four axle truck, the extremes of any group of axles must be at least 716 cm (23.5 ft) apart. This equates to a truck with a wheelbase of at least 655.3 cm (258 in) with a minimum length of 609 mm (24 in) from the center of tridem axle to the center of the rear axle and equipped with a pusher axle. If this truck is equipped with a tag axle, it could carry 27,442 kg (60,500 lb).

PTO, Pump, Reservoir

1. Select the PTO according to the PTO Selection pages shown earlier in this section. PTO's are not furnished by the factory.
2. Install the PTO and PTO shifting mechanism according to the PTO manufacturer's instructions. If PTO has a reverse gear, it must be blocked out. Pump must not run backwards.

CAUTION

Rotating the pump in the wrong direction damages the pump.

3. If PTO integral mount flanges are to be used, the pump can be mounted directly to the PTO. Be sure adequate clearance exists for this type of pump mount. Sometimes the pump is powered through a drive line with the pump located no more than 106.6cm (42 in) from the PTO. The drive line should not exceed a 15° angle. The drive line U-joint yokes on both ends of the drive line must be parallel with each other. Drive lines should be sized so they can safely carry the maximum pump horsepower requirements. See "PTO Selection" pages. Drive lines are not normally furnished by the factory.
4. Plan the location of the pump mounting bracket and drive line, if used, so that ample clearance is maintained between pump and truck drive line or exhaust system. Pump should be situated so that hydraulic lines can be connected without sharp bends especially the large suction line from the reservoir. Pump mounting brackets may be attached to existing frame crossmembers or a 152.4 mm (6 in) channel crossmember can be made and installed.
5. Install pump mounting bracket (driveline driven pumps only) securely to the truck frame. Attach pump to pump mounting plate or directly to the PTO using capscrews provided. Install the pump support bar at the rear of the pump and bolt or weld the upper end to a crossmember if the pump is driven by a driveline, or attach to a transmission bolt if the pump is direct mounted to the PTO. The rear of the pump must be supported regardless of the mounting method.

NOTE: Some of the pipe fittings used are sealed by means of two threaded tapered sections, one male and one female. When these two tapers meet, you will note a sudden increase in the force required to screw the fittings together. This is true of all tapered pipe threads. Further tightening will not only fail to increase the pressure tightness of the joint, but may ruin the connections and make correct assembly impossible.

Other fittings are of the O-ring boss type. These are installed by first screwing the lock nut flush to the upper thread land and installing the fitting into the port until the nut contacts the surface of the port. Adjust fitting to desired direction. Tighten locknut.

Most pressure fittings are the O-ring face seal types. A small O-ring is compressed between the male and the female fittings of the joint. Be sure the O-ring is present on the fitting and seated properly in its groove before the fittings are tightened.

6. Remove the dust covers from the pump inlet and outlet and determine that the suction and pressure sides of the pump are correct while rotating the pump in the same direction as the PTO. Rotate the pump in the mounting bracket so suction side is toward the reservoir suction port. An arrow is cast into the rear pump housing to identify rotation.
7. If using a drive shaft type of mount, connect PTO drive shaft to pump and PTO. Drill a 0.31 in dia. x 0.12 deep hole on the flat of the hex shaft at the fixed yoke end of the drive shaft to engage the yoke set screw. A small flat area should be ground in the O.D. of the splined pump shaft to engage the pump yoke set screw. Apply Loctite® and tighten the shaft setscrews. Grease the PTO universal joints.

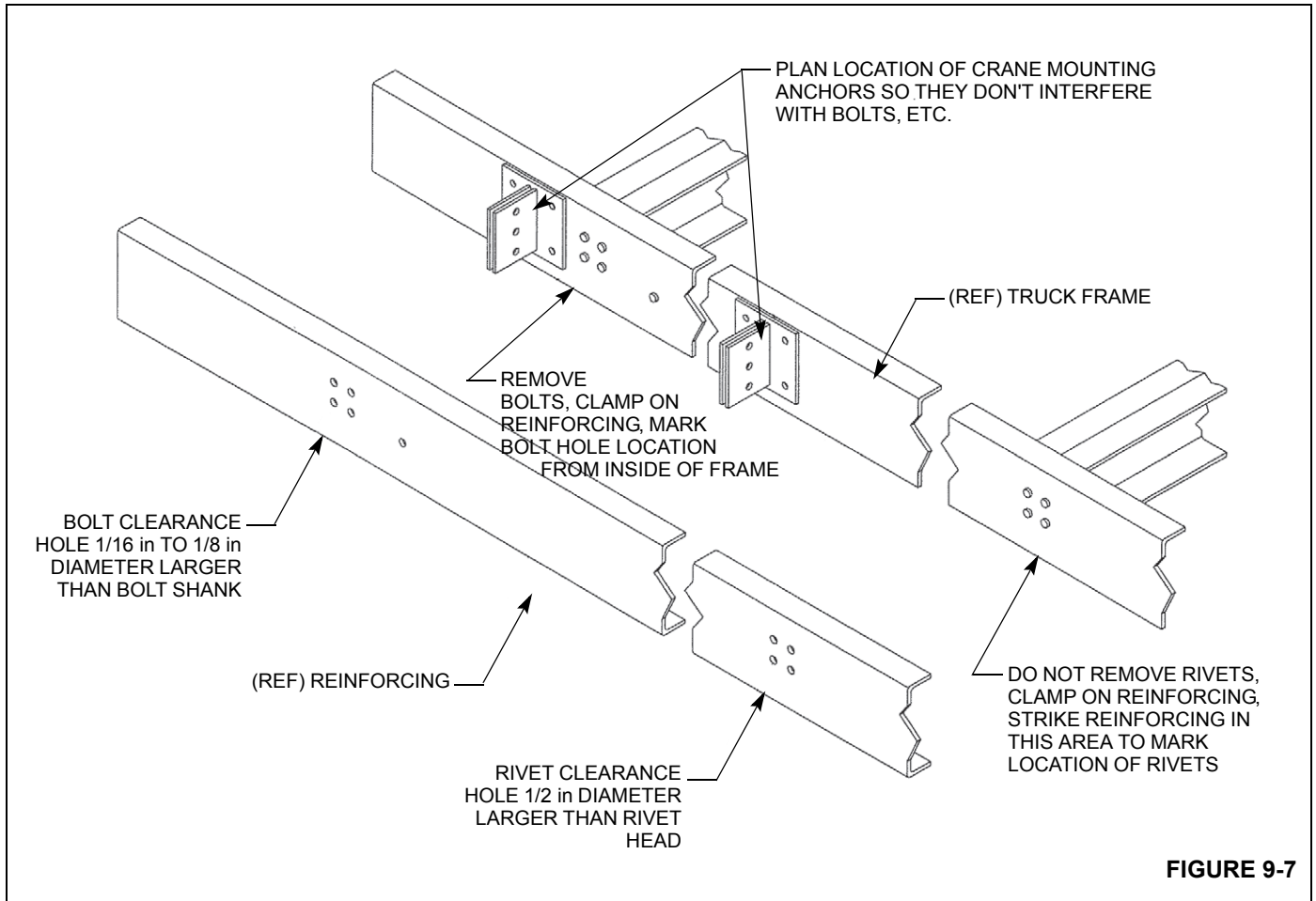
Reinforcing After Frame Extension

1. Refer to “Truck Frame Strength” and “Section Modulus” tables. Determine section modulus by actual measurement of the truck frame. If reinforcing is required, always use at least 100,000 psi steel to minimize the amount of reinforcing required. Use Grade 90 weld material for any welding to be done.
2. Strip the frame of obstructions in the area to be reinforced or extended, one side at a time. If the truck frame crossmembers are bolted in, remove the bolts. Do not attempt to remove any rivets.
3. If rivets are used to secure truck frame cross members. Place the reinforcing on the truck frame and clamp in place. See Figure 9-7.

Mark the location of any rivets by striking the outside of the reinforcing over the rivet area so that the rivets make an impression on the inside of the reinforcing.

Mark the approximate location of the crane mounting anchors so that no obstructions exist.

Remove the reinforcing and drill or torch cut clearance holes for bolts or rivets. See Figure 9-7.



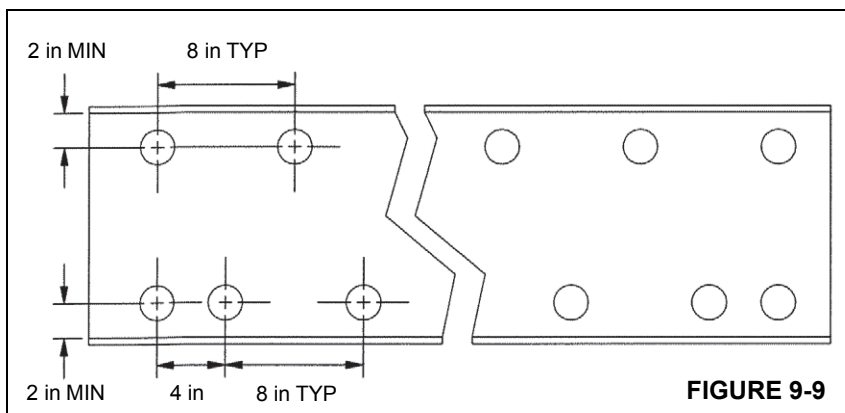
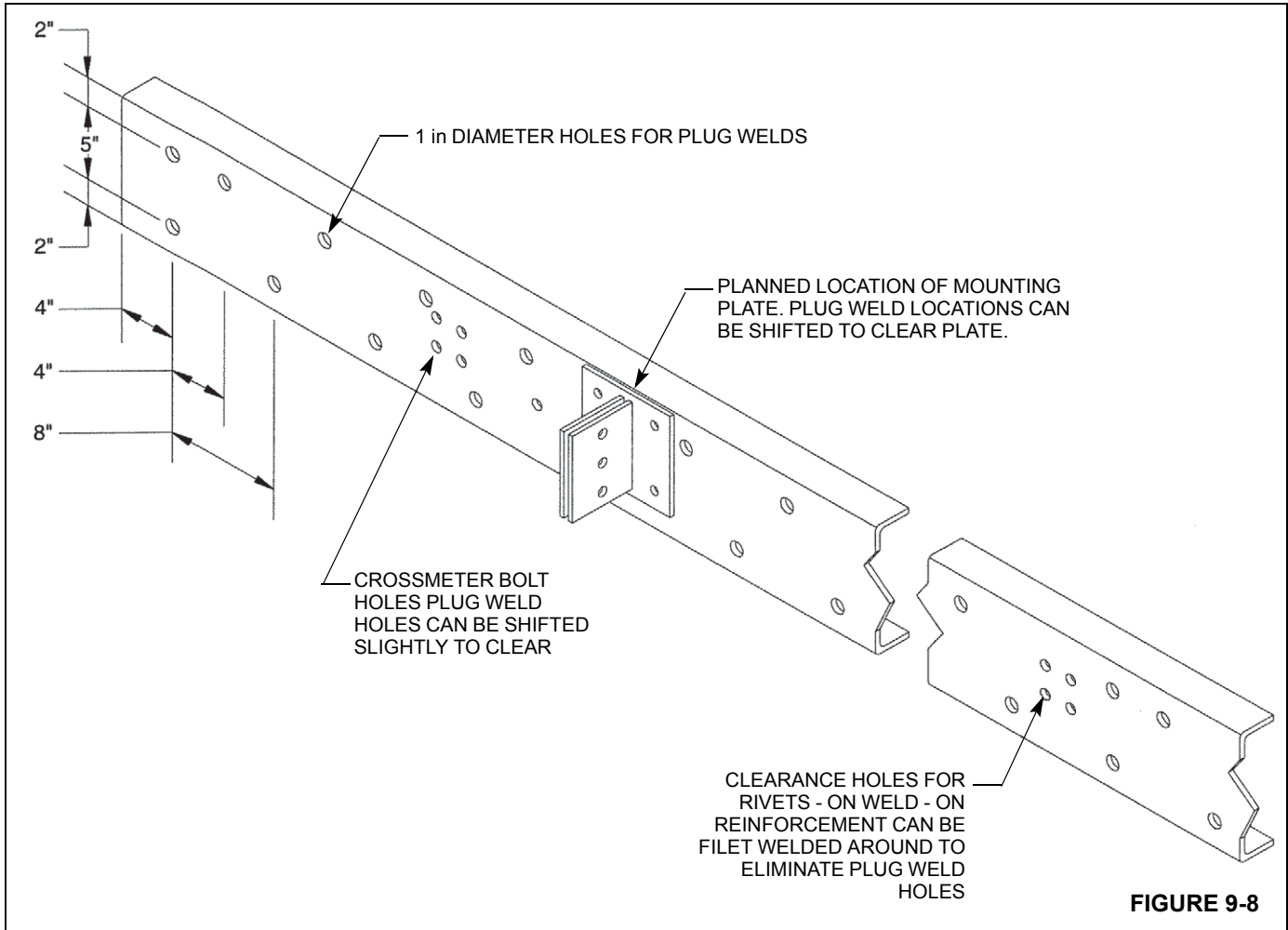
4. If reinforcing is to be welded on, torch cut hole pattern in reinforcing being careful to clear crane mounting anchors.

Install reinforcing, clamp in place, install any crossmember bolts that were previously removed and weld to truck frame as shown in Figure 9-8.

5. If bolt-on reinforcing is required, install the reinforcing, clamp in place, install any crossmember bolts that were

previously removed, then drill through reinforcing and truck frame being careful to clear crane mounting anchors and bolt reinforcing in place.

See Figure 9-9 for recommended drilling and bolting procedure. Use 5/8, Grade 8 bolts, drill holes to 39/64 diameter, drive fit bolts and properly tighten. See "Fasteners and Torque Values" on page 1-7.



6. If the frame through the rear suspension doesn't meet minimum specifications for RBM and section modulus as shown on *Truck Frame Strength*, page 9-11, it can be reinforced by adding an angle type of reinforcing as in Figure 9-10.

See "Section Modulus tables, Table B for the required size of reinforcing.

Strip all easily removable equipment from the frame through the suspension such as spring stops, etc.

Butt the reinforcing angle up against the reinforcing forward of the suspension and mark the areas that will require cutting so that the angle will slide up around the spring hangers and against the existing truck frame and forward reinforcing.

Torch out the marked areas in the long leg of the angle deep enough so that the lip of the angle can be slid up from underneath the frame to contact either existing truck frame or spring hanger brackets (if they extend down below the existing truck frame).

7. If reinforcing angle is to be welded to truck frame, cut out plug weld hole pattern as in Figure 9-8.

Slide the reinforcing angle up from the bottom, butt it to existing forward reinforcing and weld rear suspension reinforcing to forward reinforcing.

Replace as much of the spring hanger cut out areas as possible and butt weld these pieces in.

8. If reinforcing angle is to be bolted on, drill hole pattern and install bolts according to Figure 9-9. Reinforce spring hanger cut outs and the weld area, suspension

reinforcing to forward reinforcing by adding bars under these areas.

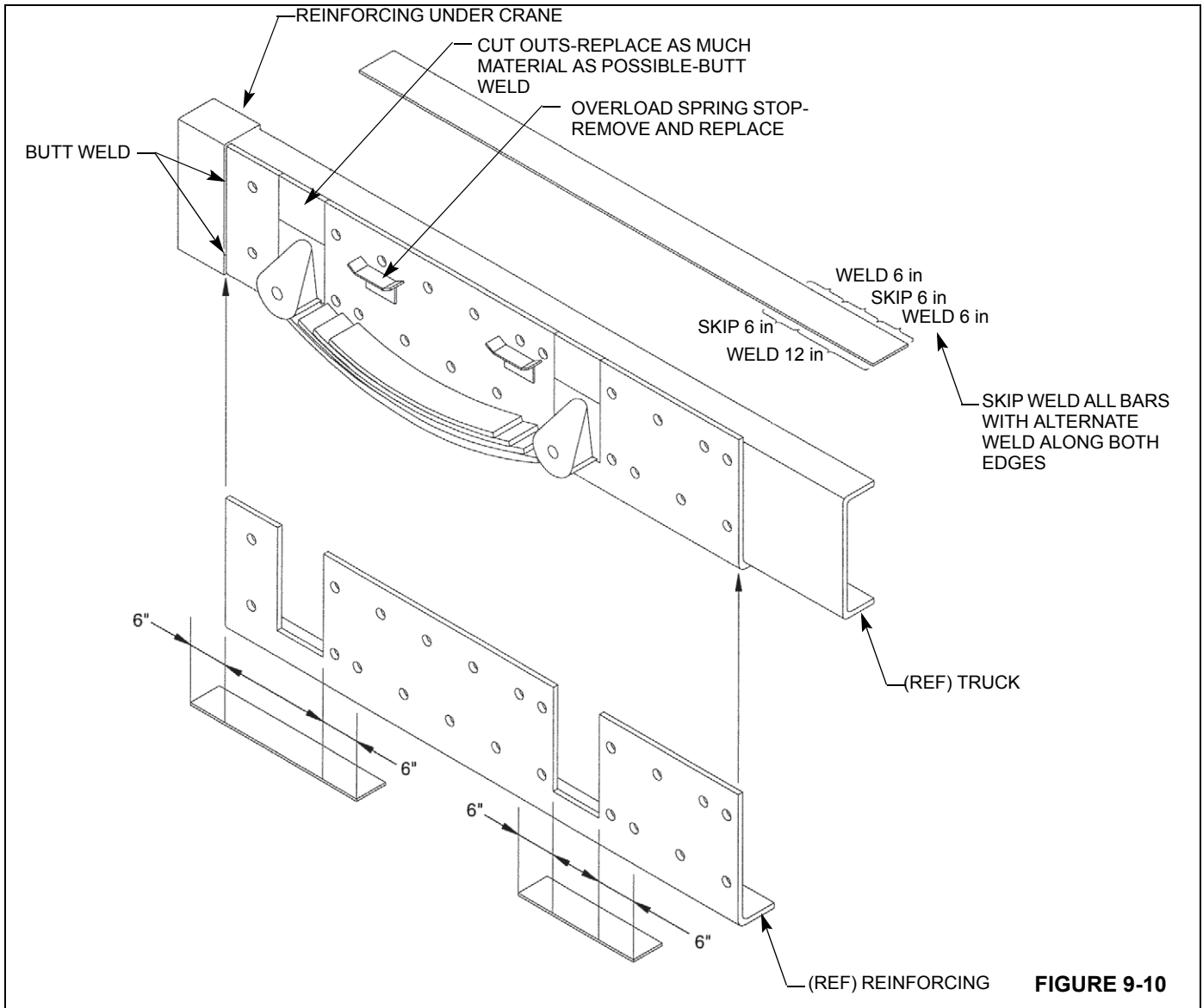
The bars should be of the same thickness, width and yield strength as the reinforcing angle lip, and should be long enough to extend at least 152.5 mm (6 in) beyond either side of the weld or cut out areas. Weld these reinforcing bars to the underside of the reinforcing with length-wise welds. **Do not weld across the flanges.**

Replace any equipment that had been removed.

9. The NBT60 will usually require an after frame of approximately 3,302mm (130 in) of after frame for a tridem or tag axle.

Calculate the weight distribution of the complete crane in order to determine where the crane center of rotation will be in relationship to the center of the rear axles. A typical mount will position the crane centerline forward of the center of tridem by 0 to 16 in. If AF is too long, cut off excess and remove any crossmembers from back of truck frame.

If AF is too short, the frame will have to be lengthened. Use channels fabricated from 100,000 psi yield material that are the same size as the truck frame. Weld these channels to the ends of the existing truck frame channels. Bevel the ends of the channels to get 100% weld joints with Grade 90 weld material. Fabricate an inner channel of the same thickness as the truck frame channels to span the weld joint for at least 304.8 mm (12 in) on each side of joint. Plug weld this channel to the inside of the truck frame, then skip weld the inside edge of the top and bottom flanges to the truck frame flanges.



MOUNTING THE CRANE

T-Box Installation



DANGER

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

Make sure the truck has been configured to meet the minimum truck, PTO, and frame strength requirements as described previously in this section. Use the following procedures and refer to Figure 9-11 when installing the T-box to the truck frame.

NOTE: All welds used to secure the crane to the truck frame must be grade 90 or better.

NOTE: See “Fasteners and Torque Values” on page 1-7 for the proper torque value when tightening any fasteners.

1. Place the crane assembly on the truck frame as determined by the information contained in the section titled *Positioning Crane on Truck* on page 9-15.
2. Locate the six mounting plates (12) and spacer plates (11) on the truck frame (18) and clamp in place (Details A and D). Be sure the hole pattern of the mounting plates (12) and spacer plates (11) is centered vertically to the frame rails. Also, be sure the left and right side mounting plates are aligned across from each other.

Drill 16 mm holes through the truck frame (18) using the existing holes in the mounting plates (12) and spacer plates (11) as templates.

Bolt the six mounting plates (12) and spacer plates (11) to the truck frame (18) using the 16x75 mm bolts, flat washers and nuts.

3. Bolt one anchor bar (13) to each of the six mounting plates (12) that are attached to the truck frame (18) (Details A and D).
4. Bolt a mounting plate (12) to each anchor bar (13) finger tight; clamp the mounting plates flush against the T-box frame (19) (Details A and D).
5. Weld the six upper mounting plates (12) to the T-box frame (19). See Detail D for weld requirements.

6. Starting on the passenger side, locate the front strap plate (8) and spacer plate (10) on the truck frame (18); clamp in place (Details A and B). Be sure the hole pattern of the front strap plate (8) is centered vertically to the frame rail. Align the driver side front strap plate (8) and spacer plate (10) directly across from the passenger side strap plate and spacer plate; clamp in place.

Drill 16 mm holes through the truck frame (18) using the existing holes in the front strap plates (8) and spacer plates (10) as templates.

Bolt the front strap plates and spacer plates to the truck frame using the 16x75 mm bolts, flat washers and nuts.

7. Position the two collar plates (9) above the front strap plates (8) on the T-box frame (19); clamp in place. Weld the front strap plates (8) and collar plates (9) to the T-box frame (19). See Detail C for locator dimensions and weld requirements.
8. If necessary, cut the two channel assemblies (2) to fit inside the truck frame (18) at a location immediately in front of the front outrigger box. Install the two channel assemblies (2) inside the truck frame (Detail E).
9. Install a locknut and flat washer onto one end of the four 20x900 mm studs (3). Working at the front of the outrigger box on top of the T-box frame (19), insert the four studs (3) down through the existing holes in the T-box frame (19), ensuring the studs (3) on the inside of the truck frame rails pass through the slotted holes in the channel assemblies (2) (Detail E).

Install clamp plates (1) onto the studs (3) and slide up against the bottom of the truck frame (18), then secure with lock washers and nuts.

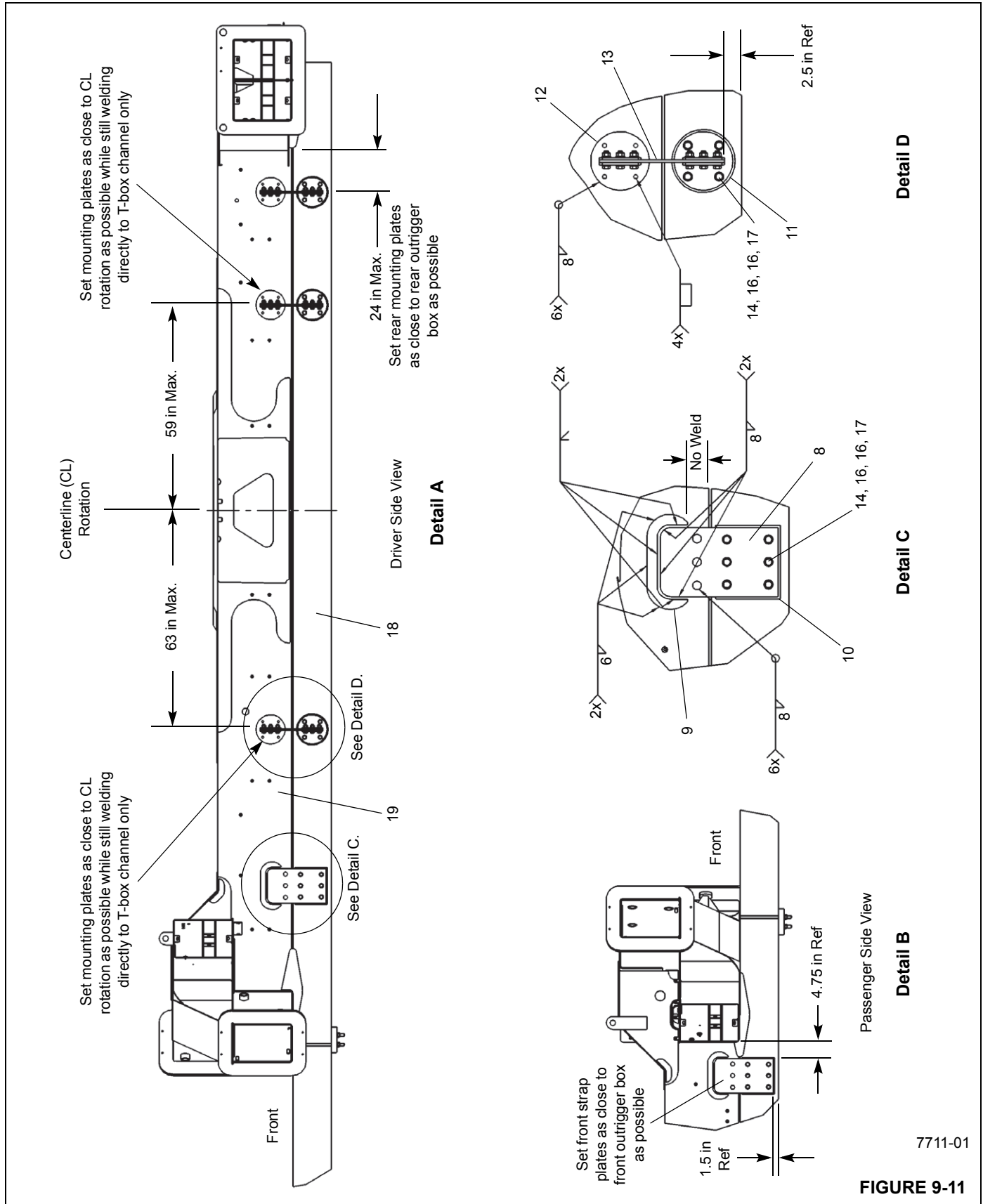
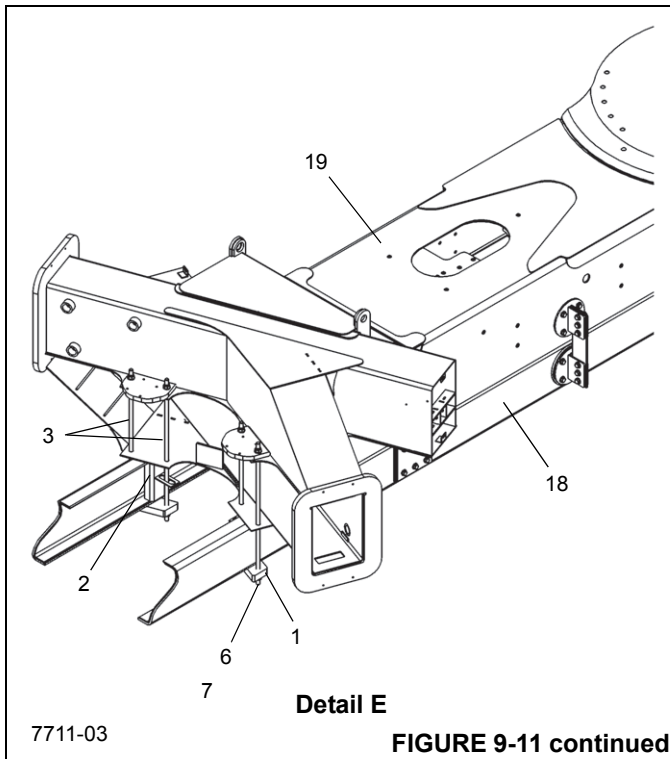


FIGURE 9-11



Item	Description
1	Clamp Plate
2	Channel Assembly
3	Stud M20x900 10.9
4	Hex Lock Nut M20 8 ISO 7040
5	F Washer 20-HRC38 ANSI B18.22M
6	L Washer 20-HRC44-51 DIN 7980
7	Hex Nut M20 8 ISO 4032
8	Plate
9	Plate
10	Plate, Shear Plate Spacer
11	Plate, Flex Plate Spacer
12	Anchor ASM
13	Bar
14	HHCS M16x75 10.9 ISO 4014
15	HHCS M16x55 10.9 ISO 4014
16	F Washer 5/8" Hard ASTM F-436
17	Hex Nut M16 10 ISO 4032
18	Truck Frame
19	T-box Frame

Rear Bumper and Light Installation

Use the following procedures and refer to Figure 9-12 when installing the rear bumper and lights.

- Position the left and right bumper mounting brackets (4, 5) against their respective frame rail (19); clamp in place. See Detail A.

Using the bumper mounting brackets as templates, drill five 17 mm holes through each mounting bracket and truck frame (19). Use the bumper mounting bracket's wide hole pattern on a truck with a long frame rail (Detail A) or the narrow hole pattern on a truck with a short frame rail (Detail B). Bolt the mounting brackets to the truck frame.
- Mount the light plate (2) and the bumper (3) to the left and right bumper mounting brackets (4, 5). Attach the two taillight mounting brackets (6) to the light plate (2). See Details A, D, and E.
- Mount the light cover plate (1) to the top of the T-box frame as shown in Detail E.

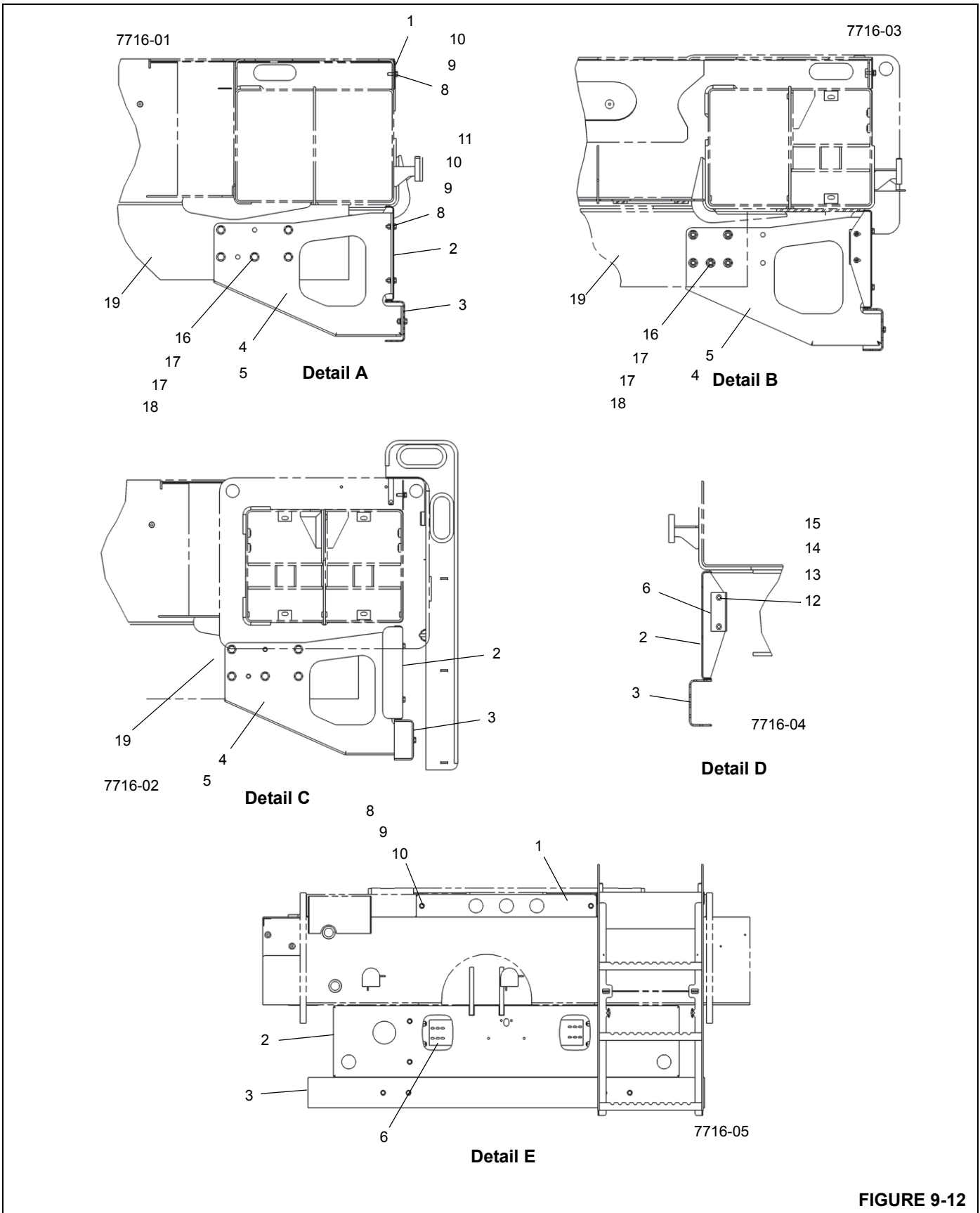


FIGURE 9-12

Item	Description
1	Light Cover Plate
2	Light Plate
3	Bumper
4	Bumper Mounting Bracket LH
5	Bumper Mounting Bracket RH
6	Plate
7	Ladder Assembly
8	HHCS M10x30 SS ISO 4014
9	F Washer 3/8" Wide MS
10	L Washer 10-HRC44-51 DIN 7980
11	Hex Nut M10 8 ISO 4032
12	HHCS M6x20 SS ISO 4017
13	F Washer 1/4" Wide MS
14	L Washer 6-HRC44-51 DIN 7980
15	Hex Nut M6 8 ISO 4032
16	HHCS M16x55 10.9 ISO 4014
17	F Washer 5/8" Hard ASTM F-436
18	Hex Nut M16 10 ISO 4032
19	Truck Frame

Decking and Ladder Installation

Use the following procedures and refer to Figure 9-13 through Figure 9-15 when installing the decking and ladder.

1. Install the mounting brackets (5, 6, 8, 9, 43, 44) on the T-box frame in the locations indicated. Add Loctite ® 243 to all mounting hardware.
2. Install the driver side front and rear fender (1, 3) and the passenger side front and rear fender (2, 4). Secure the fender to one another and also to the T-box frame using the angled mounting brackets (7) and the supplied hardware. Add Loctite ® 290 to all mounting hardware.
3. Install the front and rear outrigger covers (14, 15) on the outrigger boxes.
4. Install the outrigger cover (16) on the front outrigger.

5. Install a mud flap plate (20) on the left and right side rear fender (1, 2), then attach a mud flap (22) on each mud flap plate (20) using a bracket (21).
6. Install cover panel plates (17) on the top front and rear portions of the T-box frame. Install cover plates (18) on top of the left and right rear outrigger boxes.
7. Install decal plates (46) on the sides of the driver and passenger side front fender (3, 4).
8. Measure and cut the trim strip (24) to fit around the openings in the sides of the driver and passenger side front fender (3, 4).
9. Attach the ladder (10) to the passenger side front fender (4), then secure the ladder (10) to the T-box frame with the ladder support (11). Install a handle (12) on each side of the ladder (10). Add Loctite ® 243 to all mounting hardware.
10. Mount the bracket hold down (19) to the top of the driver side rear fender (1); add Loctite ® 243 to mounting hardware. Measure and cut the trim strip (24) to fit around the opening in the handle of the ladder assembly (13). Attach the ladder assembly to the top of the driver side rear fender using the shoulder bolt, flat washers, nylon washer and nut (37, 38, 39, 40, 41, 42). Make sure the leg of the ladder assembly (13) engages the bracket hold down (19), then secure in place with the lock pin (23).

11. Install the ladder catches (61) to the sides of the driver side front and rear fender (1, 3).
12. Install the level adjustment plate (57), with the flat side down, and level (56) on the driver and passenger side front fender (3, 4).

Once the outriggers are operational, each level (56) must be calibrated by doing the following:

- a. Place a level on a machined surface of the T-box frame, such as the bearing plate. Do not use the outrigger box or decking.
- b. Using the outrigger controls, level the crane both laterally and longitudinally.
- c. Adjust the level adjustment plate (57) until the bubble inside the level (56) is within the circle.
- d. Repeat Step 12c for level on opposite side of the crane.

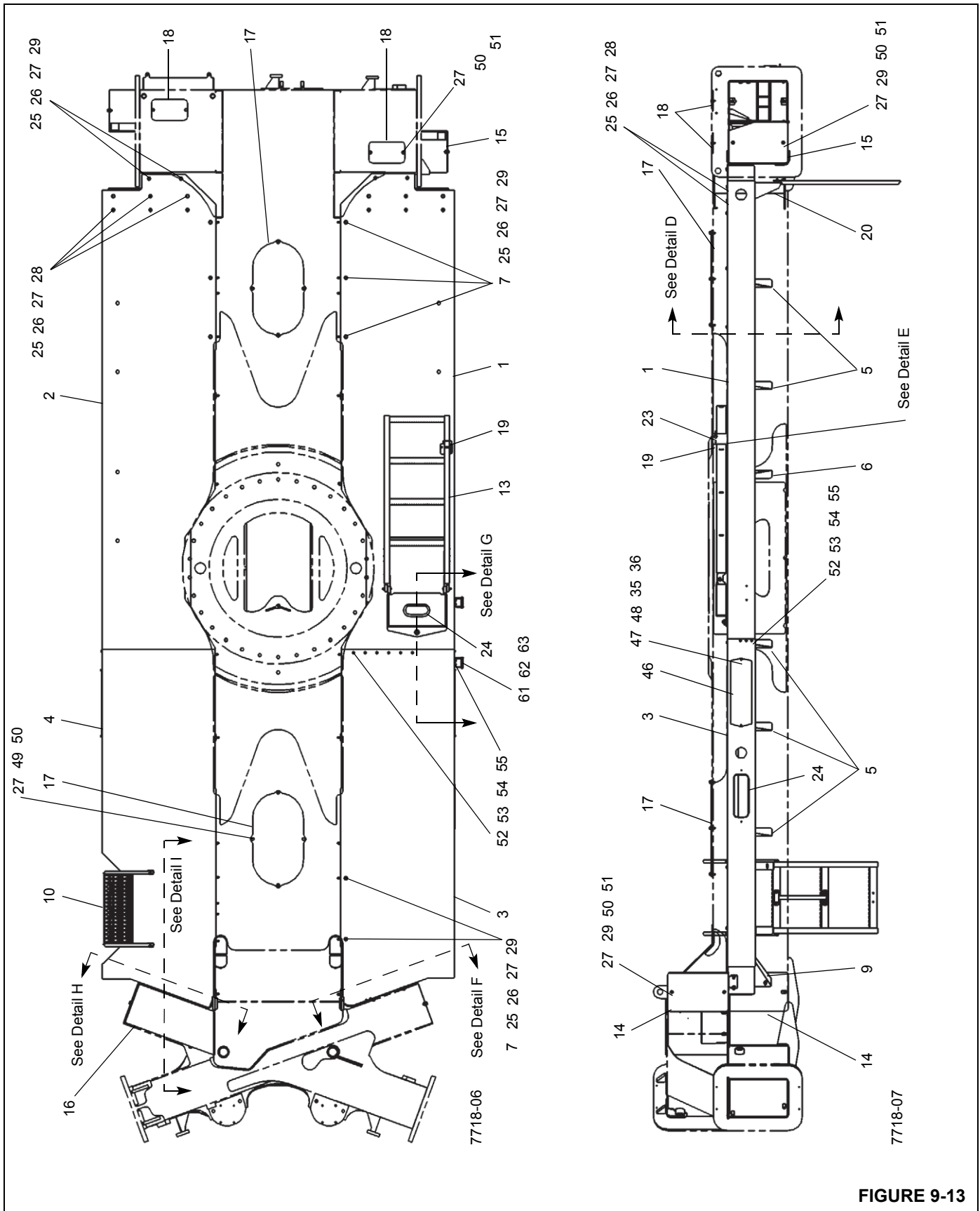


FIGURE 9-13

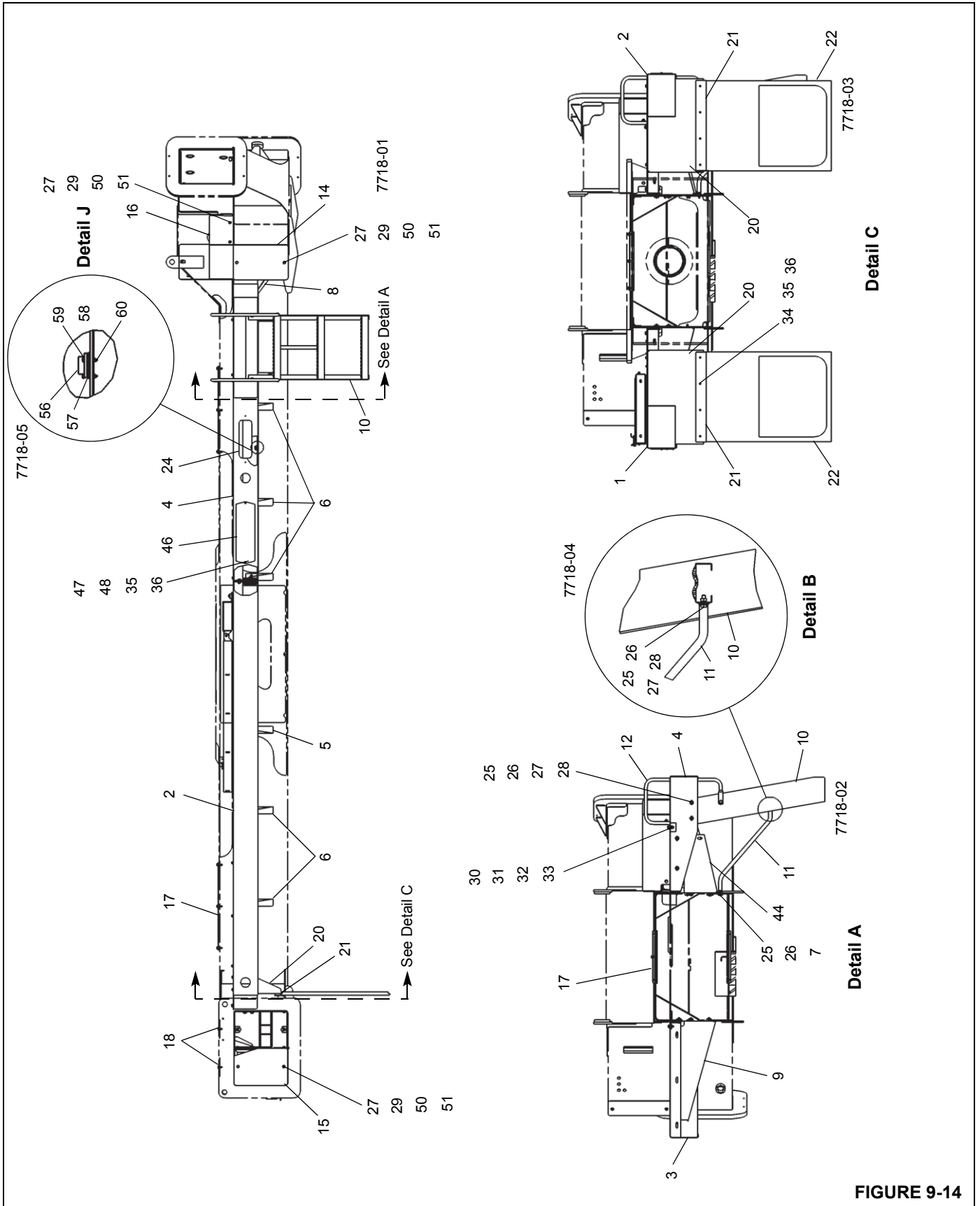


FIGURE 9-14



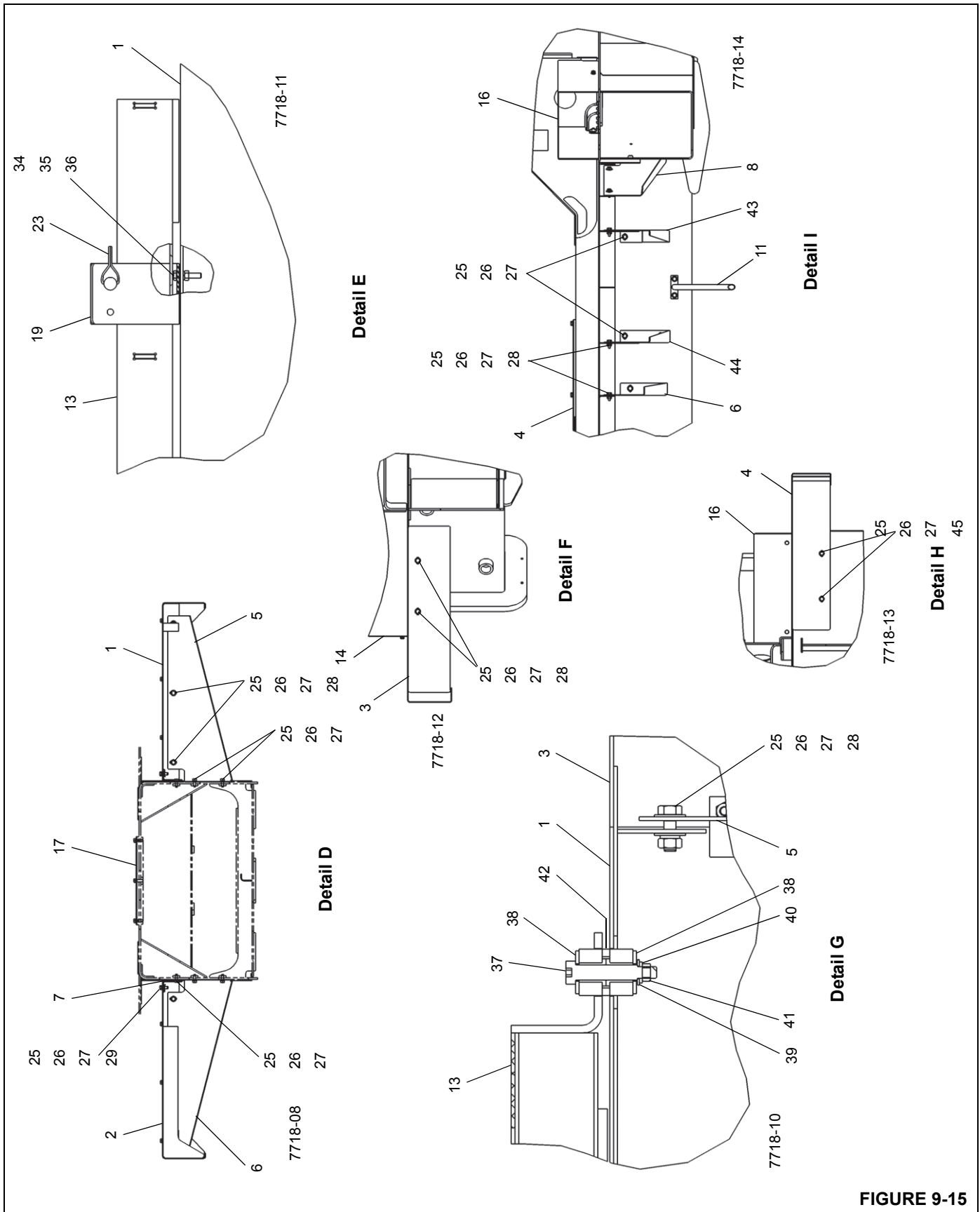


FIGURE 9-15

Item	Description
1	LH Rear Fender
2	RH Rear Fender
3	LH Fender
4	RH Front Fender
5	Mounting Bracket
6	Mounting Bracket
7	Angle
8	Mounting Bracket Angled
9	Mounting Bracket Angled
10	Step
11	Support Ladder
12	Step Handle
13	Ladder (Asm)
14	Front O/R Cover
15	Rear O/R Cover
16	O/R Cover
17	Plate, Cover Panel
18	Cover Plate
19	Bracket hold Down
20	Mud Flap Plate
21	Bracket
22	Mud Flap
23	Lock pin 3/8x2.25
24	Trim Strip
25	Hex Head Capscrew M10x30 SS
26	Flat Washer 3/8" Wide MS
27	Lock Washer 10
28	Hex Nut M10 ISO 4032
29	Retaining Nut M10
30	Hex Head Capscrew M12x30 SS
31	Flat Washer 12
32	Lock Washer 12
33	Hex Nut M12
34	Hex Head Capscrew M6x30
35	Lock Washer 6
36	Hex Nut M6

Item	Description
37	Shoulder Bolt
38	Flat Washer 1/2" Wide MS
39	Flat Washer 3/8" Nar MS
40	Lock Washer 3/8
41	Hex Nut 3/8-16UNC SAE-2
42	Flat Washer 7/8" Nylon
43	Mounting Bracket
44	Mounting Bracket
45	Hex Head Capscrew M10x20
46	Decal Plate
47	Hex Head Capscrew M6x25
48	Flat Washer 6
49	Hex Head Capscrew M10x35 SS
50	Flat Washer 3/8" Nar MS
51	Hex Head Capscrew M10x25 SS
52	Hex Head Capscrew M8x25
53	Flat Washer 8
54	Hex Nut M8
55	Lock Washer 8-HR
56	Level
57	Plate-Level Adjusting
58	Slot PMS M3x20 SS
59	Flat Washer 3
60	Hex Nut M3
61	Ladder Catch
62	Clevis Pin 0.5x3
63	Cotter Pin 0.09x0.75

Single Front Outrigger Installation (SFO) - Optional

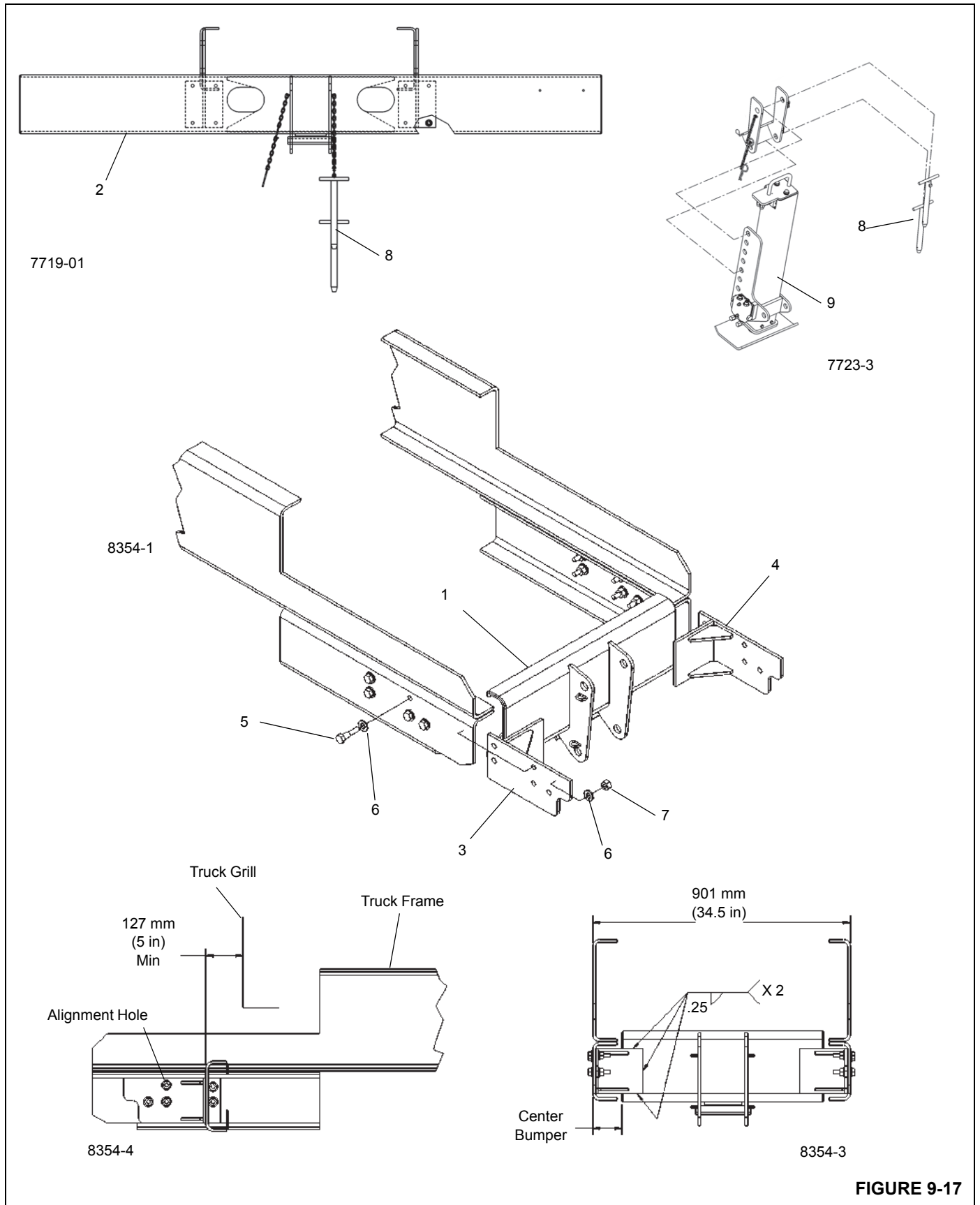
Bumper Installation

Bumper bracket kits are available from National Crane to mount a single front outrigger (SFO) to a particular manufacturer's truck. Regardless of truck manufacturer, the bottom of the single front outrigger (SFO) - if equipped, must have a ground clearance of 355 to 482 mm (14 to 19 in). Refer to Figure 9-16 for a listing of the different bumper brackets available and their part numbers.

Part Number	Description	Figure	International	Freightliner	Mack	Kenworth	Peterbilt	Ford
80040553	SFO Bumper Peterbilt 365/367 SBFA w/o Extended Front Rails	Figure 9-22					X	
80049699	SFO Bumper Peterbilt 365/367 SBFA - Hd w/o Extended Front Rails	Figure 9-23					X	
80052375	SFO Bumper Peterbilt 365/367 SBFA w-Extended Front Rails	Figure 9-17					X	
80058417	SFO Bumper Peterbilt 367 SFFA - Hd w/o Extended Front Rails	Figure 9-23					X	
80041904	SFO Bumper Peterbilt 348 - Hd w/o Extended Front Rails	Figure 9-24					X	
80046700	SFO Bumper Peterbilt 348 w/ Extended Front Rails	Figure 9-25					X	
80046683	SFO Bumper Kenworth T800 w/o Extended Front Rails	Figure 9-21				X		
80052375	SFO Bumper Kenworth T800 w/ Extended Front Rails	Figure 9-17				X		
80046677	SFO Bumper International 7400/7500/7600 w/ Extended Front Rails	Figure 9-18	X					
80051293	SFO Bumper International 4300 w/ Extended Front Rails	Figure 9-19	X					
80049124	SFO Bumper International 4300 w/ Extended Front Rails	Figure 9-18	X					
80046677	SFO Bumper Freightliner M2106V and 108SD w/ Extended Front Rails	Figure 9-18		X				
80047755	SFO Bumper Freightliner M2112V and 114SD w/ Extended Front Rails	Figure 9-19		X				
80056288	SFO Bumper Ford 750 w/o Extended Front Rails	Figure 9-26						X
80052619	SFO Bumper Mack Granite w/ 6 in. Bolt On Extension	Figure 9-20			X			
80047755	SFO Bumper Mack w/ Extended Front Rails	Figure 9-19			X			

NOTE: This chart is for reference only, as some bumpers may fit a chassis not marked. Always check with the Engineering Department of Manitowoc if a bumper requires modification.

FIGURE 9-16

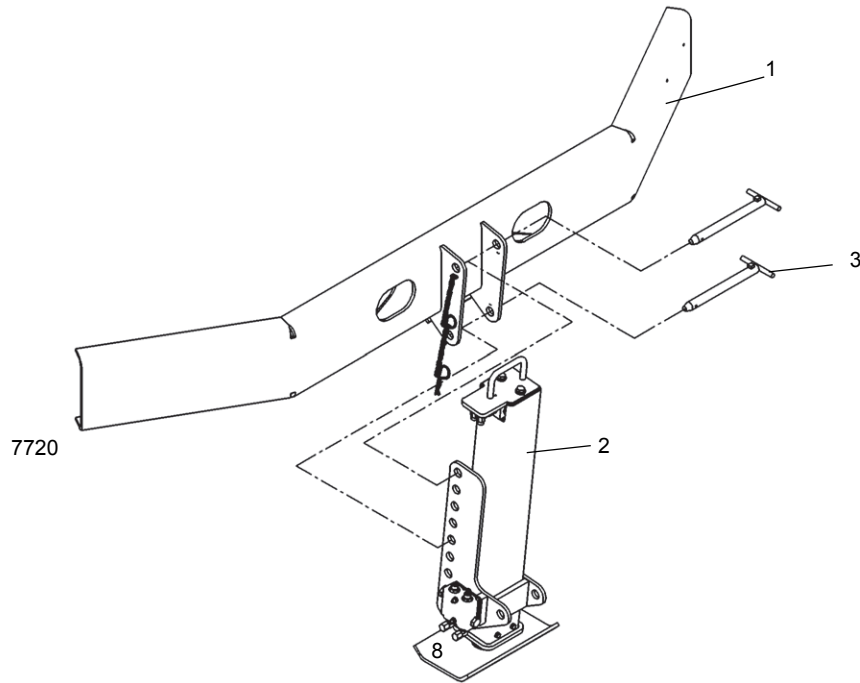


Item	Description
1	Extended Frame Bumper
2	Bumper
3	Bracket
4	Bracket
5	Hex Head Capscrew 5/8-11UNCx2.5 G8
6	Flat Washer 5/8" Hard St
7	Hex Nut 5/8-11UNC SAE-8
8	Pin
9	Single Front Outrigger (SFO) Cylinder Assembly
10	Decal-Danger Outrigger Crush Hazard

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11.

1. Remove the existing bumper (2).
2. Position the mounting brackets (3, 4) on the truck frame such that the bottom of the brackets do not hang more than 152 mm (6 in) below the truck frame while giving a ground clearance between 355 to 482 mm (14 to 19 in) under the SFO.
3. Clamp the mounting brackets (3, 4) to the truck frame using the alignment hole in the frame rail. Then match drill a minimum of four 15.5 mm (5/8 in) holes through each bracket and truck frame.
4. Bolt the mounting brackets (3, 4) to the truck frame, ensuring the bolt threads are not in the shear plane.
5. Center the extended frame bumper (1) between the truck frame rails and clamp in place. Weld the mounting brackets (3, 4) to the extended frame bumper.
6. Bolt the bumper (2) to the mounting brackets (3, 4).
7. Attach the SFO (9) to the bumper (1) using the two pins (8).

FIGURE 9-17 continued



Item	Description
1	Bumper
2	Single Front Outrigger (SFO) Cylinder Assembly
3	Pin
4	Decal-Danger O/R Crush Hazard

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11.

1. Remove the existing bumper.
2. Install replacement bumper (1) using existing hardware.
3. Using the two pins (10), attach the SFO (2) to the bumper (1) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.

FIGURE 9-18

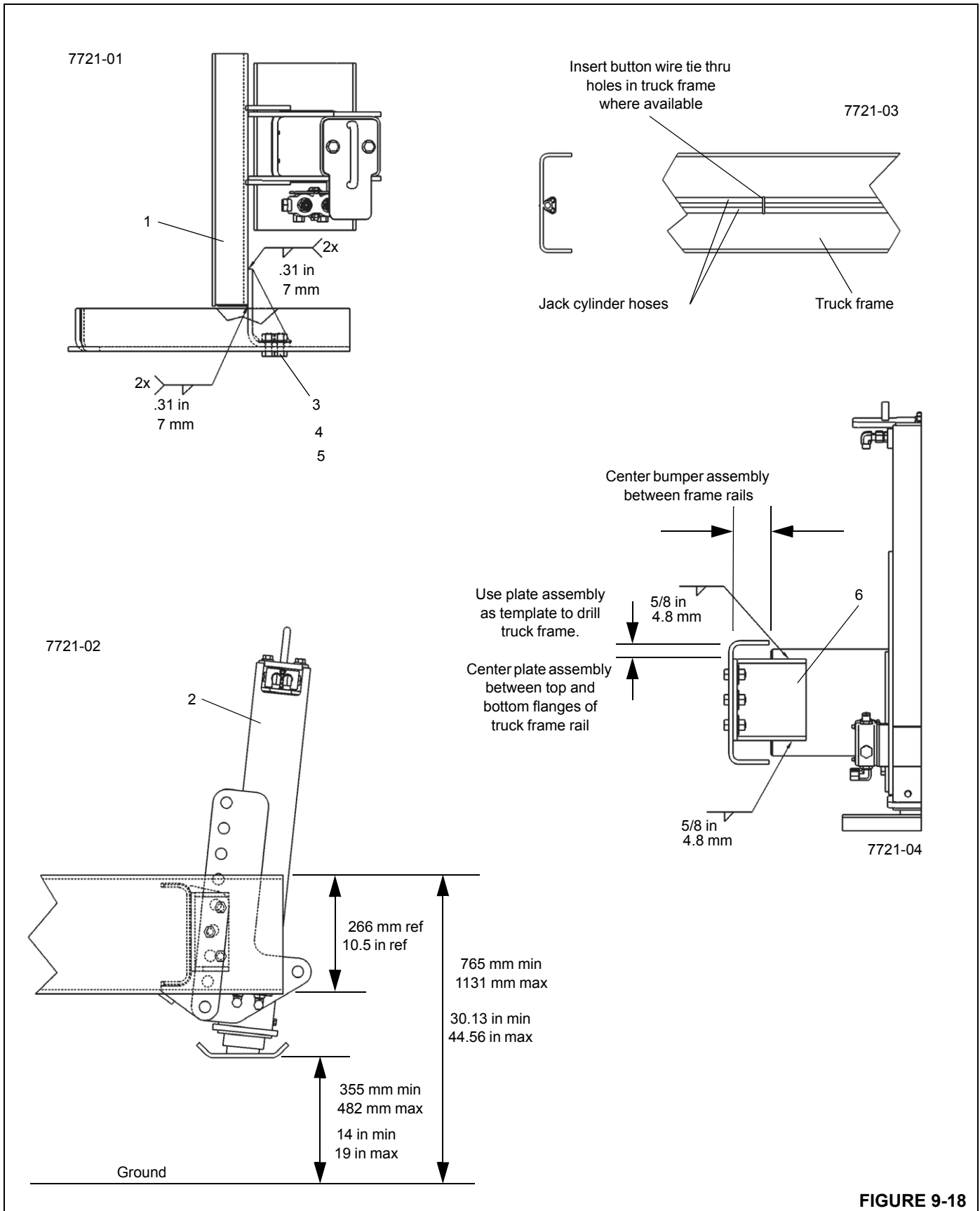


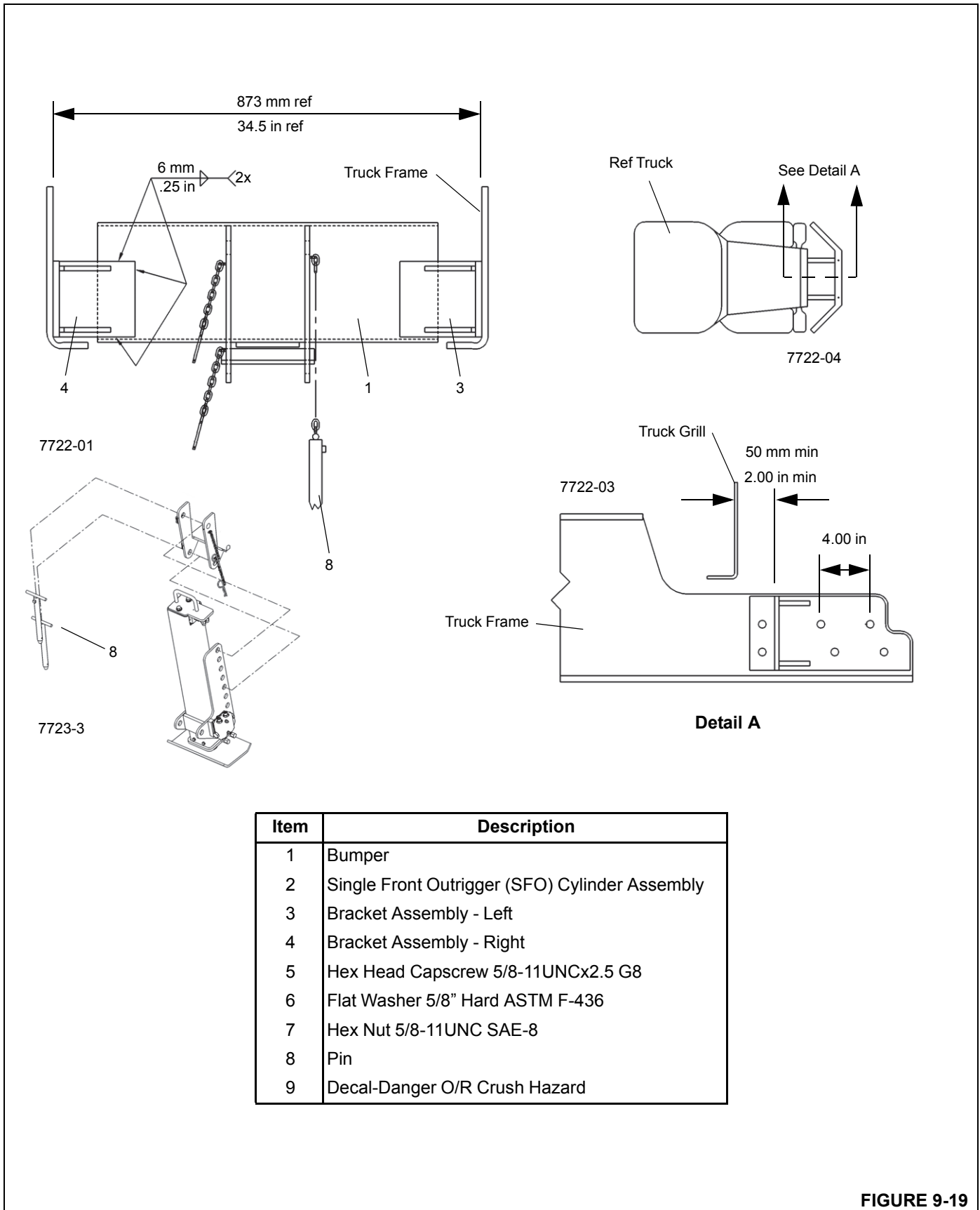
FIGURE 9-18

Item	Description
1	Bumper
2	Single Front Outrigger (SFO) Cylinder Assembly
3	Hex Nut 5/8-11UNC SAE-8
4	Flat Washer 5/8" Hard St
5	Hex Head Capscrew 5/8-11UNCx2 G8
6	Plate
7	Installation Drawing
8	Pin
9	Decal-Danger Outrigger Crush Hazard

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11 and that the top of the truck frame has a ground clearance between 765 to 1131 mm (30.13 to 44.56 in).

1. Remove the existing bumper.
2. Center the mounting plates (6) between the top and bottom flanges of the truck frame rails. Clamp plates in place, then drill six 15.5 mm (5/8 in) holes (three per side) through the truck frame using the mounting plates as templates.
3. Attach the mounting plates (6) to the truck frame rails.
4. Center the bumper (1) between the frame rails such that there is a ground clearance of between 355 to 482 mm (14 to 19 in) under the front outrigger jack, then tack weld to the mounting plates.
5. Remove the mounting plate/bumper assembly from the truck, then finish welding the mounting plates (6) to the bumper (1) following the weld requirements found on the drawing in Figure 9-18; all welds to be grade 70.
6. Attach the mounting plate/bumper assembly to the truck frame using the supplied hardware (3, 4, 5).
7. Attach the outrigger jack (2) to the bumper (1) using the two attaching pins (8).

FIGURE 9-18 continued



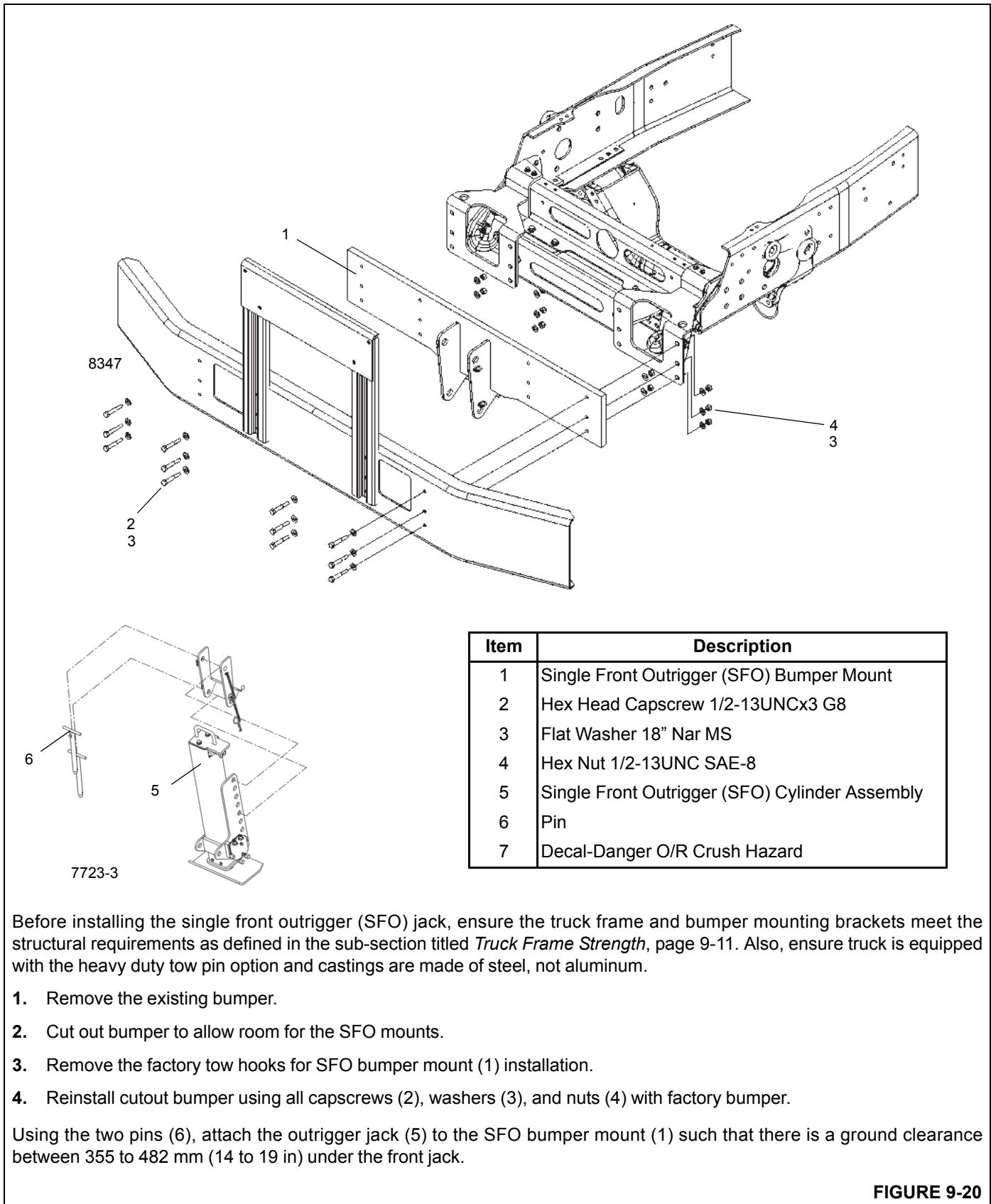
Item	Description
1	Bumper
2	Single Front Outrigger (SFO) Cylinder Assembly
3	Bracket Assembly - Left
4	Bracket Assembly - Right
5	Hex Head Capscrew 5/8-11UNCx2.5 G8
6	Flat Washer 5/8" Hard ASTM F-436
7	Hex Nut 5/8-11UNC SAE-8
8	Pin
9	Decal-Danger O/R Crush Hazard

FIGURE 9-19

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11.

1. Remove the existing bumper.
2. Position the left mounting brackets (3) and right mounting brackets (4) on the truck frame rails so that the front of the bumper (1), when mounted, will be a minimum of 50 mm (2 in) from the truck's grill. Clamp the brackets in place, then mark and drill 15.5 mm (5/8 in) holes (six per side) through the mounting brackets and truck frame using a bolt pattern of 101 mm (4 in).
3. Attach the mounting brackets (3, 4) to the truck frame rails.
4. Center the bumper (1) horizontally between the frame rails, then vertically such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front outrigger jack. Tack weld the bumper to the mounting plates.
5. Remove the mounting plate/bumper assembly from the truck, then finish welding the mounting plates (3, 4) to the bumper (1) following the weld requirements found on the drawing in Figure 9-19; all welds to be grade 70.
6. Attach the mounting plate/bumper assembly to the truck frame using the supplied hardware (5, 6, 7).
7. Attach the outrigger jack (2) to the bumper (1) using the two pins (8).

FIGURE 9-19 continued

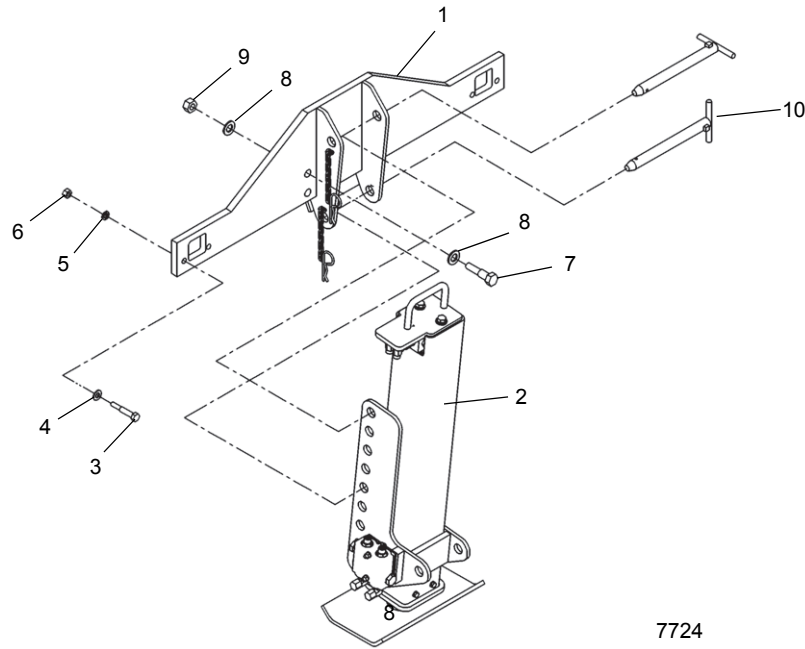


Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11. Also, ensure truck is equipped with the heavy duty tow pin option and castings are made of steel, not aluminum.

1. Remove the existing bumper.
2. Cut out bumper to allow room for the SFO mounts.
3. Remove the factory tow hooks for SFO bumper mount (1) installation.
4. Reinstall cutout bumper using all capscrews (2), washers (3), and nuts (4) with factory bumper.

Using the two pins (6), attach the outrigger jack (5) to the SFO bumper mount (1) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.

FIGURE 9-20



7724

Item	Description
1	Bumper
2	Single Front Outrigger (SFO) Cylinder Assembly
3	Hex Head Capscrew 1/2-13UNCx3 G8
4	Flat Washer 1/2" Nar MS
5	Lock Washer 1/2" Reg HRC45-51
6	Hex Nut 1/2-13UNC SAE-5.2
7	Hex Head Capscrew 3/4-10UNCx3 G8
8	Flat Washer 3/4" Hard ASTM F-436-
9	Hex Nut 3/4-10UNC SAE-8
10	Pin
11	Decal-Danger O/R Crush Hazard

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11.

1. Remove the existing bumper.
2. Cut out bumper (1) to allow room for the SFO mounts.
3. Reinstall cutout bumper (1) using all ten capscrews (3, 7), washers (4, 5, 8), and nuts (6, 9) with bumper (1) between chassis castings and bumper.
4. Using the two pins (10), attach the jack (2) to the bumper (1) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.

FIGURE 9-21

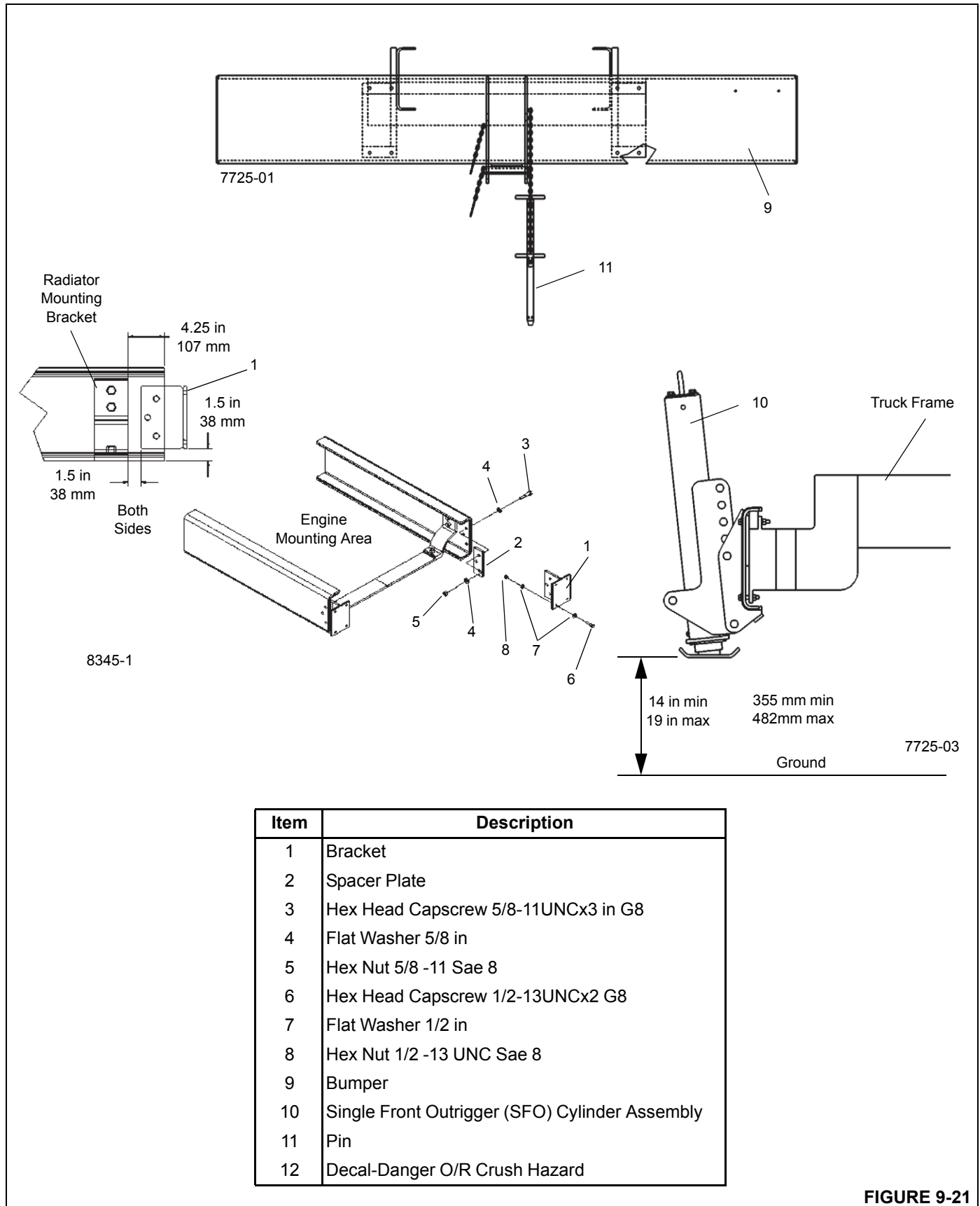
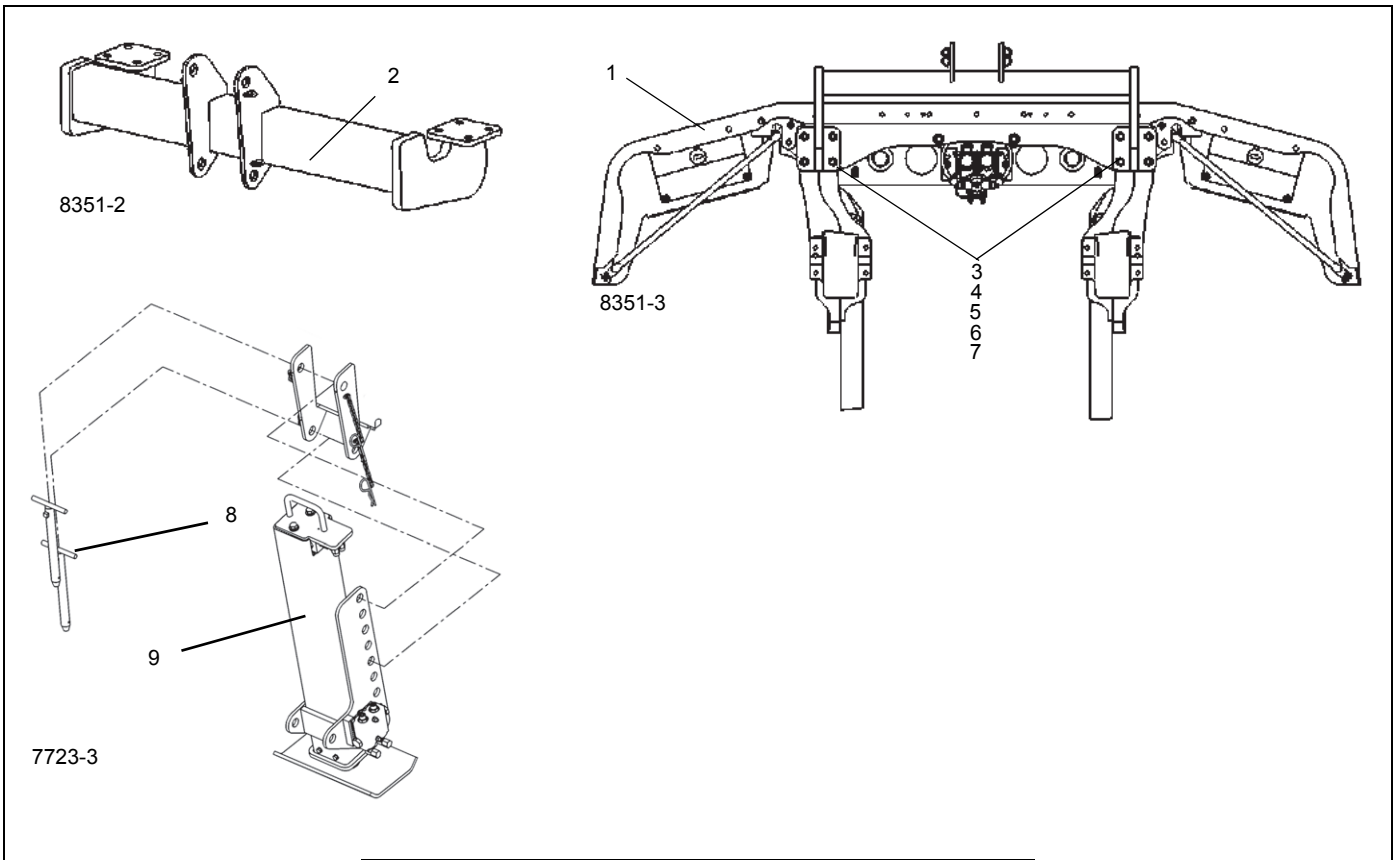


FIGURE 9-21

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11. Also, ensure truck is equipped with the steel castings.

1. Remove the existing bumper.
2. Cut front of truck frame to dimensions shown at radiator bracket.
3. Use bracket (1) as a template to, drill six 16 mm (.65 in) holes in truck frame.
4. Install spacer plate (2) between frame and bracket (1) using capscrew (3), washer (4) and nut (5).
5. Center the bumper (1) horizontally between the frame rails, then clamp the bumper (9) to the truck's bumper brackets (1).
6. Using the truck's bumper castings as a template, drill eight 12 mm (1/2 in) holes in the bumper (1).
7. Mount the bumper (9) to the truck's bumper brackets using the capscrews (6), washers (7), and nuts (8).
8. Using the two pins, attach the jack (2) to the bumper (1) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.

FIGURE 9-21 continued



Item	Description
1	Bumper
2	Single Front Outrigger (SFO) Cylinder Mount
3	Hex Head Capscrew 1/2-13UNCx2.5 G8
4	Flat Washer 1/2" Nar MS
5	Lock Washer 1/2" Reg HRC45-51
6	Hex Nut 1/2-13UNC SAE-5.2
7	Hex Head Capscrew 1/2-13UNCx4 G8
8	Pin
9	Single Front Outrigger (SFO) Jack
10	Decal-Danger O/R Crush Hazard

This bumper installation is to be used on Peterbilt 365/367 SBFA w/o extended front rails.

1. Remove the existing chrome bumper.
2. Mount the single front outrigger (SFO) cylinder mount (2) under the bumper (1) to the truck's frame using the capscrews (3, 7), washers (4, 5), and nuts (6).
3. Using the two pins (8), attach the jack to (9) to the bumper (1) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.

FIGURE 9-22

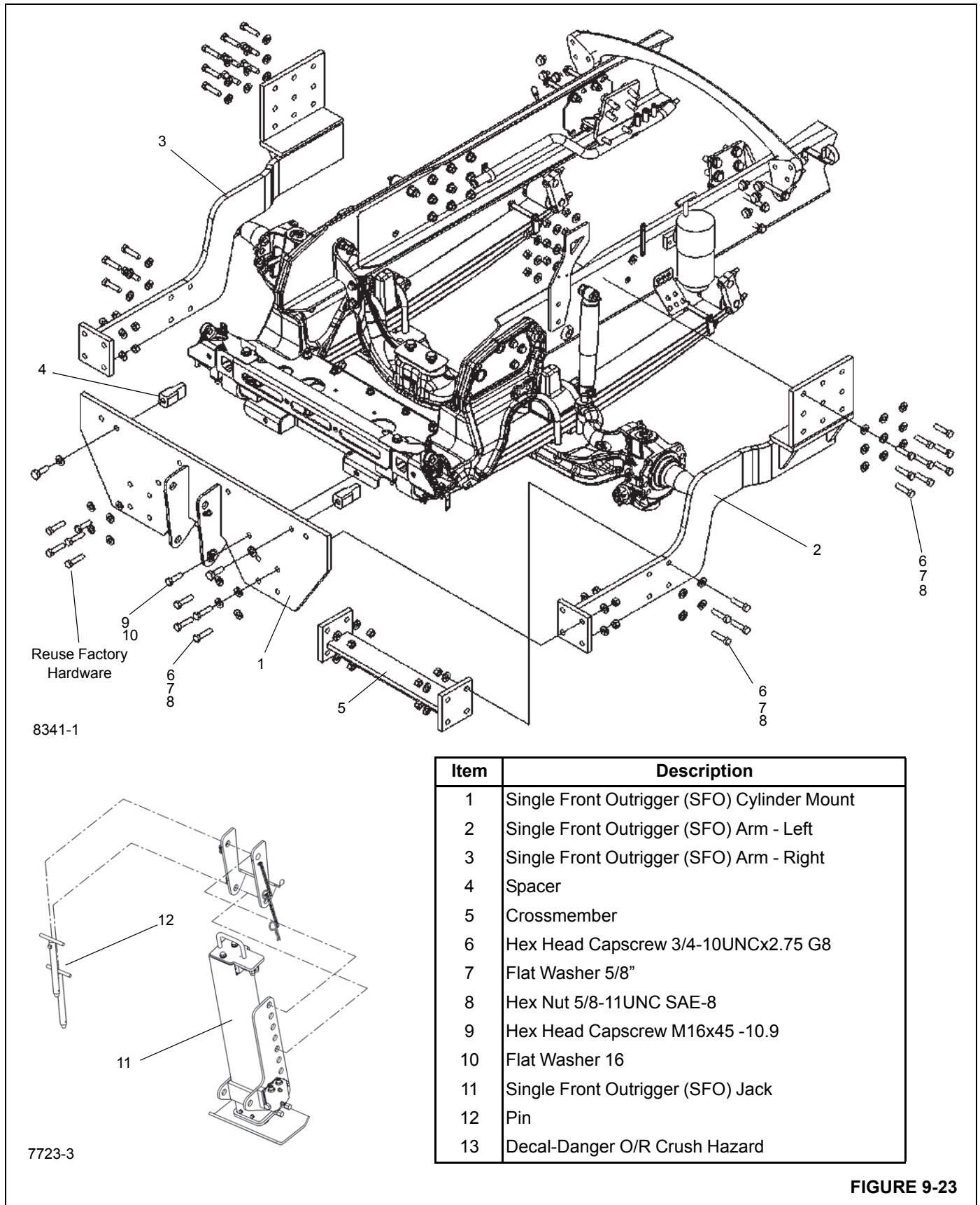
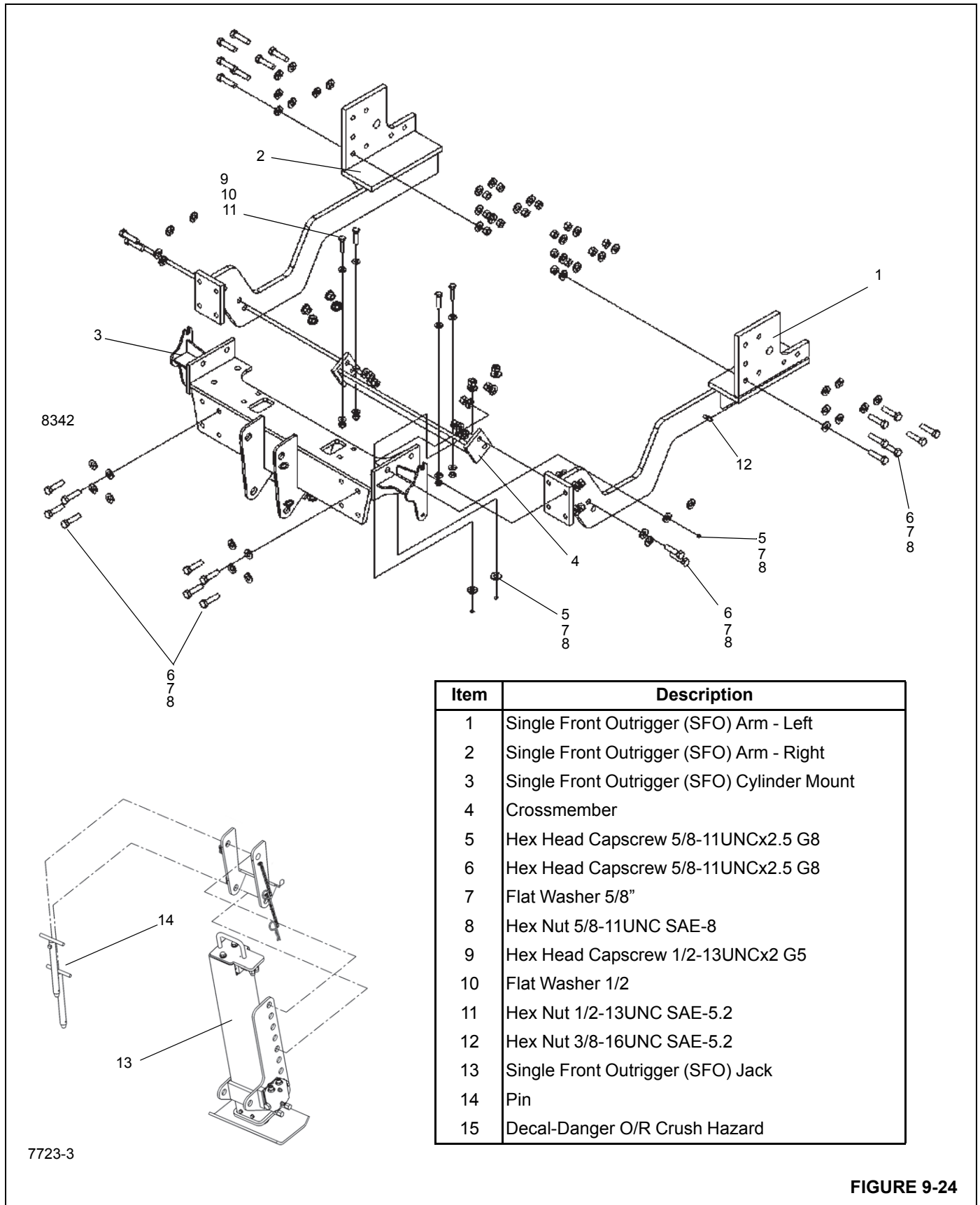


FIGURE 9-23

This bumper installation is to be used on Peterbilt 365/367 SBFA w/extended front rails.

1. Remove the existing bumper.
2. Mount the crossmember (5) between the single front outrigger (SFO) arms (2) and (3) reusing the existing factory hardware.
3. Mount the SFO cylinder mount (1) under the bumper to the truck's frame using the capscrews (6, 9), washers (7, 10), and nuts (8).
4. Using the two pins (12), attach the SFO Jack (11) to the SFO cylinder mount (1) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.
5. All fasteners to be installed with Loctite ® 243.

FIGURE 9-23 continued



Item	Description
1	Single Front Outrigger (SFO) Arm - Left
2	Single Front Outrigger (SFO) Arm - Right
3	Single Front Outrigger (SFO) Cylinder Mount
4	Crossmember
5	Hex Head Capscrew 5/8-11UNCx2.5 G8
6	Hex Head Capscrew 5/8-11UNCx2.5 G8
7	Flat Washer 5/8"
8	Hex Nut 5/8-11UNC SAE-8
9	Hex Head Capscrew 1/2-13UNCx2 G5
10	Flat Washer 1/2
11	Hex Nut 1/2-13UNC SAE-5.2
12	Hex Nut 3/8-16UNC SAE-5.2
13	Single Front Outrigger (SFO) Jack
14	Pin
15	Decal-Danger O/R Crush Hazard

FIGURE 9-24

This bumper installation is to be used on Peterbilt 348 w/o extended front rails.

1. Remove the existing tow pin/bumper brackets.
2. Mount the crossmember (4) between the single front outrigger (SFO) arms (1) and (2) reusing the existing factory hardware.
3. Mount the SFO cylinder mount (3) under the bumper to the truck's frame using the capscrews (5, 6, 8, 9), washers (7, 10), and nuts (8).
4. Using the two pins (14), attach the SFO Jack (13) to the SFO cylinder mount (3) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.
5. Ensure that items (1) and (2) sit tight against the side and the bottom of frame.
6. Ensure ground wires are reattached to the threaded stud on item (1).
7. Factory radiator support bracket will need to be notched to clear bottom bolt.
8. Factory bumper may require trimming to fit before it can be remounted.
9. All fasteners to be installed with Loctite ® 243.

FIGURE 9-24 continued

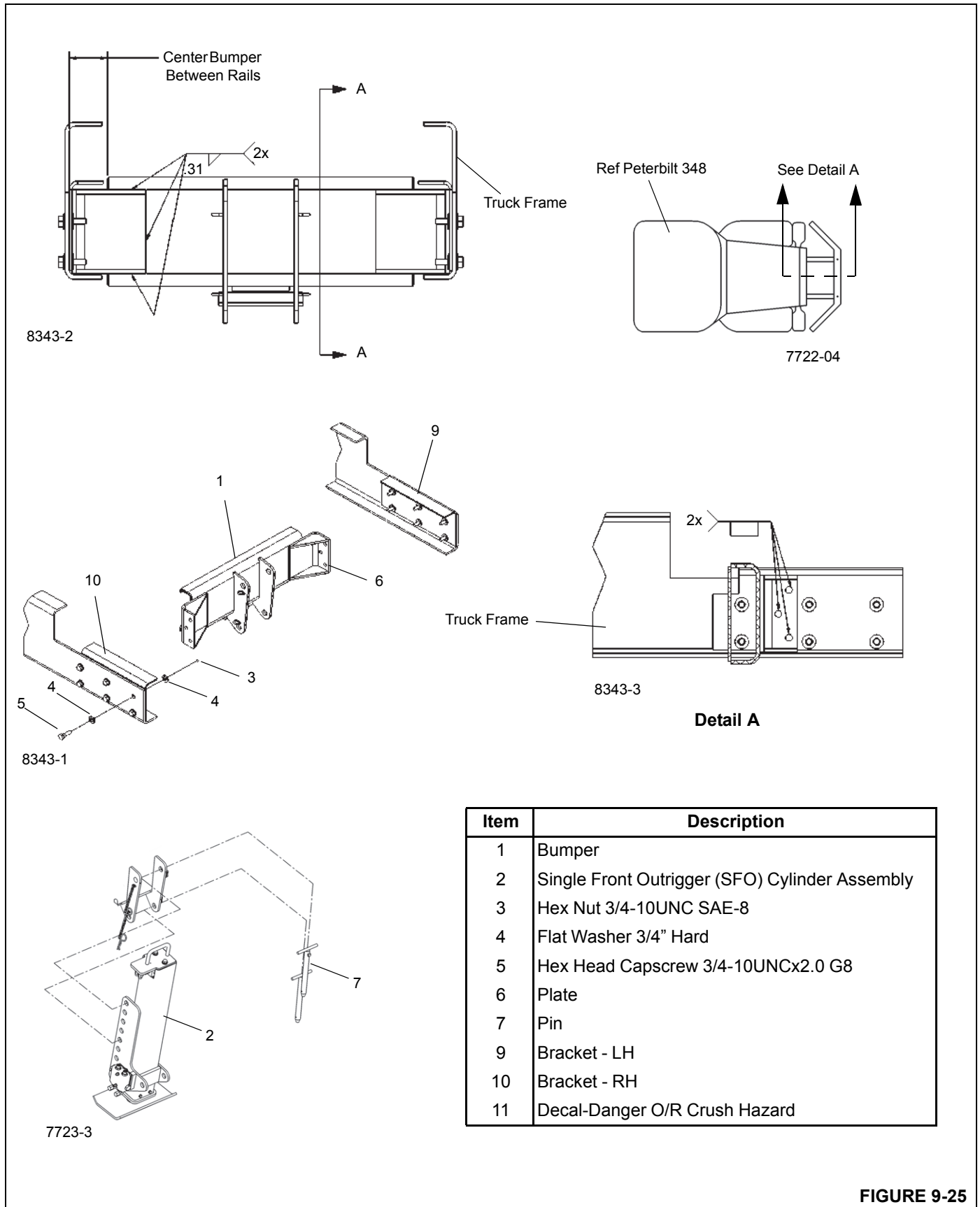
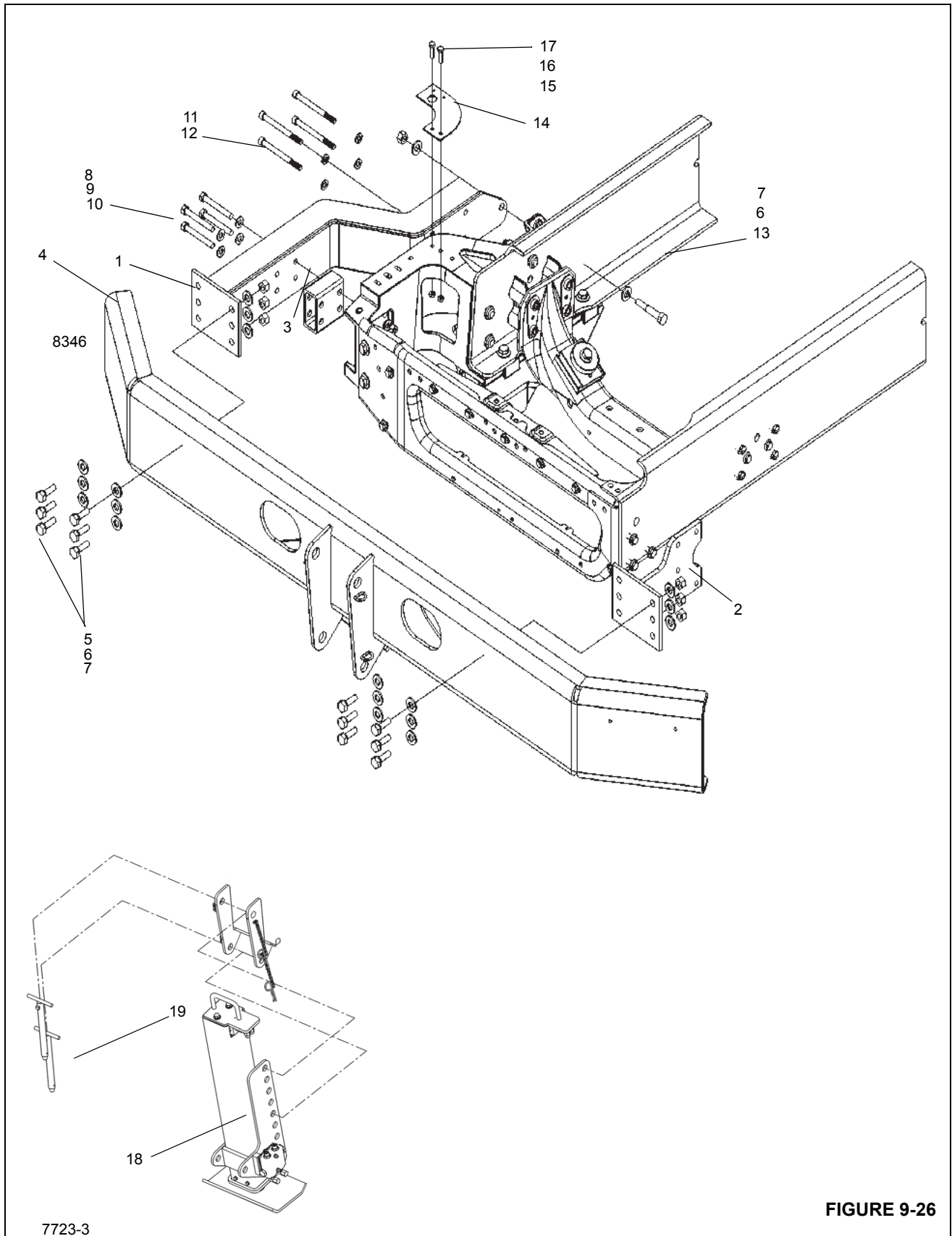


FIGURE 9-25

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-11.

1. Remove the existing bumper.
2. Remove the angle brackets bolted to the extended front frame from the factory and position the left and right mounting brackets (9, 10) on the truck frame rails. Clamp the brackets in place, then mark and drill 19 mm (3/4 in) holes (six per side) through the mounting brackets and truck frame using a bolt pattern of 101 mm (4 in).
3. Attach the mounting plates (6) to the truck frame rails.
4. Center the bumper (1) horizontally between the frame rails, then vertically such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack. Tack weld the bumper to the mounting plates.
5. Remove the mounting plate/bumper assembly from the truck, then finish welding the mounting plates (6) to the bumper (1) following the weld requirements found on the drawing in Figure 9-25; all welds to be grade 90.
6. Attach the mounting plate/bumper assembly to the truck frame using the supplied hardware (3, 4, 5).
7. Attach the jack (2) to the bumper (1) using the two pins (7).

FIGURE 9-25 continued



Item	Description
1	Single Front Outrigger (SFO) Bracket - Right
2	Single Front Outrigger (SFO) Bracket - Left
3	Spacer
4	Bumper Assembly
5	Hex Head Capscrew 5/8-11UNCx1.75 G8
6	Flat Washer 5/8"
7	Hex Nut 5/8-11UNC SAE-8
8	Hex Head Capscrew 1/2-13UNCx4 G8
9	Flat Washer 1/2
10	Hex Nut 1/2-13UNC SAE-8
11	Socket Head Capscrew M12X140-12.9 Iso4762
12	Flat Washer M12
13	Hex Head Capscrew 5/8-11UNCx3.5 G8
14	Bracket
15	Hex Head Capscrew 3/8-16UNCx1.25 G5
16	Hex Nut 3/8-16UNC SAE-2
17	Flat Washer 3/8 Wide
18	Single Front Outrigger (SFO) Cylinder Assembly - Front
19	Pin
20	Decal-Danger O/R Crush Hazard

This bumper installation is to be used on Ford 750 w/o extended front rails (Pass Side Mega Bracket).

1. Support engine crossmember before removing factory bolts and replacing them with items (11) and (12).
2. Remove the existing factory tow pin/bumper brackets and replace with item (2) single front outrigger (SFO) bracket - left to the left side of the truck's frame reusing existing hardware.
3. Mount the spacer (3) between the SFO bracket - right (1) and the right side of the truck's frame using the capscrews (8), washers (6) and nuts (10).
4. Center and mount the bumper assembly (4) on truck frame and drill 15.5 mm (0.625) holes.
5. Secure bumper using capscrews (5), flat washers (6) and nuts (7).
6. Using the two pins (19), attach the SFO Jack (18) to the bumper assembly (4) such that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the front jack.
7. All fasteners to be installed with Loctite ® 243.

FIGURE 9-26 continued

Single Front Outrigger (SFO) Hydraulic Connection

Using the hydraulic hoses provided, connect the single front outrigger (SFO) to the front outrigger control manifold as shown in Figure 9-27. Route hydraulic hoses without sharp bends and with clearance or protection between hoses and

stationary or moving parts which could wear against the hose. Connect the piston side of the jack to port “3” of the front outrigger control manifold; using a T-fitting, connect the rod side of the jack to the “A” port of the front outrigger control manifold.

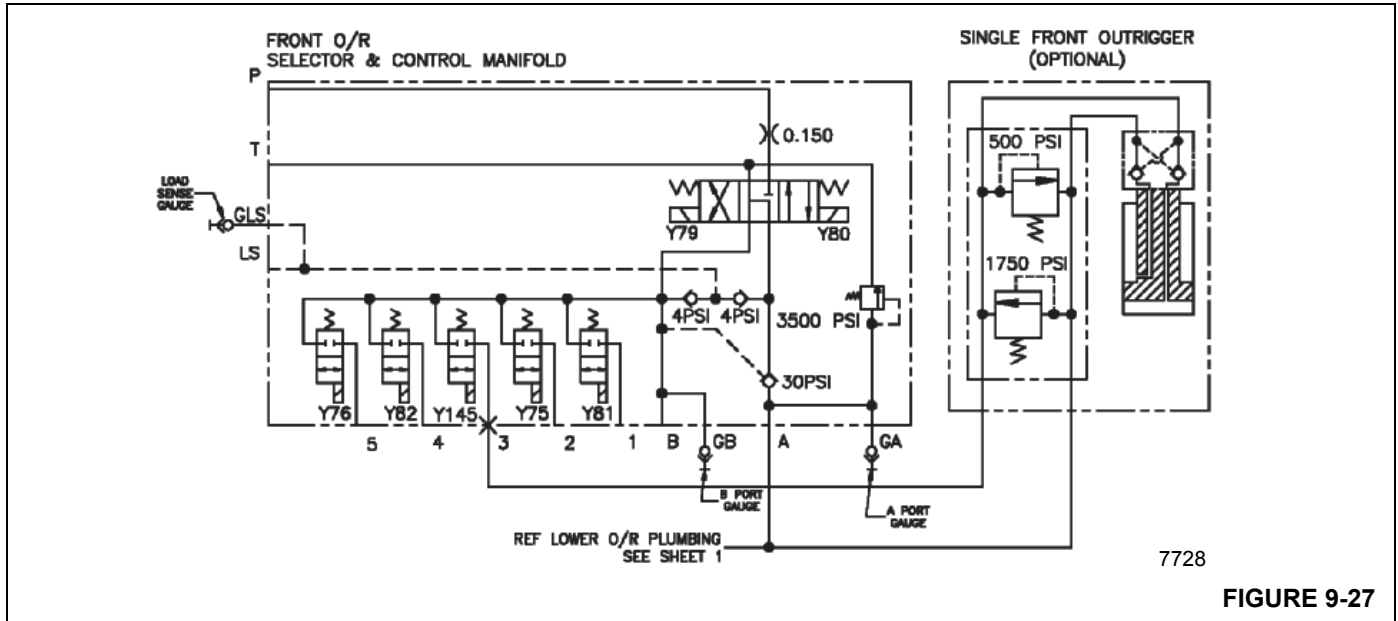


FIGURE 9-27

Truck Interface Electrical Connection

Make the electrical connection between the crane and truck using the following procedures and information in Figure 9-28.

1. Working at the rear of the truck, install the five red marker lights (8) in the light cover plate and light plate (Detail B), then connect the marker lights to the main wire harness (1).
2. Install the original truck taillights to the truck wire harness using the integral brackets in the light plate.
3. Install the license plate light assembly (9) in the light plate using the supplied hardware (10, 11, 12, 16) (Detail B), then connect the light assembly to the main wire harness (1).
4. If equipped, install the backup/motion alarm (13) and grommet (14) in the light plate (Detail B), then connect the alarm to the main wire harness (1).
5. Install the red marker lights (8) in the driver and passenger side rear fender (Detail C), then connect the marker lights to the main wire harness (1).
6. Install the yellow marker lights (7) in the driver and passenger side front fender (Detail C), then connect the marker lights to the main wire harness (1).
7. Install the left and right remote O/R control panels (left - 2, right - 3) in their respective front fender using the

supplied hardware (4, 5, 6) (Detail C), then connect the control panels to the main wire harness (1). The control panels need configured prior to starting from the superstructure cab. Once control panels are configured, the locations are not reversible.

8. Using the two butt connectors (15), splice the #396 wire of the main wire harness (1) into the truck’s PTO indicator wire (Detail A and E).
9. Route the breakout wires #52 (crane start signal), #112 (truck acc signal), and #901 (crane ign signal) of the main wire harness (1) through the truck’s firewall and into the dashboard (Detail A). Connect the wires to the keyswitch.

NOTE: The crane is equipped with a terminating resistor for the J1939 network which is located as part of the fuse and relay panel in the back of the cab. This resistor must be removed if the truck’s resistor is used.

10. Make the wire connections to the truck ECM and set the truck ECM and crane EEPROM settings using the information in the applicable engine chart in Figure 9-28.
11. Connect the #7 wire and three fuse holders (one 60 amp and two 40 amp) of the main wire harness (1) to the positive terminal of the battery. Connect the two #51 wires of the main wire harness (1) to the negative terminal of the battery (Detail D).

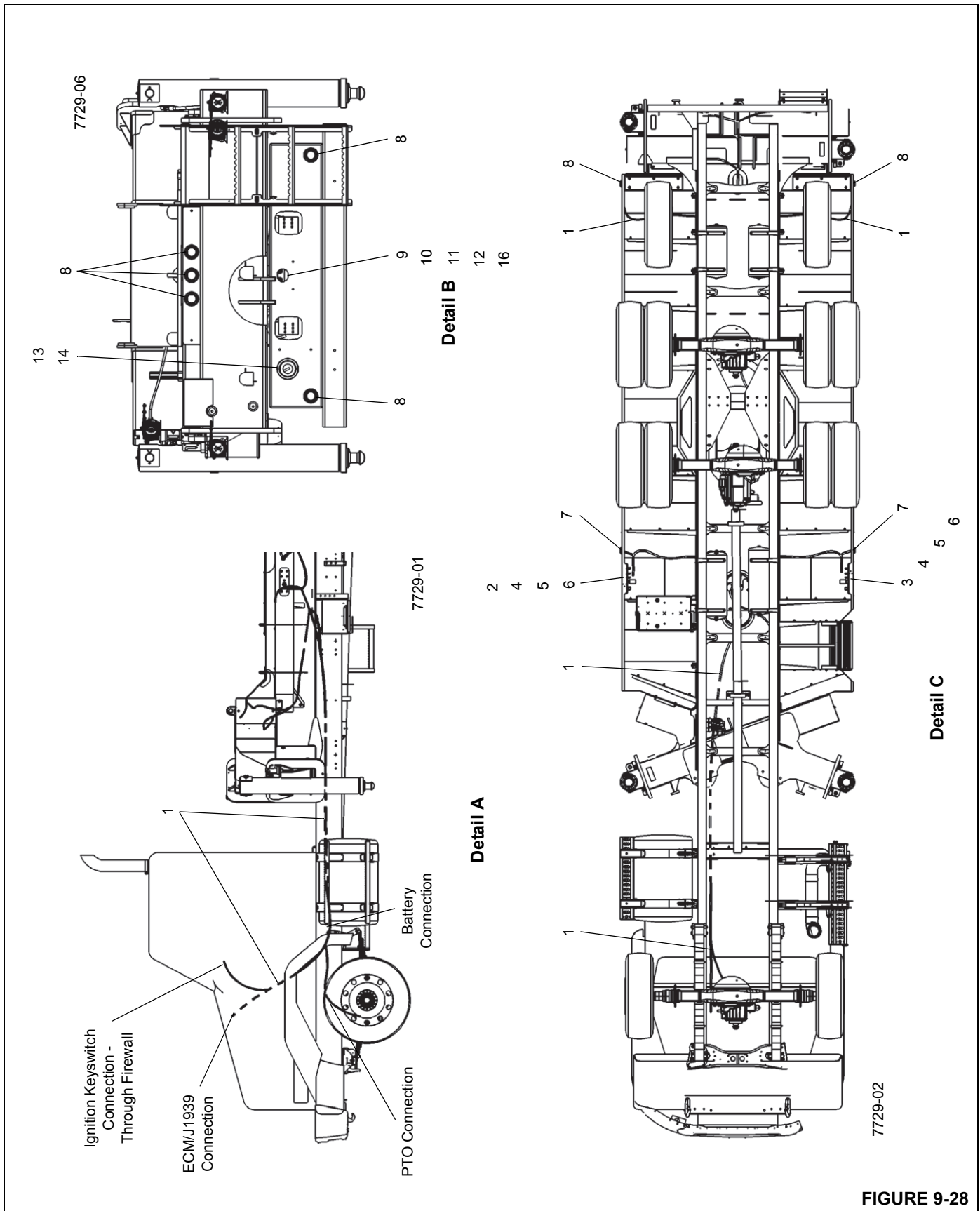
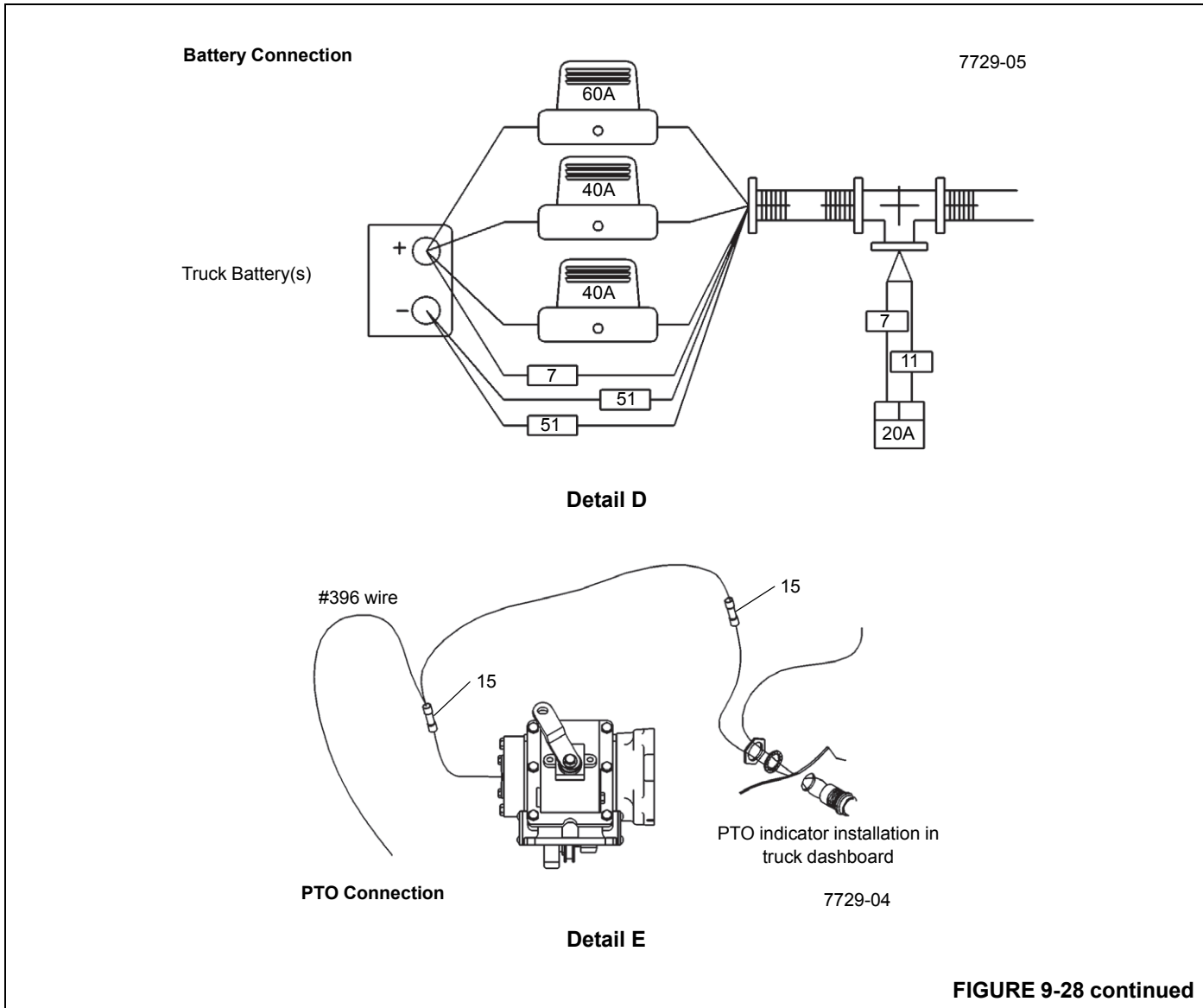


FIGURE 9-28



Item	Description
1	Lower Wire Harness
2	Panel Assy-LH Remote O/R Ctrl
3	Panel Assy-RH Remote O/R Ctrl
4	HHCS M6x25 8.8 ISO 4017
5	F Washer 6 -St ISO 7089
6	Retaining Nut M6
7	Yellow LED Marker LT w/Grommet
8	Red LED Marker LT w/Grommet

Item	Description
9	License Plate Light Assem
10	Slot PMS #8-32UNCx0.75 G1
11	L Washer #8 Reg HRC44-51
12	Hex Nut #8-32UNC Sae-2
13	Dual Tone Backup Alarm
14	Grommet
15	22-16 Ga Butt Conn Ins Melt
16	F Washer #8 Nar MS

Truck Keyswitch and ECM Interface		
Wire#	Function	Comments
52	Crane Start Signal	Connect at start relay or keyswitch
112	Truck ACC Signal	Connect at keyswitch
396	PTO Enabled Signal	Connect at PTO - see PTO detail view
901	Crane Ign Signal	Connect at keyswitch
1159	PTO Output (CAT)	Connect to ECM, see engine detail
1592	Remote Throttle (+)	Connect at ECM, see engine detail
1593	CAT Throttle (-)	Connect at ECM, see engine detail
1289	J1939 High (+)	
1290	J1939 Low (-)	
2149	Analog Throttle (+)	Connect to ECM, see engine detail
2154	Throttle Enable (+)	Connect to ECM, see engine detail

Mercedes Engine Remote Throttle Settings		
Truck ECM Settings		
Category	Parameter	Value
PGN 0	TSC1 Source Address	51
Remote Throttle - Crane EEPROM		
Category	Parameter	Value
Production	Engine Select	2
Production	EEJ1939 Tx Address EEprom	51
Production	Mercedes Low Idle	(Idle Engine RPM) x 8
Production	Mercedes High Idle	(RPM Value from TCC) x 8
Truck ECM Wiring		
#1289/#1290	J1939 Connection	

Mack Engine Remote Throttle Settings		
Truck ECM Settings		
Category	Parameter	Value
PGN 0	TSC1 Source Address	23
Crane EEPROM Settings		
Category	Parameter	Value
Production	Engine Select	3
Production	EEJ1939 Tx Address EEprom	23
Production	Mack Low Idle	(Idle Engine RPM) x 8
Production	Mack high Idle	(RPM Value from TCC) x 8
Truck ECM Wiring		
#1289/#1290	J1939 Connection	

FIGURE 9-28 continued

International Engine Remote Throttle Settings			
Truck ECM Settings			
ID	Name	Value	
75001	Aux. Throttle Cntrl - Mode	Remote Operation Only	
75021	Aux. Throttle Cntrl - In Cab Mode	Stationary Variable	
75041	Aux. Throttle Cntrl - RMT Pedal Enable	Enable	
75081	Aux. Throttle Cntrl - Max Engine Speed	RPM Value from TCC	
Crane EEPROM Settings			
Category	Parameter	Value	
Production	Engine Select	6	
Production	EEJ1939 Tx Address EEprom	23	
Truck ECM Wiring			
Wire#	Description	Conn/Pin	Int Wire#
2149	Analog Throttle	BB2/1	K92-A5
2154	Throttle Enable	BB1/3	K92-A12

Cummins Engine Remote Throttle Settings		
Truck ECM Settings		
Category	Parameter	Value
SAE J1939 Multiplexing	Remote Accelerator Pedal or Lever	Enable
SAE J1939 Multiplexing	Remote Accelerator Pedal or Lever Switch	Enable
Remote Accelerator Pedal or Lever	Source Address	23
Remote Accelerator Pedal or Lever Switch	Source Address	23
Vehicle Speed Source	Max Engine Speed Without VSS	RPM Value from TCC
Crane EEPROM Settings		
Group	Parameter	Value
Production	Engine Select	1-N.A. 5-Export Engines
Production	EEJ1939 Tx Address EEprom	23
Truck ECM Wiring		
#1289/#1290	J1939 Connection	

Detroit Diesel Engine Remote Throttle Settings		
Truck ECM Settings		
Category	Parameter	Value
PGN 0	TSC1 Source Address	231
Remote Throttle - Crane EEPROM		
Category	Parameter	Value
Production	Engine Select	2
Truck ECM Wiring		
#1289/#1290	J1939 Connection	

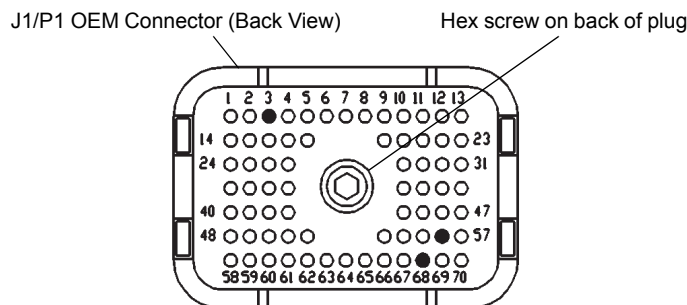
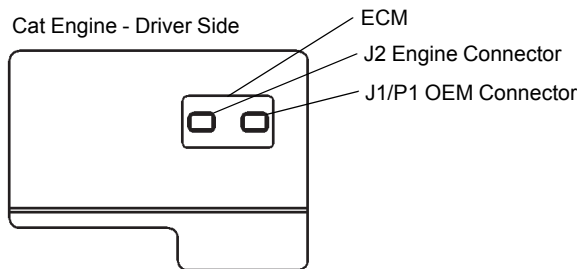
FIGURE 9-28 continued

Caterpillar Engine Remote Throttle Settings		
Truck ECM Settings		
Category	Parameter	New Value
Dedicated PTO Parameters	PTO Configuration	Remote Throttle and J1939 Speed Command
Dedicated PTO Parameters	PTO Engine Limit	RPM Setting Indicated on TCC
Input Selections	PTO On/Off Switch	J1/P1:56

J1/P1 Connector on Engine ECM Wire Connections						
	Description	Wire Color	Wire #	Pin #	Notes	Detail
A	Remote Throttle Ground	Blk	N/A	3	Splice into existing wire	F
B	Remote Throttle Signal	Wht	N/A	68	If pin location is occupied, remove existing and replace	F
C	PTO Ground Signal	Org	N/A	56	If pin location is occupied, remove existing and replace	F

Crane Wire Connections		
Description	Wire #	Notes
PTO Enable	396	Sends the PTO enabled signal to crane
J1939 Connection	1289/1290	Connects the crane to truck's J1939

Crane EEPROM Settings		
Group	Parameter	New Value
Production	Engine Select	"0"
Production	EEJ1939 Tx Address EEprom	23

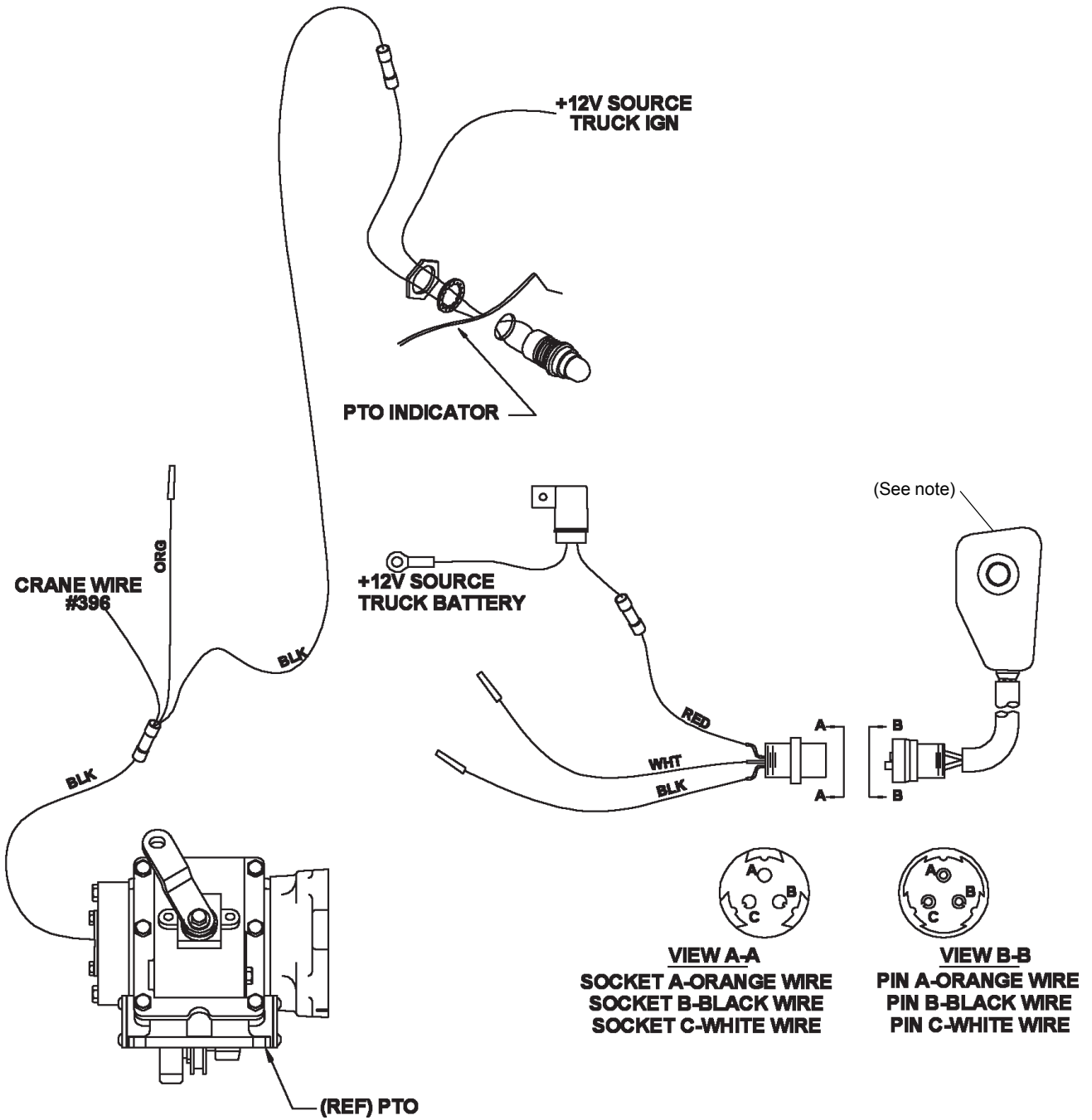


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Detail F

FIGURE 9-28 continued

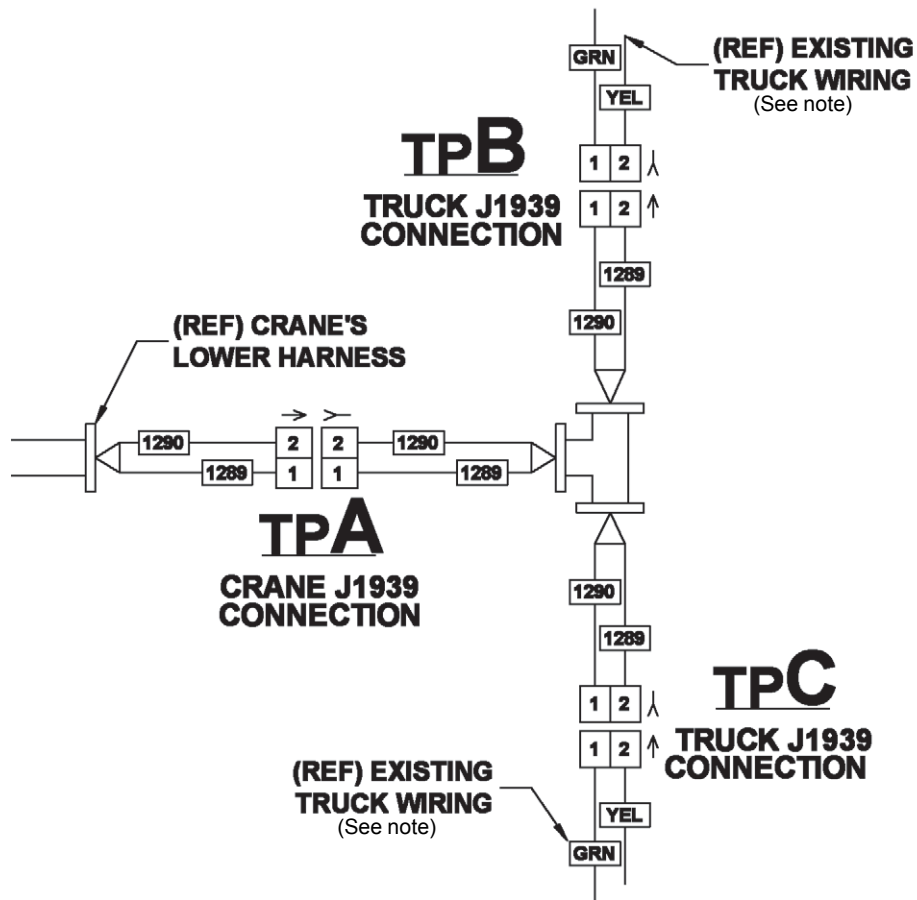
CAT - PTO and Throttle Sensor Wire Connections



Note: CAT throttle sensor is used only to send the ECM a valid idle signal all the time. Sensor can be tie strapped to the truck wiring in the engine compartment.

FIGURE 9-28 continued

CAT J1939 Connection



Note: Locate the blue connector vertically mounted above CAT ECM connectors. Disconnect this connector and locate 4 pin sleeve with resistor. Remove this resistor from the sleeve and connect in the J1939 splitter harness. There is a resistor located at the crane master module that replaces this resistor.

FIGURE 9-28 continued

Fuel Level Select EEPROM

The Fuel Level Select EEPROM depends on the chassis manufacturer's J1939 CAN network as to what message is being sent for the fuel level. This is not engine specific. See Figure 9-29 for examples of the fuel icons in this section of the various states the fuel level icon will display.

The most common values found are listed in Table 9-2. If this EEPROM is set to the default, but no Fuel Level is shown on the diagnostics screen, try the remaining EEPROMS until the correct value for that particular chassis is set. This

EEPROM can be found in the group called "J1939". Refer to Figure 9-28.

If one of the EEPROMS listed on Table 9-2 does not show the fuel level on the diagnostic screen, but "grays" out the fuel level icon, then the particular chassis does not support sending a fuel level message to the crane network.

Setting the EEPROM to any value other than those listed in Table 2 will result in the fuel level being grayed out as shown here. This can be used to "disable" the fuel level feature so that the fuel level does not show incorrectly on the diagnostic screen.

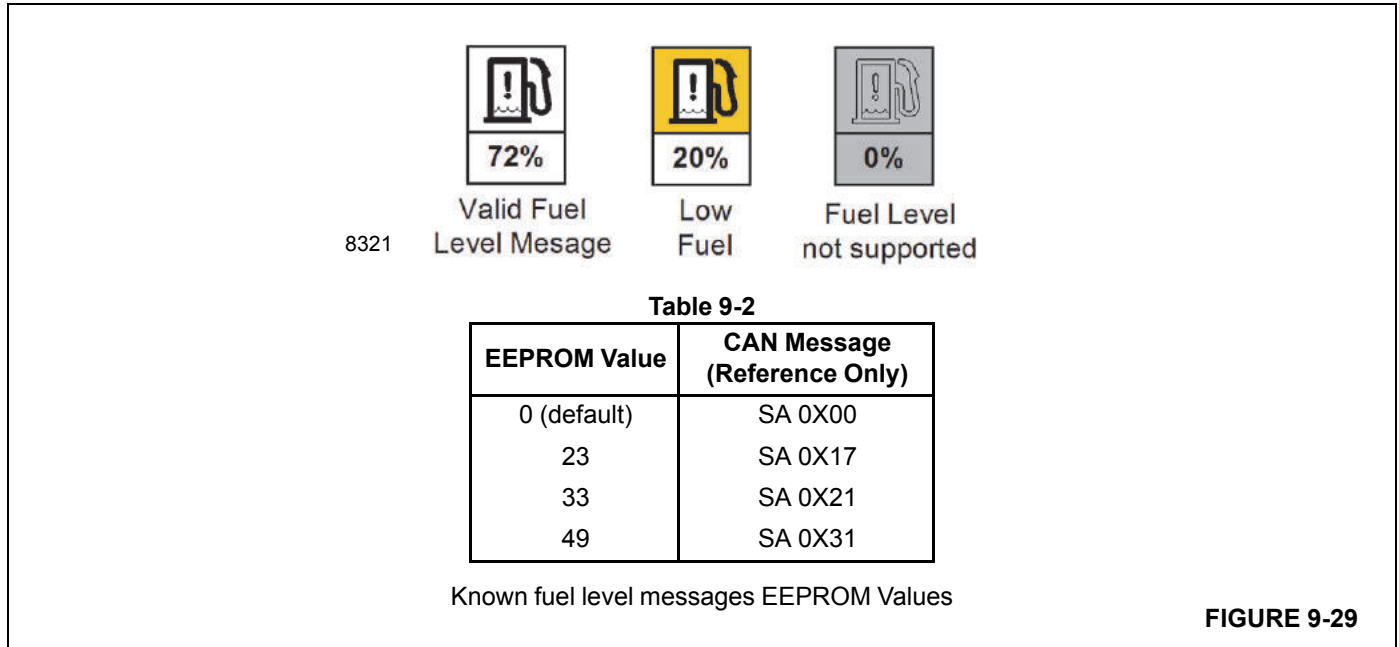


FIGURE 9-29

Hydraulic Pump Connection

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

For pump installation, use the following procedures:

1. Mount the pump to the truck using the procedures in the sub-section titled *PTO, Pump, Reservoir*, page 9-15.
2. Connect the hydraulic hoses coming from the T-box frame to the pump using the procedures in the sub-section titled *Supply Pressure And Return Circuit*, page 2-7.
3. Startup the pump using the procedures in the sub-section titled *A. Pump Startup Procedure*, page 2-16 to prevent damage to the pump or other components in the hydraulic system.

INITIAL CRANE RUN IN PROCEDURE

1. With the crane in an open area for testing that will permit full operation of all its functions, engage the PTO, start the truck from the crane cab, and program the RCL. It is recommended to completely follow the on screen sensor calibration and configuration steps before operating the crane and outriggers through all of the functions at least six (6) times to purge cylinders of air. Operate the control valves slowly with the truck engine at idle and cycle each cylinder through its complete stroke each time. Check to see that movement of outriggers and boom correspond with direction indicated on switches and levers. Refer to hydraulic or electrical schematic to correct any problems.

NOTE: Add oil to reservoir as required to keep air from reentering the system.

2. Set throttle according to engine RPM and PTO ratio to get 2200 rpm pump shaft speed.
3. When all cylinders have operated through complete cycles, stow crane and place the outriggers in the up position. The oil level should be visible near the top of the sight gage.
4. Lift and stability test must now be performed on the crane. (See “Stability Test” on page 9-60.) Hoist and crane tests should be conducted to ensure proper performance.
5. After testing is completed, the mounting bolts and all cable clamp bolts should be re-torqued to specifications.
6. Upon completion, overall height of crane vehicle combination must be measured and posted inside of cab informing driver of overall height.

STABILITY TEST

The chassis weight before the crane is mounted is included for use only as a guide in determining the total weight required for the crane to be stable with an 85% tipping factor (i.e. when lifting capacity load, the crane is at 85% of tipping or less).

In order to ensure the stability of the crane with an 85% tipping factor, a live load stability test must be performed on each completed crane. Proceed as follows:

1. Test the crane on a firm level surface. Provide cribbing under outrigger pads if they tend to sink when loaded.
2. With the boom in the rest, raise and level the crane on the outriggers with all tires clear of the ground according to procedures outlined in the Operation Section. Set the single front outrigger jack (if equipped).
3. All the loads listed on the Capacity Chart which are not shaded or notated with an asterisk (*) are loads which are limited by stability. In order to determine if the crane

is capable of lifting all stability loads with an 85% tipping factor, it is necessary to lift 1.176 times the rated load at the boom lengths and radii shown:

Model	Boom Length	Loaded Radius
NBT60 w/39 m (128 ft) Boom, 360° w/2721.5 kg (6000 lb) Counterweight	26.2m (86 ft) 35.9 (118 ft)	24.3 (80 ft) 32m (105 ft)
NBT60 w/39 m (128 ft) Boom, Over-Rear w/2721.5 kg (6000 lb) Counterweight	32.6 (107 ft) 35.9 (118 ft)	25.9m (85 ft) 25.9m (85 ft)
NBT60 Heavy Lift w/39 m (128 ft) Boom, 360° w/2721.5 kg (6000 lb) Counterweight	32.6 (107 ft) 35.9 (118 ft)	21.3m (70 ft) 32m (105 ft)
NBT60 Heavy Lift w/39 m (128 ft) Boom, Over-Rear w/2721.5 kg (6000 lb) Counterweight	35.9 (118 ft) 22.8 (75 ft)	30.4m (100 ft) 15.2m (50 ft)
Note: Cwt = Counterweight		

 DANGER

Stability test conditions represents overloads at crane positions where boom weight and CG location make up a large portion of the overturning moment. Great care should be taken to control boom position and keep hook load close to the ground. Test loads should not be allowed to swing out past rated radius. If overturning caused by the load is allowed to start, and boom angle gets too low, boom weight may cause the crane to upset.

4. 360° Example, starting over side on a NBT60 heavy lift with 39 m (128 ft) boom, without jib, assemble a load of $4,105^* \text{ kg} \times 1.176 = 4827.58 \text{ kg}$ or $(9,050 \text{ lb}^* \times 1.176 = 10,643 \text{ lb})$ (including hook block and slings) and measure 21.3 m (70 ft) from the center of rotation directly out to the side of the crane. Extend the boom to 32.6 m (107 ft), lift the load just slightly off the ground (approximately one foot) and boom down while hoisting up to move the load out to the 21.3 m (70 ft) radius. Move the load very slowly when approaching 21.3 m

(70 ft) so the load doesn't swing out. If the 4827.58 kg (10,643 lb) load can be kept from contacting the ground at the 21.3 m (70 ft) radius, the crane is stable over the side tested. Use the same procedure to check stability over the opposite side of the crane and also over the front and back of the crane.

5. Over the rear Example, starting over the rear on a NBT60 with 39 m (128 ft) boom, without jib, at 32.6 m (107 ft) boom length, assemble a load of $2880.3 \times 1.176 = 3387.4$ kg (6,350* x 1.176 = 7,468 lb) (including hook block and slings) and measure 25.9 m (85 ft) from the center of rotation directly out to the back of the crane. Move this stability load out to 25.9 m (85 ft) as previously done on 360° stability test. Example, if the 2880.3 kg (6,350 lb) load can be kept from contacting the ground at the 25.9 m (85 ft) radius, the crane is stable over the rear.

6. To ensure that the loads have been lifted directly over the sides, back and front, the loads may be slowly rotated in these areas.
7. If crane is unstable, counterweight will have to be added. If unstable over the rear, add weight at the front bumper or at the front of the subbase. If unstable over the side, add weight to the rear most area of the turret near the cast counterweight slab(s). Welding is not permitted to the counterweight castings.
8. Be sure the weights lifted are accurate. A 1% increase in load weight can result in a 10% increase in stability weight required.

NOTE: *If the NBT60 crane is equipped with a 7.9 m (26 ft) fixed jib or a 7.9 -13.71 m (26 - 45 ft) telescopic jib, refer to the appropriate "jib stowed" load chart to get the rated 85% stability load and multiply by 1.176 as indicated.

SPECIFICATIONS

Hydraulic

Hydraulic Pump	286 l/min (75.5 gpm) at 2200 rpm, Variable displacement, axial piston with load sense
Hydraulic Pump Displacement	130 cc/rev (7.93 in ³ /rev)
Pump Max Pressure	338 bar (4900 psi)
Load Sense Relief Valve.....	322 bar (4663 psi)
Pump Load Sense Margin	25 bar (363 psi)
Boom Up	182 l/min at 280 bar (48 gpm at 4061 psi)
Boom Down.....	72 l/min at 140 bar (19 gpm at 2031 psi)
Telescope Extend	189 l/min at 175 bar (50 gpm at 2538 psi)
Telescope Retract.....	57 l/min at 140 bar (15 gpm at 2031 psi)
Outrigger Extend	207 bar (3000 psi)
Outrigger Retract.....	128 bar (1850 psi)
Hoist System	132 l/min at 321 bar (35 gpm at 4663 psi)
Swing	102 l/min at 205 bar (27 gpm at 3000 psi)
Swing Park Brake	Hydraulic released disc, released at 20.7 bar (300 psi)
Cab Air Conditioner	8 gpm at 1450 psi
Reservoir Capacity	386 l (102 gal)
Reservoir Return Filter	5 micron
Reservoir Suction Filter	250 micron

Air Conditioner

Air Conditioner Hydraulic System.....	3500 (+/-100) psi
Minimum Evacuation Time	30 minutes
Refrigerant Charge Levels	2.0 pounds (+/- 0.5 Ounce)
Additional Pag Oil Required Above 6 ounces in Compressor	4.0 ounces

Hoist System

Wire Rope:	
Length	137 m (450 ft)
Diameter (Rotation Resistant).....	16 mm (5/8 in)
Nominal Breaking Strength	25,592 kg (56,420 lb)
Synthetic Rope: Optional	
Length	157 m (450 ft)
Diameter	18 mm (.70 in)
Operating Pressure	345 bar (5000 psi)
Flow.....	132.5 l/min (35 gpm)
Gearbox Capacity.....	2.3 l (2.5 qt)
Brake Capacity236 l (1/4 qt)

Hoist Line Pull/Layer		
Layer	Low Speed kN (lb)	High Speed kN (lb)
1	67 (15,000)	33 (7,500)
2	60 (13,500)	30 (6,800)
3	55 (12,300)	27 (6,100)

Hoist Line Pull/Layer		
Layer	Low Speed kN (lb)	High Speed kN (lb)
4	50 (11,300)	25 (5,600)
5	46 (10,400)	23 (5,200)

Line Speed (no load at high engine idle speed)		
Layer	Low Speed m/min (ft/min)	High Speed m/min (ft/min)
1	45 (150)	90 (290)
2	50 (160)	100 (320)
3	55 (170)	110 (350)
4	60 (190)	120 (380)
5	65 (210)	130 (410)

NBT60 Crane Operating Speeds

- (Performance based on full governed RPM and 37.8°C (100°F) hydraulic reservoir temperature.)
- Rotation 360° 30 ± 5 sec (1.8 ± 0.2 rpm) Adjustment Knob Closed
 - Boom up 0° to 80° 27 ± 5 sec
 - Boom Down 0° to 0° 32 sec ± 5 sec
 - Boom Extend/Retract Five Section
 - Extend (Angle 60°) 70 sec ± 10 sec
 - Retract (Angle 60°) 70 sec ± 10 sec
 - Outrigger Beam Extend 10 sec ± 3 sec
 - Outrigger Beam Retract 10 sec ± 3 sec
 - Outrigger Jack Extend 13 sec ± 3 sec
 - Outrigger Jack Retract 16 sec ± 3 sec

Counterweight

- Weight - Top 1,360 kg (3,000 lb)
- Weight - Bottom 1,360 kg (3,000 lb)
- Weight - IPO (without auxiliary hoist option) 317.5 kg (700 lb)

General

- Capacity NBT60 60 tons (54.4 metric tons) at 2.4 m (8 ft) radius
- Overall Length 12.10 m (39.7 ft), with 39.0 m (128 ft) Boom
- Overall width 2591 mm (102 in)
- Overall Height 4,020 mm (158.2 in)
- Boom Length, 39 l (128 ft), 5 section Retracted 9.7 m (32 ft), Extended 39.01 m (128 ft)
- Boom Weight 6,812 kg (15,017 lb)
- Jib Length - Optional Retracted 7.9 m (26 ft), Extended 13.7 m (45 ft)
- Jib Weight 828 kg (1,825 lb)
- Jib Offset - Optional 0° and 30°
- Gross Vehicle Weight - 4-axle minimum truck 39,009 kg (86,000 lbs)
- Gross Vehicle Weight - heavy lift truck - Tandem/Tridem 48,080 kg (106,000 lbs)
- Federal Bridge Law Compliant:
 - Gross Vehicle Weight - 7-axle pusher 1 3,629 kg (8,000 lbs)
 - Gross Vehicle Weight - 7-axle pusher 2 3,629 kg (8,000 lbs)
 - Gross Vehicle Weight - 7-axle tag 3,629 kg (8,000 lbs)

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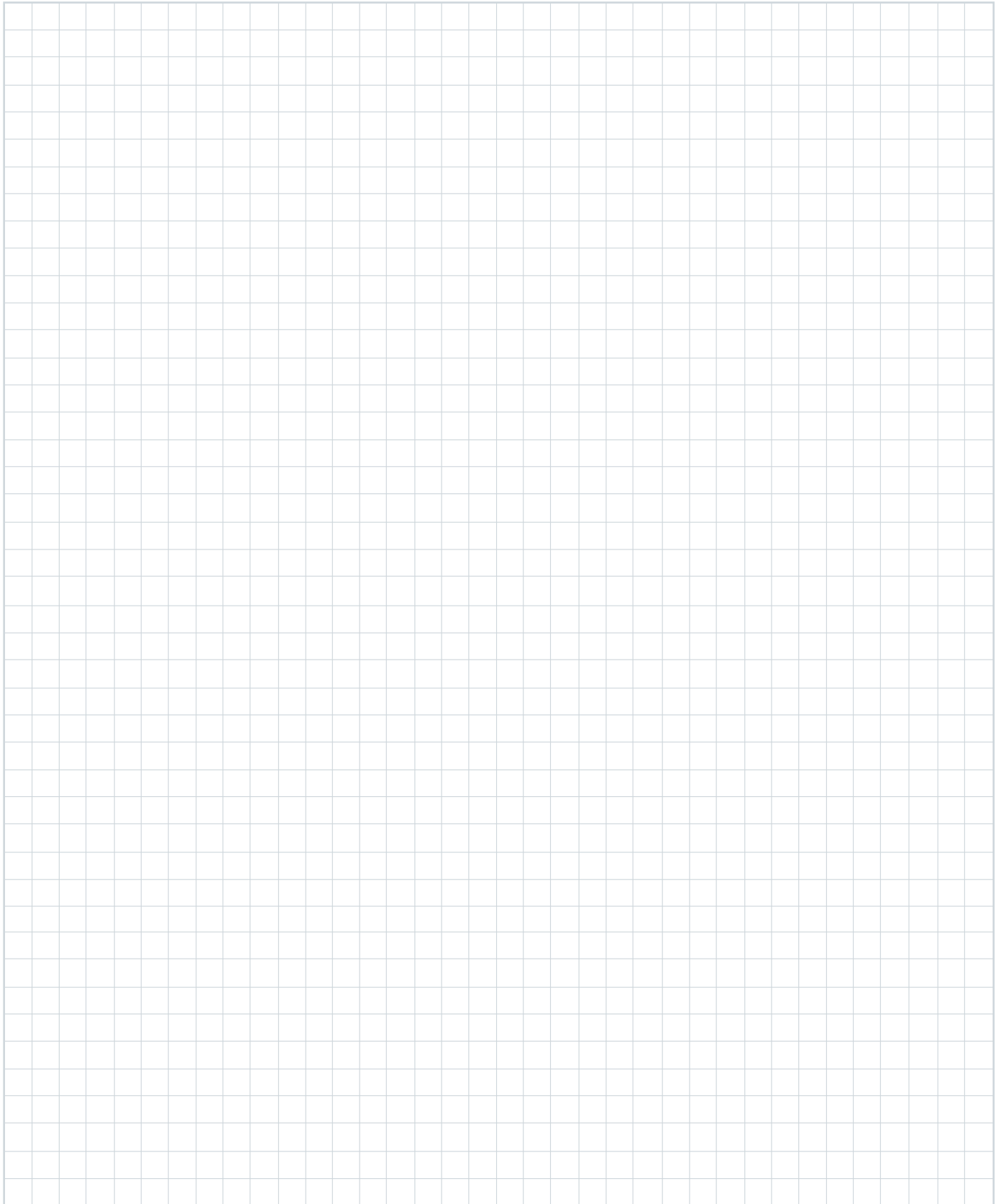
SECTION 10 SCHEMATICS

For your convenience, the latest version of schematics available at the time of printing are placed in this section.

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Grove

Manitowoc

National Crane

Potain

