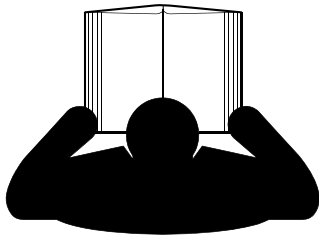


# OPERATOR MANUAL

## Supplement

### Crane Warm-up Procedures

For Reference Only



## **⚠ DANGER**

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

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

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- Swing Drive and Turntable Bearing ..... 1
- Axles ..... 2
- Hydraulic Oil System ..... 2

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For  
Reference  
Only

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This Supplement provides information regarding the proper warm-up procedures for operating the crane in colder temperatures. The information provided here supplements the *Operator* and *Service Manuals* and must be used in conjunction with these manuals.

## COLD CLIMATE ENGINE OPERATION

Engine specific cold climate operation information is available through your Cummins dealer/service center under Service Bulletin 3379009.

## CRANE WARM-UP PROCEDURES

The following procedures detail the actions that must be taken to properly warm the different crane components before operating the crane.

**NOTE:** For temperatures below -9°C (15°F) refer to arctic lubricants and conditions in the *Operator* and *Service Manuals*.

Before starting the crane, ensure the appropriate lubricants are used in order to provide lubrication for the prevailing ambient temperatures in which the crane will operate in (a list of lubricants and their temperature ranges can be found in the Lubrication section of your crane's *Operator Manual*, by contacting your local Manitowoc distributor, or by contacting Manitowoc Crane Care directly).

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### CAUTION

#### Crane Damage Hazard!

Operating the crane with the incorrect lubricants and fluids for the prevailing ambient temperature and/or failing to adequately warm the crane prior to cold weather operation can lead to a failure of a crane component or system.

Always use Manitowoc recommended lubricants and fluids for the prevailing ambient temperature and properly start and warm the crane using the cold weather procedures found in this *Operator Manual* and supplement before operating the crane at full load.

---

## Engine

### Warm-up Procedures for All Temperature Ranges:

1. Upon startup, allow the engine to idle for 3 to 5 minutes before operating with a load.
2. Cold Engine Startup: After allowing the engine to warm by idling it for 3 to 5 minutes, slowly increase the engine speed to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.

## Transmission

Operating the transmission with a sump temperature below normal operating temperature is limited to:

- operating in the neutral gear or
- driving with an unloaded crane while not exceeding 1500 engine RPM and not exceeding half throttle.

### Warm-up Procedures for Rough Terrain (RT) and Industrial Cranes:

1. Engage the parking brake and apply the service brake.
2. Shift the transmission into the highest gear and increase the engine RPM to 1500 for 15 seconds, then allow the engine RPM to return to idle.
3. Repeat Step 2 until the temperature of the transmission sump reaches normal operating temperature.

### Alternate Warm-up Procedures for Rough Terrain (RT) and Industrial Cranes:

1. Setup the crane on outriggers.
2. Engage the transmission with 4-wheel drive selected (if equipped) and allow crane to run at idle until the temperature of the transmission sump reaches normal operating temperature.

**NOTE:** Warm-up operation of 4-wheel drive transmission engaged in 2-wheel drive only could cause transmission damage.

### Alternate Warm-up Procedures for Truck Mount (TM/TMS) Cranes:

1. Setup the crane on outriggers.
2. Engage the transmission and allow crane to run at idle until the temperature of the transmission sump reaches normal operating temperature.

## Hoist

Performing a warm-up procedure is recommended at every startup and is required at ambient temperatures below 4°C (40°F).

### Warm-up Procedures:

1. Without operating the hoist function, warm the hydraulic oil (see *Hydraulic Oil System*, page 2-2).
2. Once the hydraulic system is warm, operate the unloaded hoist, in both directions, at low speeds several times to prime all hydraulic lines with warm hydraulic oil and to circulate gear lubricant through the planetary gear sets.

---

## Swing Drive and Turntable Bearing

### Warm-up Procedures for Temperatures Above -7°C (20°F):

1. Setup the crane on fully extended outriggers, with the boom fully retracted and near maximum lift angle with no load applied.
2. Rotate the superstructure at a speed of less than one RPM for at least one complete revolution in one direction, then rotate the superstructure at a speed of less than one RPM for at least one complete revolution in the opposite direction.

### Warm-up Procedures for Temperatures Below -7°C (20°F):

1. Ensure the boom is fully retracted and near maximum lift angle with no load applied.
2. Rotate the superstructure at a speed of less than one-half RPM for at least two complete revolutions in one direction, then rotate the superstructure at a speed of less than one-half RPM for at least two complete revolutions in the opposite direction.

## Axles

### Warm-up Procedures for Temperatures Below -35°C (-30°F):

1. Setup the crane on outriggers.
2. Engage the transmission (see *Transmission*, page 2-1) with 4-wheel drive selected (if equipped) and allow

crane to run at idle until the temperature of the transmission sump reaches normal operating temperature.

**NOTE:** Warm-up operation of 4-wheel drive transmission engaged in 2-wheel drive only could cause transmission damage.

## Hydraulic Oil System

### Operating Limits and Warm-up Procedures:

- **From 4°C to -10°C (40°F to 15°F):** Crane operation without a load is allowed with medium engine RPM and medium function speed (joystick position) until the fluid reaches at least 10°C (50°F). It is then recommended that all crane functions be cycled to remove cold fluid from all components and cylinders of the hydraulic system. If there is any unusual sound coming from the crane's hydraulic pumps or motors, stop the operation and engine immediately and contact a Manitowoc distributor.
- **From 10°C to 4°C (50°F to 40°F):** Crane operation with a load is allowed with medium engine RPM and medium function speed (joystick position) until the fluid reaches at least 10°C (50°F).
- **From 95°C to 10°C (200°F to 50°F):** Crane operation with a load is allowed with no restrictions.
- **Above 95°C (200°F):** No crane operation is allowed. Let the crane's hydraulic oil cool by running the engine at idle with no functions actuated.

# Grove RT530E-2

## Operator 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](http://www.P65warnings.ca.gov/diesel)

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

### **California Spark Arrestor**

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

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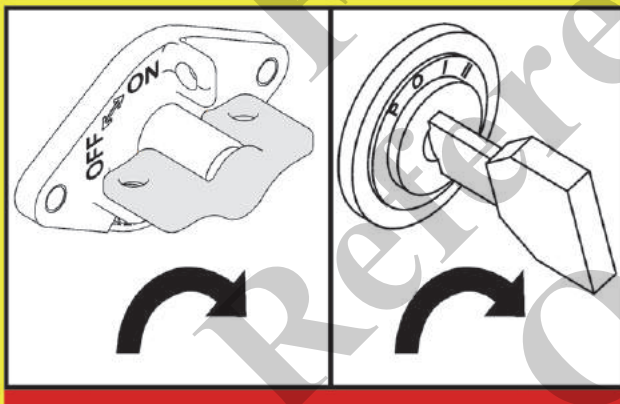
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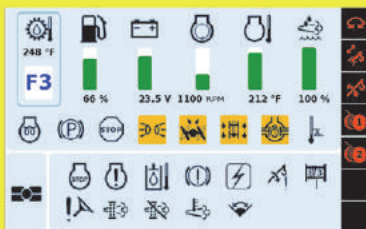
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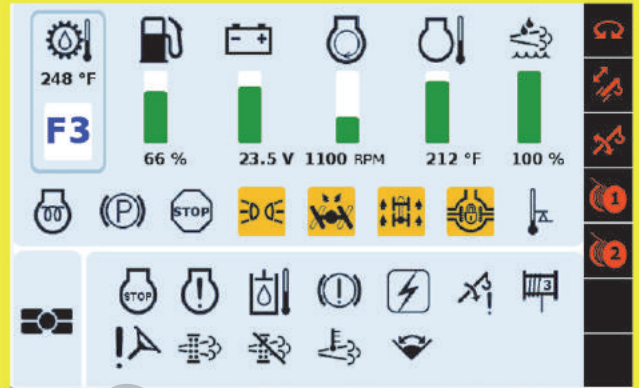
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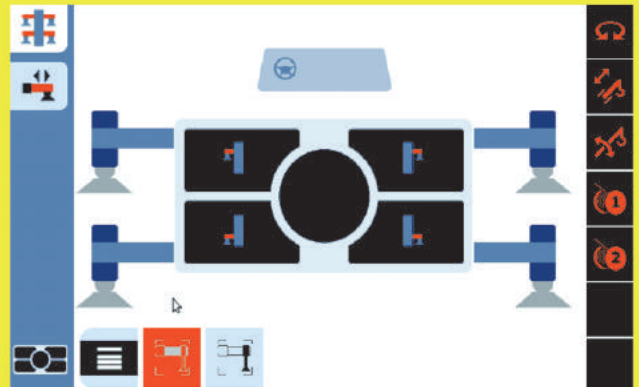
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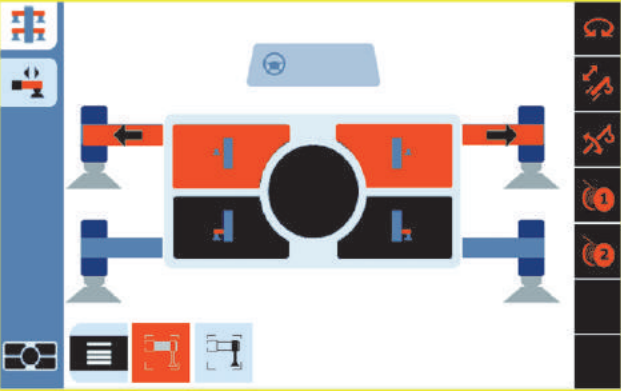
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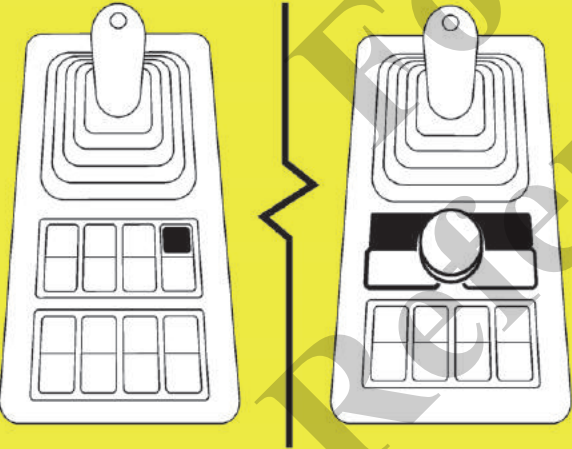



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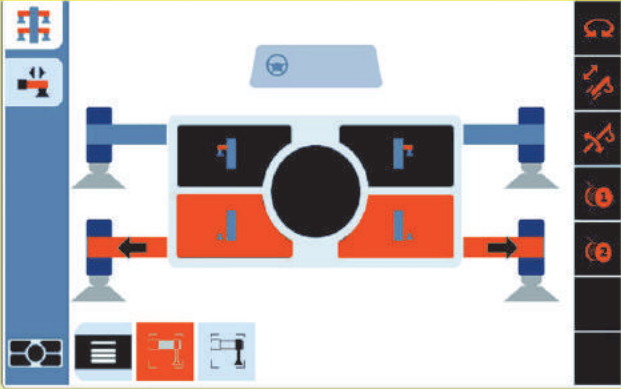


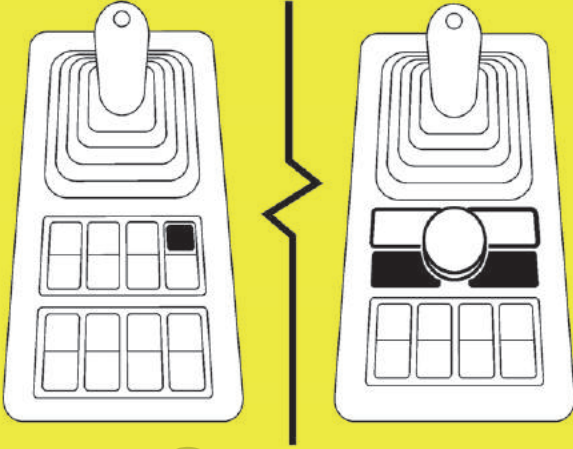
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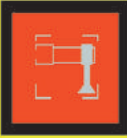



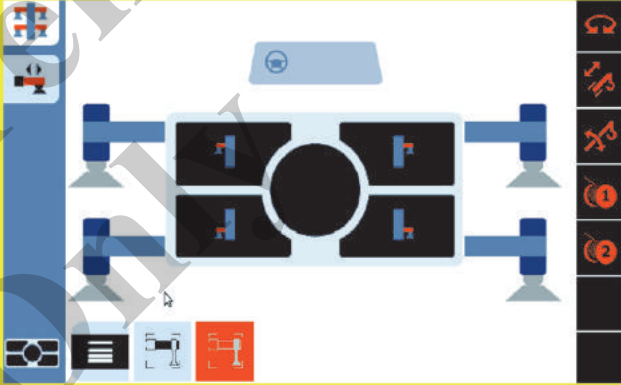
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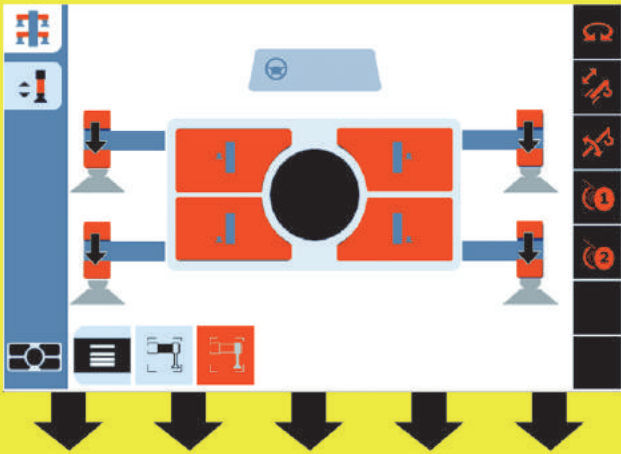


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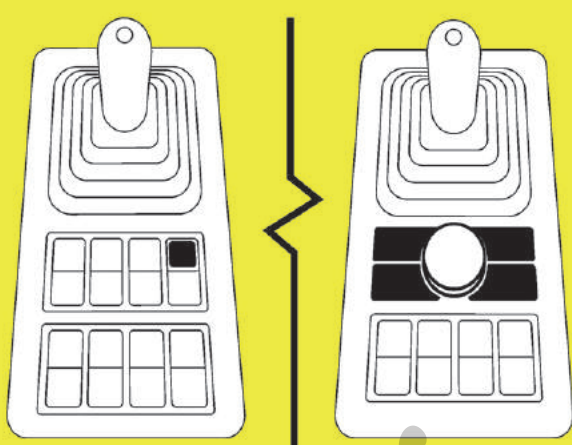


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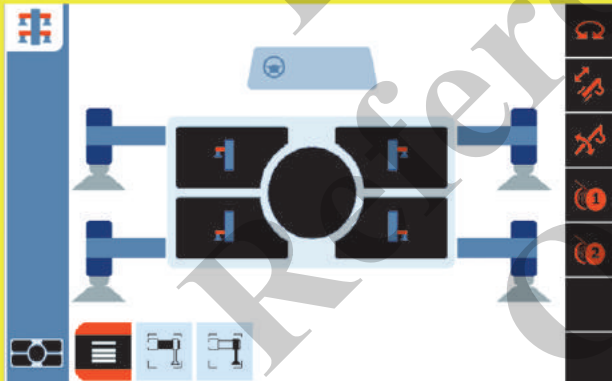
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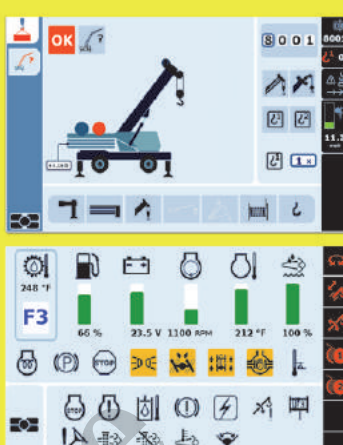
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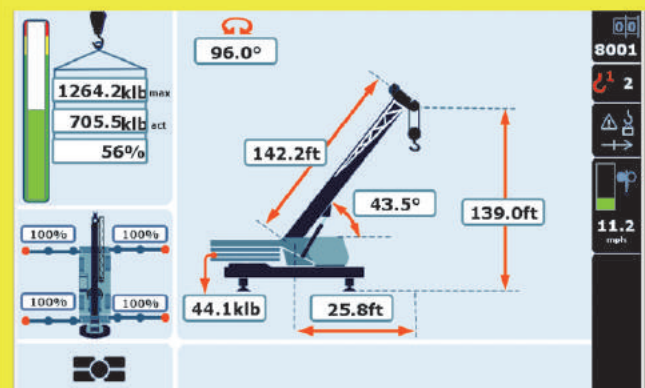
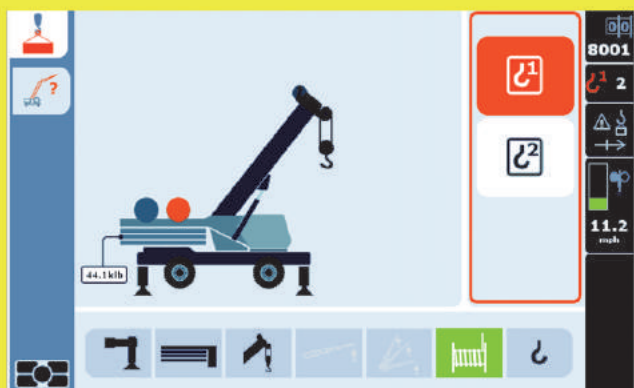
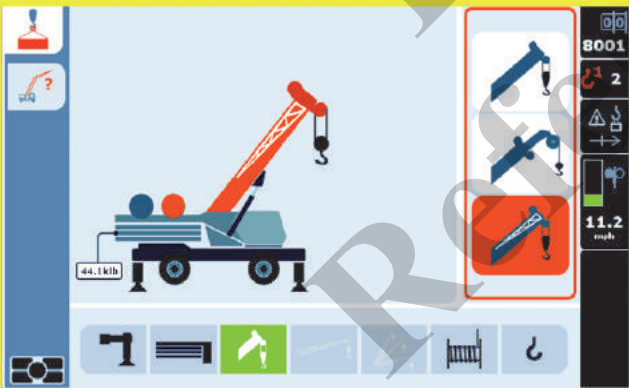
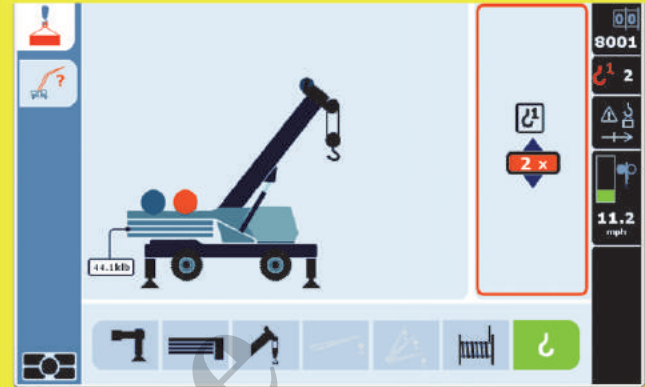
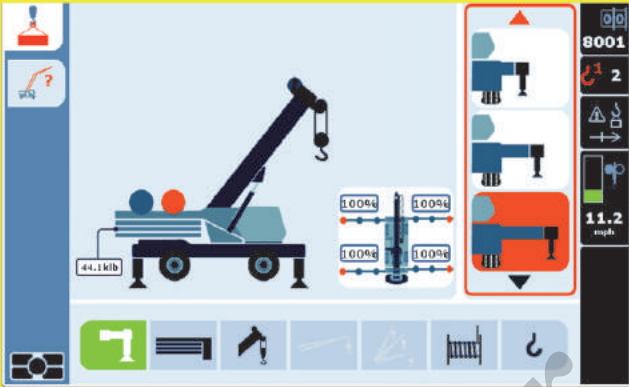


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# OPERATOR MANUAL

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

## RT530E-2

Crane Model Number

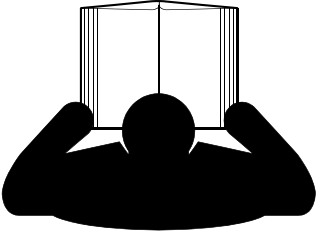
This Manual is divided into the following sections:

SECTION 1	INTRODUCTION
SECTION 2	SAFETY INFORMATION
SECTION 3	OPERATING CONTROLS AND PROCEDURES
SECTION 4	SET-UP AND INSTALLATION PROCEDURES
SECTION 5	LUBRICATION
SECTION 6	MAINTENANCE CHECKLIST

### 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 operator's cab. **Always furnish crane serial number** when ordering parts or communicating service problems with your distributor or the factory.



## **DANGER**

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

- You are trained in the safe operation of this crane. Maniowoc 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.

*For  
Reference  
Only*

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### GENERAL

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

This Handbook provides important information for the operator of the Model RT530E-2 Series Grove Crane.

The rough terrain crane incorporates an all welded steel frame, using planetary drive axles to provide four-wheel drive. Axle steering is accomplished utilizing hydraulic steer cylinders. The engine is mounted at the rear of the crane and provides motive power through a six speed forward and reverse transmission. Hydraulic, double box, sliding beam outriggers are integral with the frame.

The carrier frame incorporates an integral fifth wheel, to which the rear axle is mounted, to provide axle oscillation. Axle oscillation lockout is automatic when the superstructure rotates from the travel position.

The superstructure is capable of 360° rotation in either direction. All crane functions are controlled from the fully-enclosed cab mounted on the superstructure. The crane is equipped with a four-section cable synchronized full power boom. Additional reach is obtained by utilizing a swingaway boom extension. Lifting is provided by a main hoist and an optional auxiliary hoist.

### NOISE/VIBRATION TEST RESULTS

#### Noise Level Test Results

- When equipped with the CE certification package, the guaranteed sound power level at the operator's station with closed cab operation is  $L_{WA}$  is 105 dB(A) as measured by Directive 2000/14/EC and 80 db(A) at the crane operator position as measured by Annex G.1 of EN 13000:2010+A1:2014.

#### Vibration Level Test Results

- At the operator's station with closed cab operation, vibration levels are less than 0.5 m/s/s for Whole Body Vibration exposure and are less than 2.5 m/s/s for Hand Arm Vibration exposure when measured according to 89/392/EEC Community Legislation on Machinery per standard ISO 2631/1 - Evaluation of Human Exposure to Work Body Vibration, ISO 5349 - Guidelines for the Measurement and Assessment of Human Exposure to Hand Transmitted Vibrations, and ISO/DIS 8041 - Human Response Vibration Measuring Instrumentation.

### Customer Support

Manitowoc 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.

**New Owners**

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

Go to: [http://www.manitowoccranes.com/MCG\\_CARE/Includes/EN/changeofownership.cfm](http://www.manitowoccranes.com/MCG_CARE/Includes/EN/changeofownership.cfm) and complete the form.

**LIST OF SPECIFICATIONS**

**General**

Model	RT530E-2
Rated Capacity	See Load Chart in cab
Drive	4 x 4
Gross Weight	See Axle Weight Distribution Table

**Dimensions**

**NOTE:** Dimensions listed are for a crane with all components fully retracted in the travel mode with 20.5 x 25-24 Earthmover bias ply tires.

Wheelbase	3.66 m (144 in)
Overall Crane Length	12.29 m (483.7 in)
Overall Crane Width	2.54 m (100 in)
Overall Crane Height	3.24 m (127 in)
Tail-Swing	3.66 m (144 in)
Outrigger Spread	
Retracted	2.39 m (7 ft 10 in)
Mid Extend	4.27 m (14 ft)
Fully Extended	6.10 m (20 ft)

**Capacities**

Fuel Tank	220 l (58 gal)
Coolant System	See Engine Specifications
Engine Lubrication System	See Engine Specifications
Hydraulic Tank (Reservoir Capacity)	
Total	442 l (117 gal)
at Full Level	396 l (105 gal)
at Low Level	369 l (97 gal)
Expansion Space	46 l (12 gal)
Hoists	5.2 l (5.5 qt)
Swing Gearbox	4 l (4.25 qt)
Axle Planetary Hubs	1.7 l (3.5 pt)
Axle Differentials	9.5 l (20 pt)
Transmission (includes Torque Converter)	24 l (25 qt)

**Torque Converter/Transmission**

Stall Ratio	2.024:1
Charge Pump Capacity	70 l/min (14.5 gpm)

@ 2000 rpm

**Gear Ratios**

Forward/Reverse	
Lo 1st	10.07
Lo 2nd	4.64
Lo 3rd	2.00
Hi 1st	4.05
Hi 2nd	1.86
Hi 3rd	0.80

**Engine**

**Cummins QSB6.7**

Displacement	6.7 l (409 cu in)
Firing Order	1-5-3-6-2-4
Lube Amount	17.5 l (18.5 qt)
Coolant System	28.5 l (30 qt)

**Axles**

Total Ratio	20.06:1
Carrier Ratio	5.57:1
Wheel End Ratio	3.60:1

**Brakes**

Type	Hydraulic/Split system acting on all four wheels
------	--

**Wheels and Tires**

Lugs	12
Torque	461 to 488 Nm (340 - 360 lb-ft)
Tire Size	
Standard	20.5 x 25-24 ply rating
For roading and lifting pressures, refer to the Load Chart Book in the cab.	

**Swing Gearbox**

Reduction Ratio	36:1
Output Torque	755 Nm (6680 in-lb)

**Boom**

Length	
Retracted	8.8 m (29 ft)
Extended	29.0 m (95 ft)
Power	4 Section, Full Power
Elevation	-3 to +76 degrees
Extensions	
Fixed Offsettable	7.9 meters (26 ft)
Folding*	7.9 - 13.7 meters (26 - 45 ft)
*Extensions are offsettable at 0, 15, or 30 degrees.	

**Swivel Assembly**

Electrical	20 Slip Rings
Hydraulic	10 ports
Water	2 ports
Air Conditioning	2 ports

Hydraulic Pumps

Pump #1

NOTE: Pump output is theoretical @ no-load engine speed.

Type .....Piston  
 Sections .....1  
 Output - @ 275.8 bar (4,000 psi) w/no load  
 Section 1 .....283.7 l/min (62.4 gpm)

Pump #2

Type .....Gear  
 Sections .....1  
 Output - @ 172.4 bar (2,500 psi) w/no load  
 Section 1 .....82.8 l/min (21.9 gpm)

Pump #3

Type ..... Gear with priority flow divider

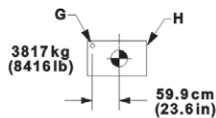
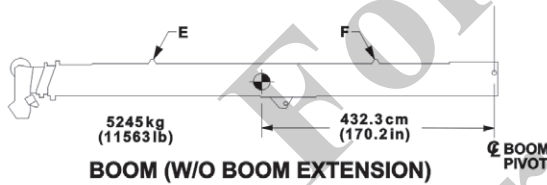
Sections .....1  
 Output - @ 199.9 bar (2,900 psi) w/no load  
 Section 1 .....57.2 l/min (15.1 gpm)

Hoists

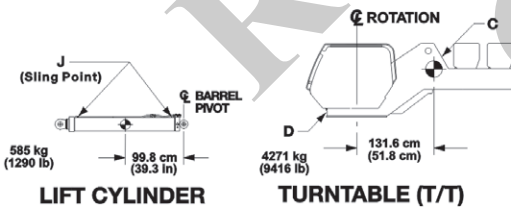
Drum Dimensions  
 Diameter ..... 270 mm (10.63 in)  
 Length (Standard) ..... 419 mm (16.5 in)  
 Cable  
 Diameter ..... 16 mm (5/8 in)  
 Length-Main ..... 138 m (452 ft)  
 Length-Aux. .... 138 m (452 ft)  
 Max. Permissible Line Pull (6x36)  
 .....51.7 kN (11,640 lb)  
 Max. Single Line Speed . . . 156.7 m/min (514 fpm)  
 Hoist Motor Displacement  
 Low ..... 54.0 cm<sup>3</sup> (3.3 in<sup>3</sup>) per revolution  
 High ..... 39.3 cm<sup>3</sup> (2.4 in<sup>3</sup>) per revolution



TRANSPORTATION AND LIFTING DATA RT530E-2

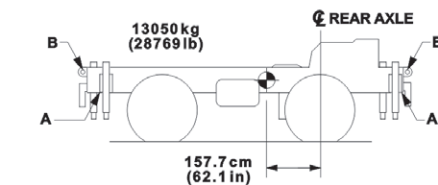


COUNTERWEIGHT (CWT)

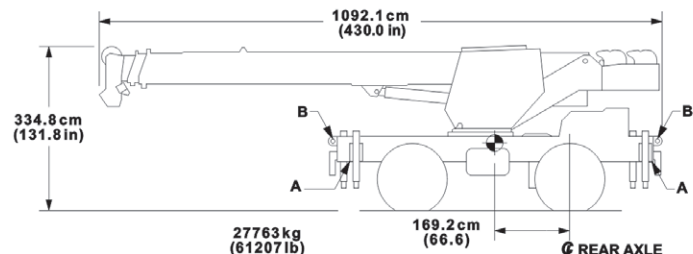


LIFT CYLINDER

TURNTABLE (T/T)



CARRIER



TOTAL UNIT (WITH BOOM EXT)

FITTINGS	NO./UNIT	TOTAL UNIT		CARRIER		LIFT CYL.	T/T	BOOM	CWT	FITTING CAPACITY (TONS)				
		LIFT	TOW	LIFT	TOW					LIFT	TOW	FORE & AFT	SIDE	DOWN
		LIFT	TIEDOWN	LIFT	TIEDOWN	LIFT	LIFT	LIFT	LIFT	TOW	FORE & AFT	SIDE	DOWN	
A	4	X								12	SEE NOTE #5			
B	4	X	X	X	X						82	25	7.1	35
C	2						X			7.9				
D	2						X			2.3				
E	2							X		3.2				
F	2							X		3.2				
G	2								X	2.2				
H	2								X	9.4				
J	-					X				N/A				

- LIFTING OF ENTIRE CRANE OR MAJOR CRANE ASSEMBLIES MUST BE ACCOMPLISHED BY UTILIZING SPECIFIC FITTINGS INDICATED ON ABOVE CHART. USE OF FITTINGS FOR PURPOSES OTHER THAN THOSE DESIGNATED ON CHART IS PROHIBITED. FITTING CAPACITIES ARE MAXIMUM ALLOWABLE LOADS PER INDIVIDUAL FITTING.
- RIGGING PERSONNEL SHALL BE RESPONSIBLE FOR PROPER SELECTION AND PLACEMENT OF ALL SLINGS AND LOAD HANDLING DEVICES.
- DIMENSIONS AND WEIGHTS SHOWN ARE FOR HEAVIEST CONFIGURATION AVAILABLE.
- RIGGING PERSONNEL SHALL VERIFY DIMENSIONS AS REQUIRED FOR CLEARANCE.
- EXTEND OUTRIGGER BEAMS 46 CM (18 IN) AND SLING AROUND BEAMS.
- DO NOT USE PINTLE HOOKS OR CWT LUGS FOR LIFTING OR TIE DOWN OF ENTIRE CRANE.

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FIGURE 1-1

SERIAL NUMBER LOCATION



Refel Only

COMPONENT LOCATIONS

1

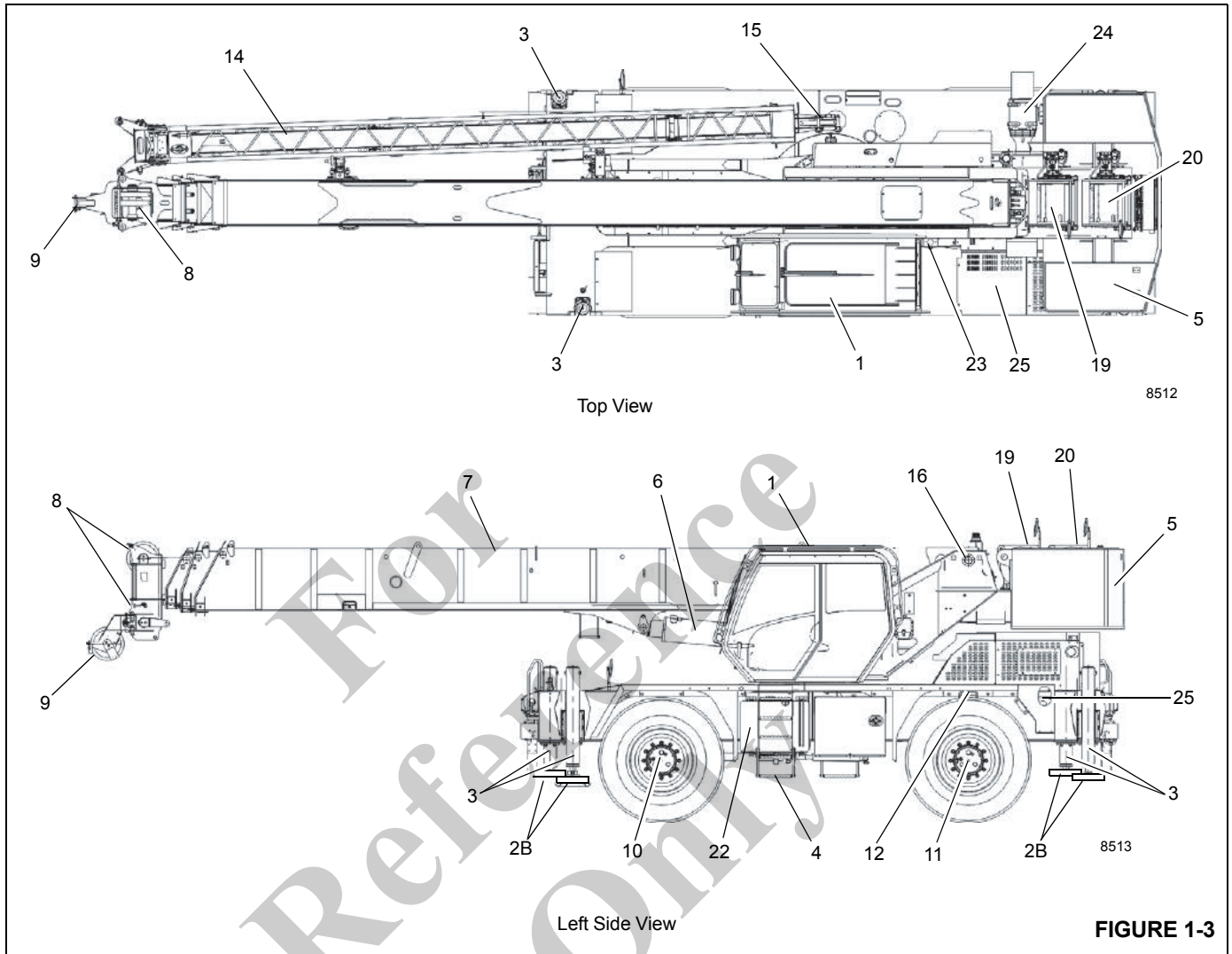


FIGURE 1-3

1	Cab	13	Boom Extension Mast Sheave
2A	Outrigger Float Stowed	14	Boom Extension
2B	Outrigger Float Installed	15	Boom Extension Nose
3	Outrigger Jack Cylinder	16	Boom Pivot
4	Steps	17	Hydraulic Tank
5	Counterweight	18	Hydraulic Filter
6	Lift Cylinder	19	Main Hoist
7	Boom	20	Auxiliary Hoist
8	Boom Nose Sheaves	21	Hookblock
9	Auxiliary Boom Nose	22	Fuel Tank
10	Front Axle	23	Windshield Washer Fluid Container
11	Rear Axle	24	Air Cleaner
12	Engine (Behind Cover)	25	Diesel Exhaust Fluid (DEF) Tank

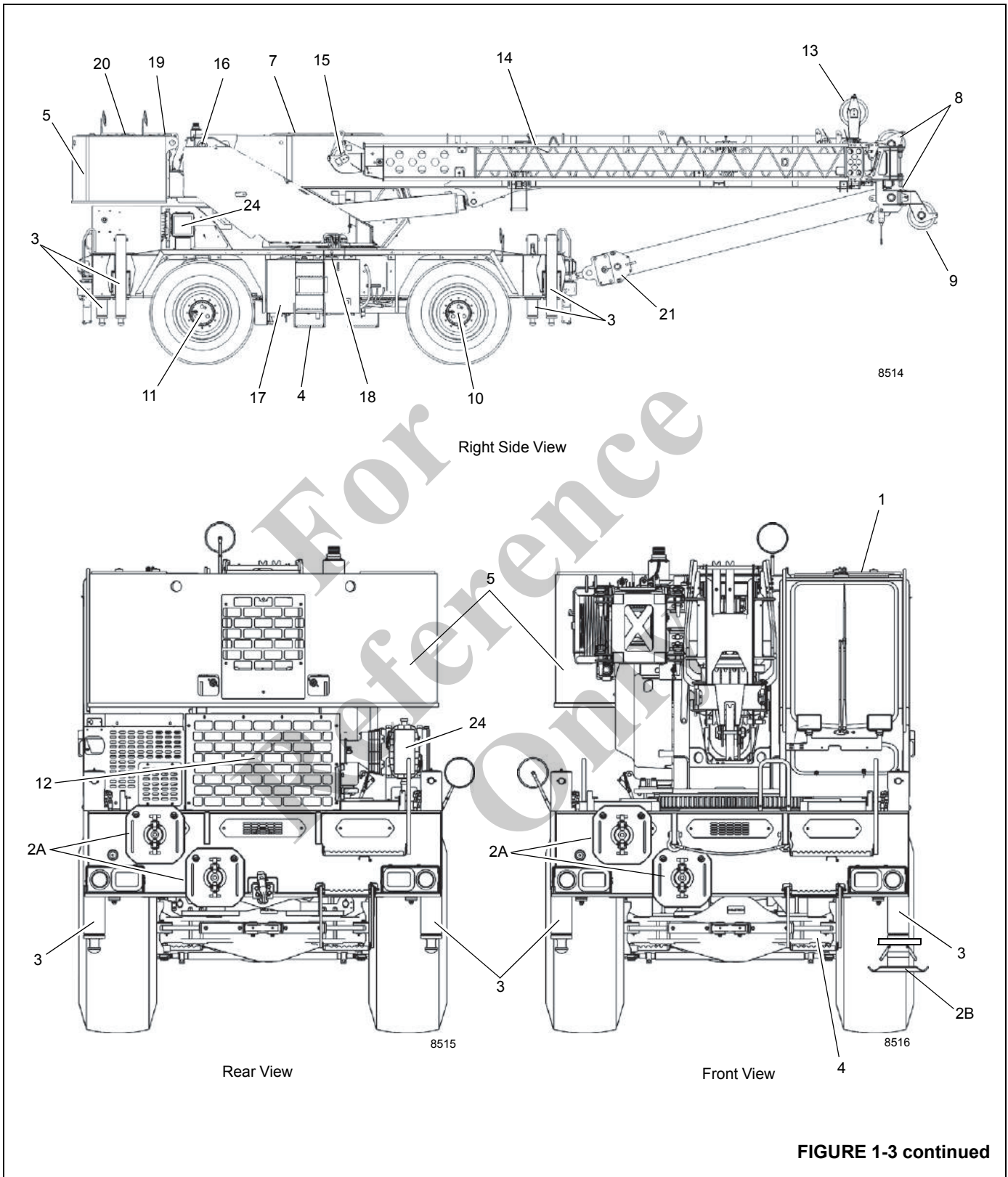


FIGURE 1-3 continued

## SECTION 2 SAFETY INFORMATION

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### SAFETY MESSAGES

#### General

The importance of safe operation and maintenance cannot be overemphasized. Carelessness or neglect on the part of operators, job supervisors and planners, rigging personnel,

and job site workers can result in their death or injury and costly damage to the crane and property.

To alert personnel to hazardous operating practices and maintenance procedures, safety messages are used throughout the manual. Each safety message contains a

safety alert symbol and a signal word to identify the hazard's degree of seriousness.

## Safety Alert Symbol



This safety alert symbol means **ATTENTION!** Become alert - **your safety is involved!** Obey all safety messages that follow this symbol to avoid possible death or injury.

## Signal Words



### DANGER

Identifies **hazards** that will result in death or serious injury if the message is ignored.



### WARNING

Identifies **hazards** that may result in death or serious injury if the message is ignored.



### CAUTION

Identifies **hazards** that could result in minor or moderate injury if the message is ignored.

### CAUTION

Without the safety alert symbol, identifies **hazards** that could result in property damage if the message is ignored.

**NOTE:** Emphasizes operation or maintenance procedures.

## GENERAL

It is impossible to compile a list of safety precautions covering all situations. However, there are basic principles that **must** be followed during your daily routine. Safety is **your primary responsibility**, since any piece of equipment is only as safe as **the person at the controls**.

Read and follow the information located in *Model Specific Information* near the end of this section.

This information has been provided to assist in promoting a safe working atmosphere for yourself and those around you. It is not meant to cover every conceivable circumstance

which could arise. It is intended to present basic safety precautions that should be followed in daily operation.

Because you are the only part of the crane that can think and reason, your responsibility is not lessened by the addition of operational aids or warning devices. Indeed, you must guard against acquiring a false sense of security when using them. They are there to assist, not direct the operation. Operational aids or warning devices can be mechanical, electrical, electronic, or a combination thereof. They are subject to failure or misuse and should not be relied upon in place of good operating practices.

You are the only one who can be relied upon to assure the safety of yourself and those around you. Be a **professional** and follow the **rules of safety**.

**Remember**, failure to follow just one safety precaution could cause an accident that results in death or serious injury to personnel or damage to equipment. You are responsible for the safety of yourself and those around you.

## Warning Signs

Refer to the *Parts Manual* for a drawing indicating the location of warning signs on the crane.

## ACCIDENTS

Following any accident or damage to equipment, the Manitowoc dealer must be immediately advised of the incident and consulted on necessary inspections and repairs. Should the dealer not be immediately available, contact should be made directly with Manitowoc Product Safety at the address below. The crane must not be returned to service until it is thoroughly inspected for any evidence of damage. All damaged parts must be repaired or replaced as authorized by your Manitowoc distributor and/or Manitowoc Crane Care.

If this crane becomes involved in a property damage and/or personal injury accident, **immediately** contact your Manitowoc distributor. If the distributor is unknown and/or cannot be reached, contact Product Safety at:

### The Manitowoc Company, Inc.

1565 East Buchanan Trail  
Shady Grove, PA 17256-0021

Phone: 888-777-3378 (888-PSR.DEPT)  
717-597-8121

Fax: 717-593-5152

E-mail: [product.safety@manitowoc.com](mailto:product.safety@manitowoc.com)

## OPERATOR INFORMATION

You must **read** and **understand** this *Operator Manual* and the *Load Chart* before operating your new crane. You must also **view** and **understand** the supplied safety video. This manual and *Load Chart* must be readily available to the



operator at all times and must remain in the cab (if equipped) or operator's station while the crane is in use.

The *Operator Manual* supplied with and considered part of your crane must be read and completely understood by each person responsible for assembly, disassembly, operation and maintenance of the crane.

No personnel shall be allowed to climb onto the crane or enter the crane cab or operator's station unless performance of their duties require them to do so, and then only with knowledge of the operator or other qualified person.

Allow **No One** other than the operator to be on the crane while the crane is operating or moving, unless they are seated in a two-man cab.



**Do not remove** the *Load Chart*, this *Operator Manual*, or any decal from this crane.

Inspect the crane every day (before the start of each shift). Ensure that routine maintenance and lubrication are being dutifully performed. Don't operate a damaged or poorly maintained crane. You risk lives when operating faulty machinery - including your own.

If adjustments or repairs are necessary, the operator shall notify the next operator.

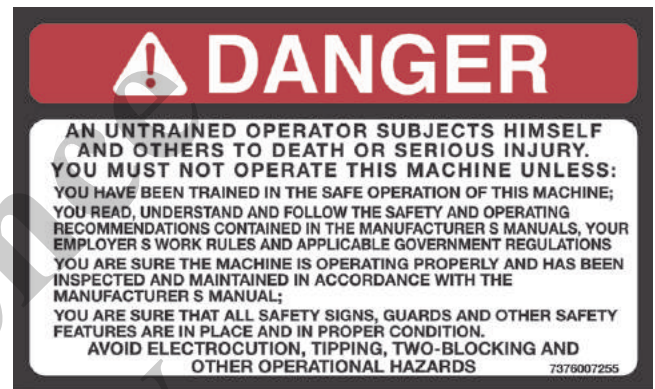
## OPERATOR QUALIFICATIONS

**Qualified person** is defined as one who by reason of knowledge, training and experience is thoroughly familiar with crane operations and the hazards involved. Such a person shall meet the operator qualifications specified in Occupational Safety and Health Administration (OSHA) Regulations (United States Federal Law), in ASME B30.5 American National Standard, or in any other applicable federal, state or local laws.

Ensure that all personnel working around the crane are thoroughly familiar with safe operating practices. You must be thoroughly familiar with the location and content of all placards and decals on the crane. Decals provide important instructions and warnings and must be read prior to any operational or maintenance function.

Refer to the *Parts Manual* for this crane for the locations of all safety decals.

You must be familiar with the regulations and standards governing cranes and their operation. Work practice requirements may vary slightly between government regulations, industry standards, and employer policies so a thorough knowledge of all such relevant work rules is necessary.



An untrained operator subjects himself and others to death or serious injury.

**You must not operate this crane unless:**

- You have been trained in the safe operation of this crane.
- You read, understand, and follow the safety and operating recommendations contained in the manufacturer's manuals, your employer's work rules, and applicable government regulations.
- You are sure the crane has been inspected and maintained in accordance with the manufacturer's manuals and is operating properly.
- You are sure that all safety signs, guards, and other safety features are in place and in proper condition.

Do not attempt to operate the crane unless you are trained and thoroughly familiar with all operational functions. Controls and design may vary from crane to crane; therefore, it is important that you have specific training on the particular crane you will be operating.

Training is ESSENTIAL for proper crane operation. Never jeopardize your own well-being or that of others by attempting to operate a crane on which you have not been trained.

You must be mentally and physically fit to operate a crane. Never attempt to operate a crane while under the influence of medication, narcotics, or alcohol. Any type of drug could impair physical, visual and mental reactions, and capabilities.

As operator of this crane, you are granted the authority to stop and refuse to lift loads until safety is assured.

## OPERATIONAL AIDS

Operational aids are accessories that provide information to facilitate operation of a crane or that take control of particular functions without action of the operator when a limiting condition is sensed, as stated in the latest revision of the ASME B30.5, and ASME B30.8 standards. Examples of such devices include, but are not limited to, the following: anti-two-block device, rated capacity indicator, rated capacity limiter, boom angle or radius indicator, boom length indicator, crane level indicator, hoist drum rotation indicator, load indicator, and wind speed indicator.

Manitowoc remains committed to providing reliable products that enable users and operators to safely lift and position loads. Manitowoc has been an industry leader in the incorporation of operational aids into the design of its cranes. Federal law requires that cranes be properly maintained and kept in good working condition. The manuals that Manitowoc provides that are specific for each crane and the manufacturer's manuals for the operational aids shall be followed. If an operational aid should fail to work properly, the crane user or owner must assure that repair or recalibration is accomplished as soon as is reasonably possible. If immediate repair or recalibration of an operational aid is not possible and there are exceptional circumstances which justify continued short-term use of the crane when operational aids are inoperative or malfunctioning, the following requirements shall apply for continued use or shutdown of the crane:

- Steps shall be taken to schedule repairs and recalibration immediately. The operational aids shall be put back into service as soon as replacement parts, if required, are available and the repairs and recalibration can be carried out. Every reasonable effort must be made to expedite repairs and recalibration.
- When a *Load Indicator*, *Rated Capacity Indicator*, or *Rated Capacity Limiter* is inoperative or malfunctioning, the designated person responsible for supervising the lifting operations shall establish procedures for determining load weights and shall ascertain that the weight of the load does not exceed the crane ratings at the radius where the load is to be handled.
- When a *Boom Angle* or *Radius Indicator* is inoperative or malfunctioning, the radius or boom angle shall be determined by measurement.

- When an *Anti-Two-Blocking Device*, *Two-Blocking Damage Prevention Device* or *Two-Block Warning Device* is inoperative or malfunctioning, the designated person responsible for supervising the lifting operations shall establish procedures, such as assigning an additional signal person to furnish equivalent protection. This does not apply when lifting personnel in load-line supported personnel platforms. Personnel shall not be lifted when anti-two-block devices are not functioning properly.
- When a *Boom Length Indicator* is inoperative or malfunctioning, the designated person responsible for supervising the lifting operations shall establish the boom lengths at which the lift will be made by actual measurements or marking on the boom.
- When a *Level Indicator* is inoperative or malfunctioning, other means shall be used to level the crane.

## Rated Capacity Limiter (RCL) Systems (If Equipped)

Your crane may be equipped with an RCL system which is intended to aid the operator. An RCL is a device that automatically monitors radius, load weight, and load rating and prevents movements of the crane, which would result in an overload condition.

Test daily for proper operation. Never interfere with the proper functioning of operational aids or warning devices.

Under **no condition** should it be relied upon to replace the use of *Load Charts* and operating instructions. Sole reliance upon these electronic aids in place of good operating practices can cause an accident.

Know the weight of all loads and always check the capacity of the crane as shown on the *Load Chart* before making any lifts.

NEVER exceed the rated capacity shown on the *Load Chart*. Always check the *Load Chart* to ensure the load to be lifted at the desired radius is within the rated capacity of the crane.

For detailed information concerning the operation and maintenance of the RCL system installed on the crane, see the RCL manufacturer's manual supplied with the crane. Manufacturers of rated capacity limiters may refer to them in their manuals as a load moment indicator (LMI), a hydraulic capacity alert system (HCAS), a safe load indicator (SLI), or an EKS5; Manitowoc refers to these systems as a rated capacity limiter (RCL) throughout its *Operator* and *Service Manuals*.

## Anti-Two-Blocking Device

This crane should have a functional Anti-Two-Block and Control Lock-Out System. Test daily for proper operation.

Two-blocking occurs when the load block (hook block, headache ball, rigging, etc.) comes into physical contact with the boom (boom nose, sheaves, jib, etc.). Two-blocking can cause hoist rope (wire rope or synthetic rope), rigging, reeving, and other components to become highly stressed and overloaded in which case the hoist rope may fail allowing the load, block, etc. to free fall.

Two-blocking is more likely to occur when both the main and auxiliary hoist lines are reeved over the main boom nose and jib nose respectively. An operator, concentrating on the specific line being used, may telescope or lower the boom allowing the other hoist line attachment to contact the boom or jib nose, thus causing damage to the sheaves, or causing the hoist rope to fail, dropping the lifting device to the ground and possibly injuring personnel working below.

Caution must be used when lowering the boom, extending the boom or hoisting up. Let out load line(s) simultaneously to prevent two-blocking the boom tip(s) and the hook block, etc. The closer the load is carried to the boom nose the more important it becomes to simultaneously let out hoist rope as the boom is lowered. Keep load handling devices a minimum of 107 cm (42 in) below the boom nose at all times.

Two-blocking can be prevented. Operator awareness of the hazards of two-blocking is the most important factor in preventing this condition. An Anti-Two-Block System is intended to assist the operator in preventing dangerous two-block conditions. It is not a replacement for operator awareness and competence.

Never interfere with the proper functioning of operational aids or warning devices.

**Working Area Limiter (If Equipped)**

This crane may be equipped with a working area limiter as part of the RCL system, designated as either Work Area Definition System (WADS) or Working Range Limiter (WRL). You must read and understand the operator manual before operating the working area limiter system. Become familiar with all proper operating procedures and with the identification of symbol usage.

The working area limiter is intended to be used as an aid to the operator. It is not a substitute for safe crane operating practices, experience and good operator judgements.



**⚠ DANGER**

	<p><b>TIPPING HAZARD</b></p> <p>To avoid death or serious injury, ensure load and crane's configuration are within capacity as shown on crane's load rating chart and notes.</p> <p>This crane should have a functional load moment indicator and control lock-out system. Test daily for proper operation.</p> <p><b>POSITION CRANE ON FIRM SURFACE. EXTEND OUTRIGGERS AND LEVEL CRANE.</b></p>	<p><b>TO AVOID DEATH OR SERIOUS INJURY:</b></p> <p><b>NEVER</b> handle personnel with this machine unless the requirements of the applicable national, state and local regulations and safety codes are met.</p> <p><b>NEVER</b> use this crane for bungee jumping or any form of amusement or sport.</p> <p><b>NEVER</b> permit anyone to ride loads, hooks, slings or other rigging for any reason.</p> <p><b>NEVER</b> get on or off a moving crane.</p> <p><b>NEVER</b> allow anyone other than the operator to be on this crane while it is operating or traveling.</p>
	<p><b>TWO-BLOCKING HAZARD</b></p> <p>To avoid death or serious injury, keep load handling devices away from boom/jib tip when extending or lowering the boom and when hoisting up.</p> <p>This crane should have a functional anti-two-block and control lock-out system. Test daily for proper operation.</p> <p><b>DO NOT PASS LOADS OR BOOM OVER GROUND PERSONNEL.</b></p>	<p><b>ELECTRONIC EQUIPMENT</b> on this crane is intended as an aid to the operator.</p> <p>Under no condition should it be relied upon to replace the use of capacity charts and operating instructions. Sole reliance upon these electronic aids in place of good operating practices can cause an accident.</p> <p>Do not remove any decal, the load chart, or the Operator's and Safety Handbook from this crane.</p>

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**FOLLOW INSTRUCTIONS IN OPERATOR'S AND SAFETY HANDBOOK.**
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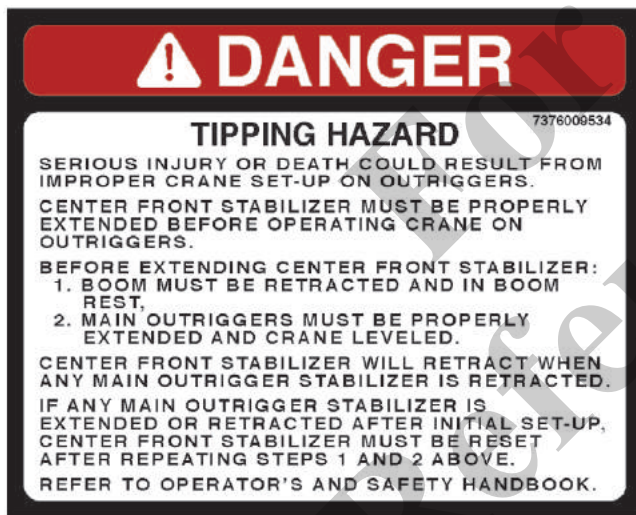
## CRANE STABILITY/STRUCTURAL STRENGTH

To avoid death or serious injury, ensure that the crane is on a firm surface with load and crane's configuration within capacity as shown on the crane's *Load Chart* and notes.

Ensure all pins and floats are properly installed and outrigger beams are properly extended before lifting on outriggers. On models equipped with outriggers that can be pinned at the mid-extend position (vertical stripe, if applicable), the outriggers must also be pinned when operating from the mid-extend position.

Use adequate cribbing under outrigger floats to distribute weight over a greater area. Check frequently for settling.

Read and follow the following safety decal for cranes with center front stabilizers.



Carefully follow the procedures in this Operator Manual when extending or retracting the outriggers. Death or serious injury could result from improper crane setup on outriggers.

The operator must select the proper *Load Chart* and Rated Capacity Limiter (RCL) System program for the outrigger position selected.

Before swinging the superstructure over the side when the outriggers are retracted, check the *Load Chart* for backwards stability.

Long cantilever booms can create a tipping condition when in an extended and lowered position. Retract the boom proportionally with reference to the capacity of the applicable *Load Chart*.

Check crane stability before lifting loads. Ensure the outriggers (or tires if lifting on rubber) are firmly positioned on solid surfaces. Ensure the crane is level, brakes are set, and the load is properly rigged and attached to the hook. Check the *Load Chart* against the weight of the load. Lift the load

slightly off the ground and recheck the stability before proceeding with the lift. Determine the weight of the load before you attempt the lift.

Unless lifting within On Rubber capacities, outrigger beams and jack cylinders (plus center front stabilizer, if equipped) must be properly extended and set to provide precise leveling of the crane. Tires must be clear of the ground before lifting on outriggers.



KEEP THE BOOM SHORT. Swinging loads with a long line can create an unstable condition and possible structural failure of the boom.

## Load Charts

*Load Charts* represent the absolute maximum allowable loads, which are based on either tipping or structural limitations of the crane under specific conditions. Knowing the precise load radius, boom length, and boom angle should be a part of your routine planning and operation. Actual loads, including necessary allowances, should be kept below the capacity shown on the applicable *Load Chart*.

*Load Chart* capacities are based on freely suspended loads.

You must use the appropriate *Load Chart* when determining the capability of the crane in the configuration required to perform the lift.

Maximum lifting capacity is available at the shortest radius, minimum boom length, and highest boom angle.

Do not remove the *Load Charts* from the crane.

## Work Site

Prior to any operation, you must inspect the **entire** work site, including ground conditions, where the crane will travel and

operate. Be sure that the surfaces will support a load greater than the crane's weight and maximum capacity.

Be aware of all conditions that could adversely effect the stability of the crane.

Be aware of the danger for people entering the working area. Do not allow unnecessary personnel in the vicinity of the crane while operating.

## WIND FORCES

There are basic principles that must be followed while operating in windy conditions. This information has been provided to assist in determining safe operation in windy conditions.

Always use extreme caution when windy conditions exist. NEVER exceed the rated capacity shown on the *Load Chart*.

**Always check the *Load Chart* to ensure the load to be lifted is within the rated capacity of the crane.**

Table 2-1 Beaufort Wind Scale

Beaufort Number	Description	Maximum Wind Speed			Visible Indicator Effects of wind as observed on land
		m/s	km/h	mph	
Zero (0)	Calm	0.3	1.1	0.7	Calm; smoke rises vertically
1	Light Air	1.5	5.4	3.4	Smoke drift indicates wind direction. Leaves and wind vanes are stationary.
2	Light Breeze	3.3	11.9	7.4	Wind felt on exposed skin. Leaves rustle. Wind vanes begin to move.
3	Gentle Breeze	5.4	19.4	12.1	Leaves and small twigs constantly moving. Light flags extended.
4	Moderate Breeze	7.9	28.4	17.7	Dust and loose paper raised. Small branches begin to move.
5	Fresh Breeze	10.7	38.5	23.9	Branches of a moderate size move. Small trees in leaf begin to sway.
6	Strong Breeze	13.8	49.7	30.9	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic bins tip over.
7	High Wind	17.1	61.6	38.3	Whole trees in motion. Effort needed to walk against the wind.
8	Gale	20.7	74.5	46.3	Some twigs broken from trees. Cars veer on road. Progress on foot is seriously impeded.
9	Strong Gale	24.4	87.8	54.6	Some branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over.
10	Storm	28.4	102.2	63.5	Trees are broken off or uprooted, structural damage likely.

## Wind Speeds

The maximum permissible wind speed referred to in the load charts is the 3-second wind gust speed measured at the boom tip height and is designated as  $V(z)$ . This value is either recorded at boom tip or calculated based on mean

Wind can have a significant effect on loads that may be lifted by a crane. Wind forces act differently on a crane depending upon the direction from which the wind is blowing (e.g., wind on the rear of the boom can result in decreased forward stability, wind on the underside of the boom can result in decreased backward stability, wind on the side of the boom can result in structural damages, etc.)

Wind forces can exert extreme dynamic loads. Manitowoc recommends that a lift not be made if the wind can cause a loss of control in handling the load.

Wind forces can be determined by typical visible effects on the landscape. To assist you in determining prevailing wind conditions, refer to Table 2-1.

**NOTE:** The wind speed corresponding to the Beaufort scale in the table is mean wind speed at 10 m (33 ft) elevation over a period of 10 minutes.

wind speed recorded at crane operation site. For lift planning purposes only, the 3-second wind gust speed,  $V(z)$ , may be calculated based on mean wind speed reported at <http://www.windfinder.com> "Super Forecast".

This 3-second wind gust is assumed to act on the entire crane and the load. The wind effect on the load can be conservatively estimated as:

- a) If  $V(z)$  is  $\leq 13.4$  m/s (30 mph), then the **allowable** load is the published rated capacity from the Load Chart.
- b) If  $V(z)$  is  $> 13.4$  m/s (30 mph) and is  $\leq 20.1$  m/s (45 mph), the **allowable** load is the published rated capacity multiplied by the Capacity Reduction Factor from Table 2-4 (metric) or (non-metric).

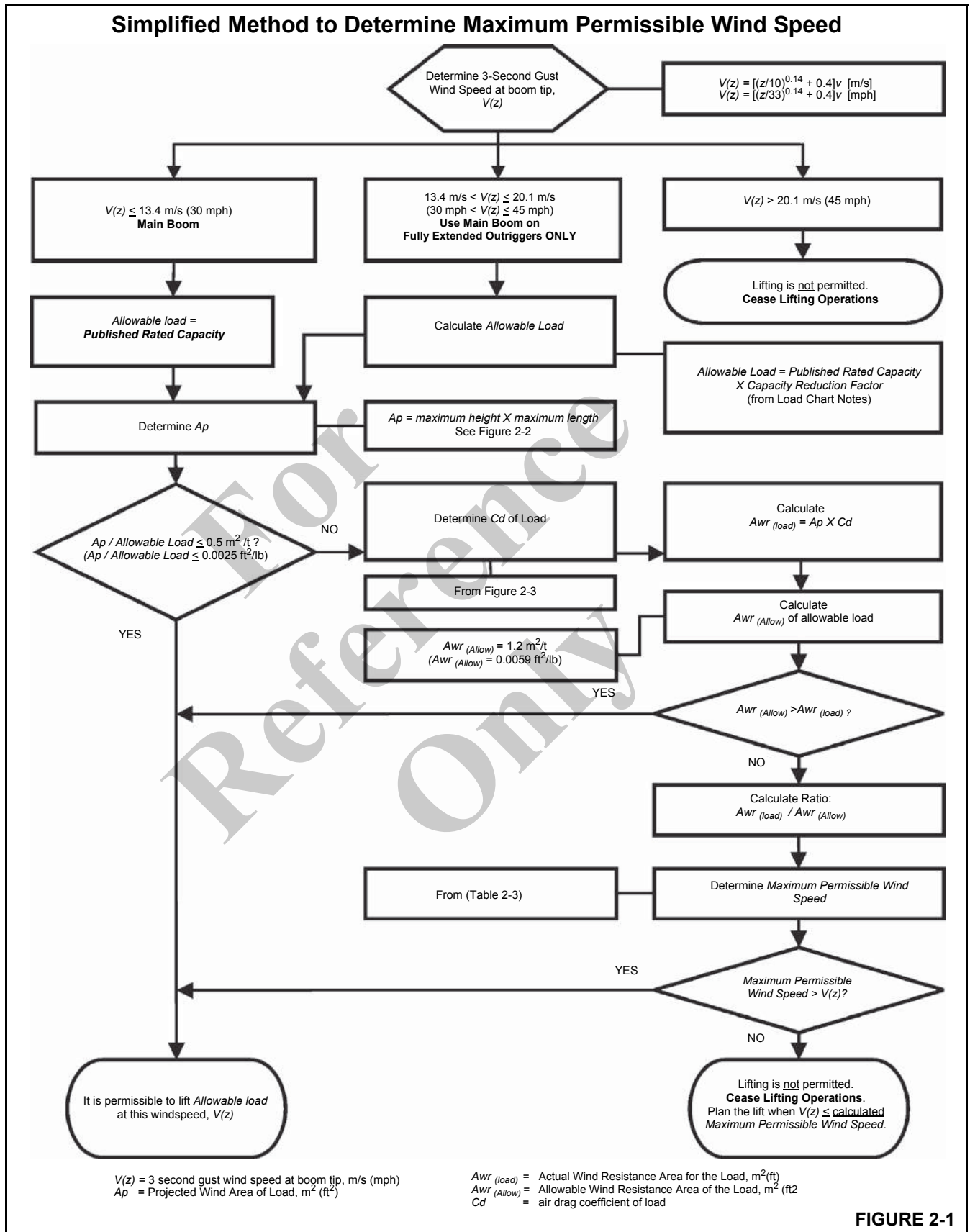
**NOTE:** This condition is limited to operation with the main boom on fully extended outriggers only.

- c) If  $V(z)$  is  $> 20.1$  m/s (45 mph), then lifting is **NOT** permitted. Cease lifting operations and lower and retract the boom.

In both cases **a)** and **b)** above, the lift may also be limited by the projected wind area of the load  **$A_p$**  and by the wind drag coefficient  **$C_d$** : This limit can be determined by comparing the **Actual** wind resistance area with the **Allowable** wind resistance area.

Refer to Figure 2-2 for a simplified calculation method to determine permissible wind speed.

For  
Reference  
Only



**Determination of 3-second wind gust speed at boom tip height:**

The following example illustrates how to calculate 3-second wind gust speed at boom tip height based on mean wind speed recorded by the device located at the crane operation site:

$V(z)$  is the 3-second wind gust speed at boom tip height  $Z$  then:

Metric, with  $Z$  [m] and  $V$  [m/s]

$$V(z) = [(Z/10)^{0.14} + 0.4] \times V \quad (2.1)$$

Non-metric, with  $Z$  [ft] and  $V$  [mph]

$$V(z) = [(Z/33)^{0.14} + 0.4] \times V \quad (2.2)$$

where:

$V$  [m/s] [mph] - Mean wind speed at 10 m (22 ft) elevation (upper limit of Beaufort scale)

**Example:** Suppose you want to lift the load with the maximum boom tip height of 30 m (100 ft) and the recorded mean wind speed by the device located at the crane operation site is 5.5 m/s (13 mph). This mean wind speed of 5.5 m/s (13 mph) corresponds to Beaufort number 4 (see Table 2-1). The maximum wind velocity according to the Beaufort scale of 4 is 7.9 m/s (17.7 mph).

The mean wind speed (upper limit of Beaufort number) at 10 m (33 ft) height, to be used for calculation is:

$$V = 7.9 \text{ m/s (17.7 mph)}$$

Boom tip height for this lift is  $Z = 30 \text{ m (100 ft)}$

then:

Metric, with  $Z$  [m] and  $V$  [m/s]

$$V(z) = [(30/10)^{0.14} + 0.4] \times 7.9 = 12.4 \text{ m/s}$$

Non-metric, with  $Z$  [ft] and  $V$  [mph]

$$V(z) = [(100/33)^{0.14} + 0.4] \times 17.7 = 27.8 \text{ mph}$$

Since  $V(z)$  is  $\leq 13.4 \text{ m/s (30 mph)}$ , the allowable loads are the published rated capacities from the Load Chart and can be lifted at this condition.

**Size and Shape of the load:**

These rated capacities are also based on the assumption that the Wind Resistance Area of load,  $Awr_{(load)}$  is not more than 0.0012 square meters per kilogram (0.0059 sq.ft per pound of load. (See below Formulas 2.4 and 2.5.)

The load capacities shall be reduced to account for the larger wind resistance area of load and 3-second wind gust speed at boom tip height. Use tag lines when the wind gust speed is above 13.4 m/s (30 mph) to help control the movement of the load. **Manitowoc recommends that a lift not be made if the wind can cause a loss of control in handling the load.**

The lift may also be limited by the projected wind area of the load  $Ap$  and by the wind drag coefficient  $Cd$ . This limit can be determined by comparing the actual wind resistance area of the load with the allowable wind resistance area.

$$Awr_{(load)} = Ap \times Cd \quad (2.3)$$

where:

$Awr_{(load)}$  [m<sup>2</sup>] [ft<sup>2</sup>] - Wind resistant area of the load

$Ap$  [m<sup>2</sup>] [ft<sup>2</sup>] - projected wind area,

$Cd$  - wind drag coefficient.

$Ap$  is determined by using the calculation of maximum height x maximum length (see Figure 2-3).

For  $Cd$ , refer to Table 2-2. If the  $Cd$  cannot be calculated or estimated, use a value of 2.4.

The allowable wind resistant area of the load  $Awr_{(allow)}$  is equal to 0.0012 square meters per kilogram (0.0059 sq.ft per pound) of allowable load:

Metric, with  $m_{(load)}$  [kg] - Mass of the allowable load

$$Awr_{(allow)} = 0.0012 \times m_{(load)} \quad (2.4)$$

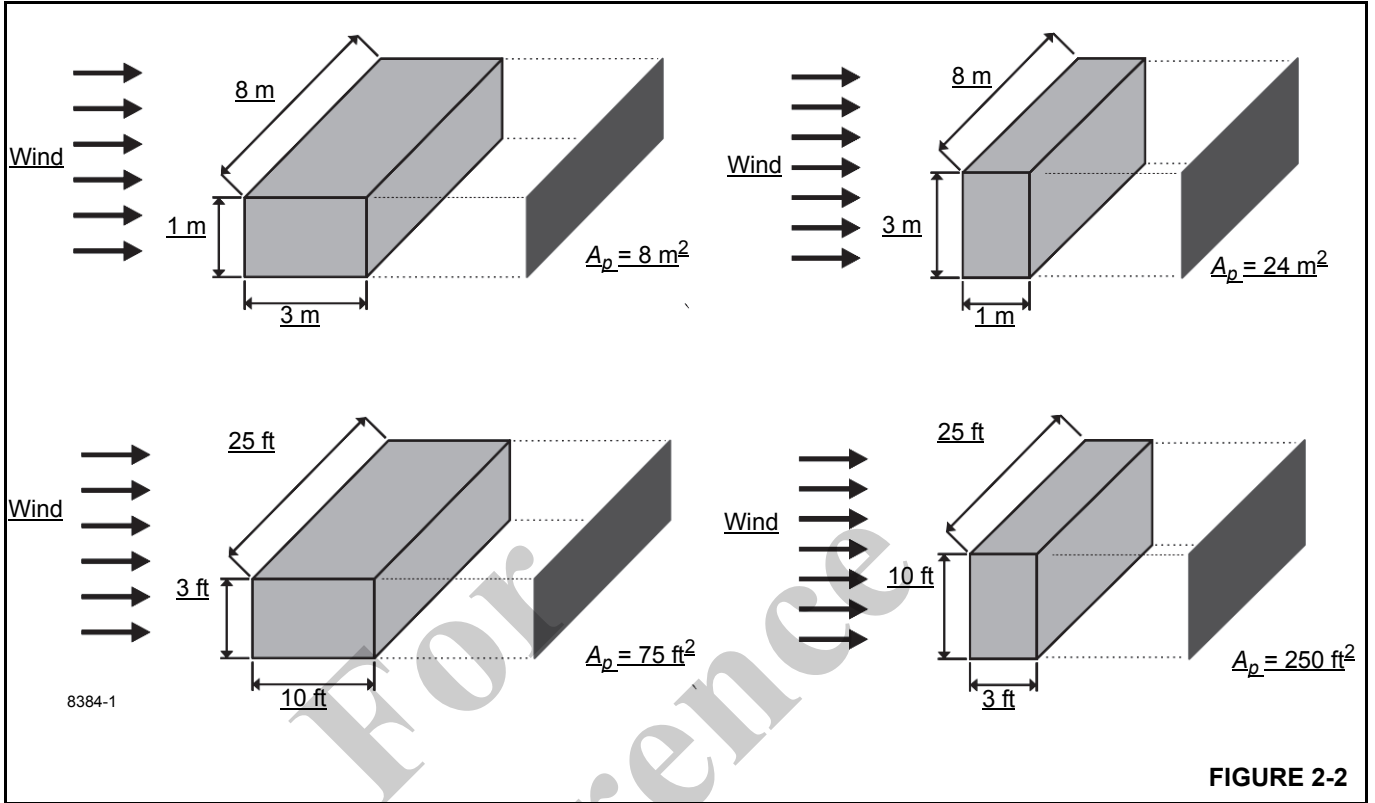
Non-metric, with  $m_{(load)}$  [lb] - Mass of the allowable load

$$Awr_{(allow)} = 0.0059 \times m_{(load)} \quad (2.5)$$

If  $Awr_{(load)}$  is greater than  $Awr_{(allow)}$ , then lifting this load at this wind speed  $V(z)$  is NOT permitted.



Calculation of Projected Wind Area ( $A_p$ ):



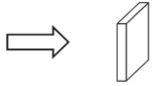

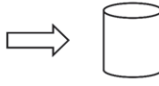
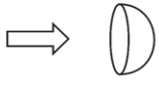
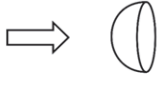
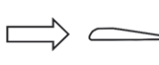

**Determining Wind Drag Coefficient ( $C_d$ )**

Table 2-2 shows the typical Shapes and corresponding Wind Drag Coefficient ( $C_d$ ) values.

If the exact Wind Drag Coefficient of a shape is not known, use the maximum value of the shape's range (Table 2-2).

If the wind drag coefficient of the load cannot be estimated or determined, it shall be assumed that ( $C_d$ ) = 2.4.

Table 2-2 Wind Drag Coefficient

Shape	$C_d$	
	1.1 to 2.0	
	0.3 to 0.4	
	0.6 to 1.0	
	0.8 to 1.2	
	0.2 to 0.3	
	0.05 to 0.1	Turbine Blade or Complete Rotor
	Approximately 1.6	

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**Maximum Permissible Wind Speed**

If the wind resistant area of the load  $Awr_{(load)}$  is greater than the allowable wind resistant area  $Awr_{(allow)}$ , the ratio can be used to determine a permissible wind speed  $V(z)$  for the load using Table 2-3.

Table 2-3  $Awr$  Ratio and Permissible Wind Speed  $V(z)$  - Non - metric

Note: Permissible and rated wind speeds in this table are the 3-second gust wind speeds at boom tip height.					
Ratio:	1.2	1.4	1.6	1.8	2
	Maximum Permissible Wind Speed (mph)				
For Rated Capacity at 30 mph	27.4	25.4	23.7	22.4	21.2
For Allowable Capacity at 45 mph	41.1	38.0	35.6	33.5	31.8

Rated Load Chart Example - Metric

RATED LIFTING CAPACITIES IN KILOGRAMS  
10.9 m - 33.5 m BOOM  
ON OUTRIGGERS FULLY EXTENDED - 360°

Radius in Meters	#001								
	Main Boom Length in Meters								
	10.9	12.2	15.2	**18.4	21.3	24.4	27.4	30.5	33.5
3	+60,000 (69.5)	40,950 (72)	40,950 (76)						
3.5	53,000 (66.5)	40,950 (69.5)	40,950 (74)	28,350 (78)					
4	47,450 (63.5)	40,950 (66.5)	40,950 (72)	28,350 (75.5)	*18,225 (78)				
4.5	42,875 (60.5)	40,950 (64)	40,950 (70)	28,350 (73.5)	18,225 (76)				
5	39,050 (57.5)	39,025 (61.5)	38,300 (67.5)	28,350 (72)	18,225 (75)	*18,225 (78)			
6	32,950 (50.5)	32,925 (55.5)	32,825 (63.5)	28,350 (68.5)	18,225 (72)	18,225 (75)	*18,225 (78)		
7	28,325 (42.5)	28,300 (49)	28,225 (59)	26,250 (65)	18,225 (69)	18,225 (72)	18,225 (74.5)	*16,725 (78)	*11,400 (78)
8	24,150 (32.5)	24,150 (42)	23,975 (54.5)	23,275 (61)	18,225 (69.5)	18,225 (72)	16,575 (74.5)	15,250 (74.5)	11,400 (76)
9	20,600 (16.5)	20,550 (33.5)	20,375 (49.5)	20,250 (55)	18,225 (63)	16,575 (67)	15,050 (70)	13,875 (72.5)	11,400 (74.5)
10		17,200 (20.5)	17,175 (41)	17,125 (54)	17,325 (60)	15,175 (64)	13,725 (67.5)	12,700 (70.5)	11,400 (72.5)
12			14,025 (35)	12,575 (45.5)	12,575 (53.5)	11,600 (59)	11,600 (63)	10,725 (66.5)	10,050 (69)
14				9,000 (35)	9,360 (46)	9,730 (53.5)	9,955 (58.5)	9,205 (62)	8,620 (65)
16				6,750 (19)	7,110 (37.5)	7,470 (47)	7,920 (53)	7,980 (57.5)	7,470 (61.5)
18					5,960 (47)	5,960 (39.5)	6,340 (47.5)	6,525 (53)	6,530 (57.5)
20						4,755 (30.5)	5,145 (41)	5,320 (48)	5,495 (53)
22							3,790 (16.5)	4,210 (33.5)	4,545 (48.5)
24								3,435 (23.5)	3,780 (43.5)
26									2,975 (28)
28									2,400 (16)
30									2,135 (22)
Minimum boom angle (°) for indicated length (no load)									0
Maximum boom length (m) at 0° boom angle (no load)									33.5

NOTE: ( ) Boom angles are in degrees.  
#RCL operating code. Refer to RCL manual for operating instructions.  
\*This capacity is based on maximum boom angle.  
+ 9 parts line required to lift this capacity (using aux. boom nose) when using wire rope with a minimum breaking strength of 36,287 kg. Refer to Operator's & Safety Handbook for reeving diagram.  
NOTE: For allowable capacities while operating in 3-second wind gust speeds greater than 13.4 m/s and up to 20.1 m/s, refer to Capacity Reduction Factors for wind speed (3-second gust speed) V(z) greater than 13.4m/s.

Lifting Capacities at Zero Degree Boom Angle									
Boom Angle	Main Boom Length in Meters								
	10.9	12.2	15.2	**18.4	21.3	24.4	27.4	30.5	33.5
0°	13,775 (9.2)	11,675 (10.4)	8,145 (13.5)	5,930 (16.6)	4,565 (19.6)	3,535 (22.6)	2,860 (25.7)	2,220 (28.7)	1,770 (31.8)

NOTE: ( ) Reference radii in meters.  
\*\* Boom length is with inner-mid fully extended and outer-mid & fly fully retracted.

FIGURE 2-3



**Table 2-4 Example-Capacity Reduction Factors for Wind Speed V(z) Greater than 13.4 m/s - Metric**

(Only for lifting with main boom on fully extended outriggers, with or without stowed extension)  
 For wind speed **V(z)** (3-second gust speed at boom tip height)  $V(z) > 13.4 \text{ m/s} \leq 20.1 \text{ m/s}$ , the Reduced Capacity shall be calculated by multiplying the Published Rated Capacity by the following factors:

Wind Speed $V(z) > 13.4 \text{ m/s}$ $\leq 20.1 \text{ m/s}$	Main Boom Length in Meters								
	10.9	12.2	15.2	18.4	21.0	24.4	27.4	30.5	33.5
Factor	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.6

Wind resistance area of load,  $Awr_{(load)}$  shall not exceed maximum allowable wind resistance area  $Awr_{(allow)}$ .  
 Maximum allowable wind resistance area,  $Awr_{(allow)} = 0.0012 \times \text{calculated reduced capacity in kg}$ .  
 Wind resistance area of load,  $Awr_{(load)}$  = projected wind area  $Ap$  x wind drag coefficient  $Cd$  for the load.  
 For wind resistance Area of load,  $Awr_{(load)} >$  maximum allowable wind resistance area,  $Awr_{(allow)}$  refer to crane Operator Manual.

**Table 2-5 Awr Ratio and Permissible Wind Speed V(z) - Metric**

Note: Permissible and rated wind speeds in this table are the 3-second gust wind speeds at boom tip height.

Ratio:	1.2	1.4	1.6	1.8	2
	Maximum Permissible Wind Speed (m/s)				
For Rated Capacity at 13.4 m/s	12.2	11.4	10.6	10.0	9.5
For Allowable Capacity at 20.1 m/s	18.3	17.0	15.9	15.0	14.2

**Example and Sample Calculations (metric)**

The following example illustrates how to calculate allowable load while operating in wind speed (3-second wind gust speed) above 13.4 m/s (30 mph) and maximum permissible wind speeds with various combinations of lifted load and wind resistance area.

**NOTE:** Permissible and calculated wind speeds in this example are the **3-second wind gust speeds at boom tip height V(z)**.

**Example 1: Crane Configuration:**

- boom length = 27.4 m,
- load radius = 9 m,
- wind speed is measured at  $V(z) \leq 20.1 \text{ m/s}$ .

From the **Rated Load Chart Example - Metric** (Figure 2-3), at maximum permissible wind speed,  $V(z) = 13.4 \text{ m/s}$ , the rated lifting capacity  $m_{(allow)}$  for this configuration is 15,050 kg.

The maximum allowable wind resistance area of load is

$$Awr_{(allow)} = 0.0012 \times m_{(load)} \tag{2.4}$$

$$Awr_{(allow)} = 0.0012 \times 15,050 = 18.06 \text{ m}^2$$

**Lifting Limits at wind speed  $V(z) \leq 13.4 \text{ m/s}$  at this configuration:**

- Maximum load 15,050 kg
- Maximum wind resistance area of load 18.06 m<sup>2</sup>

For the allowable wind speed  $> 13.4 \text{ m/s}$  and  $\leq 20.1 \text{ m/s}$ , reduce the allowable load. Per Table 2-4, the Factor for main boom length of 27.4 m is 0.8, the allowable load is:

$$m_{(allow)} = 0.8 \times 15,050 = 12,040 \text{ kg}$$

This reduced capacity load has an allowable wind resistance area of:

$$Awr_{(allow)} = 0.0012 \times 12,040 = 14.45 \text{ m}^2$$

**Lifting Limits at wind speed  $V(z) > 13.4 \text{ m/s}$  and  $\leq 20.1 \text{ m/s}$ , at this configuration:**

- Maximum load 12,040 kg
- Maximum wind resistance area of load 14.45 m<sup>2</sup>

At wind speeds greater than 13.4 m/s, it is not permissible to lift a load greater than 12,040 kg, even if the wind resistance area of the load is less than 14.45 m<sup>2</sup>.

Refer to the information from the above crane configuration, examine several load conditions.

**Load example 1.1:**

With known Wind Drag Coefficient of the load **Cd**, and

- load to be lifted of 11,200 kg,
- Projected Wind Area **Ap** = 9.20 m<sup>2</sup>,
- Wind Drag Coefficient **Cd** = 1.5

wind resistance area of load can be estimated as

$$Awr_{(load)} = Ap \times Cd = 9.2 \times 1.5 = 13.8 \text{ m}^2$$

Refer to the above **Lifting Limits at wind speed V(z) > 13.4 m/s and ≤ to 20.1 m/s**. Comparing the load and wind resistant area to the allowable:

- Is the load to be lifted less than allowable load?  
11,200 kg ≤ 12,040 kg YES
- Is **Awr<sub>(load)</sub>** less than **Awr<sub>(allow)</sub>** ?  
13.8 m<sup>2</sup> ≤ 14.45 m<sup>2</sup> YES

**Conclusion:** This load is permissible to lift in wind speed up to 20.1 m/s.

**Load example 1.2:**

With unknown Wind Drag Coefficient of the load **Cd**,

- Load to be lifted of 10,000 kg,
- Projected Wind Area **Ap** = 5.45 m<sup>2</sup>,
- Wind Drag Coefficient **Cd** = unknown

**NOTE:** If exact Wind Drag Coefficient is not known, it shall be assumed as 2.4.

the wind resistance area of load can be estimated as

$$Awr_{(load)} = Ap \times Cd = 5.45 \times 2.4 = 13.08 \text{ m}^2$$

Refer to the above **Lifting Limits at V(z) > 13.4 m/s and ≤ 20.1 m/s**. Comparing the load and wind resistant area to the allowable:

- Is the load to be lifted less than allowable load?  
10,000 kg ≤ 12,040 kg YES
- Is **Awr<sub>(load)</sub>** less than **Awr<sub>(allow)</sub>** ?  
13.08 m<sup>2</sup> ≤ 14.45 m<sup>2</sup> YES

**Conclusion:** This load is permissible to lift in wind speed up to 20.1 m/s.

**Load example 1.3a:**

With large wind resistance area of the load **Awr<sub>(load)</sub>**,

- Load to be lifted of 14,000 kg,
- Projected Wind Area **Ap** = 21.85 m<sup>2</sup>,
- Wind Drag Coefficient **Cd** = 1.2

the wind resistance area of load can be estimated as:

$$Awr_{(load)} = Ap \times Cd = 21.85 \times 1.2 = 26.22 \text{ m}^2$$

Refer to the above **Lifting Limits at wind speed V(z) > 13.4 m/s and ≤ 20.1 m/s**. Comparing the load to the allowable:

- Is the load to be lifted less than allowable load?  
14,000 kg ≤ 12,040 kg NO

**Conclusion:** This load is NOT permissible to lift in wind speed up to 20.1 m/s.

Refer to the above **Lifting Limits at wind speed V(z) < 3.4 m/s**. Comparing the load to the allowable:

- Is the load to be lifted less than allowable load?  
14,000 kg ≤ 15,050 kg YES

The maximum permissible wind speed for this load is 13.4 m/s, depending on the wind resistance area of the load.

- Is **Awr<sub>(load)</sub>** less than **Awr<sub>(allow)</sub>** ?  
26.22 m<sup>2</sup> ≤ 18.06 m<sup>2</sup> NO

**Conclusion:** This load is NOT permissible to lift in wind speed at 13.4 m/s, but is permitted to lift at a reduced wind speed calculated as follows:

$$\text{Ratio} \frac{Awr_{(load)}}{Awr_{(allow)}} = \frac{26.22}{18.06} = 1.45$$

From Table 2-5, the maximum permissible wind speed at ratio of 1.45 (rounded to next higher table value of 1.6) is 10.6 m/s.

**Conclusion:** This load is permissible to lift in wind speed up to 10.6 m/s only.

**Load example 1.3b:**

With large wind resistance area of the load **Awr<sub>(load)</sub>**,

- Load to be lifted of 8,000 kg,
- Projected Wind Area **Ap** = 15.25 m<sup>2</sup>,
- Wind Drag Coefficient **Cd** = 1.3

the wind resistance area of load can be estimated as

$$Awr_{(load)} = Ap \times Cd = 15.25 \times 1.3 = 19.83 \text{ m}^2$$

Refer to the above **Lifting Limits at wind speed V(z) > 13.4 m/s and ≤ 20.1 m/s**. Comparing the load and wind resistant area to the allowable:



- Is the load to be lifted less than allowable load?  
8,000 kg ≤ 12,040 kg YES
- Is  $Awr_{(load)}$  less than  $Awr_{(allow)}$ ?  
19.83 m<sup>2</sup> ≤ 14.45 m<sup>2</sup> NO

**Conclusion:** This load is NOT permissible to lift in wind speed up to 20.1 m/s, but permitted to lift at a reduced wind speed calculated as follows:

$$\text{Ratio} \frac{Awr_{(load)}}{Awr_{(allow)}} = \frac{19.83}{14.45} = 1.37$$

From Table 2-5, the maximum permissible wind speed at ratio of 1.37 (rounded to next higher table value of 1.4) is 17.0 m/s.

**Conclusion:** This load is permissible to lift in wind speed up to 17.0 m/s only.

For  
Reference  
Only

Rated Load Chart Example - Non-metric

RATED LIFTING CAPACITIES IN POUNDS  
36 FT. - 110 FT. BOOM  
ON OUTRIGGERS FULLY EXTENDED - 360°

Radius in Feet	#0001								
	Main Boom Length in Feet								
	36	40	50	**60	70	80	90	100	110
10	130,000 (69.5)	90,300 (71.5)	90,300 (75.5)	*62,500 (78)					
12	112,500 (65.5)	90,300 (68.5)	90,300 (73)	62,500 (76.5)	*40,200 (78)				
15	93,250 (60)	90,300 (63.5)	90,250 (69.5)	62,500 (73.5)	40,200 (76)	*40,200 (78)			
20	71,550 (49.5)	71,500 (55)	71,300 (63)	62,500 (68)	40,200 (71.5)	40,200 (74.5)	40,200 (78)	*36,900 (78)	
25	56,650 (38.5)	56,600 (45)	56,350 (56)	53,650 (83)	40,200 (67)	40,200 (70.5)	37,950 (73)	34,900 (75)	*25,150 (78)
30	43,500 (11.5)	44,300 (32)	43,950 (48.5)	43,650 (57.5)	40,200 (62.5)	37,050 (66)	32,750 (69.5)	30,200 (72)	25,150 (74)
35			33,550 (40)	33,700 (51.5)	34,700 (58)	33,550 (62)	28,550 (66)	26,400 (69)	24,700 (71.5)
40			25,800 (28)	26,150 (44.5)	26,300 (52.5)	27,300 (58.5)	25,200 (62.5)	23,300 (66)	21,800 (68.5)
45				20,300 (36.5)	21,450 (47)	22,300 (54)	22,400 (59)	20,700 (62.5)	19,400 (65.5)
50				15,500 (25)	17,400 (41)	18,250 (49.5)	19,100 (55)	18,550 (59.5)	17,350 (62.5)
55					14,300 (33.5)	15,150 (44)	16,000 (51)	16,400 (56)	15,800 (60)
60					11,000 (23.5)	12,700 (38)	13,550 (46.5)	13,950 (52.5)	14,100 (56.5)
65						9,000 (31.5)	11,550 (41.5)	11,950 (48.5)	12,300 (53.5)
70						9,010 (22.5)	9,920 (36)	10,250 (44)	10,650 (50)
75							8,510 (29.5)	8,890 (39.5)	9,250 (46)
80							7,260 (21)	7,690 (34.5)	8,050 (42.5)
85								6,620 (28.5)	7,010 (38)
90								5,630 (20)	6,100 (33)
95									5,240 (27)
100									4,480 (19.5)
Minimum boom angle (°) for indicated length (no load)									0
Maximum boom length (ft.) at 0° boom angle (no load)									110

NOTE: ( ) Boom angles are in degrees.  
#RCL operating code. Refer to RCL manual for operating instructions.  
\*This capacity is based on maximum boom angle.  
NOTE: For allowable capacities while operating in 3-second wind gust speeds greater than 30 mph and up to 45 mph, refer to Capacity Reduction Factors for wind speed (3-second gust speed) V(z) greater than 30 mph.

Lifting Capacities at Zero Degree Boom Angle									
Boom Angle	Main Boom Length in Feet								
	36	40	50	**60	70	80	90	100	110
0°	30,350 (30.1)	25,700 (34.2)	17,950 (44.2)	13,050 (54.6)	10,050 (64.2)	7,790 (74.2)	6,300 (84.2)	4,900 (94.2)	3,900 (104.2)

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NOTE: ( ) Reference radii in feet.  
\*\* Boom length is with inner-mid fully extended and outer-mid & fly fully retracted.

FIGURE 2-4



Table 2-6 Example-Capacity Reduction Factors for Wind Speed  $V(z)$  Greater than 30 mph - Non-metric

(Only for lifting with main boom on fully extended outriggers, with or without stowed extension)									
For wind speed $Vz$ (3-second gust speed at boom tip height) is greater than 30 mph $\leq$ 45 mph, the Reduced Capacity shall be calculated by multiplying the Published Rated Capacity by the following factors:									
	Main Boom Length in Feet								
Wind Speed $Vz < 30$ mph $\leq 45$ mph	36	40	50	60	70	80	90	100	110
Factor	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.5
Wind resistance area of load, $Awr_{(load)}$ , shall not exceed maximum allowable wind resistance area $Awr_{(allow)}$ .									
Maximum allowable wind resistance area in $lb$ , $Awr_{(allow)} = 0.0059 \times$ calculated reduced capacity in $lb$ .									
Wind resistance area of load, $Awr_{(load)} =$ projected wind area $Ap \times$ wind drag coefficient $Cd$ for the load.									
For wind resistance area of load, $Awr_{(load)} >$ maximum allowable wind resistance, $Awr_{(allow)}$ , refer to crane Operator Manual.									

Table 2-7  $Awr$  Ratio and Permissible Wind Speed  $V(z)$  - Non-Metric

Note: Permissible and rated wind speeds in this table are the 3-second gust wind speeds at boom tip height.					
Ratio:	1.2	1.4	1.6	1.8	2
	Maximum Permissible Wind Speed (mph)				
For Rated Capacity@ 30 mph	27.4 mph	25.4 mph	23.7 mph	22.4 mph	21.2 mph
For Allowable Capacity@ 45 mph	41.1 mph	38.0 mph	35.6 mph	33.5 mph	31.8 mph

**Example and Sample Calculations** (Non-metric)

The following example illustrates how to calculate allowable load while operating in wind speed (3-second wind gust speed) above 13.4 m/s (30 mph) and maximum permissible wind speeds with various combinations of lifted load and wind resistance area.

**NOTE:** Permissible and calculated wind speeds in this example are the **3-second wind gust speeds at boom tip height  $V(z)$** .

**Example 2:**

A crane is configured with:

- boom length = 90 ft,
- load radius = 40 ft, and
- wind speed is measured at  $V(z) \leq 45$  mph.

The **Rated Load Chart Example - Non-metric** (Figure 2-4), at maximum permissible wind speed,  $V(z) = 30$  mph, the

rated lifting capacity  $m_{(allow)}$  for this configuration is 25,200 lb.

The maximum allowable wind resistance area of load is:

$$Awr_{(allow)} = 0.0059 \times m_{(load)} \quad (2.5)$$

$$Awr_{(allow)} = 0.0059 \times 25,200 = 149 \text{ ft}^2$$

**Lifting Limits at wind speed  $V(z) < 30$  mph** at this configuration:

- Maximum load 25,200 lb
- Maximum wind resistance area of load 149 ft<sup>2</sup>

For the allowable wind speed  $> 30$  mph and  $\leq 45$  mph, reduce the allowable load. , the Factor for a main boom length of 90 ft is 0.8, thus the allowable load is:

$$m_{(allow)} = 0.8 \times 25,200 = 20,160 \text{ lb}$$

This reduced capacity load has an allowable wind resistance area of:

$$Awr_{(allow)} = 0.0059 \times 20,160 = 119 \text{ ft}^2$$



**Lifting Limits at wind speed  $V(z) > 30$  mph and  $\leq 45$  mph** at this configuration:

- Maximum load 20,160 lb
- Maximum wind resistance area of load 119 ft<sup>2</sup>

Example, wind speeds greater than 13.4 m/s is NOT permissible to lift a load greater than 20,160 lb, even if the wind resistance area of the load is less than 119 ft<sup>2</sup>.

Refer to the above crane configuration for the following load conditions:

**Load example 2.1:**

With known Wind Drag Coefficient of the load **Cd**,

- load to be lifted of 19,500 lb,
- Projected Wind Area **Ap** = 70 ft<sup>2</sup>,
- Wind Drag Coefficient **Cd** = 1.5

then the wind resistance area of load can be estimated as

$$Awr_{(load)} = Ap \times Cd = 70 \times 1.5 = 105 \text{ ft}^2$$

Refer to the above **Lifting Limits at wind speed  $V(z) > 30$  mph and  $\leq 45$  mph**. Comparing the load and wind resistant area to the allowable:

- Is the load to be lifted less than allowable load?  
19,500 lb  $\leq$  20,160 lb YES
- Is **Awr<sub>(load)</sub>** less than **Awr<sub>(allow)</sub>**?  
105 ft<sup>2</sup>  $\leq$  119 ft<sup>2</sup> YES

**Conclusion:** This load is permissible to lift in wind speed up to 45 mph.

**Load example 2.2:**

With unknown Wind Drag Coefficient of the load **Cd**,

- Load to be lifted of 18,000 lb,
- Projected Wind Area **Ap** = 45 ft<sup>2</sup>,
- Wind Drag Coefficient **Cd** = unknown

**NOTE:** If exact Wind Drag Coefficient is not known, it shall be assumed as 2.4.

the wind resistance area of load can be estimated as

$$Awr_{(load)} = Ap \times Cd = 45 \times 2.4 = 108 \text{ ft}^2$$

Refer to the above **Lifting Limits at wind speed  $V(z) > 30$  mph and  $\leq 45$  mph**. Comparing the load and wind resistant area to the allowable:

- Is the load to be lifted less than allowable load?  
18,000 lb  $\leq$  20,160 lb YES

- Is **Awr<sub>(load)</sub>** less than **Awr<sub>(allow)</sub>**?  
108 ft<sup>2</sup>  $\leq$  119 ft<sup>2</sup> YES

**Conclusion:** This load is permissible to lift in wind speed up to 45 mph.

**Load example 2.3a:**

With large wind resistance area of the load **Awr<sub>(load)</sub>**,

- Load to be lifted of 22,000 lb,
- Projected Wind Area **Ap** = 180 ft<sup>2</sup>,
- Wind Drag Coefficient **Cd** = 1.2

the wind resistance area of load can be estimated as:

$$Awr_{(load)} = Ap \times Cd = 180 \times 1.2 = 216 \text{ ft}^2$$

Refer to the above **Lifting Limits at wind speed  $V(z) > 30$  mph and  $\leq 45$  mph**. Comparing the load to the allowable:

- Is the load to be lifted less than allowable load?  
22,000 lb  $\leq$  20,160 lb NO

**Conclusion:** This load is NOT permissible to lift in wind speed up to 45 mph.

Refer to the above **Lifting Limits at wind speed  $V(z)$  up to 30 mph**. Comparing the load to the allowable:

- Is the load to be lifted less than allowable load?  
22,000 lb  $\leq$  25,200 lb YES

The permissible wind speed for this load is 30 mph, depending on the wind resistance area of the load.

- Is **Awr<sub>(load)</sub>** less than **Awr<sub>(allow)</sub>**?  
216 ft<sup>2</sup>  $\leq$  149 ft<sup>2</sup> NO

**Conclusion:** This load is NOT permissible to lift in wind speed at 30 mph, but permitted to lift at a reduced wind speed calculated as follows:

$$\text{Ratio } \frac{Awr_{(load)}}{Awr_{(allow)}} = \frac{216}{149} = 1.45$$

From Table 2-7, the maximum permissible wind speed at ratio of 1.45 (rounded to next higher table value of 1.6) is 23.7 mph.

**Conclusion:** This load is permissible to lift in wind speed up to 23.7 mph only.

**Load example 2.3b:**

With large wind resistance area of the load **Awr<sub>(load)</sub>**,

- Load to be lifted of 12,000 lb,
- Projected Wind Area **Ap** = 125 ft<sup>2</sup>,
- Wind Drag Coefficient **Cd** = 1.3

the wind resistance area of load can be estimated as:

$$Awr_{(load)} = Ap \times Cd = 125 \times 1.3 = 162 \text{ ft}^2$$

Refer to the above **Lifting Limits at wind speed  $V(z) > 30$  mph and  $\leq 45$  mph**. Comparing the load and wind resistant area to the allowable:

- Is the load to be lifted less than allowable load?  
12,000 lb  $\leq$  20,160 lb YES
- Is  $Awr_{(load)}$  less than  $Awr_{(allow)}$ ?  
162 ft<sup>2</sup>  $\leq$  119 ft<sup>2</sup> NO

**Conclusion:** This load is NOT permissible to lift in wind speed up to 45 mph, but permitted to lift at a reduced wind speed calculated as follows:

$$\text{Ratio} \frac{Awr_{(load)}}{Awr_{(allow)}} = \frac{162}{119} = 1.37$$

From Table Table 2-7, the maximum permissible wind speed at ratio of 1.37 (rounded to next higher table value of 1.4) is 38.0 mph.

**Conclusion:** This load is permissible to lift in wind speed up to 38.0 mph only.

## Lifting Operations

Before lifting, position the crane on a firm surface, properly extend and set the outriggers, and level the crane. Depending on the nature of the supporting surface, adequate cribbing may be required to obtain a larger bearing surface.

The crane is equipped with a bubble level that should be used to determine whether the crane is level. The load line can also be used to estimate the levelness of the crane by checking to be sure it is in-line with the center of the boom at all points on the swing circle.

If the jib, or auxiliary boom nose is to be used, ensure the electrical cable and the weight for the Anti-Two-Block Switch are properly installed and the Rated Capacity Limiter (RCL) is programmed for the crane configuration. Refer to the RCL operator manual supplied with the crane.

Verify the crane's capacity by checking the *Load Chart* against the weight of the load. Then, lift the load slightly at first to ensure stability before proceeding with the lift.

Be sure the load is properly rigged and attached. Always determine the weight of the load before you attempt to lift it and remember that all rigging (slings, etc.) and lifting devices (hook block, jib, etc.) must be considered part of the load.

Measure the load radius before making a lift and stay within approved lifting areas based on the range diagrams and working area diagrams on the crane's *Load Chart*.

Always keep the load as near to the crane and as close to the ground as possible.

**Do not overload the crane** by exceeding the capacities shown on the appropriate *Load Chart*. Death or serious

injury could result from the crane tipping over or failing structurally from overload.

The crane can tip over or fail structurally if:

- The load and crane's configuration is not within the capacity as shown on the applicable *Load Chart* and notes.
- The ground is soft and/or the surface conditions are poor.
- Outriggers are not properly extended and set. On models equipped with outriggers that can be pinned at the mid-extend position, the outriggers must also be pinned when operating from the mid-extend position.
- Cribbing under the outrigger pads is inadequate.
- The crane is improperly operated.

Do not rely on the crane's tipping to determine your lifting capacity.

Be sure the hoist line is vertical before lifting. Do not subject the crane to side loading. A side load can tip the crane or cause it to fail structurally.

*Load Chart* capacities are based on freely suspended loads. Do not pull posts, pilings, or submerged articles. Be sure the load is not frozen or otherwise attached to the ground before lifting.

If you should encounter a tipping condition, immediately lower the load with the hoist line and retract or elevate the boom to decrease the load radius. Never lower or extend the boom; this will aggravate the condition.

Use tag lines whenever possible to help control the movement of the load.

When lifting loads, the crane will lean toward the boom and the load will swing out, increasing the load radius. Ensure the crane's capacity is not exceeded when this occurs.

Do not strike any obstruction with the boom. If the boom should accidentally contact an object, stop immediately. Inspect the boom. Remove the crane from service if the boom is damaged.

Never push or pull with the crane boom.

Avoid sudden starts and stops when moving the load. The inertia and an increased load radius could tip the crane over or cause it to fail structurally.

Using only one hoist at a time when lifting loads is recommended. See "Tilt-Up Panel Lifting" on page 2-21 for additional lifting instructions.

Always use enough parts-of-line to accommodate the load to be lifted. Lifting with too few parts-of-line can result in failure of the hoist rope.

## Counterweight

On cranes equipped with removable counterweights, ensure the appropriate counterweight sections are properly installed for the lift being considered.

Do not add material to the counterweight to increase capacity. United States Federal law prohibits modification or additions which affect the capacity or safe operation of the equipment without the manufacturer's written approval. [29CFR 1926.1434]

## Outrigger Lift Off

Regarding "lifting" of an outrigger pad during craning activities, be advised that the rated loads for these cranes, as indicated on the crane's *Load Chart*, do not exceed 85% of the tipping load on outriggers as determined by SAE J765 OCT90 "Cranes Stability Test Code." An outrigger pad may lift off the ground during operation of the crane within the capacity limits of the *Load Chart*, yet the crane will not have reached instability. The "balance point" for stability testing according to SAE and Manitowoc criteria is a condition of loading wherein the load moment acting to overturn the crane is equal to the maximum moment of the crane available to resist overturning. This balance point or point of instability for a crane does not depend on "lifting" of an outrigger but rather on comparison of the "opposing" load moments.

The occurrence of an outrigger lifting from the ground is often attributed to the natural flex in the crane's frame. This may happen when lifting a load in certain configurations within the capacity limits of the *Load Chart* and is not necessarily an indication of an unstable condition.

Provided the crane is properly set up, the crane is in good working condition, that all operator's aids are properly programmed, that the qualified crane operator adheres to the instructions found in the applicable *Load Chart*, *Operator Manual* and decals on the crane, the crane should not be unstable.

## Multiple Crane Lifts

Multiple crane lifts are not recommended.

Any lift that requires more than one crane must be precisely planned and coordinated by a designated person. If it is necessary to perform a multi-crane lift, the operator shall be responsible for assuring that the following minimum safety precautions are taken:

- Secure the services of a designated person to direct the operation.
- Use one qualified signal person.
- Coordinate lifting plans with the operators, designated person, and signal person prior to beginning the lift.

- Maintain communication between all parties throughout the entire operation. If possible, provide approved radio equipment for voice communication between all parties engaged in the lift.
- Use outriggers on cranes so equipped.
- Calculate the amount of weight to be lifted by each crane and attach slings at the correct points for proper weight distribution.
- Ensure the load lines are directly over the attach points to avoid side loading and transfer of loading from one crane to the other.
- Do not travel. Lift only from a stationary position.

## Tilt-Up Panel Lifting

Requirements and recommendations regarding operation and use of Grove Cranes are stated on decals and in the Operator and Safety Handbook and other manuals provided with each specific model machine. Using the subject crane to perform tilt-up panel lifting with two hoist lines poses new and different hazards than does normal lifting use.

Therefore, the following additional precautions must be taken if it is necessary for the crane to be used to perform tilt-up panel lifting using a crane equipped with two hoists:

- The crane must be set up and operated in accordance with Grove's instructions in the Operator and Safety Handbook, Load Capacity Chart, and decals affixed to the crane.
- The hoist rope from the main hoist shall be reeved over the main boom nose reeved for two parts of line.
- The hoist rope from the auxiliary hoist shall be reeved over the auxiliary boom nose reeved for one part of line.
- The load shall be connected with the main hoist line connected to the end closest to crane and the auxiliary hoist line connected to the end farthest from the crane.
- The anti-two block system shall be installed and inspected to confirm that it is active to monitor both hoist lines.
- The RCL hoist selection shall be set to main hoist and two parts offline.
- The wire rope and sheaves shall be inspected prior to and following the lifting operations for chaffing or scrubbing.
- The total gross load shall not exceed 80% of the standard load chart. The operator shall be responsible to control this as the RCL does not have a feature to set reduced lifting limits.
- The auxiliary hoist line shall be considered part of the deducts to determine net allowable load.

- The panel shall be lifted so that the hoist lines are in line with the crane.
- The load shall be controlled to prevent rotation of the load and to ensure the load stays in line with the boom.
- The load must be balanced with the auxiliary: load line not taking more than half the load at any time during the lift. The RCL will not be providing coverage for the line pull of the auxiliary hoist line.
- The effect of wind loads on the crane and panel shall be taken into consideration. Operations shall be halted if the wind can cause a loss of control in handling the load.
- The main hoist line shall be used to raise the panel into the vertical position.

Ensure that all personnel working on and around the crane are properly trained and thoroughly familiar with operational functions of the crane and safe operating and work practices. Personnel should be thoroughly familiar with regulations and standards governing cranes and their operation. Work practices may vary slightly between government regulations, industry standards, local and job-site rules and employer policies so a thorough knowledge of and compliance with all relevant work rules is necessary.

## PILE DRIVING AND EXTRACTING

Pile driving and extracting are applications approved by Manitowoc, provided all equipment is operated within factory guidelines. The following operating requirements must be used during pile driving and extracting with a Manitowoc mobile hydraulic crane:

Pile driving and pile extraction using a mobile crane introduces many variable and unknown factors that must be considered when using a crane for this application. Because of these factors, discretion must be exercised when pile driving or pile extraction is being considered.

It is not the intention of Manitowoc to recommend specific types or makes of pile driving and pile extraction equipment, but rather to advise of the operational requirements to help avoid the detrimental effects that pile driving and pile extraction can have on the crane.

In addition to the operating requirements that are detailed in the operating manuals and on the load capacity chart, pile driving and extracting operations are approved by Manitowoc, provided all guidelines outlined below are followed:

- All pile driving and extracting operations shall be restricted to fully extended outriggers with all tires clear of the ground.
- The combined weight of the driver or extractor, piling, leads, attachments, etc., shall not exceed 80% of the published load chart values for on-outriggers operation.

- The pile driver or pile extractor and attachments shall be kept clear of the boom nose at all times.
- The pile driver and piling shall be suspended from a hoist cable with sufficient line speed to meet or exceed the rate of descent of the driver and piling to preclude impact loading or vibration from being induced into the boom and crane structure.
- Pile driving or extracting shall be restricted to over the main boom only and shall not be permitted over a jib.
- Pile extraction using only the crane's hoist line is unsafe and not permitted since load values cannot be accurately determined. Only pile extraction devices that do not transmit vibration or shock loading into the crane are permitted. All possible precautionary measures shall be taken to prevent shock loads or vibration from being imposed on crane components, either directly through the hoist cable or indirectly from ground borne vibration.
- The load lines shall be kept vertical at all times during pile driving and pile extraction operations.
- The operator and other personnel associated with the pile driving and pile extraction operation shall have read and understood all safety standards applicable to crane operations as well as being thoroughly trained in the safe operation of pile driving and extracting equipment.

## Crane Equipment

- Hoists shall be equipped with a cable follower to aid in proper spooling of cable.
- All cable retainer pins and cable guides/retainers shall be in place.
- All jibs must be removed from the machine before pile driving or extraction begins.
- All hoist hooks shall be equipped with a positive locking latch.

## Crane Inspection

- In addition to the crane's frequent and periodic inspections, dated daily records shall be maintained showing inspections were performed on the crane during the time it was used for pile driving or extraction.
- All anti-two block warning devices and RCL systems shall be inspected daily and verified to be functional.
- All areas of the crane subject to fatigue shall be inspected monthly, and before the crane is to return to lifting service.
- The boom shall be inspected daily to ensure all wear pads remain in place. Cranes which utilize pinned boom sections shall be inspected daily to ensure the pinning mechanism operates properly and to check for undue wear at the pins and pinning plates. The hoist cable shall

be inspected daily to ensure no chafing or wear is occurring.

**ELECTROCUTION HAZARD**

Thoroughly read, understand, and abide by all applicable federal, state, and local regulations regarding operation of cranes near electric power lines or equipment.

**United States federal law prohibits the use of cranes closer than 6 m (20 ft) to power sources up to 350 kV and greater distances for higher voltages unless the line's voltage is known [29CFR1910.180 and 29CFR1926, subpart CC].**

**To avoid death or serious injury, Manitowoc recommends that all parts of crane, boom, and load be kept at least 6 m (20 ft) away from all electrical power lines and equipment less than 350 kV.**



**DANGER**

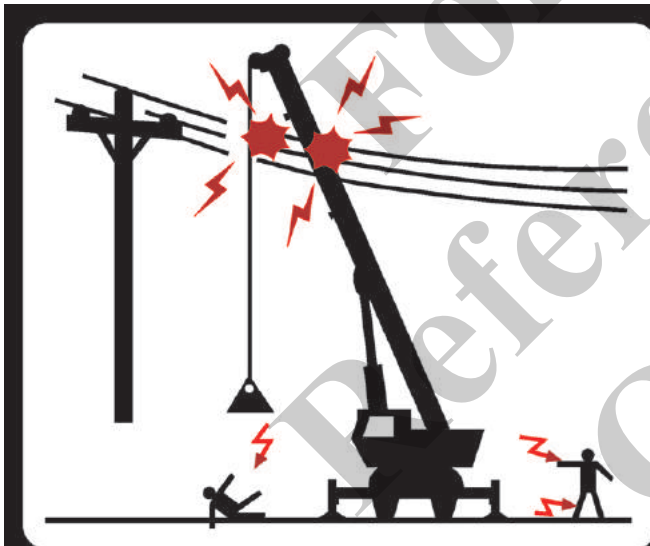
**Electrocution Hazard!**

Manitowoc cranes are not equipped with all features required to operate within OSHA 29CFR1926.1408, Power Line Safety, Table A clearances when the power lines are energized.

If operation within 3 m (10 ft) of any power lines cannot be avoided, the power utility **must** be notified and the power lines **must** be de-energized and grounded **before** performing any work.

If contact is ever accidentally made with a power line and any part of this crane, its rigging or load, **never** touch the crane or even approach or come near the crane.

Electrocution **can occur** even without direct contact with the crane.



**THIS CRANE IS NOT INSULATED.**



**ELECTROCUTION HAZARD TO AVOID DEATH OR SERIOUS INJURY**

Keep **ALL** parts of the crane, rigging and load at least 20 feet (6 meters) away from any energized power line. You **MUST** follow the OSHA requirements set forth in 29CFR 1926.1407 through 1926.1411.

This crane is not designed or equipped for use within 10 feet (3 meters) of energized power lines [Refer to 29CFR1926.1410 Table A]. If operation within 10 feet (3 meters) of any power lines cannot be avoided, the power utility **MUST** be notified and the power lines **MUST** be de-energized and grounded **BEFORE** performing any work.

If contact is ever accidentally made with a power line and any part of this crane, its rigging or load, **NEVER** touch the crane or even approach or come near the crane.

Electrocution **CAN OCCUR** even without direct contact with the crane.

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Crane operation is dangerous when close to an energized electrical power source. Exercise extreme caution and prudent judgement. Operate slowly and cautiously when in the vicinity of power lines.

Before operating this crane in the vicinity of electrical power lines or equipment, notify the power utility company. Obtain positive and absolute assurance that the power has been turned off.

This crane is **not insulated**. Always consider all parts of the load and the crane, including the hoist rope, wire rope, pendant cables, and tag lines, as conductors. You, the

operator, are responsible for alerting all personnel of dangers associated with electrical power lines and equipment. Do not allow unnecessary personnel in the vicinity of the crane while operating. Permit no one to lean against or touch the crane. Permit no one, including riggers and load handlers, to hold the load, load lines, tag lines, or rigging gear.

If the load, hoist rope, boom, or any portion of the crane contacts or comes too close to an electrical power source, everyone in, on, and around the crane can be seriously injured or killed.

Most overhead power lines **are not** insulated. Treat all overhead power lines as being energized unless you have reliable information to the contrary from the utility company or owner.

The rules in this *Operator Manual* must be followed at all times, even if the electrical power lines or equipment have been de-energized.

The safest way to avoid electrocution is to stay away from electrical power lines and electrical power sources.

It is not always necessary to contact a power line or power source to become electrocuted. Electricity, depending on magnitude, can arc or jump to any part of the load, load line, or crane boom if it comes too close to an electrical power source. Low voltages can also be dangerous.

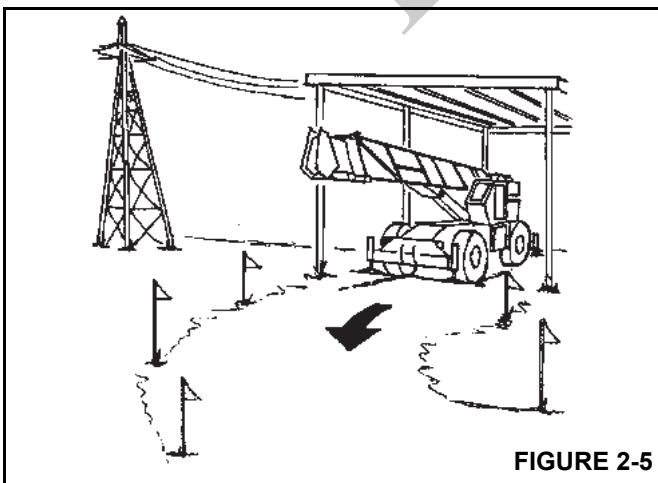
## Set-Up and Operation

During crane use, assume that every line is energized (“hot” or “live”) and take the necessary precautions.

Set up the crane in a position such that the load, boom, or any part of the crane and its attachments cannot be moved to within 6 m (20 ft) of electrical power lines or equipment. This includes the crane boom (fully extended to maximum height, radius, and length) and all attachments (jibs, rigging, loads, etc.). Overhead lines tend to blow in the wind so allow for lines’ movement when determining safe operating distance.

A suitable barricade should be erected to physically restrain the crane and all attachments (including the load) from entering into an unsafe distance from electrical power lines or equipment.

Plan ahead and always plan a safe route before traveling under power lines. Rider poles should be erected on each side of a crossing to assure sufficient clearance is maintained.



United States OSHA regulations require a flagman when operating in close proximity to energized power lines.

Appoint a reliable and qualified signal person, equipped with a loud signal whistle or horn and voice communication equipment, to warn the operator when any part of the crane or load moves near a power source. This person should have no other duties while the crane is working.

Tag lines should always be made of non-conductive materials. Any tag line that is wet or dirty can conduct electricity.

**Do not** store materials under power lines or close to electrical power sources.

## Electrocution Hazard Devices

The use of insulated links, insulated boom cages/guards, proximity warning devices, or mechanical limit stops does not assure that electrical contact will not occur. Even if codes or regulations require the use of such devices, failure to follow the rules listed here may result in serious injury or death. You should be aware that such devices have limitations and you should follow the rules and precautions outlined in this manual at all times even if the crane is equipped with these devices.

Insulating links installed into the load line afford limited protection from electrocution hazards. Links are limited in their lifting abilities, insulating properties, and other properties that affect their performance. Moisture, dust, dirt, oils, and other contaminants can cause a link to conduct electricity. Due to their capacity ratings, some links are not effective for large cranes and/or high voltages/currents.

The only protection that may be afforded by an insulated link is below the link (electrically downstream), provided the link has been kept clean, free of contamination, has not been scratched or damaged, and is periodically tested (just before use) for its dielectric integrity.

Boom cages and boom guards afford limited protection from electrocution hazards. They are designed to cover only the boom nose and a small portion of the boom. Performance of boom cages and boom guards is limited by their physical size, insulating characteristics, and operating environment (e.g. dust, dirt, moisture, etc.). The insulating characteristics of these devices can be compromised if not kept clean, free of contamination, and undamaged.

Proximity sensing and warning devices are available in different types. Some use boom nose (localized) sensors and others use full boom length sensors. No warning may be given for components, cables, loads, and other attachments located outside of the sensing area. Much reliance is placed upon you, the operator, in selecting and properly setting the sensitivity of these devices.

Never rely solely on a device to protect you and your fellow workers from danger.

Some variables you must know and understand are:

- Proximity devices are advertised to detect the existence of electricity and not its quantity or magnitude.
- Some proximity devices may detect only alternating current (AC) and not direct current (DC).
- Some proximity devices detect radio frequency (RF) energy and others do not.
- Most proximity devices simply provide a signal (audible, visual, or both) for the operator; this signal must not be ignored.
- Sometimes the sensing portion of the proximity devices becomes confused by complex or differing arrays of power lines and power sources.

**Do not** depend on grounding. Grounding of a crane affords little or no protection from electrical hazards. The effectiveness of grounding is limited by the size of the conductor (wire) used, the condition of the ground, the magnitude of the voltage and current present, and numerous other factors.

## Electrical Contact

If the crane should come in contact with an energized power source, you must:

1. Stay in the crane cab. **Don't panic.**
2. Immediately warn personnel in the vicinity to stay away.
3. Attempt to move the crane away from the contacted power source using the crane's controls which may have remained functional.
4. Stay in the crane until the power company has been contacted and the power source has been de-energized. **No one** must attempt to come close to the crane or load until the power has been turned off.

Only as a last resort should an operator attempt to leave the crane upon contacting a power source. If it is absolutely necessary to leave the operator's station, **jump completely clear of the crane. Do not step off.** Hop away with both feet together. **Do not** walk or run.

Following any contact with an energized electrical source, the Manitowoc distributor must be immediately advised of the incident and consulted on necessary inspections and repairs. Thoroughly inspect the hoist rope and all points of contact on the crane. Should the dealer not be immediately available, contact Manitowoc Crane Care. The crane must not be returned to service until it is thoroughly inspected for any evidence of damage and all damaged parts are repaired or replaced as authorized by your Manitowoc distributor or Manitowoc Crane Care.

## Special Operating Conditions and Equipment

Never operate the crane during an electrical thunderstorm.

When operating near transmitter/communication towers where an electrical charge can be induced into the crane or load:

- The transmitter shall be deenergized OR,
- Tests shall be made to determine if an electrical charge will be induced into the crane or load.
- The crane must be provided an electrical ground.
- If taglines are used, they must be non-conductive.
- Every precaution must be taken to dissipate induced voltages. Consult a qualified RF (radio frequency) Consultant. Also refer to local, state, and federal codes and regulations.

When operating cranes equipped with electromagnets, you must take additional precautions. Permit no one to touch the magnet or load. Alert personnel by sounding a warning signal when moving a load. Do not allow the cover of the electromagnet power supply to be open during operation or at any time the electrical system is activated. Shut down the crane completely and open the magnet controls switch prior to connecting or disconnecting magnet leads. Use only a non-conductive device when positioning a load. Lower the magnet to the stowing area and shut off power before leaving the operator's cab (if equipped) or operator's station.

## PERSONNEL HANDLING

The American Society of Mechanical Engineers issued a new American National Standard entitled, *Personnel Lifting Systems*, ASME B30.23-2011:

This Volume establishes the design criteria, equipment characteristics, and operational procedures that are required when hoisting equipment within the scope of the ASME B30 Standard is used to lift personnel. Hoisting equipment defined by the ASME B30 Standard is intended for material handling. It is not designed, manufactured, or intended to meet the standards for personnel handling equipment, such as ANSI/SIA A92 (Aerial Platforms). The equipment and implementation requirements listed in this Volume are not the same as that established for using equipment specifically designed and manufactured for lifting personnel. Hoisting equipment complying with the applicable Volumes of the ASME B30 Standard shall not be used to lift or lower personnel unless there are no less hazardous alternatives to providing access to the area where work is to be performed. The lifting or lowering of personnel using ASME B30-compliant hoisting equipment is prohibited unless all applicable requirements of this volume have been met.

This new standard is consistent with the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) regulations for Construction that state, in 29CFR1926.1431:

General requirements. The use of a crane or derrick to hoist employees on a personnel platform is prohibited, except when the erection, use, and dis-

mantling of conventional means of reaching the worksite, such as a personnel hoist, ladder, stairway, aerial lift, elevating work platform or scaffold, would be more hazardous or is not possible because of structural design or worksite conditions.

Additional requirements for crane operations are stated in ASME B30.5, *Mobile and Locomotive Cranes*, ASME B30.8, *Floating Cranes and Floating Derricks*, and in OSHA regulations 29CFR1910.180 for *General Industry* and 29CFR1926.1431 for *Construction*.

Use of a Manitowoc crane to handle personnel is acceptable provided:

- The requirements of the applicable national, state and local regulations and safety codes are met.
- A determination has been made that use of a crane to handle personnel is the least hazardous means to perform the work.
- The crane operator shall be qualified to operate the specific type of hoisting equipment used in the personnel lift.
- The crane operator must remain at the crane controls at all times when personnel are off the ground.
- The crane operator and occupants have been instructed in the recognized hazards of personnel platform lifts.
- The crane is in proper working order.
- The crane must be equipped with a boom angle indicator that is visible to the crane operator.
- The crane's *Load Chart* is affixed at the operator's station and readily accessible to the operator. The total weight of the loaded personnel platform and related rigging shall not exceed 50 percent of the rated capacity for the radius and configuration of the crane.
- The crane is level within one percent of level grade and located on a firm footing. Cranes with outriggers shall have them all deployed following manufacturer's specifications.
- The crane's *Operator Manual* and other operating manuals are at the operator's station and readily accessible to the operator.
- The platform meets the requirements as prescribed by applicable standards and regulations.
- For hoist rope suspended platforms:
  - The crane is equipped with a hook that can be closed and locked, eliminating the throat opening.
  - The crane is equipped with a functional anti-two-block device.
  - The platform is properly attached and secured to the load hook.

- For boom mounted platforms:
  - The platform is properly attached and secure.

To avoid death or serious injury:

- NEVER use this crane for bungee jumping or any form of amusement or sport.
- NEVER handle personnel on the loadline unless the requirements of applicable national, state and local regulations and safety codes are met.
- NEVER permit anyone to ride loads, hooks, slings or other rigging for any reason.
- NEVER get on or off a moving crane.
- NEVER allow anyone other than the operator to be on this crane while the machine is operating or traveling.
- NEVER allow anyone on the hoist access platform while traveling.

The following standards and regulations regarding personnel handling are available by mail at the following addresses:

- *ASME (formerly ANSI) B30 Series American National Safety Standards For Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings; ASME B30.5, Mobile And Locomotive Cranes, and ASME B30.23, Personnel Lifting Systems*, are available by mail from the ASME, 22 Law Drive, Fairfield, New Jersey, 0700-2900
- *US DOL/OSHA Rules and Regulations* are available by mail from the Superintendent of Documents, PO Box 371954, Pittsburgh, PA, 15250-7954.

## ENVIRONMENTAL PROTECTION

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

Potentially harmful waste used in Manitowoc 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.



## MAINTENANCE

The crane must be inspected prior to use on each work shift. The owner, user, and operator must ensure that routine maintenance and lubrication are being dutifully performed. **Never** operate a damaged or poorly maintained crane.

Manitowoc continues to recommend that cranes be properly maintained, regularly inspected and repaired as necessary. Manitowoc reminds crane owners to ensure that all safety decals are in place and legible. Manitowoc continues to urge crane owners to upgrade their cranes with rated capacity limiter and control lever lockout systems for all lifting operations.

Shut down the crane while making repairs or adjustments.

Always perform a function check after repairs have been made to ensure proper operation. Load tests should be performed when structural or lifting members are involved.

Follow all applicable safety precautions in this manual when performing crane maintenance as well as crane operations.

Keep the crane free of mud, dirt, and grease at all times. Dirty equipment introduces hazards, wears-out faster, and makes proper maintenance difficult. Cleaning solutions used should be non-flammable, non-toxic and appropriate for the job.

Routine maintenance and inspection of this crane must be performed by a qualified person(s) according to the recommendations in the *Manitowoc Crane Care Maintenance and Inspection Manual*. Any questions regarding procedures and specifications should be directed to your Manitowoc distributor.

## Service and Repairs



### WARNING

#### Fall Hazard!

Working at elevated heights without using proper fall protection can result in severe injury or death.

Always use proper fall protection as required by local, state or federal regulations.

Service and repairs to the crane must only be performed by a qualified person. All service and repairs must be performed in accordance with manufacturer's recommendations, this manual, and the service manual for this machine. If there is any question regarding maintenance procedures or specifications, contact your Manitowoc distributor for assistance.

**Qualified person** is defined as one who by reason of knowledge, training and experience is thoroughly familiar

with the crane's operation and required maintenance as well as the hazards involved in performing these tasks.

### Training and qualification of maintenance and repair personnel are crane owner's responsibility.

Any modification, alteration, or change to a crane which affects its original design and is not authorized and approved by Manitowoc is **strictly prohibited**. All replacement parts must be Manitowoc approved. Such action invalidates all warranties and makes the owner/user liable for any resultant accidents.

#### Hydraulic Fluid:

- Do not use your hand or any part of your body to check for hydraulic fluid leaks when the engine is running or the hydraulic system is under pressure. Fluid in the hydraulic system can be under enough pressure that it will penetrate the skin, causing serious injury or death. Use a piece of cardboard, or piece of paper, to search for leaks. Wear gloves to protect your hands from spraying fluid.
- If any hydraulic fluid is injected into the skin, obtain medical attention immediately or gangrene may result.
- Do not attempt to repair or tighten any hydraulic hose or fitting while the engine is running, or when the hydraulic system is under pressure.
- Never disconnect any hydraulic lines unless the boom is fully lowered, the engine is shut off, and the hydraulic pressure is relieved. To relieve hydraulic pressure, stop the engine, turn the ignition switch to RUN and move the hydraulic controls in both directions several times.



### WARNING

#### Pressurized Fluid Hazard!

Hydraulic pressure may still be present in portions of the hydraulic system due to accumulators or trapped circuitry.

- Hot hydraulic fluid will cause severe burns. Wait for the fluid to cool before disconnecting any hydraulic lines.
- Hydraulic fluid can cause permanent eye injury. Wear appropriate eye protection.

#### Moving Parts:

- Do not place limbs near moving parts. Amputation of a body part may result. Turn off the engine and wait until the fan and belts stop moving before servicing crane.
- Pinch points, which result from relative motion between mechanical parts, are areas of the machine that can cause personal injury or death. Do not place limbs or your body in contact with pinch points either on or around the machine. Care must be taken to prevent

motion between pinch points when performing maintenance and to avoid such areas when movement is possible.

- Do not allow persons to stand near extending or lowering outriggers. Foot crushing could occur

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

- The boom should be fully retracted and lowered and the load placed on the ground.
- Do not get under a raised boom unless the boom is blocked up safely. Always block up the boom before doing any servicing that requires the boom to be raised.
- Stop the engine and disconnect the battery.
- Controls should be properly tagged. Never operate the crane if it is **tagged-out** nor attempt to do so until it is restored to proper operating condition and all tags have been removed by the person(s) who installed them.

After maintenance or repairs:

- Replace all guards and covers that have been removed.
- Remove all tags, connect the battery, and perform a function check of all operating controls.
- Consult with Manitowoc Crane Care to determine if load testing is required after a structural repair is performed.

## Lubrication

The crane must be lubricated according to the manufacturer's recommendations for lubrication points, time intervals, and types. Lubricate at more frequent intervals when working under severe conditions.

Exercise care when servicing the hydraulic system of the crane, as pressurized hydraulic oil can cause serious injury. The following precautions must be taken when servicing the hydraulic system:

- Follow the manufacturer's recommendations when adding oil to the system. Mixing the wrong fluids could destroy seals, causing component failure.
- Be certain all lines, components, and fittings are tight before resuming operation.

## Tires



### WARNING

#### Possible equipment damage and/or personal injury!

Driving the crane with a tire and split-rim assembly under inflated at 80% or less of its recommended pressure can cause the wheel and/or tire to fail. Per *OSHA Standard 1910.177(f)(2)*, when a tire has been driven under inflated at 80% or less of its recommended pressure, it must first be completely deflated, removed from the axle, disassembled, and inspected before re-inflation.

Inspect the tires for nicks, cuts, embedded material, and abnormal wear.

Ensure all lug nuts are properly torqued.

Ensure pneumatic tires are inflated to the proper pressure (refer to the *Load Chart*). When inflating tires, use a tire gauge, clip-on inflator, and extension hose which will permit standing clear of the tire while inflating.

## HOIST ROPE

### Synthetic Hoist Rope

For detailed information concerning synthetic hoist rope, refer to KZ100 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.

Always make daily inspections of the hoist rope, keeping in mind that all hoist rope will eventually deteriorate to a point where it is no longer usable. Refuse to work with worn or damaged hoist rope.

During regular inspections, operator shall 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.

**NOTE:** Example; if usage of a wire rope has cut grooves with sharp edges in a wear pad, they need to be addressed before the synthetic hoist rope is used in that same position.

Use **only** the hoist rope specified by Manitowoc as indicated on the crane's *Capacity Chart*. Substitution of an alternate hoist rope may require the use of a different permissible line pull and, therefore, require different reeving.

**NOTE:** Hoist rope may be purchased by contacting Manitowoc Crane Care.

## Wire Rope

Always make daily inspections of the rope, keeping in mind that all wire rope will eventually deteriorate to a point where it is no longer usable. Refuse to work with worn or damaged wire rope. Rope shall be taken out of service when any of the following conditions exist:

- For rotation-resistant running ropes: more than two (2) broken wires in a length of rope equal to six (6) times the rope diameter, or more than four (4) broken wires in a length of rope equal to thirty (30) times the rope diameter.
- For running ropes other than rotation resistant: six (6) broken wires in one rope lay or three (3) broken wires in one strand.
- One valley break where the wire fractures between strands in a running rope is cause for removal.
- Abrasion of the rope resulting in a 5% reduction in the original wire diameter.
- Any kinking, bird caging, crushing, corrosion, or other damage resulting in distortion of the rope structure.
- Rope that has been in contact with a live power line or has been used as a ground in an electric circuit (eg. welding) may have wires that are fused or annealed and must be removed from service.
- In standing ropes, more than three (3) breaks in one rope lay in sections beyond the end connection or more than two (2) broken wires at an end connection.
- Core deterioration, usually observed as a rapid reduction in rope diameter, is cause for immediate removal of the rope.

The following is a brief outline of the basic information required to safely use wire rope.

- Wire ropes wear out. The strength of a rope begins to decrease when the rope is put to use and continues to decrease with each use. Rope will fail if worn-out, overloaded, misused, damaged or improperly maintained.
- The nominal strength, sometimes called catalog strength, of a wire rope applies only to a new, unused rope.
- The nominal strength of a rope should be considered the straight line pull which will actually break a new unused rope. The nominal strength of a rope should never be used as its working load.
- Each type of fitting attached to a rope has a specific efficiency rating which can reduce the working load of the rope assembly or rope system.

- Never overload a rope. This means never use the rope where the load applied to it is greater than the working load determined by the rope manufacturer.
- Never “shock load” a rope. A sudden application of force or load can cause both visible external and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a rope.
- Lubricant is applied to the wires and strands of a wire rope when it is manufactured. The lubricant is depleted when the rope is in service and should be replaced periodically. Refer to the *Service Manual* for more information.
- In the U.S.A., regular inspections of the rope and keeping of permanent records signed by a qualified person are required by OSHA for almost every wire rope application. The purpose of the inspection is to determine whether or not a rope may continue to be safely used on the application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by OSHA, ANSI, ASME and similar organizations. See the *Service Manual* for inspection procedures.

When inspecting ropes and attachments, keep all parts of your body and clothing away from rotating hoist drums and all rotating sheaves. Never handle the rope with bare hands.

Some conditions that lead to problems in wire rope systems include:

- Sheaves that are too small, worn or corrugated cause damage to a wire rope.
- Broken wires mean a loss in strength.
- Kinks permanently damage a rope and must be avoided.
- Ropes are damaged by knots. Rope with knots must never be used.
- Environmental factors such as corrosive conditions and heat can damage a wire rope.
- Lack of lubrication can significantly shorten the useful life of a wire rope.
- Contact with electrical wires and resulting arcing will damage a wire rope.
- An inspection should include verification that none of the specified removal criteria for this usage are met by checking for such things as:
  - Surface wear; nominal and unusual.
  - Broken wires; number and location.
  - Reduction in diameter.

- Rope stretch (elongation).
- Integrity of end attachments.
- Evidence of abuse or contact with another object.
- Heat damage.
- Corrosion.

**NOTE:** A more detailed rope inspection procedure is given in the *Service Manual*.

- When a rope has been removed from service because it is no longer suitable for use, it must not be reused on another application.

When installing a new rope:

- Keep all parts of your body and clothing away from rotating hoist drums and all rotating sheaves.
- Never handle the wire rope with bare hands.
- Follow proper instructions for removing rope from a reel.
- Apply back tension to the storage/payoff reel of the new rope to insure tight, even spooling onto the hoist drum.
- Operate the new rope - first through several cycles at light load and then through several cycles at intermediate load to allow the rope to adjust to operating conditions.

When using a wedge socket:

- Always inspect socket, wedge, and pin for correct size and condition.
- Do not use parts that are damaged, cracked, or modified.
- Assemble the wedge socket with live end of rope aligned with the centerline of pin and assure proper length of tail (dead end) protrudes beyond the socket.

## Sheaves

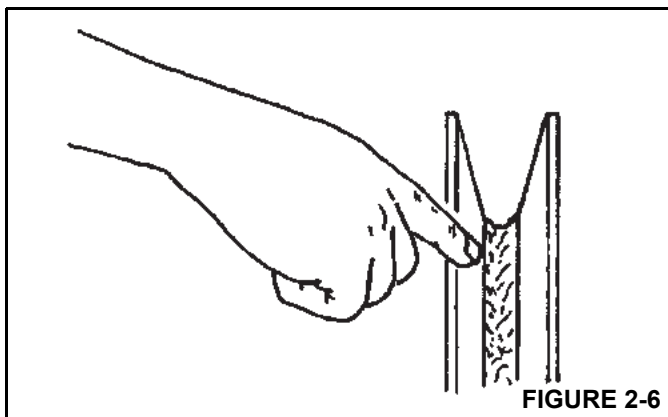


FIGURE 2-6

Inspect the boom nose and hook block sheaves for proper operation, excessive wear, and damage every 50 hours or

weekly. Inoperable, damaged and/or worn sheaves cause rapid deterioration of rope.

Ensure sheaves carrying ropes that can be momentarily unloaded are equipped with close fitting guards or other devices to guide the rope back into the groove when the load is reapplied. Ensure sheaves in the lower load block are equipped with close fitting guards that will prevent the ropes from becoming fouled when the block is lying on the ground with loose ropes.

To attain maximum hoist rope life and minimize hook block rotation, it is recommended that even numbers of parts-of-line be used in multiple-part reeving whenever possible.

The use of nylon (polyamide) sheaves, as compared with metallic sheaves, may change the replacement criteria of rotation-resistant hoist rope.

**NOTE:** The use of cast nylon (polyamide) sheaves will substantially increase the service life of rope. However, conventional rope retirement criteria based only upon visible wire breaks may prove inadequate in predicting rope failure. The use of cast nylon sheaves is therefore cautioned that a retirement criteria should be established based upon the user's experience and the demands of his application.

## Batteries

Battery electrolyte must not be allowed to contact the skin or eyes. If this occurs, flush the contacted area with water and consult a doctor immediately.

When checking and maintaining batteries, exercise the following procedures and precautions:

- Wear safety glasses when servicing batteries.
- If equipped, disconnect battery with the battery disconnect switch before disconnecting the ground battery cable. For cranes with a Cummins engine using an engine ECM:
  - a. Ensure that the key switch has been off for 2 minutes.
  - b. Turn the battery disconnect switch to the OFF position.
  - c. Remove the ECM power fuse.
  - d. Remove negative battery cables.
- Do not break a live circuit at the battery terminal. Disconnect the ground battery cable first when removing a battery and connect it last when installing a battery.
- Do not short across the battery posts to check charge. Short circuit, spark, or flame could cause battery explosion.

- If applicable, maintain battery electrolyte at the proper level. Check the electrolyte with a flashlight.
- If applicable to your crane, check battery test indicator on maintenance-free batteries.
- Check battery condition only with proper test equipment. Batteries shall not be charged except in an open, well-ventilated area that is free of flame, smoking, sparks, and fire.

## Engine

Fuel the crane only with the engine turned off. Do not smoke while fueling the crane. Do not store flammable materials on the crane.

Be familiar with the location and use of the nearest fire extinguisher.

Be careful when checking the engine coolant level. The fluid may be hot and under pressure. Shut down the engine and allow the radiator time to cool before removing the radiator cap.

Shut down the engine and disconnect the battery before performing maintenance. If unable to do so for the task required, keep hands clear of the engine fan and other moving parts while performing maintenance.

Be careful of hot surfaces and hot fluids when performing maintenance on or around the engine.

Do not use ether to start the engine on cranes equipped with intake manifold grid heaters.

The engine can enter into a engine exhaust cleaning mode where the exhaust temperature can be high, ensure the exhaust is not pointed at materials that can melt, burn or explode.

## TRANSPORTING THE CRANE

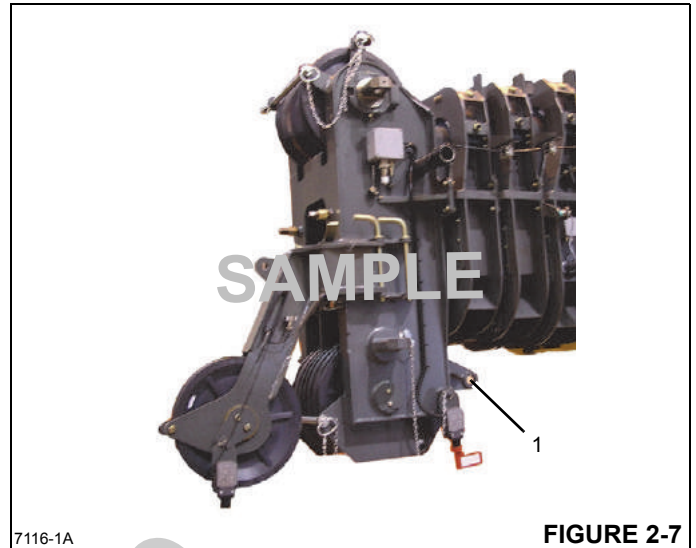
Before transporting the crane, check the suitability of the proposed route with regard to the crane height, width, length, and weight.

Check load limits of bridges on the travel route and ensure they are greater than the combined weight of the crane and transporting vehicle.

When loading or unloading the crane on a trailer or railroad car, use a ramp capable of supporting the weight of the crane.

Ensure the crane is adequately secured to the transporting vehicle.

Do not use the dead end lug (1, Figure 2-7) on the boom nose for tying down the boom during transport. Damage to the lug and boom can result from usage as a tie down point.



Before transporting the crane on a road or highway, first check state and local restrictions and regulations.

Either the hook block may be reeved over the main boom nose or the headache ball may be reeved over the main boom nose or auxiliary boom nose; the other must be removed. If the hook block or headache ball remains reeved on the boom, it must be secured at the tie down on the carrier to prevent swinging.

When using hookblock tie downs, excessive loading can be applied by pulling the cable too tight, particularly when reeved with multiple part lines. When the cable is hooked into the hookblock tie down, the cable should be merely "snugged-up" with adequate slack provided at the center line of sheave to anchor point. Do not draw cable taut. Care must be exercised anytime any crane function is being performed while the cable is hooked into the hookblock tie down.

## TRAVEL OPERATION

Only the crane operator shall occupy the crane when traveling.

When traveling, the boom should be completely retracted and lowered to the travel position and the turntable pin swing lock, if equipped, should be engaged. If equipped with boom rest, lower the boom into the boom rest and engage the turntable lock.

Strictly adhere to the guidelines and restrictions in the *Load Chart* for pick and carry operations.

RT and Industrial cranes are manufactured with no axle suspension system. Traveling at high speeds, especially on rough ground, may create a bouncing effect that can result in loss of control. If bouncing occurs, reduce travel speed.

Death or serious injury could result from being crushed by revolving tires.

Stunt driving and horse-play are strictly prohibited. Never allow anyone to hitch a ride or get on or off a moving crane.

Follow the instructions in this manual when preparing the crane for travel.

If using a boom dolly/trailer, thoroughly read and understand all the steps and safety precautions in this manual for setup and travel.

When driving the crane, ensure the cab is down, if equipped with a tilting cab.

Secure the hook block and other items before moving the crane.

Watch clearances when traveling. Do not take a chance of running into overhead or side obstructions.

When moving in tight quarters, post a signal person to help guard against collisions or bumping structures.

Before traveling a crane, check suitability of proposed route with regard to crane height, width, and length.

Never back up without the aid of a signal person to verify the area behind the crane is clear of obstructions and/or personnel.

On cranes equipped with air-operated brakes, do not attempt to move the crane until brake system air pressure is at operating level.

Check load limit of bridges. Before traveling across bridges, ensure they will carry a load greater than the crane's weight.

If it is necessary to take the crane on a road or highway, check state and local restrictions and regulations.

Keep lights on, use traffic warning flags and signs, and use front and rear flag vehicles when necessary. Check state and local restrictions and regulations.

Always drive the crane carefully obeying speed limits and highway regulations.

Stay alert at the wheel.

If equipped, ensure that the hoist access platform hand rail and step are in the travel configuration.

Slopes:

- Pick and carry on level surfaces only.
- Refer to the *Operation Section* for more detailed information on traveling on slopes.
- Driving across a slope is dangerous, as unexpected changes in slope can cause tip over. Ascend or descend slopes slowly and with caution.
- When operating on a downhill slope, reduce travel speed and downshift to a low gear to permit compression braking by the engine and aid the application of the service brakes.

## WORK PRACTICES

### Personal Considerations

Always adjust the seat and lock it in position, and fasten the seat belt securely before you start the engine.

Do not wear loose clothing or jewelry that can get caught on controls or moving parts. Wear the protective clothing and personal safety gear issued or called for by the job conditions. Hard hat, safety shoes, ear protectors, reflective clothing, safety goggles, and heavy gloves may be required.

### Crane Access



#### WARNING

##### Fall Hazard!

Working at elevated heights without using proper fall protection can result in severe injury or death.

Always use proper fall protection as required by local, state or federal regulations.

You must take every precaution to ensure you do not slip and/or fall off the crane. Falling from any elevation could result in serious injury or death.

Never exit or enter the crane cab or deck by any other means than the access system(s) provided (i.e., steps and grab handles). Use the recommended hand-holds and steps to maintain a three-point contact when getting on or off the crane.

If necessary, use a ladder or aerial work platform to access the boom nose.

Do not make modifications or additions to the crane's access system that have not been evaluated and approved by Manitowoc Crane Care.

Do not step on surfaces on the crane that are not approved or suitable for walking and working. All walking and working surfaces on the crane should be clean, dry, slip-resistant, and have adequate supporting capacity. Do not walk on a surface if slip-resistant material is missing or excessively worn.

Do not use the top of the boom as a walkway.

Do not step on the outrigger beams or outrigger pads (floats) to enter or exit the crane.

Use the hoist access platform (if equipped) when working in the hoist area.

Wear shoes with a highly slip-resistant sole material. Clean any mud or debris from shoes before entering the crane cab/operator's station or climbing onto the crane superstructure. Excessive dirt and debris on the hand-holds, access steps,

or walking/working surfaces could cause a slipping accident. A shoe that is not clean might slip off a control pedal during operation.

Do not allow ground personnel to store their personal belongings (clothing, lunch boxes, water coolers, and the like) on the crane. This practice will prevent ground personnel from being crushed or electrocuted when they attempt to access personal belongings stored on the crane.

## Job Preparation

Before crane use:

- Barricade the entire area where the crane is working and keep all unnecessary personnel out of the work area.
- Ensure that the crane is properly equipped including access steps, covers, doors, guards, and controls.
- Conduct a visual inspection for cracked welds, damaged components, loose pins/bolts, and wire connections. Any item or component that is found to be loose or damaged (broken, chipped, cracked, worn-through, etc.) must be repaired or replaced. Inspect for evidence of improper maintenance (consult your *Service Manual*).
- Check for proper functioning of all controls and operator aids (for example, RCL).
- Check all braking (for example, wheel, hoist, and swing brakes) and holding devices before operation.

You must ensure that the outriggers and jack cylinders are properly extended and set before performing any lifting operations. On models equipped with outriggers that can be pinned at the mid-extend position, the outriggers must also be pinned when operating from the mid-extend position.

Clear all personnel from the outrigger area before extending or retracting the outriggers. Carefully follow the procedures in this *Operator Manual* when extending or retracting the outriggers. Death or serious injury could result from improper crane set up on outriggers.

Be familiar with surface conditions and the presence of overhead obstructions and power lines.

## Working

Operator shall be responsible for all operations under his/her direct control. When safety of an operation is in doubt, operator shall stop the crane's functions in a controlled manner. Lift operations shall resume only after safety concerns have been addressed or the continuation of crane operations is directed by the lift supervisor.

Know the location and function of all crane controls.

Make sure all persons are away from the crane and the Travel Select Lever is in the "N" (Neutral) position with the Parking Brake engaged before starting the engine.

Sparks from the crane's electrical system and/or engine exhaust can cause an explosion. **Do not** operate this crane in an area with flammable dust or vapors, unless good ventilation has removed the hazard.

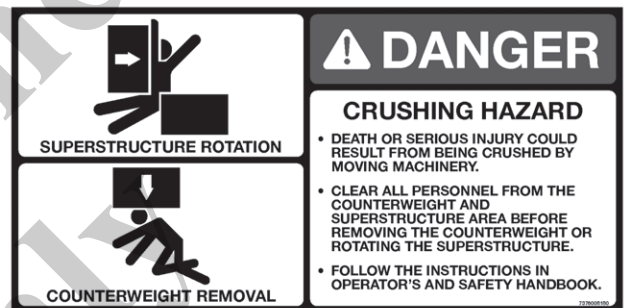
Carbon monoxide fumes from the engine exhaust can cause suffocation in an enclosed area. Good ventilation is very important when operating the crane.

Before actuating swing or any other crane function, sound the horn and verify that all personnel are clear of rotating and moving parts.

Never operate the crane when darkness, fog, or other visibility restrictions make operation unsafe. Never operate a crane in thunderstorms or high winds.

Always be aware of your working environment during operation of the crane. Avoid contacting any part of the crane with external objects.

Clear all personnel from the counterweight and superstructure area before removing the counterweight.



Keep unauthorized personnel clear of the working area during operation.

Only the crane operator shall occupy the crane when in operation.

You must always be aware of everything around the crane while lifting or traveling. If you are unable to clearly see in the direction of motion, you must post a look out or signal person before moving the crane or making a lift. Sound the horn to warn personnel

Operate the crane only from the operator's seat. Do not reach in a window or door to operate any controls.

Operate the crane slowly and cautiously, looking carefully in the direction of movement.

A good practice is to make a "dry run" without a load before making the first lift. Become familiar with all factors peculiar to the job site.

Ensure the hoist rope is properly routed on the hook block and boom nose and that all rope guards are in place.

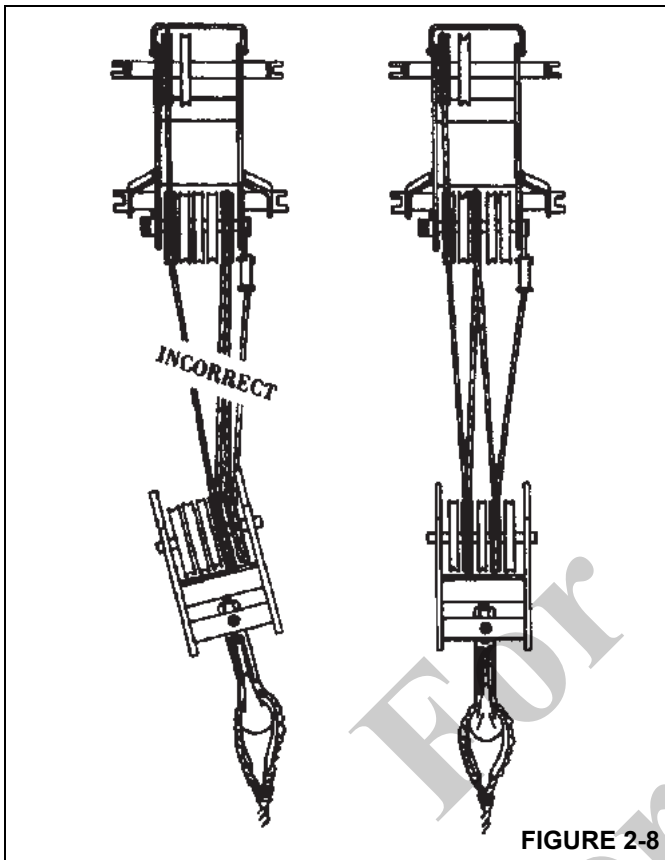


FIGURE 2-8

## Lifting

**Use enough parts of line for all lifts and check all lines, slings, and chains for correct attachment.** To obtain maximum lifting capacities, the hook block must be set up with enough parts of line. Too few parts of line can result in failure of the hoist rope or hoist. **No less than three wraps of wire rope** should remain on the hoist drum. **No less than eight wraps of synthetic rope** should remain on the hoist drum. When slings, ties, hooks, etc., are used, make certain they are correctly positioned and secured before raising or lowering the loads.

Be sure the rigging is adequate before lifting. Use tag lines when possible to position and restrain loads. Personnel using tag lines should be on the ground.

Be sure good rigging practices are being used. Refuse to use any poorly maintained or damaged equipment. Never wrap the hoist cable around a load.

If using a clam bucket, do not exceed 80% of the crane's capacity.

Make certain the boom tip is centered directly over the load before lifting.

Ensure that all slings, ties, and hooks are correctly placed and secured before raising or lowering the load.

Be sure the load is well secured and attached to the hook with rigging of proper size and in good condition.

Check the hoist brake by raising the load a few inches, stopping the hoist and holding the load. Be sure the hoist brake is working correctly before continuing the lift.

When lowering a load always slow down the load's descent before stopping the hoist. Do not attempt to change speeds on multiple-speed hoists while the hoist is in motion.

Watch the path of the boom and load when swinging. Avoid lowering or swinging the boom and load into ground personnel, equipment, or other objects.

**Lift one load at a time.** Do not lift two or more separately rigged loads at one time, even if the loads are within the crane's rated capacity.

Never leave the crane with a load suspended. Should it become necessary to leave the crane, lower the load to the ground and stop the engine before leaving the operator's station.

Remember, all rigging equipment must be considered as part of the load. Lifting capacities vary with working areas. If applicable, permissible working areas are listed in the *Load Chart*. When swinging from one working area to another, ensure *Load Chart* capacities are not exceeded. Know your crane!

Stop the hook block from swinging when unhooking a load.

Swinging rapidly can cause the load to swing out and increase the load radius. Swing the load slowly. Swing with caution and keep the load lines vertical.

Look before swinging your crane. Even though the original setup may have been checked, situations do change.

Never swing or lower the boom into the carrier cab (if applicable).

Never push or pull loads with the crane's boom; never drag a load.

Do not subject crane to side loading. A side load can tip the crane or cause it to fail structurally.

If the boom should contact an object, stop immediately and inspect the boom. Remove the crane from service if the boom is damaged.

When lifting a load the boom may deflect causing the load radius to increase—this condition is made worse when the boom is extended. Ensure weight of load is within crane's capacity on *Load Chart*.

Avoid sudden starts and stops when moving the load. The inertia and an increased load radius could tip the crane over or cause it to fail structurally.

Use tag lines (as appropriate) for positioning and restraining loads. Check the load slings before lifting.



Be sure everyone is clear of the crane and work area before making any lifts.

Never swing over personnel, regardless of whether load is suspended from or attached to the boom.

### Hand Signals

A single qualified signal person shall be used at all times when:

- Working in the vicinity of power lines.
- The crane operator cannot clearly see the load at all times.

- Moving the crane in an area or direction in which the operator cannot clearly see the path of travel.

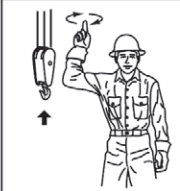
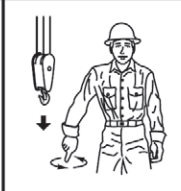


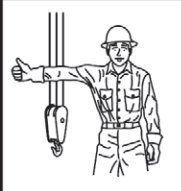

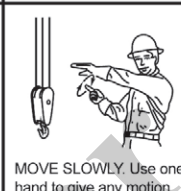
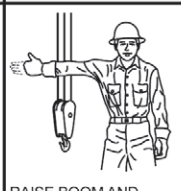


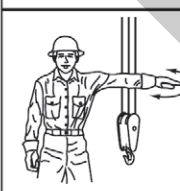
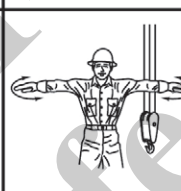
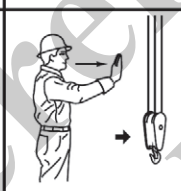
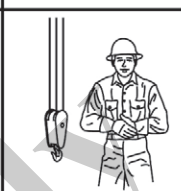
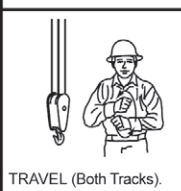
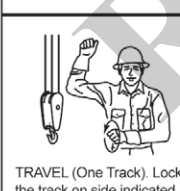

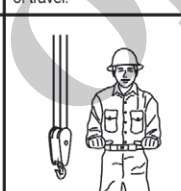


At all times use standardized hand signals - previously agreed upon and completely understood by the operator and signal person.

If communication with the signal person is lost, crane movement must be stopped until communications are restored.

Keep your attention focused on the crane's operation. If for some reason you must look in another direction, stop all crane movement first.

Obey a signal to stop from anyone.

For  
Reference  
Only

STANDARD HAND SIGNALS FOR CONTROLLING CRANE OPERATIONS				
Complies with ASME B30.5-2011				
				
HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle.	LOWER. With arm extended downward, forefinger pointing down, move hand in small horizontal circle.	USE MAIN HOIST. Tap fist on head; then use regular signals.	USE WHIPLINE (Auxiliary Hoist). Tap elbow with one hand; then use regular signals.	RAISE BOOM. Arm extended, fingers closed, thumb pointing upward.
				
LOWER BOOM. Arm extended, fingers closed, thumb pointing downward.	MOVE SLOWLY. Use one hand to give any motion signal and place other hand motionless in front of hand giving the motion signal (hoist slowly shown as an example).	RAISE BOOM AND LOWER LOAD. With arm extended, thumb pointing up, flex fingers in and out as long as load movement is desired.	LOWER BOOM AND RAISE LOAD. With arm extended, thumb pointing down, flex fingers in and out as long as load movement is desired.	SWING. Arm extended, point with finger in direction of swing of boom.
				
STOP. Arm extended, palm down, move arm back and forth horizontally.	EMERGENCY STOP. Both arms extended, palms down, move arms back and forth horizontally.	TRAVEL. Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.	DOG EVERYTHING. Clasp hands in front of body.	TRAVEL (Both Tracks). Use both fists in front of body, making a circular motion about each other, indicating direction of travel, forward or backward. (For land cranes only.)
				
TRAVEL (One Track). Lock the track on side indicated by raised fist. Travel opposite track in direction indicated by circular motion of other fist, rotated vertically in front of body. (For land cranes only.)	EXTEND BOOM (Telescoping Booms). Both fists in front of body with thumbs pointing outward.	RETRACT BOOM (Telescoping Boom). Both fists in front of body with thumbs pointing toward each other.	EXTEND BOOM (Telescoping Boom). One Hand Signal. One fist in front of chest with thumb pointing outward.	RETRACT BOOM (Telescoping Boom). One Hand Signal. One fist in front of chest, thumb pointing outward and heel of fist tapping chest.

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FIGURE 2-9

## JIB

To avoid death or serious injury, follow the procedures in this manual during erection, stowage, and use of the jib.

Install and secure all pins properly.

Control movement of the jib at all times.

Do not remove right side boom nose pins unless jib is properly pinned and secured on front and rear stowage brackets.



### DANGER

#### Boom Extension Hazard!

To avoid death or serious injury, follow procedures in *Load Chart*, safety, and operation manuals during erection, stowage and use of jib. Install and secure all pins properly and control jib movement at all times.

Do not remove all the pins from both front and rear stowage brackets unless the jib is pinned to the right side of the boom nose.

Properly inspect, maintain, and adjust jib and mounting.

When assembling and disassembling jib sections, use blocking to adequately support each section and to provide proper alignment.

Stay outside of jib sections and lattice work.

Watch for falling or flying pins when they are being removed.

## PARKING AND SECURING



### DANGER

#### Tipping Hazard!

When parking the crane and leaving it unattended follow the instructions in Section 3 of this manual.

Failure to comply with these instructions may cause death or serious injury

When parking on a grade, apply the parking brake and chock the wheels.

Section 3 of this manual provides instructions for parking and securing a crane when it is to be left unattended. These instructions are intended to allow the crane to be placed in the most stable and secure position. However, Manitowoc recognizes that certain jobsite conditions may not permit the boom and jib of a crane to be fully lowered to the ground. When a qualified person at a jobsite determines that it is not practical to lower the boom to the ground, we recommend the following additional instructions be followed:

- The crane should be left in the smallest, most stable, valid operational configuration that the job site practically allows.
- The crane can not be left running, with a load on the hook, or in erection mode, or in wind conditions in excess of allowed values.
- The boom should be retracted as far as is practical, the crane configured in as stable a configuration as possible (boom angle, superstructure orientation, jib angle, etc.)
- In high winds the boom and jibs should be lowered, or secured. Changing weather conditions including but not limited to: wind, ice accumulation, precipitation, flooding, lightning, etc. should be considered when determining the location and configuration of a crane when it is to be left unattended.

## SHUT-DOWN

Use the following steps when shutting down the crane:

- Engage the parking brake.
- Fully retract and lower the boom.
- Engage the swing lock pin or 360 degree swing lock (if equipped).
- Place crane function power switch to OFF (if equipped).
- Place controls in neutral position.
- Shut down the engine and remove the ignition key.
- Turn the battery disconnect switch to the OFF position.
- Chock the wheels, if not on outriggers.
- Lock the operator's cab (if applicable) and install vandal guards, if used.

## COLD WEATHER OPERATION

Cold weather operation requires additional caution on the part of the operator.

Check operating procedures in this manual for cold weather starting.

Don't touch metal surfaces that could freeze you to them.

Clean the crane of all ice and snow.

Allow ample time for hydraulic oil to warm up.

In freezing weather, park the crane in an area where it cannot become frozen to the ground. The drive line can be damaged when attempting to free a frozen crane.

If applicable to your crane, frequently check all air tanks for water in freezing weather.

If applicable to your crane, always handle propane tanks according to the supplier's instructions.

Never store flammable materials on the crane.

If cold weather starting aids are provided on your crane, use them. The use of aerosol spray or other types of starting fluids containing ether/volatiles can cause explosions or fire.

## TEMPERATURE EFFECTS ON HOOK BLOCKS

The following information applies to Gunnebo Johnston crane hook blocks:

**Never use a hook block in extreme temperatures...**Sudden failure can occur.

Hook blocks shall not be heated above 82°C (180°F). Hook Block Working Load Limit is valid between 82°C (180°F) and service temperature given on the identification tag with normal lifting precautions.

Additional lifting precautions are required below the service temperature given on the identification tag because cold temperature begins to affect the hook block material properties.

Lifting above 75% of the Working Load Limit (WLL), at temperatures between the service temperature given on the identification tag and -40°C (-40°F), must (be) done at a slow and steady rate to avoid stress spikes common in normal hoisting dynamics.

75% of the WLL must not be exceeded, when lifting in temperatures below -40°C (-40°F).

## TEMPERATURE EFFECTS ON HYDRAULIC CYLINDERS

Hydraulic oil expands when heated and contracts when cooled. This is a natural phenomena that happens to all liquids. The coefficient of expansion for API Group 1 hydraulic oil is approximately 0.00077 cubic centimeters per cubic centimeter of volume for 1°C of temperature change (0.00043 cubic inches per cubic inch of volume for 1°F of temperature change). **Thermal contraction will allow a cylinder to retract as the hydraulic fluid which is trapped in the cylinder cools.**

The change in the length of a cylinder is proportional to the extended length of the cylinder and to the change in temperature of the oil in the cylinder. For example, a cylinder extended 7.6 m (25 ft) in which the oil cools 15.5°C (60°F)

would retract approximately 196 mm (7 3/4 in) [see Table 2-9 and Table 2-8]. The rate at which the oil cools depends on many factors and will be more noticeable with a larger difference in oil temperature verses the ambient temperature.

Thermal contraction coupled with improper lubrication or improper wear pad adjustments may, under certain conditions, cause a “stick-slip” condition in the boom. This “stick-slip” condition could result in the load not moving smoothly. Proper boom lubrication and wear pad adjustment is important to permit the boom sections to slide freely. Slow movement of the boom may be undetected by the operator unless a load is suspended for a long period of time. To minimize the effects of thermal contraction or “Stick-slip” it is recommended that the telescope control lever is activated periodically in the extend position to mitigate the effects of cooling oil.

If a load and the boom is allowed to remain stationary for a period of time and the ambient temperature is cooler than the trapped oil temperature, the trapped oil in the cylinders will cool. The load will lower as the telescope cylinder(s) retracts allowing the boom to come in. Also, the boom angle will decrease as the lift cylinder(s) retracts causing an increase in radius and a decrease in load height.

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

Table 2-8 and Table 2-9 have been prepared to assist you in determining the approximate amount of retraction/extension that may be expected from a hydraulic cylinder as a result of change in the temperature of the hydraulic oil inside the cylinder. The chart is for dry rod cylinders. If the cylinder rod is filled with hydraulic oil, the contraction rate is somewhat greater.

**NOTE:** Operators and service personnel must be aware that load movement, as a result of this phenomena, can be easily mistaken as leaking cylinder seals or faulty holding valves. If leaking seals or faulty holding valves are suspected to be the problem, refer to Service Bulletin dealing with testing telescope cylinders. (*Service Bulletin 98-036* applies to TMS700 and *Service Bulletin G06-005A* applies to RT890 and RT9130.

Table 2-8: Boom Drift Chart (Cylinder length change in inches)

Coeff. = 0.00043 (in <sup>3</sup> /in <sup>3</sup> / °F)											
STROKE	Temperature Change (°F)										
(FT.)	10	20	30	40	50	60	70	80	90	100	
5	0.26	0.52	0.77	1.03	1.29	1.55	1.81	2.06	2.32	2.58	
10	0.52	1.03	1.55	2.06	2.58	3.10	3.61	4.13	4.64	5.16	
15	0.77	1.55	2.32	3.10	3.87	4.64	5.42	6.19	6.97	7.74	
20	1.03	2.06	3.10	4.13	5.16	6.19	7.22	8.26	9.29	10.32	
25	1.29	2.58	3.87	5.16	6.45	7.74	9.03	10.32	11.61	12.90	
30	1.55	3.10	4.64	6.19	7.74	9.29	10.84	12.38	13.93	15.48	
35	1.81	3.61	5.42	7.22	9.03	10.84	12.64	14.45	16.25	18.06	
40	2.06	4.13	6.19	8.26	10.32	12.38	14.45	16.51	18.58	20.64	
45	2.32	4.64	6.97	9.29	11.61	13.93	16.25	18.58	20.90	23.22	
50	2.58	5.16	7.74	10.32	12.90	15.48	18.06	20.64	23.22	25.80	
55	2.84	5.68	8.51	11.35	14.19	17.03	19.87	22.70	25.54	28.38	
60	3.10	6.19	9.29	12.38	15.48	18.58	21.67	24.77	27.86	30.96	

Length change in inches = Stroke (Ft.) X Temperature Change ( °F) X Coeff. (in<sup>3</sup>/in<sup>3</sup>/ °F) X 12 in/ft



Table 2-9 Boom Drift Chart (Cylinder length change in millimeters)

Coeff. = 0.000774 (1/ °C)		<i>Metric</i>									
STROKE	Temperature Change (°C)										
(m)	5	10	15	20	25	30	35	40	45	50	55
1.5	6	12	17	23	29	35	41	46	52	58	64
3	12	23	35	46	58	70	81	93	104	116	128
4.5	17	35	52	70	87	104	122	139	157	174	192
6	23	46	70	93	116	139	163	186	209	232	255
7.5	29	58	87	116	145	174	203	232	261	290	319
9	35	70	104	139	174	209	244	279	313	348	383
10.5	41	81	122	163	203	244	284	325	366	406	447
12	46	93	139	186	232	279	325	372	418	464	511
13.5	52	104	157	209	261	313	366	418	470	522	575
15	58	116	174	232	290	348	406	464	522	581	639
16.5	64	128	192	255	319	383	447	511	575	639	702
18	70	139	209	279	348	418	488	557	627	697	766

Length change in mm = Stroke (m) X Temperature Change ( °C) X Coeff. (1/ °C) X 1000 mm/m

**OVERLOAD INSPECTION**

**MODEL SPECIFIC INFORMATION**

The RT530E-2 on rubber load charts have a minimum radius of 3 m (9.84 ft) with a load. Without a load, a radius of 2.5 m (8.20 ft) is safe for 360 degrees on rubber. A radius of less than 2.5 m (8.20 ft) must be avoided on rubber because of backward stability considerations.

This information supplements the Rated Capacity Limiter (RCL) manual supplied with each Grove crane.

When the RCL system has acknowledged an overload on your crane, you must carry out specified inspections on the crane.

These inspections apply only to overloads up to 50%. For overloads of 50% or higher, crane operation must be stopped immediately and Crane Care must be contacted for corrective action.

The following illustrations may not be an exact representation of your crane and are to be used for reference only.

**WARNING****Overload Hazard!**

To avoid an accident caused by overload damage to your crane:

- Perform the inspections outlined in this publication for overloads up to 50%.
- Stop operating the crane and contact Manitowoc Crane Care immediately for overloads of 50% and higher.

---

**NOTE:** If your crane is equipped with CraneSTAR, an overload warning will be posted to the web site for review by the crane owner.

Overload warnings do NOT indicate real time events! Warnings could be sent 24 hours (or more) after the actual event.

For  
Reference  
Only

Boom Inspection

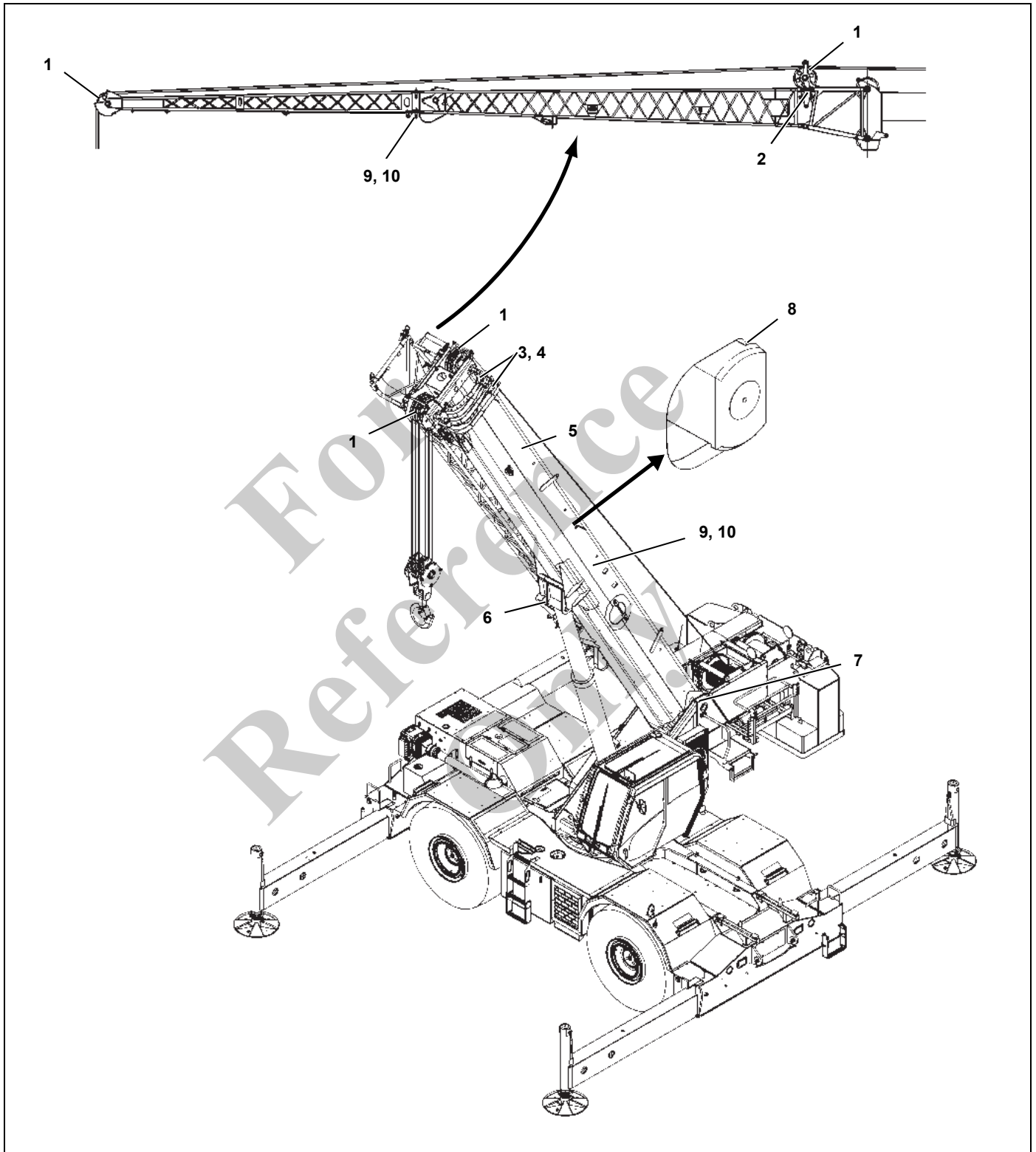


Illustration for reference only.  
Your crane may be different.

<b>Overload less than 25%</b>			
1	Sheaves	Inspect all for damage.	
2	Luffing Mechanism/ Cylinder	Inspect for damage/leaks.	
3	Collar-wear pads	Inspect all for damage.	
<b>Overload from 25% to 49%</b>			
1	Sheaves	Inspect all for damage.	
2	Luffing Mechanism/ Cylinder	Inspect for damage/leaks.	
3	Collar-wear pads	Inspect all for damage.	
4	Collar-welds	Inspect all for cracks.	
5	Telescopic Sections	Inspect for bent or twisted sections. Check the boom for straightness.	
6	Lift Cylinder Head Area	Inspect for bends or cracked welds.	
7	Turret-Base Section	Inspect for cracked welds.	
8	Locking Area (Pin Booms)	Inspect for elongated holes.	
9	Welds	Inspect for cracks.	
10	Paint	Inspect for cracked paint which could indicate twisted, stretched, or compressed members.	



Superstructure Inspection

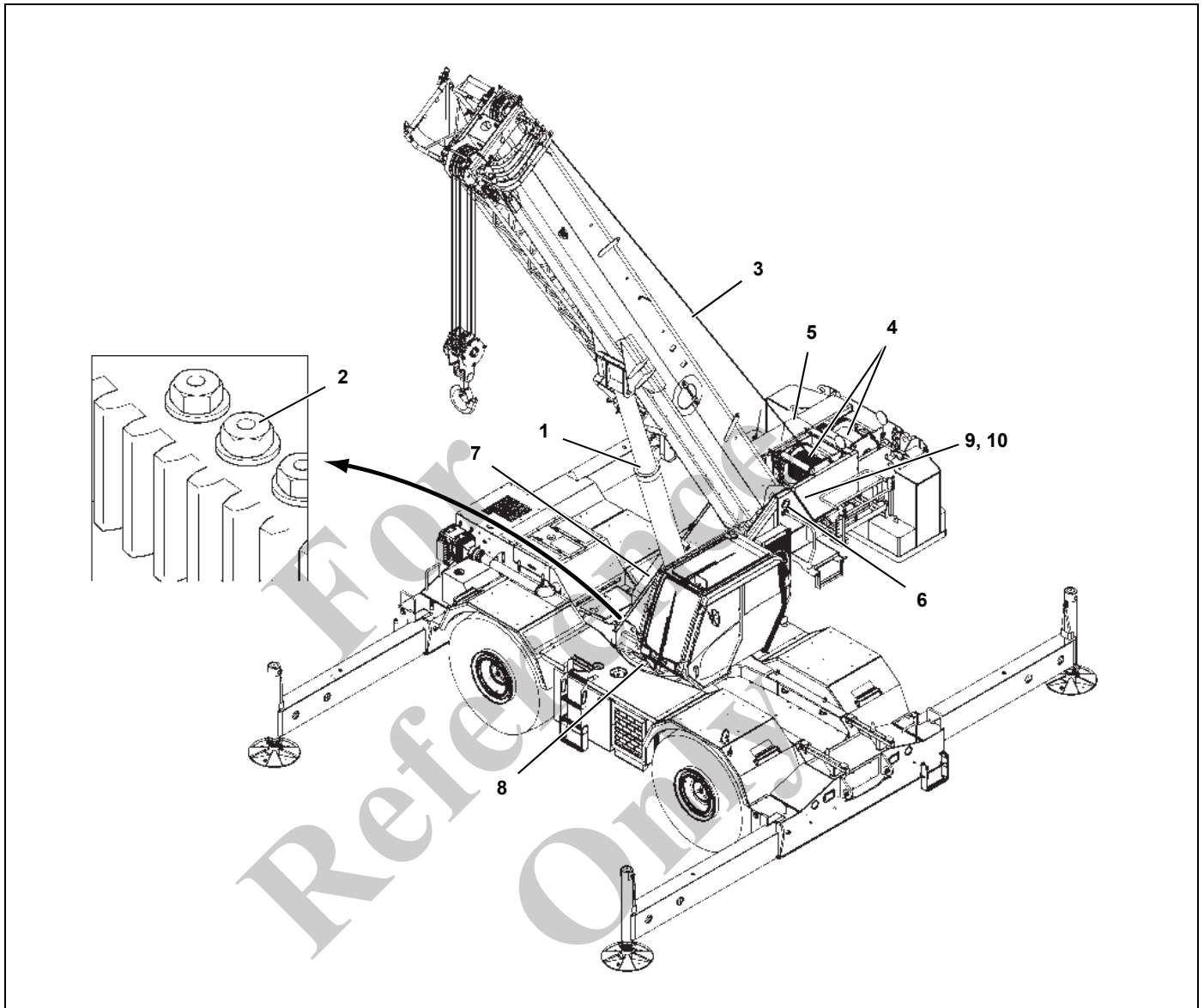


Illustration for reference only.  
Your crane may be different.

<b>Overload less than 25%</b>			
1	Lift Cylinder	Inspect for leaking.	
2	Turntable Bearing	Check bolts for proper torque.	See topic in Swing section of Service Manual.
3	Wire Rope	Inspect all for damage.	See topic in Introduction section of Service Manual.
<b>Overload from 25% to 49%</b>			
1	Lift Cylinder	Inspect for leaking.	
2	Turntable Bearing	Check bolts for proper torque.	See topic in Swing section of Service Manual.
3	Wire Rope	Inspect all for damage.	See topic in Introduction section of Service Manual.
4	Hoist/Drums	Inspect each for damage.	
5	Hoist Brakes	Brakes must hold rated line pull.	
6	Bearing Main Boom Pivot Pin	Inspect for deformation, cracked welds.	
7	Lift Cylinder-lower mount	Inspect pin and welds.	
8	Turntable	Inspect for deformation, cracked welds.	
9	Welds	Inspect for cracks.	
10	Paint	Inspect for cracked paint which could indicate twisted, stretched, or compressed members.	

Carrier Inspection

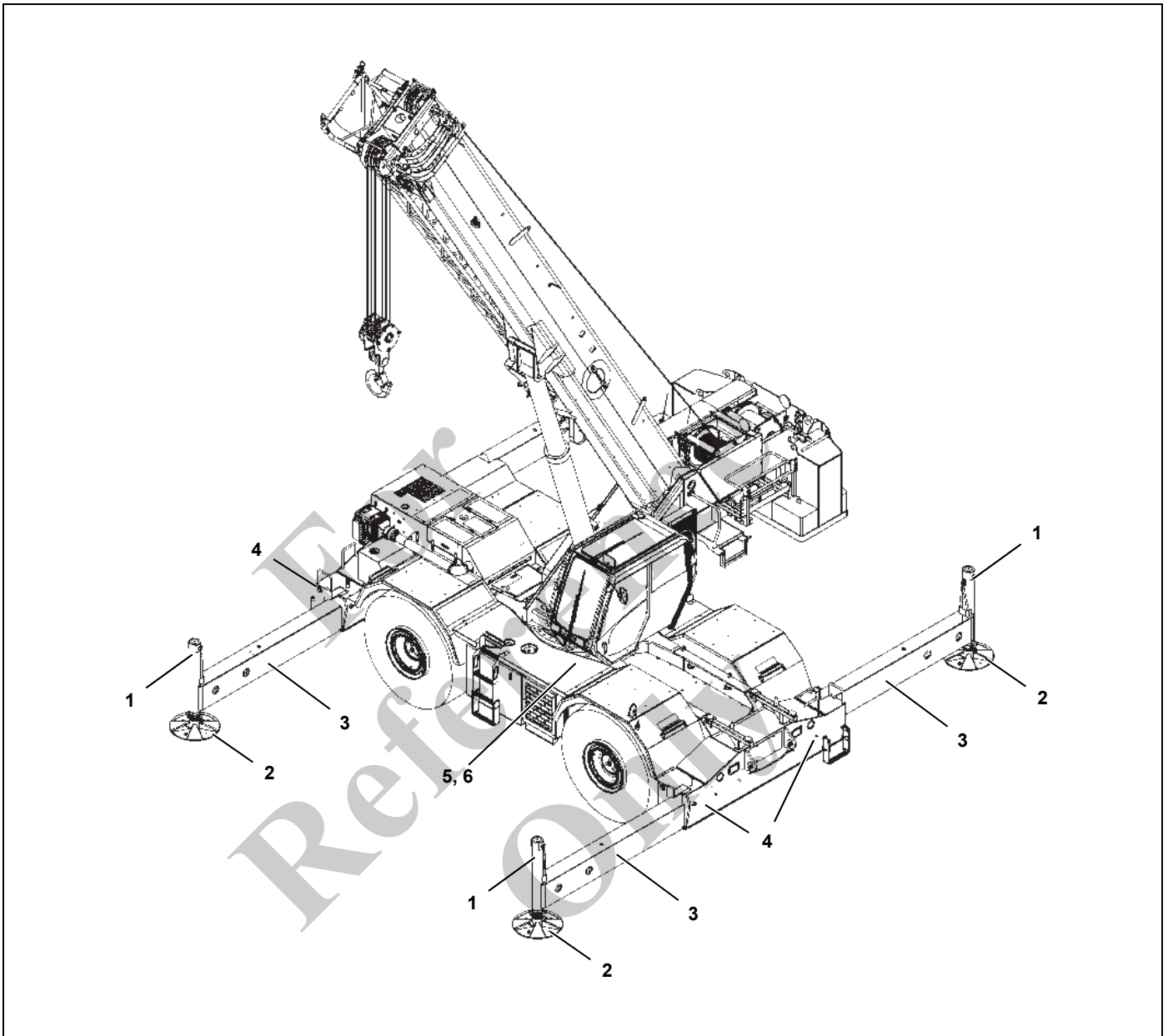


Illustration for reference only.  
Your crane may be different.

<b>Overload less than 25%</b>			
1	Stabilizer Cylinders	Inspect for leaking.	
2	Outrigger Pads	Inspect for deformation and cracked welds.	
<b>Overload from 25% to 49%</b>			
1	Stabilizer Cylinders	Inspect for leaking.	
2	Outrigger Pads	Inspect for deformation and cracked welds.	
3	Outrigger Beams	Inspect for deformation and cracked welds.	
4	Outrigger Boxes	Inspect for deformation and cracked welds.	
5	Welds	Inspect for cracks.	
6	Paint	Inspect for cracked paint which could indicate twisted, stretched, or compressed members.	

For Reference Only

## SECTION 3

### OPERATING CONTROLS AND PROCEDURES

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**CONTROLS AND INDICATORS**

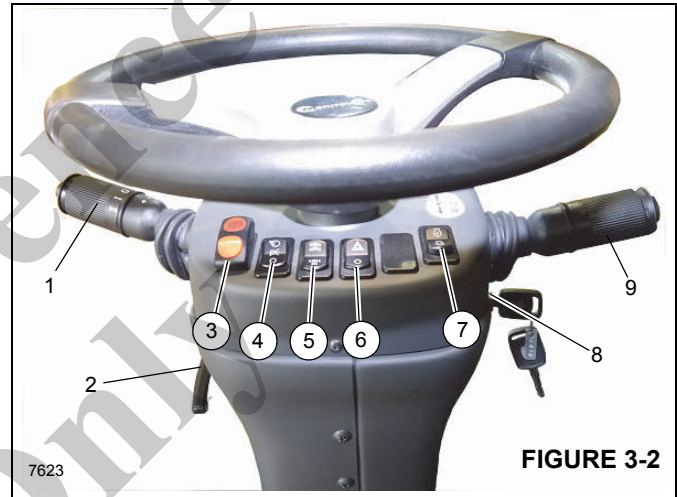
The engine is electronically controlled by the Electronic Control Module (ECM); it is the control center of the entire engine system. The ECM processes all of the inputs and sends commands to the fuel systems as well as vehicle and engine control devices. This Operator Manual does not include information on the engine ECM, however a separate manual as prepared in detail by the engine manufacturer is shipped with the crane from the factory.

All the controls and indicators to operate and monitor crane functions are found inside the crane cab Figure 3-2 and include the following:

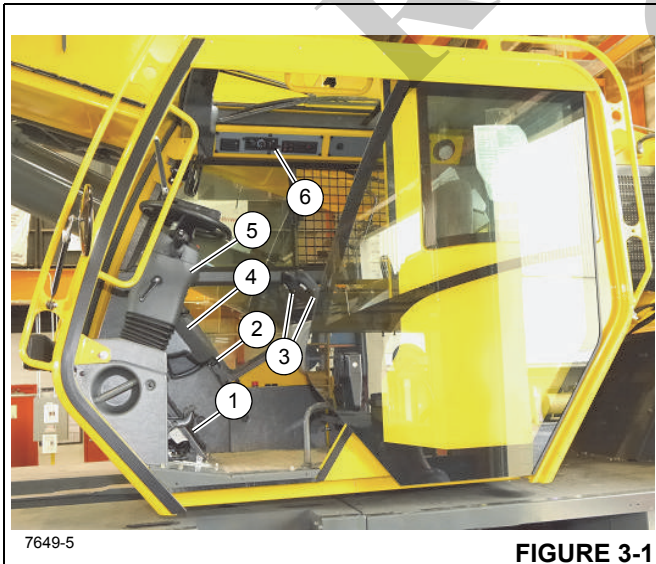
1. Foot Pedals
2. Turntable Swing Pin Lock Control
3. Seat Joystick and Armrest Controls
4. CCS and RCL Display Panels
5. Steering Column
6. Overhead Control Panels

**Steering column**

The steering column assembly (5) (Figure 3-1) is a pedestal style tilt and telescoping steering column. It can tilt rearward 30° or raise vertically approximately 60 mm (2.3 in). It includes the ignition and other control switches (Figure 3-2).



**FIGURE 3-2**



**FIGURE 3-1**

1	Turn Signal Lever and Windshield Wiper/Washer/Horn Controls
2	Steering Column Tilt Lever
3	Park Brake Control Switch
4	Headlights Switch
5	Drive Axle Selector Switch
6	Hazard Lights Switch
7	Engine Speed Increment/Decrement Switch (RPM)
8	Ignition Switch
9	Transmission Shift Lever

## Turn Signal Lever and Windshield Wiper/Washer/Headlight /Horn Controls

The Turn Signal Lever and Windshield Wiper/washer Controls (1) (Figure 3-2) are located on the left side of the steering column. Pushing the turn signal lever down causes the left front and left rear turn signals to flash. Pushing the turn signal lever up causes the right front and right rear turn signals to flash.

The windshield wiper switch is incorporated in the turn signal lever. The knob of the lever has four positions: O, I, II and interval wiping. Pushing the button in the end of the knob energizes the windshield washer pump to spray washer fluid on the windshield. Positioning the knob to I operates the wiper at low speed and positioning the knob to II operates the wiper at high speed. Positioning the knob to O turns the wiper motor off and automatically returns the wiper to the parked position.

Pushing the small button on the end of the lever sounds the horn.

## Steering Column Tilt Lever

The steering control column can be rotated rearward approximately 30° and raised approximately 60 mm (2.3 in). Rotate the control lever (2) (Figure 3-2) down to lock the steering column in place; rotating the lever up releases the steering column for adjustment.

## Park Brake Control Switch

The Park Brake Control Switch (3) (Figure 3-2) is located on the front of the steering column. This two-position rocker switch (ON/OFF) is used to apply and release the parking brake on the drive line. The red Park Brake Indicator light on the display is illuminated when the pressure switch in the brake release system is activated and the brake is applied.

## Headlights Switch

The Headlights Switch (4) (Figure 3-2) is located on the front of the steering column. This three-position rocker switch (OFF/Park/Headlight) controls operation of the instrument lights, switch LED's, and the marker lights on the front, rear, and side of the crane. The switch is illuminated when the key is in the ON or Start position.

## Drive Axle Selector Switch

The Drive Axle Selector Switch (5) (Figure 3-2) is located on the front of the steering column. This two-position rocker switch is used to select either two-wheel drive (high range) or four-wheel drive (low range). The switch controls a solenoid valve (energized for two-wheel drive) that operates the speed range and axle disconnect cylinders on the transmission. The icon background on the CCS operating display turns yellow when the crane is in four-wheel drive mode. This icon will flash if, while the engine is running, the

switch position is changed when the transmission is not in Neutral and the brake pedal is not pressed. The drive axle can only be changed when the gearshift is in Neutral and the brake pedal is pressed. The switch is illuminated when the key is in the ON or Start position.

## Hazard Lights Switch

The Hazard Lights Switch (6) (Figure 3-2) is located on the front of the steering column. The switch is a two-position rocker switch (ON/OFF) that causes the four turn signal lights to flash at the same time when the switch is positioned to ON. When the switch is positioned to ON, the turn signal indicator lights on the steering column will flash.

## Increment/Decrement Switch

The Increment/Decrement Switch (7) (Figure 3-2) is a three position momentary rocker switch with center maintained position being off. Use this switch to adjust engine speed. Press the top or bottom of the Increment/Decrement Switch to increase or decrease the low engine idle.

The Increment/Decrement Switch is used to adjust engine rpm. Quickly press the top of the switch once to go to full engine rpm; quickly press the bottom of the switch once to return to low engine idle. If the engine speed is below the minimum rpm setting, pressing and holding the top of the switch will cause the engine rpm to slowly increase; release the switch when the desired rpm is attained. If the engine speed is above the maximum rpm setting, pressing and holding the bottom of the switch will cause the engine rpm to slowly decrease; release the switch when the desired rpm is attained.

## Ignition Switch

The Ignition Switch (8) (Figure 3-2) is on the right side of the steering column under the transmission shift lever (9).

The switch is key-operated and has three positions: OFF [0], RUN [1], and START [2]. In the OFF position, all electrical power is off except for lights controlled by the Headlights Switch, turn/hazard/stop lights, dome light, and work light. Positioning switch to RUN energizes the ignition circuit and all electrical components except for the start solenoid. Positioning the switch to START energizes the start relay, which in turn energizes the cranking motor solenoid and cranks the engine for starting. The switch is spring returned from START to RUN. To shut down the engine, position switch to OFF.

The Ignition switch has a mechanical anti-restart built into it. If the engine does not start after the first attempt, the key switch must go to the OFF position and then back to START in order to try and start the engine another time.

**Transmission Shift Lever**

**CAUTION**

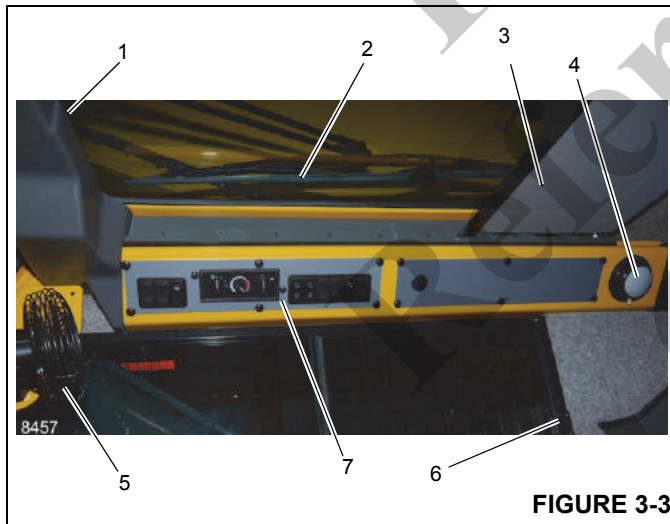
**Transmission Damage!**

To prevent transmission damage: shift between two-wheel and four-wheel drive only with the crane stopped with the transmission in neutral.

The Transmission Shift Lever (9) (Figure 3-2) is located on the right side of the steering column. The control lever operates the transmission selector valve electrically. Positioning the lever up actuates forward and positioning the lever down actuates reverse. When the lever is in neutral, it rests in a detent. To move the lever up or down, pull up on the lever first. To shift the transmission to first, second, or third gear, rotate the knob to 1, 2, or 3.

The transmission has six forward gears and six reverse gears. To use the three low gears, put the Drive Axle switch to four-wheel drive. To use the three high gears, put the Drive Axle switch to two-wheel drive.

**CAB OVERHEAD CONTROLS**



**FIGURE 3-3**

1	Skylight Window Latch
2	Skylight Wiper
3	Skylight Sunscreen
4	Dome Light
5	Cab Circulating Fan
6	Window Latch
7	Overhead Control Panels

**Skylight Window Latch**

The Skylight Window Latch (1) (Figure 3-3) is at the front of the window. Squeeze the latch and slide the window to the rear to open. To close slide the window forward until the latch engages.

**Skylight Wiper and Wiper Motor**

The Skylight Wiper (2) (Figure 3-3) is controlled by the Skylight Wiper Switch, (4) (Figure 3-4), and operated by the Wiper Motor.

**Skylight Sunscreen**

The Skylight Sunscreen (3) (Figure 3-3) is used to diminish direct sunlight. The sunscreen is self retracting and can be set to screen all the light or adjusted rearward by moving it into the notches provided.

**Dome Light**

The cab Dome Light (4) (Figure 3-3) is on the right rear corner of the cab overhead console and provides illumination in the cab. The dome light is controlled by a switch on the light.

**Cab Circulating Fan**

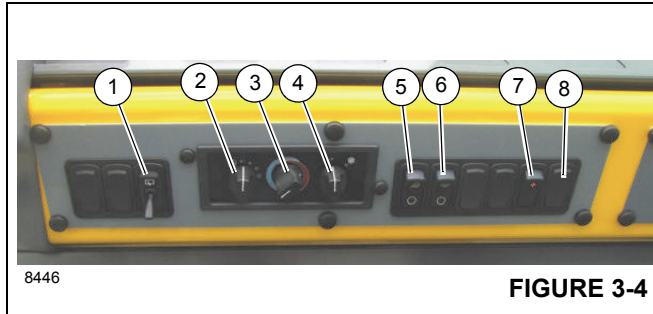
The Cab Circulating Fan (5) (Figure 3-3) is located on the left front side of the cab, above the window frame. A swivel allows the fan to be rotated and a switch on the fan base controls the fan. The switch has a high, low and off position.

**Right Side Window Latch**

The window on the right side of the cab can be opened. Squeeze latch (6) (Figure 3-3) to release and slide forward. To close, slide the window rearward until the latch engages.



## Overhead Control Panel



8446 **FIGURE 3-4**

1	Skylight Wiper Switch
2	Heater/Air Conditioner Fan Speed Switch
3	Heater Control Switch
4	Air Conditioning Switch
5	Work Lights Switch
6	Flood Lights Switch (Optional)
7	Crane Function Power Switch
8	Exhaust System Cleaning Switch (Tier 4 only)

### Skylight Wiper Switch

The electrically-operated Skyline Wiper is installed to remove moisture from the skylight. The Skyline Wiper is controlled by the Skyline Wiper Switch (1) (Figure 3-4). This switch has 6 positions, including the intermittent setting.

### Heater/Air Conditioner Fan Speed Switch

The Heater/Air Conditioner Fan Speed Switch (2) (Figure 3-4) controls the cab fan's speed. Fan speed controls the volume of heated air output (or cooled air output) of the fan. Settings are off, low speed, medium speed, and high speed.

### Heater Control Switch

The Heater Control Switch (3) (Figure 3-4) controls intensity of heating temperature. Turn the switch to the right (clockwise) to open the valve for heat. (Heat comes from heated fluid going through the heater coil.) Turn the switch to the left (counterclockwise) to close the valve to stop fluid flow and minimize heat.

### Air Conditioner Switch

The Air Conditioning Switch (4) (Figure 3-4) controls the operation of the optional air conditioning system. Settings are off (O) and on (I).

### Work Lights Switch

The Work Lights Switch (5) (Figure 3-4) controls the crane's work lights mounted on the bottom front of the superstructure cab. Press the top of the switch to turn on the work lights. Press the bottom of the switch to turn off the work lights.

### Crane Function Power Switch

The Crane Function Power Switch (7) (Figure 3-4) is located on the overhead control panel. This spring return switch permits the operator to activate all crane functions at once or disconnect power from the crane functions controlled by the remote controllers on the armrests. Pressing it turns ON all crane functions. Pressing a second time turns OFF all crane functions. Turn off all crane functions to prevent inadvertent operation of functions due to bumping the controllers while roading or any other operation.

## Exhaust System Cleaning Switch (Tier 4 Engines Only)



### WARNING

#### Extreme Heat Hazard!

During the cleaning process the exhaust becomes very hot. Do not park the vehicle near objects that are flammable.

Use caution near the exhaust tailpipe as it will also become very hot.

The Engine DPF (Diesel Particulate Filter) Switch (8) (Figure 3-4) is located on the right side of the overhead control panel. This switch is a three position switch, Inhibit Cleaning/Permit Active Cleaning/Initiate Manual Cleaning. Center position enables clean to occur when required, or press this switch to force manual cleaning to begin immediately or to disable cleaning indefinitely:

- Manual Cleaning (7649-10)
- Inhibit Cleaning (7649-11)



8522

FIGURE 3-5

To manually clean, set the crane parking brake, the crane transmission must be in neutral and have the brake and throttle pedals released. Refer to *Exhaust System Cleaning (Tier 4 Only)*, page 7 for cleaning mode definitions and a description of when manual cleaning is needed.

Set up a safe area around the crane's exhaust; remove tools, rags, grease or any debris from the engine exhaust area.

With the engine idling push the Cleaning Switch (8) to initiate manual cleaning.

Within 5 seconds the engine should rev up to 1000 to 1400 rpm. The engine will continue to run at this speed for up to 45 minutes.

As a warning, the light (1, Figure 3-5) above the exhaust pipe (2, Figure 3-5) will blink during exhaust system cleaning.

Pressing brake or throttle pedal during cleaning or activating the Inhibit Cleaning Switch will interrupt the manual cleaning process.

Make sure the crane and surrounding area are monitored during manual cleaning. If any unsafe condition occurs, shut off the engine immediately.

During this period the sound of the engine may change. When manual cleaning is complete the engine will return to its normal idle speed.

## Exhaust System Cleaning (Tier 4 Only)

The Exhaust System Cleaning Required Indicator (24) is located in the CCS display (Figure 3-14). This indicator illuminates amber when the exhaust system is in need of cleaning.

When the DPF indicator illuminates or flashes, start the manual cleaning process at the next opportune time.

The indicator will be illuminated continuously during the early stages of required cleaning. If this condition continues, the lamp will begin to flash and a slight engine derate will occur.

If this condition continues further, the Engine Warning light (17) will illuminate in addition to the cleaning indicator (24) and severe engine derate will occur.



### WARNING

#### Extreme Heat Hazard!

During the cleaning process the exhaust becomes very hot. Do not park the vehicle near objects that are flammable.

Use caution near the exhaust tailpipe as it will also become very hot.

The only way in which either of these conditions can occur is if cleaning has been inhibited or a manual cleaning was interrupted. Refer to *Exhaust System Cleaning Switch (Tier 4 Engines Only)*, page 3-6, for more detail on these.

The exhaust system cleaning process can take place in three different modes:

**Passive:** the exhaust is hot enough during normal working operation to burn off any hydrocarbon (soot) accumulation

**Active:** Active cleaning occurs when there is not sufficient heat in the exhaust to convert all the hydrocarbon being collected in the DPF. Exhaust temperatures are raised by injecting a small amount of fuel. The resulting chemical reaction raises exhaust gas temperatures high enough to oxidize the hydrocarbon from the filter. This is all done without any operator intervention.

**Manual:** Manual or stationary, cleaning is the same as active cleaning but takes place while the equipment is not being operated. It offers the equipment operator the option, if needed, of performing cleaning outside the normal duty cycle. Inhibit Exhaust System Cleaning (Tier 4 Engines Only)

The Inhibit Exhaust System Cleaning Indicator (25) is located in the CCS display (Figure 3-14). When the Cleaning Switch (8) (Figure 3-4) is in the exhaust system cleaning position, this amber indicator is illuminated and active and manual exhaust system cleaning is prevented.

## Diesel Exhaust Fluid (Tier 4 Final Only)

The Diesel Exhaust Fluid (DEF) Indicator (6) (Figure 3-14) is located in the CCS display. The indicator has four different stages which will be triggered by the fluid level sensor in the DEF tank:

**Low Tank** - First warning to the operator is that the reducing agent in the tank is low. The DEF Indicator (6) will be lit continuously.

**Derate** - The DEF Indicator (6) will start to flash as a warning to the operator that a derate will be activated if the reducing agent in the DEF tank is not refilled.

**Low Level Inducement** - The DEF Indicator (6) will flash and the Engine Warning Indicator (17) will be lit continuously. Derate will be activated at this stage.

**Severe Inducement** - Once the DEF (6) tank is empty, the crane operation will be restricted. The DEF Indicator (6) will flash and the Stop Engine Indicator (16) is solid red.

### CAUTION

#### Engine Damage Hazard!

Ultra low sulfur diesel fuel is required in Tier 4 engines.

If "Ultra Low Sulfur" fuel is not used in engines that require it, the Cummins warranty will be void and the engine performance will quickly deteriorate and may stop running.

## High Exhaust System Temperature

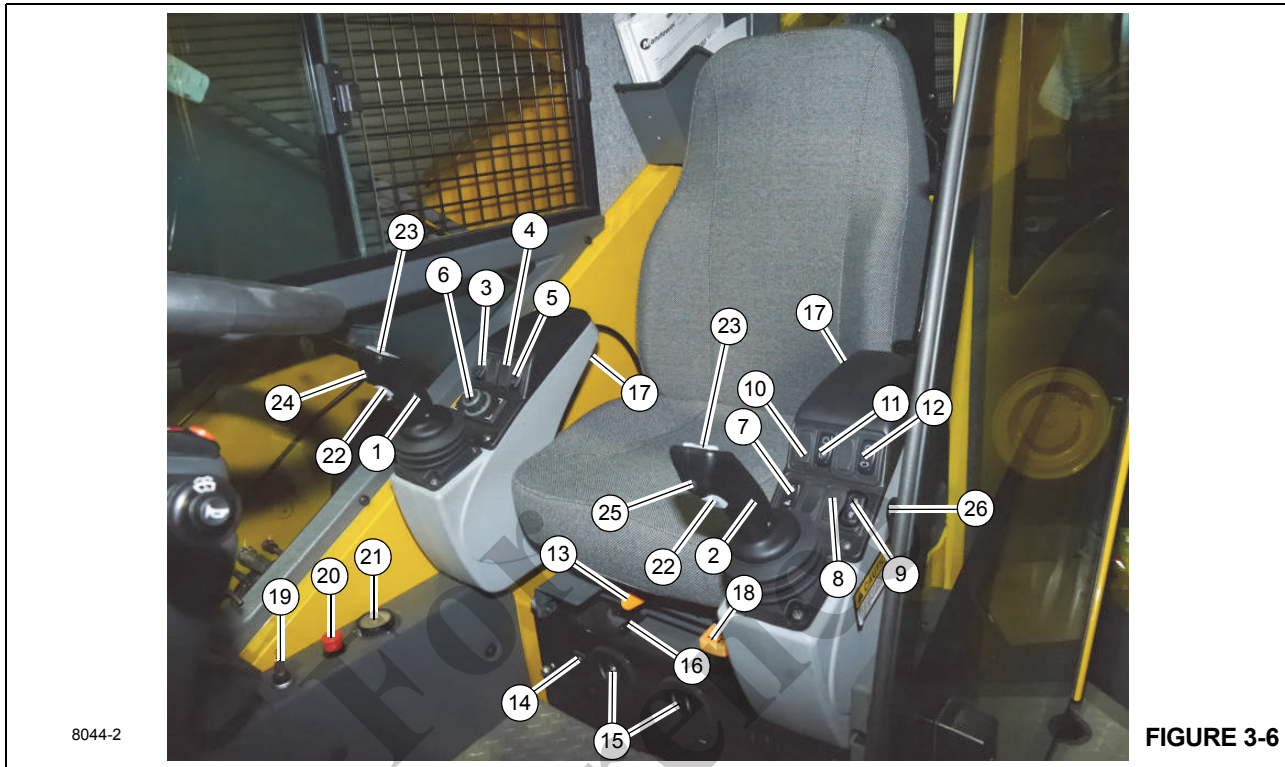
The High Exhaust System Temperature (HEST) Indicator (26) (Figure 3-14) is located on the CCS Main Screen display.

During exhaust system cleaning it is possible for the engine exhaust to reach temperatures exceeding 650° C (1200° F). The HEST indicator will illuminate red to warn the operator of when temperatures reach 675° C (1247° F) and will stay on until the temperatures falls below 625° C (1157° F).

A warning light near the tailpipe will flash during exhaust system cleaning when high exhaust temperatures exist.

For more information on the exhaust system cleaning process, refer to *Exhaust System Cleaning (Tier 4 Only)*, page 3-7.

CONTROL SEAT ASSEMBLY



8044-2

FIGURE 3-6

1	Boom Lift/Main Hoist Control Lever	15	AC/Heater Vents
2	Swing/Telescope or Swing/Auxiliary Hoist Control Lever	16	Seat Frame Slide Lever
3	Main Hoist Enable Switch	17	Armrest Adjustment Button(s) (Underside)
4	Boom Up Bypass (Optional)	18	Seat Height Adjustment Lever
5	Boom Lift Function Enable Switch	19	RCL Bypass Switch
6	Jog Dial	20	Emergency Stop Switch
7	Outrigger Function Enable Switch	21	Level Indicator
8	Differential Lock On/Off (Optional)	22	Deadman Switches (Optional) (Dual Axis Control Levers only)
9	Rear Steer Switch	23	Hoist Speed Toggle Switches
10	Auxiliary Hoist Enable Switch (Optional)	24	Horn
11	Boom Telescope Enable Switch	25	Free Swing Button
12	Swing Enable Switch	26	Cab Door Release Lever
13	Seat Slide Lever	27	Hoist Rotation Indicators (Not Shown)
14	AC/Heater Climate Unit	28	Seat Switch (Not Shown)

## Boom Lift/Main Hoist Control Lever (Dual Axis)

The Boom Lift/Main Hoist Control Lever (1) (Figure 3-6) is located on the right armrest. The controller, when pushed to the right lowers the boom, or pushed left raises the boom.

When used for main hoist, the controller, when pushed forward lowers the cable, or pulled back raises the cable.

## Swing/Telescope or Swing/Auxiliary Hoist Control Lever (Dual Axis)



### DANGER

#### Crushing Hazard!

Death or serious injury could result from being crushed by moving machinery.

Before actuating swing or any other function, sound horn and verify that all personnel are clear of rotating and moving parts.

The Swing/Telescope or Swing/Auxiliary Hoist (Swing/Telescope or Swing/Aux) Control Lever (2) (Figure 3-6) is located on the end of the left armrest. The lever controls swing and telescope functions when the crane is not equipped with an auxiliary hoist. When equipped with an auxiliary hoist, the lever controls swing and auxiliary hoist functions and telescope functions are controlled through a foot pedal.

If not equipped with an auxiliary hoist, positioning the lever to the left or right actuates a control valve through hydraulic pilot pressure to provide 360 degree continuous rotation in the desired direction. Positioning the lever forward actuates the control valve to telescope the boom out and pulling the lever back actuates the boom to telescope in.

If equipped with an auxiliary hoist, positioning the lever forward actuates the control valve to let out hoist cable. Pulling the lever back reels the cable in. Moving the lever in a diagonal direction actuates the two functions simultaneously.

## Main Hoist Enable Switch

The Main Hoist Enable Switch (3) (Figure 3-6) is a momentary switch that is located on the right armrest. Press once to enable hoist; press again to disable hoist. Pressing the switch twice rapidly enables hoist at high speed. Pressing once and holding the switch for about 2 seconds also enables high speed.

## Boom Up Bypass Switch (Optional)

The Boom Up Bypass Switch (4) (Figure 3-6) is a momentary two-position rocker switch that, when installed, is located on the right armrest. While lift function is enabled and in a RCL lockout condition, activating the Boom Up Bypass Switch will enable boom lift up.

## Lift Function Enable Switch

The Lift Function Enable switch (5) (Figure 3-6) is a momentary switch that enables boom up and boom down.

## Jog Dial

The Jog Dial Control (6) (Figure 3-6) is located on the right arm rest. It selects and chooses functions on the screen(s) to navigate the Crane Control System.

## Outrigger Function Enable Switch

The Outrigger Function Enable Switch (7) (Figure 3-6) switches between extension/retraction of outriggers and raising/lowering of the jacks. Press and hold switch to force the lower screen display to change to the outrigger page.

## Differential Lock On/Off Switch (Optional)

The Differential Lock Switch (8) (Figure 3-6) is located on the left arm rest. It engages the differential lock function for better traction when Four Wheel Drive is selected. It can be activated for a maximum of 30 seconds at a time.

**NOTE:** Differential lock operates only when crane is in 4WD mode.

## Rear Steer Switch

The Rear Steer Control Switch (9) (Figure 3-6) is a three-position, spring centered to off, rocker switch, located on the left armrest. Press bottom of the switch to actuate a control valve to turn rear wheels to the left, causing crane to turn to the right. Pressing top of the switch actuates a control valve to turn rear wheels to the right, causing crane to turn to the left. When wheels are not centered, the Wheels Not Centered icon on the CCS Operating Display illuminates. Releasing the switch causes it to return to the center off position.

To straighten rear wheels, press the switch until Rear Wheels Not Centered icon indicator light goes off.

## Auxiliary Hoist Enable Switch (Optional)

The Auxiliary Hoist Enable Switch (10) (Figure 3-6) is located on the left arm rest. It enables the Auxiliary Hoist and sets the high speed the same as the Main Hoist Enable Switch does for the Main Hoist.

## Boom Telescope Enable Switch

The Boom Telescope Enable Switch (11) (Figure 3-6) is located on the left arm rest. It enables the boom telescoping function for the optional Telescope Control Foot Pedal, or for the Control Lever (joystick) if there is no auxiliary hoist.

## Swing Enable Switch

The Swing Enable Switch (12) (Figure 3-6) is located on the left arm rest. This two-position rocker switch (On/Off) is used to control a hydraulic valve that directs a regulated flow of pressure to and from the swing brake. When the joystick moves to swing the crane the brake releases. When the crane stops swinging the swing brake re-engages.

## Seat Slide Lever

Moving the Seat Slide Lever (13) (Figure 3-6) will enable only the seat to slide, either forward or backward.

## Air Conditioner/Heater Climate Unit

The crane cab Air Conditioner/Heater Climate Unit (14) (Figure 3-6) is located in the cab under the driver's seat. The vents (15) are part of the climate unit and can be adjusted to direct the flow of air.

## Seat Frame Slide Lever

Moving the Seat Frame Slide Lever (16) (Figure 3-6) will slide both the seat and the armrests either forward or backward.

## Armrest Adjustment Knobs

The left and right armrest and armrest controls can be adjusted using the adjustment buttons (17) (Figure 3-6) found under the rear of the armrest. Press the button to rotate the entire armrest; release button at the desired position.

## Seat Height Adjustment Lever

To adjust the height of the seat, lift the height adjustment lever (18) (Figure 3-6) and then adjust the seat as needed.

## Rated Capacity Limiter (RCL) Bypass Switch

The RCL Bypass (Override) Switch (19) (Figure 3-6) is a momentary type switch. Turn the key clockwise to bypass the 3rd Wrap Indicator and Anti Two-Block Switch. It will be bypassed only as long as the switch is held in this position.

Turn the key counterclockwise to bypass the Anti Two-Block Switch, Telescope extend/retract, 3rd Wrap Indicator (hoist lowering limit) and Boom up/down. It is important to read and understand the RCL Override Warning information before using the RCL Bypass or On/Off Switch.

## Emergency Stop Switch

The crane Emergency Stop Switch (20) (Figure 3-6) is located on the cab right console and is used to shut down the crane's engine. Push the red button in to shut down the engine, which illuminates the Emergency Stop icon on the CCS operator display. Rotate the knob and pull out to resume normal operation.

## Level Indicator

The Level Indicator (21) (Figure 3-6) is located on the right side of the cab by the Emergency Stop Switch. The indicator provides the operator with a visual aid in determining the levelness of the crane.

## Deadman Switches (Optional) (Dual Axis Control Levers only)

The Deadman Switches (22) (Figure 3-6) are located on the front of both control levers. Either of these switches can be used instead of the seat switch to keep crane functions active.

## Hoist High Speed Toggle Switches

The Hoist High Speed Toggle Switches (23) (Figure 3-6) are thumb operated two-position center spring return switches. Pressing the right side maintains high speed until it is deactivated; pressing the left is momentary speed increase.

## Horn Button

The Horn Button (24) (Figure 3-6) is located on the upper front of the right control lever. The button sounds the horn during craning operations.

## Free Swing Button

The Free Swing Button (25) (Figure 3-6) is located on the upper front of the left control lever. The Free Swing Button releases the Swing Brake and allows the boom to be centered over the load.

## Cab Door Release Lever

Use the Cab Door Release Lever (26) (Figure 3-6) to open and close the cab door from inside the cab.

## Hoist Rotation Indicators (Not Shown)

The Hoist Rotation Indicators (27) (Figure 3-6 Item Numbers) for the auxiliary and main hoists are located on top of each hoist control lever (1, 2) (Figure 3-6). Each indicator is electronically driven by an input signal from a sensor attached to its related hoist and an output signal from a control module. Each hoist control lever (1, 2) pulses when its hoist is running so the operator's thumb can sense it.

## Seat Switch (Not Shown)

This switch (28) (Figure 3-6 Item Numbers) is located within the seat. An operator must be sitting in the seat, enabling the switch, before any crane functions can be activated.

## OPERATING PROCEDURES

### Pre-Starting Checks

A complete walk-around visual inspection of the crane should always be made with special attention to structural damage, loose equipment, leaks, or other conditions that would require immediate correction for safe operation. Refer to *Maintenance Checklist*, page 6-1.

The following items are suggested to be checked to ensure the crane is prepared for starting the day's work.

#### **Fuel Supply**

Fill the fuel tank and ensure the cap is on tight.

#### **Engine Oil**

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### CAUTION

Do not overfill.

---

Check the oil level in the crankcase and ensure it is within the ADD and FULL marks on the dipstick. Do not overfill.

#### **Engine Coolant**



### DANGER

Do not loosen radiator cap while engine and radiator are hot. Steam or hot coolant will cause severe burns.

---

Check the coolant level in the radiator and fill to the proper level. Do not overfill, and ensure the radiator cap is secure.

#### **Batteries**

Check that the battery cables and clamps are tight and not corroded.

#### **Hydraulic Reservoir and Filter**

Check the hydraulic level sight gauge and filter condition indicator on the hydraulic tank. Hydraulic fluid should be at normal operating temperature, with both the boom and outriggers in a retracted position, and the boom level.

Check breather for cleanliness and ensure it is secure.

#### **Wire Rope**

Inspect the wire rope in accordance with applicable Federal Regulations. Sheaves, guards, guides, drums, flanges, and any other surfaces that come in contact with the rope should be inspected for any condition that could cause possible damage to the rope.

#### **Hook Block and Headache Ball**

Inspect for nicks, gouges, cracks, and evidence of any other damage. Replace a hook that has cracks or shows evidence of excessive deformation of the hook opening (including twist). Be sure the safety latch is free and aligned.

#### **Seats and Mirrors**

Adjust seat and mirrors for clear vision and safe driving.

#### **Seat Belts**

##### **Seat Belt Maintenance**

Seat belt assemblies are maintenance-free; however, they should be periodically inspected to ensure that they are not damaged and are in proper operating condition, especially if they have been subjected to severe stress.

##### **Cleaning Seat Belt Webbing**

Wash the seat belt webbing with any mild soap or detergent. Do not use commercial solvents. Also, bleaching or re-dyeing the webbing is not recommended because of possible loss of webbing strength.

##### **Signal and Running Lights**

Check all signal and running lights for proper operation. Replace burned out lamps with those of the same number, or equivalent.

##### **Service and Parking Brakes**

Check for proper operation.

##### **Tires**

Check for severe cuts, foreign objects embedded in treads, and for correct inflation pressures. A tire inflation chart, providing the correct air pressures, is located in the Load Chart Manual in the crane cab.

##### **Wheels**

Maintain proper torque on wheel lugs and check for proper wheel mounting. If equipped with steel or aluminum wheels, the wheels should be retorqued 80 to 160 km (50 to 100 mi) after initial installation or after any time the tires and wheels are removed. Doing this will reseal the lug nuts. Recheck the lug nuts for proper torque every 800 km (500 mi) thereafter.

##### **Safety Equipment**

Check all lights, windshield wipers, washers, washer liquid supply, horn, instruments, signaling devices, etc.

##### **Daily Lubrication**

Ensure all components requiring daily lubrication have been serviced. Refer to *Lubrication*, page 5-1.

**Boom**

Before extending the boom, ensure the large access cover on top of the boom base section is installed.

For crane operation below  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ ), derate load chart capacities by 6.60% for each degree Celsius or by 3.67% for each degree Fahrenheit below  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ ).

**Air Cleaner**

Check the filter restriction indicator (Tier 3 models only). Check filter and tubing for security.

**Air Intake Restriction Monitoring (AIRM) Communications System - Tier 4 Only**

The Tier 4 engine includes the Cummins AIRM Communications System. This calculates real-time air filter restriction at operational flow rate using the temperature and pressure input from the TBAP sensor, which is included on the Direct Flow air cleaner.

A maintenance fault (Fault Code (FC) 5576) is initiated at the dirty filter restriction level, generating a blinking "Check Engine" light for 30 seconds at every key on until the intake air restriction drops below the dirty filter restriction threshold. A severe warning fault (FC 3341) is initiated if the maintenance fault condition degrades to a severe restriction level for a given time period, generating a solid amber "Check Engine" light and initiating a progressive engine derate in order to protect the engine from damage until the intake restriction drops below the dirty filter restriction threshold.

**Cold Weather Operation**

Regions with ambient temperatures below  $-9^{\circ}\text{C}$  ( $15^{\circ}\text{F}$ ) are considered arctic. The following recommendations are for operating Grove cranes in very low (i.e., sub-zero) temperatures.

Use particular care to ensure that cranes being operated in very cold temperatures are operated and maintained in accordance with the procedures as provided by Manitowoc. Therefore, always ensure adequate lubrication during system warm-up and proper operation of all crane functions when operating in cold weather and regardless of the oil viscosity of the crane's lubricants, always follow the cold weather start-up and operating procedures described in the *Operator Manual*. To ensure adequate lubrication during system warm-up and proper operation of all crane functions, (Refer to *Arctic Conditions Below  $-9^{\circ}\text{C}$  ( $15^{\circ}\text{F}$ )*, page 5-3.) If in doubt of the suitability of a specific fluid or lubricant, check with an authorized Manitowoc distributor or Manitowoc Crane Care. Cranes should have appropriate hydraulic oil, lubricants, and other auxiliary items required for operation in sub-zero temperatures.

Manitowoc recommends the crane is equipped with the following cold weather accessories:

 **$-29^{\circ}\text{C}$  ( $-20^{\circ}\text{F}$ ) Package**

- Battery heater
- Fuel line heater
- Engine hood insulation
- Fan clutch
- Radiator air shutters
- Air diverter
- Diesel fired cab heater
- Cold weather alternator
- Fluids suitable to  $-29^{\circ}\text{C}$  ( $-20^{\circ}\text{F}$ )
  - Arctic windshield washer fluid
  - Arctic fuel

 **$-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ ) Package**

- Coolant heater (to circulate warm coolant through heaters and engine)
- Transmission heater
- Swivel heater
- Battery heater
- Fuel line heater
- Engine hood insulation
- Fan clutch
- Radiator shutters
- Air diverter
- Diesel fired cab heater
- Cold weather alternator
- Super-capacitor starting system
- Fluids suitable to  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ ):
  - Arctic windshield washer fluid
  - Arctic fuel

Individual crane functions should be operated to ensure they are sufficiently warmed prior to performing a lift. Allow at least 30 minutes of engine run time for warm up.

Operation of cranes at full rated capacities in ambient temperatures between  $-9^{\circ}\text{C}$  and  $-40^{\circ}\text{C}$  ( $15^{\circ}\text{F}$  and  $-40^{\circ}\text{F}$ ) or lower should be accomplished only by competent operators who possess the skill, experience, and dexterity to ensure smooth operation. Shock loading shall be avoided. See Section 5 of this manual for more detailed information on operation of cranes down to  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ ).



### Component Coolant Heater

A diesel fueled coolant heater circulates warm coolant through engine and crane components when operating during arctic temperatures. The coolant heater should be activated 2 hours before starting the crane to allow sufficient time to preheat fluids and assist with easy start-up conditions.



### WARNING

#### Explosion Hazard!

Before switching on, check if the heater can be operated at the current site of the crane. There is a danger of explosion when using the heater around combustible objects! Do not park the vehicle near objects that are flammable.

Use caution near the exhaust tailpipe as it will also become very hot.

**NOTE:** Operation of the heater is not permissible:

- At locations where flammable gas or vapors are found or can be formed (example: at fuel stations and chemical factories)
- At locations where explosive dust is found or can be formed (example: coal, wood or grain dust).
- There is a risk of suffocation when using the heater!
- Do not operate the heater in enclosed spaces (example: garages).

To activate the heater, ensure the fuel supply valve from the heater fuel reservoir is turned to the ON position. Ensure the battery disconnect switch is turned to the ON position and push the activation button at the heater control panel. A green light will illuminate indicating the system is activated. The start-up and shutdown cycles may take approximately 2 minutes for initialization. Ensure the coolant, transmission heater, swivel, battery heater, in-line fuel pump, in-line fuel heater, and hydraulic reservoir heater are heating properly.

To deactivate the heater, push the button at the heater control panel. The green light will turn off indicating the system is deactivated. The shutdown cycle may take approximately 2 minutes.

**NOTE:** Accelerated discharging of battery will occur when the crane engine is switched off. If you run the heater while the crane engine is stopped, the batteries voltage will need to be recharged after short periods of time.

### Radiator Shutters

When starting the engine the shutters on the radiator will close and will open when the coolant temperature reaches 71°C (160°F).

### Auxiliary Cab Heater

The superstructure crane cab is heated with an auxiliary air heating system that runs independently of the engine. The heat is generated by burning fuel taken from the heater fuel reservoir.

To heat the operator's cab, activate the auxiliary diesel heater and adjust the temperature control switch mounted in the overhead panel. The fan for the heating system delivers warm air into an air distribution box. The air is circulated according to the setting of the controls and then delivered into the crane cab by a fan through the various air extraction and air delivery vents.

Do not cover the vents with bags, articles of clothing or any other objects. Keep the hot air inlet and hot air outlet free of dirt and foreign bodies. Soiled or blocked hot air lines may cause overheating, and result in damage.

The crane auxiliary cab heater can be operated while the diesel engine is running or is stopped as part of the programmable auxiliary heating system. Maximum cab temperature will be achieved by running only the auxiliary heater and using the standard cab heater fan when the engine is sufficiently warmed up. The standard hot water crane cab heater can also be turned on after the engine has started and is warmed to operating temperature.

**NOTE:** When using the heater at high altitudes, the factory heater setting will need to be re-calibrated for proper heater operation.

- Heating at altitudes up to 1,500 m (4,921 ft)  
Unlimited heating is possible
- Heating at altitudes over 1,500 m - 3,000 m (4,921 ft - 9,842 ft):

Heating is possible for short periods at this altitude (example: driving over a mountain pass or taking a break while traveling between job sites).

During longer stays, (example: construction job project), the fuel supply must be adjusted to the altitude or the heater will malfunction. This can be done by installing an air pressure sensor kit (Manitowoc part number 90037674). Contact an authorized Manitowoc distributor or Manitowoc Crane Care for additional assistance.

**NOTE:** Accelerated discharging of battery will occur when the crane engine is switched off. If you run the heater while the crane engine is stopped, the batteries' voltage will need to be recharged after short periods of time.

**Battery Heater**

An in-line battery coolant heater circulates warm coolant under the battery when the temperature is below -9°C (15°F). The battery coolant heater should be activated 2 hours before starting the crane to allow sufficient time to preheat batteries and assist with easy start-up conditions.

Ensure battery heater coolant valve is turned to off position in ambient temperatures above -9°C (15°F).

**Air Diverter**

An air diverter directs warmed air collected from under the engine hood when the temperature is below -9°C (15°F) to preheat the air intake going to the engine.

Ensure air diverter is switched to outside air intake in ambient temperatures above -9°C (15°F).

**Super Capacitor**

The super capacitor provides additional cranking during cold weather startup. The super capacitor is connected to the standard batteries with an isolation relay. The positive relay feed is activated when the key is in the crank and run positions. The super capacitor allows the starter to be cranked for 30 seconds then cycled off for 60 seconds before cranking again until the engine starts.

If crane has been left with battery disconnected for an extended period of time, super capacitor will need up to 30 minutes to charge before having full cranking capacity.

Charge of capacitor can be measured by the following:

- Turn battery disconnect to on position.
- Press black button located on top of capacitor:
- If light flashes green, capacitor is charging and may not successfully start machine.
- If light is solid green, capacitor is charged and ready for starting.

Any other color or flash pattern may indicate an error, reference decal located on capacitor.

**Diesel Fuel**

Diesel fuel with low temperature characteristics is required to operate the engine down to an ambient temperature range from -40°C (-40°F) to 49°C (120°F). Refer to the applicable engine manual for proper specifications.

Use the correct grade of fuel for the prevailing temperature. Diesel fuel should have a cloud point of 6°C (10°F) less than the lowest expected temperature. In case of emergency, kerosene may be added to the fuel to bring the cloud point down to the required temperature. This will minimize clogging of filters and small passages by wax crystals. The addition of kerosene is NOT recommended for general use. Refer to the *Arctic Conditions Below -9°C (15°F)*, page 5-3 of this operator manual.

**CAUTION****Engine Damage Hazard!**

If "Ultra Low Sulfur" fuel is not used in engines that require it, the engine warranty will be void and the engine performance will quickly deteriorate and may stop running.

**Operation Below -40°C (-40°F)**

For crane operation below -40°C (-40°F), derate load chart capacities by 6.60% for each degree Celsius or by 3.67% for each degree Fahrenheit below -40°C (-40°F).

**Crane Warm-up Procedures**

The following procedures detail the actions that must be taken to properly warm the different crane components before operating the crane.

**NOTE:** For temperatures below -9°C (15°F) refer to arctic lubricants and conditions in the Operator and Service Manuals.

Before starting the crane, ensure the appropriate lubricants are used for the prevailing ambient temperatures in which the crane will operate in (a list of lubricants and their temperature ranges can be found in the Lubrication section of your crane's *Operator Manual*, by contacting your local Manitowoc distributor, or by contacting Manitowoc Crane Care directly).

**CAUTION****Crane Damage Hazard!**

Operating the crane with the incorrect lubricants and fluids for the prevailing ambient temperature and/or failing to adequately warm the crane prior to cold weather operation can lead to a failure of a crane component or system.

Always use Manitowoc recommended lubricants and fluids for the prevailing ambient temperature and properly start and warm the crane using the cold weather procedures found in this Operator Manual and supplement before operating the crane at full load.

## Engine

### Warm-up Procedures for All Temperature Ranges:

1. Upon startup, allow the engine to idle for 3 to 5 minutes before operating with a load.
2. Cold Engine Startup: After allowing the engine to warm by idling it for 3 to 5 minutes, slowly increase the engine speed to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.

## Transmission

Operating the transmission with a sump temperature below normal operating temperature is limited to:

- operating in the neutral gear or
- driving with an unloaded crane while not exceeding 1500 engine RPM and not exceeding half throttle.

### Warm-up Procedures for Rough Terrain (RT) Cranes:

1. Engage the parking brake and apply the service brake.
2. Shift the transmission into the highest gear and increase the engine RPM to 1500 for 15 seconds, then allow the engine RPM to return to idle.
3. Repeat Step 2 until the temperature of the transmission sump reaches normal operating temperature.

### Alternate Warm-up Procedures for Rough Terrain (RT) Cranes:

1. Setup the crane on outriggers.
2. Engage the transmission with 4-wheel drive selected (if equipped) and allow crane to run at idle until the temperature of the transmission sump reaches normal operating temperature.

**NOTE:** Warm-up operation of 4-wheel drive transmission engaged in 2-wheel drive only could cause transmission damage.

## Hoist

Performing a warm-up procedure is recommended at every startup and is required at ambient temperatures below 4°C (40°F).

### Warm-up Procedures:

1. Without operating the hoist function, warm the hydraulic oil (see *Hydraulic Oil System*, page 3-16).
2. Once the hydraulic system is warm, operate the unloaded hoist, in both directions, at low speeds several times to prime all hydraulic lines with warm hydraulic oil and to circulate gear lubricant through the planetary gear sets.

## Swing Drive and Turntable Bearing

### Warm-up Procedures for Temperatures Above -7°C (20°F):

1. Setup the crane on fully extended outriggers, with the boom fully retracted and near maximum lift angle with no load applied.
2. Rotate the superstructure at a speed of less than one RPM for at least one complete revolution in one direction, then rotate the superstructure at a speed of less than one RPM for at least one complete revolution in the opposite direction.

### Warm-up Procedures for Temperatures Below -7°C (20°F):

1. Setup the crane on fully extended outriggers, with the boom fully retracted and near maximum lift angle with no load applied.
2. Rotate the superstructure at a speed of less than one-half RPM for at least two complete revolutions in one direction, then rotate the superstructure at a speed of less than one-half RPM for at least two complete revolutions in the opposite direction.

## Axles

### Warm-up Procedures for Temperatures Below -35°C (-30°F):

1. Setup the crane on outriggers.
2. Engage the transmission with 4-wheel drive selected (if equipped) and allow crane to run at idle until the temperature of the transmission sump reaches normal operating temperature.

**NOTE:** Warm-up operation of 4-wheel drive transmission engaged in 2-wheel drive only could cause transmission damage.

## Hydraulic Oil System

### Operating Limits and Warm-up Procedures:

- **From 4°C to -10°C (40°F to 15°F):** Crane operation without a load is allowed with medium engine RPM and medium function speed (joystick position) until the fluid reaches at least 10°C (50°F). It is then recommended that all crane functions be cycled to remove cold fluid from all components and cylinders of the hydraulic system. If there is any unusual sound coming from the crane's hydraulic pumps or motors, stop the operation and engine immediately and contact a Manitowoc distributor.
- **From 10°C to 4°C (50°F to 40°F):** Crane operation with a load is allowed with medium engine RPM and medium function speed (joystick position) until the fluid reaches at least 10°C (50°F).
- **From 95°C to 10°C (200°F to 50°F):** Crane operation with a load is allowed with no restrictions.

Above 95°C (200°F): No crane operation is allowed. Let the crane's hydraulic oil cool by running the engine at idle with no functions actuated.

## Engine Operation

Start-up and shutdown procedures for most diesel engines are generally the same. Therefore, the following procedures can be applied, except where specific differences are noted. (Refer to the applicable engine manufacturer's manual for detailed procedures).

### Start-Up Procedure

Make an under-the-hood inspection for fuel, oil, and coolant leaks, worn drive belts, and trash build-up.



### DANGER

Diesel engine exhaust can be harmful to your health. Only operate the engine in a well ventilated area or vent exhaust outside.

### CAUTION

Never crank engine for more than 30 seconds during an attempted start. If engine does not start after 30 seconds, allow starter motor to cool for two minutes before attempting another start.

### CAUTION

If engine does not start after four attempts, correct malfunction before attempting another start.

Use the correct grade of oil for the prevailing temperature in the crankcase to prevent hard cranking. Diesel fuel should have a pour point of 6°C (10°F) less than the lowest expected temperature. In case of an emergency, white kerosene can be added to the fuel to bring the pour point down to the required temperature. This will prevent clogging of filters and small passages by wax crystals. The addition of kerosene is NOT recommended for general use.

Ensure Battery Disconnect Switch handle (1) (Figure 3-7) is in the ON position (handle shown in the OFF position)



FIGURE 3-7

**Cold Engine**

The engine warning and engine stop indicators will illuminate and go off in sequence after about two seconds (as a check) when the key is first turned on. If an indicator comes on and continues to blink after initial start-up, there is a problem that needs to be corrected. If the engine warning icon is selected, a screen will open listing the engine error codes.

An engine block heater and grid heater are provided to aid in cold-starting.

1. Ensure the emergency stop switch is not pressed.
2. Set the parking brake to ON and position the transmission shift lever to neutral.

**NOTE:** The engine will not crank unless the transmission shift lever is in neutral.

**NOTE:** The engine “wait to start” indicator located on the top left side of the front console illuminates amber for a period of time when the ignition is turned to the on position. The engine should not be cranked until the indicator turns off.

3. Turn the key to the first position. The CCS screen will provide data for the various engine systems and alert the operator to any detected fault codes. Sound the horn (left of steering wheel) once.
4. Turn the ignition switch to start (far right position) and release immediately when the engine starts. Do not push or hold the throttle down. The ECM will automatically provide the proper amount of fuel to start the engine.

**CAUTION**

If oil pressure and/or temperature indicator(s) do not display the proper readings, shut down engine and correct malfunction.

5. Allow the engine to warm up for about five minutes before applying a load. Do not race the engine for a faster warm up.

**Idling Engine**

Idling the engine unnecessarily for long periods of time wastes fuel and fouls injector nozzles. Unburned fuel causes carbon formation; oil dilution; formation of lacquer or gummy deposits on the valves, pistons and rings; and rapid accumulation of sludge in the engine.

**NOTE:** When prolonged engine idling is necessary, maintain at least 800 rpm.

**Racing Engine**

DO NOT race the engine during the warm-up period or operate the engine beyond governed speed (as might occur in downhill operation or downshifting). Engine bearings, pistons, and valves may be damaged if these precautions are not taken.

**Shutdown Procedure**

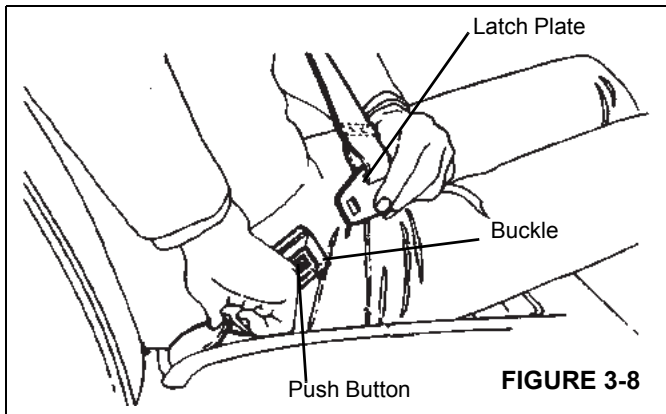
1. Allow the engine to run at fast idle speed for about five minutes to avoid high internal heat rise and allow for heat dissipation.
2. Position the ignition switch to off (vertical position).
3. Drain the fuel filter-water separator.

**Battery Disconnect**

The battery disconnect switch is located in the battery box on the left side of the crane. To disconnect the batteries, turn the battery disconnect switch to OFF. Turn the switch to ON to connect the batteries.

## Crane Travel Operation

### Seat Belts



**FIGURE 3-8**

1. Before fastening a seat belt, always adjust the driver's seat to the position in which you will drive.
2. Pull the belt across your lap and push the latch plate into the buckle until it clicks (Figure 3-8).
3. To reduce the risk of sliding under the belt during a collision, position the belt across your lap as low on your hips as possible and pull it toward the door to a snug fit.

### Traveling — General



#### **WARNING**

##### **Inadvertent Operation Hazard!**

Before traveling, ensure that the crane functions are fully disabled. The crane function enable switch is a spring return switch and cannot be put in a specific OFF position. This will prevent inadvertent operation of craning functions due to bumping of the controllers while traveling.

RT machines are subject to the same road regulations as any truck, regarding gross weight, width, and length limitations.

Although RT machines are specifically designed for rough terrain, the operator should be extremely cautious and aware of the terrain in which he is operating.



#### **WARNING**

##### **Tipping Hazard!**

Avoid holes, rocks, extremely soft surfaces, and any other obstacles which might subject the crane to undue stresses or possible overturn.

Do not drive the crane with the boom off center because automatic oscillation lockout will occur, making the crane subject to tipping on uneven surfaces. Center the boom over the front, disable swing functions and engage the Turntable Lock Pin (if equipped).

Fully retract the boom and ensure the swingaway jib is properly stowed and secured.

#### **CAUTION**

##### **Machine Damage Hazard!**

Do not travel with an empty hook in a position where it can swing freely (except where noted). Either remove the hook block and/or headache ball from the hoist cable(s) and stow securely or make sure the hook block or headache ball is properly secured to the tie down provided for that purpose.

Do not drive the crane with the lift cylinder bottomed. At a minimum, position the boom slightly above horizontal.

Fully retract the outrigger jacks and properly store the floats.

Disengage the pumps (if applicable) for extended traveling.

#### **CAUTION**

##### **Machine Damage Hazard!**

Manitowoc recommends towing or pulling another vehicle with the optional pintle hook (if equipped) or by attaching at a point no higher than the pintle hook height, or severe damage may occur to the drivetrain.

Do not tow or pull by attaching to the tie-down lugs unless the attaching point is no higher than the pintle hook height.

Use four-wheel drive when greater traction is necessary to avoid severe damage to the drivetrain.

Should the crane become mired down, use a tow truck or tractor to free the vehicle. Severe damage to the drivetrain may occur if the operator attempts to free the crane unassisted.

- Use four-wheel drive only when greater traction is necessary. (Refer to *Four-Wheel Drive Operation*, page 3-23 for operating instructions.)
- Ensure the outrigger beams and jacks are fully retracted with the floats properly stowed.
- Conduct all travel with the assistance of a ground person to warn the operator of any changing conditions in the terrain being traversed.

The owner/lessee must take appropriate measures to ensure that all persons operating or working with the affected models are in compliance with The Manitowoc Company, Inc. recommendations. The operator of the crane assumes responsibility for determining the suitability of traveling conditions. Traveling under the controlled conditions specified in these guidelines, must be conducted with the utmost diligence and care to ensure the safety of all personnel performing the operation and/or working around the crane.

### **Traveling — Towing/Pulling**

---

#### **CAUTION**

##### **Machine Damage Hazard!**

Manitowoc recommends towing or pulling another vehicle with the optional pintle hook (if equipped) or by attaching at a point no higher than the pintle hook height, or severe damage may occur to the drivetrain.

Do not tow or pull by attaching to the tie-down lugs unless the attaching point is no higher than the pintle hook height.

Use four-wheel drive when greater traction is necessary to avoid severe damage to the drivetrain.

Should the crane become mired down, use a tow truck or tractor to free the vehicle. Severe damage to the drivetrain may occur if the operator attempts to free the crane unassisted.

To avoid severe damage to the drive train while using the crane to tow or pull another vehicle, follow these recommendations:

- Ensure the boom is in a horizontal position and not elevated above 0°.
- Ensure the outrigger beams and jacks are fully retracted with the floats properly stowed.
- Tow or pull on open ground when possible.
- Connect to the optional pintle hook (if equipped) or attach cables/straps to the crane at a point no higher than the pintle hook height.

- Use four-wheel drive when greater traction is necessary. (Refer to *Four-Wheel Drive Operation*, page 3-23 for operating instructions.)
- Should the crane become mired down, use a tow truck or tractor to free the vehicle. Severe damage to the drivetrain may occur if the operator attempts to free the crane unassisted.
- Conduct all travel with the assistance of a ground person to warn the operator of any changing conditions in the terrain being traversed.

### **Traveling — Being Towed/Pulled**

Manitowoc recommends connecting to a pintle hook (if equipped) or evenly attaching to the tie-down lugs when being towed by another vehicle.

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#### **CAUTION**

##### **Machine Damage Hazard!**

It is recommended to attach cables/straps to the optional pintle hook (if equipped) or evenly attach to the tie-down lugs if being towed by another vehicle.

Should the crane become mired down, use a tow truck or tractor to free the vehicle. Severe damage to the drivetrain may occur if the operator attempts to free the crane unassisted.

- 
- Ensure the boom is in a horizontal position and not elevated above 0°.
  - Ensure the outrigger beams and jacks are fully retracted with the floats properly stowed.

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#### **CAUTION**

##### **Machine Damage Hazard!**

It is recommended to attach cables/straps to the pintle hook if one is available or evenly attach to the tie-down lugs if being towed by another vehicle.

Should the crane become mired down, use a tow truck or tractor to free the vehicle. Severe damage to the drivetrain may occur if the operator attempts to free the crane unassisted.

To avoid severe damage to the drive train while the crane engine is disabled:

- Disconnect drivelines.
- Disengage parking brake by manually turning parking brake adjustment until axle turns free.

**DANGER****Run-away Crane Hazard!**

Disabling the parking brake may result in the crane rolling away freely without the ability of the operator to stop the crane.

Ensure wheel chocks are properly placed when parking crane with the parking brake disabled.

Death or serious injury and damage to machinery could result from moving machinery.

- Secure steering to prevent turning while towing.
- Conduct all travel with the assistance of a ground person to warn the operator of any changing conditions in the terrain being traversed.

**Traveling on Slopes**

Crane operators need to exercise caution whenever operating the crane on uneven surfaces. Travel on slopes is permitted as long as the following conditions are met.

- Do not exceed a 15% (8.5°) slope side-to-side or fore-and-aft.
- Travel must be on an improved surface or on hard-packed dry earth having a minimum 0.5 coefficient of adhesion.
- Limit travel to a forward direction only.
- Do not exceed a speed of 1.6 km/h (1 mph).
- Fully retract all boom sections.
- Stow or remove the boom extension from the crane.
- Lower the boom to horizontal and position over the front of the crane.
- Engage the swing brake and turntable lock pin.
- Either the hook block may be reeved over the main boom nose or the headache ball may be reeved over the main boom nose or auxiliary boom nose; the other must be removed. If the hook block or headache ball remains reeved on the boom, it must be secured at the tie down on the carrier to prevent swinging.
- Inflate tires to the recommended pressure for pick and carry operations.
- Ensure the hydraulic tank is filled to the specified level. Ensure the fuel tank is over half full.
- Do not support any loads by the boom (i.e., no pick and carry loads) while traversing a slope.
- Remove all cribbing or other non-standard accessories from the crane.

- Avoid holes, rocks, extremely soft surfaces, and any other obstacles that might subject the crane to undue stresses and possible overturn.
- Conduct all travel with the assistance of a ground person to warn the operator of any changing conditions in the terrain being traversed.

The owner/lessee must take appropriate measures to ensure that all persons operating or working with the affected models are in compliance with The Manitowoc Company, Inc. recommendations. The operator of the crane assumes responsibility for determining the suitability of traveling on a slope. Traveling on a slope should only be attempted under the controlled conditions specified in these guidelines, and must be conducted with the utmost diligence and care to ensure the safety of all personnel performing the operation and/or working around the crane.

Should the operator need to traverse slopes outside the criteria defined in the above guidelines contact the The Manitowoc Company, Inc. for further guidance.

**Traveling with Elevated Boom****WARNING****Overhead Objects Hazard**

Contacting overhead objects while driving the crane may result in death, severe injury, and/or equipment damage. Traveling with the boom elevated should only be attempted under the controlled conditions specified in this section.

Exercise caution whenever driving the crane with the boom elevated. Travel with the boom elevated is permitted as long as the following steps are followed.

- Limit travel to firm, level surfaces.
- Inspect the route of travel prior to moving the crane. Pay particular attention to any changing conditions in the terrain being traversed. Also, avoid any overhead obstructions.
- Travel must be performed in a controlled fashion.
- Do not exceed a speed of 24 km/h (15 mph).
- Inflate tires to the recommended pressure for travel operations.
- When using the towing attachments, the boom must remain horizontal.
- Fully retract all boom sections.
- Refer to *Traveling with Boom Extension Erected*, page 3-21 if the boom extension is in the erected position.
- Position the boom over the front of the crane.



- Engage the swing brake and turntable lock pin.
- The hook block may be reeved over the main boom nose. The headache ball may be reeved over the main boom nose or auxiliary boom nose. The block and ball may be suspended below the boom nose. It is also acceptable to secure the block or the ball to the tie down point on the carrier to prevent swinging if necessary.
- Limit boom angle to a maximum of 20°.
- Do not support any load from the boom (see Pick and Carry Load chart for limitations for this application).
- Remove all cribbing or other non-standard accessories from the crane.
- Avoid holes, rocks, extremely soft surfaces and any other obstacles that might subject the crane to undue stresses and possible overturn.
- Ensure adequate clearance to any overhead obstructions that the crane may be required to travel beneath.
- Ensure that all personnel involved in the operation and those working around the crane are aware of any hazards that may be encountered and are trained about how to avoid the hazards.

### **Traveling with Boom Extension Erected**

#### **7.9 m (26 ft) Boom Extension**

Follow the steps below when traveling with the 7.9 m (26 ft) extension erected.

- Position the 7.9 m (26 ft) boom extension at minimum offset. Pin the 5.8 m (19 ft) extension in the fully retracted position.
- Travel only on a firm, level surface.
- Fully retract the main boom.
- Limit main boom angle to a minimum of 0° and a maximum of 30°.
- Do not exceed a speed of 2.7 km/h (1.7 mph) and ensure crane is in low range, first gear.
- Ensure main counterweight is installed.
- Position the boom over the front of the crane.
- Engage the swing brake and turntable lock pin.
- Remove hookblock from main boom nose.
- Headache ball may be reeved over boom extension, hanging 0.9 m (3 ft) below sheave.

#### **13.7 m (45 ft) Boom Extension**

Travel with the 13.7 m (45 ft) boom extension erected is **not** permitted.

### **Extended Travel**

Depending upon the tire manufacturer, the higher inflation pressures normally specified for lifting on rubber are not recommended for site to site transfer over extended distances. The higher static/creep 8 km/h (5 mph) inflation pressures may remain in the tire while operating the crane on site within a distance of less than 6.4 km (4 mi).

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### **CAUTION**

#### **Tire Damage Hazard!**

For extended travel, check the cold tire pressure prior to start. (Refer to tire inflation chart in Load Chart Book.) After every one hour of travel time, regardless of ambient temperature, stop and allow the tires to cool off for at least 30 minutes. At the destination, the tires must be allowed to cool to ambient temperature before crane lifting on rubber.

---

### **Traveling — Forward**

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### **CAUTION**

#### **Machine Damage Hazard!**

Engage the turntable lock pin for extended travel. Failure to engage the lock pin may allow the superstructure to swing uncontrolled, damaging the machine and/or property.

1. With the Transmission Shift Lever in the neutral (N) position, start the engine and allow it to adequately warm up.
2. Depress the Service Brake Foot Pedal.



### **WARNING**

#### **Run-away Crane Hazard!**

Releasing the parking brake while the low service brake pressure indicator is illuminated and the buzzer is sounding, indicating the service brakes are inoperable, may result in the crane rolling away freely without the ability of the operator to stop the crane.

Never release the parking brake while the low service brake pressure indicator is illuminated and the buzzer is sounding.

3. Disengage the parking brake.
4. Position the Drive Axle Switch to either two-wheel high or four-wheel low.

**CAUTION**

Use four-wheel drive only when more traction is required.

5. Lift the Transmission Shift Lever up out of its detent and push the lever to the forward (F) position, then rotate the Transmission Shift Lever Knob to the first (1) gear position. The gear selection "F1" will appear in the CCS Display to indicate that forward propulsion and first (1) gear have been selected; if the Service Brake Foot Pedal is not depressed prior to shifting to a gear, the gear selection will flash in the CCS Display until the Transmission Shift Lever is returned to the neutral (N) position, and the transmission will not shift.
6. Release the Service Brake Foot Pedal and depress the Foot Throttle Pedal until maximum first gear speed is attained, then rotate the Transmission Shift Lever Knob to the second (II) gear position to continue to increase speed. For additional speed, continue shifting to a higher gear.

**CAUTION**

**Possible Machine Damage!**

Do not downshift to a lower gear if the road speed is greater than the maximum speed of the lower gear.

**Traveling — Reverse**

Traveling in reverse is accomplished the same way as traveling forward, except for shifting the Transmission Shift Lever to reverse (R). Refer to *Traveling — Forward*, page 3-21.

**CAUTION**

**Possible Machine Damage!**

Apply service brakes and bring crane to a complete stop before shifting transmission into reverse.

**Steering**

Steering is accomplished by the steering wheel and the rear steer control. These controls, used singly or together, provide front wheel steering, rear wheel steering, four-wheel steering, and crabbing capabilities (Figure 3-9).

**Front Wheel Steering**

Conventional front wheel steering is accomplished with the steering wheel. This method of steering should always be used when traveling at higher speeds.



**WARNING**

**Unexpected Operation Hazard!**

Operate the rear steer ONLY at slow speeds for added job site maneuverability.

**Rear Wheel Steering**

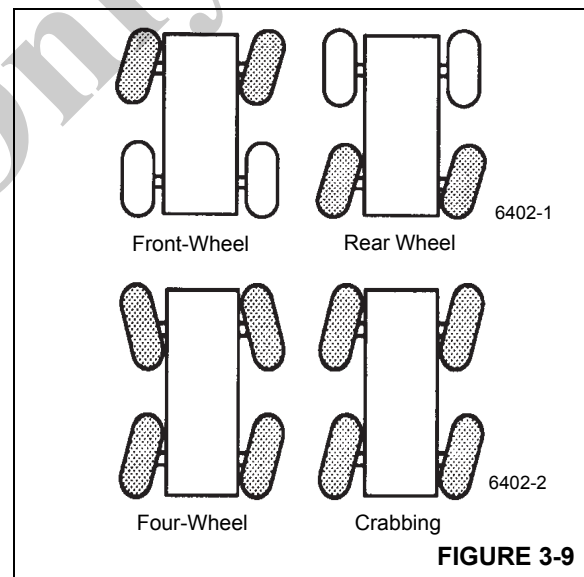
Rear wheel steering is controlled by the Rear Steer Control Switch. Moving the control switch to the desired position activates the rear steer cylinders, thereby steering the crane in the selected direction.

**Four Wheel Steering**

Four wheel steering is accomplished with the steering wheel and the Rear Steer Control Switch. Depending upon which direction the operator wishes to travel, the steering wheel is turned opposite direction of the Rear Steer control position. This allows the crane to turn or maneuver in close, restricted areas.

**Crabbing**

Crabbing is accomplished with the steering wheel and the Rear Steer Control Switch. Depending upon which direction the operator wishes to travel (crab), the steering wheel is turned in the same direction as the Rear Steer Control Switch. This permits driving the crane forward or backward in a crabbing manner.



**FIGURE 3-9**

**Four-Wheel Drive Operation****CAUTION****Machine Damage Hazard!**

Do not tow or pull in 1st gear with the Drive Axle Selector Switch in two-wheel drive position. Severe damage to the drive train will result. Always engage four-wheel drive.

If more traction is required due to slipping or spinning wheels, engage the front axle drive as follows:

**CAUTION****Possible Machine Damage!**

Before shifting from two-wheel drive to four-wheel drive (or from four back to two), crane travel must be stopped.

1. Stop the crane by depressing the Service Brake Foot Pedal.
2. Position the Transmission Shift Lever to the neutral (N) position.
3. Position the Drive Axle Selector Switch to four-wheel low.

**NOTE:** If the Drive Axle Selector Switch is positioned to four-wheel low and the Service Brake Foot Pedal is not depressed and the Transmission Shift Lever is not in neutral (N) position, the Four-Wheel Drive Indicator will flash and the four-wheel drive function will not engage.

4. Select gear speed and direction of travel using the Transmission Shift Lever and Knob.
5. Drive the crane as described under *Traveling — Forward*, page 3-21.
6. Return the Drive Axle Selector Switch to the two-wheel high position as soon as two-wheel traction will suffice and crane motion has stopped; again, the Service Brake Foot Pedal must be depressed and the Transmission Shift Lever must be in the neutral (N) position to shift from four-wheel low to two-wheel high.

**Differential Lock Operation (Optional)****CAUTION****Unexpected Operation!**

When using the differential lock, steering characteristics may be affected.

Try to use four-wheel drive to gain adequate traction before using the differential lock.

Do not operate the differential lock when traveling downhill; at speeds above 16.1 km/h (10 mph); on hard, dry surfaces; and/or during axle spin-out.

**NOTE:** The differential lock will not operate unless the Drive Selector Switch is in the four-wheel low position.

**General**

The purpose of the differential lock is to provide maximum traction and control on poor road or highway surfaces. When the differential locks are actuated, the clutch collar completely locks the differential case, gearing, and axle shafts together, thus maximizing traction to both wheels of each axle. The lock position will also protect against spinout. When normal driving conditions exist (during periods of good traction), the differential locks should not be actuated. The axles should be allowed to operate with differential action between both wheels.

Follow the steps below when engaging/disengaging the differential lock function.

1. Lock the differentials by pressing and holding the Axle Differential Control Switch in the lock position; disengage the function by releasing the switch.
2. Lock/unlock the differentials only when the vehicle is standing still or moving at a constant low speed with the wheels not slipping.

**CAUTION****Possible Machine Damage!**

When driving on hard, dry surfaces with the differentials locked, do not turn the wheels. Damage to the drive line components can result.

Do not lock the differentials when the wheels are slipping. Damage to the differentials can result.

3. Locked differentials cause the crane's turning radius to increase, creating an understeer condition; use caution, good judgement and drive at low speeds when operating the vehicle with lock differentials.
4. Lock the differentials only when maximum traction is needed on poor road or highway surfaces.

**CAUTION****Possible Loss of Vehicle Stability!**

Do not lock the differentials when the vehicle is traveling down steep grades and traction is minimal.

5. Always unlock the differentials when the need for maximum traction has passed or when traveling on good road or highway surfaces.

**Operation**

The differential lock function should preferably be engaged when the crane is stationary but may be engaged when moving, if the following conditions are met:

1. The crane is moving very slowly (creep speed).
2. The wheels are not spinning at the time of engagement.

When traveling with the differentials locked, do not deviate from a straight path more than is absolutely necessary. Engage the differential locks by doing the following:

1. Position the Axle Differential Lock Control Switch to the locked position with the crane stationary or moving at a slow speed.

If moving at a slow speed, let up momentarily on the Foot Throttle Pedal to relieve torque on the differential gearing. This will fully engage the differential locks.

**NOTE:** When the differentials are locked, the Axle Differential Locked Indicator illuminates.

2. Proceed over the poor road condition cautiously.

When the adverse condition has passed, disengage the differential locks by doing the following:

1. Release the Axle Differential Lock Control Switch, allowing it to return to the unlocked position while maintaining a slow speed.
2. Let up momentarily on the Foot Throttle Pedal to relieve torque on the differential gearing, allowing the differential to fully unlock.

**NOTE:** When the differentials are unlocked, the Axle Differential Locked Indicator will not be illuminated.

3. Resume driving at a normal speed using good driving judgement.

**Axle Oscillation Lockouts Operation**

The following procedure should be used to periodically check the axle oscillation system and ensure that it is in proper working condition.

1. Ensure the tires are inflated to the recommended pressure. Refer to the *Load Chart Book* in the crane cab for proper inflation pressures.
2. With the hook unloaded, the boom fully retracted and centered over the front at no more than a 10° to 15° boom angle, position the crane on a block or curb so that one rear tire is approximately 6 to 12 in (15 to 30 cm) above the level of the opposite tire.
3. Slowly swing the superstructure to the left or right until the axle oscillation lockout valve is activated. This will lock the rear axle out of level. Do not swing beyond the tire track.
4. After engaging the swing brake, slowly drive off of the block or curb and stop. The rear tires should both be touching the road surface and the opposite front tire should be light or slightly off the road surface.
5. Release the swing brake and swing the superstructure until it is centered over the front.

**DANGER****Tipping Hazard!**

Do not operate the crane if the axle oscillation lockout system is not functioning properly.

Failure to comply with this warning may result in death or serious injury.

If the axle oscillation lockout valve is functioning properly, the crane will re-level itself; if the valve is not working properly, the crane will not re-level itself. If the rear axle does not lock or unlock properly, evaluate the lockout system and repair as necessary.

**General Crane Operation****Pump Drive**

The main #1 hydraulic pump is driven by a transmission PTO. The #2 hydraulic pump is mounted to the rear of pump #1 and is direct engine driven.

**Control Lever Operation**

The control lever operation for crane functions is proportional, i.e., the closer the lever is to neutral (center), the slower the system responds. Return the control lever to neutral to hold the load. Do not feather the hoist control to hold the load.

**NOTE:** Always operate the control levers with slow, even pressure.

**Preload Check**

After the crane has been readied for service, an operational check of all crane functions (with no load applied) should be performed. Preload check is as follows:

- Extend and set the outriggers and level the crane.
- Raise, lower, and swing the boom right and left at least 45 degrees.
- Telescope the boom out and back in, ensuring all sections extend and retract properly.
- Raise and lower the cable a few times at various boom lengths. Make sure there are no kinks and that the cable is spooling on the hoist properly.

**CAUTION**

Run the engine at or near the governed RPM during operation of all crane functions.

**NOTE:** Carefully read and become familiar with all crane operating instructions before operating the crane.

**Using Your Load Chart**

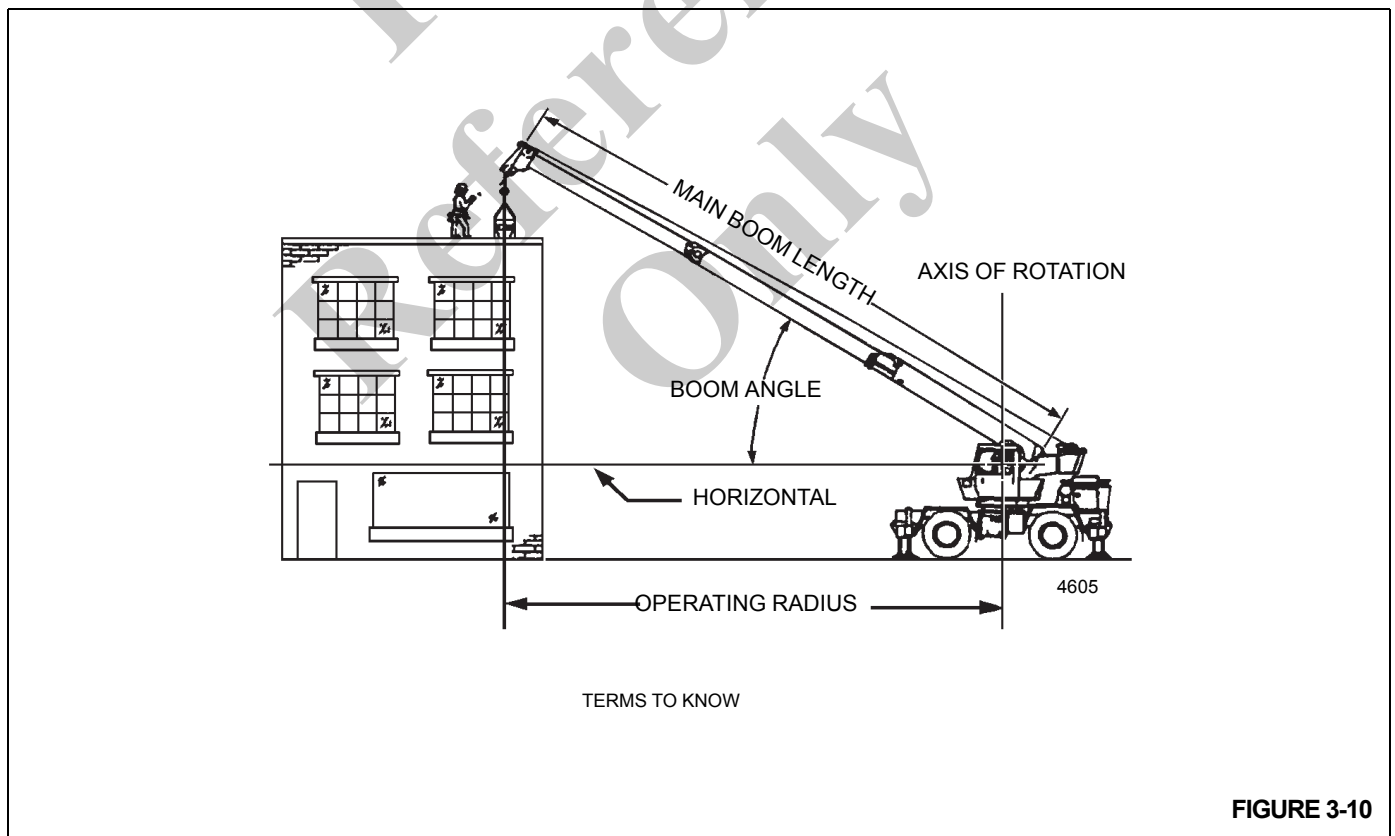
**NOTE:** One of the most important tools of every Grove crane is the load chart found in the crane operator's cab.

**NOTE:** Refer to (Figure 3-10) for terms to know in determining lifting capacities.

The load chart contains the lifting capacities of the crane in all allowable lifting configurations, and must be thoroughly understood by the operator.

The load chart is divided into capabilities limited by crane structural strength and stability which is shown by a bold line across the chart. Structural strength limits are above the line and stability limits are below the line.

The left column is the load radius, which is the distance from the axis of the crane rotation to the load center of gravity. The top row lists various boom lengths from fully retracted to fully extended (with swingaway extension). The number at the intersection of the left column and top row is the total load limit for that load radius and boom length. The number in parentheses below the total load limit is the required boom angle (in degrees) for that load. The lower weight limit for the 2 boom lengths should be used.

**FIGURE 3-10**

Another important section is the range diagram. The range diagram shows the operating radius and tip height that can be achieved at a given boom length and angle. If the

operator knows the radius and tip height required for a specific lift, the angle and boom length can quickly be determined from the range diagram. Or if he knows the boom

length and angle, he can quickly determine the tip height and operating radius.

A lifting diagram is included for over-side, over-rear, and over-front lifting areas. The lifting area diagram shows that the locations of the outrigger jack cylinders in the full extended position are used to mark the boundaries of the lifting areas.

Another section contains notes for lifting capacities. Be sure to read and understand all notes concerning lifting capacities.

The load chart also gives weight reductions for Manitowoc/ Grove load handling devices such as hookblocks, overhaul balls, boom extension sections, etc., which must be considered as part of the load. The weight of any other load handling devices such as chains, slings, or spreader bars must also be added to the weight of the load.

**NOTE:** The information in the following paragraph is an example of how to compute a lift. The numbers used in the example may not coincide with the load chart in the crane cab.

**Problem:** A concrete beam weighing 2268 kg (5000 lb) needs to be lifted to a height of 9.1 m (30 ft) at a radius of 15.2 m (50 ft) (maximum). The range diagram indicates the boom must be extended to 18.9 m (62 ft) in order to reach a height of 9.1 m (30 ft) at a radius of 15.2 m (50 ft).

First we need to check the crane for load handling devices. In our example, the crane is equipped with a auxiliary boom nose (rooster sheave) and a five ton overhaul ball. The rooster sheave is 50 kg (110 lb), and the overhaul ball is 78 kg (172 lb) for a total of 128 kg (282 lb). The lift requires slings and spreader bars weighing 159 kg (350 lb) which makes the total weight for the load handling devices 286 kg (632 lb).

A check of the load chart for a 15.2 m (50 ft) radius and 19.5 m (64 ft) of boom length shows a capacity of 3601 kg (7940 lb) on outriggers over-front and 4970 lb on outriggers 360 degrees. We subtract the load handling weight of 632 lb from the load capacity of 3601 kg (7940 lb) and 2254 kg (4970 lb). The result is a weight capacity of 3315 kg (7308 lb) over-the-front and 1968 kg (4338 lb) for 360 degrees. We are constricted in making the lift over-front only and the boom angle will be about 29 degrees.

### Proper Leveling of the Crane

ASME B30.5 specifies that if a crane is not level within 1% of grade, the allowable capacities must be reduced. Therefore, whether lifting on rubber or outriggers, it is essential that the crane is level to within 1% of grade. The bubble level indicator that is provided on the crane is calibrated to be accurate within 1% of grade.

To properly level the crane, the boom must be positioned over the front of the crane, fully lowered to horizontal and

fully retracted (for cranes fitted with a boom rest, the boom shall be stowed onto the rest). Raise and level the crane using the outriggers; refer to *The crane also allows operations with the outriggers fully retracted.*, page 3-27.

A working crane may settle during lifting operations. Frequently check the crane for level. When rechecking the crane for level, the boom must be positioned over the front of the crane, fully lowered to horizontal and fully retracted (for cranes fitted with a boom rest, the boom shall be stowed onto the rest). If necessary, relevel the crane using the procedures under *The crane also allows operations with the outriggers fully retracted.*, page 3-27.

### Level Indicator Adjustment

The Level Indicator should be checked periodically; if it is suspected that the Level Indicator is out of adjustment, verify and adjust the level as follows:

1. Position the crane on a firm, level surface.
2. Extend and set the outriggers. Level the crane, as indicated by the level indicator, using the outriggers.
3. Place a miracle pointer level, carpenter level, or similar type device on a machined surface such as the turntable bearing or bearing mounting surfaces.
4. Using the outriggers, level the crane as indicated on the leveling device used in step 3.
5. Using the level indicator mounting screws, adjust the level indicator to show level.

## Crane Functions

### Using the Outriggers

The outriggers are operated from the front console in the cab or by using the jog dial on the armrest.



### DANGER

To prevent serious injury or death, keep clear of moving outrigger beams/jacks.

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### DANGER

Death or serious injury could result from improper crane setup on outriggers.

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**WARNING**

Be sure the outriggers are properly extended and set, and the crane is level for operation on outriggers.

All four outrigger beams must be equally extended to the mid position vertical stripe or fully extended position before beginning operation.

**WARNING**

When operating the crane on outriggers, the outriggers should always be fully extended or locked in the mid-extend position.

**NOTE:** The crane also allows operations with the outriggers fully retracted.

**Setting Outriggers**

1. Engage the Parking Brake.

**NOTE:** To enable outrigger functions: The crane must be in four wheel drive, the parking brake must be engaged, the swing brake must be engaged, and all crane functions must be off.

2. Position the outrigger floats directly out from each outrigger to where the outriggers will be properly extended.

**CAUTION****Possible Equipment Damage!**

Always depress one of the outrigger-selector switches before positioning the outrigger extension/retraction switch to extend or retract. Failure to do this may cause a hydraulic lock against the individual solenoid valves, preventing them from opening.

**DANGER****Electrocution Hazard!**

To avoid death or serious injury, keep all parts of this machine, the rigging, and materials being lifted at least 20 feet away from electrical power lines and equipment.

3. If extending the outrigger to the mid-extend or fully extended position, use the Outrigger Function Enable Switch and the CCS menu with either the CCS display buttons or the jog dial to select the outrigger. The

appropriate outrigger beam will extend. Refer to , page 3-28 if the crane is to be operated with any outrigger at the mid-extend position.

**DANGER****Tipping Hazard!**

All four outrigger beams must be deployed to one of three positions before beginning operation, which include fully retracted, mid-extend, or fully extended; do not operate the crane with the outriggers in any other position.

**NOTE:** More than one outrigger beam can be extended at a time. However, to ensure that each outrigger is fully extended, repeat step 3 for each outrigger after a multi-outrigger extension.

4. After deploying the four outrigger beams to one of the three proper positions (fully retracted, mid-extend, fully extended), navigate to the jack operation on the CCS screen and select the jack extend function on the Outrigger Function Enable Switch.

Extend each jack, using either the CCS display buttons or the jog dial, positioning the float as necessary, until the locking levers of the float engage the jack cylinder barrel.

**NOTE:** More than one jack can be extended at a time.

5. Extend the front jacks approximately 8 to 10 cm (3 to 4 in).
6. Extend the rear jacks approximately 8 to 10 cm (3 to 4 in).

**NOTE:** If crane is equipped with tilting cab, ensure cab is in the lowered position before leveling machine.

7. Repeat step 4 until all wheels are clear of the ground and the crane is level as indicated by the level indicator located on the right side of the cab.

**NOTE:** If it is suspected that the level indicator is out of adjustment, verify and adjust the level using the procedures under *Level Indicator Adjustment*, page 3-26.

**DANGER****Tipping Hazard!**

The mid-extend outrigger beam lock pin must be engaged before operating on any beam from the mid-extend position.

For cranes not equipped with an Outrigger Monitoring System (OMS), the operator must select the proper rigging code from the load chart and RCL program for the outrigger position selected. The OMS will NOT change the rigging code to match the existing outrigger position.

### **Outrigger Monitoring System (OMS) (Optional—Standard in North America)**

The Outrigger Monitoring System (OMS) aids the operator in accurately programming the Rated Capacity Limiter (RCL) by automatically identifying the horizontal position of each outrigger beam. The OMS uses four sensors, one per outrigger beam, to indicate when an outrigger beam is positioned to one of three pre-defined locations, including fully retracted, mid-extend, and fully extended.

Set up of the outriggers is the same for cranes equipped with OMS; refer to *The crane also allows operations with the outriggers fully retracted.*, page 27.

If the crane is setup on outriggers and “On Outriggers” is chosen when programming the RCL, then the OMS indicates to the RCL the horizontal position of each of the four outrigger beams. When the outriggers are at the proper position, the screen icon is transparent; if an outrigger is not in the proper position it will be shown as red. The RCL does not lock out the crane or select a different chart based on outrigger position.

### **Engaging Mid Extend Lock Pin**

**NOTE:** It may be necessary to jog the outrigger extension/retraction switch slightly to ensure proper pin engagement.

1. With the outriggers fully retracted, turn the locking pin 90° from its stowed position and allow the pin to slip into the lug on the jack beam. If the pin will not slip into the lug, slowly extend or retract the outrigger beam, allowing the locking pin to drop into the lug.
2. Slowly extend or retract the outrigger beam, allowing the locking pin to drop into the hole in the top of the outrigger beam, engaging the outrigger beam at the desired length.

### **Stowing Outriggers**

**NOTE:** To enable outrigger functions, the crane must be in four wheel drive, the parking brake must be engaged and swing must be off.

1. Use the screen buttons or jog dial with the Outrigger Function Enable Switch to select the left or right rear outrigger on the CCS screen. Retract until the rear jacks have retracted several inches.
2. Use the screen buttons or jog dial with the Outrigger Function Enable Switch to select the left or right front outrigger on the CCS screen. Retract until the front jacks have retracted several inches.

**DANGER**

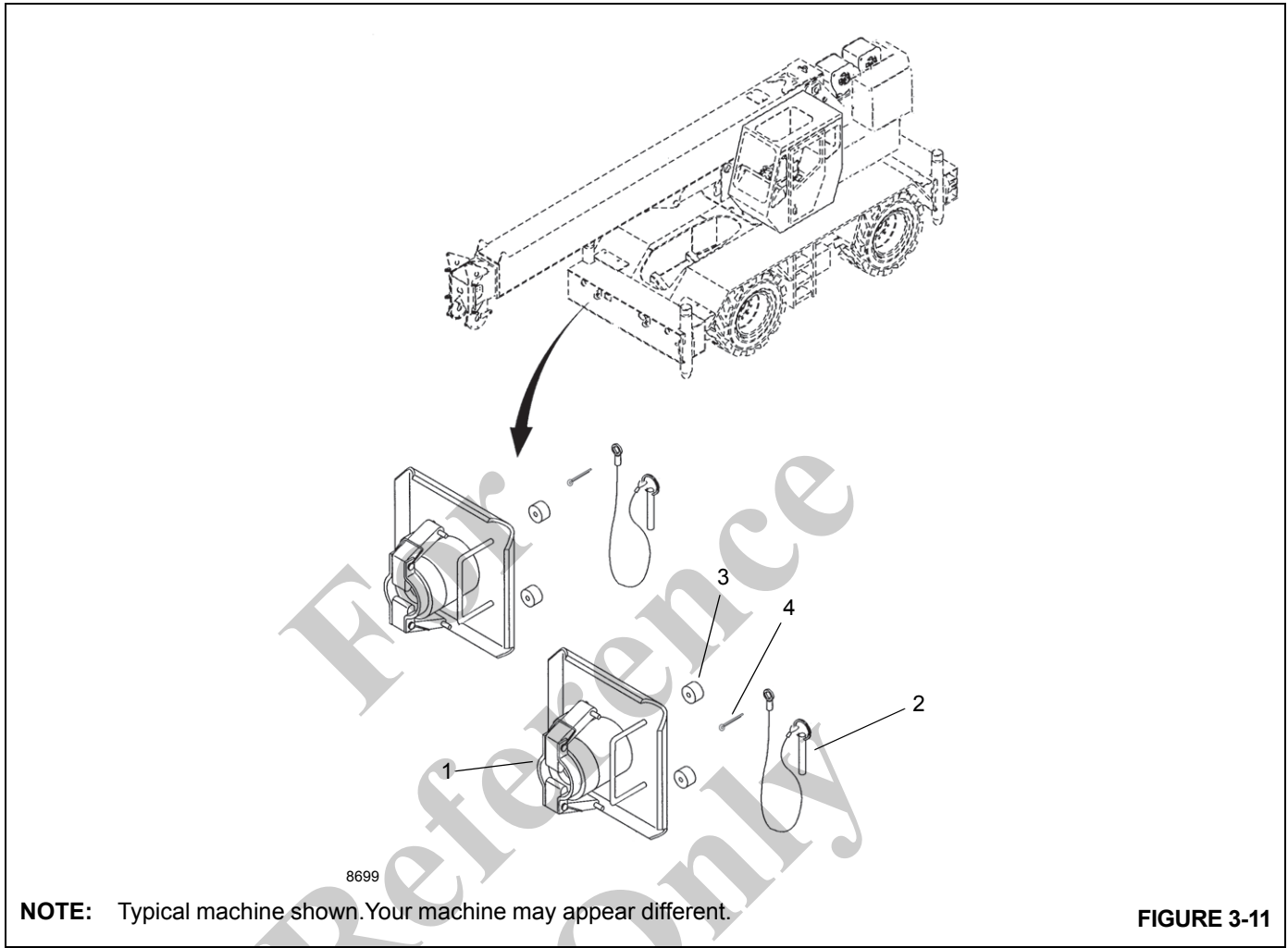
Keep feet and hands clear of floats when unlocking the floats from the jacks.

3. Repeat steps 1 and 2 until the crane is resting on all wheels and the jack floats are several inches off the ground.
  4. Release the locking levers and allow the floats to drop to the ground.
  5. Continue to retract the jacks until they are fully retracted.
  6. Use the screen buttons or jog dial with the Outrigger Function Enable Switch to select and retract each outrigger beam. Refer to *Stowing the Mid-Extend Lock Pin* below if the crane was operated at the mid-extend position.
- NOTE:** More than one outrigger beam may be retracted at a time.
7. After all outriggers are fully retracted, stow outrigger floats (Figure 3-11).

### **Stowing Mid-Extend Lock Pin**

**NOTE:** If the lock pin is wedged in the hole in the outrigger beam, it may be necessary to jog the outrigger extend/retract switch slightly while pulling upward on the pin.





**NOTE:** Typical machine shown. Your machine may appear different.

**FIGURE 3-11**

1	Outrigger Float Assembly	3	Rubber Bumper
2	Quick Pin With Lanyard	4	Cotter Pin

**Swinging the Superstructure**

 **DANGER**  
**Crushing Hazard!**

Death or serious injury could result from being crushed by moving machinery. Before activating swing, sound the steering wheel horn and verify that all personnel are clear of rotating and moving parts.

Keep the area beneath the boom clear of all obstructions and personnel when lowering the boom.

The operator must select the proper load chart and RCL program for the outrigger position selected.

**CAUTION**

Never push or pull the swing control lever through neutral to the opposite direction to stop swing motion. The automatic swing brake is activated by the control lever to stop swing rotation.

To swing the boom, activate the Swing Enable Switch, push the control lever on the left hand armrest to the right for right swing (rotates turntable clockwise), or to the left for left swing (rotates turntable counterclockwise). Always operate the control lever with a slow, even pressure.

**NOTE:** The swing brake activates automatically, when the control lever is returned to the stop or neutral position, to prevent further rotation.

**Elevating and Lowering the Boom**

**Elevating the Boom**

 **DANGER**  
**Crushing Hazard!**

Keep the area above and below the boom clear of all obstructions and personnel when elevating the boom.

1. To elevate the boom, activate the Lift Enable Switch, push the controller on the right hand armrest to the left (raises the boom), and hold until the boom reaches the desired elevation.

**Lowering the Boom**

 **DANGER**

**Crushing and/or Tipping Hazard!**

Keep the area beneath the boom clear of all obstructions and personnel when lowering the boom.

Long cantilever booms can create a tipping condition, even when unloaded and in an extended, lowered position.

 **WARNING**  
**Machine Damage!**

When lowering the boom, simultaneously let out the hoist cable to prevent two-blocking the boom nose and hook block.

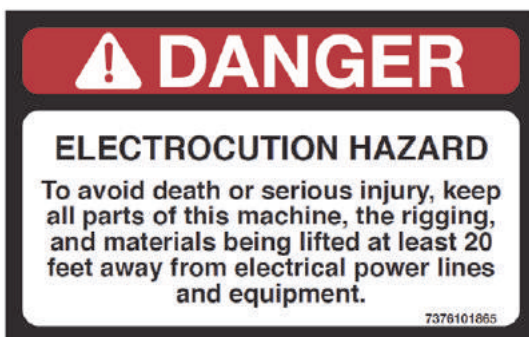
**CAUTION**

The closer the load is carried to the boom nose, the more important it becomes to simultaneously let out the hoist cable as the boom is lowered.

1. To lower the boom, activate the Lift Enable Switch, push the controller on the right hand armrest to the right (lowers the boom) and hold until the boom is lowered to the desired position.

**Telescoping the Boom**

**NOTE:** The telescope function is controlled by a foot pedal if the crane is equipped with an auxiliary hoist.



## Extending the Boom



### **DANGER** Crushing Hazard!

Check the *Load Chart* for the maximum load at a given radius, boom angle, and length before extending the boom with a load.

### **CAUTION**

Before extending the boom, ensure the large access cover on top of the boom base section is installed.

When extending the boom, simultaneously let out the hoist cable to prevent two-blocking the boom nose and hookblock.

To extend the boom on cranes with no auxiliary hoist, activate the Telescope Enable Switch, push the controller on the left hand armrest forward and hold until the boom reaches the desired length.

## Retracting the Boom



### **DANGER** Crushing Hazard!

When retracting the boom, the load will lower unless the hoist cable is taken in at the same time

To retract the boom on cranes with no auxiliary hoist, activate the Telescope Enable Switch, pull the controller on the left armrest back and hold until the boom retracts to the desired position.

## Telescope Control Pedal

The telescope control pedal is used on cranes equipped with an auxiliary hoist. Activate the telescope function with the Telescope Enable Switch, then push on the top of the pedal to extend the boom or push on the bottom of the pedal to retract the boom.

## Lowering and Raising the Hoist Cable



### **DANGER** Crushing Hazard!

Keep the area beneath the load clear of all obstructions and personnel when lowering or raising the cable (load).



### **DANGER** Crushing Hazard!

Do not jerk the control lever when starting or stopping hoist. Jerking the lever causes the load to bounce, which could result in possible damage to the crane.

**NOTE:** When the load is stopped at the desired height, the automatic brake will engage and hold the load as long as the controller remains in neutral.

## Lowering the Cable

Turn on the Hoist Enable Switch, push the main hoist (right hand armrest) or auxiliary hoist (left hand armrest) controller forward, away from the operator, and hold until the hook or load is lowered to the desired height.

## Raising the Cable

Turn on the Hoist Enable Switch, pull the main hoist (right hand armrest) or auxiliary hoist (left hand armrest) controller, toward the operator, and hold until the hook or load is raised to the desired height.

## Hoist Speed Range Selection

While there is no separate hoist speed switch on a CCS crane, high speed may be activated in one of several ways:

1. When enabling the function, hold the hoist selector switch for 1.5 seconds.
2. When enabling the function, double click the hoist enable switch.
3. On a dual axis joystick, tap the thumb rocker switch towards the operator to enable/disable high speed (persistent state).
4. On a dual axis joystick, hold the thumb rocker switch away from the operator to temporarily enable/disable high speed (momentary state). High speed mode is disabled when the rocker switch is released.

### **CAUTION**

Do not change speeds while the hoist is active.

### Stowing and Parking

When parking the crane, do the following:

**! DANGER**  
**Tipping Hazard!**

Never park crane near holes, on rocky surfaces, or on soft spots. This may cause crane to overturn, resulting in injury or death to personnel.

1. Remove the load from the hook.
2. Remove or stow boom extensions if so equipped.
3. Fully retract all boom sections.
4. Lower the boom to normal travel position.
5. Engage the swing brake and swing lock pin.
6. Retract all jack cylinders and outrigger beams.
7. Park the crane on a stable surface.
8. Apply the parking brakes and if necessary, chock wheels.
9. Ensure all operating controls are in neutral position.
10. Shut down engine following proper procedures specified in this *Operator Manual* and the applicable engine manual.
11. Remove the keys.
12. Close and lock, if applicable, all windows, covers, and doors.
13. Turn battery disconnect to OFF position if machine will be inactive for over 24 hours (Figure 3-7).

### Unattended Crane

**! WARNING**  
**Tipping Hazard!**

Changing weather conditions including, but not limited to, wind, ice accumulation, precipitation, flooding, lightning, etc. should be considered when determining the location and configuration of a crane when it is to be left unattended.

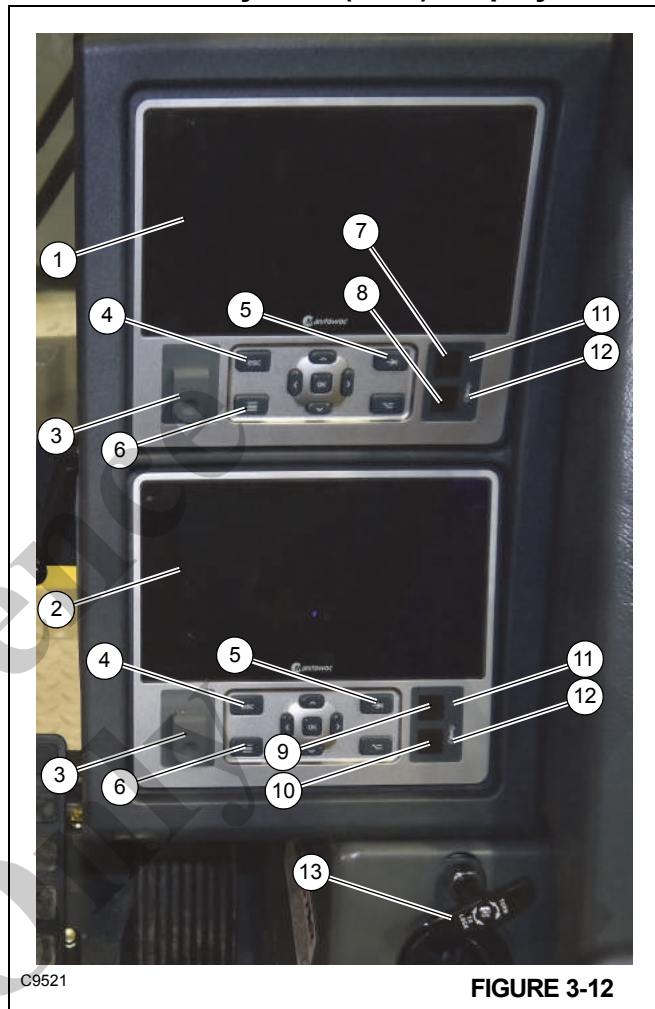
Failure to comply with these instructions may cause death or serious injury.

The configuration in which the crane should be left while unattended shall be determined by a qualified, designated individual familiar with the job site, configuration, conditions, and limitations.

### CRANE CONTROL SYSTEM (CCS)

The CCS includes a cab control unit and control modules distributed over the superstructure and carrier.

#### Crane Control System (CCS) Display



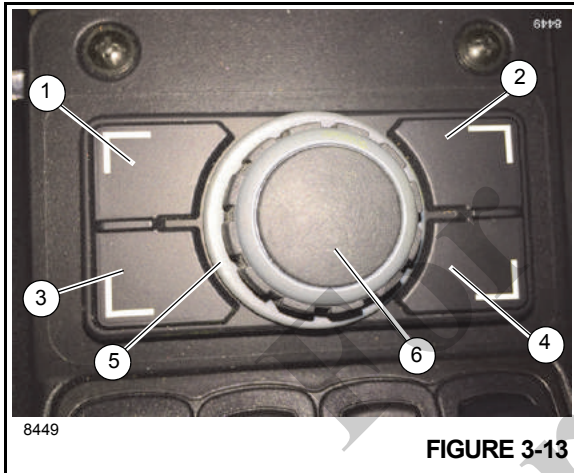
C9521

FIGURE 3-12

1	Rated Capacity Limiter (RCL) Display
2	CCS Operation Display
3	USB Diagnostic Connector
4	Escape Button
5	Tab Button
6	Menu Button
7	RCL Shutdown Warning Indicator
8	RCL Early Warning Indicator
9	Anti Two-Block Indicator
10	Swing Brake Engaged Indicator
11	Brightness Sensor
12	Internal Temperature Warning Indicator
13	Turntable Pin Swing Lock Control

**Menu Control**

The Jog Dial operates the CCS identically to the buttons on the display console, providing easier access for the operator. Spinning the jog dial performs the same function as the navigation arrow buttons on the display console. The icon in the lower left corner of the display screen reminds the operator which display is being controlled by the jog dial at that time. The Screen Toggle Button (4) (Figure 3-13) is used to switch screens. The tab button can also be used to temporarily silence audible alarms. The functionality of the other buttons is different depending on the area, screen and menu.



**FIGURE 3-13**

1	Escape Button
2	Tab Button
3	Menu Button
4	Screen Toggle Button
5	Jog Dial (Rotate dial to move cursor)
6	OK/Enter Button (Press Jog Dial to select)

**Turntable Lock Control (Pin Type)**

The Swing Lock Pin Control Handle (13) (Figure 3-12) is located beside the front console on the right side of the cab. The purpose of the swing lock pin is to lock the superstructure in position directly over the front for pick and carry loads. When the control handle is pushed down and the superstructure is directly over the front, the swing lock pin drops into the socket on the carrier frame, locking the superstructure in place. When the control handle is pulled up, the pin is pulled out of the socket, unlocking the superstructure.

**Sensors**

There is a Temperature Sensor (12) and a Brightness Sensor (11) (Figure 3-12). The Brightness Sensor automatically adjusts the brightness of all displays.

CCS Main Screen Symbols and Icons

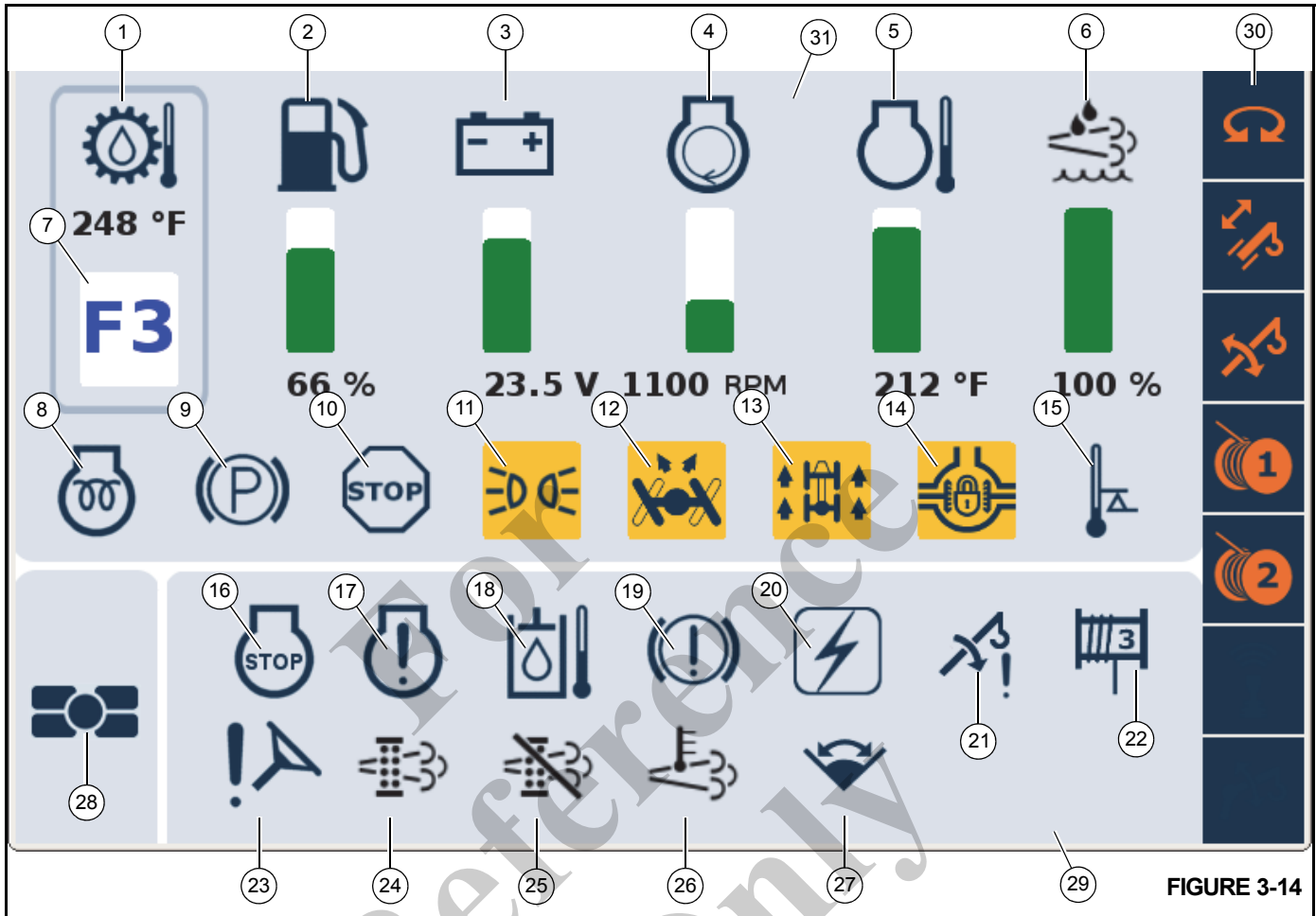


FIGURE 3-14

1	Transmission Temperature	17	Engine Warning Indicator
2	Fuel Level	18	Hydraulic Oil Temperature
3	Battery Voltage	19	Low Brake Pressure
4	Engine Speed (Tachometer)	20	System Fault
5	Engine Coolant Temperature	21	Boom Angle Too Low (Optional)
6	Diesel Exhaust Fluid (Optional)	22	Third Wrap Indicator (Optional)
7	Direction/Gear Number	23	Low Steering Pressure (Optional)
8	Engine Warm-up Indicator (Wait-to-start)	24	Regen Needed (Optional)
9	Park Brake	25	Regen Inhibited (Optional)
10	Emergency Stop	26	High Exhaust Temperature (Optional)
11	Marker/Position/Side Light	27	Work Range Limiter Indicator (Optional)
12	Rear Wheels Not Centered	28	Active Screen Indicator
13	Four-Wheel Drive Indicator	29	Alerts Area
14	Differential Lock Indicator (Optional)	30	Status Bar
15	Cold Temperature Warning (Optional)	31	Status Area
16	Engine Stop		

CCS Menu Screen

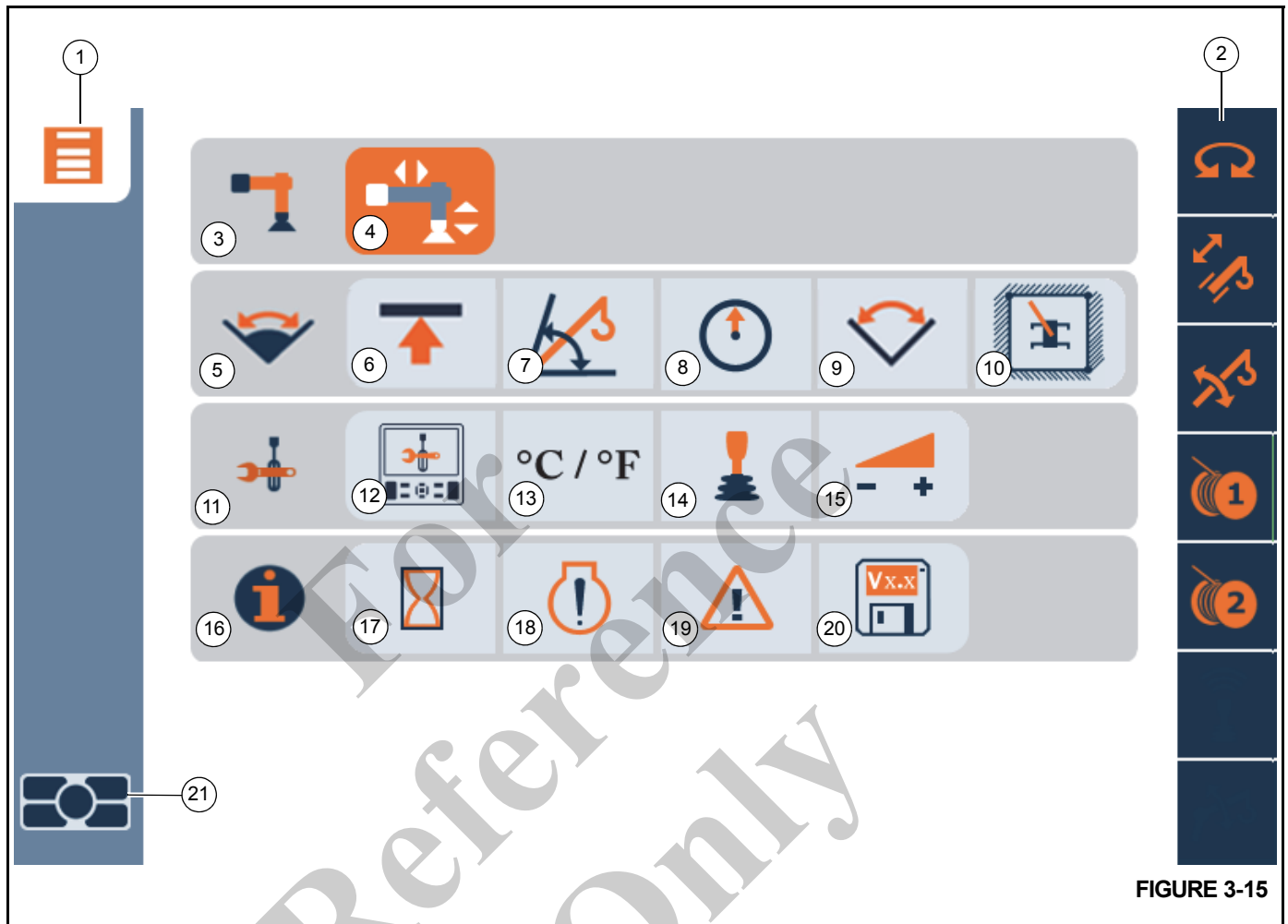


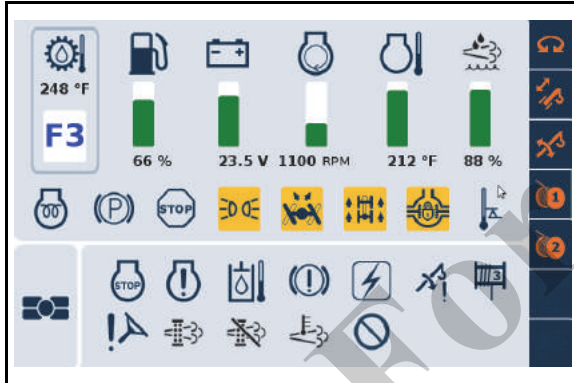
FIGURE 3-15

1	Menu Screen Indicator	12	Display Brightness Settings
2	Status Indicator Bar	13	Standard/Metric Display
3	Outrigger Group	14	Control Lever Settings
4	Outrigger Button	15	Function Speed Setting
5	WRL Swing Group	16	Information Group
6	WRL Height Limit	17	Operating Hours
7	WRL Boom Angle Limit	18	Engine System Warning
8	WRL Swing Angle Limit	19	Crane Error
9	WRL Radius Limit	20	Software Revision
10	WRL Virtual Wall Limit	21	Active Screen Indicator
11	Tools Group		

**CCS Operation Display**

There are three different levels: The Main Screen, the Menu Screen and the Sub Level menus.

The main screen (below) appears on the operating display (lower screen) when the key is turned on. The main screen displays the status of the crane systems. The amber lit icons are enabled. It also displays data from codes on other screens. The operator can choose and activate areas from this screen. The Escape Button (1) (Figure 3-13) defaults back to the main screen.



When one of the icons on the right side vertical bar is flashing, it indicates that the joystick was not at a zero position when either the function enable button or the all crane functions button was pressed. To enable the function, the operator must move the joystick to the center/no motion position, then try to enable the function again.

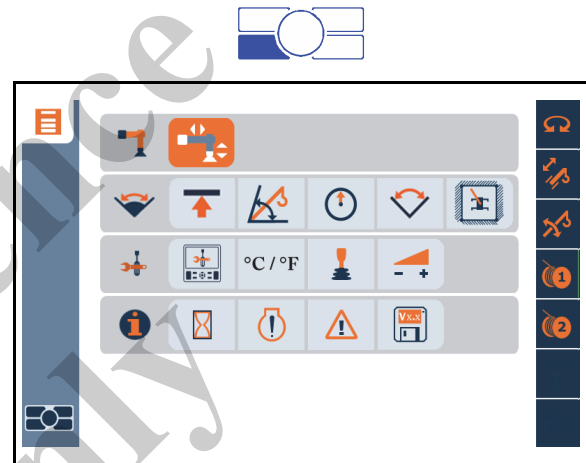
For example, if the Swing Enable icon is flashing, it is NOT enabled. To enable swing, the operator must allow the Swing Enable joystick to move to the center/no motion position, then try to enable the swing function again

**Menu Screen**

When the menu button on the jog dial (3) (Figure 3-13) or control panel of the CCS is pressed, the overview of the menu groups appears, for opening menus and sub-menus.

The menu buttons are categorized by groups. Each group has its own group icon that is displayed at the beginning of each group bar. Each group has its own member buttons, such as telescope group has 3 member buttons.

A symbol is selected with the jog dial or the arrow keys to call up a menu. The selected symbol is shown in orange. A menu is opened by pressing the jog dial or the OK button on the control panel. There is always one symbol shown selected. In this case, it is the outrigger function. Press the jog dial enter button for the Outrigger Operation Menu.





### RATED CAPACITY LIMITER (RCL) SYSTEM

The Rated Capacity Limiter (RCL) is an electro-mechanical sensing system designed to alert the crane operator of impending capacity when the system has been properly preset by the operator. The control panel is mounted in the front console of the operator cab. When an overload condition is sensed, the system provides the operator with a visual and audible warning, and locks out the control levers to prevent lowering the boom, extending the boom, or raising the main or auxiliary hoist cables.

Three additional features are included within the RCL system:


- Swing Angle Set Limitation
- Working Range Limiter
- Anti-two Block Device

**Swing Angle Set Limitation** allows left and right swing angle to be preset. When the preset angle is reached, the system will provide an audible warning.

**Working Range Limiter** allows the crane operator to describe the crane’s working area by setting up “virtual walls”. They are referred to as virtual walls because they exist in the system and are not real walls. The virtual walls represent obstacles (i.e. buildings, towers, poles, etc.) in the crane’s working range. They are set by defining points along the outer limits of the working area with the tip of the boom. Once the working area has been defined, the system will provide both a visual and an audible warning if the boom approaches a virtual wall.

The RCL Setup Screen appears on the RCL Display (upper screen) when the key is turned on. The operator can select the rigging first, or go directly into the setup wizard.

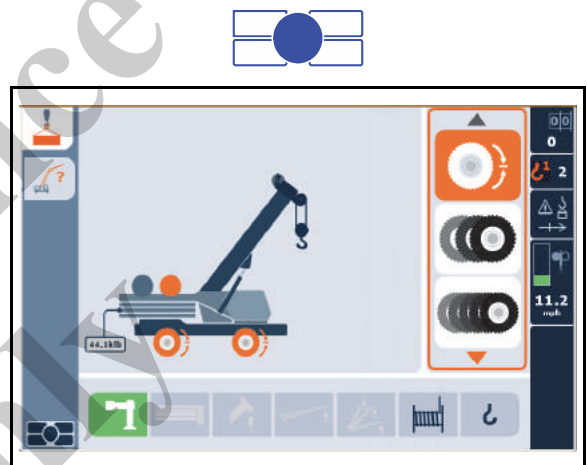



DANGER

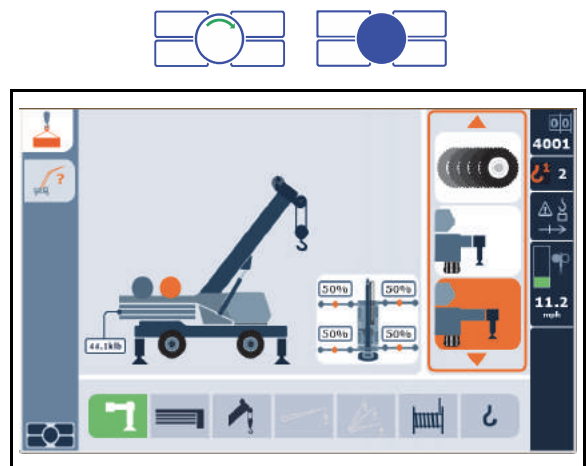
Electronic equipment on this crane is intended as an aid to the operator. Under no condition should it be relied upon to replace the use of capacity charts and operating instructions. Sole reliance upon these electronic aids in place of good operating practices can cause an accident.

### Mode of Operation

The rigging options on this screen enable the operator to select static rubber, pick and carry or outrigger configuration. The Outrigger Operation Menu is navigated on the lower CCS Screen.



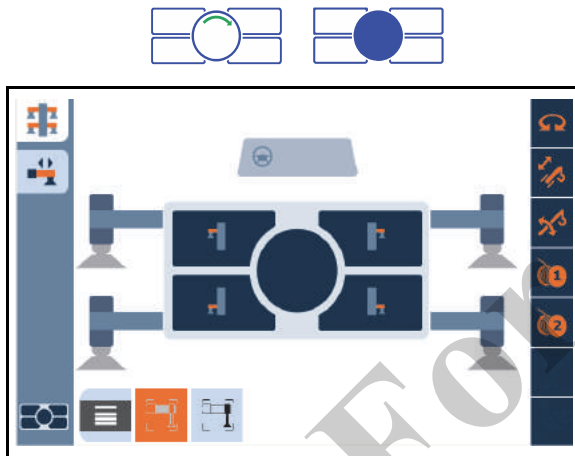
To choose one of the outriggers’ proper positions, fully retracted, mid-extend or fully extended.



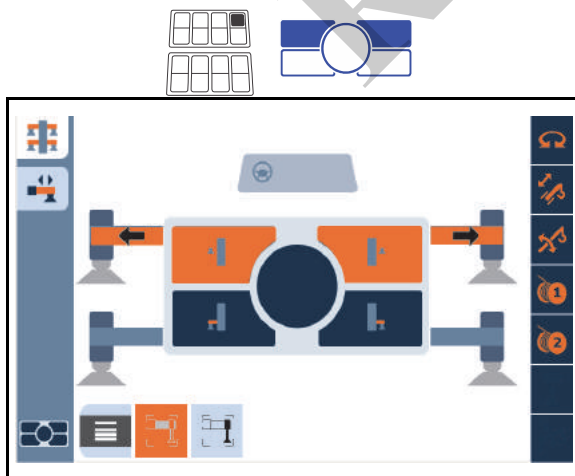
### Outrigger Operation Menu

For choosing options during rigging. This is the only function where the menu button (3) (Figure 3-13) will not automatically navigate directly to the menu screen. It must be selected and chosen with the menu icon on the lower left of this screen

#### Set the outriggers

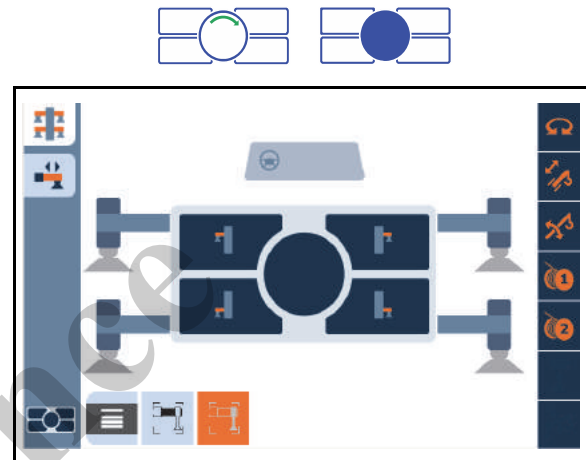


The operator can choose which beam, or combination of beams, to extend or retract. Press the top of the Outrigger Function Enable Switch on the left armrest to select outrigger extension.

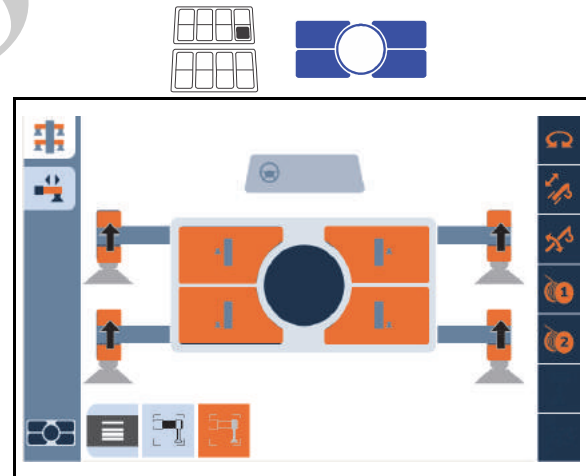


### Raising the Jacks

Spin the jog dial clockwise and press OK button to select and choose jack operation. Press the lower side of the Outrigger Function Enable Switch on the left armrest to enable jack operation.

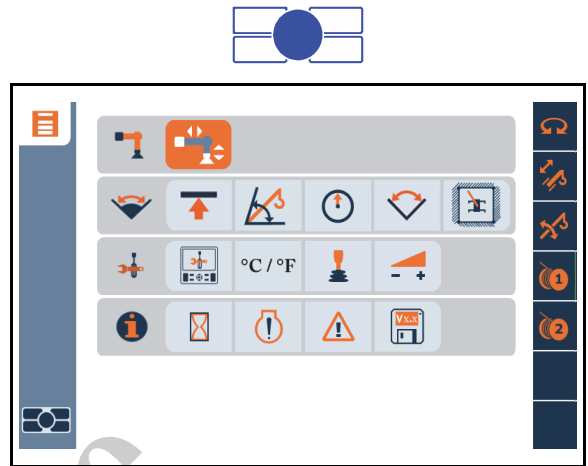
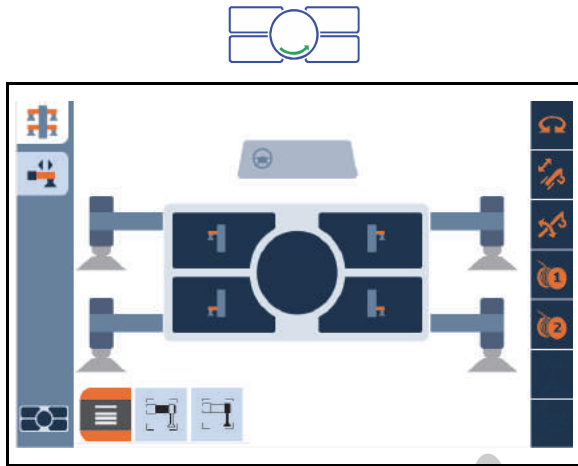


The operator can now choose which jack, or combination of jacks, to raise or lower.



Toggle counterclockwise and select the menu icon to exit this group.

Press OK/enter button on display or jog dial (6) (Figure 3-13) to exit the outrigger screen.

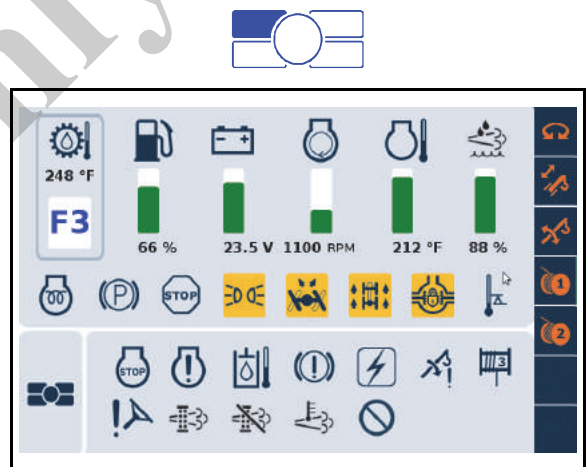


**CAUTION**

The operator must select the proper load chart and RCL program for the outrigger position selected.

Press escape button (1) (Figure 3-13) to leave menu and return to CCS main screen. The operator can now navigate to the RCL screen.

Reference Only



**RCL Setup Wizard**

The RCL can be set graphically, or by direct number input or rigging code. The rigging code is determined using the load chart. This screen always appears with some rigging code displayed, even if it does not match the actual crane configuration.



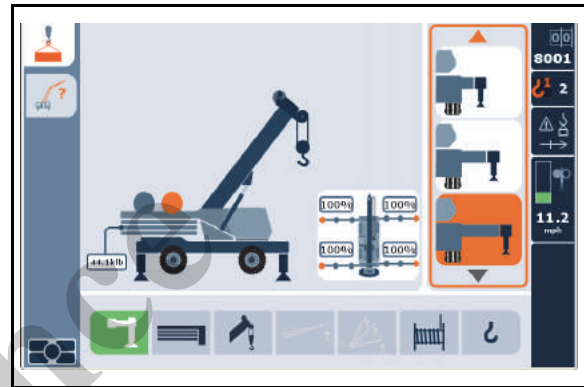
The RCL is working correctly at this point if no error message is showing. If any fault codes are present, the fault indicator on the main CCS screen will be illuminated in red.

**NOTE:** If the RCL is not working correctly, do not start work with the crane but notify Manitowoc Crane Care.

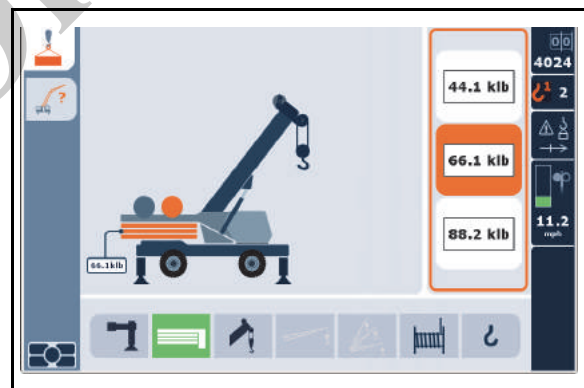
**Set the Counterweight**

When rigging is complete, the operator can toggle clockwise to exit the outrigger position and move on to setting the counterweight.

**NOTE:** Rough Terrain cranes have a fixed counterweight; for them, the next function will be setting the boom.



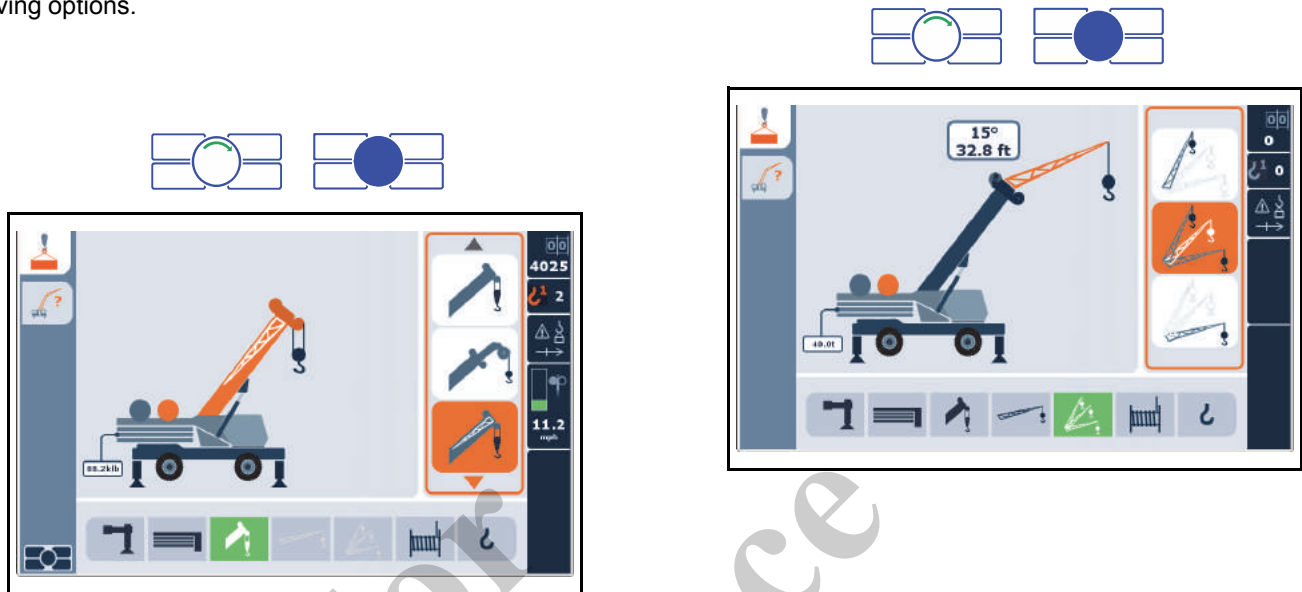
Toggle clockwise and select the counterweight icon. The available choices will assemble on the right of the screen.



**NOTE:** When the RCL override icon (above, the third icon from the top on the status indicator bar on the right) is flashing, it means that the override switch was active at crane startup. In this case the override is NOT active. To override the RCL, turn the switch OFF for 1 second. Then, the override can be turned ON again, and the RCL will be bypassed.

**Set the Boom**

Turn jog dial clockwise to set boom, including aux nose and reeving options.



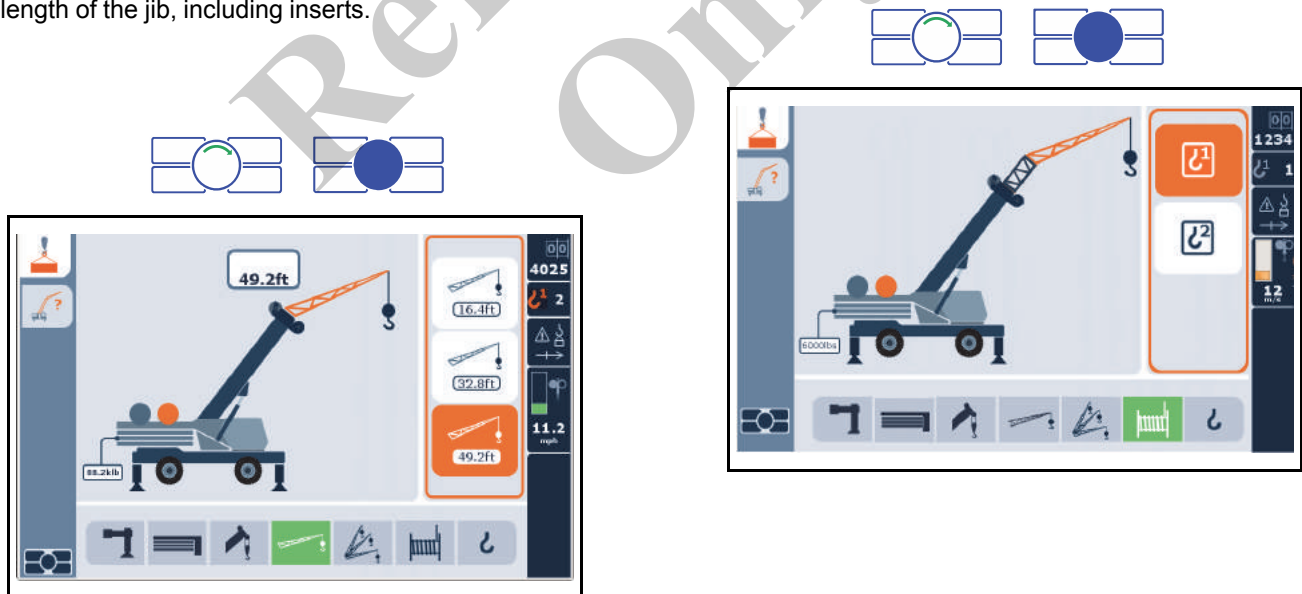
**NOTE:** If no jib configuration is chosen for the boom, the following selection will be for reeving.

**Hoist Selection**

Turn jog dial clockwise to select between the main and optional auxiliary hoists.

**Set the Jib Length (if installed)**

Turn jog dial clockwise and select to determine and choose the length of the jib, including inserts.

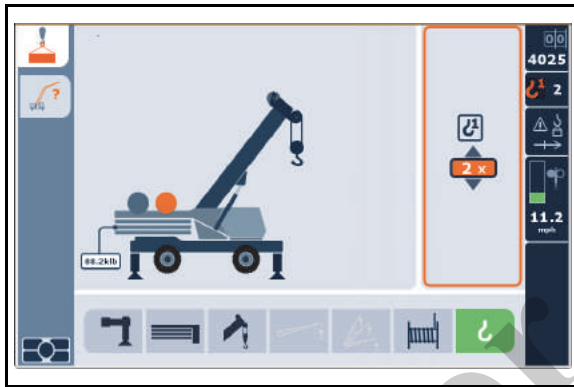
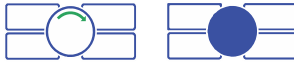


**Set the Jib Angle (if installed)**

Turn jog dial clockwise to program the jib angle after the length is selected.

**Reeving Selection**

Turn jog dial clockwise to select the icon for reeving options. Press ENTER a second time and turn dial to change reeving number options.



Press ENTER button on Jog Dial to choose and set the desired reeving option and move on to the next screen.

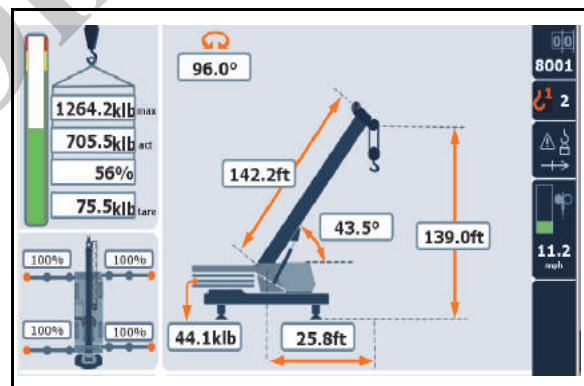
**Switch to RCL Home Screen Display**

Press Screen Toggle button (4) (Figure 3-13) on the Jog Dial menu control to switch to the RCL main menu screen.

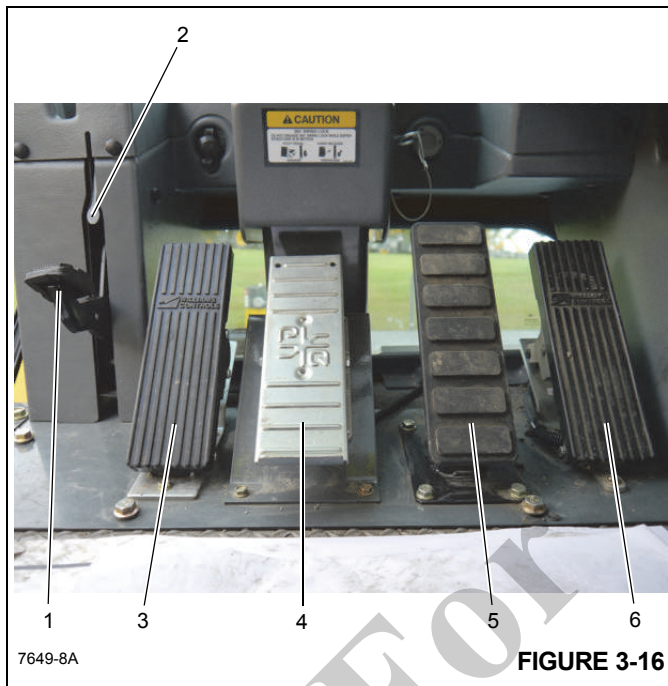


Press ENTER on Jog Dial or Menu button to access RCL Main Screen. This screen appears after the key is turned on, but the operator must press the tab button to display the tare value.

Reference Only



**FOOT PEDAL CONTROLS**



7649-8A **FIGURE 3-16**

1	360° Swing Lock Pedal
2	360° Swing Lock Release Lever
3	Swing Brake Pedal
4	Telescope Control Foot Pedal (Optional)
5	Service Brake Pedal
6	Foot Throttle Pedal

**360° Swing Lock Pedal**

The 360° Swing Lock Pedal (1) (Figure 3-16) is located on the left side of the crane cab floor. The pedal is used to activate the swing lock to prevent the superstructure from turning. To release the swing lock, pull up on the 360° Swing Lock Release Lever (2).

**Swing Brake Pedal**

The Swing Brake Pedal (3) (Figure 3-16) is located on the left side of the cab floor. The swing brake pedal is used to actuate the swing brake to slow or stop swing motion. Braking is proportional to pedal depression. With the pedal not depressed and the swing brake control valve disengaged, hydraulic pressure is applied to the brake, overcoming spring pressure and releasing the brake. Depressing the pedal actuates a swing power brake valve to apply pressure to the brake assembly. This pressure aids the spring pressure to overcome the hydraulic pressure being applied to the brake release circuit and applies the spring brake according to the pressure from the swing power brake valve.

**Telescope Control Pedal (Optional)**

The Telescope Control Pedal (4) (Figure 3-16) is supplied when the crane is equipped with an auxiliary hoist, is located in the middle of the cab floor. Pushing forward on the top of the pedal will extend the boom and pushing down on the bottom of the pedal will retract the boom.

**Service Brake Pedal**

The Service Brake Pedal (5) (Figure 3-16) is the second pedal from the right on the cab floor. Depressing the pedal controls the application of the service brakes.

**Foot Throttle Pedal**

The Foot Throttle Pedal (6) (Figure 3-16) is located on the right side of the floor. It is used to control engine RPM which increases or decreases proportionately with the amount of foot pressure applied to the pedal. The pedal is electrically connected to the superstructure control module which sends the signal to the engine ECM via the J1939 data link.

**MISCELLANEOUS CONTROLS AND INDICATORS**

**Fuse Panel**

The fuse panel (1) (Figure 3-17) is located behind the cab seat on the cab fuse and relay panel assembly. It contains up to 20 fuses that protect the various electrical components of the crane.

**Buzzer**

The buzzer in the display sounds when the following conditions exist:

- Engine Alarms
- Emergency Stop Switch activated
- Low brake pressure
- High hydraulic oil temperature
- High transmission oil temperature
- Low steer pressure condition (for CE units)
- Hoist third wrap condition (for CE units)
- Anti Two-Block alarm
- Engine compartment protection program



## RCL Emergency Override Switch (Non-CE Certified Cranes)



### WARNING

#### Loss of RCL Monitoring Hazard!

The RCL Emergency Override switch is to be used in emergency situations only.

Do not operate the crane with the RCL overridden during normal operations.

When the RCL is overridden always have a helper on the ground to signal you.

The RCL system, when programmed accurately, will lockout nearly every crane function—boom up/down, telescope extend/retract, hoist up and swing left/right—when a lift is attempted at or above the crane's capacity or when a two-block condition exists. Only the particular function(s) that cause the existing lockout condition are blocked. Locking out these functions prevents the overload or two-block condition from worsening.

The RCL emergency override switch (2) (Figure 3-17) is a key operated switch that is located inside the operator cab on the panel assembly behind the seat. When actuated (turned clockwise), the switch will override and prevent the RCL from locking out craning functions (Third Wrap Limit and Anti Two-Block) should an overload condition occur. Turn the key counterclockwise to bypass the Anti Two-Block Switch, Telescope extend/retract, 3rd Wrap Indicator (hoist lowering limit) and Boom up/down.

Overriding the RCL with this switch should only be done in the case of an emergency or when servicing the boom.

A flashing light on the RCL display indicates the switch has been activated.

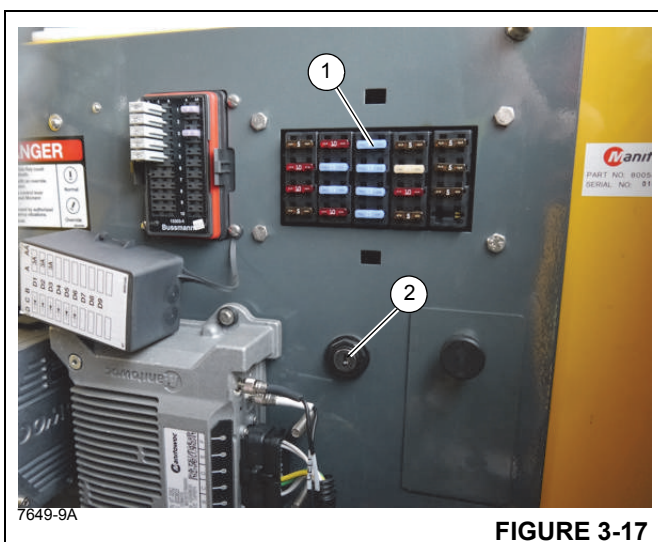


FIGURE 3-17

## RCL Emergency Override Switch and Indicator (CE Certified Cranes)



### WARNING

#### Loss of RCL Monitoring Hazard!

The RCL Emergency Override Switch is to be used in emergency situations only.

Do not operate the crane with the RCL overridden during normal operations.

When the RCL is overridden, always have a helper on the ground to signal you.

The RCL system, when programmed accurately, will lockout nearly every crane function—boom up/down, telescope extend/retract, hoist up and swing left/right—when a lift is attempted at or above the crane's capacity or when a two-block condition exists. Only the particular function(s) that cause the existing lockout condition are blocked. Locking out these functions prevents the overload or two-block condition from worsening.

The RCL emergency override switch is located inside a key-locked single-door enclosure (1) (Figure 3-18) that is attached to the outside rear of the operator's cab. The switch is a two-position momentary rocker switch that, when actuated, will override and prevent the RCL, for a period of 30 minutes, from locking out craning functions (boom down, telescope extend, third wrap limit and hoist up) should an overload condition occur.

The other RCL emergency override switch (19) (Figure 3-6) is a key operated switch that is located inside the operator cab below the CCS screen, in front of the Emergency Stop Switch. When actuated (turned clockwise), the switch will override and prevent the RCL from locking out craning functions (Third Wrap Limit and Anti Two-Block) should an overload condition occur. Turn the key counterclockwise to bypass the Anti Two-Block Switch, Telescope extend/retract, 3rd Wrap Indicator (hoist lowering limit) and Boom up/down.

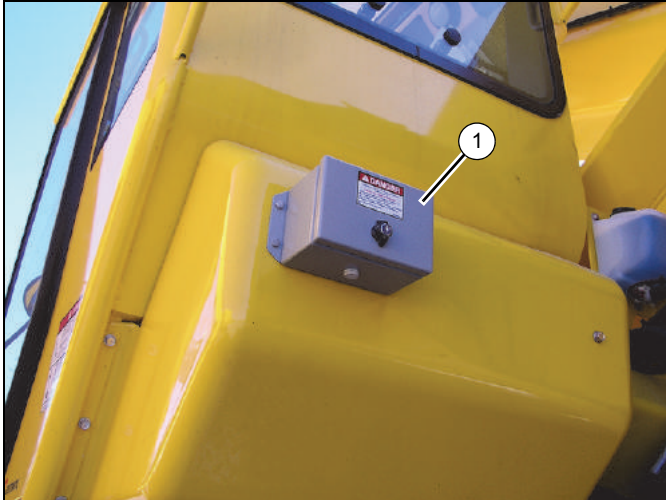
Overriding the RCL with this switch should only be done in the case of an emergency or when servicing the boom.

Upon activation, all craning function movements are reduced to 15% of their normal maximum speeds.

The RCL override function is automatically cancelled after 30 minutes. The RCL override function can also be cancelled by the operator by either pressing the RCL emergency override switch a second time or by turning off the engine. However, turning off crane functions does not disable the RCL override.

**NOTE:** Before powering up crane, ensure that the RCL Override Switch is in the Normal (not Override) position to avoid an error code.





7649-36

FIGURE 3-18

### RCL Internal Light Bar (Optional)

The Rated Capacity Limiter (RCL) Internal Light Bar is located on the upper left hand corner of the crane cab. The RCL is an operational aid that warns a crane operator of approaching overload conditions and other conditions that could cause damage to equipment and personnel.

### Strobe Light or Beacon (Optional) (Not Shown)

The strobe light or beacon is on the right side of the superstructure. It is on when the ignition switch is on.

















### Backup Alarm (Not Shown)


















The backup alarm is an audio system used to warn personnel outside the crane when the crane is backing up. The alarm system is electrical and consists of the backup alarm and its associated wiring. The alarm is connected to the electrical wiring for the transmission reverse solenoids. It is activated when the transmission shifter is in the reverse position. The backup alarm is installed in the rear outrigger box behind the grill plate.
















### Emergency Exit

















The windshield is considered the Emergency Exit. In an emergency, push out on the windshield and escape through the opening.

Appendix A: Crane Control System (CCS) Symbols and Icons

Symbol	Description
	3rd Wrap Warning
	4-Wheel Drive
	Auxiliary Hoist Status
	Auxiliary Hoist Disabled
	Auxiliary Hoist Enabled
	Auxiliary Hoist Raise
	Auxiliary Hoist Not In Use
	Auxiliary Hoist Lower
	Battery Voltage
	Boom Lift Status
	Boom No Load Chart
	Bypass 1 Active
	Bypass 2 Active
	Bypass 3 Active
	Bypass 1 Pressed
	Bypass 2 Pressed

Symbol	Description
	Bypass 3 Pressed
	Coolant Temp
	Differential Lock
	Engine Preheat
	Engine Speed (RPM)
	Engine Warning (Error)
	Emergency Stop
	Fuel Level
	Hoist Limit Switch Shutdown
	Hydraulic Oil Temp
	Information Group
	Jib Angle Difference
	Jib Angle Too High
	Jib Angle Too Low
	Jib Load Too High
	Jib No Load Chart
	Load Too Low

Symbol	Description
	Low Brake Pressure
	Low Steering Fluid Pressure
	Main Hoist Status
	Main Hoist Disabled
	Main Hoist Enabled
	Main Hoist Raise
	Main Hoist Not In Use
	Main Hoist Lower
	Marker/Position/Side Light <i>THIS PAGE BLANK</i>
	Rear Wheels Not Centered
	Oil Feed Filter Contaminated
	Outrigger Button
	Outrigger Front Left
	Outrigger Front Right
	Outrigger Group
	Outrigger Rear Left
	Outrigger Rear Right
	Park Brake

Symbol	Description
	RCL Override
	Status Light Bar Error
	Swing Status
	Swing Brake
	Swing Group
	SLI Early Warning
	SLI Shutdown
	Swing Brake
	Telescope Status
	Tools Group
	Transmission Temperature Warning
	Transmission Status
	WRL Area Limit
	WRL Height Limit
	WRL Radius Limit
	WRL Swing Angle Limit

*For  
Reference  
Only*

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## SECTION 4 SET-UP AND INSTALLATION PROCEDURES

### SECTION CONTENTS

<b>General</b> .....	<b>4-1</b>	Dead-end Rigging .....	<b>4-7</b>
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### GENERAL

This section provides procedures for installing the hoist cable on the hoist drum, cable reeving, and erecting and stowing the boom extension.

### INSTALLING CABLE ON HOIST

#### CAUTION

If cable is wound from the storage drum, the reel should be rotated in the same direction as the hoist.

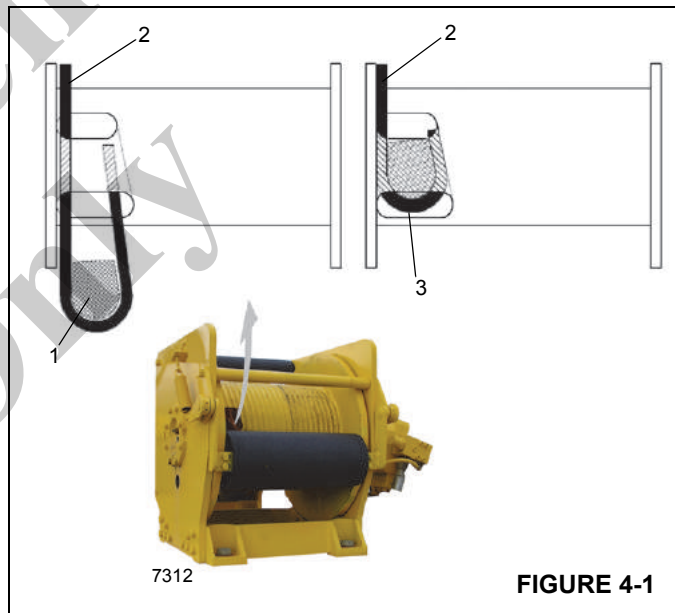
**NOTE:** The cable should preferably be straightened before installation on the hoist drum.

Install cable on the hoist drum in accordance with the following procedure.

1. Position the cable over the boom nose sheave and route to the hoist drum.
2. Position the hoist drum with the cable anchor slot on top.
3. Insert the cable through the slot and position around the anchor wedge (1) (Figure 4-1).

**NOTE:** The end of the cable should be even with the bottom of the slot for the anchor wedge.

4. Position the anchor wedge in the drum slot; pull firmly on the free end (2) of the cable to secure the wedge.
5. Slowly rotate the drum, ensuring the first layer of cable is evenly wound onto the drum.
6. Install the remainder of the cable, as applicable.



**FIGURE 4-1**

**NOTE:** If the wedge does not seat securely in the slot, carefully tap (3) the top of the wedge with a mallet.



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**ANTI TWO BLOCK (A2B) SWITCH**

If a hoist rope has been reeved and two A2B switches are installed, the unused A2B switch must be locked (disabled) to allow all crane operations.

**Lock**

**CAUTION**

If the A2B switch is locked (disabled), the hook block could hit the main boom head or extension, resulting in damage to the hook block, main boom head or extension, and hoist rope. Never lock an A2B switch with a switch weight attached.

1. Remove A2B weight.
2. (A) Remove cap (1) from switch.
3. Pull lanyard (2) down.
4. (B) Secure lanyard (2) in this position using cap (1). A2B switch is locked (disabled).

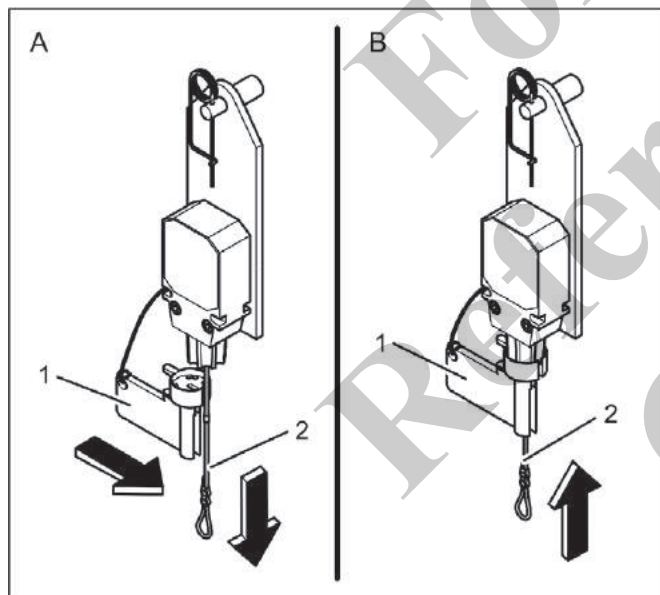
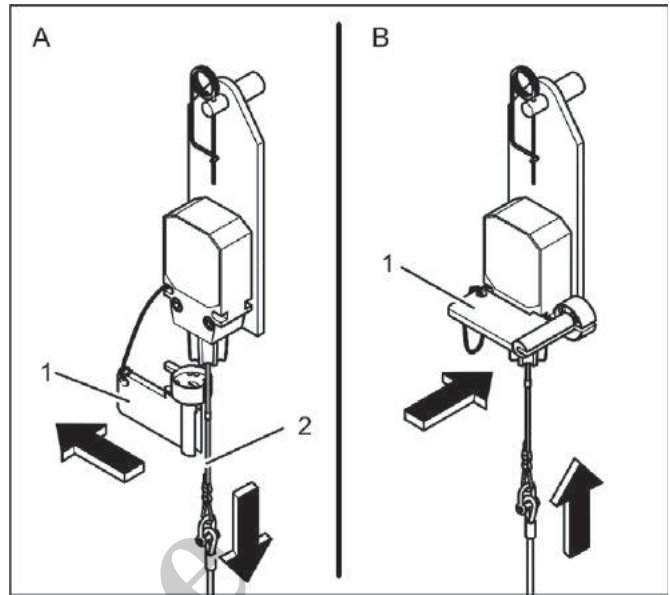


FIGURE 4-2

**Unlock**

**NOTE:** Always remove the switch lock (enable) before installing an A2B weight around the hoist rope.

1. (A) Pull down lanyard (2) and remove cap (1). Switch is unlocked (enabled).
2. (B) Install cap (1) on A2B switch.



8684-2

FIGURE 4-3

**Before Operation**

Check the following electrical connections before operating the crane to ensure the LMI system is properly connected for the crane configuration.

**Cranes With Main Hoist Only**

If the crane is operated only with the boom and without boom extension or lattice extension, no additional connections are necessary. It must however be ensured that the A2B switch weight is correctly mounted on the main boom hoist rope. With even numbers of rope lines, the lifting limit switch weight shall be attached to the "dead end" of the hoist rope. With odd numbers of rope lines, the lifting limit switch weight shall be attached to the rope line with the lowest operating speed.

If the crane is operated with a main boom extension or top section, the connecting cable must be mounted between the distributor socket on the lattice extension and the distributor socket on the main boom. The main boom A2B switch weight must be disconnected and mounted on the extension or fly boom A2B switch.

**WARNING**

Failure to reposition the A2B weight will prevent the A2B system from functioning properly. No weight shall be mounted on the A2B switch of the main boom when working with the extension/top section.



### **Machines with Main and Auxiliary Hoists**

If the main boom extension or fly section is not used, then the bridging plug must be plugged into the distributor socket on the main boom and the lifting limit switch weight must be mounted on the main boom.

If the crane is operated with a main boom extension and/or with a lattice extension, then the connecting cable must be mounted between the distributor socket on the extension or on the top section and the distributor socket on the main boom. In addition, weights must be fitted to both the A2B switch of the main boom and the extension or fly section.

If the boom extension or lattice extension are in working position and if the main boom is not equipped with a hoist rope, then the weight of the A2B switch on the main boom must be removed to prevent endangering personnel or damaging equipment.

After electrical connections have been checked to ensure the system is properly connected for the respective crane configuration, the following checks must be made:

1. Check electrical wiring connecting various parts of the system for physical damage.
2. Check A2B switches and weights for free movement.
3. Inspect spring cable drum for smooth running, initial drum tension, and correct cable winding.
4. Inspect mechanical and electrical installation of power measurement sockets on the lattice extension (if present).

#### **WARNING**

The following tests must be performed with care to prevent personnel injury or crane damage. Proper functioning of the CCS requires successful completion of these tests before starting work.

If the operator cannot see the hook block approaching the pulley head, this task must be assigned to an assistant (slinger).

The crane operator must be prepared to stop the crane immediately if the CCS is not working correctly, i.e. when warning indicators do not display, the acoustic alarm does not sound, and crane movements such as raising, extending and luffing are not disabled.

Check *Hoist limit switch warning light* and acoustic alarm as follows:

1. Manually raise weight fitted on the A2B switch. As soon as weight is raised, the acoustic alarm should sound and A2B switch warning should display.
2. Using the main hoist, pull hook block slowly against the A2B switch weight. As soon as the hook block raises the weight, the acoustic alarm should be triggered, the A2B switch warning should display, and the main hoist should switch off. Lower the hook block slightly to eliminate this condition.
3. Slowly lower the boom to bring about a potential hoist limit situation. As soon as the hook block raises the weight, the acoustic alarm should sound, the A2B switch warning should display, and the luffing gear should switch off. Lower the hook block slightly to eliminate this condition.
4. Slowly extend (telescope out) the boom to bring about a potential hoist limit situation. As soon as the hook block raises the weight, the acoustic alarm should sound, the A2B switch warning should display, and the telescoping function should switch off. Lower the hook block slightly to eliminate this condition.

#### **WARNING**

If warning indicators and audible alarm do not function as described and crane movements are not switched off, the system is not working properly. The malfunction must be corrected before starting work.

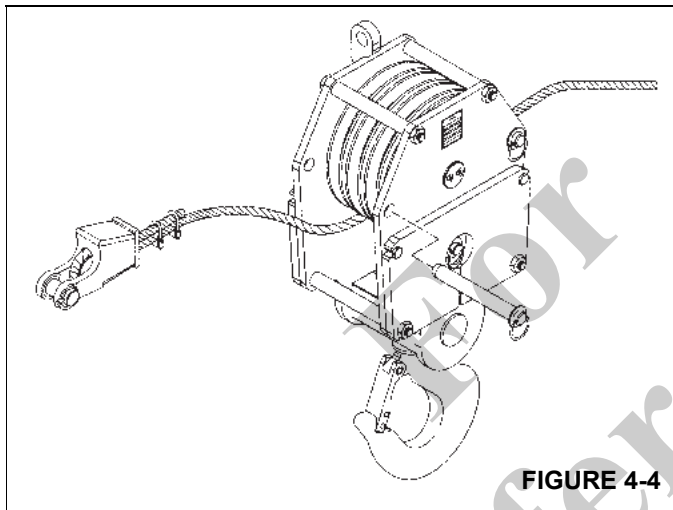
5. If crane is equipped with a main boom or lattice extension, the inspection procedure must be repeated for the A2B switch of the extension/top section.
6. Check display of main boom length agrees with actual boom length.
7. Check display of main boom angle agrees with actual boom angles.
8. Check display of the crane operating radius agrees with the actual radius.
9. Check load display by lifting a load of known weight. Load display accuracy must be within the tolerance range.

**CABLE REEVING**

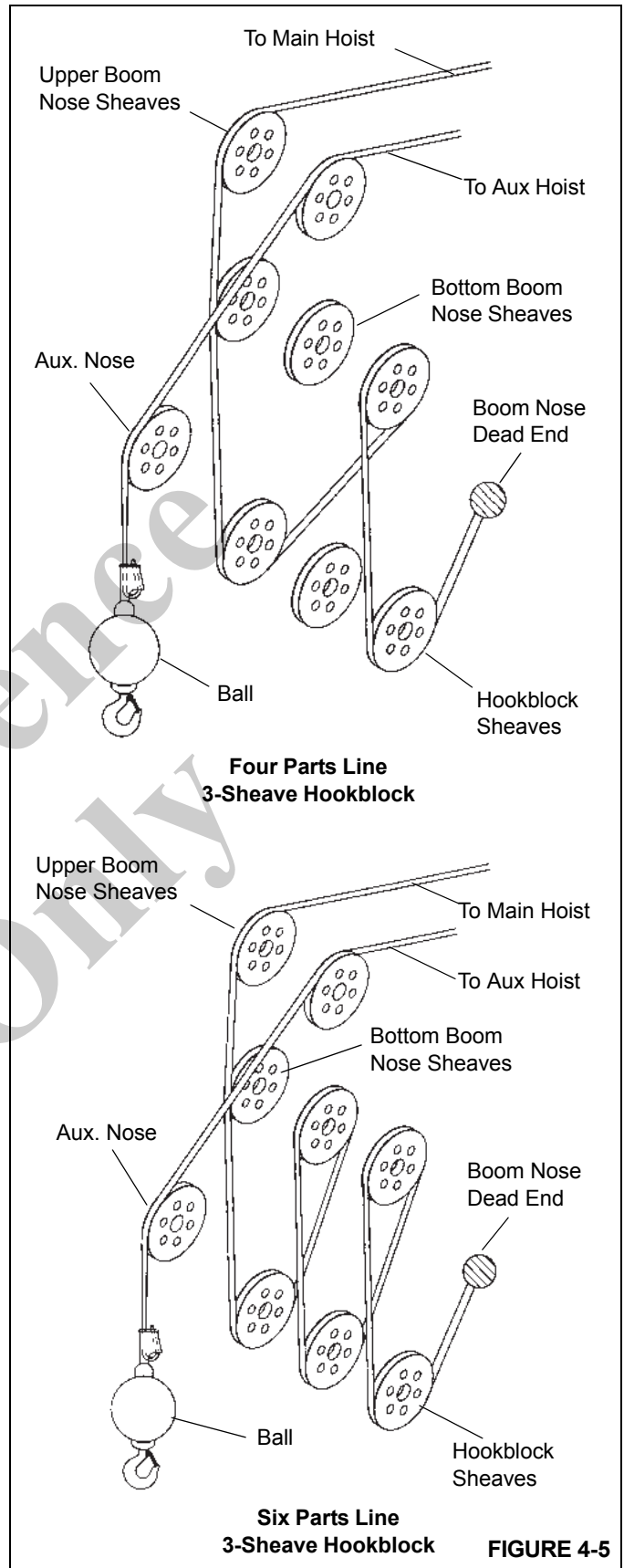
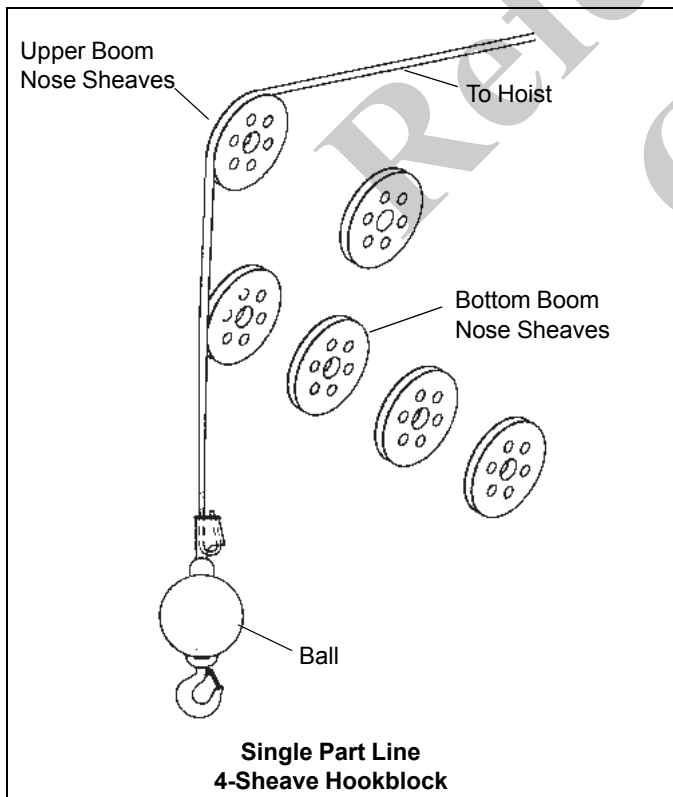
**NOTE:** The type of cable (wire rope) available on this crane is 35 x 7 (non-rotating).

Within the limits of the load and range charts and permissible line pull, multi-part lines allow the operator to raise a greater load than can be raised with a single part line. Various cable reeving (part line) is possible with the boom nose and hook block. This reeving should be accomplished by a qualified rigger using standard rigging procedures (Figure 4-5).

In order to quick reeve the hook block without removing the wedge socket on the end of the cable, see (Figure 4-4).



**FIGURE 4-4**



**FIGURE 4-5**

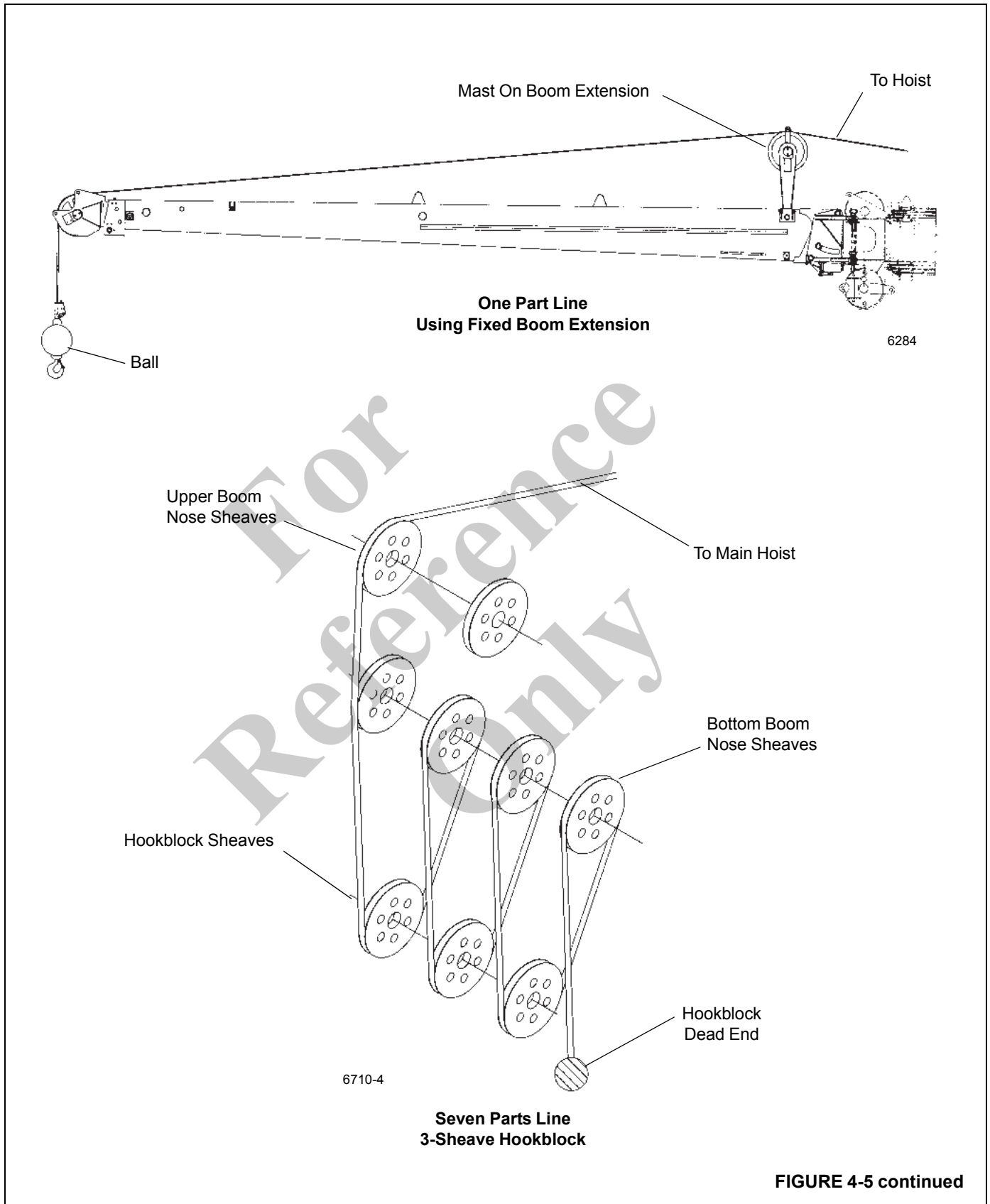


FIGURE 4-5 continued

**DEAD-END RIGGING/WEDGE SOCKETS**

Wedge socket assemblies are popular rigging accessories and have been successfully used for decades to terminate wire ropes on mobile cranes. A wedge socket assembly is easily installed and dismantled but it must be installed and used correctly. It is essential to use only a wedge and socket of the correct size for the rope fitted. Failure to do so may result in the rope pulling through the fitting.

Since state and local laws may vary, alternate attachment methods may be necessary depending upon work conditions. If alternate methods are selected, the user is responsible and should proceed in compliance with the regulations in force. If there are any questions, contact your local Grove Distributor or Manitowoc Crane Care.

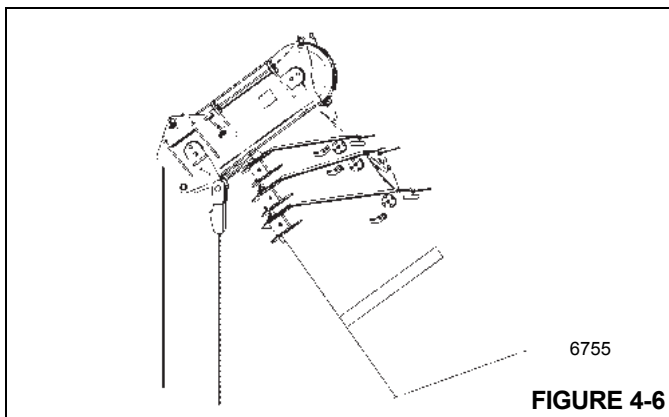
Do not mix components from different manufacturers. The selection, installation and use of a wedge socket assembly must be in accordance with the requirements of the wedge socket manufacturer and the wire rope manufacturer upon whose wire rope the wedge socket assembly will be used.

Manitowoc Crane Group specifies the size, type, class and line pulls for wire rope, predominately rotation resistant wire rope, and rigging accessories such as overhaul balls and hook blocks for use with each new crane that it manufactures. Other wire ropes and rigging accessories are available from various vendors. Different wire rope manufacturers have differing requirements for the construction, handling, cutting, seizing, installation, termination, inspection and replacement of the wire ropes they produce. Their advice should be sought for each specific type of wire rope a crane user intends to install on a mobile crane.

When assembly is complete, raise the boom to a working position with a load suspended to firmly seat the wedge and rope into the socket before the crane is used operationally.

**CAUTION**

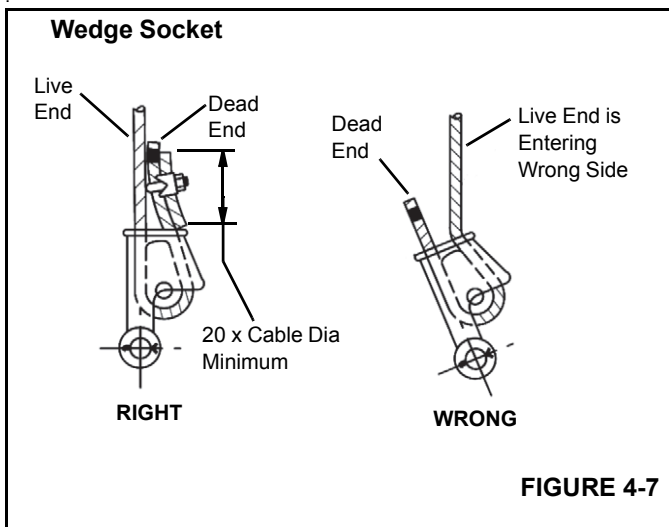
If the socket is not positioned with the flat face toward the boom sections, structural damage will occur.



When anchoring the socket to the boom, ensure the flat face of the socket is in position, as shown, toward the boom sections (Figure 4-6).

**Installing Wedge And Socket**

1. Inspect the wedge and socket. Remove any rough edges and burrs.
2. The end of the wire rope should be seized using soft, or annealed wire or strand. If the end of the rope is welded, the welded end should be cut off. Do not weld on size 6X37 rope. This will allow the distortion of the rope strands, caused by the bend around the wedge, to adjust themselves at the end of the line. Refer to SECTION 1 - INTRODUCTION in the Service Manual for wire rope procedures.
3. Make sure the live-end (Figure 4-7) of the rope is directly in line with the ears of the socket and the direction of pull to which the rope will be subjected. If the rope is loaded into the socket incorrectly, under a load the rope will bend as it leaves the socket, and the edge of the socket will wear into the rope causing damage to the rope and eventual failure.



4. Insert the end of the wire rope into the socket, form a loop in the rope, and route the rope back through the socket allowing the dead-end (Figure 4-7) to protrude from the socket. Ensure the dead-end of the rope is of sufficient length to apply end treatment to the dead-end after the wedge has been seated.
5. Insert the wedge into the loop and pull the live-end of the rope until the wedge and rope are snug inside the socket. It is recommended that the wedge be seated inside the socket to properly secure the wire rope by using the crane’s hoist to first apply a light load to the live-end.
6. After final pin connections are made, increase the loads gradually until the wedge is properly seated.
7. The wire rope and wedge must be properly secured inside the socket before placing the crane into lifting service. It is the wedge that secures the wire rope inside the socket. The dead-end treatment is used to restrain the wedge from becoming dislodged from the socket should the rope suddenly become unloaded due to the headache ball or hook block striking the ground, etc; refer to *Dead-end Rigging*, page 4-7.

**Dead-end Rigging**

Sketches A through F (Figure 4-8) illustrate various ANSI approved methods for treating the dead-ends of wire ropes which exit a wedge socket assembly. While use of the loop-back method is acceptable, care must be exercised to avoid the loop becoming entangled with tree branches and other components during crane transport and with the anti-two block system and other components during use of the crane.

Of the methods shown below, Manitowoc prefers that method A or F be used, i.e., clipping a short piece of wire rope to the dead-end or using a commercially available specialty clip or wedge. Typically, it is recommended that the tail length of the dead-end should be a minimum of 6 rope diameters but not less than 6 in (15.2 cm) for standard 6 to 8 strand ropes and 20 rope diameters but not less than 6 in (15.2 cm) for rotation resistant wire ropes.

When using method A, place a wire rope clip around the dead end by clamping a short extra piece of rope to the rope dead end. **DO NOT CLAMP THE LIVE END.** The U-bolt should bear against the dead end. The saddle of the clip should bear against the short extra piece. Torque the U-bolts according to the table titled Wire Rope Clip Torque Values (Table 4-1).

**NOTE:** The use of swivels is not allowed in conjunction with non-rotation resistant wire ropes.

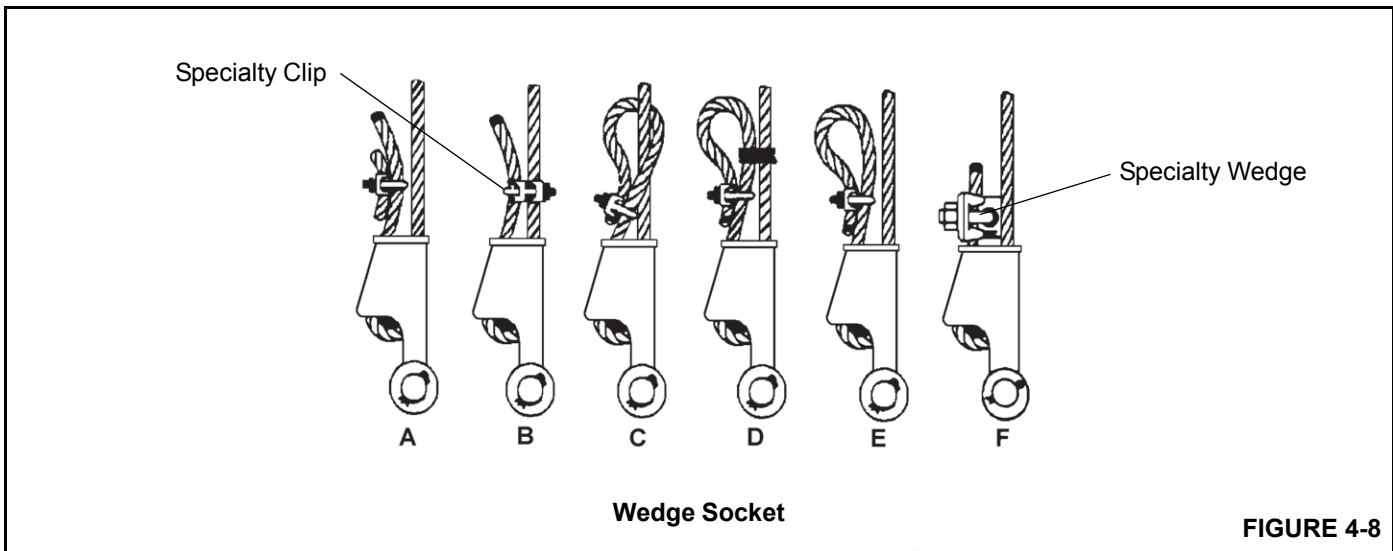
Other sources for information with which crane users should be familiar and follow is provided by the American Society of Mechanical Engineers, American National Standard, ASME B30.5, latest revised. ASME (formerly ANSI) B30.5 applies to cableways, cranes, derricks, hoists, hooks, jacks, and slings.

It states, in section 5-1.7.3, “(c) Swaged, compressed, or wedge socket fittings shall be applied as recommended by the rope, crane or fitting manufacture.” Wire ropes are addressed in ASME B30.5, section 5-1.7.2, ROPES, it states, in pertinent part, “(a) The ropes shall be of a construction recommended by the rope or crane manufacturer, or person qualified for that service.”

Additional information is published by the Wire Rope Technical Board in the Wire Rope Users Manual, latest revised edition.

**Table 4-1**

Wire Rope Clip Torque Values			
Clip Sizes		Torque	
Inches	mm	lb-ft	Nm
1/8	3.18	4.5	6
3/16	4.76	7.5	10
1/4	6.35	15	20
5/16	7.94	30	40
3/8	13.28	45	60
7/16	11.11	65	90
1/2	12.70	65	90
9/16	14.29	95	130
5/8	15.88	95	130
3/4	19.05	130	175
7/8	22.23	225	300
1	25.40	225	300
1-1/8	28.58	225	300
1-1/4	31.75	360	490
1-3/8	38.68	360	490
1-1/2	38.10	360	490



**ERECTING AND STOWING BOOM EXTENSION**

**General Warnings**

**! DANGER**

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

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

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

**! DANGER**

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

**Securing the Boom Extension with Tag Line (Rope)**

**NOTE:** A tag line attached to the tip of the extension is used to control the movement of the boom extension.

**! DANGER**

Always secure the boom extension with a tag line (rope) on the main boom before removing any connections. This will prevent the extension from swinging around and knocking you off the carrier or injuring other persons in the swing range.

The extension may swing out on its own accord when you remove the last connection that held the extension at the side of the main boom.

You must therefore secure the extension before you begin the erection procedure.

Secure the boom extension as follows:

- Attach a tag line (rope) at the front of the extension.
- Have a helper hold the tag line (rope) tight while you are removing the last connection.

**NOTE:** If you are alone, secure the other end of the tag line (rope) on the crane (e.g., on the steps of the access ladder or to the superstructure). Leave enough play in the tag line that it is tight only when you swing the extension towards the main boom head later in the procedure.

## Erecting



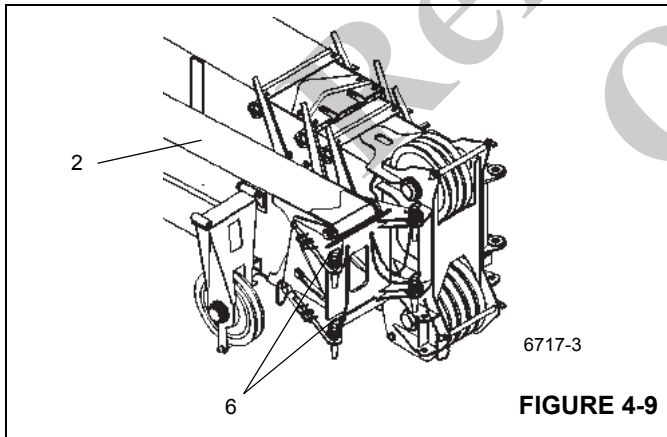
### DANGER

To prevent serious injury or death, do not stand on decking until extensions are secure.

1. Visually check to ensure all pins are installed.
2. Crane should be set up on outriggers using normal setup procedures. Refer to Section 3 - OPERATING CONTROLS and PROCEDURES.
  - a. Fully retract boom.
  - b. Lower boom to horizontal for erecting over the front of the crane.

**NOTE:** The auxiliary boom nose (rooster sheave) does not have to be removed. However, if reeved, the hoist cable must be removed from the sheave.

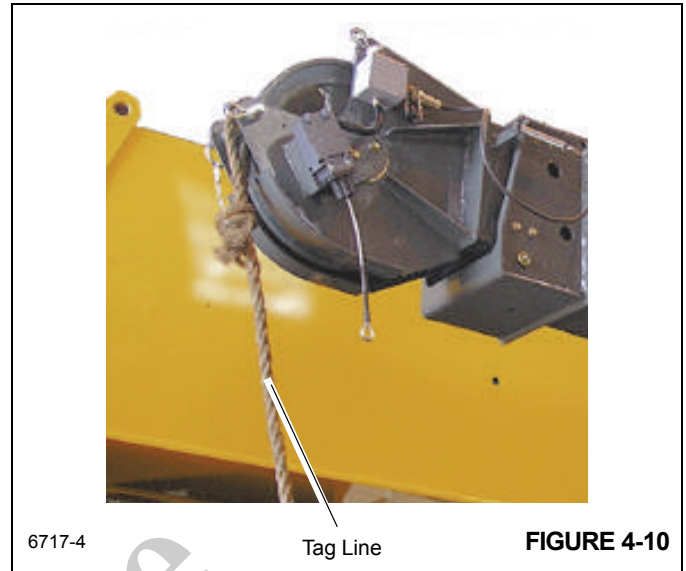
3. Rig either the main hoist or optional auxiliary hoist cable for single part line with nothing but the wedge socket on the end of the cable. Refer to CABLE REEVING and DEAD END RIGGING in this section.
4. Remove the retainer clips from the right side attachment pins (6) (Figure 4-9) (Figure 4-12) stowed in the base of the boom extension and remove the attachment pins from the boom extension (2) (Figure 4-9) (Figure 4-12). Insert the right side attachment pins through the boom attachment and boom extension anchor fittings. Install the retainer clips in the attachment pins.



6717-3

FIGURE 4-9

5. Remove the retaining pin from the hitch pin that secures the boom extension to the rear stowage bracket (Figure 4-14) (Detail A). Remove the hitch pin, unlocking the boom extension from the boom.
6. Attach a length of rope to the boom extension tip (Figure 4-10) to aid in swinging the boom extension into place ahead of the boom nose.



6717-4

Tag Line

FIGURE 4-10

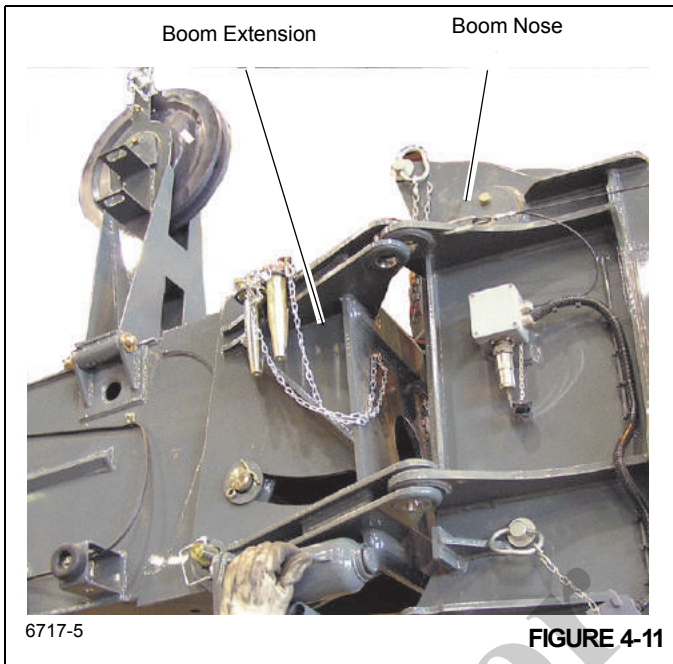
7. Raise the boom to horizontal and extend the boom approximately 51 to 64 cm (20 to 25"). Make certain that the boom extension stowage lugs clear the guide pins and ramp on the front (Figure 4-14) (Detail B) and rear (Figure 4-14) (Detail A) stowage brackets.



### DANGER

When erecting the boom extension, ensure that all personnel and equipment are kept clear of the swing path.

8. Slightly raise and/or lower the boom to help control the boom extension. Using the rope attached to the tip of the boom extension, manually swing the extension into place ahead of the boom nose (Figure 4-11), engaging the attachment fittings with the anchor fittings on the left side of the boom nose.



**! DANGER**

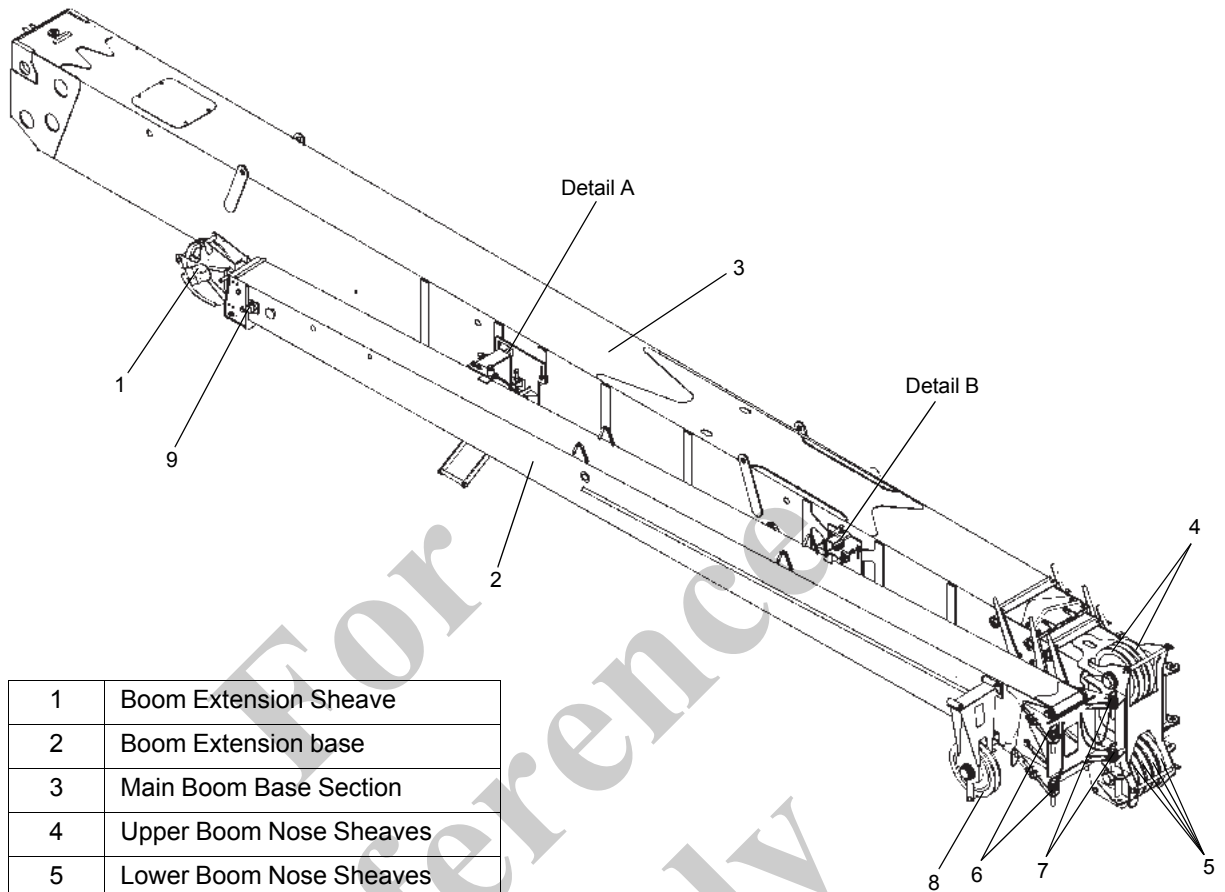
Do not modify the attachment points to permit the installation of the attachment pins.

**CAUTION**

Do not place blocking under the boom extension sheave wheel. Damage to the sheave wheel may occur.

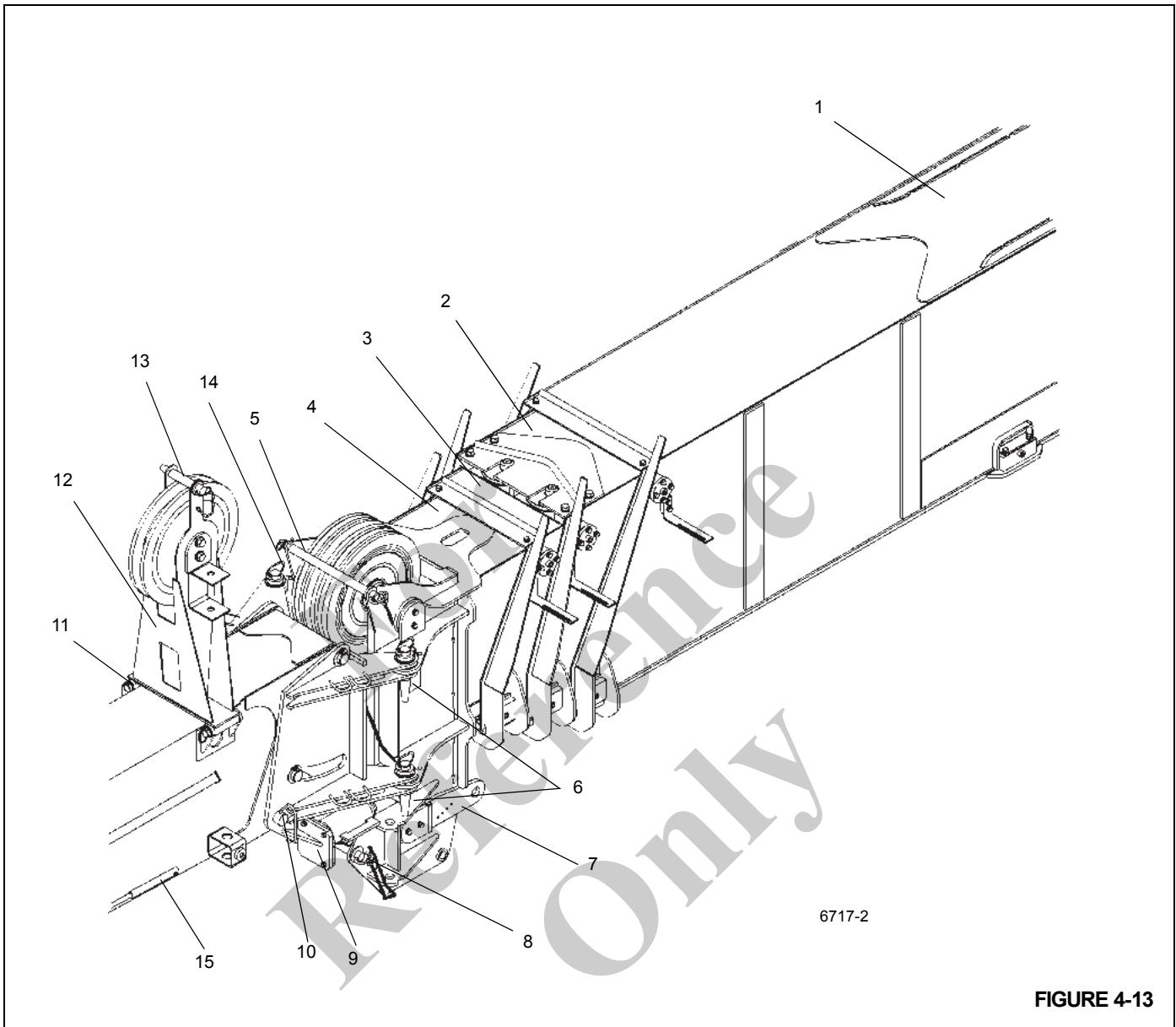
9. Install the top left side attachment pin and retainer clip into the upper anchor and attachment fittings of the boom nose (Figure 4-11).
  10. Extend the boom extension alignment jack until the lower left side boom nose and boom extension adapter lugs are aligned.
  11. Install the bottom left side attachment pin and retainer clip into the lower anchor and attachment fittings of the boom nose.
  12. Connect RCL cables:
    - a. Remove cable from boom extension.
    - b. Remove dummy plug from junction box on the boom nose.
    - c. Install cable end connector from the boom extension where dummy plug was removed
  13. Release pressure on the boom extension alignment jack.
- NOTE:** The hoist cable must be routed over the mast assembly and under the roller on the mast for all configurations.
14. Reeve the hoist cable. Refer to Cable Reeving in this section.





1	Boom Extension Sheave
2	Boom Extension base
3	Main Boom Base Section
4	Upper Boom Nose Sheaves
5	Lower Boom Nose Sheaves
6	Attach Pins
7	Attach Pins
8	Mast Assembly

FIGURE 4-12



6717-2

FIGURE 4-13

1	Boom Base Section	9	Alignment Jack
2	Inner Mid Section	10	Offset Pin
3	Outer Mid Section	11	Mast Assembly Stowage Pin
4	Fly Section	12	Mast Assembly
5	Upper Sheave Cable Retainer	13	Mast Assembly Cable Retainer
6	Left Side Attachment Pins	14	Right Side Attachment Pins
7	Boom Nose Dead End Lug	15	Jack Handle
8	Lower Sheave Cable Retainer		

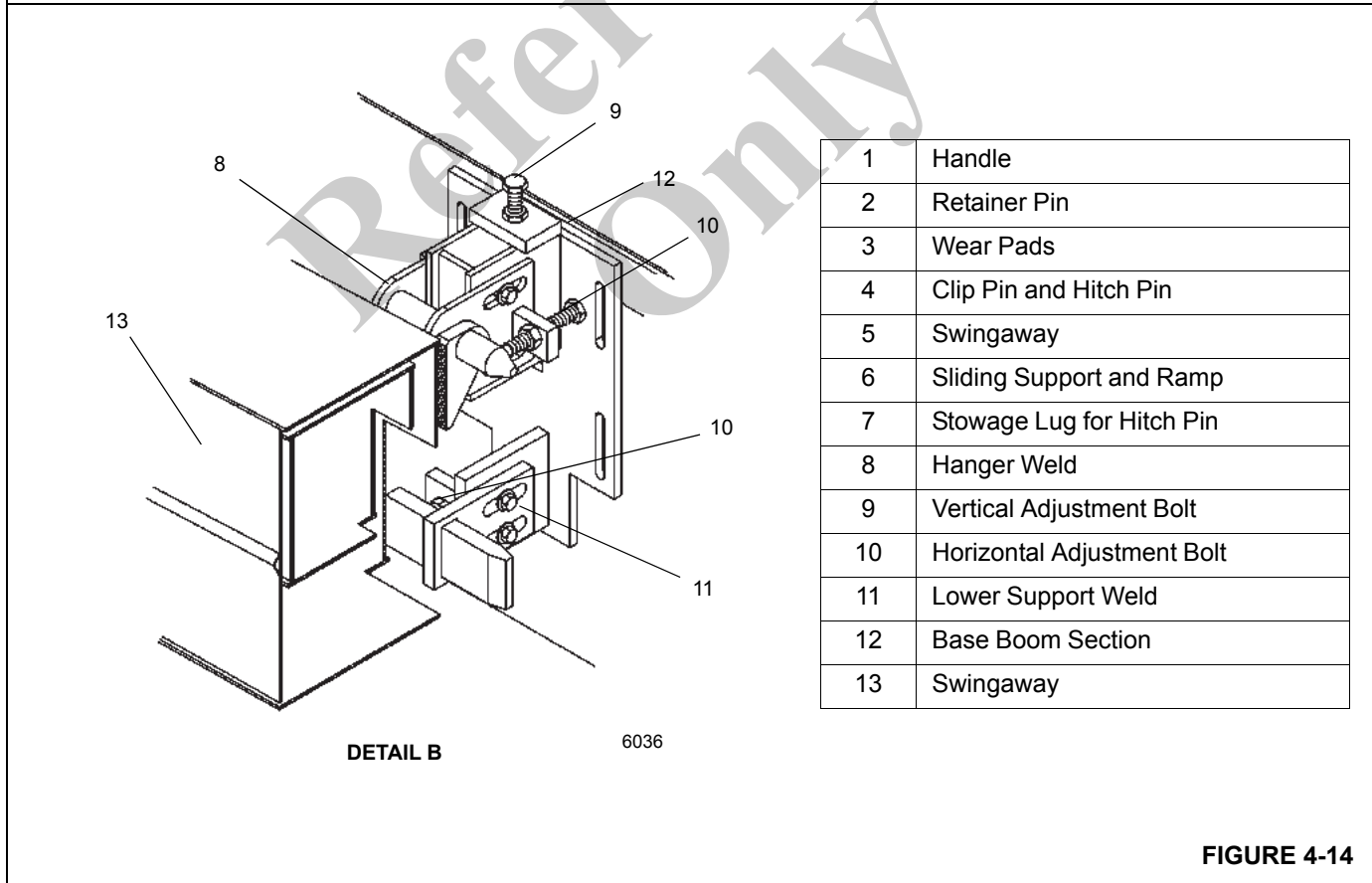
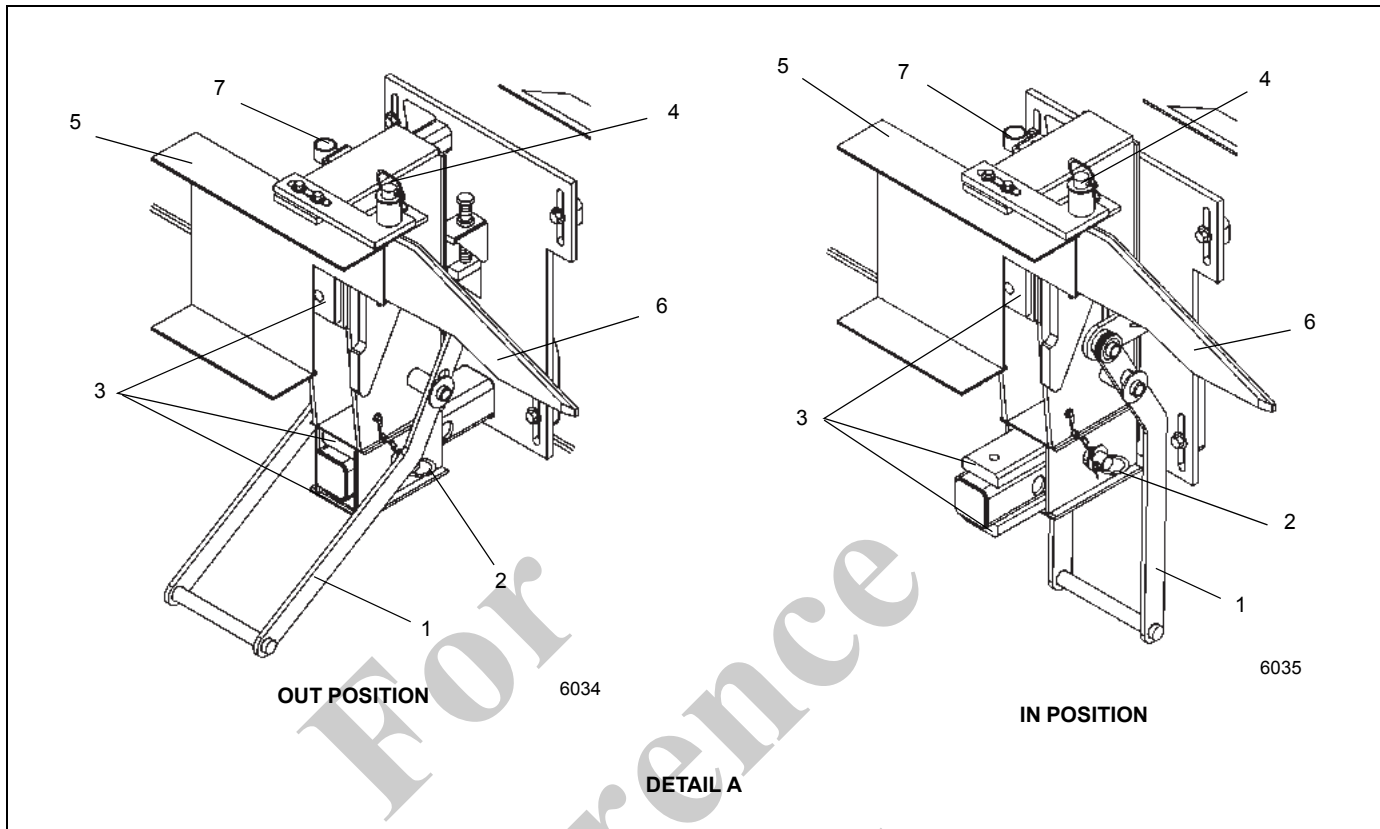


FIGURE 4-14

## Stowing

1. With crane set up on outriggers, fully retract the boom and swing to over-the-front.
2. Lower the boom to minimum elevation.
3. Remove the cable retainer pin from the boom extension tip and the mast assembly. Remove the hoist cable from the sheaves. Install the cable retainer pins.
4. Remove the mast assembly retainer pin and the pin securing the mast assembly in the upright position. Lay the mast assembly over to the stowed position. Insert the pins securing the mast to the base section.
5. Attach a length of rope to the boom extension tip.
6. Disconnect RCL cable:
  - a. Remove connector from junction box on boom nose.
  - b. Install dummy plug in junction box.
  - c. Route cable to and attach to boom extension
7. Raise the boom to horizontal.
8. Extend the boom approximately 20 to 25 in (51 to 64 cm). Make certain that the boom extension stowage lugs will line up in front of the guide pins and ramp on the stowage brackets when the boom extension is positioned to the side of the boom.
9. Ensure the hitch pin and clip pin are removed from the rear stowage bracket (Figure 4-14) (Detail A).
10. Extend the boom extension alignment jack (Figure 4-13) until the bottom left side attachment pin is free. Remove the bottom left side boom extension clip pin and attachment pin.
11. Release pressure on the boom extension alignment jack. Completely retract the jack.
12. Remove the top left side attachment pin and clip pin from the upper anchor and attachment fittings of the boom nose.



### DANGER

When stowing the boom extension, ensure that all personnel and equipment are kept clear of the swing path.

### CAUTION

Do not allow the boom extension to slam into the stowage bracket when swinging into the stowed position.

13. Using the rope attached to the tip of the boom extension, manually swing the extension to the side of the boom.

14. Align the stowage lugs on the boom extension with the guide pins and ramp on the stowage brackets and fully retract the boom.
15. Install the hitch pin and clip pin securing the boom extension to the rear stowage bracket (Figure 4-14) (Detail A).
16. Remove the attachment pins and clip pins from the anchor and attachment fittings on the right side of the boom nose and stow them in the base of the boom extension. Stow left side attachment pins and clips in outside attachment fitting on swingaway.
17. On the rear stowage bracket, remove the pin securing the sliding support in the "OUT" position. Push in on the handle to push the swingaway against the rear of the boom and disengage the swingaway anchor fittings from the boom nose attachment lugs. Install the retainer pin securing the sliding support in the "IN" position.
18. Rig the boom nose and hoist cable as desired and operate the crane using normal operating procedures.

## Setting Offset

### CAUTION

The mast assembly must be positioned on top of the base section before attempting to offset the swingaway to 30 degrees. Failure to do so can cause damage to the mast and/or swingaway adapter.

1. Extend and set the outriggers. Swing the boom over to the front of the crane.
2. To set the offset from zero degrees (0°) to thirty degrees (30°), perform the following:

### CAUTION

Do not overload the swingaway or the attachment points when lowering the boom.

- a. Slowly lower the boom until the tip of the swingaway is on the ground and the pressure on the offset pin is relieved.
- b. Remove the lock pin, two washers, and offset pin.
- c. Slowly elevate and telescope the boom at the same time until the offset shaft takes the full load of the swingaway.
3. To set the offset from thirty degrees (30°) to zero degrees (0°), perform the following:
  - a. Slowly lower the boom until the tip of the swingaway is on the ground and the offset pin can be installed.
  - b. Install the offset pin, two washers, and lock pin.
  - c. Raise the boom and operate as desired.

## Changing Boom Extension Type

1. Erect the boom extension.
2. Position the boom to horizontal.
3. Disconnect the anti-two block cable connector from the junction box.
4. Remove the telescoping section hitch pin and retaining pin.

**NOTE:** The telescoping section weighs approximately 250 kg (551 lb).

5. Extend the telescoping section and attach an adequate lifting device to support the telescoping section. Remove the stop bolts from the base section and remove the telescoping section from the base.

**NOTE:** The pin-on boom extension nose weighs approximately 60 kg (132 lb).

6. Using a adequate lifting device, position the pin-on boom extension nose in the base section and secure with the two pins and hitch pins.
7. Connect the anti-two block cable connector to the junction box.

## Setting Telescoping Extension Length

### Extending

1. Position the boom to over the front.
2. Lower the boom to horizontal.
3. Remove the loop of anti-two block cable from the spool on the side of the base section and let the cable hang free.
4. Remove the hitch pin and retainer pin securing the telescoping section in the base.
5. Carefully pull the telescoping section from the base until the holes in the base and telescoping section line up. Install the retainer pin and hitch pin.
6. If not already reeved, reeve the hoist cable over the mast and boom extension nose sheave. Install all cable retainer pins.

## Stowing

1. Unreeve the boom extension nose.
2. Position the boom to horizontal.
3. Remove the hitch pin and retainer pin securing the telescoping section in the base.
4. Push the telescoping section into the base and secure with the retainer pin and hitch pin.
5. Loop the anti-two block cable over the spool on the side of the base section.

## COUNTERWEIGHTS

### Fixed Counterweight Description

The counterweight is pinned to the rear of the turntable and weighs approximately 3817 kg (8416 lb). For cranes without an auxiliary hoist, an additional 350.6 kg (773 lb) counterweight is bolted to the hoist mounting area in lieu of the auxiliary hoist.

### Fixed Counterweight Removal



#### DANGER

Death or serious injury could result from being crushed by a falling counterweight.

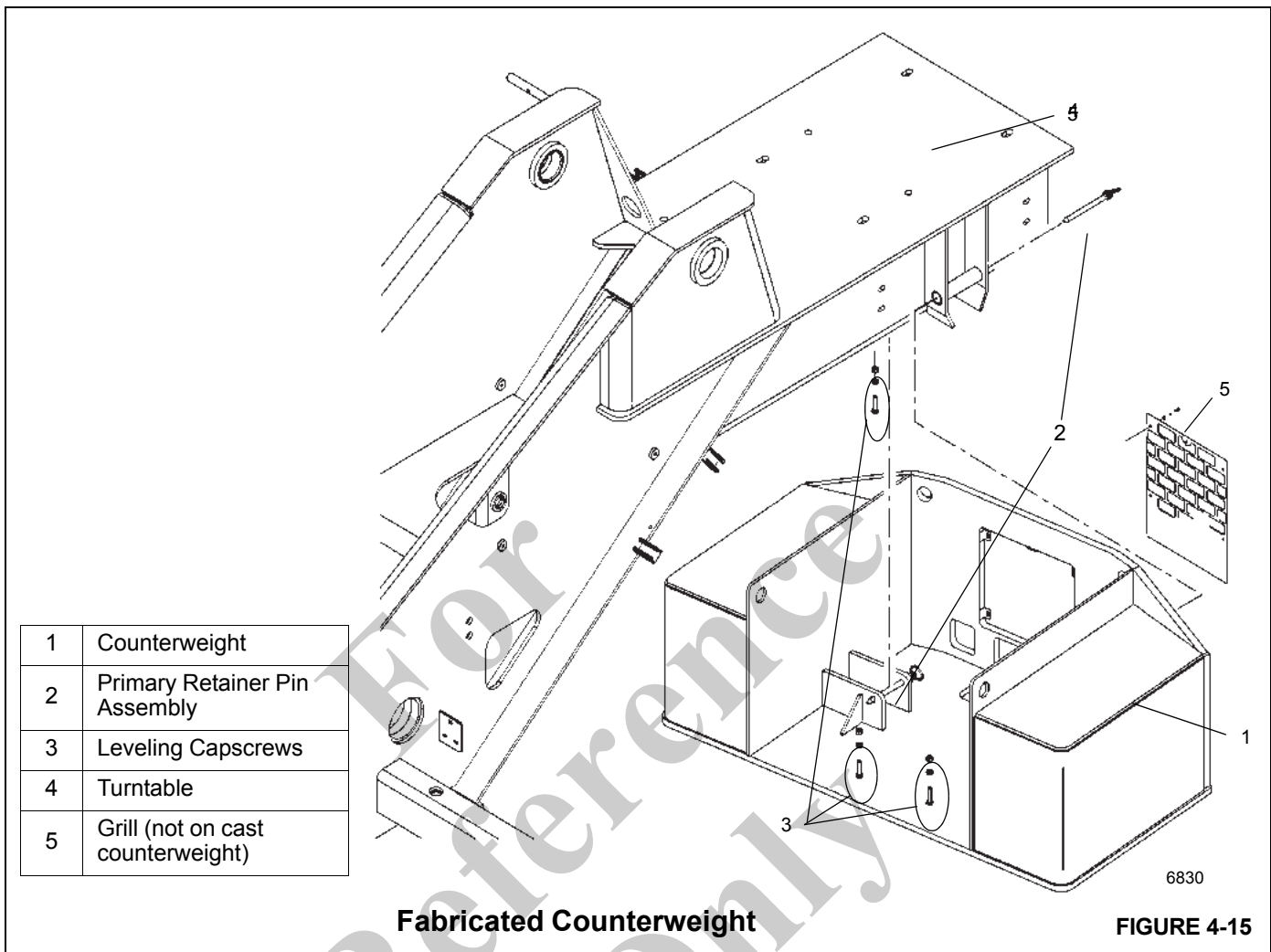


#### DANGER

Ensure the primary retainer pin assembly is properly installed to secure the counterweight.

**NOTE:** Use of a forklift to remove/install the fixed counterweight is not recommended.

**NOTE:** Refer to (Figure 4-15) for fabricated counterweight and refer to (Figure 4-16) for cast counterweight configurations.



1. Fully extend and set the outriggers.
  2. Rotate the superstructure so the counterweight is over the front of the carrier to gain additional clearance. Engaging the pin type turntable lock will aid alignment.
- NOTE:** Counterweight weighs approximately 3817 kg (8416 lb).
3. Lower and fully retract the boom.
  4. Shut down crane.
  5. Remove and cap hydraulic lines from auxiliary hoist (if installed).
- NOTE:** Attach an adequate lifting device to the counterweight. For cast counterweight configurations (Figure 4-16), remove polyurethane plugs from two upper threaded inserts (7) before inserting eyebolts (two 1-1/4 X 7UNC eyebolts are needed.)
6. Ensure the four counterweight leveling capscrews (3) are set for maximum clearance with the turntable.
  7. For cast counterweight; remove the redundant pin assembly (6) prior to removing the primary retainer pin assembly (2).
  8. Slowly raise counterweight until primary retainer pin assembly (2) can be removed by pushing and turning the pin.
  9. Remove primary retainer pin assembly (2) from opposite side.
  10. Lower counterweight until attaching lugs are clear of turntable.
  11. Back counterweight away from turntable until it is clear of crane.
  12. Replace primary retainer pin assembly (2) in turntable counterweight mounting lugs.
  13. Move counterweight far enough from crane to allow the turntable/superstructure to clear during repositioning.
  14. Rotate superstructure to the normal travel position.

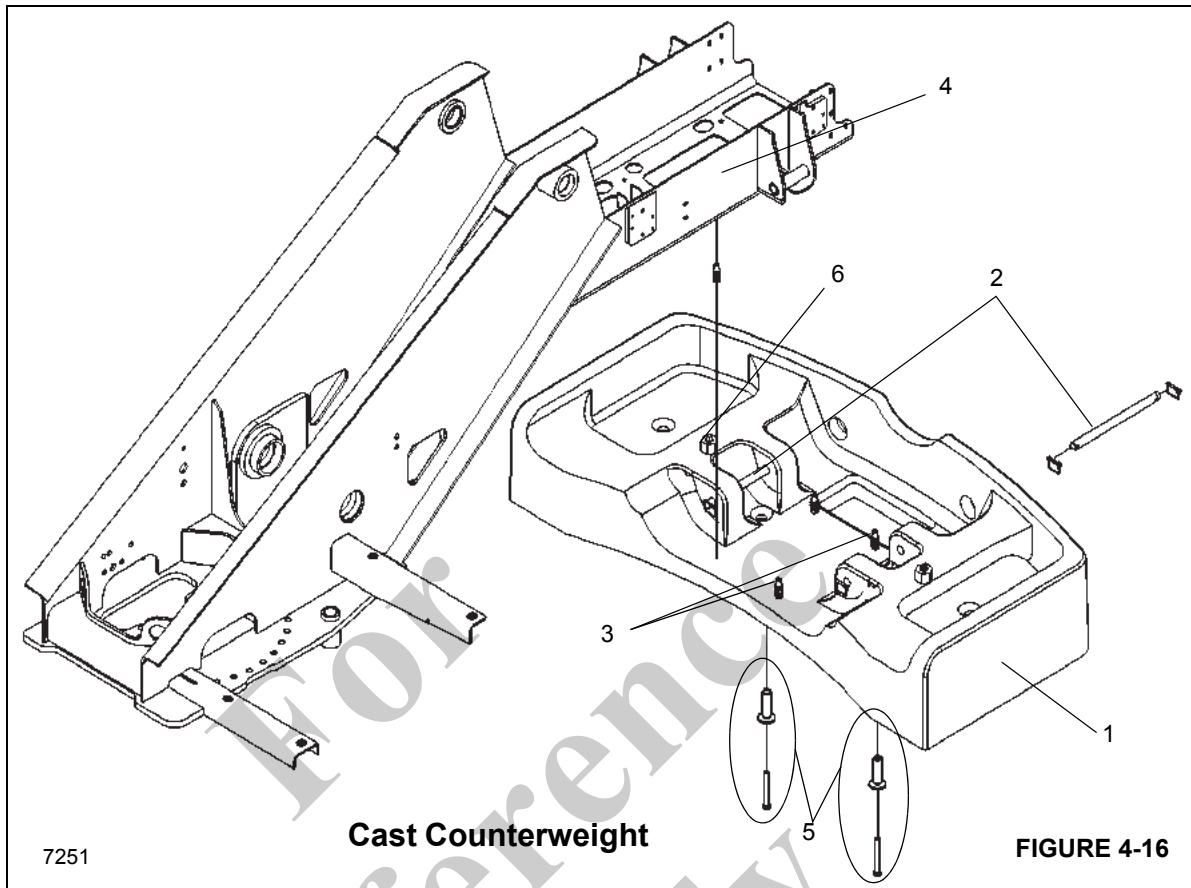


FIGURE 4-16

1	Counterweight	4	Turntable
2	Primary Retainer Pin Assembly	5	Redundant Pin Assembly
3	Leveling Capscrews	6	Threaded Insert

**Fixed Counterweight Installation**

1. Fully extend and set the outriggers.
2. Rotate the superstructure so the counterweight will be over the front of the carrier to gain additional clearance.
3. Shut down crane.
4. Remove and cap hydraulic lines from auxiliary hoist (if installed).

5. Attach an adequate lifting device to the counterweight and lift the counterweight into place on the superstructure, aligning the mounting holes on the counterweight to the holes in the superstructure.
6. Install the counterweight primary retainer pin assemblies (2) and secure them in place. Note: With cast counterweight re-install the two redundant pin assemblies (6).
7. Remove the lifting device from the counterweight.

**CAUTION**

When lifting/handling the counterweight, keep the chains/straps vertical to minimize side pull on the lifting lugs.

**NOTE:** The counterweight (1) weighs approximately 3817 kg (8416 lb).

**NOTE:** Use of a forklift to remove/install the fixed counterweight is not recommended.

Using the four counterweight leveling capscrews (3), level the counterweight and eliminate any relative movement between the counterweight and turntable. Maximum width of counterweight shall not exceed 6.0 mm (0.25 in) out of level with the turntable bearing when measured from either counterweight outer edge.

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Reference  
Only*

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## SECTION 5 LUBRICATION

### SECTION CONTENTS

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### GENERAL

Following the designated lubrication procedures is important in ensuring maximum crane lifetime and utilization. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information.

- Always fill or add fluids with a funnel or a filling pump.
- Immediately clean up any spills.

### ENVIRONMENTAL PROTECTION

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

Potentially harmful waste used in Manitowoc 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.

### LUBRICATION INTERVALS

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 Manitowoc distributor or Manitowoc Crane Care.

#### CAUTION

Chassis grease lubricants must not be applied with air pressure devices as this lubricant is used on sealed fittings.

#### CAUTION

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

**Standard Lubricants**

Standard lubricants are used on all Manitowoc cranes unless the crane is ordered with a cold weather package. These standard lubricants are effective in ambient temperatures

down to -9°C (15°F). Refer to Table 5-1 for a list of the recommended standard lubricants.

**TABLE 5-1: Standard Lubricants**

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
<b>Axle/Swing Box Gear Oil</b>	6829012964	Century Unigear Semi-synthetic Texaco Multigear SS Chevron DELO	80W-90	
<b>Engine Oil</b>	6829104182	Conoco Fleet Supreme EC Mobil Delvac 1300 Super	15W-40	CJ-4
<b>Hydraulic/Transmission Oil</b>	6829006444	Kendall Hyken 052 Exxon Torque Fluid 56 Esso Torque Fluid 56 BP-Eldoran UTH & Trak-Tran 9 BP- Blend- 7367	10W-20	John Deere Std. JDM J20C
		Exxon Mobil 424	10W-30	
<b>Hoist Gear Oil</b>	6829100213	Mobil: 600XP 150 Texaco: Meropa 150		AGMA No. 4 EP
<b>Grease, Multipurpose</b>	6829003477	Citgo Lithoplex MP# 2 Texaco Starplex Moly # 2 Phillips 66 Philube M Mobil Mobilgrease XHP 222 Special Chemtool Inc, Lube-A-Boom	NLGI 2	
<b>Grease, 3% Moly</b>	6829015304			
<b>Open Gear Lube</b>	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
<b>Antifreeze Coolant</b>	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
<b>Supplemental Coolant Additive (SCA)</b>	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
<b>Diesel Exhaust Fluid</b>	6829003476 80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		ISO 22241-1 DIN V 70070

### 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 distributor or Manitowoc Crane Care.

**NOTE:** All fluids and lubricants may be purchased by contacting Manitowoc Crane Care.

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

### Arctic Conditions Down To -40°C (-40°F)

#### **All Weather Package and Lubricants**

Engineering recommends the following lubricants for components for ambient temperatures to -40°F. Special lubricants alone are not sufficient to operate at extreme low temperatures. We also recommend the use of appropriately sized heaters for the hydraulic tank, engine oil pan, engine jacket water and batteries. The operator needs to follow the guide lines as stated in the operator manual. We assume that the customer has take steps for use of an appropriate engine antifreeze coolant, have taken care of the fuel, fuel system and starting system. And has done whatever they feel necessary to add insulation for under hood temperatures and meet the engine manufacture's intake air temperature. Other lubricants may be used if they meet the specification of the lubricant that is requested. Please consult factory. It is also recommended that the crane be equipped with the following accessories:

#### **-29°C (-20°F) Package**

- Battery heater
- Fuel line heater
- Engine hood insulation
- Fan clutch
- Radiator air shutters
- Air diverter
- Diesel fired cab heater
- Cold weather alternator
- Fluids suitable to -29°C (-20°F)
  - Arctic windshield washer fluid
  - Arctic fuel

#### **-40°C (-40°F) Package**

- Coolant heater (to circulate warm coolant through heaters and engine)
- Transmission heater
- Swivel heater
- Battery heater
- Fuel line heater
- Hydraulic reservoir heater
- Engine hood insulation
- Fan clutch
- Radiator shutters
- Air diverter
- Diesel fired cab heater
- Cold weather alternator
- Super-capacitor starting system
- Fluids suitable to -40°C (-40°F):
  - Arctic windshield washer fluid
  - Arctic fuel

TABLE 5-2: All Weather Lubricants

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
<b>Axle/Swing Box Gear Oil</b>	6829014058	Petro-Canada Traxon E Synthetic CITGO, Synthetic Gear Lube Eaton, Roadranger EP Mobil, Mobilube SCH Shell, Spirax S Sunoco Duragear EP	75W-90	GL-5
<b>Engine Oil</b>	80056036	Shell Rotella® T6 0W-40 Mobil Delvac 1 ESP 0W-40 Caterpillar at DE0-ULS	0W-40	Synthetic CJ-4
<b>Hydraulic/Transmission Oil</b>	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		John Deere Std. JDM J20C & J20d
<b>Hoist Gear /Swing Drive Oil</b>	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
<b>Grease, Multipurpose</b>	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	EM-3MG
<b>Grease, 3% Moly</b>	68291015304	Mobilgrease CM-P		
<b>Open Gear Lube</b>	6829102971	Vultrex OGL Synthetic All Season	NLGI 1-2	
<b>Antifreeze Coolant</b>	6829104212	Petro-Canada AFC Old World Industries, Inc Fleet Charge SCA Fleetguard Compleat EG Antifreeze/Coolant	Premix 60/40	
<b>Supplemental Coolant Additive (SCA)</b>	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
<b>Windshield Washer fluid</b>	90037773	Splash De-icer		
<b>Diesel Exhaust Fluid</b>	6829003476 80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		ISO 22241-1 DIN V 70070

## 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.

Cylinder operation and inclement weather will remove the Boeshield® protectant; therefore, inspect machines once a week and reapply Boeshield® to unprotected rod.

## WIRE ROPE LUBRICATION

Wire rope is lubricated during manufacturing so that the strands, and individual wires in strands, may move as the rope moves and bends. A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added periodically throughout the life of a rope to replace factory lubricant which is used or lost. For more detailed information concerning the lubrication and inspection of wire rope, refer to WIRE ROPE in Section 1- INTRODUCTION in the Service Manual.

## LUBRICATION POINTS

A regular frequency of lubrication must be established for all lubrication points. Normally, this is based on component operating time. The most efficient method of keeping track of lube requirements is to maintain a job log indicating crane usage. The log must use the engine hourmeter to ensure coverage of lube points that will receive attention based on their readings. Other lubrication requirements must be made on a time basis, i.e. weekly, monthly, etc.

All oil levels are to be checked with the crane parked on a level surface in transport position, and while the oil is cold, unless otherwise specified.

On plug type check points, the oil levels are to be at the bottom edge of the check port.

All grease fittings are SAE STANDARD unless otherwise indicated. Grease non-sealed fittings until grease is seen extruding from the fitting. One ounce(28 grams) of EP-MPG equals one pump on a standard one pound (0.45 kg) grease gun.

Over lubrication on non-sealed fittings will not harm the fittings or components, but under lubrication will definitely lead to a shorter lifetime.

On sealed U-joints, care must be exercised to prevent rupturing seals. Fill only until expansion of the seals first becomes visible.

Unless otherwise indicated, items not equipped with grease fittings, such as linkages, pins, levers, etc., should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An Anti-Seize compound may be used if rust has not formed, otherwise the component must be cleaned first.

Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

Where wear pads are used, cycle the components and relubricate to ensure complete lubrication of the entire wear area.

## CraneLUBE

Manitowoc highly recommends the use of CraneLUBE lubricants to increase your crane's reliability and performance. Contact your Manitowoc Distributor for information about the Manitowoc's CraneLUBE lubrication program.

## Cummins Oil Registration List

Cummins has a program that lists engine oils that it has tested to meet its engineering specifications. Listing of recommended oils is on QuickServe® Online. Log on to [quickservice.cummins.com](http://quickservice.cummins.com) and login with a current username and password or create a new account by selecting "Create an Account" under information, choose Limited Owners Plan and register. Once logged in, click on the "Service" Tab in the top red bar, "Service Tools" mini-tab and "Oil Registration Lists" link within the Service Tools list. This will load a list of the different Cummins Engineering Specification numbers. Select the one that applies to your engine to view the registered oils.

## Safety

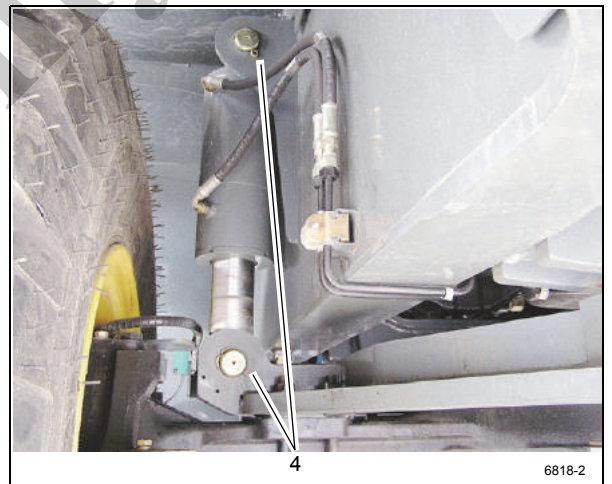
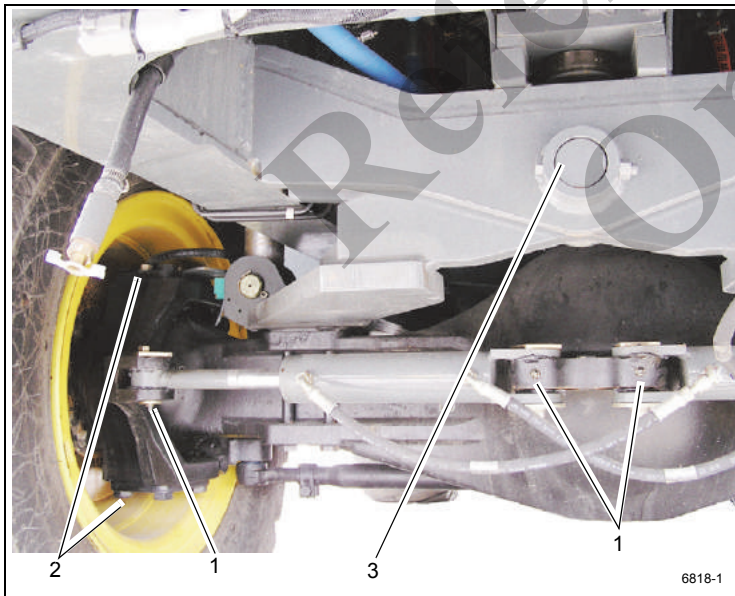
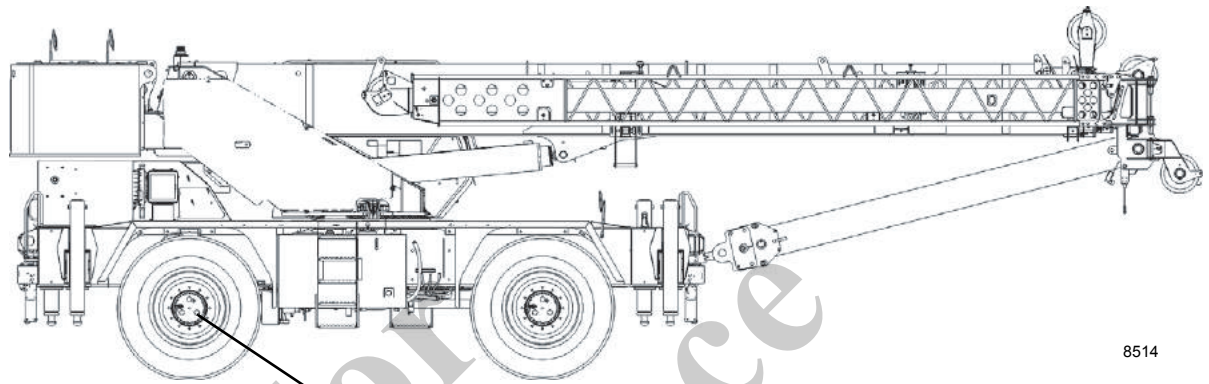
To lubricate many of the locations the engine will need to be started. After positioning areas of the unit for lubrication the engine must be turned off and the moved areas stable before approaching.

**DANGER****Crushing Hazard!**

Movement of the superstructure and the boom may create a crushing and/or pinching hazard. Failure to observe this warning could result in death or serious injury.

### Steering and Suspension

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
1	Steer Cylinder Pivot Pins	Figure 5-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	8 grease fittings
2	Upper and Lower King Pins	Figure 5-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	8 grease fittings
3	Fifth Wheel Pivots	Figure 5-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings
4	Lockout Cylinder Pivot Pins	Figure 5-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	4 grease fittings



5

FIGURE 5-1

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Axles</b>						
6	Axle Tech Differentials	As seen in Figure 5-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	20.8 l (44 pt)	<ul style="list-style-type: none"> <li>• Check level every 500 hours or 3 months</li> <li>• Drain and fill every 4000 hours or 2 years</li> </ul>	Fill to bottom of hole in housing on the steer cylinder side
<p><b>NOTE:</b> Lube level close enough to the hole to be seen or touched is not sufficient. It must be level with the hole. When checking lube level, also check and clean housing breathers.</p> <p><b>CAUTION:</b> Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.</p> <p><b>CAUTION:</b> If the makeup amount is substantially more than 0.23 liter (0.5 pint), check for leaks.</p>						
9	Axle Tech Planetary Hubs and Wheel Bearings	As seen in Figure 5-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	3.1 l (6.5pt)	<ul style="list-style-type: none"> <li>• Check level every 500 hours or 3 months</li> <li>• Drain and fill every 4000 hours or 2 years</li> </ul>	Fill to the bottom of the level hole in the housing with the fill plug and the oil level mark horizontal.
<p><b>CAUTION:</b> Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.</p>						



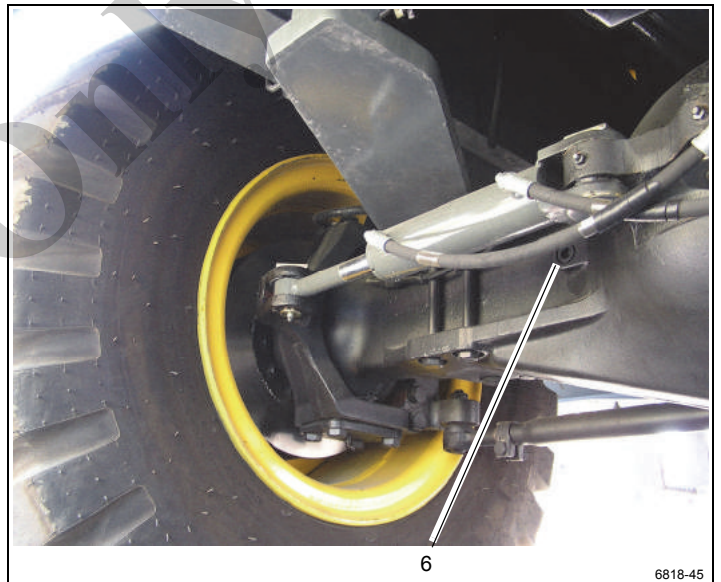
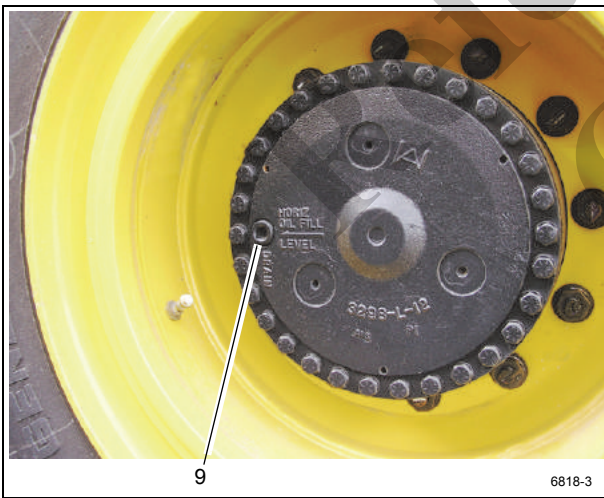
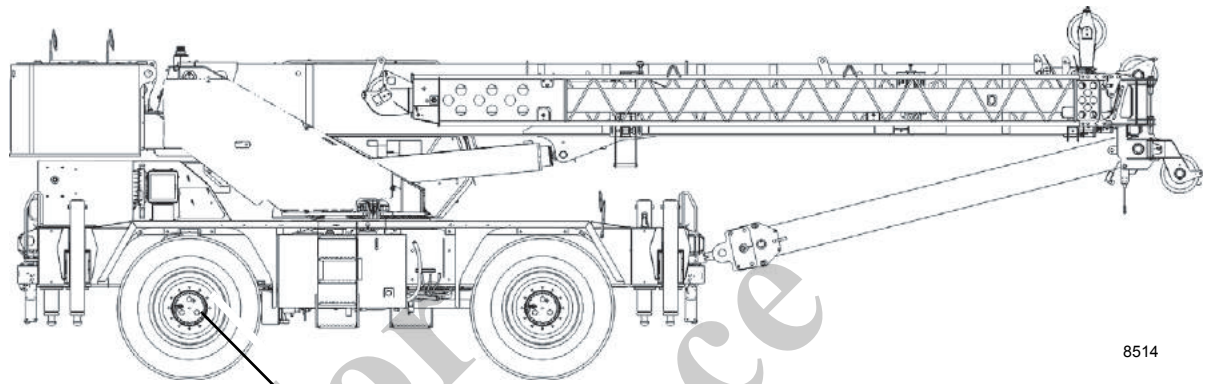


FIGURE 5-2

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Drive Train</b>						
<b>13a</b> <b>13b</b>	a. Engine Crankcase b. Filter	Figure 5-3	Engine Oil T3 Engine - SAE 15W-40 6829003483 T4 Engine - 6829104182 SAE 15W-40 80056036 EO-0W/40	17.5 l (18.5 qt)	<ul style="list-style-type: none"> <li>Check level every 10 hours or daily</li> <li>Drain, fill and replace filter every 500 hours or 6 months</li> </ul>	<ul style="list-style-type: none"> <li>Check level through dipstick.</li> <li>Fill engine oil through fill cap on engine valve cover.</li> </ul>
<b>14a</b> <b>14b</b>	a. Transmission, Torque Converter b. Filter	Figure 5-3	HYDO Hydraulic Oil 6829006444	23.6 l (25 qt)	<ul style="list-style-type: none"> <li>Check level every 10 hours or daily</li> <li>Drain and refill every 1000 hours or 6 months</li> <li>Change transmission filter after first 50 and 100 hours of service, then every 500 hours thereafter</li> </ul>	Through fill pipe to FULL mark on dipstick

**NOTE:**

- Check fluid level with engine running at 750 rpm idle and the oil at 82 to 93° C (180 to 200° F). Do not attempt an oil level check with cold oil. To bring the oil temperature to this range, it is necessary to either work the crane or stall the converter. Converter stall should be accomplished by engaging shift lever in forward high range with the brakes applied and then accelerating the engine to half or three-quarter throttle. Hold the stall until the required converter temperature is reached and stabilized.

Do not operate the converter at stall condition for longer than 30 seconds at one time. Shift to neutral for 15 seconds and repeat the procedure until the desired temperature is reached. Excessive temperature, i.e., 120° C (250° F) maximum will cause damage to transmission clutches, fluid, converter and seals.

- Drain and fill with the oil at 65 to 93° C (150 to 200° F).
- Transmission filters are located on the outside left hand frame in the area of the hydraulic oil cooler.
- To add fluid:
  - Fill to FULL mark on dipstick
  - Run engine at 750 rpm to prime torque converter and lines
  - Check oil level with engine running at 750 rpm and oil at 82 to 93° C (180 to 200° F). Add oil to bring oil level to FULL mark on dipstick.

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
15	Engine Cooling System and SCA Levels	Figure 5-3	AFC 50/50 50/50 Blended Fully Formulated Antifreeze Coolant 6829101130 SCA 6829012858	28.4 l (30 qt)	<ul style="list-style-type: none"> <li>• Check coolant level every 10 hours or daily</li> <li>• Check SCA levels every 500 hours</li> <li>• Check coolant for contamination every 1000 hours</li> </ul>	See <i>Service Manual</i>
16	Coolant Strainer (Cab Heater)	Figure 5-3	---	---	Change strainer screen after first 100 hours and every 2000 hours or 12 months intervals thereafter.	Close shutoff valves. Unscrew hex plug to clean filter.

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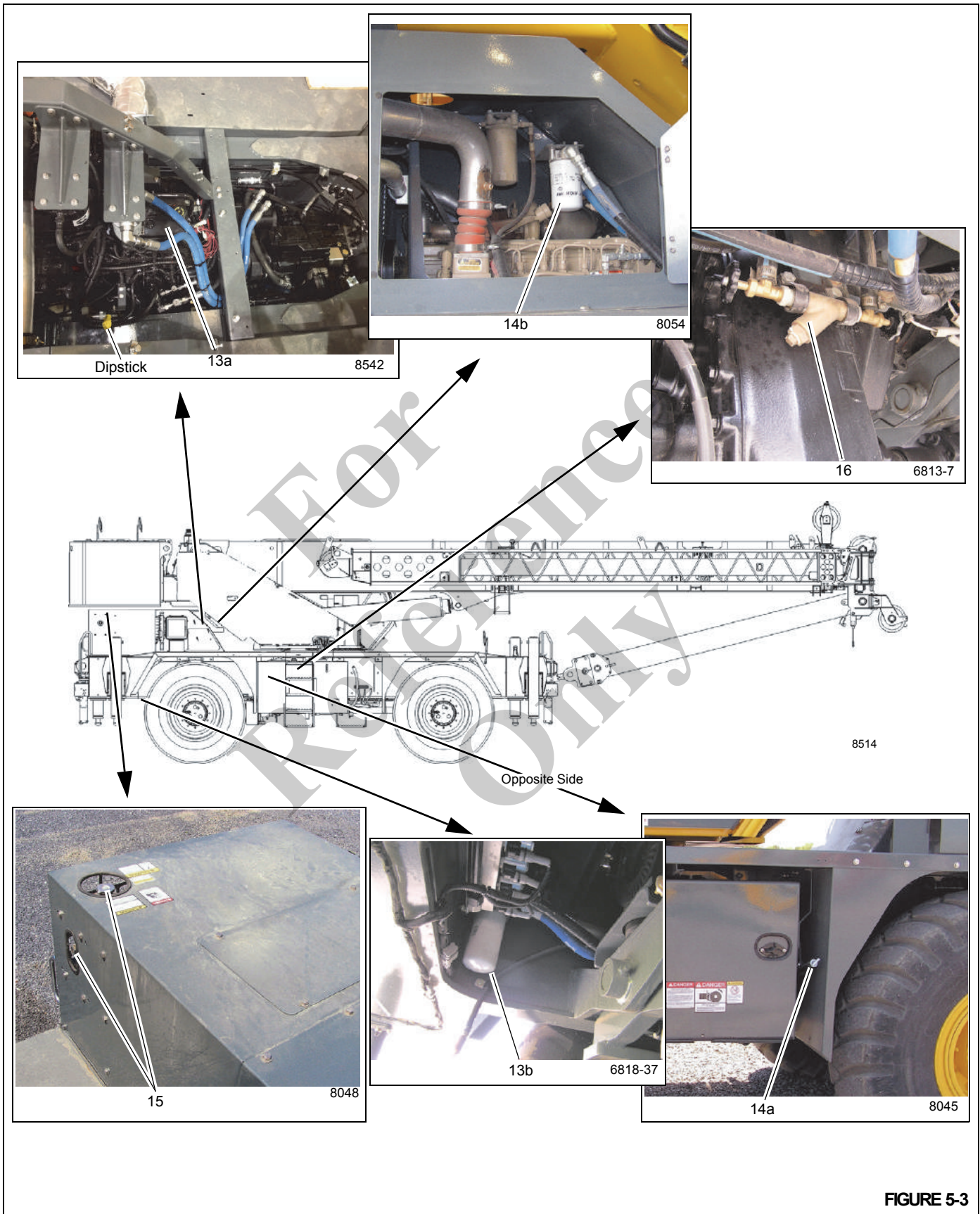


FIGURE 5-3

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Drive Train (continued)</b>						
17	Driveline - Slip Joints	Figure 5-4	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings
52	Air Cleaner Filter	Figure 5-4	---	---	<ul style="list-style-type: none"> <li>• Replace/Clean filter element when indicator shows red (25" H2O).</li> <li>• View indicator through grill from rear of crane.</li> <li>• Refer to Service Manual</li> </ul>	Remove panel behind ladder to access air filter.
53a	a. Fuel Filter	Figure 5-4	---	---	<ul style="list-style-type: none"> <li>• Change filter every 500 hours or 6 months.</li> <li>• Drain water trap every 10 hours or daily.</li> </ul>	<ul style="list-style-type: none"> <li>• Fuel filter is located on the intake manifold of engine.</li> <li>• Strainer is located near battery box.</li> </ul>
53b	b. Water Separator					

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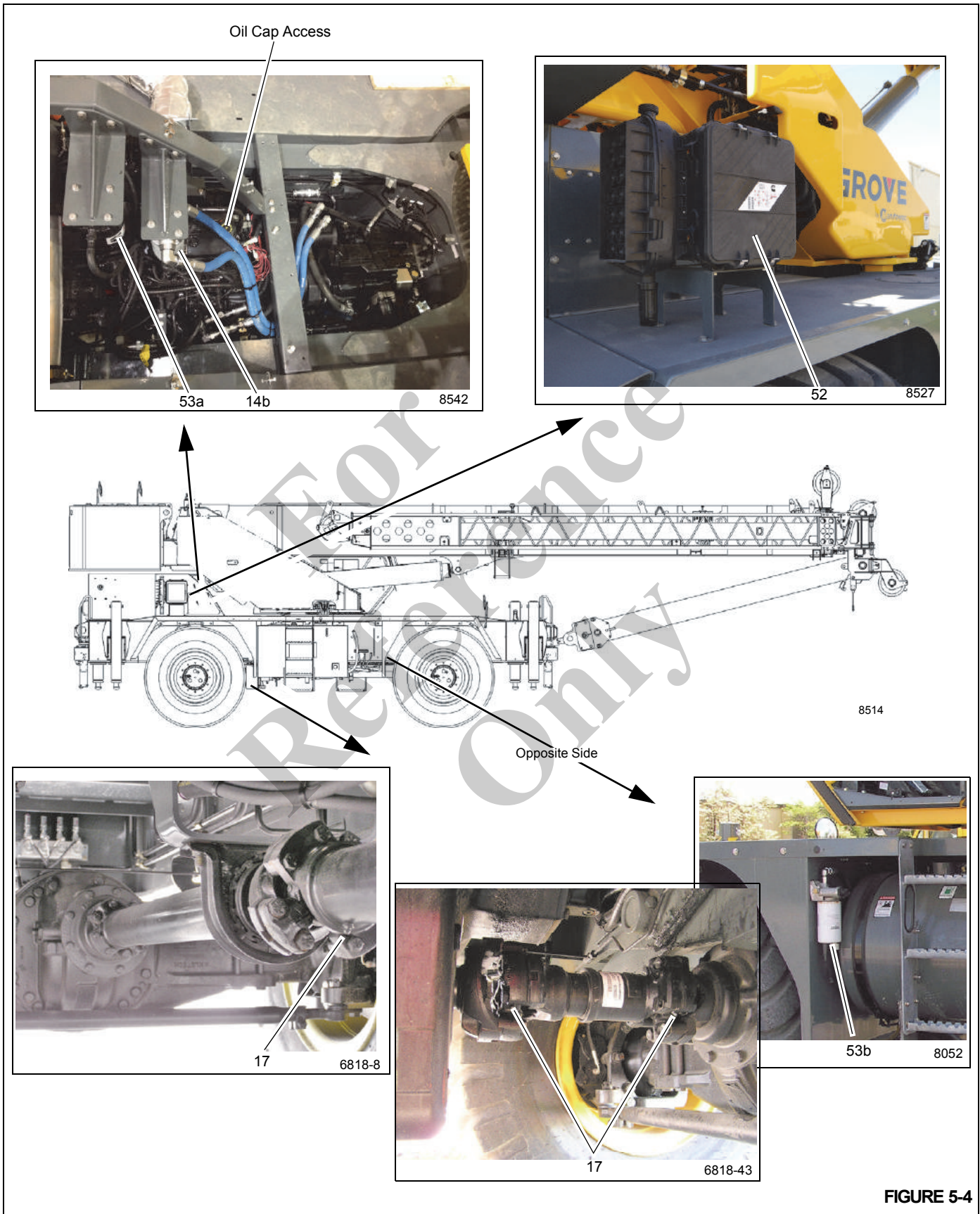
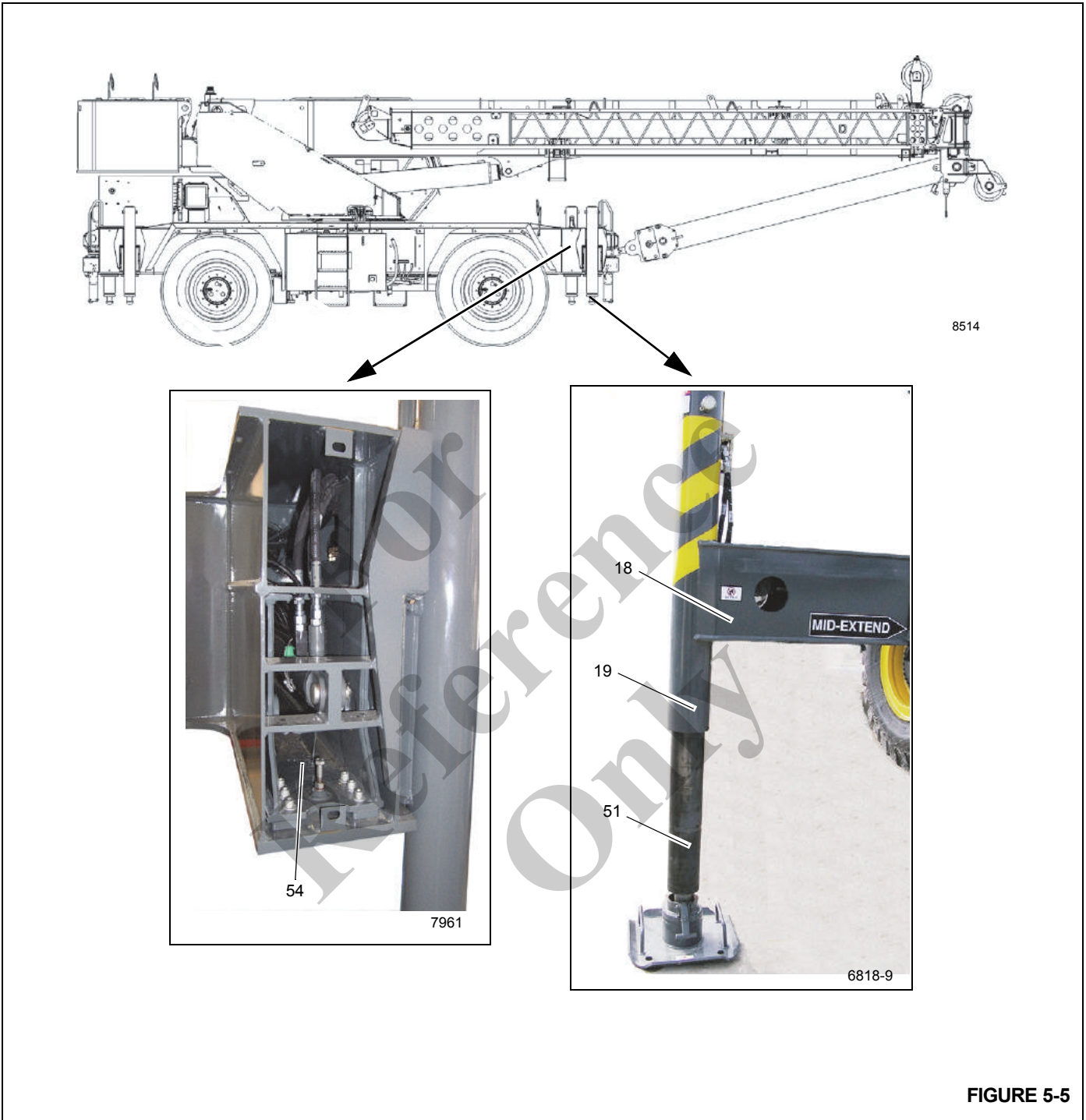


FIGURE 5-4

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Outriggers</b>						
18	Outrigger Beams (Outside)	Figure 5-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on bottom of outrigger beams
19	Jack Cylinder Support Tubes	Figure 5-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on OD of jack cylinder barrel and wear band before installing jack cylinders
51	Jack Cylinder Barrels	Figure 5-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on OD of jack cylinder support tubes (4) places before installing jack cylinders
54	Outrigger Beams (Inside)	Figure 5-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on inside bottom of outrigger beams where beam extension cylinder guide supports travel

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FIGURE 5-5



Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Turntable</b>						
20	Turntable Gear Box	Figure 5-6	GL-5 Extended Service Interval Gear Lubricant 6829012964	4.0 l (4.25 qt)	<ul style="list-style-type: none"> <li>• Check and fill every 50 hours</li> <li>• Drain and fill after first 250 hours and every 500 hours or 12 months thereafter.</li> </ul>	Use dipstick. If no dipstick, fill to top of case.
21	Turntable Gear and Drive Pinion	Figure 5-6	EP-OGL Open Gear Lubricant 6829102971	Coat all teeth	500 hours or 6 months	Spray on
22	Turntable Bearing	Figure 5-6	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes the whole circumference of the bearing	500 hours or 6 months	2 grease fittings at the front of the turntable
<b>NOTE:</b> Rotate the turntable 90° and apply grease to fittings. Continue rotating 90° and grease the fittings until the whole bearing is greased.						

Reference Only



FIGURE 5-6

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom</b>						
25	Upper Lift Cylinder Pin	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	1 grease fittings
29	Hook Block Swivel Bearing	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
30	Hook Block Sheaves	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	4 grease fittings - 35 Tons 3 grease fittings - 35 Tons
31	Telescope Cylinder Wear Pads	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat	Every boom teardown or 125 hours/3 months	2 places by brush Extend boom for access through holes
32	Side Wear Pads	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	250 hours or 3 months	12 places by brush; with boom in extended position
33	Boom Section Upper Wear Pads	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	50 hours or 1 week	6 places by brush; with boom in extended position through access holes
34	Boom Section Lower Wear Pads	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	50 hours or 1 week	3 places by brush; with boom in extended position
35	Extend Cable Sheaves	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	3 grease fittings Extend boom for access through holes
36	Retract Cable Sheaves	Figure 5-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	4 grease fittings
<b>NOTE:</b> Lubricate items more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.						

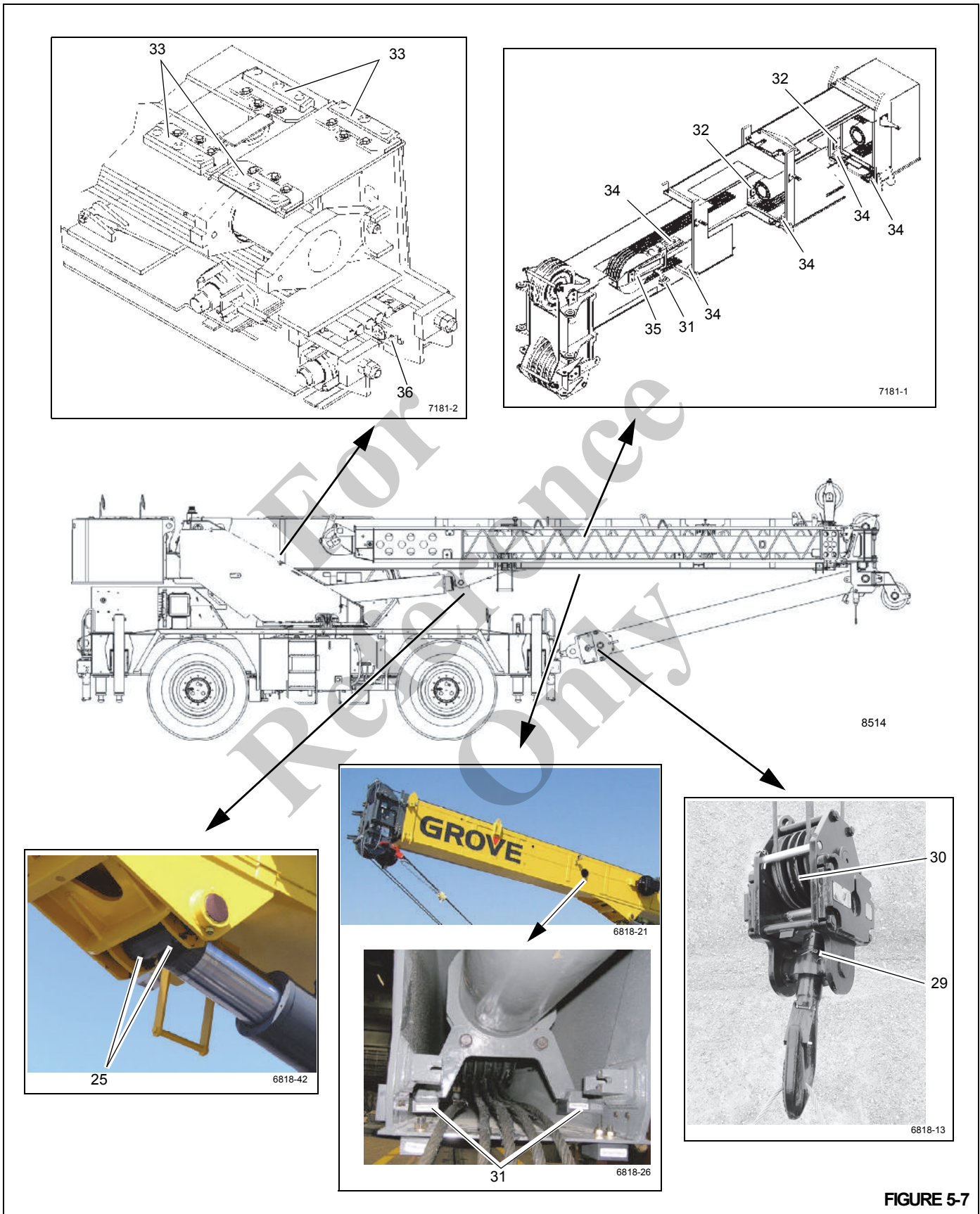


FIGURE 5-7

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom (continued)</b>						
37	Boom Pivot Shaft	Figure 5-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings
38	Boom Extension Sheave	Figure 5-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
39	Boom Extension Roller	Figure 5-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	4 grease fittings
40	Upper Boom Nose Sheave	Figure 5-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
41	Lower Boom Nose Sheave	Figure 5-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
42	Auxiliary Boom Nose Sheave	Figure 5-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
43	Mast Sheave	Figure 5-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 12 months	1 grease fitting

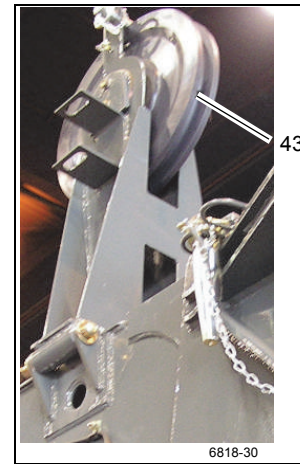
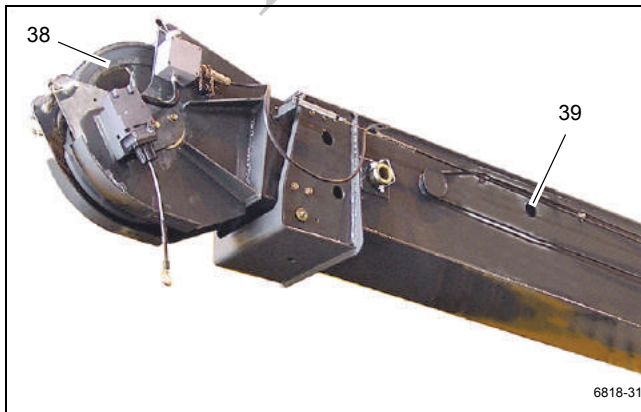
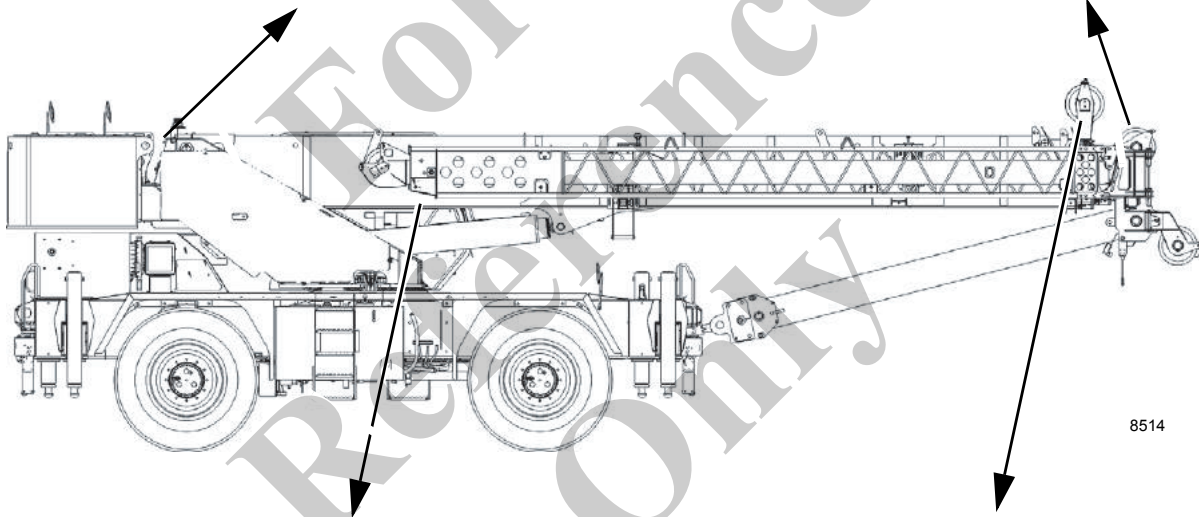
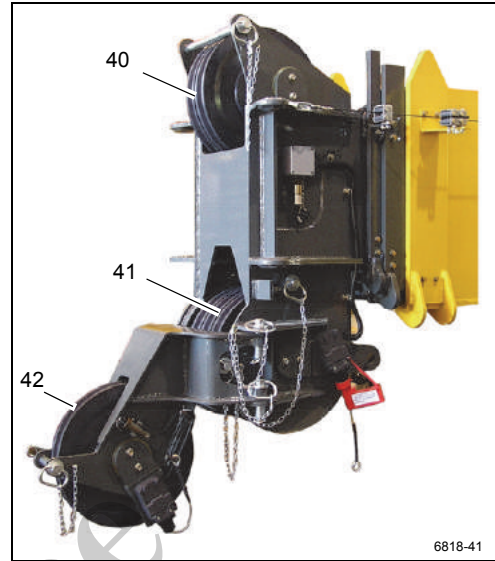


FIGURE 5-8

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Hoist</b>						
45	Main Hoist	Figure 5-9	AGMA Extreme Pressure Gear Lubricant 6829100213	5.2 l (5.5 qt)	<ul style="list-style-type: none"> <li>• Check and fill every 50 hours or weekly</li> <li>• Drain and fill every 1000 hours or 12 months</li> </ul>	Oil level must be visible in the sight glass
46	Auxiliary Hoist	Figure 5-9	AGMA Extreme Pressure Gear Lubricant 6829100213	5.2 l (5.5 qt)	<ul style="list-style-type: none"> <li>• Check and fill every 50 hours or weekly</li> <li>• Drain and fill every 1000 hours or 12 months</li> </ul>	Oil level must be visible in the sight glass
<p><b>NOTE:</b> Line up the Fill/Drain Plug with the upper cutout hole (A). Let hoist sit idle for 20 minutes for an accurate reading. Ensure hoist is level and oil temperature is 21°C ±11°C (70°F ±20°F). If oil level is not visible in sight glass, the hoist may be under filled. Oil escaping from vent plug is an indication the hoist may be over filled. If hoist is over filled, move the Fill/Drain Plug to the lower cutout hole (B) and drain until oil level falls within the sight glass.</p>						
47	Cable Follower (Arms)	Figure 5-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat	250 hours or 3 months	Spray on
<p><b>NOTE:</b> Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.</p>						

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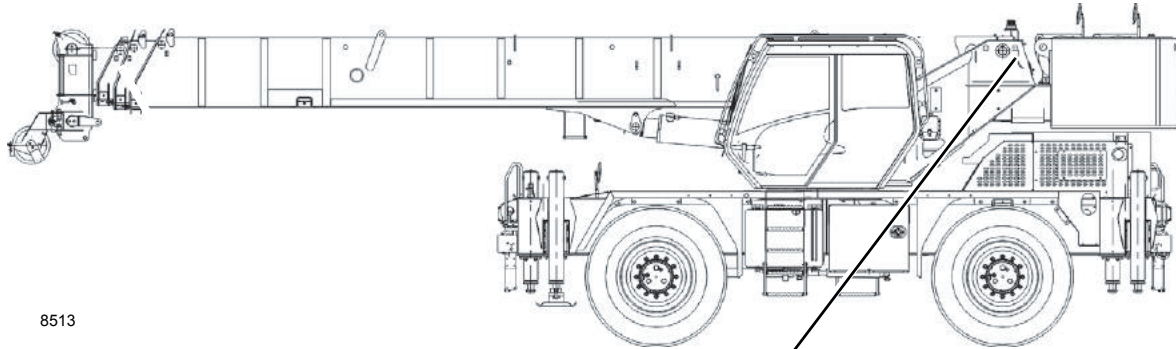
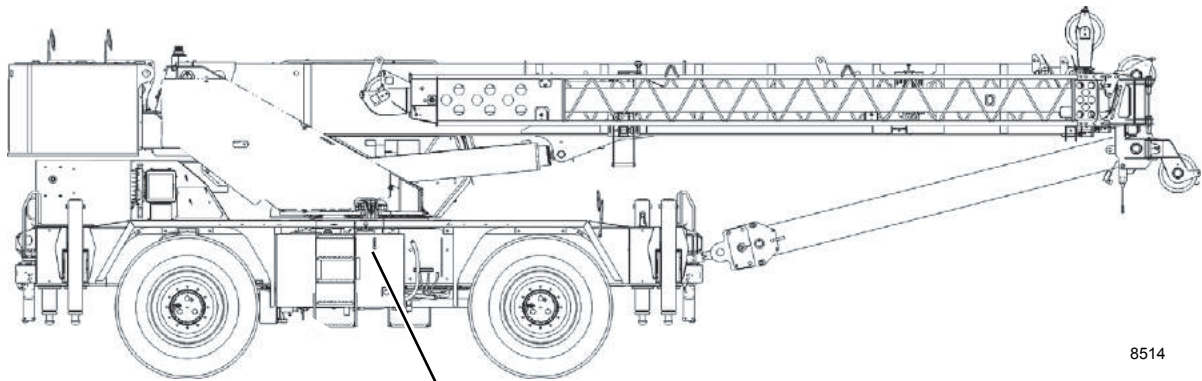


FIGURE 5-9



Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Hydraulic</b>						
48	Hydraulic Tank	Figure 5-10	HYDO Hydraulic Oil 6829006444	397.4 l (105 gal)	Check fluid level every 10 hours or daily.	<ul style="list-style-type: none"> <li>• Use sight gauge on side of tank, with boom down and all outrigger cylinders retracted.</li> <li>• Drain and refill as necessary</li> </ul>
<p><b>NOTE:</b> 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 of Grove cranes 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.</p> <ul style="list-style-type: none"> <li>• Under normal operating conditions, it is recommended that hydraulic oil, filters and breathers be inspected and oils sampled at least every 3 to 6 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 (e.g., 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 the contaminants content may be 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.</li> <li>• To inspect hydraulic oil, fill a small glass container with a sample of reservoir oil and another glass container with fresh oil. Let the samples stand, undisturbed, for one to two hours and 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 was due to air foaming, it will dissipate and the oil should closely match the fresh oil. Should you have any questions, please contact your local authorized Manitowoc distributor.</li> <li>• The hydraulic oil shall meet or exceed ISO #4406 class 17/14 cleanliness level.</li> </ul>						
49	Hydraulic Filter	Figure 5-10	HYDO Hydraulic Oil 6829006444	---	Change filter when the indicator is red	---



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FIGURE 5-10

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Diesel Exhaust Fluid (DEF) Tank</b>						
55	DEF Tank	Figure 5-11	DEF 6829003476 80019225	19 L (5 gal)	Fill when level is low per indicator.	Left rear side of carrier.

**NOTE:** Use caution when adding Diesel Exhaust Fluid (DEF) to avoid spills during vehicle fill-up.  
**CAUTION:** DEF is corrosive to certain metals and paint and should be washed off with mild soap and water if spilled.

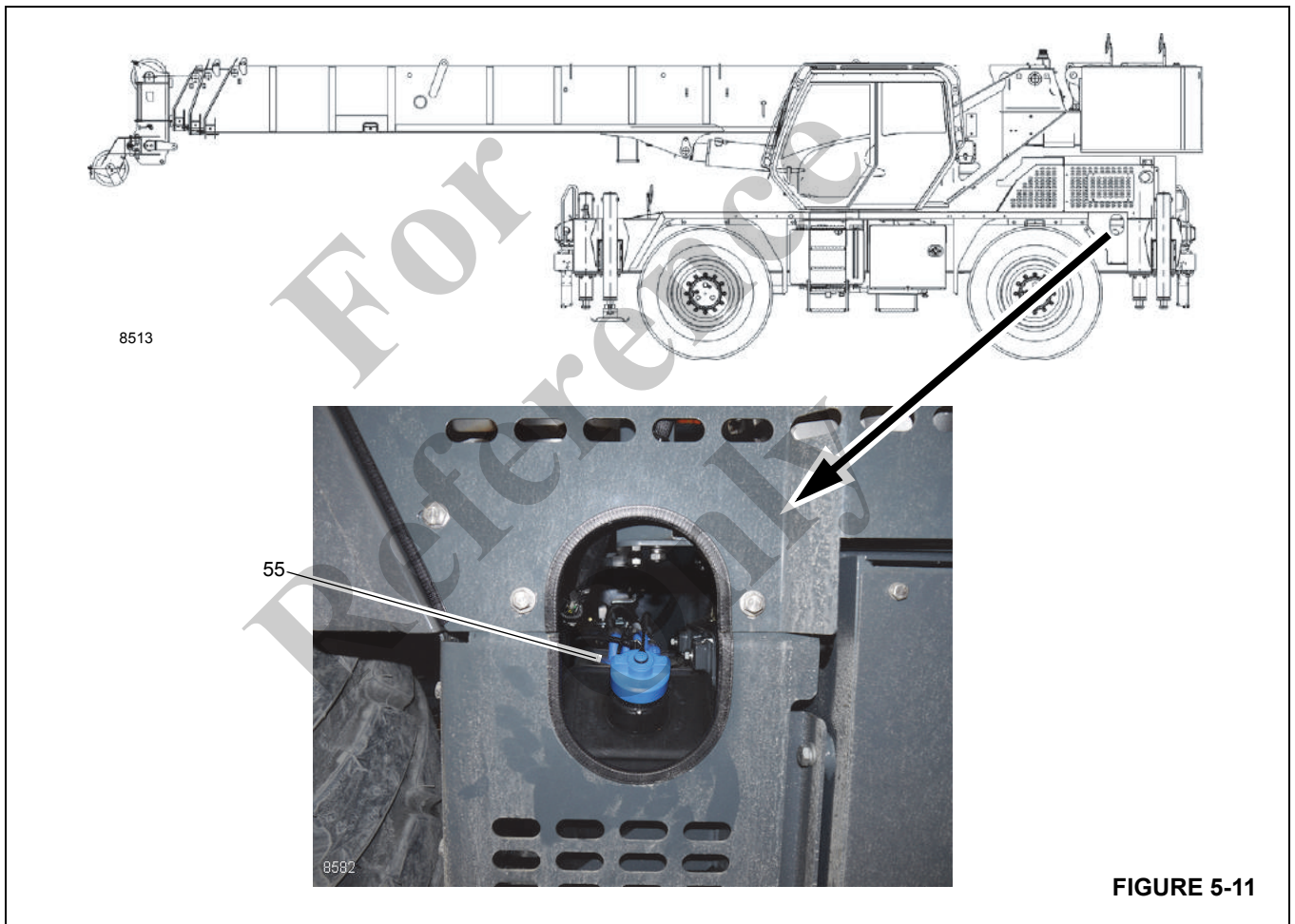


FIGURE 5-11

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## SECTION 6 MAINTENANCE CHECKLIST

### SECTION CONTENTS

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### GENERAL

This section contains a list of daily inspection and maintenance checks. Performing the checks will help maintain the safety, dependability, and productivity designed into your crane.

Refer to your Inspection and Lubrication Service Log for further requirements.

#### Daily or 10 Hour Check List

- 1 **Operator Manual:** Is item properly installed on machine?
- 2 **Signal and Running Lights and Horn:** Check for cracked or broken glass. Check for proper working order
- 3 **Backup Alarm:** Check for proper operation while operating machine
- 4 **Gauges and Instruments:** Check for proper working order. Check for proper reading while operating engine; Check for proper operation while operating machine
- 5 **Brakes (Swing, Foot and Parking):** Check for proper working order. Check for proper operation while operating machine
- 6 **Boom Angle Indicator:** Check for proper operation while operating machine
- 7 **Rated Capacity Limiter:** Check for proper operation while operating machine. Check connectors and wiring for proper alignment and insulation
- 8 **Antitwo-Block (A2B) Electrical and Hydraulic:** Check for proper operation while operating machine. Check connectors and wiring for proper alignment and insulation
- 9 **Brakes and Air System (if equipped):** Check for proper working order. Check for proper operation while operating machine. Drain moisture
- 10 **Tires:** Check for proper inflation/pressure. Check for excessive wear. Check for excess dirt, grease or foreign matter
- 11 **Hydraulic Tank:** Check for proper service/level. Check for excess dirt, grease, or foreign matter
- 12 **Hydraulic Oil Filter:** Check for proper service/level
- 13 **Wire Rope:** Check for damaged, frayed, or broken strands.
- 14 **Hoists:** Is item properly installed on machine? Check for excess dirt, grease, or foreign matter. Check for proper operation while operating machine
- 15 **Boom and Attachments:** Is item properly installed on machine? Check for excess dirt, grease, or foreign matter; Check for proper operation while operating machine
- 16 **Engine:** Check for proper service/level. Check for excess dirt, grease, or foreign matter
- 17 **Transmission/Torque Converter:** Check for proper service/level
- 18 **Cooling System:** Check for proper service/level. Check for cracks or leaks

### INSTRUCTIONS

Refer to your Service Manual for specific maintenance and adjustment procedures.

Refer to Section 5 - Lubrication (in this Operator Manual) for lubrication intervals, types of fluids and lube point locations.

- 19 **Fuel/Water Separator:** Drain moisture
- 20 **Air Cleaner:** Check for proper service/level. Check for cracks or leaks
- 21 **Hook Block and Headache Ball Safety Latch:** Check for proper working order. Check for cracks and leaks; Check for excessive wear
- 22 **Lock-out Cylinder and Swing Potentiometer:** Check for proper operation while operating machine. Check for proper adjustment

### Weekly or 50 Hour Check List

- 1 **Sheaves:** Check for proper operation, excessive wear, and damage.

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