National Crane 600H

Operator Manual

Grove Manitowoc National Crane Potain

Manitowoc

WARNING

California Proposition 65

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

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

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

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

California Spark Arrestor

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

The original language of this publication is English.

NATIONAL CRANE
by Manitowoc

OPERATOR MANUAL

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

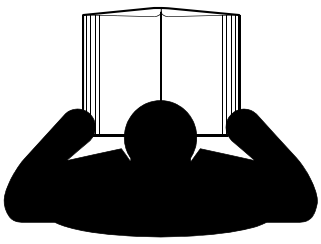
600H

This Manual is divided into the following sections:

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 right side of the turret. ***Always furnish crane serial number*** when ordering parts or communicating service problems with your distributor or the factory.



⚠DANGER

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

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

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SECTION 1
INTRODUCTION

SECTION CONTENTS

GENERAL

This manual has been compiled to assist you in properly operating and maintaining your Model 600H series National Crane.

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

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

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

The 600H has been designed for maximum performance with minimum maintenance. With proper care, years of trouble-free service can be expected.

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

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

Supplemental Information

Supplemental Information regarding Safety & Operation, Specifications, Service & Maintenance, Installation, and parts for options such as remote controls, augers, varying control configurations, baskets, grapples, etc. are included in separate manuals.

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

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

New Owner

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

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

Basic Nomenclature

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

600H-Behind the Cab

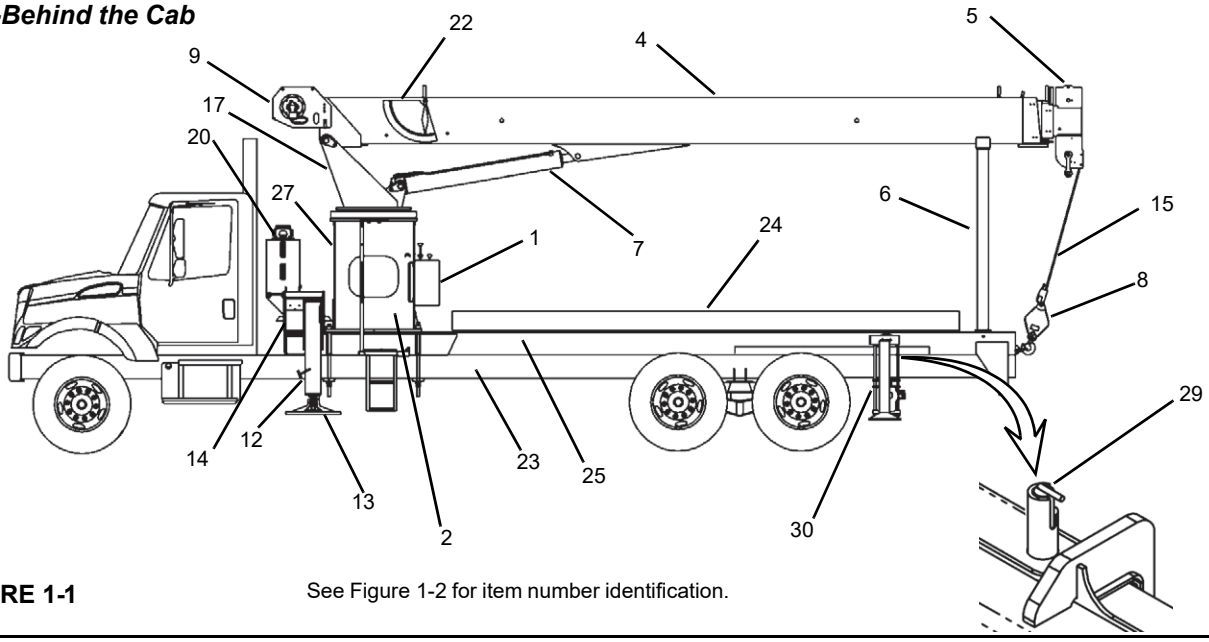
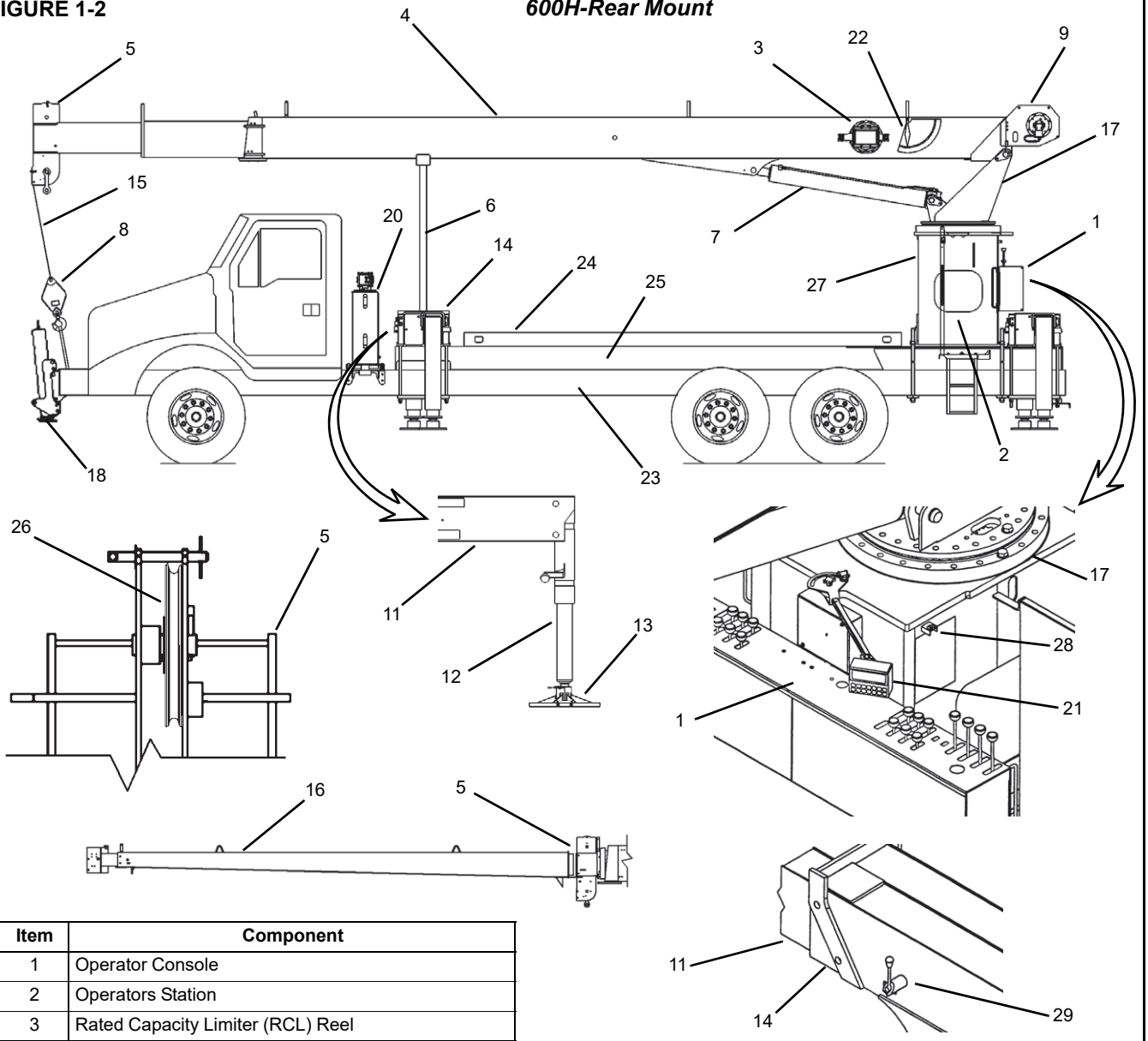


FIGURE 1-1

See Figure 1-2 for item number identification.

FIGURE 1-2 ***600H-Rear Mount***

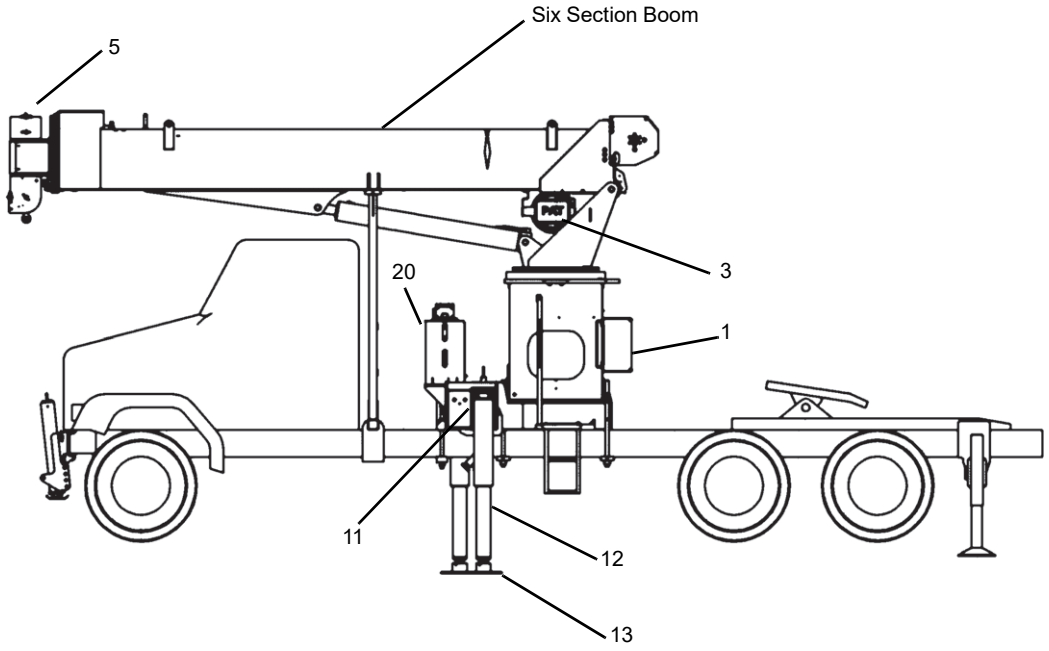


Item	Component
1	Operator Console
2	Operators Station
3	Rated Capacity Limiter (RCL) Reel
4	Boom
5	Boom Nose
6	Boom Rest
7	Lift Cylinder
8	Downhaul Weight, Hook Block
9	Hoist
11	Outrigger Beam
12	Outrigger Jack
13	Outrigger Float
14	Outrigger Box
15	Hoist Cable, Wire Rope
16	Jib
17	Turret

Item	Component
18	Stabilizer Front Outrigger (SFO), Front Outrigger Jack
20	Hydraulic Tank
21	RCL Panel
22	Boom Angle Indicator
23	Truck Frame
24	Truck Bed
25	Torsion Box, T-Box
26	Sheave
27	Crane Frame
28	Bubble Level
29	Outrigger Stop Pin
30	Rear Outrigger Out and Down (RSOD)

600H-Tractor Mount

FIGURE 1-3



See Figure 1-2 for item number identification.

NOTICE TO OWNER/USER

IMMEDIATELY report all accidents, malfunctions, and equipment damages to your local National Crane distributor. Following any accident or damage to equipment, the local National Crane distributor must be immediately advised of the incident and consulted on necessary inspections and repairs. Should the distributor not be immediately available, contact should be made directly with Manitowoc Crane Care. 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 local National Crane distributor or Manitowoc Crane Care.

SECTION 2
SAFETY PRECAUTIONS

SECTION CONTENTS

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 equipment 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. The decals shown in this section are examples. Consult the *Parts Manual* for specific decals installed on the crane.

Because you are the only part of the equipment 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.

ACCIDENTS

Following any accident or damage to equipment, the National Crane distributor must be immediately advised of the incident and consulted on necessary inspections and repairs. Should the distributor not be immediately available, contact should be made directly with Manitowoc Product Safety at the address below. The equipment 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 National Crane distributor and/or Manitowoc Crane Care.

If this equipment becomes involved in a property damage and/or personal injury accident, **immediately** contact your National Crane 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)
Fax: 717-593-5152
E-mail: product.safety@manitowoc.com

OPERATOR INFORMATION

You must **read** and **understand** this *Operator Manual* and the *Load Chart* before operating your new equipment. 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 equipment is in use.

The *Operator Manual* supplied with and considered part of your equipment must be read and completely understood by

each person responsible for assembly, disassembly, operation and maintenance of the equipment.

No personnel shall be allowed to climb onto the equipment or enter the 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 equipment while the equipment is operating or moving, unless they are seated in a two-man cab.

Keep clear of moving outriggers to avoid crushing hazards. Contact with moving components could result in death or serious injury.

Example decal. For reference only.
8819

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

Inspect the equipment 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 equipment. 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 equipment 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 equipment are thoroughly familiar with safe operating practices. You must be thoroughly familiar with the location and content of all decals on the equipment. Decals provide important instructions and warnings and must be read prior to any operational or maintenance function.

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

You must be familiar with the regulations and standards governing equipment and its 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.

Example decal. For reference only.
8788

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

You must not operate this equipment unless:

- You have been trained in the safe operation of this equipment.
- 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 equipment has been inspected and maintained in accordance with the manufacturer's manuals and is operating properly.
- You are sure that all safety decals, guards, and other safety features are in place and in proper condition.

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

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

You must be mentally and physically fit to operate equipment. Never attempt to operate equipment 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 equipment, 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 equipment or that take control of particular functions without action of the operator when a limiting condition is sensed. 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, equipment level indicator, hoist drum rotation indicator, load indicator, and wind speed indicator.

National Crane remains committed to providing reliable products that enable users and operators to safely lift and position loads. National Crane has been an industry leader in the incorporation of operational aids into the design of its equipment. Federal law requires that equipment be properly maintained and kept in good working condition. The manuals that National Crane provides that are specific for each piece of equipment and the manufacturer's manuals for the operational aids shall be followed. If an operational aid should fail to work properly, the equipment 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 equipment when operational aids are inoperative or malfunctioning, the following requirements shall apply for continued use or shutdown of the equipment:

- 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 equipment 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, or the markings and indicator on the boom.
- 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 equipment.

Rated Capacity Limiter (RCL) Systems (If Equipped)

Your equipment 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 equipment, 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 equipment as shown on the *Load Chart* before making any lifts.

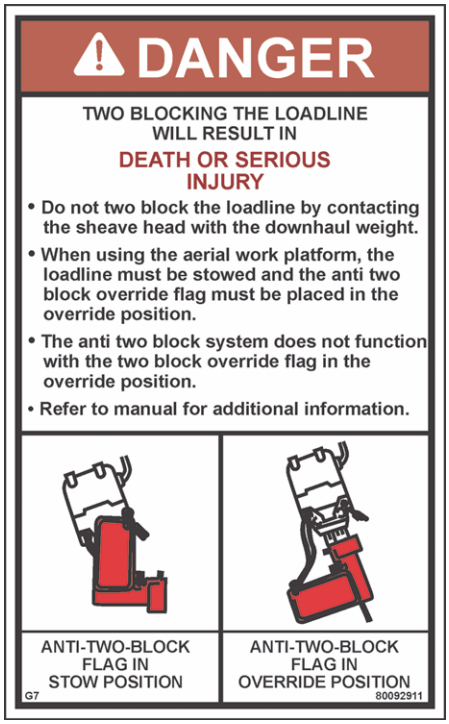
NEVER exceed the rated capacity shown on the *Load Chart*. Always check the *Load Chart* to ensure the load to be lifted at the desired radius is within the rated capacity of the equipment.

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

Anti-Two-Blocking Device

This equipment 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 lines (wire rope), rigging, reeving, and other components to become highly stressed and overloaded in which case the rope may fail allowing the load, block, etc. to free fall.



9250 **Example decal. For reference only.**

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 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 equipment 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 equipment operating practices, experience, and good operator judgments.

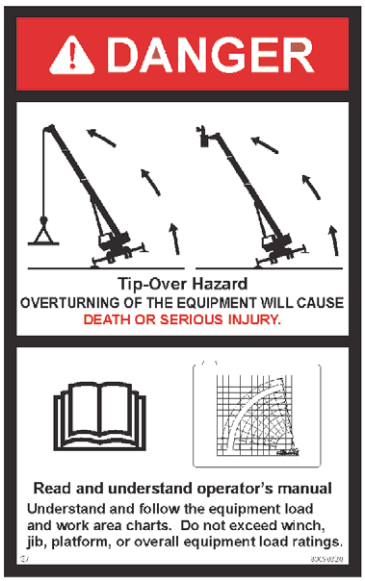
EQUIPMENT STABILITY/STRUCTURAL STRENGTH

To avoid death or serious injury, ensure that the equipment is on a firm surface with load and equipment's configuration within capacity as shown on the equipment'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 equipment with a single front outrigger.



9120 **Example decal. For reference only.**

Carefully follow the procedures in this Operator Manual when extending or retracting the outriggers. Death or serious injury could result from improper equipment 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 not fully extended and set, consult the *Load Chart* for any boom angle or boom length restrictions.

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 equipment stability before lifting loads. Ensure the outriggers are firmly positioned on solid surfaces. Ensure the equipment 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.

Outrigger beams and jack cylinders (plus single front outrigger, if equipped) must be properly extended and set to provide precise leveling of the equipment. 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 equipment 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 equipment 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 equipment.

Work Site

Prior to any operation, you must inspect the **entire** work site, including ground conditions, where the equipment will travel and operate. Be sure that the surfaces will support a load greater than the equipment's weight and maximum capacity.

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

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 equipment.

Wind can have a significant effect on loads that may be lifted by equipment. Wind forces act differently on equipment 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. National Crane 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.

Table 2-1 Beaufort Wind Scale

		Maximum Wind Speed			
Beaufort Number	**Description**	**m/s**	**km/h**	**mph**	**Visible Indicator Effects of wind as observed on land**
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 speed recorded at equipment 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 equipment and the load. The wind effect on the load can be conservatively estimated as:

a) If ***V(z)*** is ≤ 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 ≤ 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).

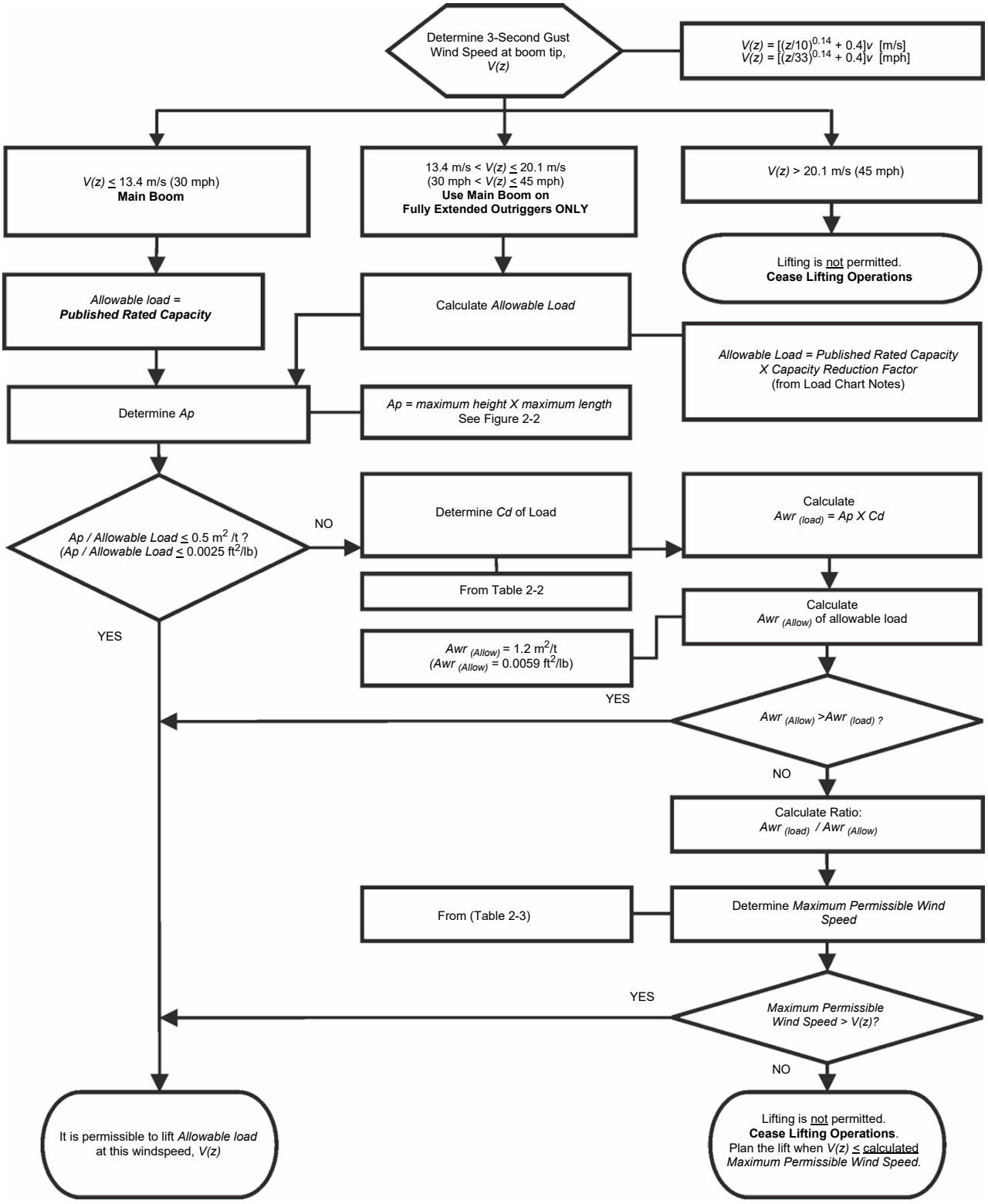
NOTE: This condition is limited to operation with the main boom on fully extended outriggers only.

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 ***Ap*** and by the wind drag coefficient ***Cd***: This limit can be determined by comparing the **Actual** wind resistance area with the **Allowable** wind resistance area.

Refer to Figure 2-1 for a simplified calculation method to determine permissible wind speed.

Simplified Method to Determine Maximum Permissible Wind Speed



V(z) = 3 second gust wind speed at boom tip, m/s (mph)
Ap = Projected Wind Area of Load, m^2 (ft^2)

Awr (load) = Actual Wind Resistance Area for the Load, m^2(ft)
Awr (Allow) = Allowable Wind Resistance Area of the Load, m^2 (ft2
Cd = air drag coefficient of load

FIGURE 2-1

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 equipment 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 equipment 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 m/s (17.7 mph)

Boom tip height for this lift is ***Z*** = 30 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 ≤ 13.4 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. **National Crane 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^2] [ft^2] - Wind resistant area of the load

Ap [m^2] [ft^2] - 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 (Ap):

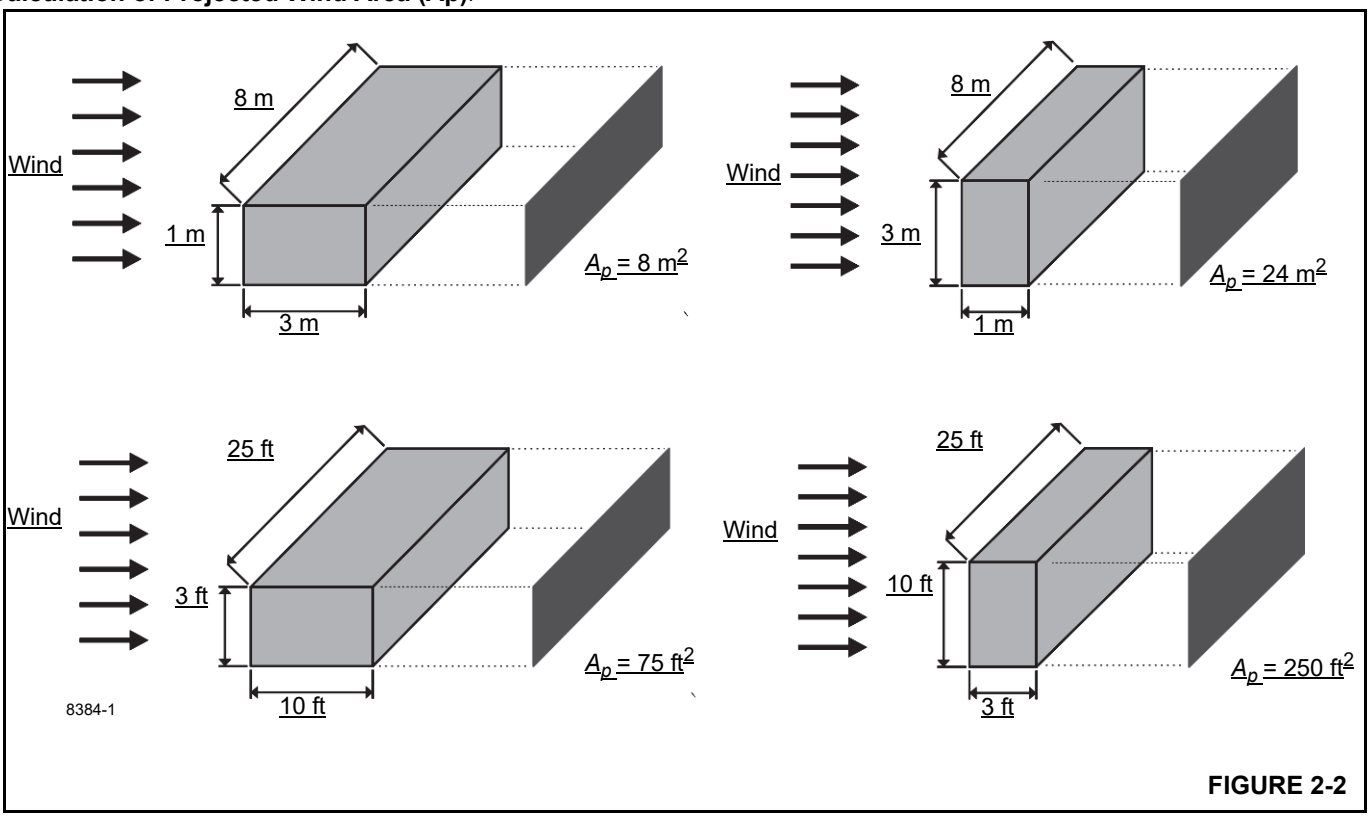


FIGURE 2-2

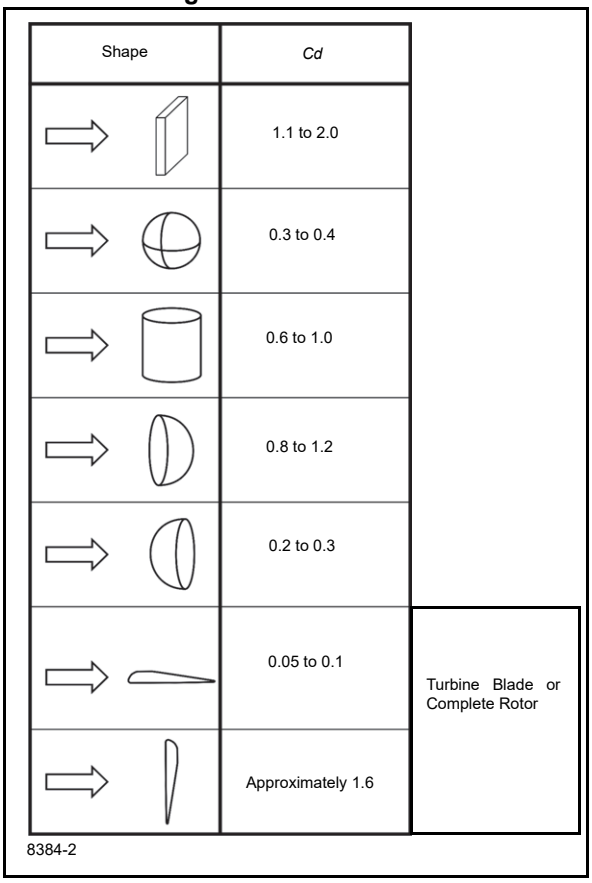
Determining Wind Drag Coefficient (Cd)

Table 2-2 shows the typical Shapes and corresponding Wind Drag Coefficient *(**Cd**)* 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 *(**Cd**)* = 2.4.

Table 2-2 Wind Drag Coefficient



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	#0001								
	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 (8)			
6	32,950 (50.5)	32,925 (55.5)	32,825 (63.5)	28,350 (68.5)	18,225 (72)	18,2 (7)	*18,225 (78)		
7	28,325 (42.5)	28,300 (49)	28,225 (59)	26,250 (65)	18,225 (69)	225 ( )	18,225 (74.5)	*16,725 (78)	*11,400 (78)
8	24,150 (32.5)	24,150 (42)	23,975 (54.5)	23,275 ( )	225 ( )	225 (69.5)	16,575 (72)	15,250 (74.5)	11,400 (76)
9	20,600 (16.5)	20,550 (33.5)	20,375 (49.5)	20,25 ( )	18,22 (63)	16,575 (67)	15,050 (70)	13,875 (72.5)	11,400 (74.5)
10		17,200 (20.5)	17 (4	17 5 (54)	17,325 (60)	15,1 5 (64.	13,725 (67.5)	12,700 (70.5)	11,400 (72.5)
12			2,07 ( )	225 (45.5)	12,575 (53.5)	2,7 ( )	11,600 (63)	10,725 (66.5)	10,050 (69)
14				9,000 (35)	9,360 (6)	9,730 (53.5)	,955 (58.5)	9,205 (62)	8,620 (65)
16				6,75 (19)	7,1 (37.5)	7 5 (47)	7,920 (53)	7,980 (57.5)	7,470 (61.5)
18					5 ( )	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)	4,380 (42.5)	4,545 (48.5)
24							3,435 (23.5)	3,620 (36)	3,780 (43.5)
26								2,975 (28)	3,150 (37.5)
28								2,400 (16)	2,620 (31)
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.

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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 m/s ≤ 20.1 m/s, the Reduced Capacity shall be calculated by multiplying the Published Rated Capacity by the following factors:

	Main Boom Length in Meters								
Wind Speed *V(z)* > 13.4 m/s ≤ 20.1 m/s	10.9	12.2	15.2	18.4	21.3	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 x 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 equipment 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: Equipment Configuration:

- boom length = 27.4 m,
- load radius = 9 m,
- wind speed is measured at ***V(z)*** ≤ 20.1 m/s.

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

The maximum allowable wind resistance area of load is

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

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

Lifting Limits at wind speed V(z) ≤ 13.4 m/s at this configuration:

- Maximum load 15,050 kg
- Maximum wind resistance area of load 18.06 m^2

For the allowable wind speed > 13.4 m/s and ≤ 20.1 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:

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

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

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

Lifting Limits at wind speed V(z) > 13.4 m/s **and ≤ 20.1 m/s,** at this configuration:

- Maximum load 12,040 kg
- Maximum wind resistance area of load 14.45 m^2

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^2.

Refer to the information from the above equipment 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^2,
- Wind Drag Coefficient ***Cd*** = 1.5

wind resistance area of load can be estimated as

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

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 $Awr_{(load)}$ less than $Awr_{(allow)}$?
  13.8 m^2 ≤ 14.45 m^2 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^2,
- 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
  $Awr_{(load)} = Ap \times Cd = 5.45 \times 2.4 = 13.08\ m^2$

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 $Awr_{(load)}$ less than $Awr_{(allow)}$?
  13.08 m^2 ≤ 14.45 m^2 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 $Awr_{(load)}$,

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

the wind resistance area of load can be estimated as:

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

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 $Awr_{(load)}$ less than $Awr_{(allow)}$?
  26.22 m^2 ≤ 18.06 m^2 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 $Awr_{(load)}$,

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

the wind resistance area of load can be estimated as

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

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^2 ≤ 14.45 m^2 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:

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.

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 ≤ 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 ≤ 45 mph	36	40	50	[illegible]	70	80	90	100	110
Factor	0.9	0.9	0.8	[illegible]	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 ft², $Awr_{(allow)}$ = 0.0059 x calculated reduced capacity in lb.

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, $Awr_{(allow)}$, refer to equipment Operator Manual.

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 (36.5)	56,600 (45)	56,350 (56)	53,650 (63)	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)	[illegible]	32,750 (69.5)	30,200 (72)	25,150 (74)
35			33,550 (40)	33,700 (51.5)	34,700 (58)	[illegible]	[illegible] (66)	26,400 (69)	24,700 (71.5)
40			25,800 (28)	26,150 (44.5)	[illegible]	27,[illegible]	25,200 (62.5)	23,300 (66)	21,800 (68.5)
45				[illegible]	[illegible] (47)	22,300 (54)	22,400 (59)	20,700 (62.5)	19,400 (65.5)
50				[illegible]	17,400 (41)	18,25[illegible] (49.5)	19,100 (55)	18,550 (59.5)	17,350 (62.5)
55					14,300 (33.5)	[illegible] (44)	16,000 [illegible]1)	16,400 (56)	15,600 (60)
60					[illegible]	12,700 (38.[illegible]	13,550 (46.5)	13,950 (52.5)	14,100 (56.5)
65						[illegible]00 (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)

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

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FIGURE 2-4

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:

Equipment is configured with:

- boom length = 90 ft,
- load radius = 40 ft, and
- wind speed is measured at ***V(z)*** ≤ 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^2

For the allowable wind speed > 30 mph and ≤ 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 ≤ 45 mph** at this configuration:

- Maximum load 20,160 lb
- Maximum wind resistance area of load 119 ft^2

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^2.

Refer to the above equipment 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^2,
- 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 ≤ 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 ≤ 20,160 lb YES
- Is $Awr_{(load)}$ less than $Awr_{(allow)}$?
  105 ft^2 ≤ 119 ft^2 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^2,
- 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 ≤ 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 ≤ 20,160 lb YES
- Is $Awr_{(load)}$ less than $Awr_{(allow)}$?
  108 ft^2 ≤ 119 ft^2 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 $Awr_{(load)}$,

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

the wind resistance area of load can be estimated as:

$Awr_{(load)}$ = **Ap** x **Cd** = 180 x 1.2 = 216 ft^2

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

- Is the load to be lifted less than allowable load?
  22,000 lb ≤ 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 ≤ 25,200 lb . . . . . YES

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

- Is $Awr_{(load)}$ less than $Awr_{(allow)}$,?
  216 ft^2 ≤ 149 ft^2. . . . . 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.**Conclusion**: This load is permissible to lift in wind speed up to 38.0 mph only.

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	25.4	23.7	22.4	21.2
For Allowable Capacity@ 45 mph	41.1	38.0	35.6	33.5	31.8

Load example 2.3b:

With large wind resistance area of the load $Awr_{(load)}$,

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

the wind resistance area of load can be estimated as:

$Awr_{(load)}$ = **Ap** x **Cd** = 125 x 1.3 = 162 ft^2

Refer to the above ***Lifting Limits at wind speed V(z) > 30 mph and ≤ 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 ≤ 20,160 lb YES
- Is $Awr_{(load)}$ less than $Awr_{(allow)}$,?
  162 ft^2 ≤ 119 ft^2 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 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.

Lifting Operations

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

The equipment is equipped with a bubble level that should be used to determine whether the equipment is level. The load line can also be used to estimate the levelness of the equipment 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 equipment configuration. Refer to the RCL operator manual supplied with the equipment.

Verify the equipment'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 equipment's *Load Chart*.

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

Do not overload the equipment by exceeding the capacities shown on the appropriate *Load Chart*. Death or serious injury could result from the equipment tipping over or failing structurally from overload.

The equipment can tip over or fail structurally if:

- The load and equipment'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 intermediate positions, the outriggers must also be pinned when operating from the intermediate position.
- Cribbing under the outrigger pads is inadequate.
- The equipment is improperly operated.

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

Be sure the hoist line is vertical before lifting. Do not subject the equipment to side loading. A side load can tip the equipment 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 equipment will lean toward the boom and the load will swing out, increasing the load radius. Ensure the equipment'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 equipment from service if the boom is damaged.

Never push or pull with the boom.

Avoid sudden starts and stops when moving the load. The inertia and an increased load radius could tip the equipment 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 2-20 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 equipment 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. [OSHA 29CFR 1926.1434]

Outrigger Lift Off

Regarding "lifting" of an outrigger pad during craning activities, be advised that the rated loads for these equipment, as indicated on the equipment's *Load Chart*, do not exceed 85% of the tipping load on outriggers as determined by SAE J765 JUNE2017 "Cranes Stability Test Code." An outrigger pad may lift off the ground during operation of the equipment within the capacity limits of the *Load Chart*, yet the equipment will not have reached instability. The "balance point" for stability testing according to SAE and National Crane criteria is a condition of loading wherein the load moment acting to overturn the equipment is equal to the maximum moment of the equipment available to resist overturning. This balance point or point of instability for equipment 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 equipment'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 equipment is properly set up, the equipment is in good working condition, that all operator's aids are properly programmed, that the qualified equipment operator adheres to the instructions found in the applicable *Load Chart*, *Operator Manual* and decals on the equipment, the equipment should not be unstable.

Multiple Equipment Lifts

Multiple equipment lifts are not recommended.

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

- Secure the services of a qualified person to direct the operation.

- Make sure all signals are coordinated through the lift director or person in charge of the lift.
- 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 equipment so equipped.
- Calculate the amount of weight to be lifted by each piece of equipment 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 piece of equipment to the other.
- Do not travel. Lift only from a stationary position.

Tilt-Up Panel Lifting

Requirements and recommendations regarding operation and use of National Cranes are stated on decals and in the Operator and Safety Handbook and other manuals provided with each specific model machine. Using the subject equipment 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 equipment to be used to perform tilt-up panel lifting using a equipment equipped with two hoists:

- The equipment must be set up and operated in accordance with instructions in the Operator and Safety Handbook, Load Capacity Chart, and decals affixed to the equipment.
- 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 equipment and the auxiliary hoist line connected to the end farthest from the equipment.
- 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 of line.
- 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 equipment.
- 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 equipment 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 equipment are properly trained and thoroughly familiar with operational functions of the equipment and safe operating and work practices. Personnel should be thoroughly familiar with regulations and standards governing equipment and its 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 National Crane, provided all equipment is operated within factory guidelines. The following operating requirements must be used during pile driving and extracting with a National mobile hydraulic equipment:

Pile driving and pile extraction using a mobile equipment introduces many variable and unknown factors that must be considered when using a equipment 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 National Crane 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 equipment.

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 National Crane, 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 equipment 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 equipment'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 equipment are permitted. All possible precautionary measures shall be taken to prevent shock loads or vibration from being imposed on equipment 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 equipment operations as well as being thoroughly trained in the safe operation of pile driving and extracting equipment.

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.

Equipment Inspection

- In addition to the equipment's frequent and periodic inspections, dated daily records shall be maintained showing inspections were performed on the equipment 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 equipment subject to fatigue shall be inspected monthly, and before the equipment is to return to lifting service.
- The boom shall be inspected daily to ensure all wear pads remain in place. Equipment that utilizes 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 equipment near electric power lines or equipment.

United States federal law prohibits the use of equipment 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 29CFR1926.1400].

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

NOTE: For detailed guidelines on operating near power lines, refer to the current edition of OSHA 29CFR1926.1408 and ASME B30.5 American National Standard.

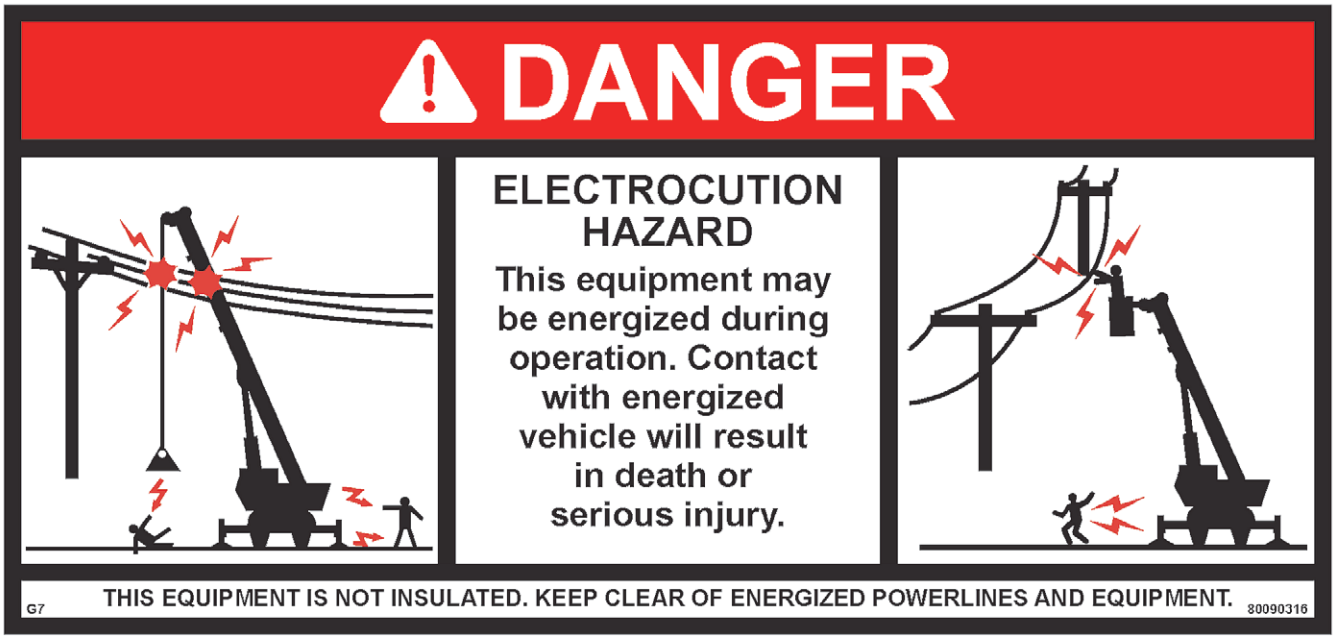
DANGER

Electrocution Hazard!

National cranes are not equipped with all features required to operate within OSHA 29CFR1926.1408, 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.

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



8822 **Example decal. For reference only.**

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

Before operating this equipment 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 equipment is **not insulated**. Always consider all parts of the load and the equipment, including the wire rope, hoist cable, 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 equipment while operating. Permit no one to lean against or touch the equipment. Permit no one, including riggers and load handlers, to hold the load, load lines, tag lines, or rigging gear.

If the load, wire rope, boom, or any portion of the equipment contacts or comes too close to an electrical power source, everyone in, on, and around the equipment 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 equipment boom if it comes too close to an electrical power source. Low voltages can also be dangerous.

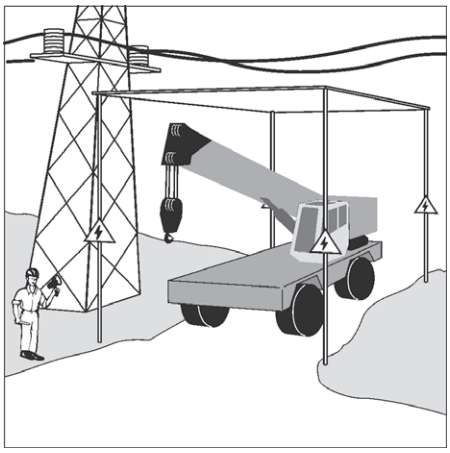
Set-Up and Operation

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

Set up the equipment in a position such that the load, boom, or any part of the equipment and its attachments cannot be moved to within 6 m (20 ft) of electrical power lines or equipment. This includes the equipment 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 equipment 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.



8823

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 equipment or load moves near a power source. This person shall have no other duties while the equipment 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 equipment 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 equipment 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 equipment 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 equipment should come in contact with an energized power source, you must:

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

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

Following any contact with an energized electrical source, the National Crane distributor must be immediately advised of the incident and consulted on necessary inspections and repairs. Thoroughly inspect the rope and all points of contact on the equipment. Should the distributor not be immediately available, contact Manitowoc Crane Care. The equipment 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 National Crane distributor or Manitowoc Crane Care.

Special Operating Conditions and Equipment

Never operate the equipment during an electrical thunderstorm.

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

- The transmitter shall be deenergized OR,
- Tests shall be made to determine if an electrical charge will be induced into the equipment or load.
- The equipment 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 equipment 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.

Grounding the Equipment

The equipment may become charged with static electricity. This may occur especially when using outrigger pads made of plastic or when the outrigger pads are packed with insulating material (e.g. wooden planks).

WARNING

Risk of accidents due to electric shock!

Ground the equipment before you start to work with it

- Near strong transmitters (radio transmitters, radio stations, etc.)
- Near high-frequency switching stations
- If a thunder storm is forecast

Use electrically conducting material for grounding.

1. Hammer a metal rod (3, Figure 2-5) (length of approximately 2.0 m (6.6 ft)) at least 1.5 m (5 ft) into the ground.
2. Moisten the soil around the metal rod (3) for better conductivity.
3. Clamp an insulated cable (2) to the metal rod (3), cross-section of at least 16 mm² (0.025 inches²).
4. Connect the free end of the cable with a clamp (1) to a good electrically conductive location on the frame.

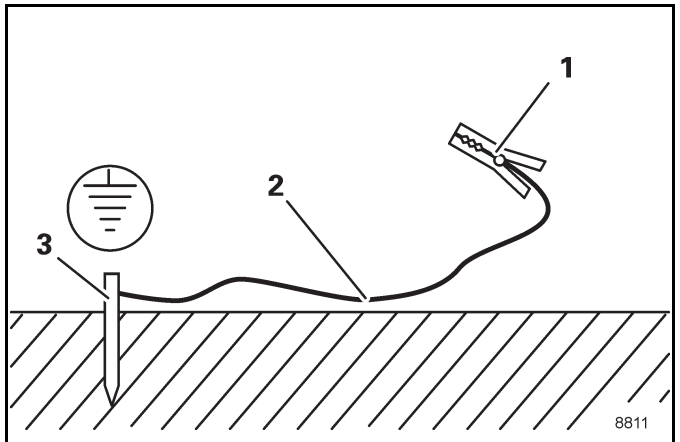


FIGURE 2-5

WARNING

Risk of accidents due to electric shock!

Ensure that the connections between the cable and the clamp are electrically conductive.

Do not attach the clamp to parts that are screwed on, such as valves, covers or similar parts.

PERSONNEL HANDLING

For equipment that is Dual-Rated as both acrane and an aerial lift, refer to the Safety Precautions - Aerial Lift section.

Also see the optional equipment manual titled Personnel Basket Manual which addresses safety, inspection, testing, operation, installation, and lubrication.

The following information is for machines that are not Dual Rated.

The American Society of Mechanical Engineers publishes the American National Standard entitled, *Personnel Lifting Systems,* ASME B30.23-2016:

> 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 830 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 standard is consistent with the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) regulations for Construction that state, in 29CFRI926.1431:

> General requirements. The use of equipment or derrick to hoist employees on a personnel platform is prohibited, except when the erection, use, and dismantling 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 equipment operations are stated in *ASME B30.5, Mobile and Locomotive Cranes*, ASME B30.8, *Floating Cranes and Floating Derricks,* and in *OSHA regulations 29CFRI910.180 for General Industry* and *29CFRI926.1431 for Construction*.

Use of a National Crane 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 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 equipment.
- 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's 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 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:
  - On a crane equipped with a boom mounted personnel platform, use only a platform approved by National Crane.
  - 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.

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

  - or -

  online at: www.asme.org/kb/standards

- *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 National cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

Handle and dispose of waste according to local, state, and federal environmental regulations.

When filling and draining equipment 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 equipment 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 equipment.

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

Shut down the equipment 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 equipment maintenance as well as equipment operations.

Keep the equipment 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 equipment 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 National Crane 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 equipment 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 National Crane distributor for assistance.

Qualified person is defined as one who by reason of knowledge, training and experience is thoroughly familiar with the equipment's operation and required maintenance as well as the hazards involved in performing these tasks.

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

Any modification, alteration, or change to equipment which affects its original design and is not authorized and approved by National Crane is **strictly prohibited**. All replacement parts must be National Crane 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 and move the hydraulic controls in both directions several times.
- 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 equipment.
- 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 equipment:

- 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 equipment 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 equipment 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 equipment, 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 equipment 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. 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 K100™ Synthetic Crane Hoist Line Manual P/N 9828100734 available by contacting Manitowoc Crane Care.

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

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

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.

Wire Rope

Use **only** the rope specified by National Crane as indicated on the equipment's *Load Chart*. Substitution of an alternate rope may require the use of a different permissible line pull and, therefore, require different reeving.

NOTE: Rope may be purchased by contacting Manitowoc Crane Care.

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

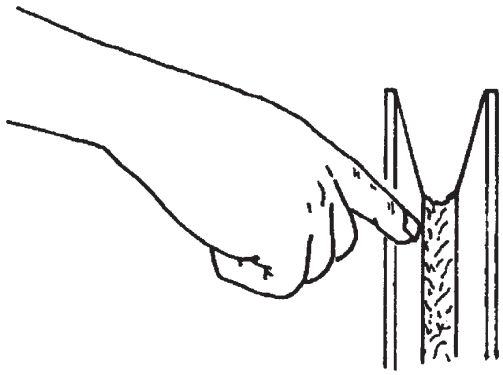
When installing a new rope:

- Keep all parts of your body and clothing away from rotating hoist drums and all rotating sheaves.
- Never handle the 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



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 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 wire 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 user 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.
- 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.
- Maintain battery electrolyte at the proper level. Check the electrolyte with a flashlight.
- If applicable to your equipment, 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 equipment only with the engine turned off. Do not smoke while fueling the equipment. Do not store flammable materials on the equipment.

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 equipment equipped with intake manifold grid heaters.

TRANSPORTING THE EQUIPMENT

Before transporting the equipment, check the suitability of the proposed route with regard to the equipment 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 equipment and transporting vehicle.

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

Ensure the equipment is adequately secured to the transporting vehicle.

Do not use the dead end lug 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 equipment 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 and avoid contact with surrounding components. Do not draw cable taut. Care must be exercised anytime any equipment function is being performed while the cable is hooked into the hookblock tie down.

TRAVEL OPERATION

Only the equipment operator shall occupy the equipment when traveling.

When traveling, the boom should be completely retracted and lowered to the travel position. If equipped with boom rest, lower the boom into the boom rest and engage the turntable swing lock pin and/or 360 degree swing lock.

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

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.

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

Follow the instructions in this manual when preparing the equipment 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 equipment, ensure the cab is level, if equipped with a tilting cab.

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

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 with equipment, check suitability of proposed route with regard to equipment height, width, and length.

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

On equipment equipped with air-operated brakes, do not attempt to move the equipment 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 equipment's weight.

If it is necessary to take the equipment 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 equipment 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:

- 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.

Equipment 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 equipment. Falling from any elevation could result in serious injury or death.

Never exit or enter the equipment operator 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 equipment.

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

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

Do not step on surfaces on the equipment that are not approved or suitable for walking and working. All walking and working surfaces on the equipment 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 equipment.

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 equipment cab/operator's station or climbing onto the equipment 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 equipment. This practice will prevent ground personnel from being crushed or electrocuted when they attempt to access personal belongings stored on the equipment.

Job Preparation

Before equipment use:

- Barricade the entire area where the equipment is working and keep all unnecessary personnel out of the work area.
- Ensure that the equipment 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 (e.g. RCL).
- Check all braking (e.g. wheel, hoist, and swing brakes) and holding devices before operation.

You must ensure that the outriggers and stabilizers are properly extended and set before performing any lifting operations. On models equipped with outriggers that can be pinned at the intermediate positions, the outriggers must also be pinned when operating from the intermediate positions.

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 equipment 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 their direct control. When safety of an operation is in doubt, operator shall stop the equipment's functions in a controlled manner. Lift operations shall resume only after safety concerns have been addressed or the continuation of equipment operations is directed by the lift supervisor.

Know the location and function of all machine controls.

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

Sparks from the equipment's electrical system and/or engine exhaust can cause an explosion. **Do not** operate this equipment 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 equipment.

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

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

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

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

8820 **Example decal. For reference only.**

Keep unauthorized personnel clear of the working area during operation.

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

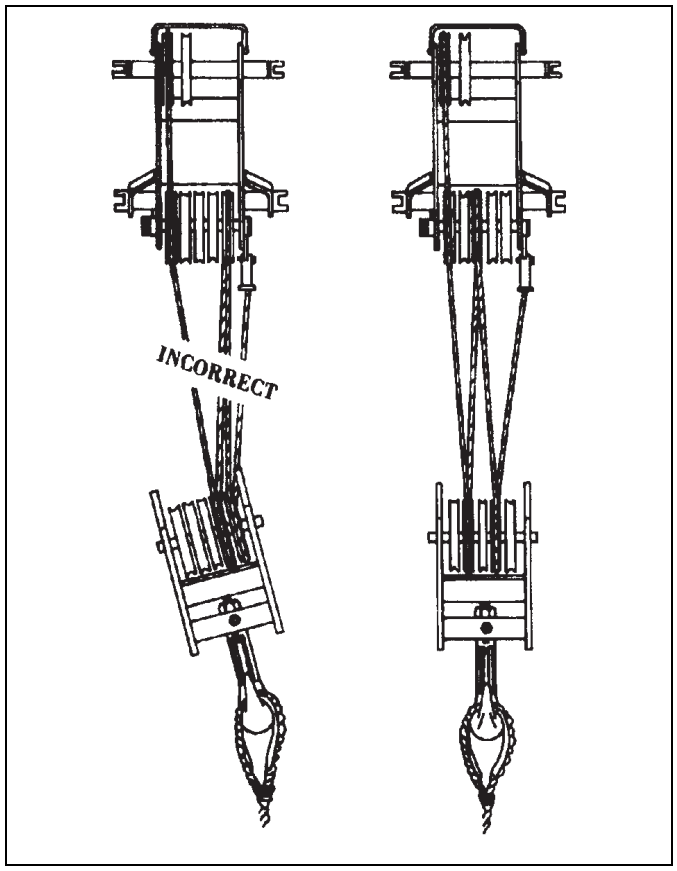
You must always be aware of everything around the equipment while lifting or traveling. If you are unable to clearly see in the direction of motion, you must post a look out or signal person before moving the equipment or making a lift. Sound the horn to warn personnel

Operate the equipment from the operator's control station. Do not reach in a window or door to operate any controls.

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



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 rope or hoist. **No less than three wraps** of 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 equipment'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 equipment's rated capacity.

Never leave the equipment with a load suspended. Should it become necessary to leave the equipment, 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 equipment!

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 equipment. 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 equipment's boom; never drag a load.

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

If the boom should contact an object, stop immediately and inspect the boom. Remove the equipment 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 equipment's capacity on *Load Chart*.

Avoid sudden starts and stops when moving the load. The inertia and an increased load radius could tip the equipment 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 equipment 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 equipment operator cannot clearly see the load at all times.
- Moving the equipment in an area or direction in which the operator cannot clearly see the path of travel.

At all times use standardized hand signals (Figure 2-6) - previously agreed upon and completely understood by the operator and signal person.

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

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

Obey a signal to stop from anyone.

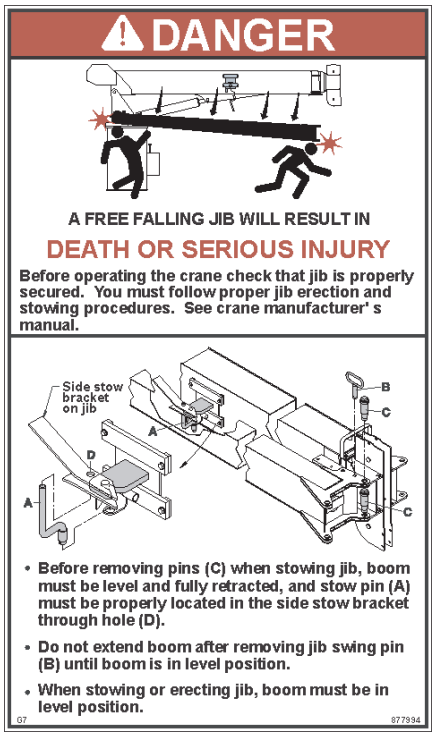
JIB

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 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.



9023-48 **Example decal. For reference only.**

Do not remove all the pins from 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.

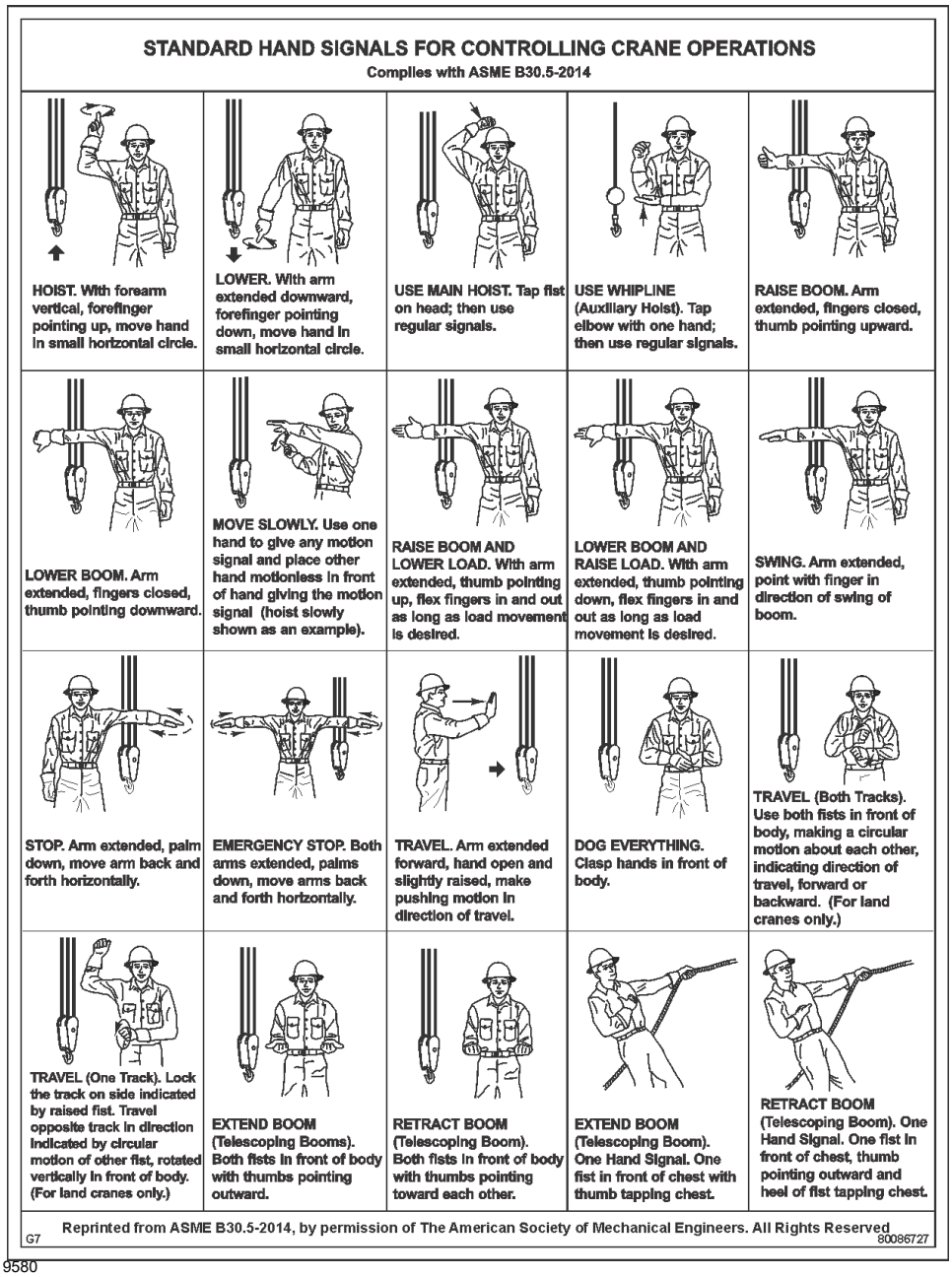


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FIGURE 2-6

PARKING AND SECURING

WARNING

Tipping Hazard!

When parking the equipment and leaving it unattended follow the instructions for the Controls and Operating Procedures 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.

The Controls and Operating Procedures section of this manual provides instructions for parking and securing equipment when it is to be left unattended. These instructions are intended to allow the equipment to be placed in the most stable and secure position. However, National Crane recognizes that certain jobsite conditions may not permit the boom and jib 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 equipment should be left in the smallest, most stable, valid operational configuration that the job site practically allows.
- The equipment cannot 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 equipment configured in as stable a configuration as possible (boom angle, superstructure orientation, jib offset 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 equipment when it is to be left unattended.

SHUT-DOWN

Use the following steps when shutting down the equipment:

- Fully retract and lower the boom.
- Engage the swing lock pin and/or 360 degree swing lock.
- Place controls in neutral position.
- Shut down the engine and remove the ignition key.
- 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 equipment of all ice and snow.

Allow ample time for hydraulic oil to warm up.

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

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

Never store flammable materials on the equipment.

National Crane recommends use of cold weather starting aids that are provided on your equipment, use them. The use of aerosol spray or other types of starting fluids is prohibited.

TEMPERATURE EFFECTS ON HOOK BLOCKS

Hook Block Working Load Limit (WLL) is valid between 60°C (140°F) and the low temperature limit given on the hook block identification plate with normal lifting precautions.

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

75% of the Working Load Limit 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 2-8]. A cylinder extended 1.5 m (5 ft) in which the oil cools 15.5°C (60°F) would only retract approximately 38 mm (1 1/2 in). 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 equipment 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.

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

Coeff. =	0.00043	(in^3/in^3/ °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^3/in^3/ °F) X 12 in/ft

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

Coeff. =	0.000774	(1/ °C)		*Metric*							
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

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.

Boom Inspection

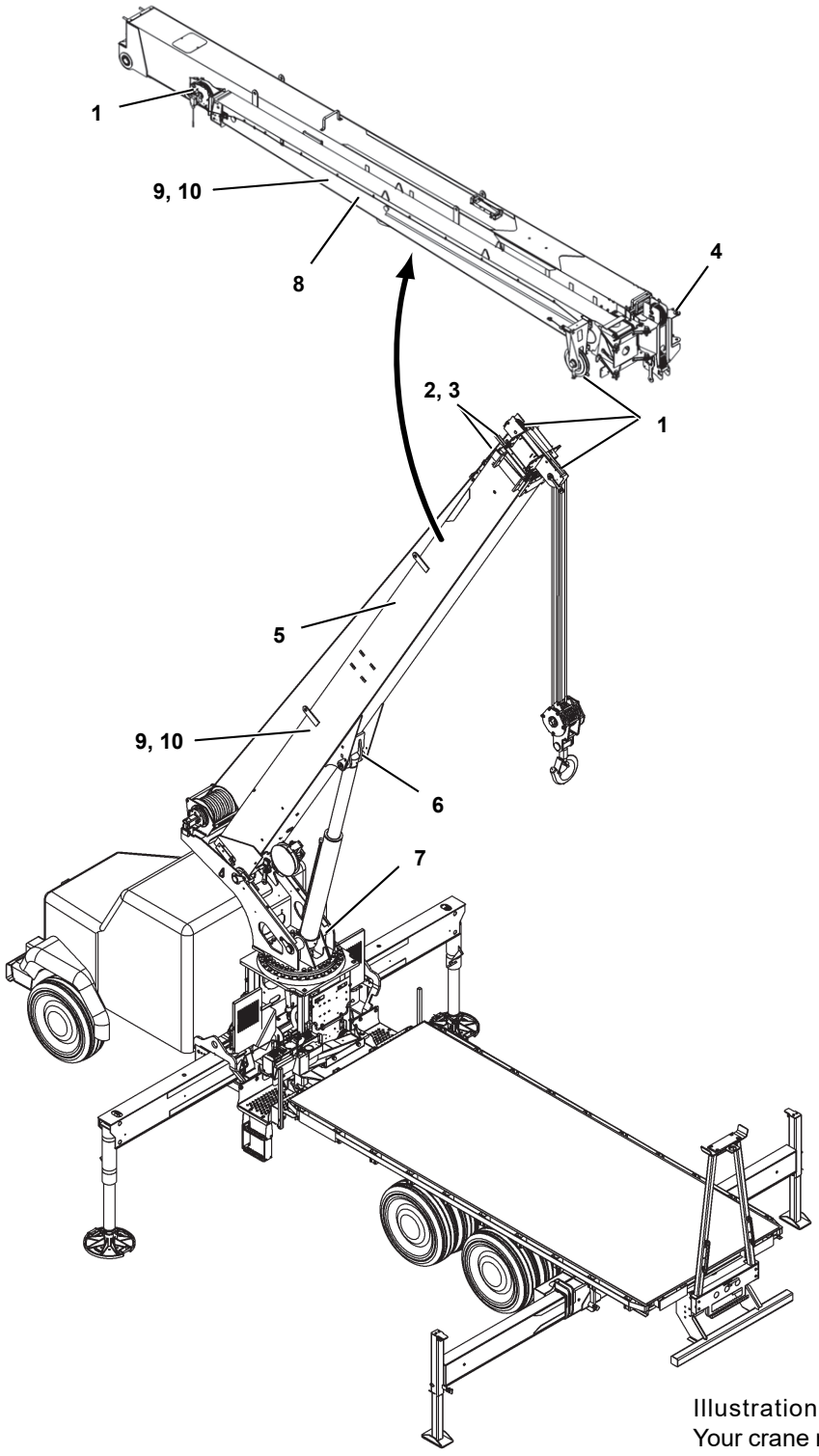


Illustration for reference only.
Your crane may be different.

NOTE: The following checklist includes all features that can be found on National Cranes. Your crane may not have some features.

Overload less than 25%			
1	Sheaves, Rope Guides	Inspect all for damage.	
2	Collar-Wear Pads, Pad Retainers	Inspect for damage.	
Overload from 25% to 49%			
1	Sheaves, Rope Guides	Inspect all for damage.	
2	Collar-Wear Pads, Pad Retainers	Inspect all for damage.	
3	Collar-welds	Inspect all for damage.	
4	Pinning Areas	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	Jib Section	Inspect for bent or twisted section. Check for straightness.	
9	Welds	Inspect for cracks.	
10	Paint	Inspect for cracked paint which could indicate twisted, stretched, or compressed members.	

Superstructure Inspection

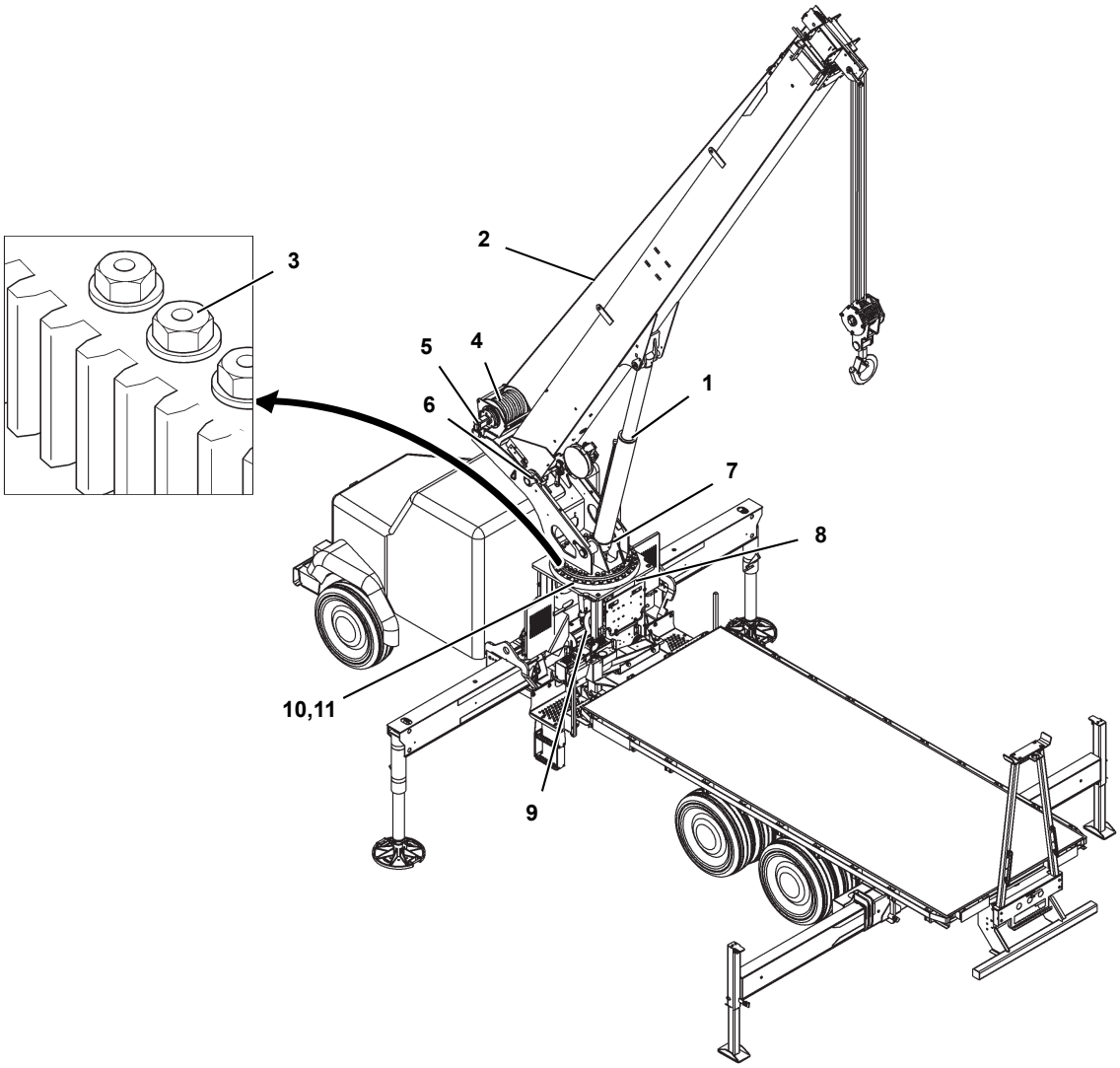


Illustration for reference only.
Your crane may be different.

NOTE: The following checklist includes all features that can be found on National Cranes. Your crane may not have some features.

Overload less than 25%			
1	Lift Cylinder	Inspect for leaking.	
2	Wire Rope	Inspect all for damage.	See topic in Introduction section of Service Manual.
3	Turntable Bearing	Check bolts for proper torque.	See topic in Swing section of Service Manual.
Overload from 25% to 49%			
1	Lift Cylinder	Inspect for leaking.	
2	Wire Rope	Inspect all for damage.	See topic in Introduction section of Service Manual.
3	Turntable Bearing	Check bolts for proper torque.	See topic in Swing 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	Turret Area	Inspect for deformation, cracked welds.	
9	Mounting Studs	Check bolts for proper torque.	
10	Welds	Inspect for cracks.	
11	Paint	Inspect for cracked paint which could indicate twisted, stretched, or compressed members.	

Carrier Inspection

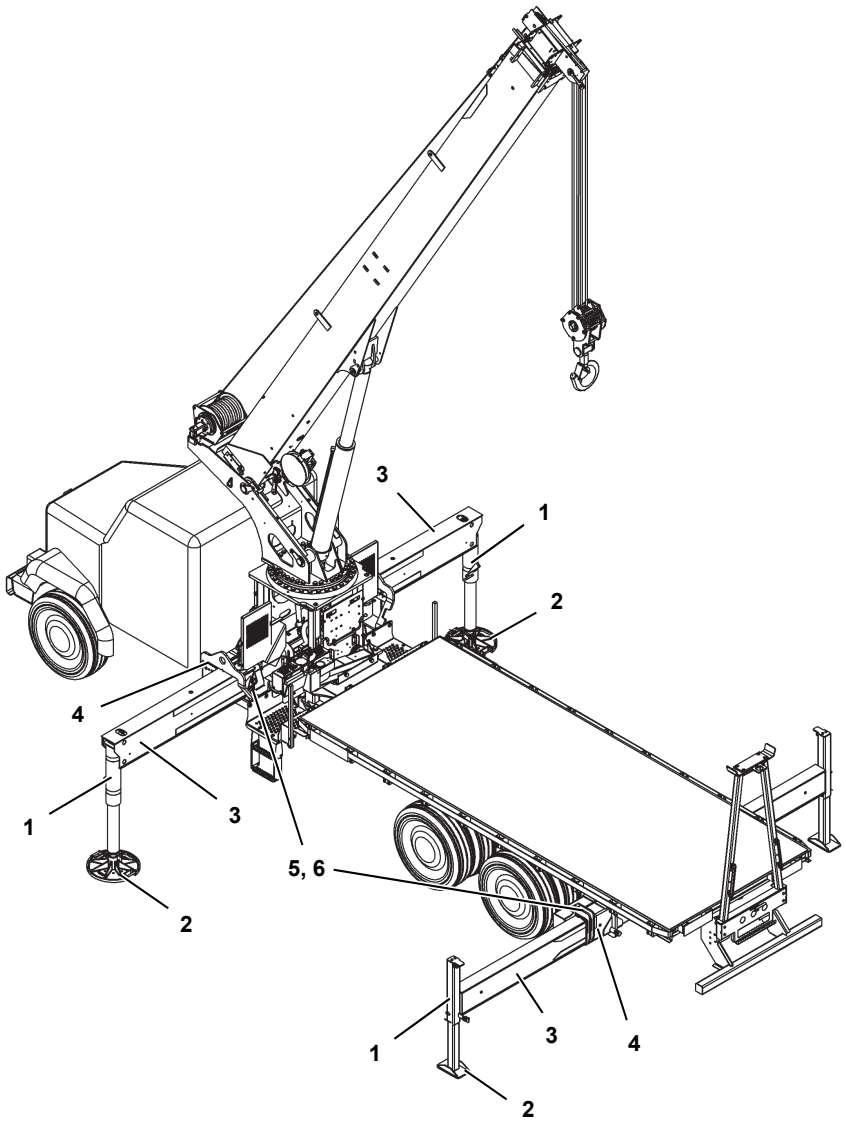


Illustration for reference only.
Your crane may be different.

NOTE: The following checklist includes all features that can be found on National Cranes. Your crane may not have some features.

Overload less than 25%			
1	Jack Cylinders	Inspect for leaking.	
2	Outrigger Pads	Inspect for deformation and cracked welds.	
Overload from 25% to 49%			
1	Jack 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.	

SECTION 3
CONTROLS AND OPERATING PROCEDURES

SECTION CONTENTS

TRUCK CAB CONTROLS

Power Take-Off

Manual Shift Control

The PTO's are engaged when the knobs on dash or floor are pulled out and disengaged when the knobs are pushed in. The truck gear shift lever must be in neutral and the clutch depressed whenever the knobs are moved.

Air Shift Control

The PTO is engaged when the switch is moved to apply air to PTO and disengaged when switch in off position. The truck gear shift lever must be in neutral and clutch depressed when switch is moved. The transmission selector lever must be returned to "N" for stationary vehicle operation. The power take-off may be disengaged while in any transmission range provided that the load has first been removed from the PTO.

Electric Shift Control

Full torque electric shift PTO's are controlled by a switch. To operate, disengage the clutch, shift to fourth or fifth gear, and operate the switch down to engage the PTO or up to disengage the PTO. Return the gear shift to neutral and engage the clutch.

Power Shift Control

If the vehicles equipped with automatic transmission, the power take-off must be engaged with the engine at idle. Refer to transmission manufacturers instructions for special procedures.

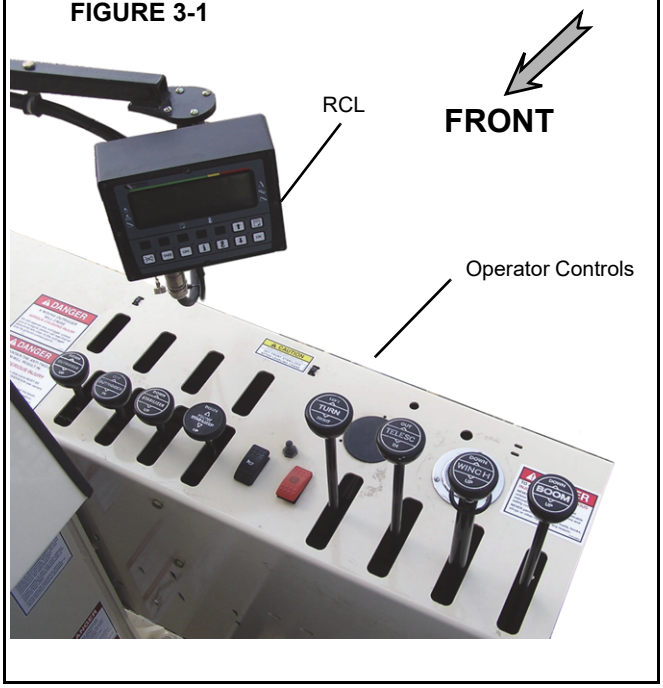
Park Brake

The truck brake must be firmly set before leaving cab to begin operation. If the ground surface is icy or slick or is sloped, chock the wheel.

CRANE CONTROLS

The unit is equipped two operator stations: one on the drivers side and one on the passengers side of the truck (Figure 3-1). Decals next to the controls indicate which direction to actuate the controls. Each station provides control of boom rotation, boom elevation, boom extension, hoist, outriggers and engine speed. An engine emergency stop switch shuts down the truck engine. All control handles except the outrigger controls are positioned in the same order at both control stations.

FIGURE 3-1



Boom Rotation

The 600H series crane is not a continuos rotation machine. A mechanical rotation stop pulls the turn control lever to the neutral position when the boom reaches over the front center. This prevents damage to the hydraulic hoses due to twisting.

On rear mounted cranes, the boom is over the front when in the boom rest. Rotate the boom to the right over the passenger side of the truck when stowing and unstowing the jib or rigging the hook block to keep from activating the rotation stop.

Swing Speed Adjustment

Located on swing motor inside frame. Turn knob in to increase the maximum speed. Turn knob out to decrease the maximum speed.

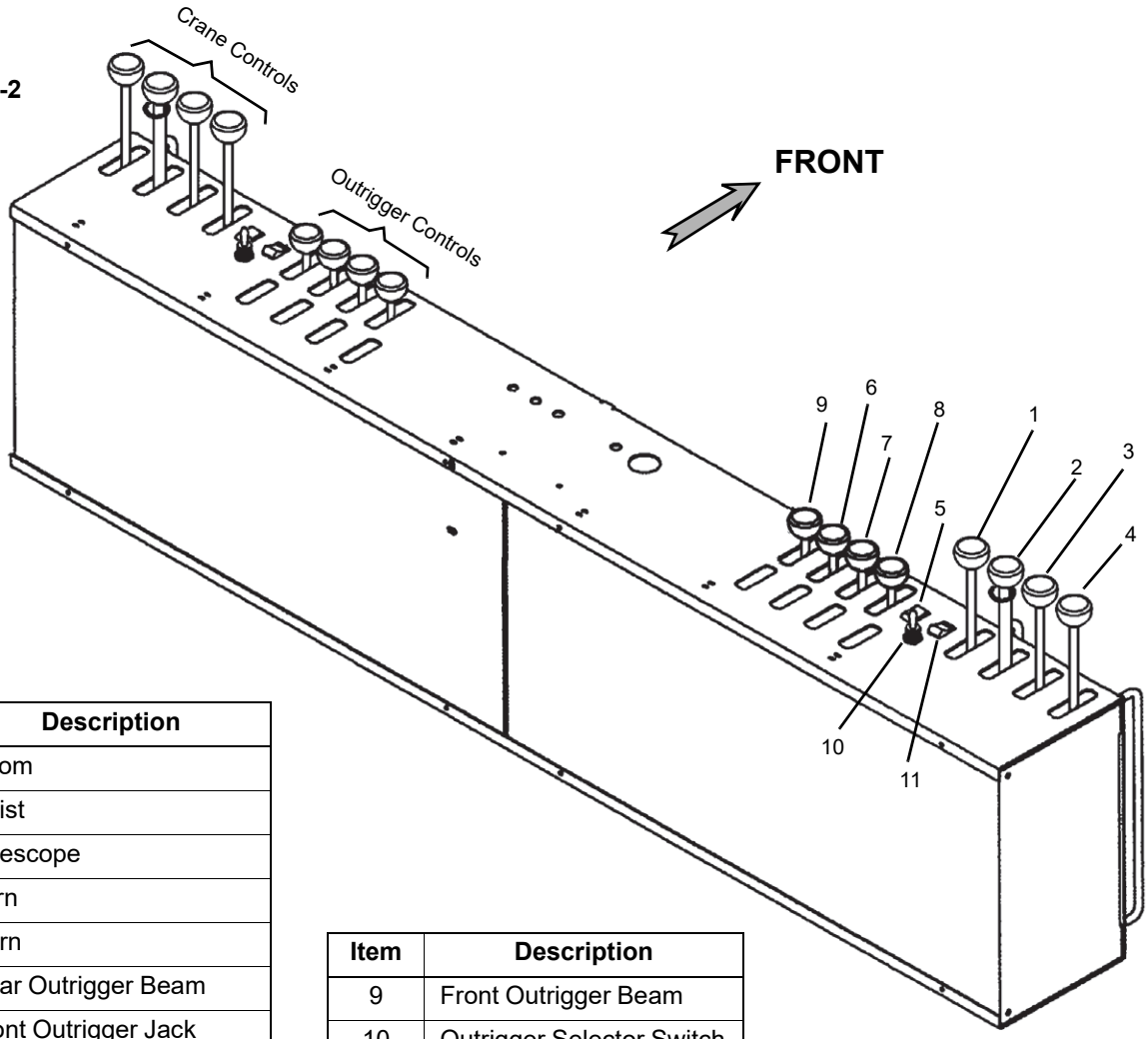
Boom

Position the control lever to DOWN to lower the boom and UP to raise the boom.

Boom Telescope

Position the control lever to OUT to extend the boom and IN to retract the boom.

FIGURE 3-2



Item	Description
1	Boom
2	Hoist
3	Telescope
4	Turn
5	Horn
6	Rear Outrigger Beam
7	Front Outrigger Jack
8	Rear Outrigger Jack

Item	Description
9	Front Outrigger Beam
10	Outrigger Selector Switch
11	Engine Stop Switch

3

Hoist

Position the control lever to DOWN to lower the loadline and UP to raise the loadline. Refer to hoist system operation section for additional information

.

DANGER

Payout loadline before extending boom. Failure to do so will cause the loadline to break or damage the crane.

Outriggers

The outrigger control is setup so that two like components can be operated simultaneously or any one component can be operated separately. The control lever activates the outrigger function and a toggle switch selects the component. If the toggle switches are not used, the front two or the back two outrigger beams or jacks move simultaneously when the control lever is activated.

Simultaneous Outrigger Component Operation

Position the appropriate control lever from neutral to the desired function. Two outrigger components (Front or Rear) are activated.

- Outrigger beams extend or retract.
- Outrigger jacks are lowered or raised.

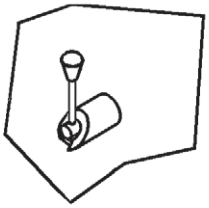
Independent Outrigger Component Operation

Position the outrigger toggle switch to other side or this side and the control lever from neutral to the desired function. A single outrigger component is activated.

- The selected outrigger beam extends or retracts.
- The selected outrigger jack is lowered or raised.

Side Midspan Outrigger Stop Pin

The side outrigger stop pin is located on the side of the outrigger box and is used to set the outrigger at the midspan position. Rotate the side stop pin 180° and extend the outrigger beam until the pin drops into the midspan hole and stops the outrigger beam. Rotate the pin back to the 0° position to retract the outriggers.



Top Midspan Outrigger Stop Pin

The top outrigger stop pin is located on top of the outrigger and is used to set the outrigger at the midspan position. Rotate the pin to the lock position and extend the outrigger until the pin drops into the midspan hole and the outrigger stops.

Foot Throttle

Depress the foot throttle to accelerate the truck engine speed. Release to return to idle speed. Increasing truck speed increases operating speed.

Emergency Stop Switch

Operate the switch to kill the truck engine under emergency conditions. Switch must be reset to the “on” position to operate truck from cab.

Horn

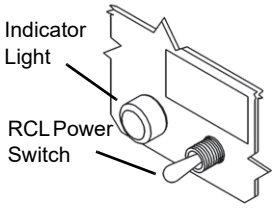
Operate horn button to warn fellow workers on construction site of pending movement of crane.

RCL System

The RCL monitors crane operation and alerts the operator of an impending tipping condition and disables the crane functions.

RCL Power Switch

A toggle switch located in the truck cab powers the RCL for crane operation. An indicator light comes on when the system is activated.



NOTE: The RCL power switch must be ON before the crane cane be operated.

Momentary RCL Override Switch

Rotate the key switch counterclockwise and push the RCL override button on the operators console to enable crane functions and remove the tipping condition.

NOTE: The key switch is located behind a door on the drivers side of the operators console.

Load Chart

This chart is located on the side of the crane frame and shows capacities of crane at various operating areas and hoist capacities with appropriate reeving (See“Load Chart” on page3-8).

Boom Angle Indicator

Located on either side of the base boom section and used to determine main boom angle with respect to horizontal. For reference only.

Boom length indicator

Located on either side of the second boom section. The letters on the intermediate boom lengths correspond to the letters on the load chart. The length indicators are used to define boom length and with the load chart and load radius are used to determine the maximum loads that may be safely lifted. The load radius must be measured from the centerline of rotation.

OPERATING PROCEDURES

You need to be familiar with the safety precautions outlined in Section 2 before operating the crane.

Equipment Familiarization

All crew members should be familiar with the location and operation of the controls, the correct operating procedure, the maximum lifting capacities, and the Safety Precautions in Section 2 of this manual. Carefully follow the operating procedures outlined below and the information in the load charts located in the crane cab.

Equipment Checks

Prior to placing the unit in operation, do a complete walk-around visual inspection and look for structural damage, loose components, leaks, or other conditions that require immediate correction for safe operation. The following inspection list is suggested.

Check:

- for any unusual conditions such as pools of hydraulic fluid or lubricating oil under the chassis, an outrigger which may have crept down or up, signs of damage, or improper maintenance.
- the tires are inflated to the proper pressure.
- the level of the hydraulic reservoir.
- the operation of the “stop” and horn circuits.
- for missing and loose bolts.
- for damaged structural members and welds.
- all rope guides and cable keepers.
- all sheaves for free turning.
- the hoist cable for kinks, broken strands or other damage in accordance with instructions on page 6-3.
- to see that the hydraulic hoses and fittings are in good condition and show no signs of leaking. Repair damaged or leaking hoses immediately.
- the RCL and anti-two-block system for proper operation.
- the electrical wiring connecting the various parts of the system for physical damage.

NOTE: Consult the truck manufacturer’s manual for vehicle checks.

Cold Weather Operation

The following recommendations are for operating National cranes in very low (i.e., sub-zero) temperatures.

Cranes should have appropriate hydraulic oil, lubricants, and other auxiliary items required for operation in sub-zero temperatures. Operate individual crane functions to ensure they are sufficiently warmed prior to performing a lift.

Operation of cranes at full rated capacities in temperatures between -9°C (15°F) and -40°C (-40°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.

Operation Below -40°C

For crane operation below -40°C, capacities shall be derated 3.67 percent of the rated load shown on the capacity charts for each degree below -40°C.

Operation Below -40°F

For crane operation below -40°F, capacities shall be derated 2 percent of the rated load shown on the capacity charts for each degree below -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 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 National Crane 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 National Crane 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

NOTE: For National Crane engine warm-up procedures, refer to chassis manufacturer’s manual.

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

NOTE: For National Crane transmission warm-up procedures, refer to chassis manufacturer’s manual.

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.

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 3-6).
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

NOTE: For National Crane axle warm-up procedures, refer to chassis manufacturer's manual.

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 National Crane 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.

JUMP STARTING HAZARD

Do not attempt to jump start the crane.

CAUTION

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

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

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger of appropriate voltage level or replace the batteries with fully charged batteries. Refer to *Charging the Battery*, page 3-6.

CHARGING THE BATTERY

When charging the batteries, do not turn on the battery charger until the charging leads have been connected to the

battery(s). Also, if the battery(s) are found to be frozen, do not attempt to charge them. Remove the battery(s) from the crane, allow them to thaw, and then charge the battery(s) to full capacity.

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

Anti-Two-Block Check

DANGER

The following tests must be performed with caution to prevent damage to the machine or injury to personnel.

Check the anti-two-block alarm light and the audible alarm by lifting the anti-two-block weight until the switch is activated. To check the anti-two-block switch:

- manually lift the weight.
- slowly raise the hoist cable.
- slowly extend (telescope) the boom.

DANGER

If the light and audible alarm do not function as described and the crane movements are not stopped, the system is not working properly. The malfunction must be corrected before operating the crane.

If the crane is equipped with a jib that is deployed and rigged for work, repeat the test procedure for the jib anti-two-block switch.

RCL Check

Perform the following checks to verify proper RCL operation.

- Check that the display of the main boom length agrees with the actual boom length.
- Check that the display of the main boom angle agrees with the actual boom angles.
- Check that the display of the operating radius of the crane agrees with the actual radius.

Check the load display by lifting a load of known weight. The accuracy of the load indication shall be within the tolerance of SAE J159.

DANGER

If there is a deviation between displayed and actual values, an authorized RCL service representative shall be called for repair and/or recalibration of RCL system.

HOIST SYSTEM OPERATION

The hoist may have lifting capabilities greater than that of the crane limits. Therefore, care must be taken to ensure that the load lifted is within the crane rating. General rules for hoist operation are:

- Unwind the hoist when extending the boom.
- Use the anti-two-block system only as an aid.
- Make sure the rope is not twisted or kinked and that it is properly seated in the hoist and in sheaves.
- Always have at least three full wraps of wire or synthetic rope on the hoist.
- Check the hoist brake when approaching the load limit of the hoist. Raise the load a few inches and return the control to neutral to check the brake.
- Do not drag the load with the hoist.
- Do not try to lift loads that are not free such as, frozen down material or poles.
- Keep tension on the rope to prevent it from becoming twisted, kinked, or improperly seated on the hoist.

Hoist Burst of Speed Operation

To engage Burst of Speed (BOS), push the hoist control valve lever fully forward. As the hoist control valve lever is moved forward it contacts a detent. Additional force in the forward direction overrides the detent and activates the BOS.

If the BOS feature is used frequently the crane needs to be equipped with an optional oil cooler.

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CAUTION

If the BOS feature is run continuously or with an overload, damage to the crane or truck could occur.

NOTE: Maximum Capacity with "BOS"

- One Part Line - 3000 lbs. (1361 kg)
- Two Part Line - 6000 lbs. (2722 kg)
- Three Part Line - 9000 lbs. (4082 kg)
- Maximum line speed on third layer - 240 FPM (73 mpm), fourth layer - 265 FPM (81 mpm)

WORKING AREA

600 H-BC Working Area

The standard working area for the 600 H-BC is 180° with no SFO. With a SFO, the work area is 360°.

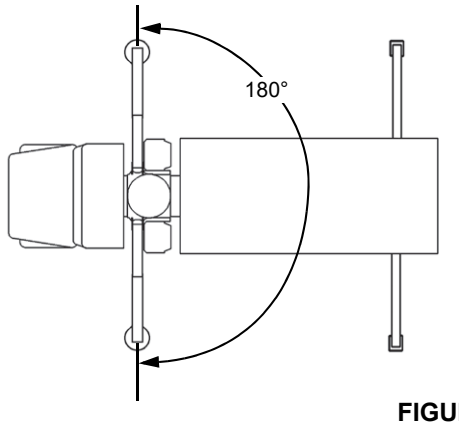


FIGURE 3-3

600 H-RM Working Area

The standard working area for the 600 H-RM is 360°.

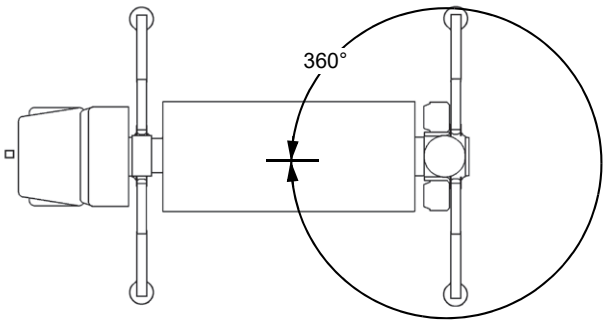


FIGURE 3-4

WORK SITE LOCATION

Select a location that is firm, level, and dry. Avoid uneven, rocky or muddy terrain, steep grades, or locations with overhead obstructions. The outrigger jacks must be supported on a firm level surface at the fully retracted, midspan, or fully extended positions. Avoid overhead power lines.

Before Leaving the Truck Cab

- Position the truck so that the outriggers can be extended with no obstructions.
- Put the truck transmission in neutral.
- Set the truck park brake. Wheel chocks may also be required.
- Engage the power takeoff.

Before Making the Lift

- Set the outriggers as described in Section 4 Set-Up.
- Program the RCL as specified in the RCL Operator Manual which is located in the document case.
- Check all controls for proper operation. If any abnormal operations are detected, the condition must be corrected before continuing.
- Check the work area for electric power lines.

LOAD CHART

Your unit is designed to provide satisfactory service if it is not loaded in excess of the maximum rated loads specified in the load chart. Overloading can create safety hazards, cause structural damage, and shorten the service life of the crane. You must understand how to use the load charts located in the document case. Make sure the load, the working area, and the crane configuration are within the load limit specified in the load chart.

NOTE: Load handling devices (hook blocks and slings) are considered part of the load.

Using the Load Chart

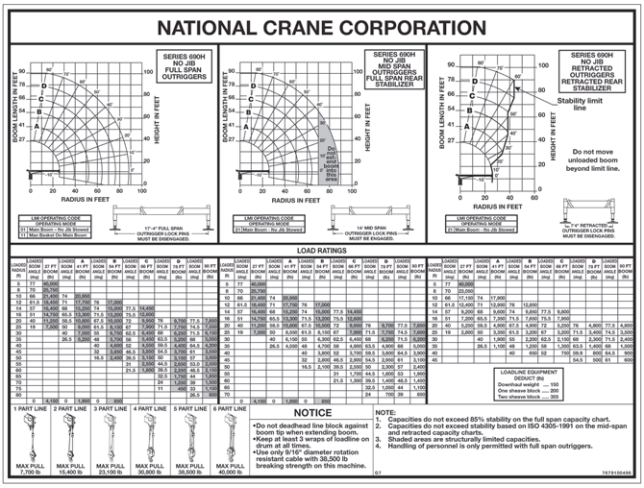
The following list is a definition of terms needed when using the load chart.

- **Load Radius** — The horizontal distance from the centerline of rotation, before loading, to the center of the vertical load line or block. This distance is slightly greater with an loaded boom due to deflection.
- **Loaded Boom Angle** — The loaded boom angle is the angle between the first section boom and the horizontal with the load. The loaded boom angle combined with the boom length approximates the operating radius.
- **Working Area** — The area measured in a circular arc above the center line of rotation to the suspended load.

NOTE: The standard work area for the 600H is 180°. With a single front outrigger (SFO) the work area is 360°.

- **Freely Suspended Load** — The load hanging free with no direct external force applied except by the loadline.

- **Side Load** — Horizontal side force applied to the lifted load either on the ground or in the air.
- **Boom Length** — The length from boom pivot pin to the boom nose. Decals on either side of the boom shows when specific boom lengths are reached.
- **Range Diagram** — The range diagram (Figure 3-6) shows the operating radius and height of the unloaded boom nose at all boom lengths and angles. It should be used as a guide to position unloaded loadline and to determine to approximate height to which the load can be lifted.
- **Structural Limit Line** — The range diagram may contain a structural limit line. It shows the lowest angle the unloaded boom can be placed at for all boom lengths. Below this line the machine is structurally overloaded.



The load chart contains the lifting capacities of the crane in all allowable lifting configurations. The information is presented in three parts, one for outriggers fully retracted, one for outriggers at mid point, and one for the outriggers fully extended. Each part contains the load chart, range diagram, and hoist data sheet. In the examples shown here, the information for the outriggers fully extended is used.

- The load chart (Figure 3-5) is used to determine the weight limit of the load based on the load radius and boom angle. All lifting devices must be included when determining the weight of the load.
- The range diagram (Figure 3-6) shows the operating radius and the height from horizontal of the unloaded boom.
- The hoist data chart (Figure 3-7) shows hoist capacity and multipart line reeving. The correct reeving for all loads listed in the load chart is also shown.

Before you can determine the crane configuration you need to know:

- the weight of the load to be lifted.
- the lifting devices and weights needed.
- the height of the lift.
- the horizontal distance from the center of rotation (load radius) to where the load is to be placed.

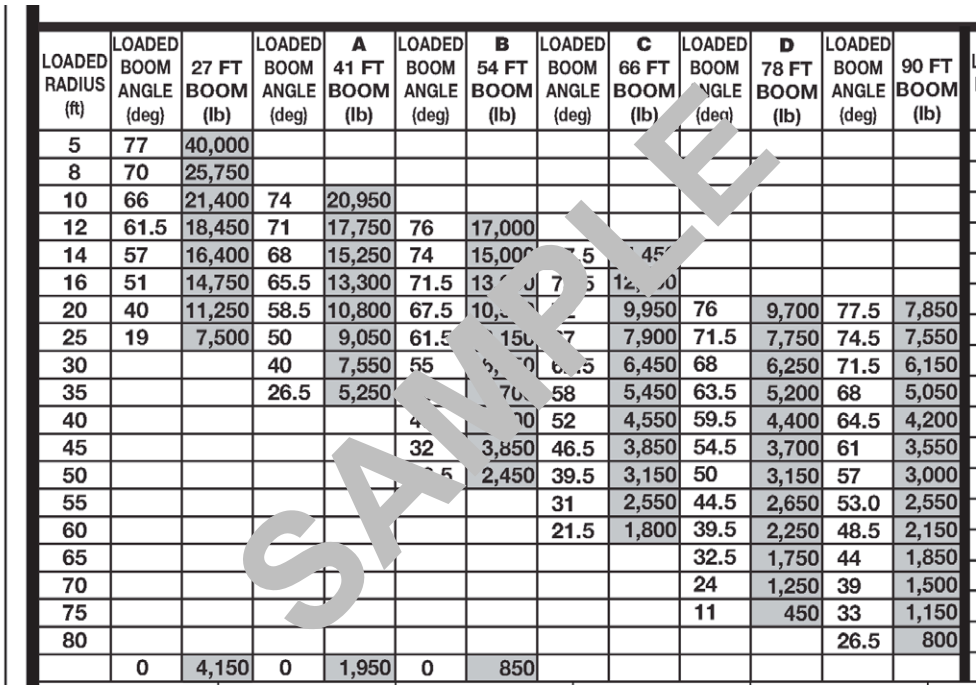
To determine the safe operating parameters you need to:

1. Get the weight of the load to be lifted.
2. Approximate the load radius. This is the horizontal distance from crane center of rotation to where the payload is to be placed.
3. Determine the lifting devices and hook block reeving using the hoist data chart.
4. Calculate the combined weight of the lifting devices and load to be lifted.
5. Determine the boom angle and length from the range diagram using the height and load radius of the lift.
6. In the load chart, take the load radius and boom angle/ length column over to the weight column and check the weight. If the weight is between two values, use the lower value.

LIFTING THE LOAD

The following general guidelines outline the proper procedure for making a lift after the crane has been properly set up.

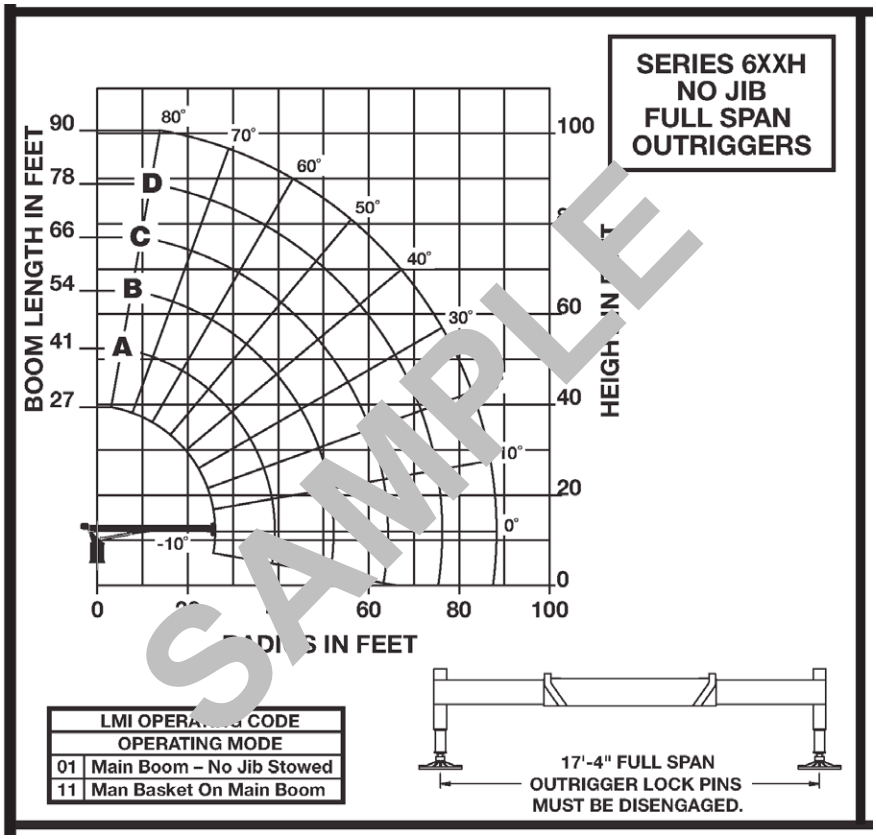
1. Position the crane in the work area and set the outriggers. See page 4-1 for outrigger setup.
2. Program the RCL. Use the load chart to estimate the values.
3. Position the boom nose over the load. Do not try and drag the load with the boom or hoist.
4. Perform the lift. Meter the controls when moving the load to avoid sudden stops.
5. Retract and lower the boom after the lift is complete.



LOADED RADIUS (ft)	LOADED BOOM ANGLE (deg)	27 FT BOOM (lb)	LOADED BOOM ANGLE (deg)	A 41 FT BOOM (lb)	LOADED BOOM ANGLE (deg)	B 54 FT BOOM (lb)	LOADED BOOM ANGLE (deg)	C 66 FT BOOM (lb)	LOADED BOOM ANGLE (deg)	D 78 FT BOOM (lb)	LOADED BOOM ANGLE (deg)	90 FT BOOM (lb)
5	77	40,000										
8	70	25,750										
10	66	21,400	74	20,950								
12	61.5	18,450	71	17,750	76	17,000						
14	57	16,400	68	15,250	74	15,000						
16	51	14,750	65.5	13,300	71.5	13		12,				
20	40	11,250	58.5	10,800	67.5	10,		9,950	76	9,700	77.5	7,850
25	19	7,500	50	9,050	61.5	150		7,900	71.5	7,750	74.5	7,550
30			40	7,550	55			6,450	68	6,250	71.5	6,150
35			26.5	5,250		70	58	5,450	63.5	5,200	68	5,050
40					4	70	52	4,550	59.5	4,400	64.5	4,200
45					32	3,850	46.5	3,850	54.5	3,700	61	3,550
50						2,450	39.5	3,150	50	3,150	57	3,000
55							31	2,550	44.5	2,650	53.0	2,550
60							21.5	1,800	39.5	2,250	48.5	2,150
65									32.5	1,750	44	1,850
70									24	1,250	39	1,500
75									11	450	33	1,150
80											26.5	800
	0	4,150	0	1,950	0	850						

Load Chart

FIGURE 3-5



Range Diagram

FIGURE 3-6

3

Hoist Data

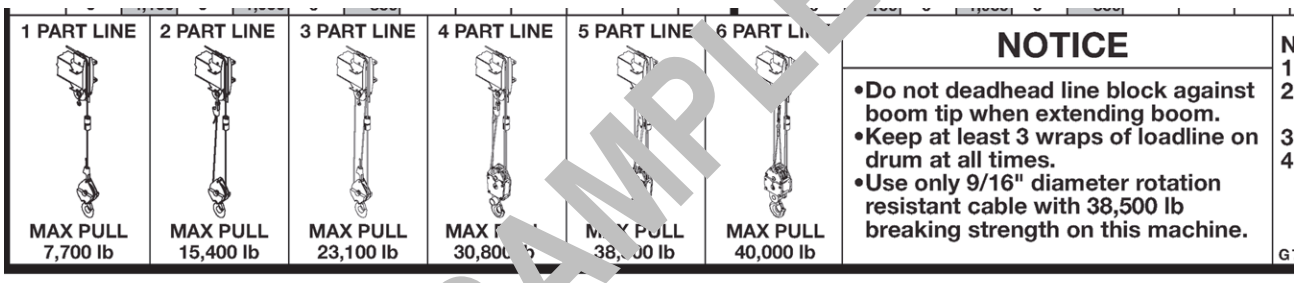


FIGURE 3-7

SHUT DOWN AND PREPARATION FOR ROAD TRAVEL

CAUTION

Disengage the hydraulic pumps for extended traveling, cold weather starting, or engine checks.

Check cold tire pressure prior to extended travel. Refer to tire inflation decal on crane.

CAUTION

Machine Damage Hazard!

Do not travel with an empty hook in a position where it can swing freely. Either remove the hook block and/or downhaul weight from the hoist cable(s) and stow securely or make sure the hook block or downhaul weight is properly secured to the tie down provided for that purpose.

Fully retract the outrigger stabilizers and properly store the floats.

1. Ensure the swingaway, if so equipped, is properly stowed and secured or removed from crane.

WARNING

Do not travel with swingaway extended to prevent damage to equipment.

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

2. Retract and place the boom in boom rest.
3. Engage the mechanical travel lock at each outrigger beam.
4. Engage the swing brake.
5. Engage the swing lock.
6. Secure the hook block/downhaul weight and A2B weight:

• Either the hook block may be reeved over the main boom nose or the downhaul weight may be reeved over the main boom nose or auxiliary boom nose. The other must be removed and stowed securely before traveling. If the hook block or downhaul weight remains reeved on the boom, it must be secured at the tie down on the carrier provided for that purpose.

- Slowly hoist up until there is a slight tension on the hoist cable. It may be necessary to override the A2B function to tension the cable.
- The A2B weight needs to be resting on the wedge socket so that there is slack in the anti-two-block-chain.

NOTE: There needs to be enough slack in the A2B chain so that the A2B switch does not switch between open and close positions during travel.

If the chain is too tight, road bounce causes the A2B switch to open and close numerous times and this can damage the switch.

7. Ensure the single front outrigger (SFO) is fully retracted, if equipped.
8. Ensure the outrigger beams and stabilizers are fully retracted.
9. Remove the stabilizer pads and place on the stowage brackets.
10. Engage the mechanical travel lock at each outrigger beam.

CAUTION

Outrigger beams must be pinned for travel.

If not pinned, outrigger beams may drift out during travel.

11. Turn off the ignition and all other switches in the crane cab.
12. Close and/or secure all windows and doors.
13. Exit the cab, lock the door, and stow the access ladder.
14. Secure any loads or lifting devices on truck bed or body.
15. Ensure tires are properly inflated.
16. Disengage the Power Take Off (PTO) and start truck from the truck cab.
17. Release the park brake before moving truck.

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.

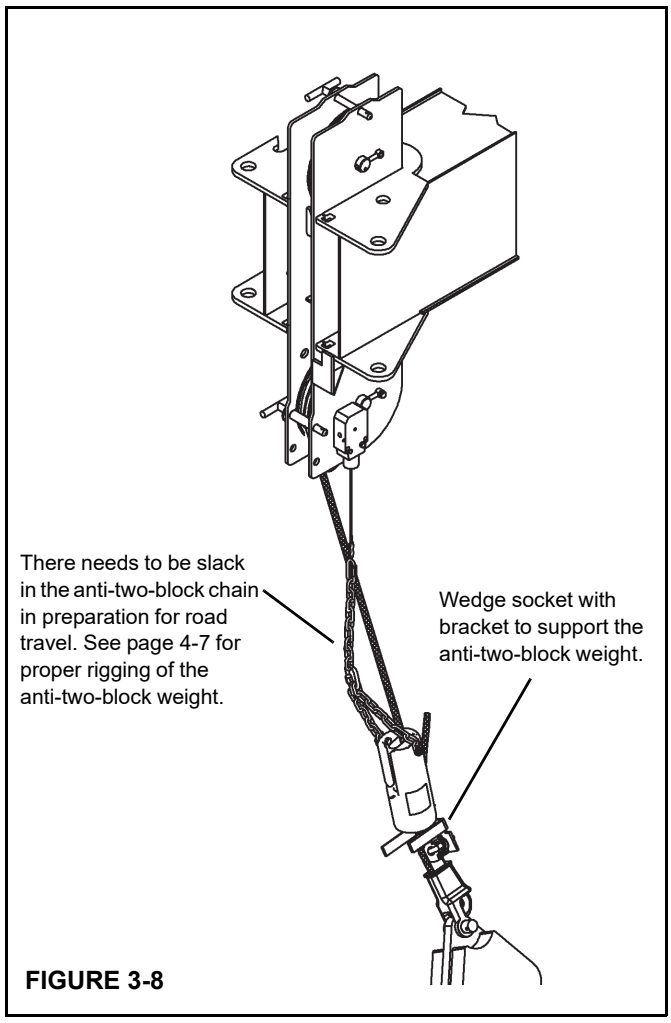


FIGURE 3-8

REMOTE CONTROL

The following sections describe the remote control function. For detailed installation and troubleshooting information, see the *Service Manual.*

Safety

DANGER

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

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

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

Danger Remote Start Hazard

DANGER

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

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

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

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

safety switch will not have the start relay installed and therefore can not be started with the radio transmitter only.

DANGER

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

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

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

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

Operation

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

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

9. Set engine throttle control if not equipped with automatic throttle advance.
10. Actuate desired crane function switch.
11. Slowly squeeze speed trigger to increase crane operating speed.
12. Slowly release speed trigger to decrease crane operating speed.
13. Release crane function switch.
14. Stow crane and shut off hand control ignition/start switch.
15. Turn Hydraulic Capacity Alert/RCL and Remotes/SLP power switches OFF - in truck cab.
16. Disconnect hand control and store in truck, (If equipped with hard wire remotes).
17. Start truck from inside of cab.
18. Stow outriggers.
19. Disengage P.T.O.

Hydraulic System Description

Solenoid Valve Assembly

Flow Control Valve in Inlet Section

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

Solenoid Valve Sections

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

Shuttle Valve

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

RADIO REMOTE CONTROLS

The following sections describe the radio remote controls. For detailed maintenance, installation, and troubleshooting information about the radio remote controls, see the *Service Manual.*

Safety

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

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

DANGER

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

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

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

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

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

Operation

General

The system consists of a Modulator/Transmitter) unit and a receiver/decoder (Receiver) unit.'The system operates on the 5 RF channels in accordance with FCC Subpart D - Lower Power Communications Devices, Part 15.117. Use of this device is subject to the provisions of FCC Part 15.103. A license is NOT required to operate this system.

Transmitter

The transmitter generates an RF signal which is FM modulated. The Modulation is a 120 bit data stream with start and stop bits, information concerning the selected switch being activated, and a specialized algorithm developed to ensure the validity of the transmission. Also transmitted are address information to enable it to "talk" to its associated receiver. This address information is set at the factory so no two devices will be the same. There may be over 20000 units in the same vicinity without any cross activation.

Receiver

The receiver receives the signal transmitted by the transmitter, decodes the data stream and checks for validity of the address and the start and stop bits of the received data. If this is correct, a proprietary software algorithm is performed to accept or reject the information to be passed on to the outputs. If for any reason this test fails, no output will be allowed to function. Once this test has passed, the appropriate output will be activated.

Single Proportional Control

The radio system is designed with its own amplifier circuit that supplies a pulse width modulation output. (An independent amplifier card is not required for the proportional valve.)

Input Voltage	10-30 VDC
Output Voltage	Same as input voltage
Output Current	5 amps maximum
Proportional Setting	Independent low end / high end settings

The independent proportional low and high end settings match the potentiometer travel with the proportional valve's working voltage and range.

The proportional valve is remote mounted between the hydraulic reservoir and the existing valve bank. A trigger controlled potentiometer is mounted in the grip of the hand held control that is spring loaded. This creates a single control, "metering" fluid to all the valves mounted on a manifold.

Electrical Circuit Description

Receiver Electrical Supply

1. Positive 12 VDC power is supplied from the battery to a 15 amp thermal circuit breaker then to plug letter "A" in the receptacle.
2. When the receiver cord is plugged in, +12 VDC power becomes available to the receiver.

Hand Control Circuitry

1. The hand control (transmitter) is activated by turning the power switch to the ON position. The radio transmits ten seconds to "initialize" the receiver. **This switch should be placed in the OFF position when not using the**

remote controls. Failure to do so will greatly reduce the life of the 9 volt battery in the hand control (transmitter).

DANGER

Failure to do so could cause inadvertent operation of the crane.

2. OFF-START switch in “CENTERED” position.
   a. Ignition circuit not energized until truck is started.
3. OFF-START switch in “START” position (Momentary).
   a. “L” (Ignition) circuit energized and stays energized when switch returns to central position.
   b. “M” (Start) circuit energized to power start relay at truck engine.
   c. “N” (Throttle Advance) circuit energized to power the throttle advance relay at truck engine (if equipped).
4. Function Switch (Turn, Telescope, Hoist, Boom, etc.) thrown (Momentary).
   a. Energizes the selected circuit to power one of the solenoid valve coils at the crane frame.
   b. At the same time, energizes “N” (throttle advance) circuit to power the throttle advance relay at the truck engine (if equipped). Throttle stays activated for five seconds after function switch is deactivated.
5. Trigger
   a. Attached directly to potentiometer shaft.
   b. Controls the speed that a crane function will operate. The more it is moved, the faster the function will operate.

Emergency Stop Function

This unit is equipped with an Emergency Stop. The transmitter has a momentary push button switch near the antenna. When initially using the radio remote control system, turn the receiver power on first. This allows power to the microprocessor and awaits for a special code from the transmitter to activate a relay to make power available to the output driver circuit.

When the transmitter is turned on, it will transmit a special code for 10 seconds to instruct the receiver to initialize. This will happen only if the transmitter is Not transmitting a function such as switch being activated. During this initial 10 seconds a function may be activated once the receiver has been Initialized. The initialization is instantaneous so you will not have any delay in operation. If the transmitter is “out of range” or a function is activated when the transmitter is turned on, the receiver will not be initialized. Once the receiver has been initialized, the unit will be allowed to operate. Should an emergency situation occur, the receiver may be “shut down” by pressing the Emergency Stop Switch on the transmitter. This must be pressed while transmitter power is in the ON position. This special code will be transmitted for a period of 10 seconds.

When the receiver receives this special code, the power to the output driver circuit will be de-activated. To resume operation, the transmitter must again send the special code to re-activate the receiver. To achieve this, turn transmitter power off and back on.

The transmitter will again go through its routine to initialize the receiver. **Please instruct your operators how to use this “Emergency Stop” and insist that they operate this feature to become familiar with the characteristics involved.**

Frequently Asked Questions

Question	Answer
What kind of range can be expected?	Advertised at 400 feet. Very likely to be much greater. The environment, terrain, antenna placement, and transmitter’s position can play an important role in achieving maximum range.
What method of transmission is being utilized?	The radio uses Radio Frequency (RF) at 49 Megahertz (49 MHz).
Why 49 MHz?	The Federal Communications Commission (FCC) dictates the frequency spectrum for the purpose of radio control devices. There are several bands that can be used. A lower band was chosen to reduce the “line-of-sight” characteristic. Lower frequencies tend to follow the curvature of the Earth, which will allow control in areas that are not “line-of-sight” such as ravines, embankments, cliffs, and even buildings.

Question	Answer
Do you use amplitude modulation (AM) or frequency modulation (FM)?	FM is utilized. FM is a must in electrically noisy environments. These environments include areas with welders, power lines, industrial machinery, etc. A good analogy is a standard automobile radio. In the above mentioned areas, the radio will have static on AM stations. Your FM stations assure definite clarity and a common extended range.
Will our current 2-way radio affect the operation of the wireless controller?	No. Two-way radios are assigned to different bands in the frequency spectrum and at high frequencies. At the lower frequencies such as 49 MHz, the power density in a given area is much lower than at higher frequencies therefore much less chance of interference.
Is the unit affected by outside interference?	Any receiver will receive frequency to which it is tuned. Should the radio remote unit receive an interfering signal which is at the same frequency, the “Smart Logic” analyzes the incoming signal to determine validity. First, it must be a digitally modulated FM carrier, it must have the exact data stream length and appropriate baud rate. The data stream length totals 120 bits of information. The baud rate is the speed at which these bits are transmitted. The first 120 bits are stored and compared to the next consecutive 120 bit data stream(s). Each of these 120 bit data streams are broken down into groups of bits called data words or bytes. These bytes reflect each individual switch and/or position along with additional information of the transmitter. Also included is an address code that must match the codes of the appropriate transmitter. If any bits of this data stream are wrong or missing the outputs will not be updated. Should there be a possible interfering signal present, normally the wireless transmitter is operated at a closer range than the interfering signal and the receiver will perform properly since it will pick up the strongest signal.
Will two radio remote units in the same vicinity operate each other?	No. Each receiver and transmitter have address codes which are set by the factory and are shipped as a set. Therefore, serial numbers should be recorded for future reference should assistance from the factory be necessary.
Is the unit protected from environmental conditions?	Yes. The unit is operable in temperature ranges from -25°F to +150°F (-32°C to +66°C). Placement of the receiver is recommended to be in the cab or tool box. The printed circuit boards in both the receiver and transmitter are coated with conformal material for protection against high humidity and moisture. The transmitter may be used in rainy conditions, do mot submerge the unit in water for any prolonged period of time. Should water get inside, remove top cover of transmitter and allow components to air dry. Replace battery, reassemble and continue use.
What type of battery is used?	A standard alkaline 9 volt battery is recommended. The Duracell Copper Top is a representative battery that fits the battery enclosure correctly and provides an acceptable service life.
How long will the battery last?	This will depend on the frequency and duration of use. Customers who use their wireless controller extensively have indicated a span of 4 to 10 weeks.

Question	Answer
How many operations can be done simultaneously?	Two functions can be activated at the same time. However, a single flow control is used to supply both functions. The single flow control allows the function operating at the lower pressure to take priority. In some cases, the function demanding the higher pressure will remain stationary until the lower pressure function reaches the end of stroke or is deactivated.

SECTION 4
SET-UP

SECTION CONTENTS

This section contains information on how to perform the following tasks:

- Set the outriggers.
- Erect the jib.
- Stow the jib
- Remove the jib.
- Use multipart reeving.
- Install the hoist cable.
- Install the anti-two-block weight.
- Install a wedge socket.

⚠ DANGER

Do not operate outriggers unless they are visible to either the operator or a designated signal person to avoid crushing injury.

OUTRIGGER SETUP

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, when lifting, it is essential that the crane is level to within 1% of grade. The bubble level 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 *Setting the Outriggers*, page 4-2.

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 *Setting the Outriggers*, page 4-2.

Bubble Level Adjustment

The bubble level adjustment should be checked periodically; if it is suspected that the bubble level indicator is out of adjustment, verify and adjust the bubble 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 bubble 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 bubble level indicator mounting screws, adjust the bubble level indicator to show level.

Site Selection

The outrigger floats must be on a firm solid surface that is level. The surface must keep the crane stable and not allow the outrigger float to sink or slide. Avoid areas that are:

- uneven
- rocky
- muddy

Setting the Outriggers

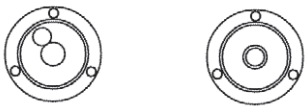
The outrigger setup procedure is as follows:

1. On the operators console select the desired outrigger control.
2. To extend any two outrigger components, position the control to activate the outrigger components.
3. Any two front or rear outrigger beams or jacks extend.
4. To activate a single component, position the outrigger selector switch to this side or other side.
5. Position the desired outrigger control to activate the component.
6. Any one front or rear outrigger beam or jack extends.
7. Set all four outrigger beams to:
   a. the fully retracted position. Does not require the outrigger beams to be extended.
   b. the midpoint position. Engage the manual midspan over-center locks for the midpoint position.
   c. the fully extended position.

DANGER

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

8. Remove the outrigger floats from the carrying brackets and place the floats under the jack.
9. Extend the jack down to engage the floats.
10. Secure the outrigger floats to the jacks with the pins and clips.
11. Extend all four jacks until the truck tires are about four inches off the ground.
12. Using the level indicator, adjust the jacks until the bubble is in the center of the bulls eye. Do not allow the tires to touch the ground. If it is suspected that the bubble level indicator is out of adjustment, verify and adjust the bubble level using the procedures under *Bubble Level Adjustment*, page 4-1.



Not Level Level **FIGURE 4-1**

13. Lower the single front outrigger (SFO) only after all other jacks are set.

WARNING

Tipping Hazard!

The mid-extend outrigger beam lock pin must be engaged before operating on any beam from the mid-extend position.

The proper load chart and RCL program must be selected for the current outrigger configuration.

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

Operation

The Outrigger Monitoring System (OMS) aids the operator in ensuring that the crane is properly setup on outriggers utilizing either a MID-SPAN (if equipped) or a FULL SPAN configuration. The OMS utilizes one sensor in each outrigger to identify when the outriggers are extended to a predefined MID SPAN configuration (if equipped) and FULL SPAN extended position in which they provide maximum stability.

The OMS utilizes an LED indicator to communicate to the operator the position of the outriggers. The Outrigger Status Indicator (1, Figure 4-2) is a bi-color LED located at each control station.

When power is on with a MID SPAN configuration (if equipped) and one or more outrigger beams are at the mid-extend position and the remaining outrigger beams are fully extended point, the Outrigger Status Indicator flashes green, indicating a lift can be made using the capacities from the mid-extend outrigger load chart.

When power is on and the outrigger beams are extended to a point at which they provide maximum stability (beams shall be fully extended on cranes), the Outrigger Status Indicator illuminates constant green, indicating a lift can be made using the capacities from the full-extend outrigger load chart. If power is on and one or more outrigger beams are not extended to a position which provides maximum stability, the Outrigger Status Indicator flashes red, indicating a lift should not be made. If the Outrigger Status Indicator illuminates constant red, there is a fault in the OMS.

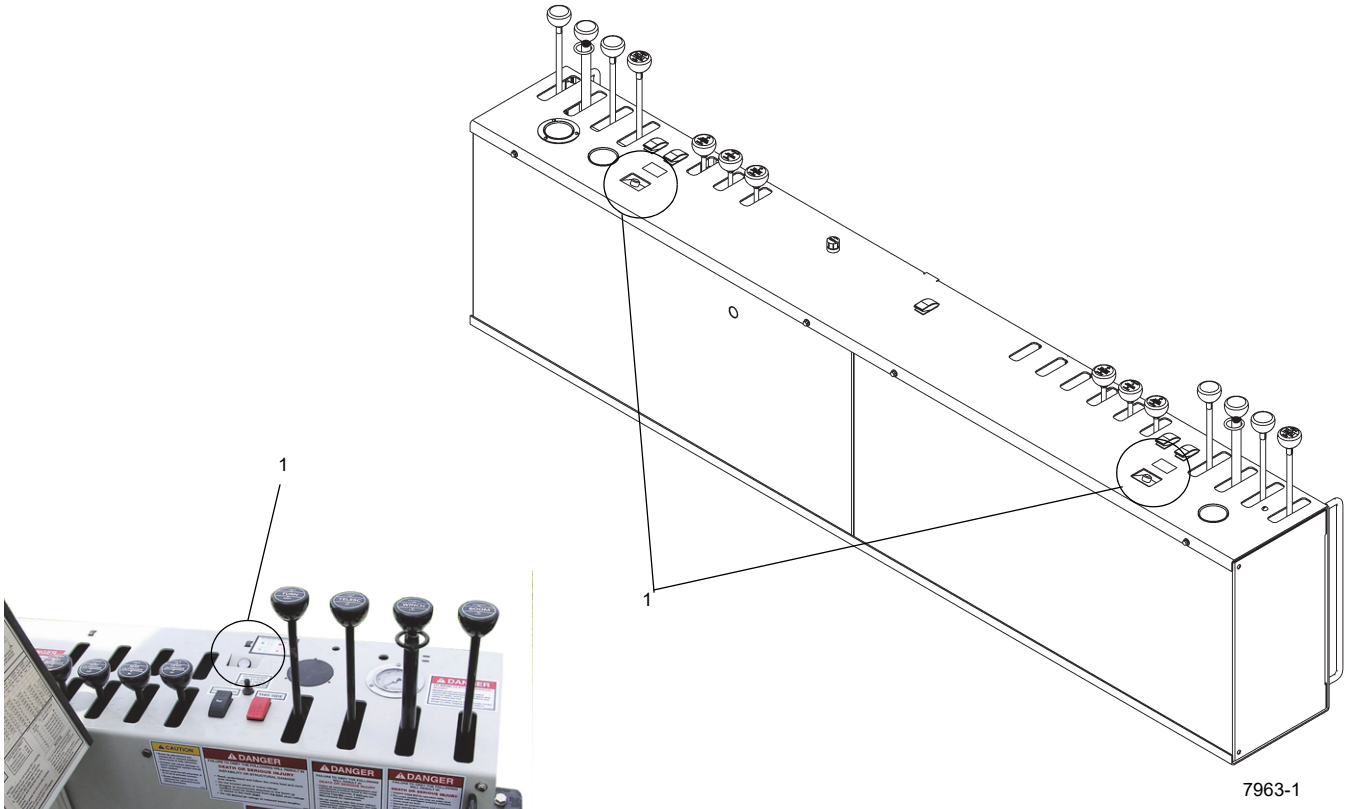


FIGURE 4-2

4

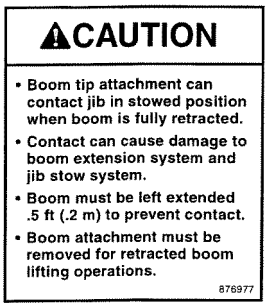
JIB SAFETY INFORMATION

1. The anti-two-block switch weight and cord must be attached to the jib when deployed.
2. Do not lift load with the boom tip when the jib is pinned on the boom tip.
3. Operate with jib by radius when main boom is fully extended. If necessary, increase boom angle to maintain loaded radius.

   When radius is between points listed on capacity chart, the load shown at the next longer radius shall be used.
4. Operate with jib by boom angle when main boom is not fully extended. Do not exceed rated jib capacities at any reduced boom lengths.

   When angle is between points listed on capacity chart, the load shown at next lower boom angle shall be used.
5. Ensure jib is stowed correctly (Figure 4-3):
   a. Removal of swing around pins, C1, without proper installation of stow pin A and jib swing pin B, may allow jib to fall off.
   b. Extending boom with jib stowed and failure to remove swing pins, C1, will damage unit upon extension.
6. Only swing jib into working or stowed position when boom is horizontal, stow pin A and jib swing pin B, are removed and swing pins, C1, are in place. Jib could swing uncontrollably if boom is not horizontal.
7. Crane shall be fully set up according to proper set-up procedures outlined previously when stowing or unstowing jib.
8. Operate boom and turn functions very slowly and carefully when using jib since jibs can increase boom length by 50%.

9. Area where jib swings around must be clear of obstructions and power lines when stowing and unstowing jib.
10. Use safety glasses when pounding pins with hammer.
11. Do not extend/retract boom unless boom is horizontal when stow pin A and jib swing pin B are removed during stowing or unstowing procedures.
12. Always put spring clips in pins to ensure that they will stay in place.
13. When the jib is stowed, the boom can not be fully retracted if a boom tip attachment option is installed.



Also, on manually extendable jib options:

1. Extension retaining pin, E, must always be installed when operating.
2. All swing around (stow and unstowing) operations shall be done with jib retracted and pinned.
3. Extendable section may slide out of 1st section jib when pin, E, is removed. Keep personnel clear of area.

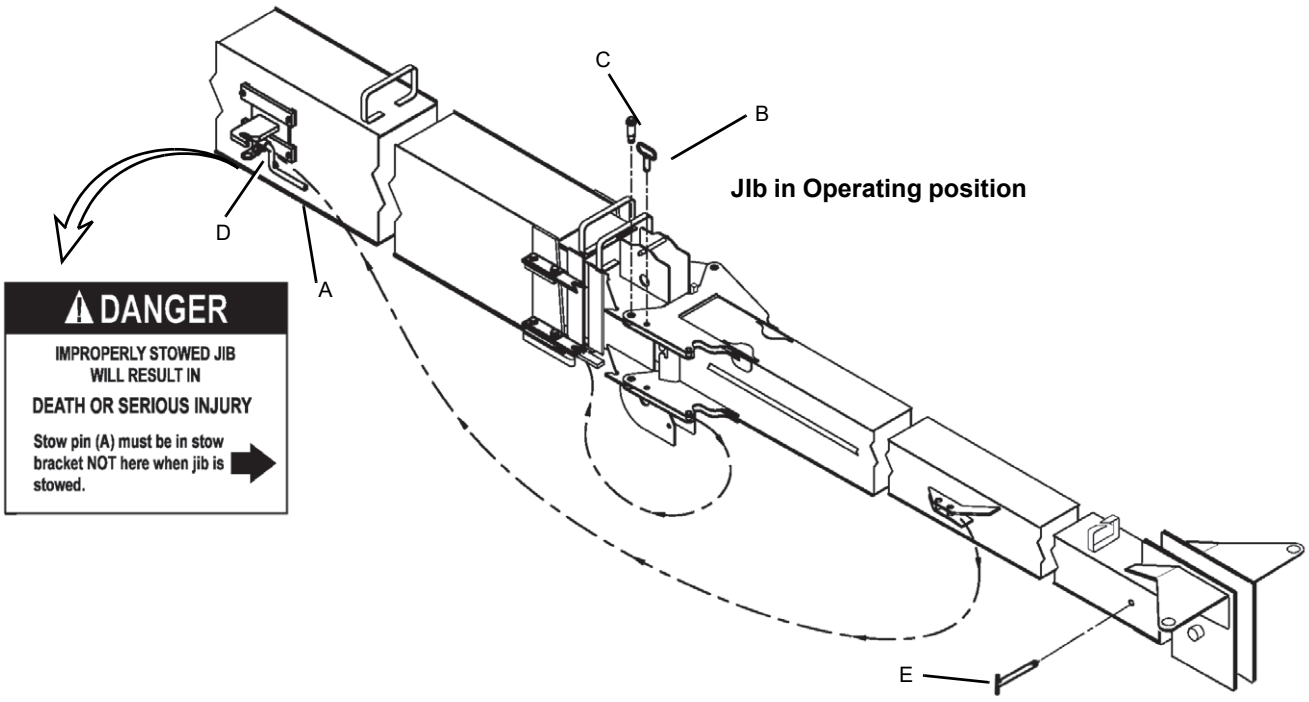
SIDE FOLDING-SWING AROUND JIB OPERATION

Deployment Procedure

1. Using boom telescope function, fully retract boom.
2. Using lift function, lower boom so that jib deployment pins C1 and C2 are easily accessible from the ground.

NOTE: When lowering the boom below horizontal, two persons may be required. With the telescope control in neutral, the boom may creep out when below horizontal.

3. Install pins C1 in upper and lower jib ears. Install retainer spring clips. These pins are used as a pivot point to swing jib into the deployed position.
4. Locate the stowed position of pins C2. If in jib attachment holes or boom sheave case jib holes, remove pins from storage location.
5. Remove jib swing Pin B from top ear of jib.
6. Remove stow Pin A from ramp/side stow bracket assembly on jib and stow in Stow Loop D and install spring clip.
7. Attach tag line to sheave case end of jib.
8. Using the lift function, raise the boom to the horizontal position.
9. Using telescope function, slowly extend boom approximately one foot. This procedure will pull the jib out of the side stow bracket.



JIb in Operating position

A	Stow Pin
B	Jib Swing Pin
C	Jib Deployment Pins
D	Stowage Loop
E	Extension Retaining Pin

Jib in Stow Position

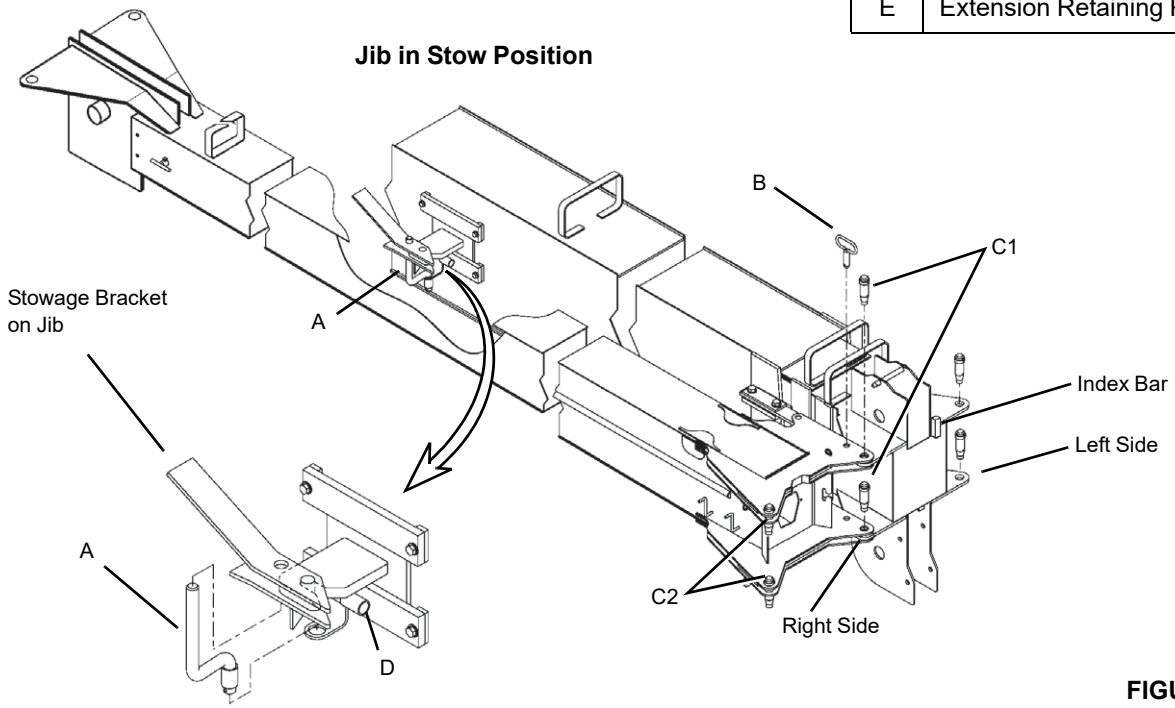


FIGURE 4-3

4

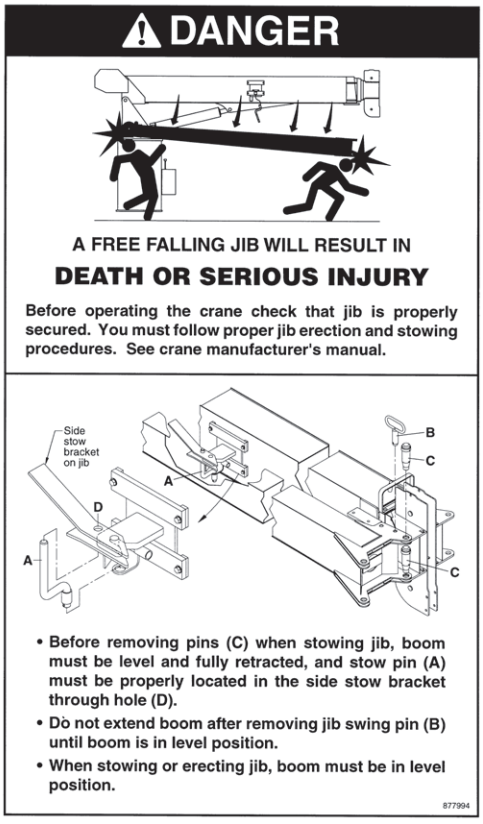
CAUTION

Use caution during this step. The jib is free to swing away from the boom upon boom extension.

10. Using tag line, swing jib into deployed position.

11. Remove cable keeper pins from boom sheave case and jib. Remove hook block. Pivot jib slightly to allow for loadline to be removed from boom sheave case. Remove loadline from boom sheave case and place in an area to minimize possible damage.

12. Pivot jib into place, visually aligning the upper C2 pin holes. Install upper C2 pin and spring clip. A slight hammer strike may be necessary to install pins. Always use proper eye protection during this step.



13. Using jib jack, position jib so that lower C2 pin holes are in alignment and install lower C2 pin and spring clip.

- **a.** Remove the jack handle and check that the jack release valve is closed.
- **b.** Extend the jack so that the lower C2 pin holes are aligned.
- **c.** Install the lower C2 pin and spring clip.
- **d.** Open the jack release valve and retract the jack.

14. Using hoist function, unspool enough loadline to reeve loadline over jib sheave case. Keep slight tension on loadline to avoid bird caging of loadline on hoist drum.

15. Route loadline over jib sheave and install keeper. Install line block to end of loadline.

16. Remove anti-two-block switch and weight/chain assembly and install on jib tip. Be certain to use keeper provided with switch.

17. Disconnect twist lock quick coupler on anti-two- block cord going to boom anti-two-block switch and attach to quick coupler on jib anti-two-block wire on rear of jib between the upper and lower jib ears.

18. Install jib swing pin B and spring clip into jib ears.

19. For manually extendable jibs, pull extension retaining pin E, and extend second section out by pulling on sheave case. The second section jib, as it extends, will hit a mechanical stop that allows for extension pin E installation. Install pin E and spring clip.

20. Make ATB cord connections as required.

Stowing Procedure

1. Using lift function, lower boom so that jib deployment pins C1 and C2 are easily accessible from the ground.

NOTE: When lowering the boom below horizontal, two persons may be required. With the telescope control in neutral, the boom may creep out when below horizontal.

2. For manually extendable jibs, pull extension retaining pin and fully retract extendable 2nd section jib into the 1st section. Retraction of 2nd section may be facilitated by attaching loadline wedge socket to jib nose. Slowly activate the hoist up function until the 2nd section is fully retracted.

3. Reinstall extension retaining pin through the 1st and 2nd section jib assembly and install spring clip.

4. Remove loadline from jib sheave case. Place loadline in area to avoid possible damage from stow procedure.

5. Disconnect twist lock anti-two-block wire connector at rear of 1st section jib. Connect twist lock connector to anti-two-block switch connector on boom tip. Move weight/chain assembly to boom tip.

6. Attach tag line to sheave case end of jib.

7. Remove spring clips from pins C2 on both upper and lower jib ears.

8. Remove jib swing pin B from the boom nose.

9. Remove pins C2 from upper and lower jib ears. Do not remove C1 pins at this time. C1 pins will be used as a

pivot point to swing jib into stow position. A slight hammer strike may be necessary to remove pins. Always use proper eye protection during this step.

10. Raise the boom to the horizontal position.
11. Extend boom approximately 1 foot (.3m).
12. Using tag line attached to jib sheave case, slowly swing jib into stow position (parallel with 1st section boom), Pins C1 are the jib pivot points during this operation.

:

CAUTION

Use caution when swinging jib to avoid unnecessary impact with 1st section boom.

13. Install jib swing pin B with spring clip through jib ear and boom sheave case holes. This pin will keep the jib assembly in line (parallel) with the I st section boom. Jib swing pin B does not retain the jib in its stowed position on the I st section boom.
14. Using boom telescope function, slowly retract boom. The ramp/side stow bracket assembly on the side of the 1st section jib will engage the hook on the side of the 1st section boom, first lifting the jib and then engaging the jib side stow bracket and the boom hook completely upon full retraction of the boom.
15. Install stow pin A with spring clip into the ramp/ side stow bracket assembly on the jib. Complete engagement of stow brackets and proper installation of pin A is critical for secure jib stow attachment.
16. Remove pins C1 from upper and lower jib ears. A slight hammer strike may be necessary to remove pins. Always use proper eye protection during this step.
17. Reinstall loadline over boom sheave case.

DANGER

Visually check all pin positions and make sure the jib is fully retracted into side stow brackets, jib stow attachment is secure, and all pins and spring clips are in their proper locations. Failure to proper secure the jib during stowing and erecting may allow the jib to fall. Serious personal injury or death could result.

Always have at least one, if not both of the following in place at all times:

- Side stow bracket completely engaged into stow hook with stow pin A properly in place.
- Both pins C1 in upper and lower jib holes properly in place through mating holes on boom tip.

:

CAUTION

The 41 ft (12.49 m) jib weights 960 lbs (435 kg) at 129 in. (328 cm) when retracted from mounting pin holes.

JIB REMOVAL

Should jib removal from the boom become necessary, proceed as follows:

1. Unstow and swing jib into position on the boom tip according to Steps 1 - 10 in the preceding jib deployment section.
2. Support and raise the jib at its balance point and remove the two swing around pins. Jib is now free of boom.
3. To install, proceed in reverse order of removal.

When the jib is stowed on side of crane, always leave the ram and handle sleeve of the jib jack pushed all the way down to reduce exposure to rusting.

Jib Maintenance

1. Lubricate as outlined in Section 5.
2. Check for free rotation of jib sheave daily when using jib.

ANTI-TWO-BLOCK WEIGHT INSTALLATION

To prevent the hoist cable from slipping out of the ant-two-block weight, rig the weight as shown in Figure 4-4.

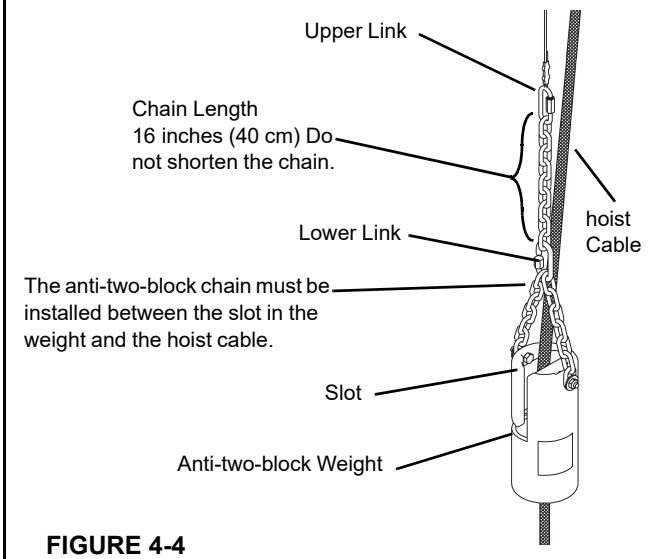


FIGURE 4-4

4

MULTIPART LINE REEVING

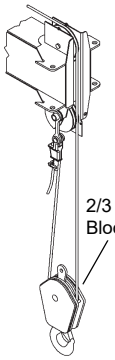
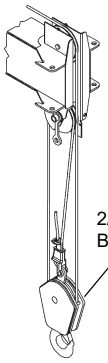
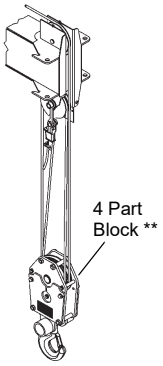
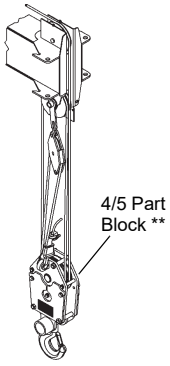
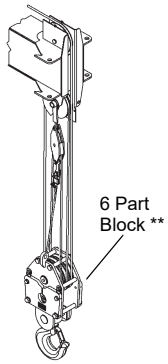
Multipart line reeving enables greater loads to be lifted than can be lifted with single part line. However, loads are limited by the stability and structural integrity of the crane. The load must be within the limits contained in the load chart.

Using Multiple Part Lines

The hoist data chart provides information for pull limitations on the hoist with various multipart reevings. These ratings are based on providing the proper operating safety factor on the cable supplied with the machine. Therefore, any replacement rope must meet the cable specification in of this manual.

Lifting A 20 Ton (40,000 Lbs) Load

The 600H is rated to lift 40,000 lbs (20 ton) at a 5 ft radius with all booms retracted with a six part block.

1 Part Line	2 Part Line	3 Part Line	4 Part Line	5 Part Line	6 Part Line
					
Maximum Pull 7,700 Lbs	Maximum Pull 15,400 Lbs	Maximum Pull 23,100 Lbs	Maximum Pull 30,800 Lbs	Maximum Pull 38,500 Lbs	Maximum Pull 40,000 Lbs
**The hook block must be sized to the number of line parts. For example, do not use a six part line hook block on a three part line reeving. Contact your National Crane Distributor or Manitowoc Crane Care to order the proper hook block.					

INSTALLING CABLE ON THE 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.

3. Position the cable over the boom nose sheave and route to the hoist drum.

4. Position the hoist drum with the cable anchor slot on top.

5. Insert the cable through the slot and position around the anchor wedge (1) Figure 4-5.

NOTE: The end of the cable should be even with the bottom of the slot for the anchor wedge.

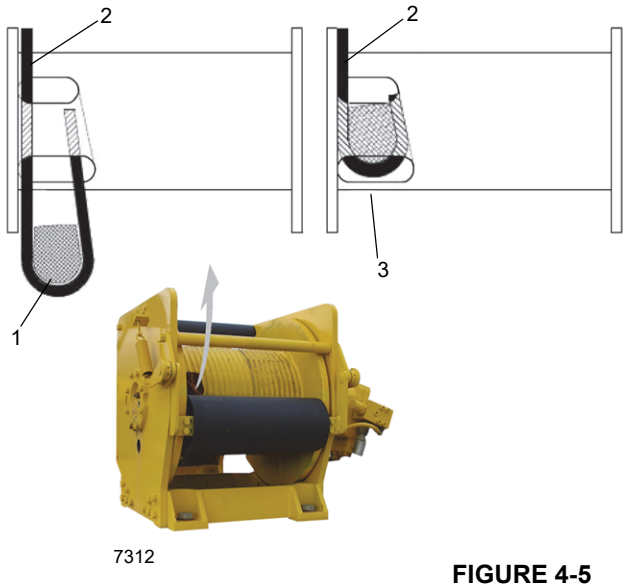


FIGURE 4-5

6. Position the anchor wedge in the drum slot; pull firmly on the free end (2) of the cable to secure the wedge.

NOTE: If the wedge does not seat securely in the slot, carefully tap (3) the top of the wedge with a mallet.

7. Slowly rotate the drum, ensuring the first layer of cable is evenly wound onto the drum.

8. Install the remainder of the cable, as applicable.

Wedge Sockets

To install a wedge socket:

- Make sure the wedge socket is the proper size for the cable.
- Do not mix components of different wedge socket manufacturers.
- The wedge socket must meet the requirements of the wedge socket and wire rope manufacturers.

State and local laws may vary and require different attachment methods depending upon work conditions. The user is responsible for alternate attachment methods.

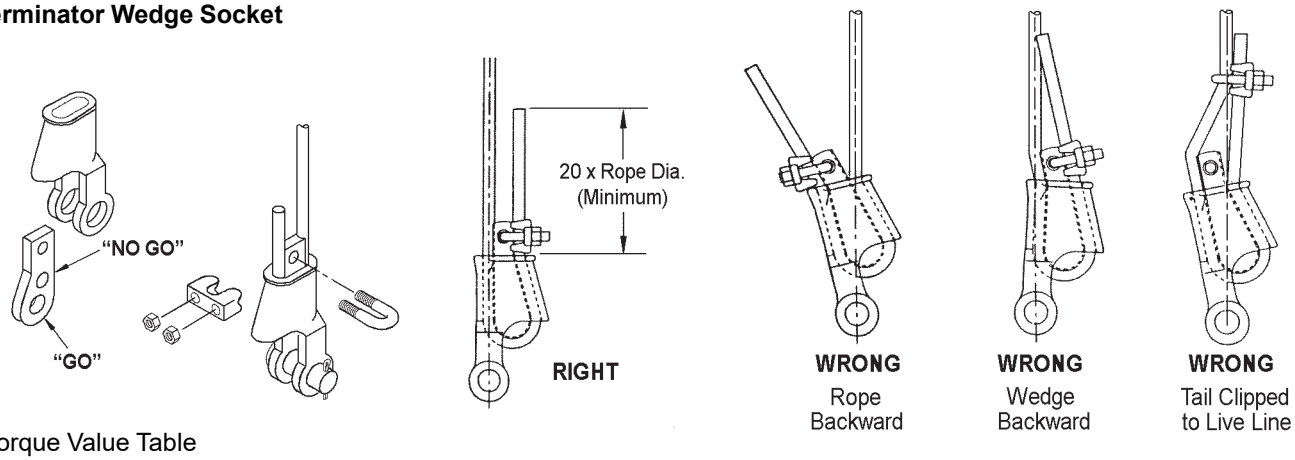
Terminator Wedge Installation

The 600H is shipped with a terminator wedge socket which is National Crane's preferred type of socket (Figure 4-6). Other wedge socket types are shown on page 4-9.

To attach a terminator wedge Figure 4-6, use the following procedure:

1. Match the socket, wedge, and clip to wire rope size.
   - The wire rope must pass through the "go" hole in the wedge.
   - It must not pass through the "no go" hole in the wedge.
2. Align the live end of rope, with center line of pin.
3. Secure dead end section of rope.
4. Tighten nuts on clip to recommended torque.
5. Do not attach dead end to live end or install wedge backwards.
6. Use a hammer to seat Wedge and Rope as deep into socket as possible before applying first load.

Terminator Wedge Socket



Torque Value Table

Cable Size (inches)	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4
Torque ft/lbs	45	65	65	95	95	130	225	225	225	360
Torque values shown are based upon clean dry threads free of lubrication.										

FIGURE 4-6

Wedge Socket Installation

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.

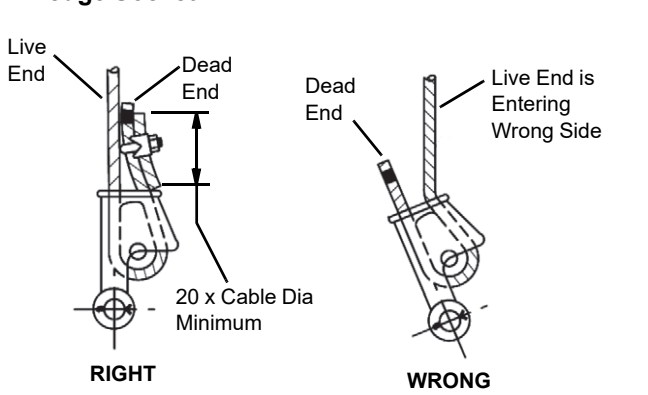


FIGURE 4-7

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 downhaul weight or hook block striking the ground, etc.

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.

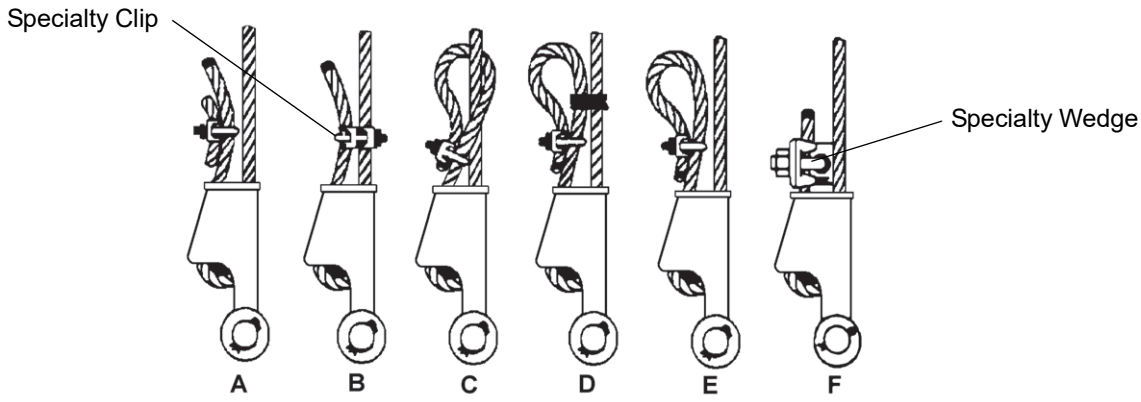
Of the methods shown below, National Crane prefers that method A or F be used, i.e., clipping a short piece of wire rope to the dead-end or using a commercially available specialty clip or wedge. Typically, it is recommended that the tail length of the dead-end should be a minimum of 6 rope diameters but not less that 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).

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) Swagged, 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



Wedge Socket

FIGURE 4-8

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SECTION 5
LUBRICATION PROCEDURE AND CHARTS

SECTION CONTENTS

GENERAL

Following a designated lubrication procedure is important to ensure a maximum crane life. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information. This section does not include lubrication requirements for the truck chassis. Refer to truck service manual for this information.

The service intervals specified are for normal operation where moderate temperature, humidity, and atmospheric conditions prevail. In areas of extreme conditions, the service periods and lubrication specifications should be altered to meet existing conditions. For information on extreme condition lubrication, contact your local National Crane distributor or Manitowoc Crane Care.

Environmental Protection

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

Potentially harmful waste used in National Cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

Handle and dispose of waste according to local, state, and federal environmental regulations.

When filling and draining crane components, observe the following:

- Do not pour waste fluids onto the ground, down any drain, or into any source of water.
- Always drain waste fluids into leak proof containers that are clearly marked with what they contain.
- Always fill or add fluids with a funnel or a filling pump.
- Immediately clean up any spills.

Lubricants

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

Arctic Lubricants and Conditions

Temperatures Below -9°C (15°F)

Regions with ambient temperatures below -9°C (15°F) are considered arctic. In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results in these temperatures. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester hydraulic fluids, may not be compatible with hydraulic system seals and wear bands. Therefore, always check with an authorized National Crane distributor or Manitowoc Crane Care if in doubt of the suitability of a specific fluid or lubricant.

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.

Chassis Grease.

CAUTION

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

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

CAUTION

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

Extreme Pressure Multipurpose Gear Lubricant (EPGL)

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

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

Open Gear Lubricant

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

Low Temperature Grease

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

Anti-wear Additives

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

Hydraulic Oil

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

CAUTION

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

NOTE: When operating the crane in temperatures -9°C (15°F) and below, follow the procedures in the section titled "Arctic Lubricants and Conditions" on page 5-2.

Standard Hydraulic Oil

Temperature Above -9°C (15°F)

The factory fill standard hydraulic oil is ISO grade 46/68 Hydraulic Oil. This fluid is acceptable for operating temperatures above -9°C (15°F). For alternate hydraulic oil products, refer to National Crane lube specifications.

NOTE: On units equipped with self-leveling platforms, low temperature service oils are necessary to provide proper boom functions at temperatures below -9°C (15°F).

CAUTION

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

Arctic Hydraulic Oil

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

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

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

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

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

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

Hydraulic Oil Inspection

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

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

To inspect the hydraulic oil, fill a small glass container with a sample of the reservoir oil and another glass container with fresh oil. Let the samples stand, undisturbed, for one or two hours. Then, compare the samples. If the reservoir oil is heavily contaminated with water, the sample will appear “milky” with only a small layer of transparent oil on top. If the “milky” appearance is due to air foaming, it will dissipate and the oil should closely match the fresh oil. Remember, replacement oil must meet ISO 17/14 or better cleanliness level and must meet John Deere Standard JDM J20c. Contact your National Crane distributor or Manitowoc Crane Care if you have any questions.

Surface Protection for Cylinder Rods

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

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

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

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

LUBRICATION

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

DANGER

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

CAUTION

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

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

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

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

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

CAUTION

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

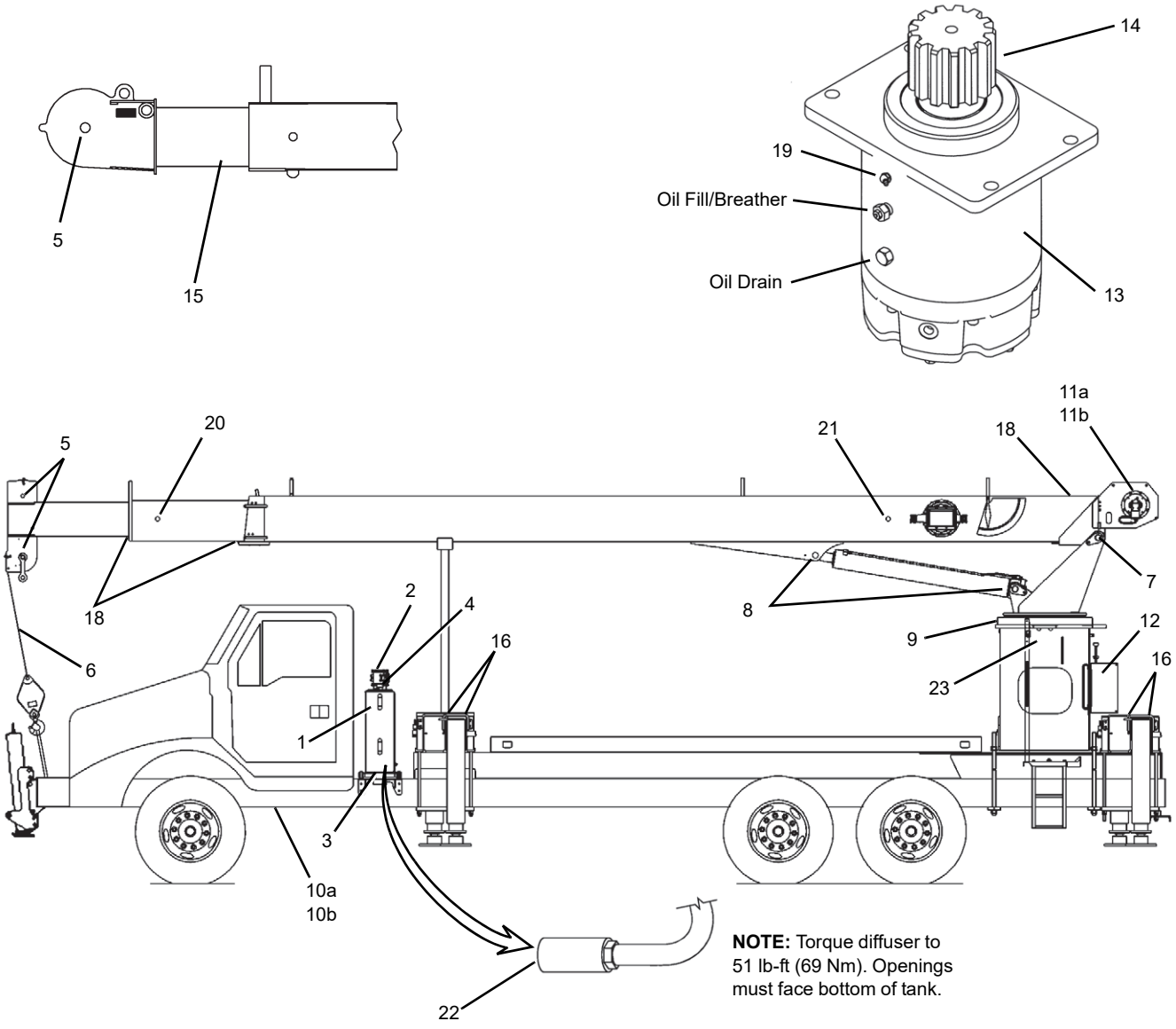
NOTE:

The following describe the lubrication points and gives the lube type, lube interval, lube amount, and application of each. Each lubrication point is numbered, and this number corresponds to the index number shown on the Lubrication Points (“Lubrication Chart” on page 5-5). Lube description and symbols are found below in Table 5-1.

Table 5-1

Symbol	Description	National Crane Lube Specification	
		Standard	Cold Weather - 40°C (-40°F)
AFC	Antifreeze/Coolant (for Cab Heater)	6829101130	6829104212
EP-MPG	Extreme Pressure Multipurpose Grease	6829003477	6829104275
GL-5	GL-5 Gear Lubricant	6829012964	6829014058
HYDO	Hydraulic Oil	6829006444	6829006993
EP-OGL	Open Gear Lubricant, CEPLATTYN 300 Spray, NLGI Grade 1-2	6829102971	6829102971
AGMA EP-4	Extreme Pressure Gear Lubricant.	6829100213	6829103636
WRL	Wire Rope Lubricant	6829015236	6829010993
EO-20W-20	Engine Oil (Light non-EP Oil), Mil-L-46152	6829005570	-
TES 295	TES295 Compliant Fluid	-	6829101690
NOTE: Cold weather lubricants are not sufficient for temperatures below 40° C (-40° F). Use hydraulic tank heaters and insulate where appropriate.			

Lubrication Chart



Item	Application	Recommended Lubricant	Procedure	Frequency
1	Hydraulic oil reservoir	HYDO	Check fill, change	Weekly, semi-annually, as required
2	Oil filter, hydraulic oil reservoir		Change or clean	After first 40 hrs. as indicated by gauge thereafter.
3	Magnetic plug, hydraulic oil reservoir		Clean	At oil filter service interval
4	Breather, hydraulic oil reservoir		Clean	Monthly
5	Sheave pins: boom (2 plcs), jib (1 plc)	EP-MPG	Grease gun	Weekly
6	Wire rope (loadline)	EP-OGL	Brush or spray	Semi-Annually
7	Boom pivot pin	EP-MPG	Grease gun	Monthly
8	Lift cylinder pins - 2 ea.	EP-MPG	Grease gun	Monthly
9	Swing bearing (turret)	EP-MPG	Grease gun	Weekly
10a	Pump drive U-Joint 2 ea.	EP-MPG	Grease gun	Weekly

Item	Application	Recommended Lubricant	Procedure	Frequency
10b	Pump spline shaft (direct mount)	EP-MPG	Remove pump and apply to shaft or grease gun	Semi-Annually
11a	Hoist gearbox.	GL-5	Check and Fill Change	Check and Fill: As part of daily crane inspection, check the gearbox for visible leaks. Change: Every 1000 hours or 6 months
11b	Hoist brake	HYDO	Check & fill Change	Check and Fill: As part of daily crane inspection, check the gearbox for visible leaks. Change: Every 1000 hours or 6 months
12	Control linkage	SAE-10W	Oil Can	As Required/Quarterly
13	Swing Drive Gearbox	GL-5	Check & Fill Change	Check and Fill: As part of daily crane inspection, check the gearbox for visible leaks. Change: After first 50 Operating Hours, every 500 hours thereafter.
14	Swing gear teeth	EP-OGL	Spray Can	Monthly
15	Boom extension	Low Temp. Chassis Grease or Never - Seize or Dry Film Lubricant	Brush, Roller or Grease Gun Spray Can	Monthly or As Required As Required
16	Outrigger beams, bottom, sides	Low Temp. Chassis Grease or Dry Film Lubricant	Brush or Roller Spray Can	Monthly or as required
17	Extension cables (not shown)	WRL	Spray or brush	Any time boom is disassembled or 5 years
18	Boom Wear Pads (not shown)	EP-MPG	See Boom Lubrication	Monthly or as required
19	Swing Motor Pinion Bearing	EP-MPG	Grease gun	Sparingly every 50 hours
20	Extend Sheaves	EP-3MG	Grease Gun w/ Nozzle tip. See Boom Maintenance Section	Weekly
21	Retract Sheaves: Extend the boom until the retract sheave grease holes are visible through the access holes along side of boom.	EP-3MG	Grease Gun w/ Nozzle tip. See Boom Maintenance Section	Weekly
22	Diffuser strainer, Hydraulic oil reservoir		Clean	Semi-Annually with oil change
23	Continuous rotation swivel (optional)	EP-MPG	Grease gun	Monthly

Internal Cable Sheave Lubrication

⚠ DANGER

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

A grease gun adapter is required to lubricate the internal sheaves. The required needle grease gun fitting is:

- A 0.25 inch (6.35 mm) diameter nozzle grease gun tip (National P/N 955045).
- Contact Manitowoc Crane Care to obtain this tip.

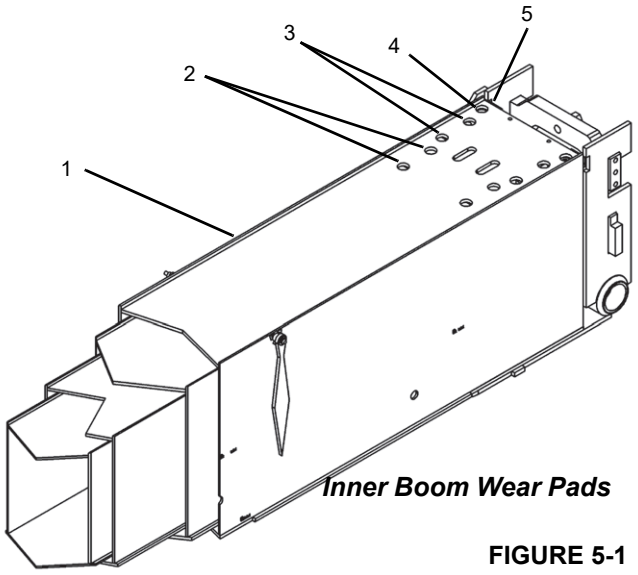
Lubrication of the extend and retract sheaves is as follows:

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

4. Lubricate the pins for the retract sheaves until a small amount of grease extrudes from the sheave pins. From in back of the boom, look up through the hoist mount at the pins to determine the amount of grease.

Boom Lubrication Inner Wear Pad

1. Fully extend and set the outriggers on a level surface.
1. With the boom fully retracted, fill upper rear pad retention pockets (pad retainers) with grease. Access pockets thru holes in rear of boom top plate.
2. With boom over rear of truck, fully extend boom and then lower to the lowest angle possible. It may be necessary to first turn boom slightly to miss boom rest. The upper rear pad retention pockets will be under the 1/4 in (6,35 mm) grease access holes in the butterfly plates on the top of the boom sections.
3. Using a 1/4 in (6,35 mm) diameter nozzle grease gun adaptor, fill pad retention pockets with grease.
4. Apply grease to the wear pads on the top of the 2nd section through the access holes (4) in the 1st section with a grease gun.
5. Extend the boom to line up the access holes on the 2nd section (3) with the wear pads on the 3rd section. Apply grease to the 3rd section wear pads with a grease gun.
6. Extend the boom to line up the access holes (2) on the 3rd section with the wear pads on the 4th section. Apply grease to the 4th section wear pads with a grease gun.
7. Raise the boom to at least 75°.
8. Extend the boom about 1/3 and retract to spread the grease.
9. Repeat steps 3 - 6. Extend the boom about 2/3 and retract to spread the grease.
10. Repeat steps 3 - 5. Fully extend and retract the boom to spread the grease.
11. These steps can be repeated as many times as necessary if unacceptable boom noise or chatter persists.



Inner Boom Wear Pads

FIGURE 5-1

Item	Description
1	1st Boom Section
2	Access Holes for 4th Section Wear Pad
3	Access Holes for 3rd Section Wear Pad
4	Access Holes for 2nd Section Wear Pad
5	2nd Section Wear Pad

Boom Lubrication Side and Bottom Wear Pad

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

Outrigger Beam Lubrication

⚠ DANGER

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

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Recommended lubricant is EP-3MG grease.

1. Fully extend and set the outriggers. Refer to (Figure 5-2.)
2. Apply grease to all wear pads and contact surfaces at the side and bottom of all beam sections and lower surface of the stabilizer/jacks with a suitable brush or putty knife.
3. Extend and retract the outriggers several times until the grease is evenly spread.
4. Repeat as necessary.

8352-2 **FIGURE 5-2**

Hoist Brake Oil

DANGER

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

Check Hoist Brake Oil

CAUTION

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

To check the hoist brake oil, remove the vent and fill plug (Figure 5-3) and visually inspect the oil level. The maximum fill capacity for the hoist brake is 0.23 liter (0.25 quart).

Drain /Add New Hoist Brake Oil

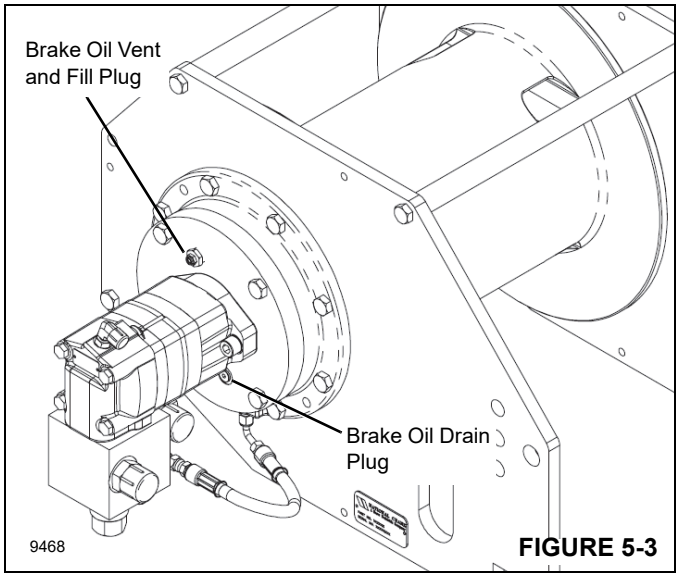
To drain and add new oil, remove the drain plug (Figure 5-3), inspection plug and vent plug and drain the brake oil.

Reinstall drain plug and add fluid at the brake oil vent hole until oil is at the bottom level of the inspection hole. Install the inspection plug and the oil vent and fill plug. The hoist brake fill capacity is 0.23 liter (0.25 quart).

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

DANGER

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



9468 **FIGURE 5-3**

Hoist Gearbox Oil

Hoist Gearbox Oil Change

Gearbox oil is drained by first removing the drain plug (*33,* Figure 5-4) by rotating the drum so that the plug is visible through the lower hole in the side plate (*See view 1*). Screw in a piece of 1 in pipe to allow the oil to drain, and then with a hex wrench remove the drain plug located inside of the 1 in pipe (*See view 2*). Examine the used oil for signs of significant metal deposits and then dispose of it in a proper manner. Remove the 1 inch pipe.

Rotate the drum so that the port is visible through the upper hole in the side plate. Install a 1 in pipe with elbow into the upper hole in the side plate (*See view 3*). Fill the gearbox with 1.42 liters (1.50 quarts) of oil. Remove the pipe and elbow, then replace the plug (33).

For information about changing hoist brake oil, see *“Drain / Add New Hoist Brake Oil” on page 5-8. See “Lubrication*

Chart" on page 5-5 for recommended oil type and grade for your application.

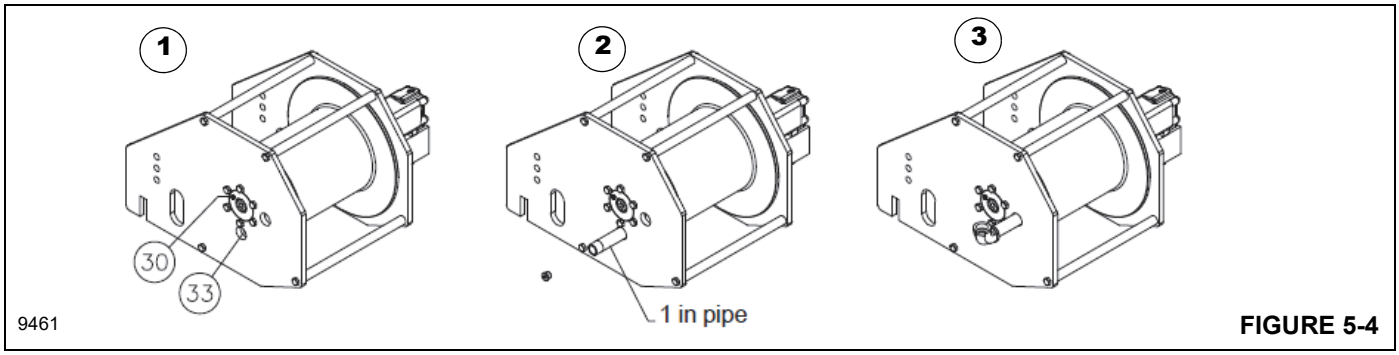


FIGURE 5-4

Swing Gearbox and Brake Oil

Check Swing Gearbox oil level:

The oil in the gearbox and brake sections is recommended to be changed after first 50 hours of operation and every 1000 hours or 6 months of usage. The capacity is 0.71 liter (0.75 qt).

1. Examine the used oil for signs of significant metal deposits.
2. Fill the swing gearbox with the appropriate amount and type of oil and then replace plug and vent. *See "Lubrication" on page 5-3 of this manual.*

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

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

HYDRAULIC OIL RESERVOIR LEVEL

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

If the oil level is too low, add the recommended hydraulic oil until the oil level is even with the upper mark. If the oil level is high, drain oil until the oil level is even with the upper mark.

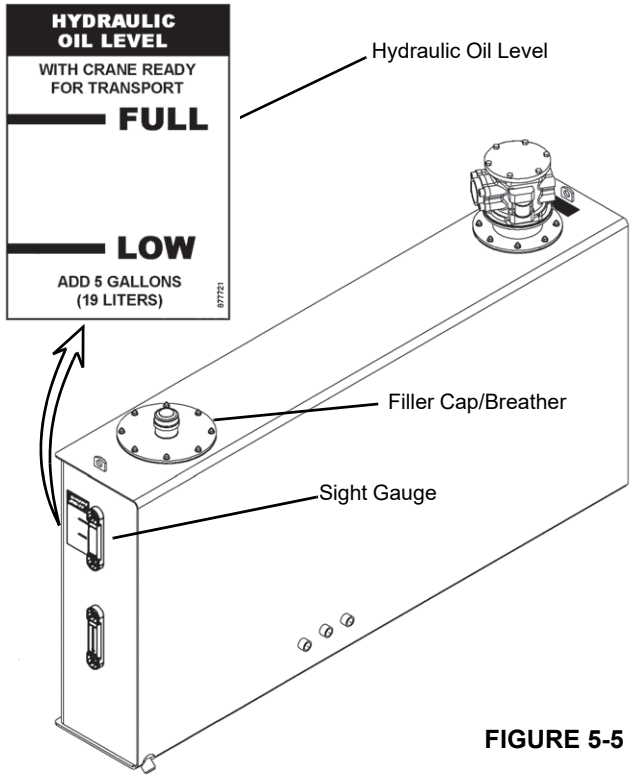


FIGURE 5-5

Hydraulic Filter Replacement

The filter is mounted in the oil reservoir, and is a replaceable element type.

The filter must be serviced with National Crane replacement elements at recommended intervals to assure the warranty remains in effect. See the *Service Manual* for filter replacement instructions.

Wire Rope Lubrication

Wire rope is lubricated during manufacture and the lubricant applied does not last the life of the rope. The wire rope must be lubricated as part of a regularly scheduled maintenance

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program. The lubricant applied must be compatible with the original lubricant and not hinder visual inspection of the rope. Consult the rope manufacturer for proper lubricant. The sections of rope which are located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention.

The object of rope lubrication is to reduce internal friction and to prevent corrosion. The type and amount of lubrication applied during manufacture depends on the rope size, type, and anticipated use. This lubrication provides the finished rope with protection for a reasonable time if the rope is stored under proper conditions. When the rope is put into service, periodic applications of a suitable rope lubricant are necessary. Characteristics of a good wire rope lubricant are that it should be:

- free from acids and alkalis.
- have sufficient adhesive strength to remain on the rope.
- of a viscosity capable of penetrating the interstices between wires and strands.
- not be soluble in the medium surrounding it under the actual operating conditions (i.e. Water).
- have a high film strength.
- resistant to oxidation.

Before applying lubrication, accumulations of dirt or other abrasive material should be removed from the rope. Clean with a stiff wire brush and solvent, compressed air, or live steam. Lubricate the rope immediately after the rope is cleaned. Techniques that can be used include:

- bath
- dripping
- pouring
- swabbing
- painting
- pressure spray

Whenever possible, the lubricant should be applied at the top of a bend in the rope, because at that point the strands are spread by bending and are more easily penetrated. There should be no load on the rope while it is being lubricated. The service life of wire rope is directly proportional to the effectiveness of the method used and amount of lubricant that reaches the working parts of the rope.

CARWELL© RUST INHIBITOR

Protecting Cranes From Corrosion

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

National Cranes will be treated with a rust inhibitor called Carwell T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on National Cranes that are treated with this product.

Carwell T32-CP-90 is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CFR 19-10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents. Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

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

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

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

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

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

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

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

Cleaning Procedures

To help protect against corrosion of National Cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleaning may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

- For scratches and marks in highly visible areas:
- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

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

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

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

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying Carwell.

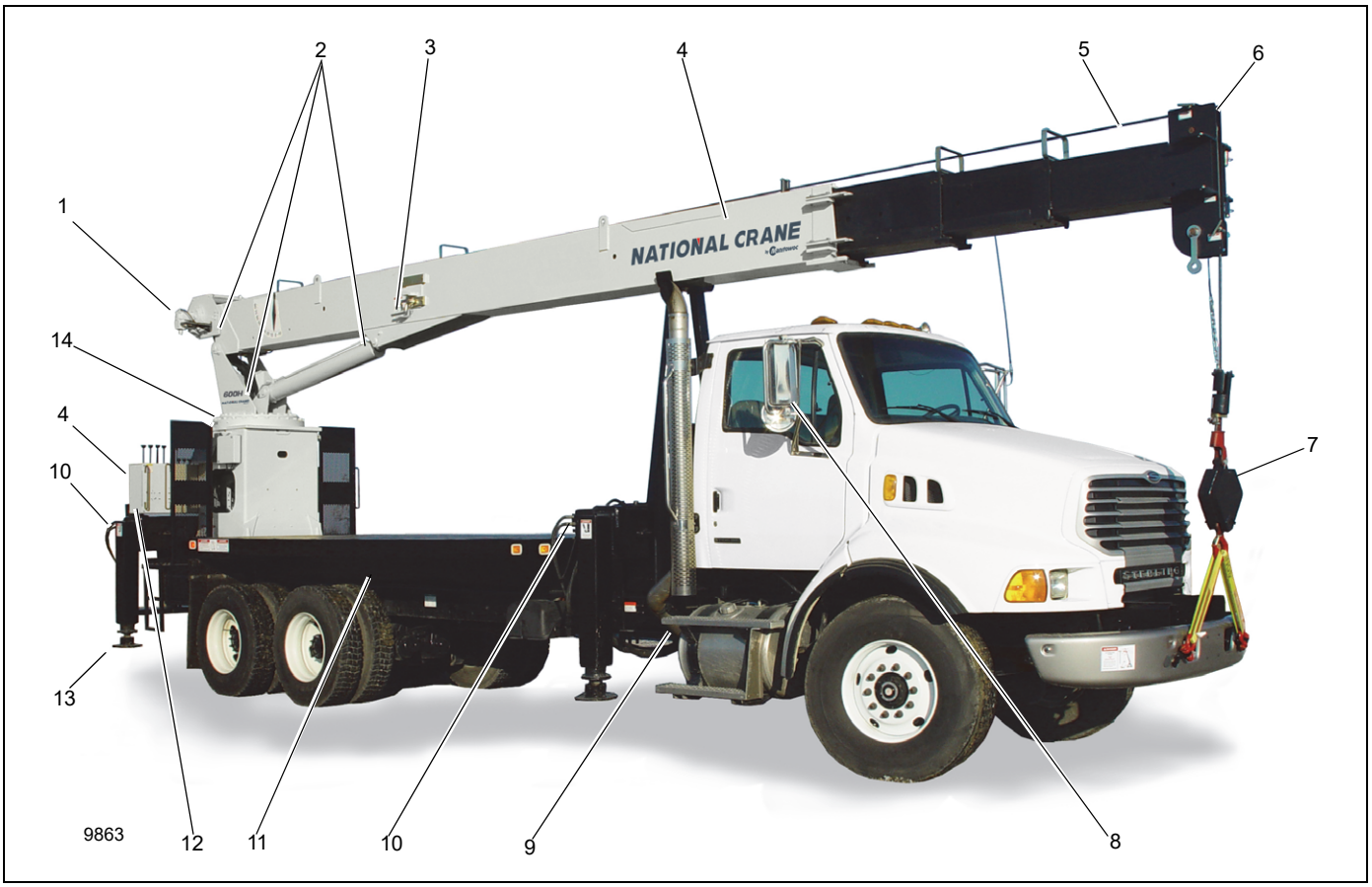
NOTE: Unit must be completely dry before applying Carwell.

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

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; Valves, hose end and fittings, Swivel, pumps, axles, drivelines, transmission, all interior surfaces of the frame
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarms.
- Superstructure applications are; hose end and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring, all bare metal surfaces.
- Boom applications areas are; pivot pins, hose end and fittings, jib pins and shafts, all bare metal surfaces, headache ball / hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have Carwell applied.



Item	Description
1	Hoist Plumbing Connections
2	Pivot Shaft
3	Hanger Hardware for Boom Extension
4	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
5	Wire Rope
6	Boom Nose Pins, Clips
7	Hook Block/Headache Ball

Item	Description
8	Mirror Mounting Hardware
9	Power Train Hardware
10	O/R Hose Connections
11	Entire underside of unit
12	Valve Bank, Hose Connections Inside Turntable
13	O/R Pins, Clips
14	Turntable Bearing Fasteners

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SECTION 6
MAINTENANCE CHECKLIST

SECTION CONTENTS

CRANE INSPECTION AND MAINTENANCE

Regularly scheduled inspections and maintenance is essential to keep your unit in peak operating efficiency. The following pages outline the inspections and maintenance required to keep the crane in proper operating condition.

Refer to the Service Manual for complete instructions on performing maintenance on this crane.

DANGER

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

Inspection

The inspection intervals listed below are to be conducted on the unit to ensure safe and proper operation. Refer to the *Service Manual* when installing missing or loose fasteners. Should a defect be found, a determination must be made as to whether the deficiency is a safety hazard or though not yet a safety hazard, needs to be monitored in the monthly inspections.

The inspections are separated into the following frequency classifications:

- Daily inspections — are performed by the operator before beginning the days work.
- Weekly inspections — are performed by the operator weekly.
- Monthly inspections — are performed by maintenance personnel monthly.
- Periodic inspections — performed by maintenance personnel at least every three months and includes all items listed under daily, weekly, and monthly inspections. Federal Laws through OSHA and ANSI B30.5 require that dated and signed records of these periodic inspections be kept. An inspection log book is available from your National Crane distributor or Manitowoc Crane Care.

WARNING

If any defect determined during the inspection is a safety hazard the machine must be removed from service and the defect corrected.

Daily Inspections

Check the following items:

1. Engine oil level.
2. Hydraulic oil level.
3. Radiator coolant level.
4. Loose parts or damage to structures or welds.
5. Operation of lights, safety equipment and gauges.

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6. Condition of tires and suspension.
7. Condition of Hoist cable and end attachment for corrosion, severe kinking, crushing, cutting, or slippage of cable clamps or wedge socket.
8. Loose parts or damage to cable centering hook blocks.
9. Position of cable with guides and on sheaves.
10. Free turning of sheaves.
11. Lubrication as specified by the Lubrication Chart.
12. Evidence of oil leak from hoses, gearboxes, or swivel.
13. Hand and foot controls for malfunction or incorrect adjustment.
14. Truck parking brake operation.
15. Boom proportioning to insure that all boom sections extend and retract equally.
16. All securing hardware such as cotter pins, snap rings, hairpins, pin keepers, and capscrews for proper installations.
17. Proper condition and operation of RCL and anti-two-block systems to include the anti-two-block switch weight and chain at the boom tip (and jib tip if equipped), power cords, audible alarms, and indicator lights on the console.
18. Proper operation of the load hook safety latch.
19. Hooks and latches for excessive wear, cracks or damage from heat or chemicals.
20. Drain holes at rear of the first section of the boom are clear of all obstructions.
21. All fasteners retaining the cable centering block are in place and tight.
22. All safety covers for proper installation.
23. Control and drive mechanisms for excessive wear and/or contamination from lubricants, water or other foreign matter.

Weekly Inspections

Check the following items:

1. Battery water level.
2. Tire pressure.
3. Lubrication as specified by the Lubrication Chart.
4. Boom lift and outrigger holding valves for proper operation.
5. Torque the swing bearing mounting bolts during the first month of operation and periodic inspections thereafter (See page 6-8 for Torque Values).
6. Hoist brake for proper operation at Hoist capacity load.
7. Torque the boom wear pad retaining bolts during first month of operation, and monthly thereafter.
8. Check to see that crane Operation Manual is with the unit. If the manual is missing, obtain the serial number of the unit and order an operation manual immediately.

Monthly Inspections

Check the following items:

1. All cylinders and valves for improper operation or signs of leaks.
2. Lubrication as specified by the Lubrication Chart.
3. Load hook for cracks or having more than 15 percent normal throat opening or 10 degree twist.
4. All structural members (boom, sub-base, turret and outriggers) for bends, cracks, or broken members.
5. All welds for breaks or cracks.
6. All pins for proper installation.
7. All control, safety, and capacity placards for readability and secure attachment.
8. Torque of cable clip bolts above wedge socket at end of loadline should be 95 ft-lb.
9. All boom wear pad retaining bolts.
10. Boom extension cables for proper tension or evidence of abnormal wear.
11. Sheaves and cable drums for wear and cracks.
12. Unspool loadline and check according to cable maintenance procedure.

Periodic Annual Inspection

Check the following items:

1. All items listed under daily, weekly, and monthly inspections.
2. Loose bolts and fasteners in all areas. Torque pin retainer bolts.
3. All pins, bearings, shafts, and gears for wear cracks or distortion to include all pivot, outriggers and sheave pins, and bearings.
4. Boom angle and boom length indicator for accuracy over full range.
5. Hydraulic systems for proper operating pressure.
6. Outrigger pads for excessive wear or cracks.
7. Cylinders for:
   a. Damaged rods

b. Dented barrels

c. Drift from oil leaking by piston

d. Leaks at rod seals, welds, or holding valves.

8. PTO drive line system for proper alignment, lubrication and tightness.

9. Hydraulic hose and tubing for evidence of damage such as blistering, crushing, or abrasion.

10. Top and bottom wear pads for excessive wear.

11. Inspect all electrical wires and connections for worn, cut or deteriorated insulation and bare wire. Replace or repair wires as required.

12. Extend and retract cables, sheaves, pins, and bearings for wear or abrasion.

13. Main frame and stabilizer mount bolts for proper torque (see Torque Chart).

14. Rotation bearing and gearbox mounting bolts for proper torque (see Torque Chart).

15. Missing or unreadable warning labels.

16. Missing or unusable/unsafe condition of steps, ladders, handrails, guards or seat.

Special Boom Inspection

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

Stability

Stability of unit throughout working area. Check the stability procedure in Installation Section of the Service Manual annually or when any changes are made to crane or truck.

HOIST CABLE INSPECTION AND MAINTENANCE

Inspection

⚠ WARNING

Worn or Damaged Equipment Hazard!

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

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

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

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

Daily Inspections

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

Monthly Inspections

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

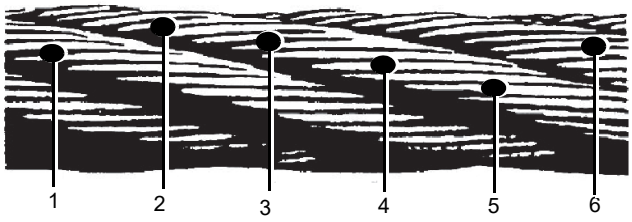
Periodic Inspections

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

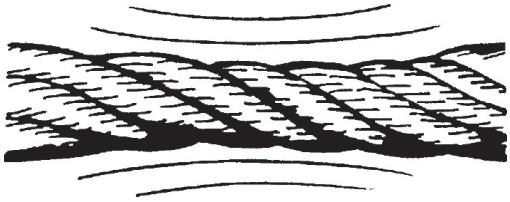
Wire Rope Replacement

It is difficult to determine the exact time for replacement of wire rope (hoist cable) since many variable factors are involved. Proper determination of the condition of a rope depends upon the judgment of an experienced person. The following reasons are sufficient for consideration of rope replacement:

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



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



- Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of heat damage.
- Reductions from nominal diameter of more than:
  - 0.0156 in (.4 mm) for rope diameters to 0.313 in (8 mm)
  - 0.031 (.8 mm) for rope diameters 0.375 in (9.5 mm) to 0.50 in (12.7 mm)
  - 0.047 in (1.2 mm) for rope diameters 0.561 in (14.3 mm) to 0.75 in (19.1 mm)
  - 0.063 (1.6 mm) for rope diameters 0.875 in (22.2 mm) to 1.125 in (28.6 mm).
- One outer wire broken at its point of contact with the core of the rope which has worked its way out of, and protrudes or loops out from the rope structure. Additional inspection of this section is required.

Care of Wire Rope

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

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

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

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

REPLACEMENT CABLE

If the hoist cable needs to be replaced, care should be taken in selecting a suitable replacement cable. The cable strength requirements are shown on the crane load chart. The types of cable are optional with 6 x 25 and Dyform being the most common. A high strength, rotation resistant cable is preferred and is furnished as standard by Grove Cranes. This cable eliminates single part line load spin and prolongs cable life. It also eliminates load block spin up when multi-part reeving is used. Do not use a swivel on rotation resistant rope. A swivel on this rope will cause premature rope core failure.

Standard
9/16 in. (14.3mm) Dia. Wire cable: Rotation Resistant 18X25 Nominal Breaking Strength: 19.25 Tons (17,463 kg)

CRANE ADJUSTMENTS AND REPAIRS

Before adjustments or repairs are started on a crane, read and be familiar with the safety information outlined under “Maintenance Practices” in Section 2.

Boom Extension Cable

If a cable replacement is required for the boom extension system, the replacement cable must be obtained through the Manitowoc Crane Care. Extension cables are pre-stretched and have special connections for proper operation

Jib Jack Service and Maintenance

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

Adding Oil to the Jib Jack

To add oil to the jib jack, do the following:

1. Set the jack in an upright level position.
2. Lower the saddle and make sure the piston is fully depressed.
3. Remove the oil filler plug.
4. Fill until the oil is level with the filler plug hole.

Changing the Jib Jack Oil

For best performance and longest life, replace the oil at least once a year. To change oil, do the following:

1. Remove the filler plug.
2. Lay the jack on its side and drain the oil into a drain pan. The oil will run slowly because air must enter as oil drains out.
3. Be careful to prevent dirt or foreign matter from entering the system.
4. Replace with proper oil as described above.

Lubrication

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

Rust Prevention

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

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

HYDRAULIC SYSTEM

Oil Cooler (Optional)

The heat exchanger must be kept clean for efficient operation of the hydraulic cooler system. Wash the heat exchanger core frequently to eliminate oil film, road dirt, and other foreign object buildup on the heat exchanger fins.

Frequent inspection and tightening of hose clamp eliminates the possibility of end connection failure due to back pressure from a cold startup.

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

Hydraulic System Trouble Diagnosis

The following chart lists malfunctions which may occur during equipment operation with possible cause and solution. These are not all inclusive but are designed to help isolate the problem and should be checked before calling the factory Service Department.

Condition	Possible Cause	Possible Solution
No response to control	RCL system inoperative.	Insure the RCL system is working properly and the anti-two-block solenoid is powered.
	Load too heavy.	Check load chart.
	PTO not engaged.	Engage PTO.
	Low hydraulic fluid supply.	Check and fill as required.
	Suction line blocked.	Drain tank and hose and remove blockage.
	Broken hydraulic pressure line.	Replace as required.
	Defective hydraulic pump.	See Pump Service Manual.
	Incorrect relief valve setting.	Adjust relief (See “Specifications” on page 6-11).
	Relief valve sticking.	Clean relief.

Condition	Possible Cause	Possible Solution
Poor hydraulic system performance	Pump not operating at proper speed.	Check PTO ratio, pump size and engine speed for proper oil flow.
	Low hydraulic fluid supply.	Check and fill as required.
	Relief valve sticking.	Remove and clean.
	Relief setting too low.	Readjust to proper setting.
	Worn pump, motor or cylinder.	Replace bad part.
	Plugged filter.	Change filter.
	Valve spools not fully open.	Adjust linkage so valve has full throw.
	Boom holding valves out of adjustment.	Adjust or clean as required.
	Oil temperature too high.	Run engine at idle with controls in the neutral position until hydraulic oil light goes out.
	Hydraulic oil too cold or dirty.	Warm oil or use less viscous oil.
	Line restricted.	Check lines; clean and repair as required.
	Internal control valve crack.	Replace valve.
	Load too heavy.	Check load chart and reduce load.
Swing moves erratic or sloppily (Standard system).	Loose turntable bearing.	Torque bearing mounting bolts.
	Loose swing gearbox mounting bolts.	Tighten bolts.
	Worn gears or bearing.	Replace worn parts or adjust gearbox spacing.
	Operator control of lever too erratic.	Operate controls smoothly.
	Motor counterbalance valves dirty or not set properly.	Clean or replace valves or set at 600 psi.
	Brake not holding properly.	Replace worn brake parts or shim brake to proper torque.
	Brake releasing at wrong time or erratically.	Bleed brakes with bleed screw on side of brake.
	Swing speed adjustment set too low.	Adjust or clean brake for proper release.
		Adjust valve on turn motor.
Swing will not turn (Standard System)	Turn circuit relief valves sticking.	Clean and check circuit pressure.
	Turntable bearing drag.	Lubricate thoroughly as rotating boom.
	Brake not releasing properly.	Check for 200 PSI brake pilot pressure. Clean pilot line or adjust motor counterbalance valves.
	Swing speed adjustment set too low.	Adjust or clean brake for proper release.
		Adjust valve on turn motor.
Excessive pump noise during operation.	Excessive pump speed.	Adjust foot throttle or check for high PTO ratio.
	Low oil temperature.	Allow unit to warm up.
	Low hydraulic oil supply.	Check and fill.
	Suction line kinked, collapsed or blocked.	Clear blockage.
	Hydraulic oil too thick.	Warm oil or use oil better suited to environment.
	Relief valve chattering.	Dirt in relief valve or damaged relief.
	Hydraulic tubing vibration.	Check for loose tubing.
	Tank breather plugged.	Clean breather.

Condition	Possible Cause	Possible Solution
Cylinders drift	Not getting oil to cylinders.	Clean and replace as required.
	Worn or damaged piston seals.	Replace as required.
	Air in hydraulic oil.	Cycle crane cylinder to remove air.
	Loose holding valve.	Tighten valve.
	Dirt in holding or check valve.	Clean valve.
Hoist will not lift or hold load.	Load too heavy.	Change to applicable multipart reeving.
	Relief valve setting too low.	Check and adjust if required.
	Motor worn excessively.	Replace motor.
	Counterbalance valve defective or leaking.	Clean and replace as necessary.
	Anti-two-block system defective.	Repair anti-two-block system.
	Brake worn out.	Repair or replace brake.
Hoist gearbox heats.	Gearbox grease low.	Check and fill as required.
	Duty cycle too high.	Reduce cycle time or speed of Hoist.
Boom chatters during extension/retraction or doesn't proportion properly.	Boom sections need lubrication.	Grease boom.
	Wear pads not shimmed correctly.	Re-shim as described in boom assembly section.
	Worn wear pads.	Replace pads.
	Extension cables out of adjustment.	Readjust cables and tension properly.
	Extend or retract cables broken.	Disassemble, inspect, and replace cables.
Boom will not extend.	Proportioning cables not attached.	Reconnect, replace and/or adjust cables.
	Anti-two-block system shut down.	Lower hook, and extend load.
	Defective anti-two-block system	Repair ATB if defective.
System is in a state of constant cut-out.	Blown fuse at the crane console.	Replace fuse.
	ATB switch open.	Ensure that ATB switch is closed.
System cuts out too early or too late.	RCL programmed wrong.	Reprogram RCL with correct lift values.
Jib Jack Troubleshooting		
Will not lift load.	No oil in system. Release valve not closed.	Add oil to reservoir. Turn handle clockwise tightly.
Will lift load only part way.	Oil level low.	Add oil to reservoir tank.
Will lift load but will not hold.	The following valve or valves leaking. a. Suction valve b. Delivery valve c. Release valve	Replace jack
	Packings worn or damaged.	Replace jack
Jack will not lower.	Release valve stuck, probably dirt or foreign matter.	Transfer load then replace dirty oil, flush oil reservoir with non-flammable solvent.
Poor lifting.	Dirty oil. Air in hydraulic system.	Change oil. Purge air from system.
Poor pumping action.	Oil seal for pump unit worn or damaged.	Replace jack.

Tire Load And Inflation Table

Definite tire inflation pressures are established for each tire size depending upon the load imposed on the tires. For greater stability, riding comfort and prolonged tire life, tires should be inflated for the loads carried. The “Load and inflation Table" shown below indicates the proper inflation pressure.

NOTE: The values in the tables below are as published by the Tire and Rim Association 2005. Your vehicle may be equipped with other tire sized or the same size tires rated differently. Always check the tire sidewalls to verify the maximum capacity and inflation. Inflation pressure and loading must not exceed the values shown on the wheel or rim.

Tire and Load Inflation Tables

Letters in parenthesis denote the load range for which the bold face loads are a maximum. International load index numbers are shown after the load range. The load range letters and corresponding ply rating are shown below.

D = 8 ply • E = 10 ply • F = 12 ply • G = 14 ply
H = 16 ply • J = 18 ply • L = 20 ply • M = 22 ply • N = 24 ply

Radial Ply Metric Tires for Trucks, Busses, and Trailers Used in Normal Highway Service
Radial Ply Tires Mounted on 15° Drop Center Rims
Tire and Rim Association Standard

TABLE TBM-2R

TIRE SIZE DESIGNATION	USAGE	TIRE LOAD LIMITS (kg/lbs.) AT VARIOUS COLD INFLATION PRESSURES (kPa/psi)											
		450 *65*	480 *70*	520 *75*	550 *80*	590 *85*	620 *90*	660 *95*	690 *100*	720 *105*	760 *110*	790 *115*	830 *120*
295/60R22.5	DUAL	1750 *3860*	1830 *4040*	1930 *4245*	2000 *4410*	2030 *4480*	2120 *4665*	2240 *4940*	2280 *5025*	2360 *5195*	2430 *5355*	2510 *5535*	**2575**(H) 141 ***5675***(H)
	SINGLE	1850 *4080*	1950 *4300*	2050 *4515*	2120 *4675*	2230 *4925*	2330 *5125*	2430 *5355*	2500 *5520*	2590 *5710*	2650 *5840*	2760 *6085*	**2800**(H) 144 ***6175***(H)
225/70R19.5	DUAL	**1180**(D) 114 ***2600***(D)	1230 *2720*	1300 *2860*	**1360**(E) 119 ***3000***(E)	1410 *3115*	1470 *3245*	**1550**(F) 123 ***3415***(F)	1580 *3490*	1640 *3615*	**1700**(G) 126 ***3750***(G)		
	SINGLE	**1250**(D) 116 ***2755***(D)	1310 *2895*	1380 *3040*	**1450**(E) 121 ***3195***(E)	1500 *3315*	1570 *3450*	**1650**(F) 125 ***3640***(F)	1690 *3715*	1740 *3845*	**1800**(G) 128 ***3970***(G)		
245/70R19.5	DUAL				1550 *3415*	1590 *3515*	1660 *3655*	**1750**(F) 127 ***3860***(F)	1790 *3940*	1850 *4075*	**1950**(G) 131 ***4300***(G)	1970 *4345*	**2060**(H) 133 ***4540***(H)
	SINGLE				1650 *3640*	1700 *3740*	1770 *3890*	**1850**(F) 129 ***4080***(F)	1900 *4190*	1970 *4335*	**2060**(G) 133 ***4540***(G)	2095 *4620*	**2180**(H) 135 ***4805***(H)
265/70R19.5	DUAL				1700 *3750*	1780 *3930*	1860 *4095*	1950 *4300*	2000 *4405*	2000 *4415*	**2120**(G) 134 ***4675***(G)		
	SINGLE				1800 *3970*	1900 *4180*	1970 *4355*	2060 *4540*	2130 *4685*	2200 *4850*	**2300**(G) 137 ***5070***(G)		
305/70R19.5	DUAL				2060 *4540*	2120 *4670*	2200 *4860*	2300 *5070*	2370 *5230*	2450 *5410*	**2575**(H) 141 **5675**(H)	2620 *5770*	**2725**(J) 143 ***6005***(J)
	SINGLE				2240 *4940*	2330 *5130*	2420 *5340*	2500 *5510*	2610 *5745*	2700 *5945*	**2800**(H) 144 ***6175***(H)	2870 *6340*	**3000**(J) 146 ***6610***(J)

Radial Ply Metric Tires for Trucks, Busses, and Trailers Used in Normal Highway Service
Radial Ply Tires Mounted on 15° Drop Center Rims
Tire and Rim Association Standard

TABLE TBM-2R
Continued

TIRE SIZE DESIGNATION	USAGE	TIRE LOAD LIMITS (kg/lbs.) AT VARIOUS COLD INFLATION PRESSURES (kPa/psi)											
		450 *65*	480 *70*	520 *75*	550 *80*	590 *85*	620 *90*	660 *95*	690 *100*	720 *105*	760 *110*	790 *115*	830 *120*
255/70R22.5	DUAL				1800 *3970*	1860 *4110*	1940 *4275*	2000 *4410*	2020 *4455*	2090 *4610*	**2120(G)** [134] ***4675*(G)**	2230 *4915*	**2300(H)** [137] ***5070*(H)**
	SINGLE				1900 *4190*	1980 *4370*	2060 *4550*	2120 *4675*	2220 *4895*	2300 *5065*	**2360(G)** [138] ***5205*(G)**	2450 *5400*	**2500(H)** [140] ***5510*(H)**
305/75R22.5	DUAL				2360 *5205*	2440 *5375*	2540 *5595*	2560 *5840*	2730 *6025*	2830 *6235*	**3000(H)** [146] ***6610*(H)**	3010 *6640*	**3150(J)** [148] ***6940*(J)**
	SINGLE				2575 *5675*	2680 *5905*	2790 *6150*	2900 *6395*	3000 *6620*	3110 *6850*	**3250(H)** [149] ***7160*(H)**	3310 *7300*	**3450(J)** [151] ***7610*(J)**
315/80R22.5	DUAL				2575 *5675*	2650 *5840*	2750 *6070*	**2900(G)** [145] ***6395*(G)**	2970 *6545*	3070 *6770*	**3150(H)** [148] ***6940*(H)**	3270 *7210*	**3450(J)** [151] ***7610*(J)**
	SINGLE				2800 *6175*	2910 *6415*	3030 *6670*	**3150(G)** [148] ***6940*(G)**	3260 *7190*	3370 *7440*	**3450(H)** [151] ***7610*(H)**	3590 *7920*	**3750(J)** [154] ***8270*(J)**
305/85R22.5	DUAL				2430 *5355*	2520 *5550*	2620 *5780*	2725 *6005*	2820 *6215*	2920 *6435*	**3075(H)** [147] ***6780*(H)**	3110 *6860*	**3250(J)** [149] ***7160*(J)**
	SINGLE				2650 *5840*	2770 *6100*	2880 *6350*	3000 *6610*	3100 *6830*	3210 *7070*	**3350(H)** [150] ***7390*(H)**	3420 *7540*	3550(J) [152] ***7830*(J)**

Radial Ply Metric Tires for Trucks, Busses, and Trailers Used in Normal Highway Service
Radial Ply Tires Mounted on 15° Drop Center Rims
Tire and Rim Association Standard

TABLE TBM-1R

TIRE SIZE DESIGNATION	USAGE	TIRE LOAD LIMIT AT VARIOUS COLD INFLATION PRESSURES											
		kPa *psi*	480 *70*	520 *75*	550 *80*	590 *85*	620 *90*	660 *95*	690 *100*	720 *105*	760 *110*	790 *115*	830 *120*
245/75R22.5 235/80R22.5	DUAL	kg *lbs.*	1430 *3160*	1500 *3315*	1600 *3525*	1640 *3615*	1710 *3765*	1800 *3970*	1840 *4055*	1900 *4195*	**1950(G)** [131] ***4300(G)***		
	SINGLE	kg *lbs.*	1570 *3470*	1650 *3645*	1750 *3860*	1800 *3975*	1880 *4140*	1950 *4300*	2020 *4455*	2090 *4610*	**2120(G)** [134] ***4675(G)***		
265/75R22.5 255/80R22.5	DUAL	kg *lbs.*	1600 *3525*	1680 *3705*	1750 *3860*	1830 *4040*	1910 *4205*	2000 *4410*	2050 *4525*	2130 *4685*	**2180(G)** [135] ***4805(G)***		
	SINGLE	kg *lbs.*	1760 *3875*	1850 *4070*	1950 *4300*	2010 *4440*	2100 *4620*	2180 *4805*	2260 *4975*	2340 *5150*	**2360(G)** [138] ***5205(G)***		
295/75R22.5 275/80R22.5	DUAL	kg *lbs.*	1860 *4095*	1950 *4300*	2060 *4540*	2130 *4690*	2220 *4885*	**2300(F)** [137] ***5070(F)***	2390 *5260*	2470 *5440*	**2575(G)** [141] ***5675(G)***	2630 *5795*	**2725(H)** [143] ***6005(H)***
	SINGLE	kg *lbs.*	2040 *4500*	2140 *4725*	2240 *4940*	2340 *5155*	2440 *5370*	**2500(F)** [140] ***5510(F)***	2620 *5780*	2710 *5980*	**2800(G)** [144] ***6175(G)***	2890 *6370*	**3000(H)** [146] ***6610(H)***
285/75R24.5 275/80R24.5	DUAL	kg *lbs.*	1870 *4135*	1970 *4340*	2060 *4540*	2150 *4740*	2240 *4930*	**2360(F)** [138] ***5205(F)***	2410 *5310*	2490 *5495*	**2575(G)** [141] ***5675(G)***	2660 *5860*	**2800(H)** [144] ***6175(H)***
	SINGLE	kg *lbs.*	2060 *4545*	2160 *4770*	2240 *4940*	2360 *5210*	2460 *5420*	**2575(F)** [141] ***5675(F)***	2650 *5835*	2740 *6040*	**2800(G)** [144] ***6175(G)***	2920 *6440*	**3075(H)** [147] ***6780(H)***

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Metric Wide Base Tires for Trucks, Busses, and Trailers Used in Normal Highway Service
Tires Used as Singles Mounted on 15° Drop Center Rims
Tire and Rim Association Standard

TABLE MWB-1

TIRE SIZE DESIGNATION	Tire Load Limits at Various Cold Inflation Pressures												
	kPa	480	520	550	590	620	660	690	720	760		790	830
	psi	*70*	*75*	*80*	*85*	*90*	*95*	*100*	*105*	*110*		*115*	*120*
445/65R19.5	kg	3410	3610	3750	3960	4100	4250	4410	4540	**4750(J)**	162		
	lbs.	*7540*	*7930*	*8270*	*8680*	*9040*	*9370*	*9730*	*10100*	***10500(J)***			
385/65R22.5	kg	2880	3060	3150	3350	3470	3650	3740	3850	4000		4100	**4250(J)** 158
	lbs.	*6380*	*6720*	*6940*	*7350*	*7650*	*8050*	*8230*	*8510*	*8820*		*9050*	***9370(J)***
425/65R22.5	kg	3430	3640	3750	3980	4130	4250	4440	4580	**4750(J)**	162	4880	**5000(L)** 164
	lbs.	*7590*	*7990*	*8270*	*8740*	*9100*	*9370*	*9790*	*10100*	***10500(J)***		*10700*	***11000(L)***
445/65R22.5	kg	3720	3950	4125	4320	4470	**4625(H)** 161	4820	4960	5150		5290	**5600(L)** 168
	lbs.	*8230*	*8660*	*9090*	*9480*	*9870*	***10200(H)***	*10600*	*11000*	*11400*		*11700*	***12300(L)***

Radial Ply Tires for Trucks, Busses, and Trailers Used in Normal Highway Service
Radial Ply Tires Mounted on 15° Drop Center Rims
Tire and Rim Association Standard

TABLE TTB-3R

TIRE SIZE DESIGNATION	USAGE	TIRE LOAD LIMITS (kg/lbs.) AT VARIOUS COLD INFLATION PRESSURES (kPa/psi)										
		480 *70*	520 *75*	550 *80*	590 *85*	620 *90*	660 *95*	690 *100*	720 *105*	760 *110*	790 *115*	830 *120*
8R19.5	DUAL	1120 *2460*	1170 *2570*	**1215(D)** 115 ***2680(D)***	1260 *2785*	1310 *2890*	**1360(E)** 119 ***3000(E)***	1410 *3100*	1460 *3200*	**1500(F)** 122 ***3305(F)***		
	SINGLE	1150 *2540*	1220 *2680*	**1285(D)** 117 ***2835(D)***	1340 *2955*	1400 *3075*	**1450(E)** 121 ***3195(E)***	1500 *3305*	1550 *3415*	**1600(F)** 124 ***3525(F)***		
8R22.5	DUAL	1250 *2750*	1300 *2870*	**1360(D)** 119 ***3000(D)***	1410 *3100*	1460 *3200*	**1500(E)** 122 ***3305(E)***	1570 *3455*	1640 *3605*	**1700(F)** 126 ***3750(F)***		
	SINGLE	1290 *2840*	1360 *2990*	**1450(D)** 121 ***3195(D)***	1500 *3305*	1550 *3415*	**1600(E)** 124 ***3525(E)***	1670 *3675*	1740 *3825*	**1800(F)** 128 ***3970(F)***		
9R22.5	DUAL	1480 *3270*	1550 *3410*	1610 *3550*	1670 *3690*	**1750(E)** 127 ***3860(E)***	1820 *4005*	1890 *4150*	**1950(F)** 131 ***4300(F)***	2010 *4425*	2070 *4550*	**2120(G)** 134 ***4675(G)***
	SINGLE	1530 *3370*	1610 *3560*	1690 *3730*	1760 *3890*	**1850(E)** 129 ***4080(E)***	1920 *4235*	1990 *4390*	**2060(F)** 133 ***4540(F)***	2120 *4675*	2180 *4810*	**2240(G)** 136 ***4940(G)***
10R22.5	DUAL	1750 *3860*	1830 *4045*	1910 *4230*	**2000(E)** 132 ***4410(E)***	2080 *4585*	2160 *4760*	**2240(F)** 136 ***4940(F)***	2300 *5075*	2360 *5210*	**2430(G)** 139 ***5355(G)***	
	SINGLE	1850 *4080*	1940 *4280*	2030 *4480*	**2120(E)** 134 ***4675(E)***	2200 *4850*	2280 *5025*	**2360(F)** 138 ***5205(F)***	2430 *5360*	2500 *5515*	**2575(G)** 141 ***5675(G)***	
11R22.5	DUAL	1990 *4380*	2080 *4580*	2160 *4760*	2250 *4950*	**2360(F)** 138 ***5205(F)***	2460 *5415*	2560 *5625*	**2650(G)** 142 ***5840(G)***	2680 *5895*	2710 *5950*	**2725(H)** 143 ***6005(H)***
	SINGLE	2050 *4530*	2160 *4770*	2260 *4990*	2370 *5220*	**2500(F)** 140 ***5510(F)***	2600 *5730*	2700 *5950*	**2800(G)** 144 ***6175(G)***	2870 *6320*	2940 *6465*	**3000(H)** 146 ***6610(H)***
11R24.5	DUAL	2110 *4660*	2210 *4870*	2300 *5070*	2390 *5260*	**2500(F)** 140 ***5510(F)***	2580 *5675*	2660 *5840*	**2725(G)** 143 ***6005(G)***	2820 *6205*	2910 *6405*	**3000(H)** 146 ***6610(H)***
	SINGLE	2190 *4820*	2300 *5070*	2410 *5310*	2520 *5550*	**2650(F)** 142 ***5840(F)***	2770 *6095*	2890 *6350*	**3000(G)** 146 ***6610(G)***	3080 *6790*	3160 *6970*	**3250(H)** 149 ***7160(H)***
12R22.5	DUAL	2170 *4780*	2260 *4990*	2350 *5190*	2440 *5390*	**2575(F)** 141 ***5675(F)***	2630 *5785*	2680 *5895*	**2725(G)** 143 ***6005(G)***	2840 *6265*	2960 *6525*	**3075(H)** 147 ***6780(H)***
	SINGLE	2240 *4940*	2360 *5200*	2470 *5450*	2580 *5690*	**2725(F)** 143 ***6005(F)***	2820 *6205*	2910 *6405*	**3000(G)** 146 ***6610(G)***	3120 *6870*	3240 *7130*	**3350(H)** 150 ***7390(H)***
12R24.5	DUAL	2300 *5080*	2400 *5300*	2500 *5520*	2600 *5730*	**2650(F)** 142 ***5840(F)***	2770 *6095*	2890 *6350*	**3000(G)** 146 ***6610(G)***	3080 *6790*	3160 *6970*	**3250(H)** 149 ***7160(H)***
	SINGLE	2380 *5240*	2500 *5520*	2630 *5790*	2740 *6040*	**2900(F)** 145 ***6395(F)***	3020 *6650*	3140 *6910*	**3250(G)** 149 ***7160(G)***	3350 *7380*	3450 *7600*	**3550(H)** 152 ***7830(H)***

SPECIFICATIONS

Hydraulic Pump

Pump Speed ..... 2500 RPM

Displacements:

- Section P1 ..... 18 GPM (68.1 LPM) at 3900 psi +100/-000 (26.89 MPa)
- Section P2 ..... 34 GPM (128.7 LPM) at 3300 psi +100/-000 (22.75 MPa)
- Section P3 ..... 10 GPM (37.8 LPM) at 2350 psi +100/-000 (16.20 MPa)

Hydraulic System

Requirements:

- Boom and Outrigger System ..... 18 GPM (68 LPM),+100/-000 (22.75 MPa)
- Boom Extend Six Section ..... 18 GPM (68 LPM), 2400 psi +50/50 (16.5 MPa)
- Boom Retract Six Section ..... 18 GPM (68 LPM), 3900 psi +100/-000 (26.80 MPa)
- Boom Extend ..... 18 GPM (68 LPM), 2800 psi +50/50 (19.31 MPa)
- Boom Retract ..... 18 GPM (68 LPM), 2900 psi +100/-000 (20.00 MPa)
- Hoist System ..... 30 GPM (128 LPM), 3300 psi +100/-000 (22.75 MPa)
- Turn ..... 10 GPM (38 LPM), 2350 psi +100/-000 (16.20 MPa)

Reservoir

- Capacity ..... 100 gal (378.5 L) at full mark
- System capacity ..... 125 gal (473 L)
- Filtration ..... 5 Micron Return

Flow rates listed are at free flow condition (approx. 100 psi/ 1 MPa)

Hoist Speed and Pull

Layer	Hoist Pull		Hoist Speed		BOS Hoist Speed		Rope Capacity	
	lbs	(kg)	fpm	(mpm)	fpm	(mpm)	ft	(m)
1	10,380	(4708)	111	(33.8)	157	(47.8)	64	19
2	9,360	(4246)	123	(37.5)	173	(52.7)	136	41
3	8,520	(3865)	192	(59)	271	(83)	215	65
4	7,820	(3547)	209	(64)	294	(90)	301	91
5	7,230	3279	257	(78)	318	(97)	394	120

NOTE: All ratings based on 34 GPM at 3300 psi (128.7 LPM at 22.75 MPa)
Burst of Speed maximum pull = 3000 lb (1361 kg)

Crane Operating Speeds

Rotation 375° ..... 35 ± 5 sec (1.8 ± 0.2 rpm) Swing speed based on and adjustment knob in closed position.

Boom up -10° to 80° ..... 25 ±5 sec

Boom Down 80° to -10° ..... 20 ±5 sec

Boom Extend/Retract Three Section 16 - 38 ft

- Extend ..... 25 ±5 sec
- Retract ..... 25 ±5 sec

Boom Extend/Retract Three Section 24 - 60 ft

- Extend ..... 45 ±5 sec
- Retract ..... 40 ±5 sec

Boom Extend/Retract Three Section 27 - 71 ft

- Extend ..... 55 ±5 sec

Retract .....50 ±5 sec
Boom Extend/Retract Four Section 16 - 49 ft
Extend .....45 ±5 sec
Retract .....75 ±5 sec
Boom Extend/Retract Four Section 27 - 90 ft
Extend .....85 ±10 sec
Retract .....140 ±10 sec
Boom Extend/Retract Four Section 24 - 80 ft
Extend .....75 ±10 sec
Retract .....125 ±10 sec
Boom Extend/Retract Five Section 21 - 80 ft
Extend .....85 ±10 sec
Retract .....85 ±10 sec
Boom Extend/Retract Six Section 19 - 84 ft
Extend .....95 ±10 sec
Retract .....45 ±5 sec

Alphabetical Index

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