# National Crane 800D

## Operator and Service Manual

## WARNING

### California Proposition 65

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

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

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

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

### California Spark Arrestor

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



The original language of this publication is English.

NATIONAL CRANE
by Manitowoc

# OPERATOR AND SERVICE MANUAL

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

## 800D

This Manual is Divided into the following Sections:

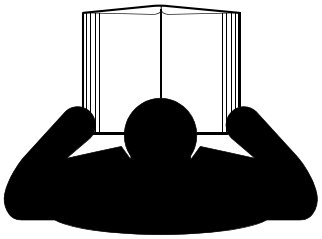




**NOTICE**

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 crane frame. ***Always furnish crane serial number*** when ordering parts or communicating service problems with your distributor or the factory.



# ⚠DANGER

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

- You are trained in the safe operation of this crane. 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
# SAFETY INFORMATION

## 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 crane and property.

To alert personnel to hazardous operating practices and maintenance procedures, safety messages are used throughout the manual. Each safety message contains a safety alert symbol and a signal word to identify the hazard's degree of seriousness.

## Safety Alert Symbol

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

## Signal Words

**DANGER**

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

**WARNING**

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

**CAUTION**

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

**CAUTION**

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

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

## GENERAL

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

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

This information has been provided to assist in promoting a safe working atmosphere for yourself and those around you. It is not meant to cover every conceivable circumstance which could arise. It is intended to present basic safety precautions that should be followed in daily operation.

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

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

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

## 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 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 National Crane distributor and/or Manitowoc Crane Care.

If this crane 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 crane. You must also **view** and **understand** the supplied safety video. This manual and *Load Chart* must be readily available to the operator at all times and must remain in the cab (if equipped) or operator's station while the crane is in use.

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

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

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


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

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

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

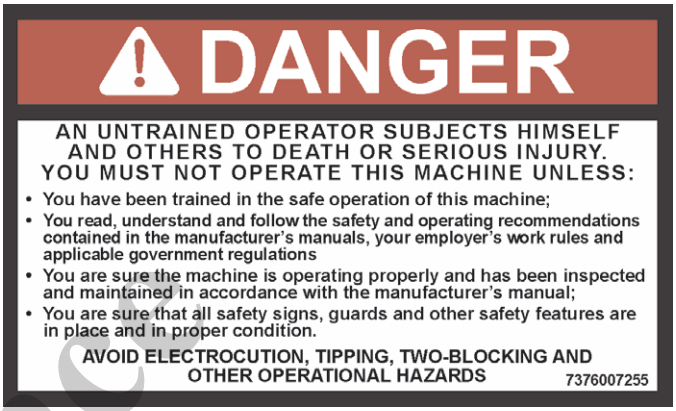
## OPERATOR QUALIFICATIONS

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

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

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

You must be familiar with the regulations and standards governing cranes and 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.




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

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

- You have been trained in the safe operation of this machine.
- 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 machine 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 crane unless you are trained and thoroughly familiar with all operational functions. Controls and design may vary from crane to crane; therefore, it is important that you have specific training on the particular crane you will be operating.

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

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

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

## OPERATIONAL AIDS

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

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 cranes. Federal law requires that cranes be properly maintained and kept in good working condition. The manuals that National Crane provides that are specific for each crane and the manufacturer's manuals for the operational aids shall be followed. If an operational aid should fail to work properly, the crane user or owner must assure that repair or recalibration is accomplished as soon as is reasonably possible. If immediate repair or recalibration of an operational aid is not possible and there are exceptional circumstances which justify continued short-term use of the crane when operational aids are inoperative or malfunctioning, the following requirements shall apply for continued use or shutdown of the crane:

- Steps shall be taken to schedule repairs and recalibration immediately. The operational aids shall be put back into service as soon as replacement parts, if required, are available and the repairs and recalibration can be carried out. Every reasonable effort must be made to expedite repairs and recalibration.
- When a *Load Indicator*, *Rated Capacity Indicator*, or *Rated Capacity Limiter* is inoperative or malfunctioning, the designated person responsible for supervising the lifting operations shall establish procedures for determining load weights and shall ascertain that the weight of the load does not exceed the crane ratings at the radius where the load is to be handled.
- When a *Boom Angle* or *Radius Indicator* is inoperative or malfunctioning, the radius or boom angle shall be determined by measurement.
- When an *Anti-Two-Blocking Device*, *Two-Blocking Damage Prevention Device* or *Two-Block Warning Device* is inoperative or malfunctioning, the designated person responsible for supervising the lifting operations shall establish procedures, such as assigning an additional signal person to furnish equivalent protection. This does not apply when lifting personnel in load-line supported personnel platforms. Personnel shall not be lifted when anti-two-block devices are not functioning properly.
- When a *Boom Length Indicator* is inoperative or malfunctioning, the designated person responsible for supervising the lifting operations shall establish the boom lengths at which the lift will be made by actual measurements or marking on the boom.
- When a *Level Indicator* is inoperative or malfunctioning, other means shall be used to level the crane.

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

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

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

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

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

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

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

### Anti-Two-Blocking Device

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

Two-blocking occurs when the load block (hook block, headache ball, rigging, etc.) comes into physical contact with the boom (boom nose, sheaves, boom extension, 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.

Two-blocking is more likely to occur when both the main and auxiliary hoist lines are reeved over the main boom nose and

boom extension 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 boom extension 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.

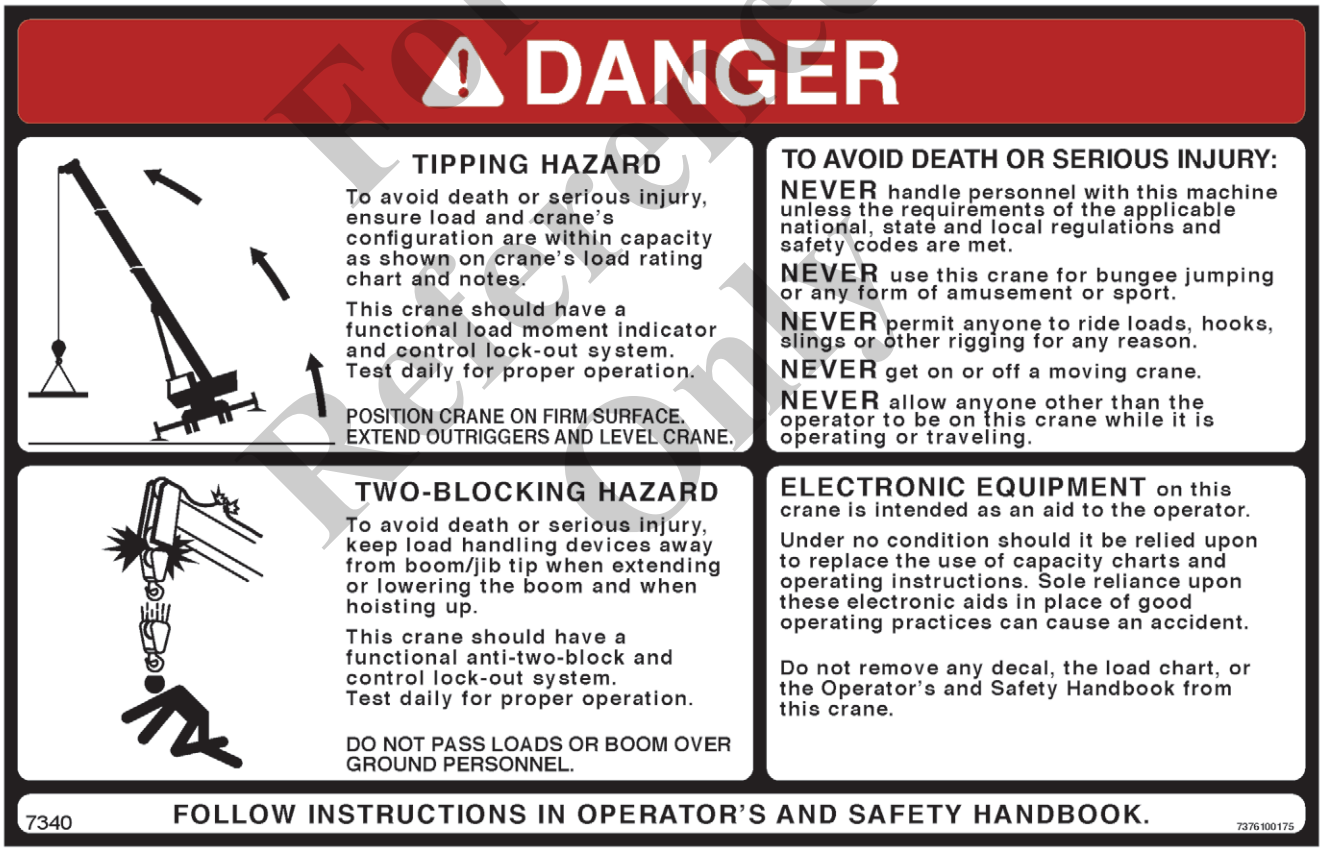
Two-blocking can be prevented. Operator awareness of the hazards of two-blocking is the most important factor in preventing this condition. An Anti-Two-Block System is intended to assist the operator in preventing dangerous two-block conditions. It is not a replacement for operator awareness and competence.

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

## Working Area Limiter (If Equipped)

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

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



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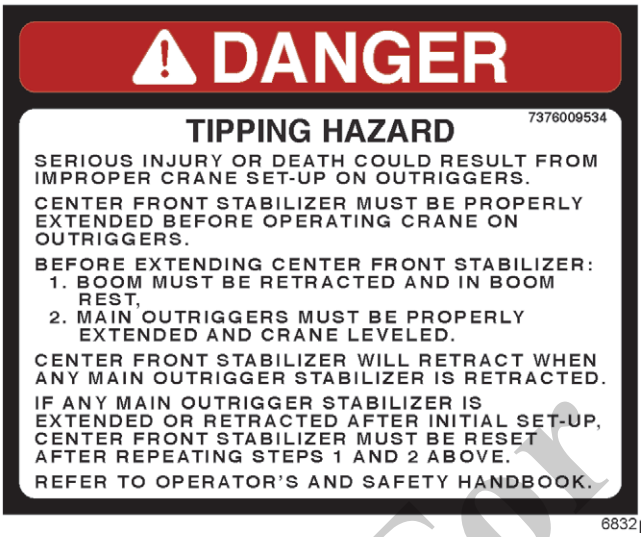
## CRANE STABILITY/STRUCTURAL STRENGTH

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

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

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

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




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

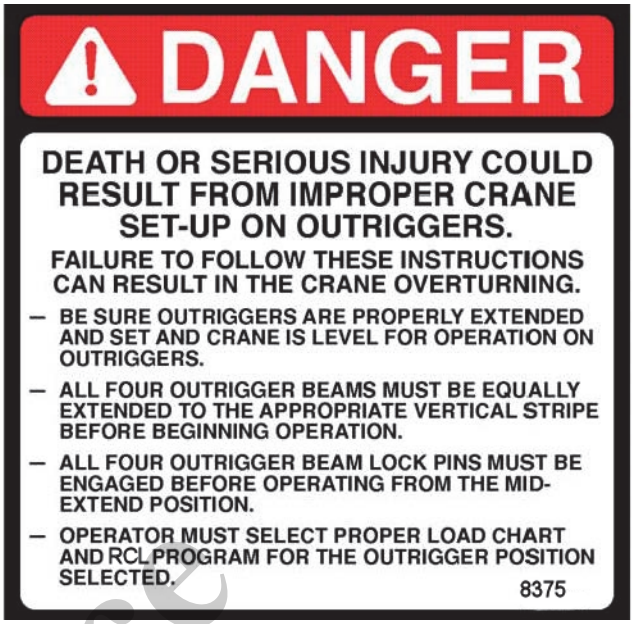
The operator must select the proper *Load Chart* and Rated Capacity Limiter (RCL) System program for the outrigger position selected.

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

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

Check crane stability before lifting loads. Ensure the outriggers are firmly positioned on solid surfaces. Ensure the crane is level, brakes are set, and the load is properly rigged and attached to the hook. Check the *Load Chart* against the weight of the load. Lift the load slightly off the ground and recheck the stability before proceeding with the lift. Determine the weight of the load before you attempt the lift.

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




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

## Load Charts

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

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

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

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

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

## Work Site

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

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

## WIND FORCES

There are basic principles that must be followed while operating in windy conditions. This information has been

provided to assist in determining safe operation in windy conditions.

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

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

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

Wind forces can exert extreme dynamic loads. 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 1-1.

**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 1-1 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 crane operation site. For lift planning purposes only, the 3-second wind gust speed, ***V(z)***, may be calculated based on mean wind speed reported at http://www.windfinder.com “Super Forecast”.

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

a) If ***V(z)*** is ≤ 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 1-4 (metric) or  (non-metric).

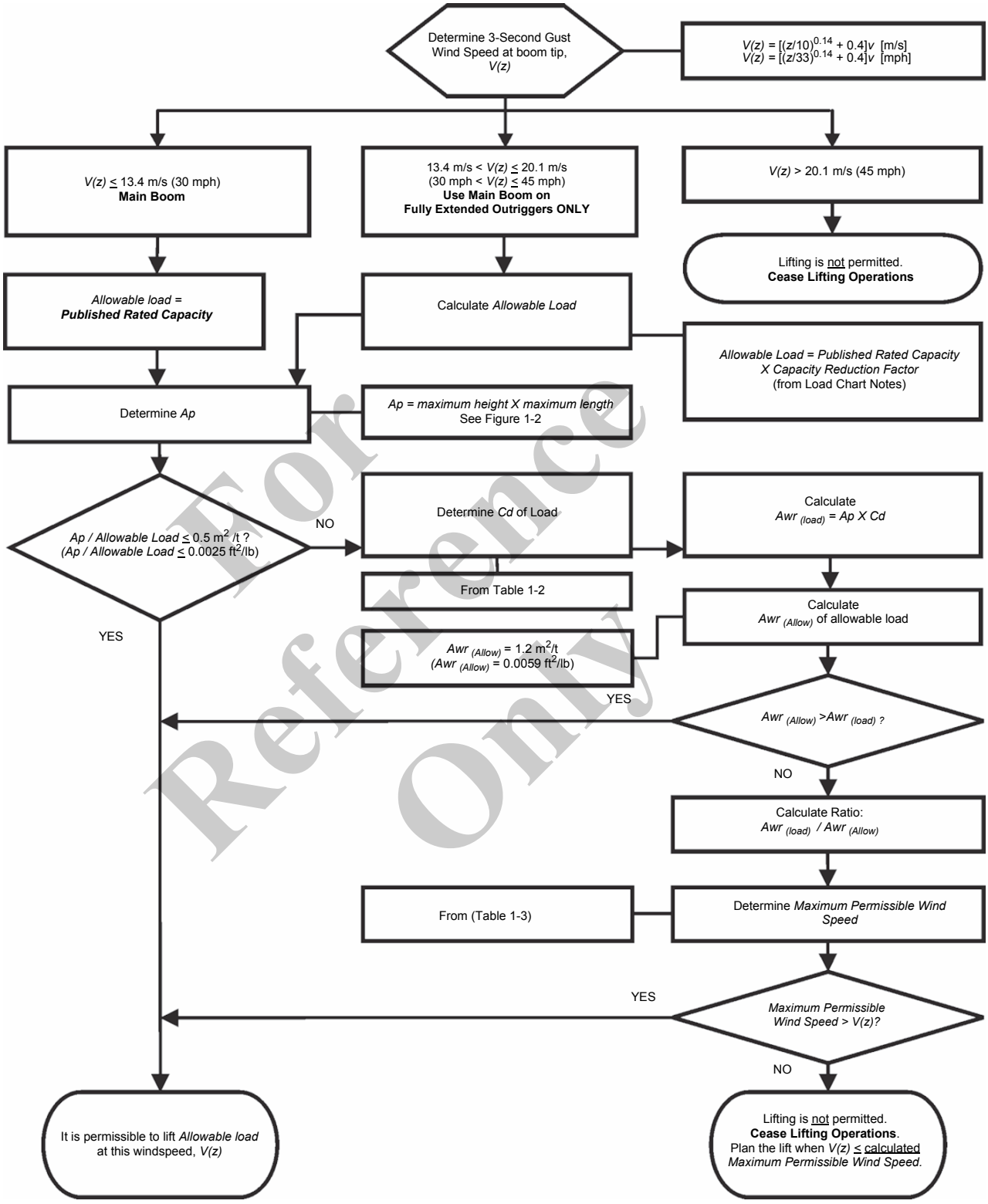
**NOTE:** This condition is limited to operation with the main boom on fully extended outriggers only.

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 1-1 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 1-1**

***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 crane operation site:

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

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

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

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

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

where:

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

**Example**: Suppose you want to lift the load with the maximum boom tip height of 30 m (100 ft) and the recorded mean wind speed by the device located at the crane operation site is 5.5 m/s (13 mph). This mean wind speed of 5.5 m/s (13 mph) corresponds to Beaufort number 4 (see Table 1-1). 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 1-3).

For ***Cd***, refer to Table 1-2. 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)**:

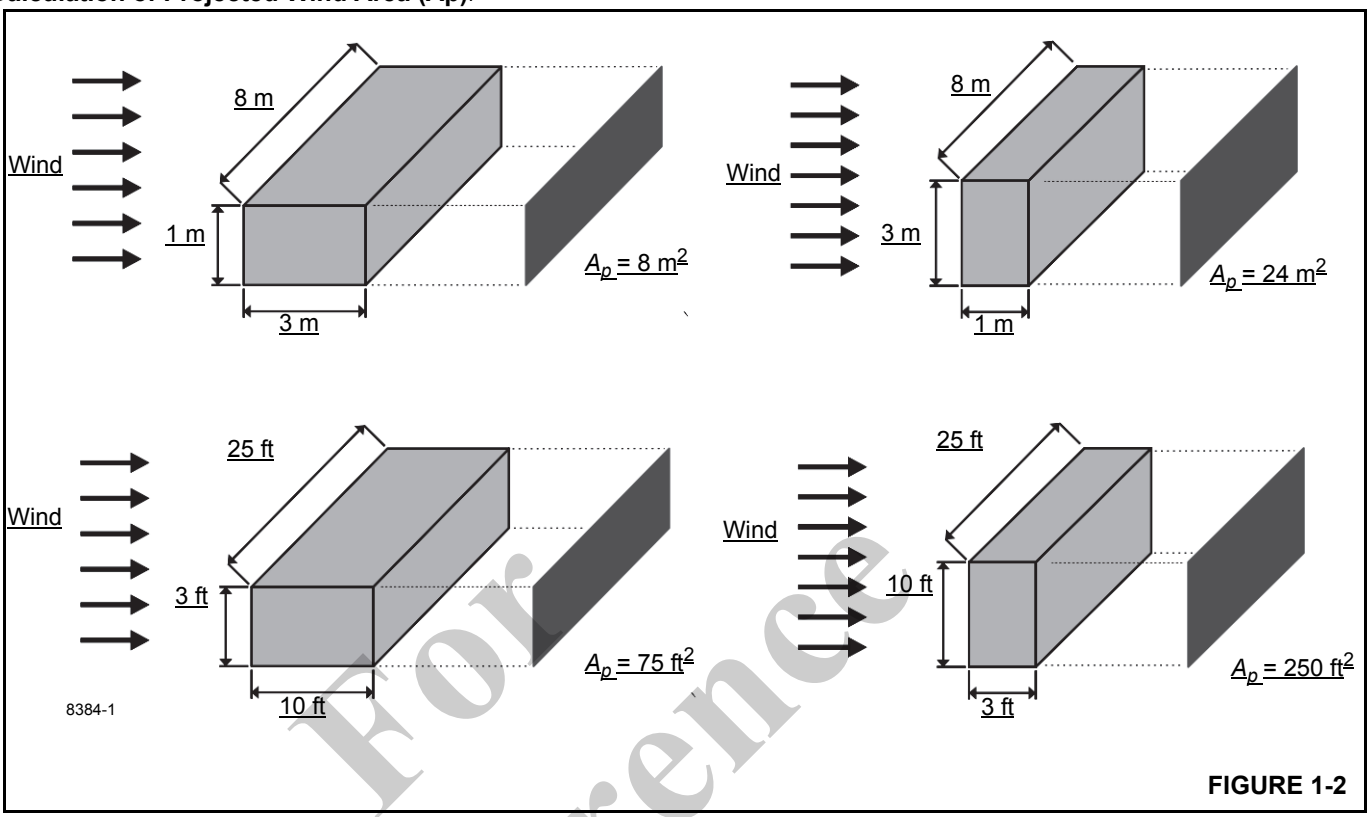



**FIGURE 1-2**

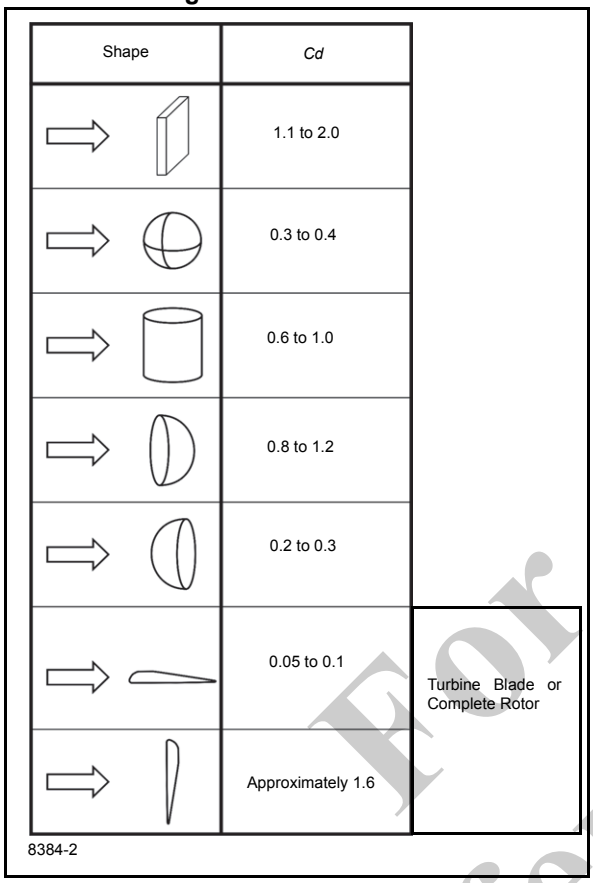
***Determining Wind Drag Coefficient (Cd)***

Table 1-2 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 1-2).

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

**Table 1-2 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 1-3.

**Table 1-3 *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 (78) | | | |
| 6 | 32,950 (50.5) | 32,925 (55.5) | 32,825 (63.5) | 28,350 (68.5) | 18,225 (72) | 18,225 (75) | *18,225 (78) | | |
| 7 | 28,325 (42.5) | 28,300 (49) | 28,225 (59) | 26,250 (65) | 18,225 (69) | 18,225 (72) | 18,225 (74.5) | *16,725 (78) | *11,400 (78) |
| 8 | 24,150 (32.5) | 24,150 (42) | 23,975 (54.5) | 23,275 (61) | 18,225 (66) | 18,225 (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 (58) | 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, (54) | 17,325 (60) | 15,1 (64. | 13,725 (67.5) | 12,700 (70.5) | 11,400 (72.5) |
| 12 | | | 1 (30 | 1 225 (45.5) | 12,575 (53.5) | (59) | 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, (47) | 7,920 (53) | 7,980 (57.5) | 7,470 (61.5) |
| 18 | | | | | (2 | 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 1-3**

**Table 1-4 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 crane Operator Manual.

**Table 1-5 *Awr* Ratio and Permissible Wind Speed *V(z)* - *Metric***

| Note: Permissible and rated wind speeds in this table are the 3-second gust wind speeds at boom tip height. | | | | | |
|---|---|---|---|---|---|
| Ratio: | 1.2 | 1.4 | 1.6 | 1.8 | 2 |
| | Maximum Permissible Wind Speed (m/s) | | | | |
| For Rated Capacity at 13.4 m/s | 12.2 | 11.4 | 10.6 | 10.0 | 9.5 |
| For Allowable Capacity at 20.1 m/s | 18.3 | 17.0 | 15.9 | 15.0 | 14.2 |

**Example and Sample Calculations (metric)**

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

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

**Example 1: Crane Configuration:**

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

From the ***Rated Load Chart Example - Metric*** (Figure 1-3), 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 1-4, 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 crane configuration, examine several load conditions.

**Load example 1.1:**

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

- load to be lifted of 11,200 kg,
- Projected Wind Area ***Ap*** = 9.20 $m^2$,
- 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:

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

From Table 1-5, 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 1-5, 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.

***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] | 26,400 (69) | 24,700 (71.5) |
| 40 | | | 25,800 (28) | 26,150 (44.5) | [illegible] | [illegible] | 25,200 (62.5) | 23,300 (66) | 21,800 (68.5) |
| 45 | | | | [illegible] | [illegible] | 22,300 (54) | 22,400 (59) | 20,700 (62.5) | 19,400 (65.5) |
| 50 | | | | [illegible] | [illegible] | 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 1-4**

**Table 1-6 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 ft$^2$, ***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 crane Operator Manual.

**Table 1-7 *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 |

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

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

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

**Example 2:**

A crane is configured with:

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

The ***Rated Load Chart Example - Non-metric*** (Figure 1-4), 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 x ***m*** $_{(load)}$ (2.5)

***Awr*** $_{(allow)}$ = 0.0059 x 25,200 = 149 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 x 25,200 = 20,160 lb

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

***Awr*** $_{(allow)}$ = 0.0059 x 20,160 = 119 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 crane configuration for the following load conditions:

**Load example 2.1:**

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

- load to be lifted of 19,500 lb,
- Projected Wind Area ***Ap*** = 70 ft$^2$,
- Wind Drag Coefficient ***Cd*** = 1.5

then the wind resistance area of load can be estimated as

$Awr_{(load)}$ = ***Ap*** x ***Cd*** = 70 x 1.5 = 105 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*** x ***Cd*** = 45 x 2.4 = 108 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 1-7, the maximum permissible wind speed at ratio of 1.45 (rounded to next higher table value of 1.6) is 23.7 mph.

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

**Load example 2.3b:**

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

- 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 Table 1-7, the maximum permissible wind speed at ratio of 1.37 (rounded to next higher table value of 1.4) is 38.0 mph.

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

## Lifting Operations

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

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

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

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

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

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

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

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

The crane can tip over or fail structurally if:

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

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

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

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

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

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

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

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

Never push or pull with the crane boom.

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

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

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

## Counterweight

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

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

## Outrigger Lift Off

Regarding "lifting" of an outrigger pad during craning activities, be advised that the rated loads for these cranes, as indicated on the crane's *Load Chart*, do not exceed 85% of the tipping load on outriggers as determined by SAE J765 JUNE2017 "Cranes Stability Test Code." An outrigger pad may lift off the ground during operation of the crane within the capacity limits of the *Load Chart*, yet the crane will not have reached instability. The "balance point" for stability testing according to SAE and National Crane criteria is a condition of loading wherein the load moment acting to overturn the crane is equal to the maximum moment of the crane available to resist overturning. This balance point or point of instability for a crane does not depend on "lifting" of an outrigger but rather on comparison of the "opposing" load moments.

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

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

## Multiple Crane Lifts

Multiple crane lifts are not recommended.

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

- Secure the services of a 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 cranes so equipped.
- Calculate the amount of weight to be lifted by each crane and attach slings at the correct points for proper weight distribution.
- Ensure the load lines are directly over the attach points to avoid side loading and transfer of loading from one crane to the other.
- Do not travel. Lift only from a stationary position.

## Tilt-Up Panel Lifting

Requirements and recommendations regarding operation and use of 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 crane to perform tilt-up panel lifting with two hoist lines poses new and different hazards than does normal lifting use.

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

- The crane must be set up and operated in accordance with instructions in the Operator and Safety Handbook, Load Capacity Chart, and decals affixed to the crane.
- The hoist rope from the main hoist shall be reeved over the main boom nose reeved for two parts of line.
- The hoist rope from the auxiliary hoist shall be reeved over the auxiliary boom nose reeved for one part of line.
- The load shall be connected with the main hoist line connected to the end closest to crane and the auxiliary hoist line connected to the end farthest from the crane.
- The anti-two block system shall be installed and inspected to confirm that it is active to monitor both hoist lines.
- The RCL hoist selection shall be set to main hoist and two parts 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 crane.
- The load shall be controlled to prevent rotation of the load and to ensure the load stays in line with the boom.
- The load must be balanced with the auxiliary: load line not taking more than half the load at any time during the lift. The RCL will not be providing coverage for the line pull of the auxiliary hoist line.
- The effect of wind loads on the crane and panel shall be taken into consideration. Operations shall be halted if the wind can cause a loss of control in handling the load.
- The main hoist line shall be used to raise the panel into the vertical position.

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

## PILE DRIVING AND EXTRACTING

Pile driving and extracting are applications approved by 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 crane:

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

It is not the intention of 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 crane.

In addition to the operating requirements that are detailed in the operating manuals and on the load capacity chart, pile driving and extracting operations are approved by 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 crane structure.
- Pile driving or extracting shall be restricted to over the main boom only and shall not be permitted over a boom extension.
- Pile extraction using only the crane's hoist line is unsafe and not permitted since load values cannot be accurately determined. Only pile extraction devices that do not transmit vibration or shock loading into the crane are permitted. All possible precautionary measures shall be taken to prevent shock loads or vibration from being imposed on crane components, either directly through the hoist cable or indirectly from ground borne vibration.
- The load lines shall be kept vertical at all times during pile driving and pile extraction operations.
- The operator and other personnel associated with the pile driving and pile extraction operation shall have read and understood all safety standards applicable to crane operations as well as being thoroughly trained in the safe operation of pile driving and extracting equipment.

### Crane Equipment

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

### Crane Inspection

- In addition to the crane's frequent and periodic inspections, dated daily records shall be maintained showing inspections were performed on the crane during the time it was used for pile driving or extraction.
- All anti-two block warning devices and RCL systems shall be inspected daily and verified to be functional.
- All areas of the crane subject to fatigue shall be inspected monthly, and before the crane is to return to lifting service.
- The boom shall be inspected daily to ensure all wear pads remain in place. Cranes which utilize pinned boom sections shall be inspected daily to ensure the pinning mechanism operates properly and to check for undue wear at the pins and pinning plates.
- The hoist cable shall be inspected daily to ensure no chafing or wear is occurring.

## ELECTROCUTION HAZARD

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

**United States federal law prohibits the use of cranes closer than 6 m (20 ft) to power sources up to 350 kV and greater distances for higher voltages unless the line's voltage is known [29CFR1910.180 and 29CFR1926.1400].**

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

**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.

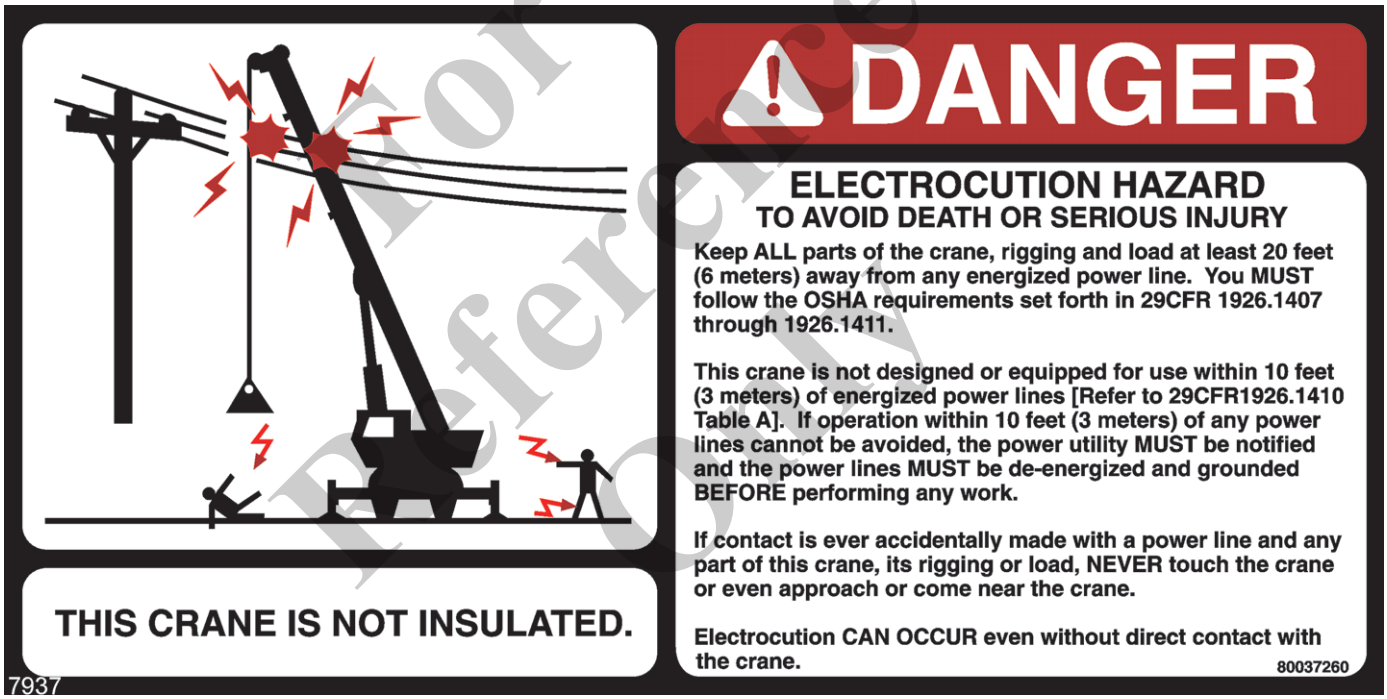
**WARNING**

**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 crane.






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

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

This crane is **not insulated**. Always consider all parts of the load and the crane, including the 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 crane while operating. Permit no one to lean against or touch the crane. Permit no one, including riggers and load handlers, to hold the load, load lines, tag lines, or rigging gear.

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

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

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

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

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

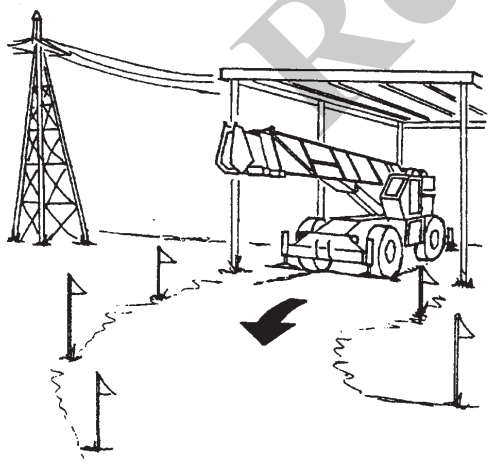
## Set-Up and Operation

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

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

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

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



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

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

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

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

## Electrocution Hazard Devices

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

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

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

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

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

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

Some variables you must know and understand are:

- Proximity devices are advertised to detect the existence of electricity and not its quantity or magnitude.

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

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

## Electrical Contact

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

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

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

Following any contact with an energized electrical source, the 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 crane. Should the distributor not be immediately available, contact Manitowoc Crane Care. The crane must not be returned to service until it is thoroughly inspected for any evidence of damage and all damaged parts are repaired or replaced as authorized by your National Crane distributor or Manitowoc Crane Care.

## Special Operating Conditions and Equipment

Never operate the crane during an electrical thunderstorm.

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

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

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

## Grounding the Crane

The crane 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 crane 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 1-5) (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.

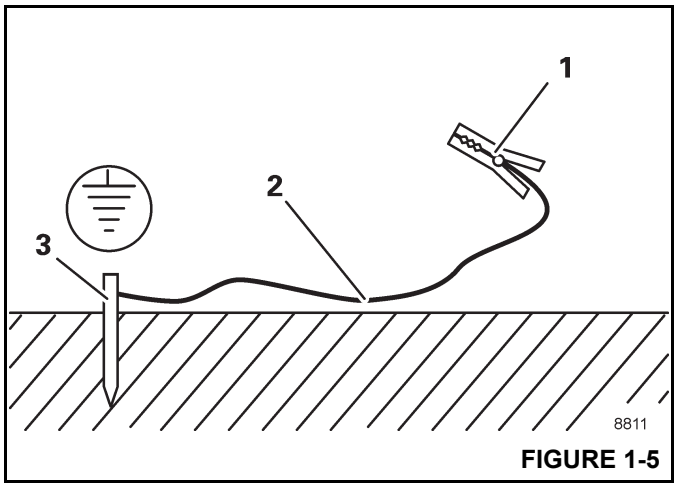



FIGURE 1-5

**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

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 a crane 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 crane 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 to handle personnel is acceptable provided:

- The requirements of the applicable national, state and local regulations and safety codes are met.
- A determination has been made that use of a crane to handle personnel is the least hazardous means to perform the work.
- The crane operator shall be qualified to operate the specific type of hoisting equipment used in the personnel lift.
- The crane operator must remain at the crane controls at all times when personnel are off the ground.
- The crane operator and occupants have been instructed in the recognized hazards of personnel platform lifts.
- The crane is in proper working order.
- The crane must be equipped with a boom angle indicator that is visible to the crane operator.
- The crane's *Load Chart* is affixed at the operator's station and readily accessible to the operator. The total weight of the loaded personnel platform and related rigging shall not exceed 50 percent of the rated capacity for the radius and configuration of the crane.
- The crane is level within one percent of level grade and located on a firm footing. Cranes with outriggers shall have them all deployed following manufacturer's specifications.
- The crane's *Operator'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 cranes 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 crane components, observe the following:

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

## MAINTENANCE

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

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

Shut down the crane while making repairs or adjustments.

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

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

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

Routine maintenance and inspection of this crane must be performed by a qualified person(s) according to the recommendations in the *Manitowoc Crane Care Maintenance and Inspection Manual*. Any questions regarding procedures and specifications should be directed to your 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 crane must only be performed by a qualified person. All service and repairs must be performed in accordance with manufacturer's recommendations, this manual, and the service manual for this machine. If there is any question regarding maintenance procedures or

specifications, contact your National Crane distributor for assistance.

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

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

Any modification, alteration, or change to a crane which affects its original design and is not authorized and approved by 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 crane.
- Pinch points, which result from relative motion between mechanical parts, are areas of the machine that can cause personal injury or death. Do not place limbs or your body in contact with pinch points either on or around the machine. Care must be taken to prevent motion between pinch points when performing maintenance and to avoid such areas when movement is possible.
- Do not allow persons to stand near extending or lowering outriggers. Foot crushing could occur

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

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

After maintenance or repairs:

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

## Lubrication

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

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

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

## Tires

**WARNING**

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

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

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

Ensure all lug nuts are properly torqued.

Ensure pneumatic tires are inflated to the proper pressure. 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 crane 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 crane'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.

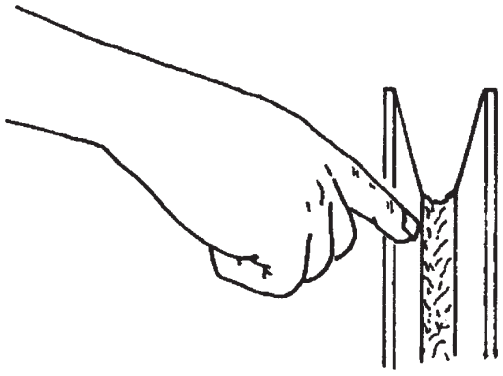
When installing a new rope:

- 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 crane, check battery test indicator on maintenance-free batteries.
- Check battery condition only with proper test equipment. Batteries shall not be charged except in an open, well-ventilated area that is free of flame, smoking, sparks, and fire.

## Engine

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

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

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

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

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

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

# TRANSPORTING THE CRANE

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

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

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

Ensure the crane is adequately secured to the transporting vehicle.

Do not use the dead end lug on the boom nose for tying down the boom during transport. Damage to the lug and boom can result from usage as a tie down point.

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

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

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

exercised anytime any crane function is being performed while the cable is hooked into the hookblock tie down.

## TRAVEL OPERATION

Only the crane operator shall occupy the crane when traveling.

When traveling, the boom should be completely retracted and lowered to the travel position. 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.

**WARNING**

**Crushing Hazard!**

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

Keep Clear of revolving tires.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Stay alert at the wheel.

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

Slopes:

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

# WORK PRACTICES

## Personal Considerations

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

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

## Crane Access

**WARNING**

**Fall Hazard!**

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

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

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

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

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

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

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

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

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

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

Wear shoes with a highly slip-resistant sole material. Clean any mud or debris from shoes before entering the crane cab/operator's station or climbing onto the crane superstructure. Excessive dirt and debris on the hand-holds, access steps, or walking/working surfaces could cause a slipping accident. A shoe that is not clean might slip off a control pedal during operation.

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

## Job Preparation

Before crane use:

- Barricade the entire area where the crane is working and keep all unnecessary personnel out of the work area.
- Ensure that the crane is properly equipped including access steps, covers, doors, guards, and controls.
- Conduct a visual inspection for cracked welds, damaged components, loose pins/bolts, and wire connections. Any item or component that is found to be loose or damaged (broken, chipped, cracked, worn-through, etc.) must be repaired or replaced. Inspect for evidence of improper maintenance (consult your *Service Manual*).
- Check for proper functioning of all controls and operator aids (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 mid-extend position, the outriggers must also be pinned when operating from the mid-extend position.

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

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

## Working

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

Know the location and function of all machine controls.

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

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

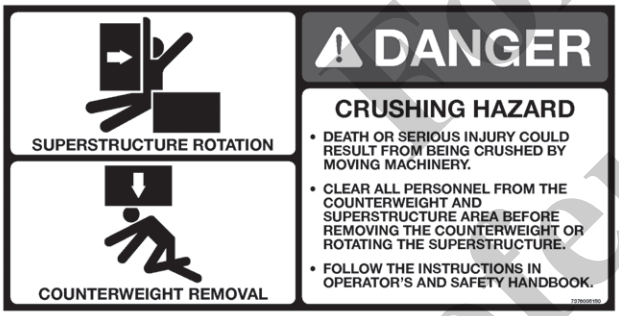
Carbon monoxide fumes from the engine exhaust can cause suffocation in an enclosed area. Good ventilation is very important when operating the crane.

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

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

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

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




Keep unauthorized personnel clear of the working area during operation.

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

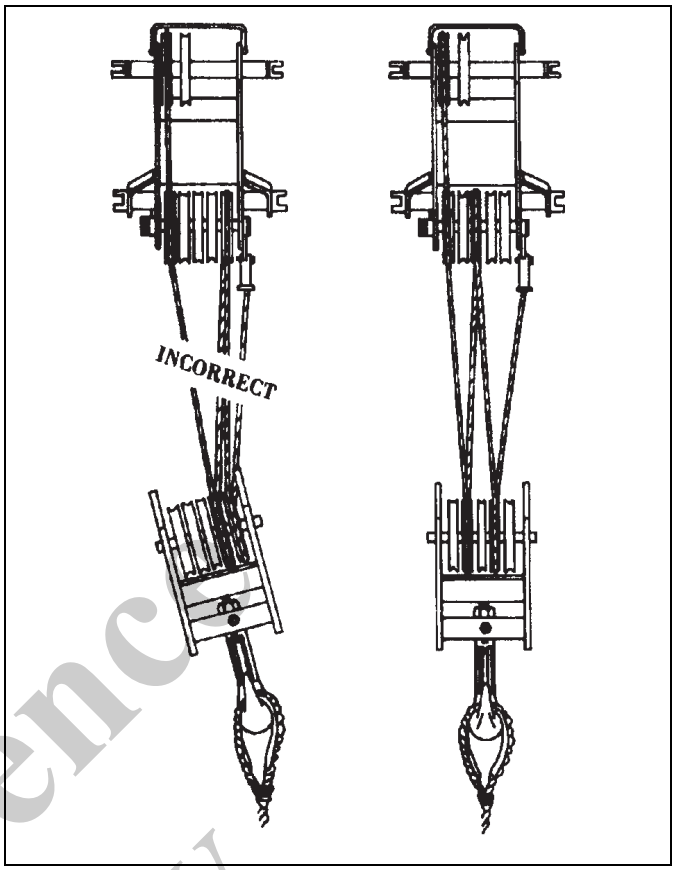
You must always be aware of everything around the crane while lifting or traveling. If you are unable to clearly see in the direction of motion, you must post a look out or signal person before moving the crane or making a lift. Sound the horn to warn personnel

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

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

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

Ensure the 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 crane's capacity.

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

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

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

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

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

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

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

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

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

Stop the hook block from swinging when unhooking a load.

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

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

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

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

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

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

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

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

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

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

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

## Hand Signals

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

- Working in the vicinity of power lines.
- The crane operator cannot clearly see the load at all times.
- Moving the crane in an area or direction in which the operator cannot clearly see the path of travel.

At all times use standardized hand signals (Figure 1-6) - previously agreed upon and completely understood by the operator and signal person.

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

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

Obey a signal to stop from anyone.

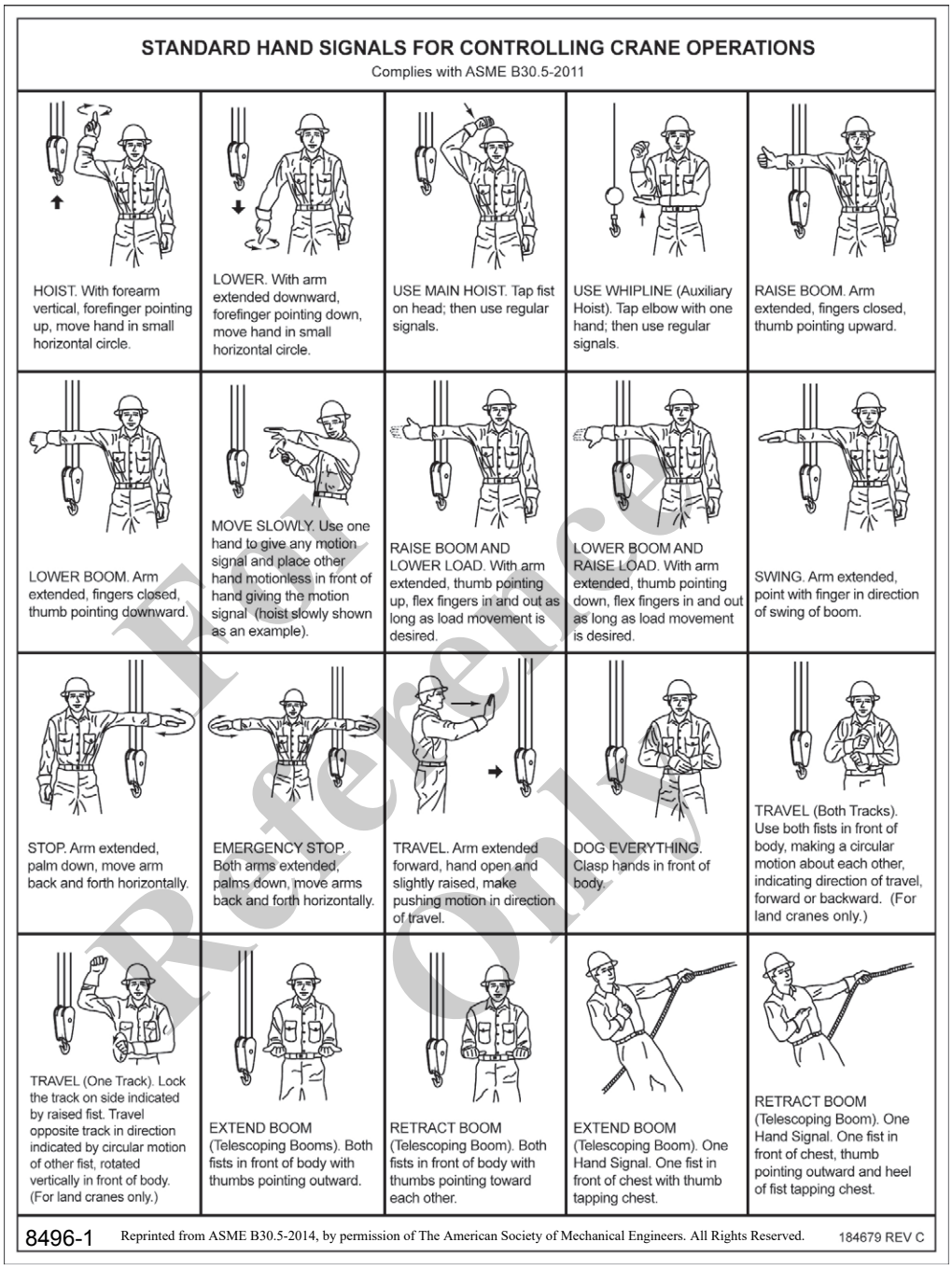





**FIGURE 1-6**

## BOOM EXTENSION

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

Install and secure all pins properly.

Control movement of boom extension at all times.

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

**DANGER**

**Boom Extension Hazard!**

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

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

Properly inspect, maintain, and adjust boom extension and mounting.

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

Stay outside of boom extension sections and lattice work.

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

## PARKING AND SECURING

**WARNING**

**Tipping Hazard!**

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

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

## SHUT-DOWN

Use the following steps when shutting down the crane:

- Engage the parking brake.
- Fully retract and lower the boom.
- Engage the swing lock pin 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 crane of all ice and snow.

Allow ample time for hydraulic oil to warm up.

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

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

Never store flammable materials on the crane.

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

## TEMPERATURE EFFECTS ON HOOK BLOCKS

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 1-8]. 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 a crane is set up in the morning with cool oil and the daytime ambient temperature heats the oil, the cylinders will extend in similar proportions.

Table 1-8 and Table 1-9 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.

**Table 1-8: 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 1-9 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 National 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*

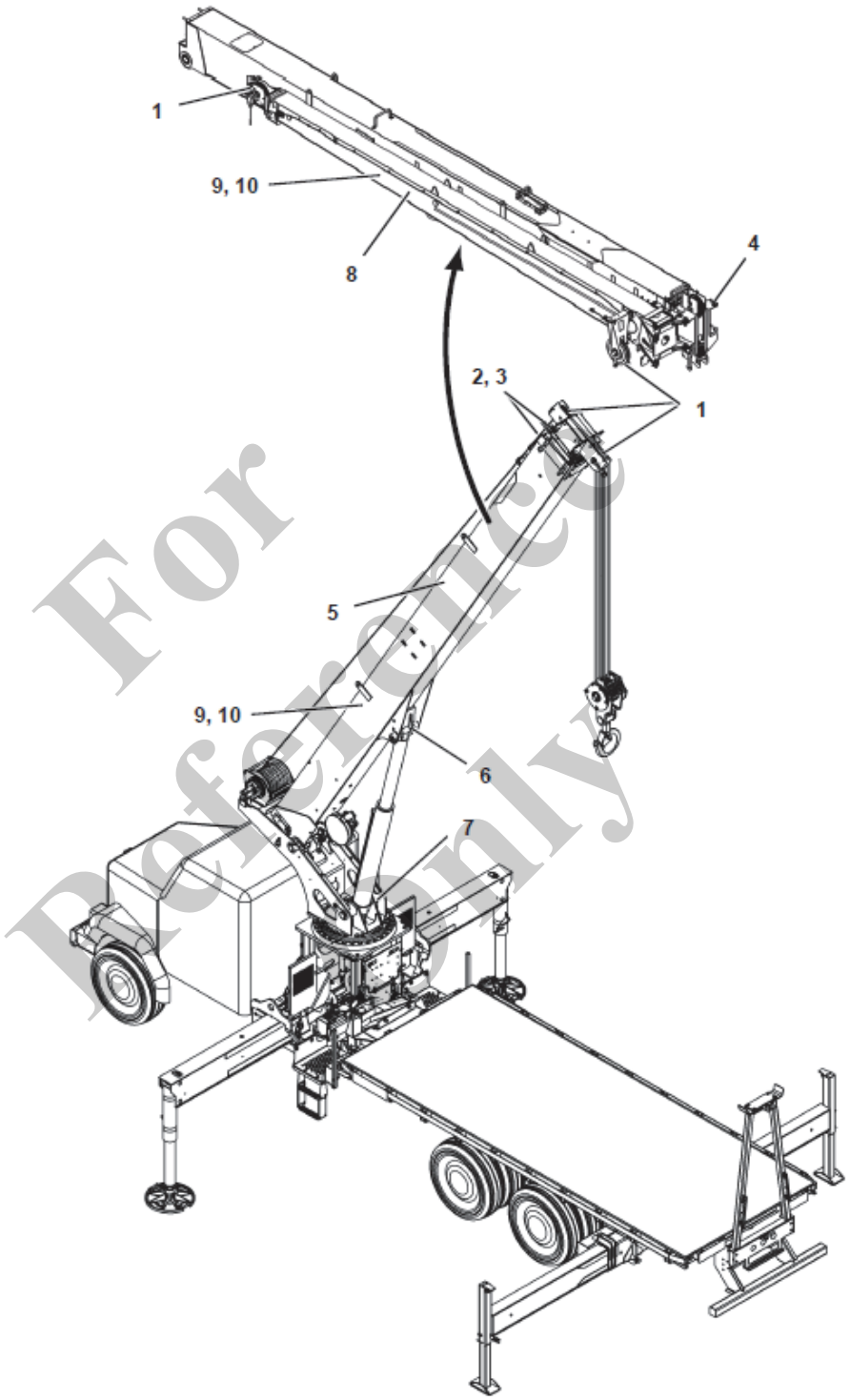



Illustration for reference only.
Your crane may be different.

**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*

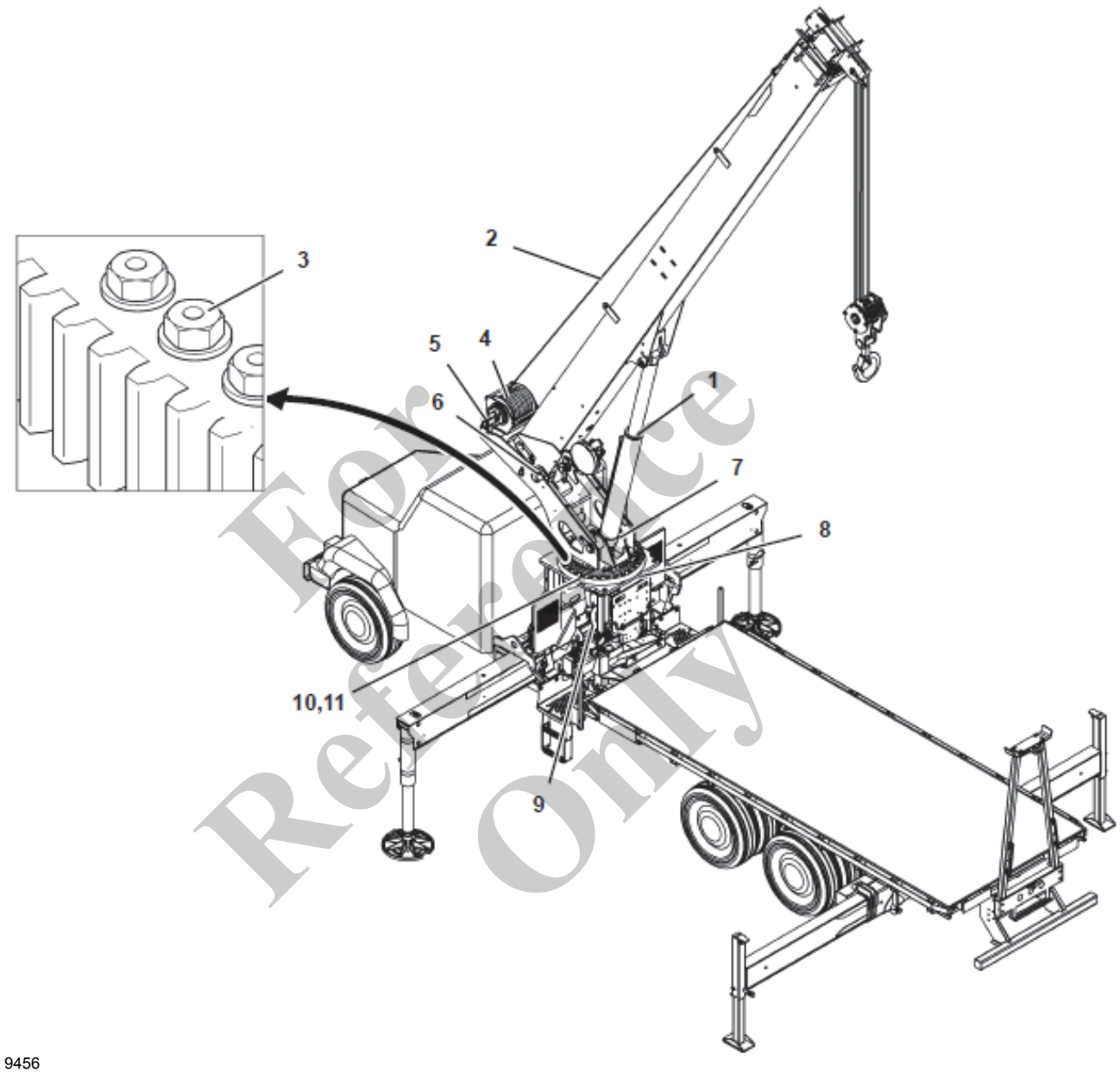





Illustration for reference only.
Your crane may be different.

**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*

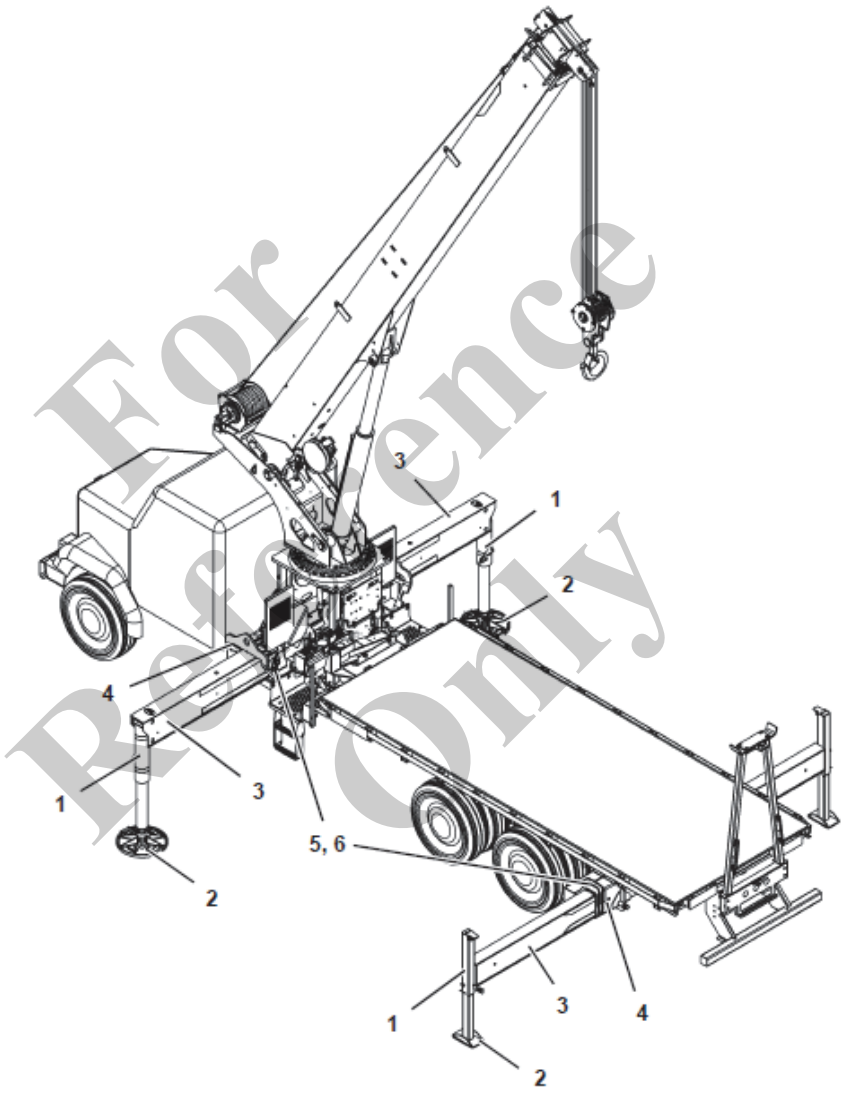



Illustration for reference only.
Your crane may be different.

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

# SECTION 2
# OPERATION

## SECTION CONTENTS





## TRUCK CAB CONTROLS

### Power Take-Off (PTO)

***Manual Shift Control*** – The PTOs 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 is 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 takeoff 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 PTOs 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 vehicle is equipped with automatic transmission, the power take-off must be engaged with the engine at idle. Refer to transmission manufacturer's 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, you may be required to help immobilize the truck with wheel chocks.

## CRANE CONTROLS

The unit is equipped with control stations on each side of the main frame. Placards on the control knobs or next to the lever indicate the direction to actuate the controls for the various unit functions. Each station is complete and provides complete control of boom rotation, boom elevation, boom extension, hoist, outriggers, engine foot throttle, the engine emergency stop switch and a horn switch. All control handles except the outrigger controls are positioned in the same order at both control stations. The hydraulic system pressure gauge is located at only one operator's station.

## Control Functions

***Turn*** – Operate the lever to **RIGHT** to rotate the boom in a clockwise direction. Operate the lever to **LEFT** to rotate the boom in a counterclockwise direction as viewed from the top of the crane.

A mechanical rotation stop pulls the turn control lever back to the center position when engaged. The boom rotation is stopped over the front of the chassis. On rear mounted cranes, rotate the boom over the passenger side of the chassis when stowing and unstowing to prevent immediate contact with the mechanical rotation stop.

***Swing Speed Adjustment*** – Located on turn motor inside frame. Turn knob in to increase maximum swing speed. Turn knob out to decrease maximum swing speed.

***Boom*** – Operate the lever to **DOWN** to lower the boom. Operate the lever to **UP** to raise the boom.

***Boom Telescope*** – Operate the lever to **OUT** to extend the boom. Operate the lever to **IN** to retract the boom.

***Hoist*** – Operate the lever to **DOWN** to payout and lower the loadline. Operate the lever to **UP** to reel in and raise the loadline. Refer to hoist system operation section for additional information.

**⚠ DANGER**

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

***Stabilizers – Up/Down*** – Operate the lever to **DOWN** to lower and UP to raise.

***Stabilizers – Extend/Retract*** – Operate the lever to **EXTEND** to move beams out and to **RETRACT** to move beams in.

***Outriggers*** – Operate the lever to **UP** to raise the outrigger legs. Operate the lever to **DOWN** to lower the outrigger legs.

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

***Engine Emergency Stop Switch*** – Operate the switch to stop the truck engine under emergency conditions. Switch must be reset to on to operate truck from cab.

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

***Pressure Gauge*** – Observe pressure gauge while booming up or down at end of stroke to determine system pressure. **Note: RCL required on cranes with jibs and/or personnel platforms.**

***RCL Display Console*** – Acts as interface between operation and load moment system. It's used to import operating conditions and display boom and load information. Refer to RCL manual.

***RCL CPU*** – Processes load information to give operator crane capacities and boom information. Refer to RCL manual in this owners manual.

***ATB Light*** – Indicator light illuminates when a two block condition is detected.

***Override Key Switch*** – The Override Key Switch continuously overrides HCA/ATB lockout conditions in emergency situations. When the key switch is turned to the ON position, the system overrides HCA/ATB lockout condition until the key is turned to the OFF position. Some units may be equipped with a Manual Reset Valve option that does not have Override Key Switch. Do not use override to continue lifting operations in an overload or two blocked condition.

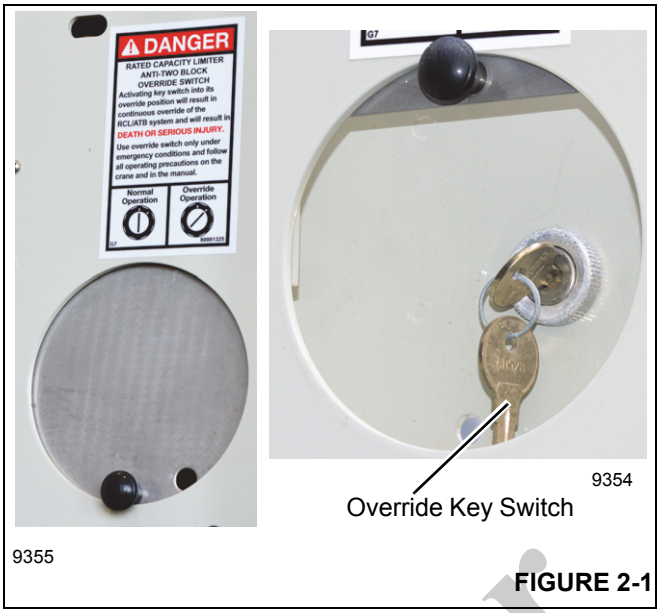



FIGURE 2-1

***Capacity Chart*** – This chart shows capacities of crane at various operating areas and hoist capacities with appropriate reeving.

***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 capacity chart. The length indicators are used to define boom length and with the capacity chart and load radius are used to determine the maximum loads that may be safely lifted. Actual radius must be measured from the centerline of rotation.

***Load Radius*** – Horizontal distance from the center of rotation of the turret to the center of the loadline hook or load with the load suspended. Use boom angle and boom length as a reference to determine loadline or load radius. When lifting maximum rated load, always know the weight of the load and measure the radius with the load suspended.

## HYDRAULIC CAPACITY ALERT (HCA) SYSTEM (IF EQUIPPED)

**Note: HCA system cannot be used with jibs and/or personnel platforms.**

***HCA Load Range Gauge*** – Aid in determining the load condition of crane. The gauge has three colors on the dial face: (1) Green – OK; (2) Yellow – Caution; and (3) Red – Overload. **Do not use the Load Range Gauge with a jib.** Refer to “Hydraulic Capacity Alert System” for more information.

***HCA Overload Light*** – Indicator light illuminates when HCA detects crane overload and boom down, extend out and hoist up functions disabled.

***ATB Light*** – Indicator light illuminates when a two block condition is detected.

***Override Key Switch*** – The Override Key Switch (Figure 2-1) continuously overrides HCA/ATB lockout conditions in emergency situations. When the key switch is turned to the ON position, the system overrides HCA/ATB lockout condition until the key is turned to the OFF position. Some units may be equipped with a Manual Reset Valve option that does not have Override Key Switch. Do not use override to continue lifting operations in an overload or two blocked condition.

***Override Button*** – The override button (Figure 2-2) temporarily overrides HCA/ATB lockout conditions in emergency situations. On newer versions of the 800D, when the button is pressed, the system momentarily overrides the lockout condition until the button is released. The override button is centrally located between operator stations, between the frame and outrigger motion alarm. On older versions of the 800D, with Override Key Switch in ON position, depress button to override the OMS and HCA systems. Do not use override to continue lifting operations in an overload or two blocked condition.


FIGURE 2-2

## RATED CAPACITY LIMITER (RCL) (IF EQUIPPED)

**NOTE:** Consult the RCL manual in the event of a RCL malfunction.

The RCL system is a CANbus system that coordinates and displays information about the crane conditions during operation. Information about the following is reported to the operator in real time on the operator console:

- Boom length and angle
- Outrigger status
- Crane hydraulic load

Reference data, such as load charts, boom weights, and dimensions, are stored in memory in the QScale console and used to calculate operating conditions. When operating limits are reached, the RCL generates warning signals that appear on the operator console. If operating limits are met, the RCL will stop aggravating crane movements, like hoist up or telescope out.

The RCL is powered by a 12V input from the truck battery through a 15 Amp fuse. A toggle switch in the truck cab turns the RCL system ON and a light next to the switch indicates when the RCL is active. The RCL memory always has power supplied by the truck battery even when the truck ignition is in the OFF position.

The RCL features the following components:

***cScale iFlex DIO*** – The cScale iFlex coordinates the inputs from and outputs to the different components in the RCL system. It is located inside the frame gusset under the turret.

***QScale Operator Console*** – The QScale operator console displays data about the crane the operator needs to operate the crane effectively and safely, including the status of the outriggers, boom status and load chart information. The monitor is mounted on a swing arm on the front assembly and can be adjusted for use on either operator platform.


9357 **FIGURE 2-3**

For more information about the console, see the QScale Operator and Service manuals.

***DIO Module*** – The DIO module coordinates inputs and outputs from various sensors on the crane. The DIO module is mounted inside the interior frame gusset. The status of the outriggers is reported on the QScale display.

**NOTE:** The Outrigger Status Indicator (1, Figure 2-5) is not used on models equipped with an RCL.

***Boom Length and Angle*** – The RCL uses information from sensors on the boom to capture boom length and angle information. This boom information is displayed on the QScale monitor.

***Piston and Rod Pressure Transducers*** – The piston and rod pressure transducers (Figure 2-4) measure crane hydraulic load. They are attached to the rod and piston side lift cylinders. The transducers are located in the interior frame gusset under the turret and feature test ports to use when bleeding air from the hydraulic hoses when calibrating the transducers. Contact Manitowoc Crane Care for more information about calibrating RCL sensors.


**FIGURE 2-4**

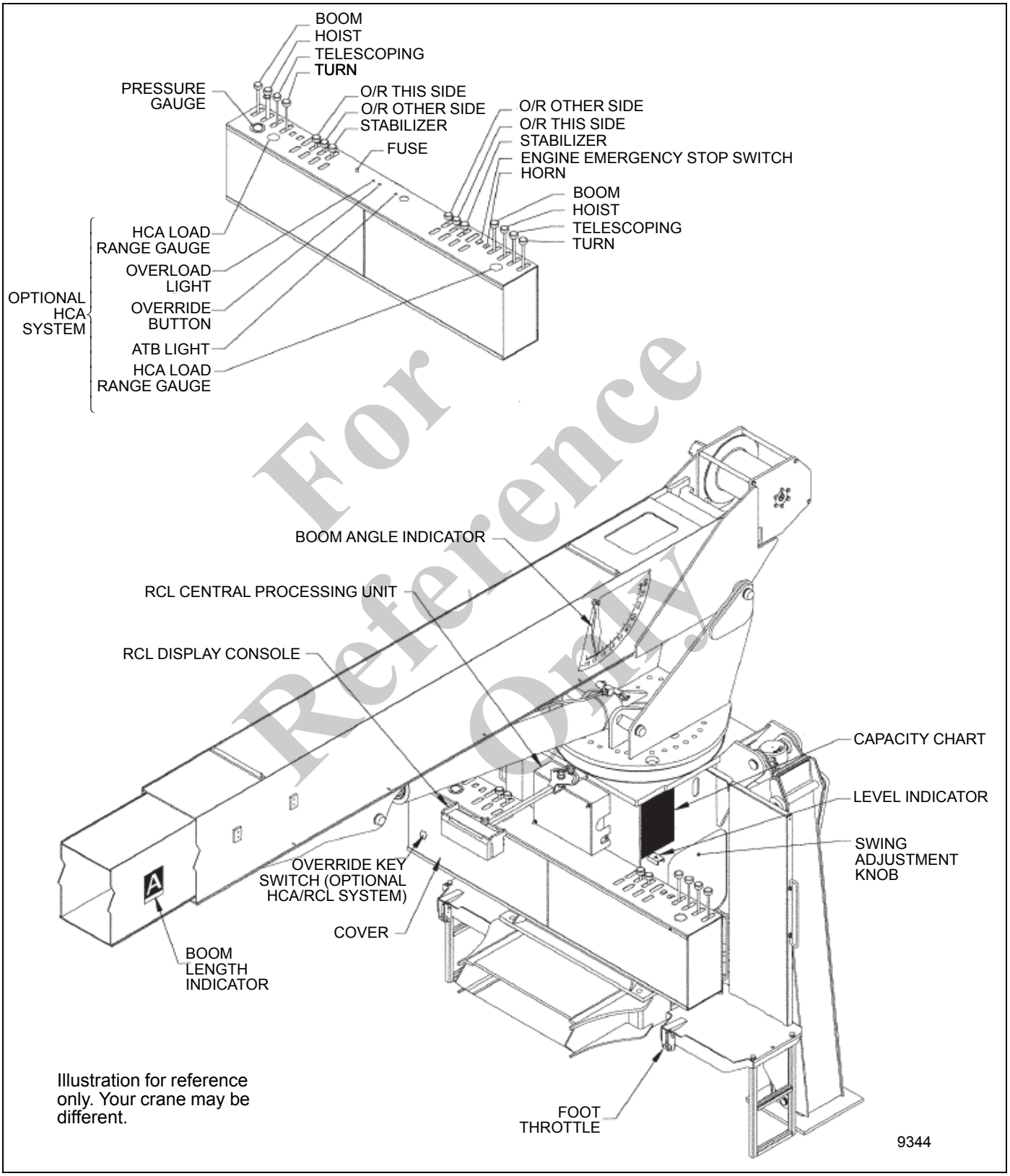
***Override Switches*** – The 800D features two RCL override switches for RCL/ATB lockout conditions:

- On/Off Key Switch
- Push Button

The override key switch (Figure 2-1) is located behind a sliding door on the left (driver's side) crane operator controls. Turning the key to the ON position will override the RCL/ATB continuously until the key is turned to the OFF position. Do not use override to continue lifting operations in an overload or two blocked condition.

The override push button (Figure 2-2) is located on the bulkhead between the crane's two operator positions. Push down the button to temporarily override the RCL/ATB system. When the button is released, the RCL/ATB system is no longer in override condition. Do not use override to continue lifting operations in an overload or two blocked condition.

# CRANE NOMENCLATURE



# OPERATING PROCEDURES

## EQUIPMENT FAMILIARIZATION

All members of the crew should become thoroughly familiar with the location and operation of controls, the correct operating procedure, the maximum lifting capacities and the safety precautions applicable to the unit before operating. This crane is a complex piece of equipment and can be overloaded in many ways. Carefully follow the operating procedures outlined below and in the instructional pages of the load rating chart at the operator's station.

## EQUIPMENT CHECKS

Perform the following checks prior to placing the unit in operation:

- Inspect for any unusual conditions such as pools of hydraulic fluid or lubricating oil under the chassis, any outrigger which may have crept down or up and any signs of damage or improper maintenance.
- Check that the tires are inflated to the proper pressure.
- Check the level of the hydraulic reservoir.
- Check the operation of the "stop" and horn circuits.
- Check for missing and loose bolts.
- Check for damaged structural members and welds.
- Check all rope guides and cable keepers.
- Check all sheaves for free turning.
- Check the loadline cable for kinks, broken strands or other damage in accordance with instructions in the "Lubrication & Maintenance" section.
- Check to see that the hydraulic hoses and fittings are in good condition and show no signs of leaking. The hoses should be free from cuts and abrasions and there should be no evidence of binding. Any damage or leakage should be repaired immediately.
- Check optional HCA and anti-two-block system or RCL and anti-two-block system for proper operation.

**Note: Consult truck manufacturer's manual for vehicle checks.**

## Cold Weather Operation

The following recommendations are for operating National cranes in regions with ambient temperatures below -9°C (15°F) which are considered arctic.

Cranes should have appropriate hydraulic oil, lubricants, and other auxiliary items required for operation in very cold 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 *Lubrication* on *page 4-1*, 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 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 2-8).
2. After 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.

## Pre-Operation Inspection and Calibration Verification

1. Check the electrical wiring connecting the various parts of the system for physical damage.
2. Check the anti-two-block switches and weights for free movement.

**⚠ DANGER**

**The following tests shall be performed with care to prevent damage to the machine or injury to personnel. Proper functioning of the system requires successful completion of these tests before operating the machine.**

If the operator cannot see the load handling device approaching the boom nose, he shall have an assistant (signal person) watch the load handling device. The operator shall be prepared to stop the machine immediately should the RCL (or optional HCA system) not function properly. If the RCL (or optional HCA system) is not functioning properly, lifting the anti-two-block weight will not activate the red warning light or the audible alarm (optional for the HCA system), and will not lock the crane movements hoist up, telescope out, and boom down.

Check the anti-two-block alarm light and the audible alarm by performing one of the following tests:

- Manually lift the weight attached to the anti-two- block switches. When the weight is lifted, the audible alarm for the RCL (or optional audible alarm for the optional HCA system) should sound and the anti-two-block alarm light should light.
- Slowly raise the main boom load handling device to create a potential two-block condition. When the load handling device lifts the weight, the audible alarm should sound, the anti-two-block alarm light should light and the motion of the load handling device should be stopped. Lower the load handling device slightly to eliminate this condition.
- Slowly extend (telescope) the boom to create a potential two-block condition. When the load handling device lifts the weight, the audible alarm should sound, the anti-two-block alarm light should light and the boom telescope out function should be stopped. Lower the load handling device slightly to eliminate this condition.

**⚠CAUTION**

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 shall be corrected before operating the crane.

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

**Operation**

After being properly checked, the RCL is operational. The operator shall be thoroughly familiar with all controls of the RCL and he shall properly set the reeving (parts of line) selector before operating the crane. The proper function of the system shall be checked by lifting a load of known weight and comparing the load to the information displayed on the RCL.

Rated loads include the weight of the hook block, slings, and auxiliary load handling devices. Their combined weights shall be subtracted from the listed load capacities as stated on the load capacity chart to obtain the net load to be lifted.

**⚠DANGER**

**If any of the displays reflect a deviation between displayed and actual values, an authorized PAT service representative shall be called for repair of the system or reverification of the crane's RCL calibration.**

**⚠DANGER**

**Any structural modifications or changes to the crane shall require reverification of the crane's RCL calibration.**

**⚠DANGER**

**The RCL will warn the operator when hoist and loadline overload occurs but will allow the boom up function to continue to operate. Booming up a hoist and loadline overload in areas where the boom capacity exceeds the loadline capacity can cause serious damage to the hoist and loadline. Always reeve the loadline properly for the load to be lifted.**

## WORK SITE POSITION

Always seek the best possible work site when parking the crane. An ideal parking location at a job site is firm, level, dry ground or pavement located in close proximity to the work station. Avoid uneven, rocky or muddy terrain, steep grades or locations with unnecessary overhead obstructions. Location should be selected such that outriggers can be fully extended and legs come down on firm level surface. Particular care must be taken in selecting a site position to the location of overhead power lines so that proper clearance conditions can be maintained. Ideally, one should select a location at which the boom could not come within minimum recommended distance of the power lines at full extension.

It is best to select a location on the site such that most of the lifting can be done over the outrigger support or rear of the truck.

## BEFORE LEAVING THE CAB

1. Position the truck so that the outriggers can be extended without encountering obstructions. Set the truck park brake securely and turn front wheels into the curb. Wheel chocks may be required under certain conditions.
2. With the gear shift in neutral, depress clutch (if equipped with a manual transmission), and engage the power takeoff by pulling out the shifting knob.
3. Bring the hydraulic system up to operating temperature (oil reservoir warm to the touch) by allowing the system to operate by actuating the outrigger retract switch with all outriggers fully retracted.

### 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, 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.

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.

### 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.

## CRANE SET UP

**⚠ DANGER**

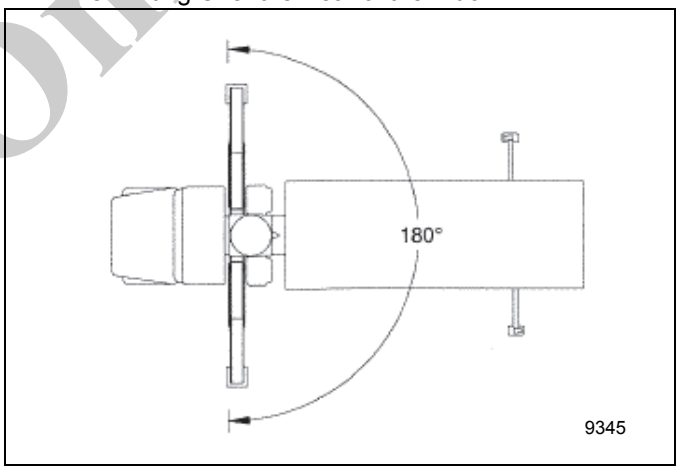
**Do not operate the boom until all outriggers are extended and set providing firm support.**

If operating on sloping ground provide blocks. When lifting is to be done on soft terrain or hot asphalt, support the outrigger and stabilizer pads with bearing pads. Some concrete and asphalt surfaces are relatively thin and cannot support outrigger or stabilizer loading. Concrete can break through and cause instability.

Variation in chassis, outrigger and mounting configurations will cause outrigger foot loading to differ on each crane, however, outrigger foot loads can be as high as 50,000 lb (22 697 kg) when outriggers are at full span [154 psi (1.06 MPa) on standard outrigger pads]. Support surface bearing capacities vary by a large amount—from 833 psi (5.7 MPa) on bed rock down to 14 psi (0.1 MPa) on soft clay. Loose sand or soft asphalt will support even less load. It is imperative that the operator take proper precautions to insure the outrigger foot has adequate cribbing for existing soil conditions.

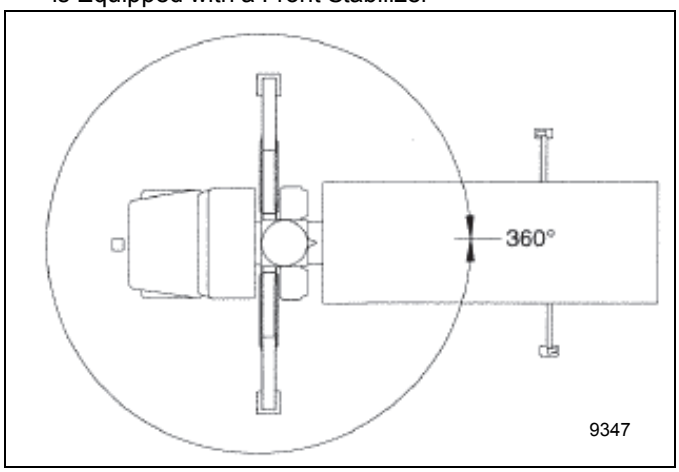
If specific outrigger foot loading is required for an individual crane, contact National Crane with actual chassis weights and crane details.

1. When Lifting Over the Rear of the Truck




Before conducting any boom operations, extend both outriggers until the chassis weight is removed from the wheels. Level the crane from side-to-side. A level indicator is provided at either control station. Then extend and lower the stabilizers to level the crane front-to-back. Again refer to the level indicator to ensure that the crane is properly leveled. Always keep the load as close to the ground as possible.

2. When Lifting Over the Front of the Truck and the Vehicle is Equipped with a Front Stabilizer




A front stabilizer is required when loads are to be lifted over the front of the vehicle. Before conducting any boom operations, extend both outriggers until the chassis weight is removed from the wheels. Level the crane side-to-side using the level indicator located at either control station as a reference. Then extend and lower the rear stabilizers to level the crane front-to-back. Again refer to the level indicator to insure that the crane is properly leveled. After the crane is leveled side-to-side and front-to-back, extend the front stabilizer leg(s) until firm contact is made with the ground. Always keep the load as close to the ground as possible.

3. Rear Mount Units Equipped with Rear Stabilizer A rear stabilizer is required when loads are to be lifted over the rear of the vehicle. Before conducting any boom operations, extend both outriggers until the chassis weight is removed from the wheels. Level the crane side-to-side using the level indicator located at either control station as a reference. Then extend and lower the HO outriggers to level the crane front-to-back. Again refer to the level indicator to insure that the crane is properly leveled. After the crane is leveled side-to-side and front-to-back, extend the rear stabilizer leg until firm contact is made with the ground. Always keep the load as close to the ground as possible.

**⚠ DANGER**

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

4. Check to ensure that the jib, if so equipped, is stowed correctly on the first section boom.

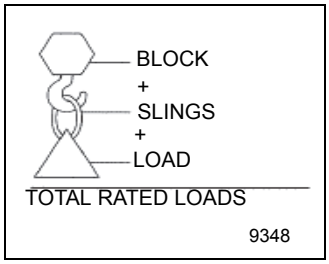
## BEFORE MAKING THE LIFT

1. Check all controls for proper operation by operating each system through one complete cycle. This is particularly important after the unit has been serviced or repaired. If any abnormal operations are detected, correct the condition before continuing.
2. During all operations, the controls should be metered when beginning or terminating a movement to prevent sudden starting or stopping which imposes undue shock loads on the equipment. This metering can be performed by metering the control lever and the foot throttle.
3. Check the operating area for electric powerlines.

## READING AND UNDERSTANDING THE LOAD CHARTS

The structures and components of your unit are designed to provide satisfactory service if the unit is not loaded in excess of the maximum rated loads specified on the load chart. Overloading can create serious potential safety hazards and can also shorten the service life of your unit. It is important that you know the weight and radius of any load that you are attempting to handle. This should be done by use of a dynamometer and tape measure or by contacting your supervisor.

Overloading a crane can cause many types of failure depending on the configuration and working position of the crane, i.e. structural damage to almost any part of the crane hoist or cable failure and tipping the unit over.




The load chart shows the maximum rated loads including load (weight being lifted), load handling equipment such as slings, buckets, and downhaul weights, etc. which can be handled by the crane and the hoist. The weight of the load handling equipment and boom attachments must be deducted from the maximum load rating shown on the load chart to determine the payload which can be lifted. Additional reduction may be necessary to make allowance for such factors as the effects of freely swinging loads, wind, ground conditions, out-of-level conditions and operating speeds.

The ratings shown on the outrigger full span load chart are maximum loads and are based on the structural integrity of the crane in shaded areas, the stability of the crane in nonshaded areas. The stability or non shaded areas represent a stability tipping factor of 85% when:

1. All outriggers are extended with positive contact on firm, level surface, the tires are free of the ground and the machine is level within 1°.
2. The proper amount of counterweight has been installed, if required.
3. The unit is mounted in accordance with factory instructions on a vehicle with proper specifications.

4. The weight of load handling devices is considered as a part of the load being lifted.
5. The correct loadline reeving is used for the load to be lifted.
6. Adverse environmental conditions such as wind are not present.
7. The operator controls the loads smoothly.
8. Tires are inflated to the proper pressure.
9. The load to be handled does not exceed the maximum capacity at the boom length and loaded radius.
10. The loads are lifted in the proper area around the truck.

A stability test should have been performed on this crane and can be repeated by referring to the Installation Section.

All capacities are given in direct relationship to the boom length and loaded radius at which the load is being handled. All radii are measured from the centerline of rotation to the loadline with the load suspended. All variances of loads and radii of operation are shown on the load capacity chart mounted on the main frame. Boom angle should be used as reference only to aid in determining radius. The correct loaded radius must be measured and not exceeded during any point of the lifting operation. The placard is located at the operators platform for the purpose of informing the operator when a load can or cannot be handled. Load ratings cannot be interpolated between load points shown on the chart in the boom areas. When boom length or radius or both are between points listed on capacity chart, the smallest load shown at either the next larger radius or boom length shall be used. Capacities of the jib cannot be interpolated between angles nor at reduced lengths because the strength of the jib and its attachment point to the boom does not increase when the boom is shortened.

**General**

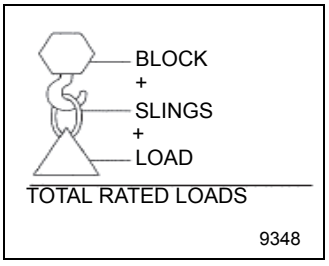
1. The equipment can be hazardous if improperly maintained or operated. Read and comply with the Operator Manual supplied with this machine for information on safety, operation and maintenance before operating this machine. If these manuals are missing, order replacements from National Crane through the distributor.
2. Rated loads shown on the capacity chart pertain to this machine as originally manufactured and equipped. Modifications to the machine or use of equipment that is not factory specified or approved can be hazardous. Refer to capacity deduction chart for weights which must be deducted from rated loads when accessories are attached to boom or loadline.

**Set-Up**

1. Inspect vehicle and crane including crane operation prior to use each day.
2. Load ratings shown on the chart are maximum allowable loads with the crane mounted on a factory approved truck and all outriggers set on a firm level surface so the crane is level. This crane is not rated for use without outriggers.
3. Depending on the nature of the supporting surface, structural supports under the outrigger floats may be necessary to spread the load to a larger bearing surface.
4. Always level the crane with the level indicator located at the operator stations located on either side of the crane frame.

**Operation**

1. Operation of this equipment in excess of maximum load rating and disregard of instructions is hazardous. Always refer to the capacity chart for load and area limits before operating the crane. Rated loads at rated radius shall not be exceeded. Over loading this crane may cause structural collapse or instability. Do not rely on the RCL or HCAS system to weigh the load and control limiting boom angle and radius. Use the system as a backup to safe operation.
2. Use the angle indicator as a reference only. When lifting maximum loads, measure radius.
3. Rated loads do not exceed 85% of the tipping load as determined by SAE Crane Stability Test Code J765a when mounted on a factory recommended truck. Structural limited ratings on the capacity chart are shaded. Stability limited loads are not shaded. Machine will not always tip before structural damage occurs.
4. Rated loads include the weight of the hook block, slings, other lifting devices and boom accessories. Their weights must be subtracted from the listed rated load to determine the net load that can be lifted.



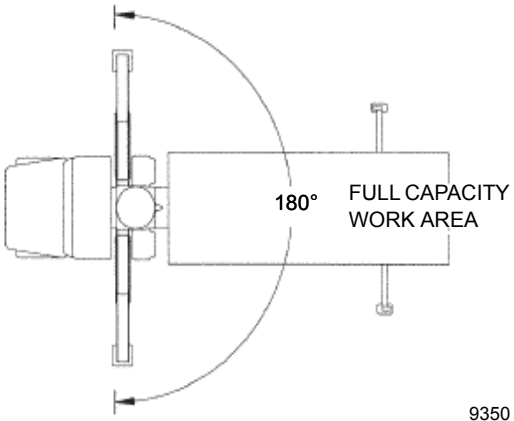

5. Rated loads are based on freely suspended loads. Always position the boom tip directly over the load before lifting. No attempt shall be made to push down with the boom or move the load sideways in any direction by pulling or dragging the load.
6. The user shall operate at reduced ratings to allow for adverse job conditions such as soft or uneven ground, high winds or erratic operation which produce swinging

(side) loads, experience of personnel, two machine lifts, or other hazardous conditions for safe operation.

7. When boom length or radius or both are between points listed on capacity chart, the smallest load shown at either the next larger radius or boom length shall be used.
8. Do not exceed jib capacities at any reduced boom length. If jib is between angle ratings on capacity chart, the smallest load shall be used.
9. It is safe to attempt to telescope or retract any load listed if rating is not exceeded. Capacities at retracted boom length cannot be telescoped without exceeding ratings.
10. Always pay out loadline before extending boom to avoid damaging loadline or crane structure.
11. Loads lifted must be within safe hoist capacity as well as safe crane capacity. Multiple part rope reeving must be used on loads exceeding hoist single part rated pull. Jibs are rated for single part use only.
12. Do not operate the boom over personnel or allow them to walk or stand beneath the boom or load.
13. Do not allow personnel on truck bed or crane frame area when operating crane.
14. Do not allow personnel to ride on hook, hook block, load or any device attached to the loadline. Use only National Crane approved personnel platforms.
15. Operate controls slowly and smoothly to avoid damage to crane or personnel.
16. Boom must be in carrying rack and outriggers fully retracted for travel.
17. Do not operate crane within 10 feet (3.05m) of live power lines.

**Definitions**

1. Load Radius-Horizontal distance from the centerline of rotation before loading to the center of the vertical load line or block with load applied.
2. Loaded Boom Angle-Loaded boom angle is the angle between the first section boom and the horizontal, after lifting the rated load at the rated radius. The boom angle before loading should be greater to account for deflections. The loaded boom angle combined with the boom length give only an approximation of the operating radius.
3. Working Area-Area measured in a circular arc above the center line of rotation as shown on the Working Area diagram. If no decal is present the work area is 360°.



**WORK AREA DIAGRAM**

4. Freely Suspended Load-Load hanging free with no direct external force applied except by the loadline.
5. Side Load-Horizontal side force applied to the lifted load either on the ground or in the air.
6. Boom Length-Length of the boom, from boom pivot pin to wire rope on last main boom section. A decal on either side of the boom shows when certain boom lengths are reached. The letters on the intermediate boom lengths correspond to the letters on the capacity chart.
7. Range Diagram-Corresponds to the pictorial in the Capacity Chart. It shows the operating radius and height of the unloaded boom tip at all boom lengths and angles. It should be used as a guide to position unloaded loadline and to determine approximate height to which the load can be lifted.

The following procedure is a typical method which must be used to determine the crane's ability to handle a load. The crane is equipped with a standard hoist:

1. Determine the weight of the load and load handling equipment.
2. Determine the radius from center line of crane rotation to position of load.
3. Determine the radius from centerline of crane rotation to center of point where load is being moved to.
4. Refer to Capacity Chart for crane and determine that load and radius of lifting are within capacity of crane.
5. Refer to Capacity Chart for hoist to determine hoist reeving is proper.

The following examples are for illustrative purposes only. The examples utilize the capacity chart shown. The load chart ratings, component weights and dimensional data may not be the same as the actual unit. Always use actual information from the crane and job site when planning a lift.

**Example 1**

A load is to be lifted from the ground and weighs 6120 lb (2776 kg) at a radius of 35 ft (10.7 m). It will be placed on the roof of a building at a radius of 25 ft (7.62 m) and a height of 65 ft (19.81 m) above the ground on the opposite side of the truck.

***Step 1.*** Determine the load.

| | | |
|---|---|---|
| Load = | 6120 lb | (2776 kg) |
| 1 Part Load Block = | 150 lb | (68 kg) |
| Sling = | 30 lb | (14 kg) |
| | 6300 lb | (2858 kg) |

***Step 2.*** Starting Radius.

Given = 35 ft (10.7 m)

***Step 3.*** Ending Radius.

Given = 25 ft (7.62 m)

***Step 4.*** Refer to crane Capacity Chart.

Starting point: The boom capacity at a 44 ft (13.41 m) length and 35 ft (10.7 m) radius is 6300 lb (2858 kg).

Ending Point: The load rating at the ending point is 7100 lb (3220 kg). The boom will be at 100 ft (30.48 m) extension and the loaded radius is 25 ft (7.62 m).

The crane has enough capacity at each end of the lift to allow the lift to be made.

In order to get the load on the roof, the load must be hoisted from the ground, swung around the rear of the truck (deadspot in rotation is over the cab) and boom extended to full 100 ft (30.48 m). At this point measure to ensure load is at 25 ft (7.62 m) radius. Raise or lower boom to achieve radius. Hoist load to a height that will clear the top of the building and rotate to the point load is to be placed. Lower the load using the hoistline to the roof.

***Step 5.*** Lastly refer to hoist Capacity Chart.

- Crane is reeved for single part line.
- Allowable load for single part line is 7700 lb (3492 kg) well above the 6300 lb (2858 kg) to be lifted.

Operator should now proceed to lift the load as smoothly as possible.

**Example 2**

Assume a load of 9000 lb (4082 kg) at 10 ft (3.04 m) radius on the ground beside the truck to be picked up, swung over and placed on the truck bed at an 8 ft (2.43 m) radius from the crane. Crane is reeved for single part.

***Step 1.*** Weight of load and load handling equipment.

| | | |
|---|---|---|
| Load = | 9000 lb | (4082 kg) |
| 1 Part Line Block = | 150 lb | (68 kg) |
| Slings = | 50 lb | (22 kg) |
| | 9200 lb | (4173 kg) |

***Step 2.*** Starting Radius.

Given = 10 ft (3.04 m)

***Step 3.*** Ending Radius.

Given = 8 ft (2.43 m)

***Step 4.*** Refer to crane Capacity Chart.

The crane capacity at the 10 ft (3.04 m) point is 25,500 lb (11 567 kg). Of course, at the 8 ft (2.43 m) radius, the capacity would be substantially more. Therefore, the crane capacity is adequate.

***Step 5.*** Refer to hoist Capacity Chart.

The capacity of a 1 part line is 7700 lb (3492 kg), which is less than load to be lifted. Crane must be revved for 2 part to lift the 9000 lb (4082 kg) load.

**Note: Two part hoist capacity is 15,400 pounds (6985 kg).**

Actually when one puts on the 2 part block, the load block weighs approximately 305 lb (138 kg) rather than the 150 lb (68 kg) figured in Step 1 so actual load lifted is 9355 lb (4343 kg). Load [9000 lb (4082 kg)] + 2 part block [305 lb (138 kg)] + slings [50 lb (22.67 kg)].

**Example 3**

A load of 2500 lb (1134 kg) is to be lifted from the roof of a building at a radius of 30 ft (9.14 m) and a height of 115 ft (35,05 m) and placed on the ground on the other side of the truck at a radius of 40 ft (12.19 m).

***Step 1.*** Weight of load and load handling equipment.

| | | |
|---|---|---|
| Load = | 2500 lb | (1134 kg) |
| 1 Part Line Block = | 150 lb | (68 kg) |
| Slings = | 30 lb | (14 kg) |
| | 2680 lb | (1216 kg) |

***Step 2.*** Starting Radius

Given = 30 ft (9.14 m)

***Step 3.*** Ending Radius

Given = 40 ft (12.19 m)

***Step 4.*** Refer to Crane Capacity Chart.

To reach the load on the roof, the jib must be utilized to clear the roof with the load. ***Important: Do not attempt to deploy the jib until reading and understanding jib operation information found later in this section of the manual.*** Both the retracted 25 ft (7.62 m) jib length and extended 44 ft (13.41 m) jib length have the necessary capacity at a 30 ft (9.14 m) radius. Only the retracted 25 ft (7.62 m) jib has the capacity at the 40 ft (12.19 m) radius to accomplish the task.

Starting Point: With the 25 ft (7.62 m) jib deployed and the boom fully extended, the capacity is 3900 lb (1769 kg) at a 30 ft (9.14 m) radius and boom angle of 78°.

Ending Point: With the main boom still fully extended, the capacity is 2800 lb (1270 kg) at a radius of 40 ft (12.19 m) and boom angle of 73°.

**Note: The capacity of the jib remains the same even with the main boom retracted. Operate with jib by radius when main boom is fully extended and operate with jib by boom angle when main boom is not fully extended. Do not exceed rated jib capacities at any reduced boom lengths.**

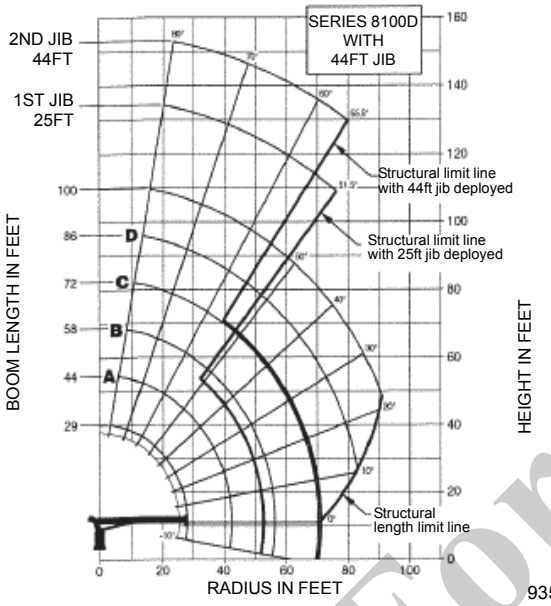
***Step 5.*** Refer to hoist Capacity Chart.

The capacity of a 1 part line is 7700 lb (3492 kg) which is well above the 2680 lb (1216 kg) to be lifted.

**Note: The HCA Load Range Gauge does not provide accurate indication of overload conditions when operating with a jib deployed. The Hydraulic Capacity Alert System will not prevent the crane from being operated in an overload condition.**

The operator should proceed to lift the load as smoothly as possible.

# NATIONAL CRANE CORPORATION




**NOTE:**

1. Operate with jib by radius when main boom is fully extended. If necessary increase boom angle to maintain loaded radius.
2. Operate with jib by boom angle when main boom is not fully extended. Do not exceed rated jib capacities at any reduced boom lengths.
3. Capacities do not exceed 85% stability.
4. Shaded areas are structurally limited capacities.

| RCL OPERATING CODE SWITCH | |
|---|---|
| **SWITCH POSITION (REF #17)** | **OPERATING MODE** |
| 01 | MAIN BOOM - NO JIB STOWED |
| 02 | MAIN BOOM - JIB STOWED |
| 03 | 25 FT TELE JIB |
| 04 | 44 FT TELE JIB |
| 11 | PERSONNEL PLATFORMON MAIN BOOM |
| 12 | PERSONNELPLATFORM ON 25 FT TELE JIB |
| 13 | PERSONNEL PLATFORM ON 44 FT TELE JIB |

## LOAD RATINGS

| | A | | B | | C | | D | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LOAD RADIUS (FEET) | LOADED BOOM ANGLE | 29FT BOOM (lb) | LOADED BOOM ANGLE | 58FT BOOM (lb) | LOADED BOOM ANGLE | 72FT BOOM (lb) | LOADED BOOM ANGLE | 86FT BOOM (lb) | LOADED BOOM ANGLE | 100FT BOOM (lb) |
| 5 | 79 | 46,000 | | | | | | | | |
| 8 | 72.5 | 30,700 | 79 | 27,900 | | | | | | |
| 10 | 68 | 25,500 | 76 | 23,200 | | | | | | |
| 12 | 63.5 | 21,800 | 73.5 | 19,700 | 78 | 18,050 | | | | |
| 14 | 59 | 19,000 | 70.5 | 17,200 | 76 | 15,750 | 79.5 | 14,350 | | |
| 16 | 54 | 16,700 | 68 | 15,200 | 74 | 13,850 | 77.5 | 12,650 | | |
| 20 | 43 | 13,400 | 61 | 12,200 | 69.5 | 11,250 | 74.5 | 10,350 | 77.5 | 9,550 |
| 25 | 25 | 9,700 | 54 | 9,700 | 64 | 8,950 | 70 | 8,250 | 74 | 7,650 |
| 30 | | | 45 | 7,900 | 58.5 | 7,350 | 66 | 6,650 | 70.5 | 6,150 |
| 35 | | | 35 | 6,300 | 53 | 6,100 | 61.5 | 5,600 | 67 | 5,200 |
| 40 | | | 20 | 4,600 | 46 | 5,100 | 56.5 | 4,750 | 63 | 4,400 |
| 45 | | | | | 38 | 4,250 | 51.5 | 4,050 | 59.5 | 3,800 |
| 50 | | | | | 28.5 | 3,400 | 46 | 3,450 | 55 | 3,250 |
| 55 | | | | | 14 | 2,200 | 40 | 2,900 | 51 | 2,800 |
| 60 | | | | | | | 33 | 2,350 | 46.5 | 2,400 |
| 65 | | | | | | | 24 | 1,800 | 41 | 2,000 |
| 70 | | | | | | | 6.5 | 700 | 35.5 | 1,600 |
| 75 | | | | | | | | | 29 | 1,250 |
| 80 | | | | | | | | | 20 | 800 |
| 85 | | | | | | | | | | |
| 90 | | | | | | | | | | |
| | 0 | 5,100 | 0 | 2,300 | 0 | 950 | 0 | 150 | | |
| ADD TO CAPACITIES WHEN NO JIB STOWED (lb) | | 800 | | 600 | | 450 | | 350 | | 300 |

| LOAD RADIUS (FEET) | LOADED BOOM ANGLE | 25FT JIB (lb) | LOADED BOOM ANGLE | 44FT JIB (lb) |
|---|---|---|---|---|
| 30 | 78 | 3,900 | 80 | 2,750 |
| 35 | 75.5 | 3,400 | 78 | 2,500 |
| 40 | 73 | 2,800 | 76 | 2,250 |
| 45 | 70.5 | 2,350 | 74 | 2,000 |
| 50 | 68 | 1,850 | 72 | 1,850 |
| 55 | 65 | 1,500 | 70 | 1,600 |
| 60 | 62.5 | 1,300 | 67.5 | 1,350 |
| 65 | 60 | 1,100 | 65 | 1,050 |
| 70 | 57 | 750 | 63 | 950 |
| 75 | 54.5 | 600 | 60.5 | 800 |
| 80 | 51.5 | 400 | 58 | 600 |
| 85 | | | 55.5 | 450 |

**LOADLINE EQUIPMENT DEDUCT (lb)**

Downhaul weight 150

One sheave block305

Two sheave block 355

Three sheave block 575

1 PART LINE


MAX. PULL
7700 lb

2 PART LINE


MAX. PULL
15,400 lb

3 PART LINE


MAX. PULL
23,100 lb

4 PART LINE


MAX. PULL
30,800 lb

5 PART LINE


MAX. PULL
38,500 lb

6 PART LINE


MAX. PULL
46,000 lb

### NOTICE

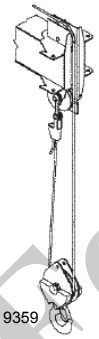
- Do not deadhead line block against boom tip when extending boom.
- Keep at least 3 wraps of loadline on drum at all times.
- Use only 9/16 in diameter rotation resistant cable with 38,500 lb breaking strength on this machine.
- Maximum capacity with “burst of speed” is 3000 lb.

## HOIST SYSTEM OPERATION

The hoist is mounted at the rear of the first section boom. It has capacities totally independent of the rest of the crane and can normally pull more than the crane itself can withstand. Therefore, care must be taken to insure that the load being lifted is within boom rating. To lift some of the heavier loads on the capacity chart, it will be necessary to multiple part reeve the hoist block to increase the lifting capacity of the hoist (the speed is proportionately slower) and remain in the strength limitations of the hoist and wire rope.

## USING MULTIPLE PART LINES

The hoist load rating chart on each machine provides the information for pull limitations on the hoist with various applicable part reevings. These ratings are based on providing the proper operating safety factor on the wire rope supplied with the machine. Therefore, any replacement rope must meet the rope specification sections of this manual.

| 1 PART LINE | 2 PART LINE | 3 PART LINE | 4 PART LINE | 5 PART LINE | 6 PART LINE |
|---|---|---|---|---|---|
|  9352 |  9359 |  9360 |  9361 |  9362 |  9363 |
| MAX. PULL 7700 lb (3492 kg) | MAX. PULL 15,400 lb (6985 kg) | MAX. PULL 23,100 lb (10 477 kg) | MAX. PULL 30,800 lb (13 970 kg) | MAX. PULL 38,500 lb (17 463 kg) | MAX. PULL 46,000 lb (20 866 kg) |

## GENERAL RULES WHEN OPERATING HOIST

1. Always operate the hoist control to payout the loadline while extending the boom. This will maintain clearance between the boom tip and loadline hook.
2. Do not rely on anti-two-block system to eliminate two blocking. Use the system as a backup to safe operation.
3. Make certain the hoist cable is not twisted or kinked and that cable is properly seated on the drum and in the sheaves.
4. Before lifting a load, always make certain that three full wraps of rope will remain on the drum at all times throughout the lift.
5. When lifting a load approaching the rated hoist load, raise the load a few inches and return the control to neutral to determine if the brake is working properly.
6. Do not drag loads in any direction with the hoist.
7. Never attempt to lift loads which are not loose and free, i.e. frozen down material or poles out of ground.
8. Maintain tension on the loadline at all times to prevent the cable from becoming twisted or kinked or improperly seated on the hoist drum or sheaves.

## LIFTING THE LOAD

After the vehicle and crane have been properly set up and it has been determined the load to be lifted is within the ratings of the crane and hoist reeving system, again check the work area for electric power lines and other obstructions so that proper clearances can be maintained. (See Safety Rules.) If load is not visible to operator throughout lift, a person must be appointed to use hand signals as shown on the last page of this section. Proceed with lifting the load.

1. Rotate, extend or move up or down until boom tip is directly over the load.
2. The crane is normally equipped with a rotation stop. It is important that you be aware of the position of the stop before lifting in order to assure maximum rotation and prevent excessive handling of the load.
3. During operations, the controls should always be metered when beginning or terminating movement to prevent sudden starting or stopping, which imposes undue shock loads on the equipment. This is especially true when handling heavy loads. The control should be slightly actuated to begin movement and then slowly increased to desired operating speed. The results obtained from metering the oil flow with the control lever

can also be aided by carefully coordinating the throttle control.

4. Lower loadline and attach load.
5. Control load by use of a non-conductive tag line.
6. Do not leave crane unattended with the boom elevated in operating position. Always secure the boom in the boom rest before leaving the work area.

## SHUTTING DOWN AND PREPARING FOR ROAD TRAVEL

1. Completely retract boom and place securely in boom rest.
2. Secure loadline block so that it cannot swing freely.
3. Anti-Two Block (ATB) Switch to prevent damage to the ATB switch, consider the following:

   With loadline hook stowed properly, verify downhaul weight is resting against the terminator wedge socket bracket. Slack in the chain assembly must be present in order for weight to be removed from ATB switch.

DO NOT SHORTEN CHAIN AT ANYTIME.

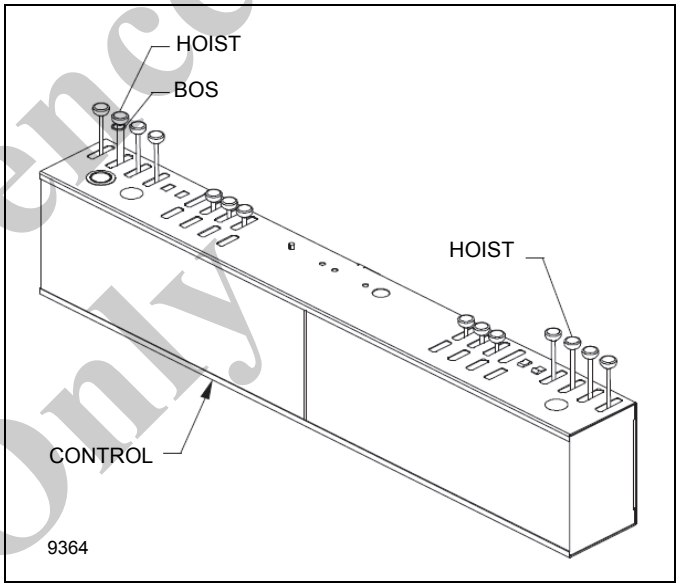
   If slack in the chain assembly is still not present, add straps between anchor point and hook block to achieve weight removal from the ATB switch.

4. Retract all outriggers/stabilizers. Optional front stabilizer should always be retracted first, before main outriggers are retracted.
5. Secure any loads or lifting devices on truck bed or body.
6. Disengage Power Take Off (PTO).
7. Release park brake before moving truck.
8. When traveling on the road, check all underpasses to be sure there is sufficient clearance for the unit.

## OPTIONAL HOIST BURST OF SPEED OPERATION

The “Burst of Speed” will increase hoist line speed 60% over normal operation by diverting oil from the multibank control valve to the hoist valve.

The “BOS” is engaged by operating the hoist control valve lever while pulling up on the BOS handle below the hoist knob. The “BOS” feature should only be operated in a temporary manner to reduce oil heat build up, prevent truck PTO overloading, and provide independent operation of the crane and hoist (normal hoist speed will not decrease when crane functions are used). If the “BOS” feature is run continuously or with an overload, damage to the crane or truck could occur. To start the “BOS” smoothly, first pull up on the BOS handle, then operate the hoist lever. To stop the “BOS” smoothly, return the hoist lever to its neutral position then release the BOS handle.




**Note:** Maximum Capacity with “BOS”

- One Part Line - 3000 lb (1361 kg)
- Two Part Line - 6000 lb (2722 kg)
- Three Part Line - 9000 lb (4082 kg)
- Maximum line speed on third layer - 206 FPM (62 mpm), fourth layer - 225 FPM (68 mpm)

## 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 and stabilizers. The OMS utilizes one sensor in each outrigger and one proximity switch in each horizontally extending stabilizer to identify when the outriggers and stabilizer beams are extended to a point in which they provide maximum stability.

The OMS utilizes an LED indicator to communicate to the operator the position of the outriggers and stabilizers. The Outrigger Status Indicator (1, (Figure 2-5)) is a bi-color LED located at each control station. On older versions of the 800D, when power is on and the outrigger and stabilizer beams are extended to a point at which they provide maximum stability (stabilizers beams shall be fully extended on cranes equipped with Rear Stabilizer Out and Down (RSOD)), the Outrigger Status Indicator illuminates constant GREEN, indicating a lift can be made. If power is on and one or more outrigger or stabilizer 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.

On newer versions of the 800D, the Outrigger Status Indicator illuminates constant RED when power is on and any of the outriggers is not fully extended. A lift should not be made when the indicator is RED. When power is on and all outriggers are fully extended, the indicator changes to constant GREEN, indicating a lift can be made. There is no flashing red state for the Indicator on newer models.

On newer versions of the 800D equipped with the optional RCL system, the outrigger status is displayed on the QScale monitor.



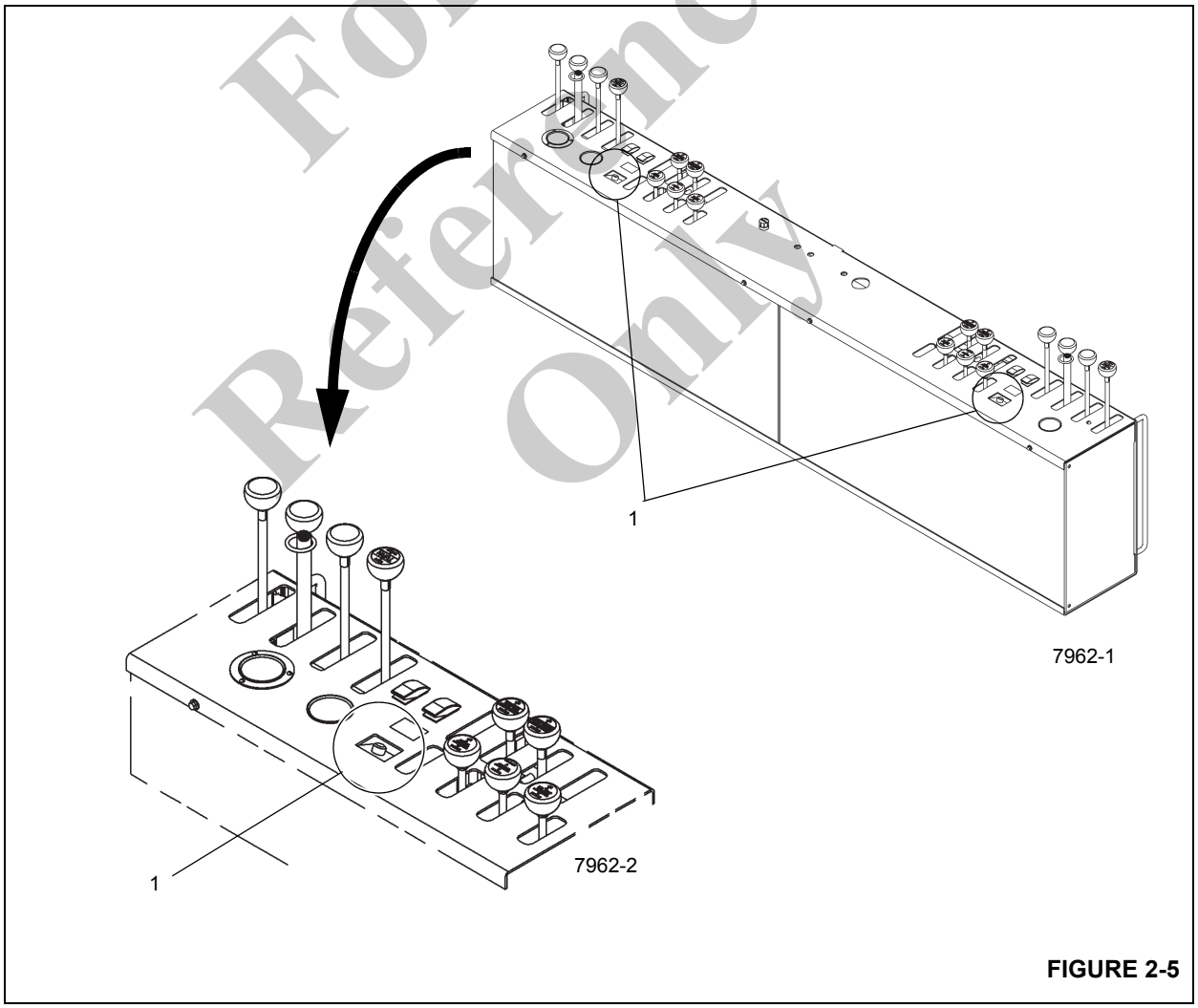



**FIGURE 2-5**

## Maintenance

## Outrigger Cylinder Length Sensor (Version 1)

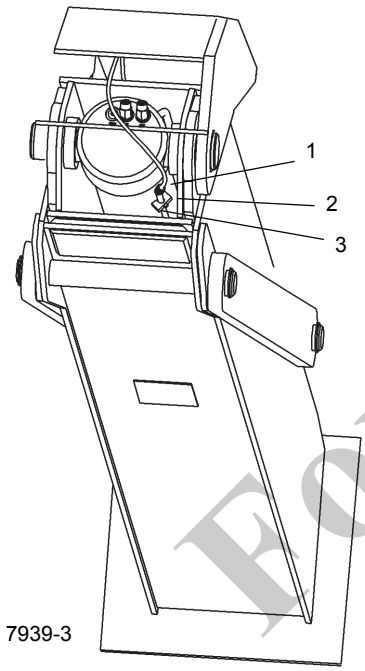



FIGURE 2-6

**Remove**

1. Fully retract outriggers.
2. Disconnect electrical connector (1, Figure 2-6) at sensor.
3. Remove setscrews securing sensor (2) holding plate.
4. Slide sensor (3) out of sensor holding bracket.

**Install**

1. Fully retract outriggers.
2. Slide sensor (3) into holding bracket.
3. Using the two setscrews and sensor holding bracket, (2) secure sensor to the hydraulic cylinder.
4. Connect electrical connector (1) to sensor.
5. Calibrate sensor. Refer to *Calibrate*, page 20.

**Calibrate**

Calibrating the cylinder length sensor requires a laptop equipped with the HED Conductor software and a USB cable connector (p/n 80009992). Contact your National Crane distributor for further assistance.

## Outrigger Proximity Switch (Version 2)

On newer versions of the 800D, the OMS and RCL use proximity switches to determine if the outriggers are fully extended. The switches are located between the operator's cab and A-frame outriggers. The proximity switch (1, Figure 2-7) uses a tab (2) on the outrigger arm to determine when the outrigger is fully extended.

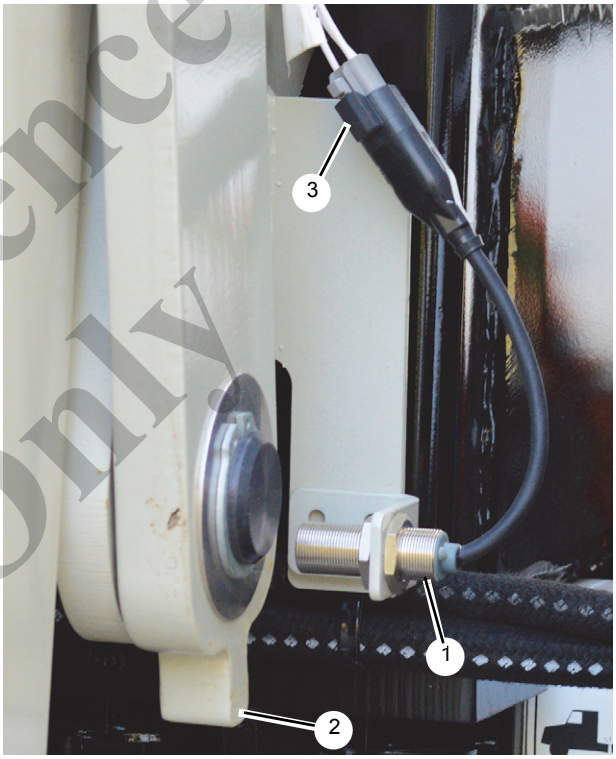



FIGURE 2-7

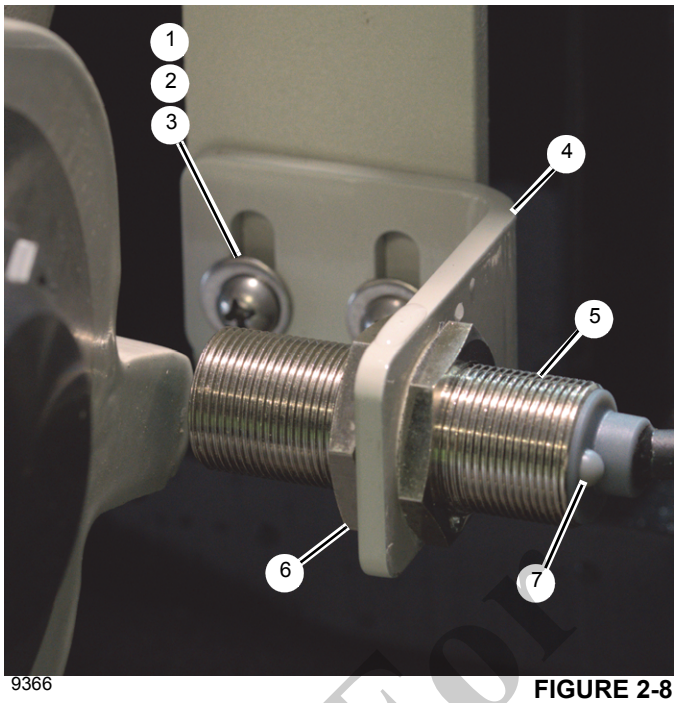



FIGURE 2-8

**Remove**

1. Fully retract the outriggers.
2. Disconnect the proximity switch (1, Figure 2-7) and sensor plug (3).
3. Remove capscrews (1, Figure 2-8), lockwashers (2), and nuts (3) to remove plate (4) and proximity switch (5) from chassis.
4. Loosen jam nuts (6) and remove proximity switch (5) from plate (4).

**Install**

1. Fully retract the outriggers.
2. Install proximity switch (5) on plate (4) using two jam nuts (6).
3. Install switch (5) and plate (4) on chassis using capscrews (1), lockwashers (2), and nuts (3).
4. Connect proximity switch (Figure 2-7) to sensor plug.

**NOTE:** The proximity switch should be a maximum of 6.4 mm (0.25 in.) from the outrigger tab.

5. With power on, fully extend the outriggers. When active, the LED light (7) on the proximity switch illuminates constant yellow. Depending on how the vehicle is equipped, verify that the proximity switch output is working as follows:
   - If equipped with Outrigger Monitoring (OMS) and HCA systems, make sure the outrigger status indicator on the operator's console (1, Figure 2-5) turns from constant red to constant green when the outrigger is fully extended.

or

   - If equipped with an RCL and OMS systems, outrigger status is shown on the QScale monitor. Make sure all outrigger status symbols turn from red to green when the outriggers are fully extended.

## Stabilizer Proximity Switch (version 1)

The following procedures describe maintenance of the proximity switches on the stabilizers located in the rear of the vehicle.

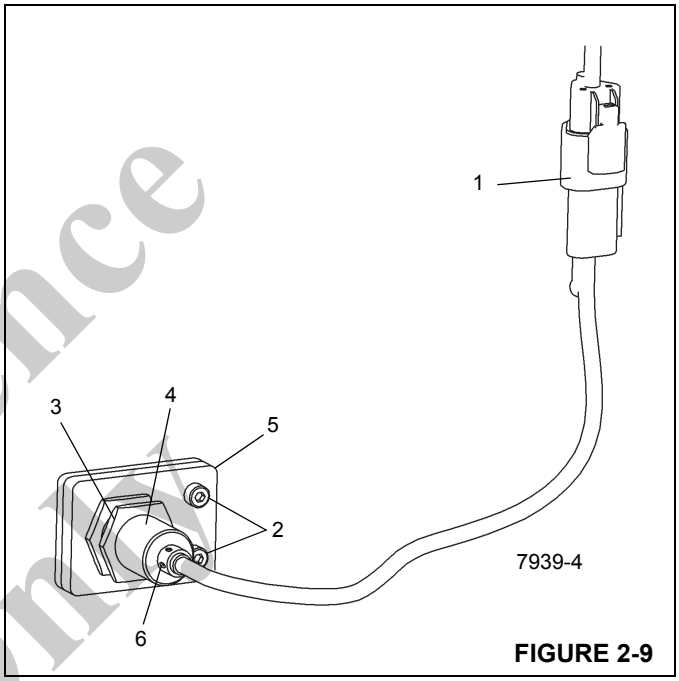



FIGURE 2-9

**Remove**

1. Disconnect electrical connector (1, Figure 2-9) at switch.
2. Remove the two screws (2, Figure 2-9) securing the mounting bracket/switch assembly to the stabilizer box.
3. Loosen jam nut (3, Figure 2-9) securing switch (4) to mounting bracket; remove switch.

**Install**

1. Fully extend stabilizer beam (horizontally).
2. Thread switch (4, Figure 2-9) into mounting bracket (5) so that face of switch protrudes 10 mm through bracket.
3. Using two screws (2, Figure 2-9), secure mounting bracket/switch assembly to stabilizer box.
4. Screw switch into stabilizer box until it contacts the stabilizer wear pad, then un-screw switch three full turns.
5. Tighten jam nut (3, Figure 2-9) on switch.
6. Connect electrical connector (1, Figure 2-9) to switch.

7. With power on and stabilizer beam fully extended, ensure LED (6, Figure 2-9) on proximity switch illuminates. Retract stabilizer beam and ensure LED is not illuminated.

## Stabilizer Proximity Switch (version 2)

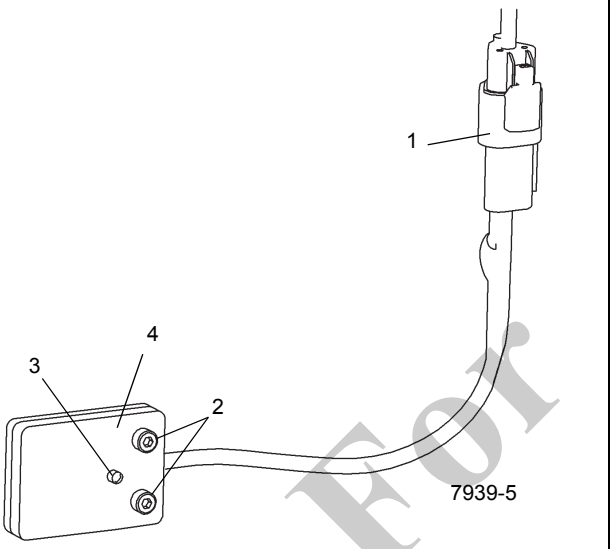



FIGURE 2-10

**Remove**

1. Disconnect electrical connector (1, Figure 2-10) at switch.
2. Remove the two screws (2, Figure 2-10) securing the switch (4) to the stabilizer box. Remove switch.

**Install**

1. Fully extend stabilizer beam (horizontally).
2. Using two screws (2, Figure 2-10) secure the switch (4) to stabilizer box.
3. Connect electrical connector (1, Figure 2-10) to switch.
4. With power on and stabilizer beam fully extended, ensure LED (3, Figure 2-10) on proximity switch illuminates. Retract stabilizer beam and ensure LED is not illuminated.

# ANTI-TWO BLOCK SYSTEM

## Description/Operation

With untrained or inexperienced or distracted operators, two blocking the hoist cable is a very real possibility. When the hoist cable and end attachments contact the underside of the sheave case, whether by hoisting up or extending the boom without paying out the hoist cable, the hoist cable can be damaged by crimping or over tensioning.

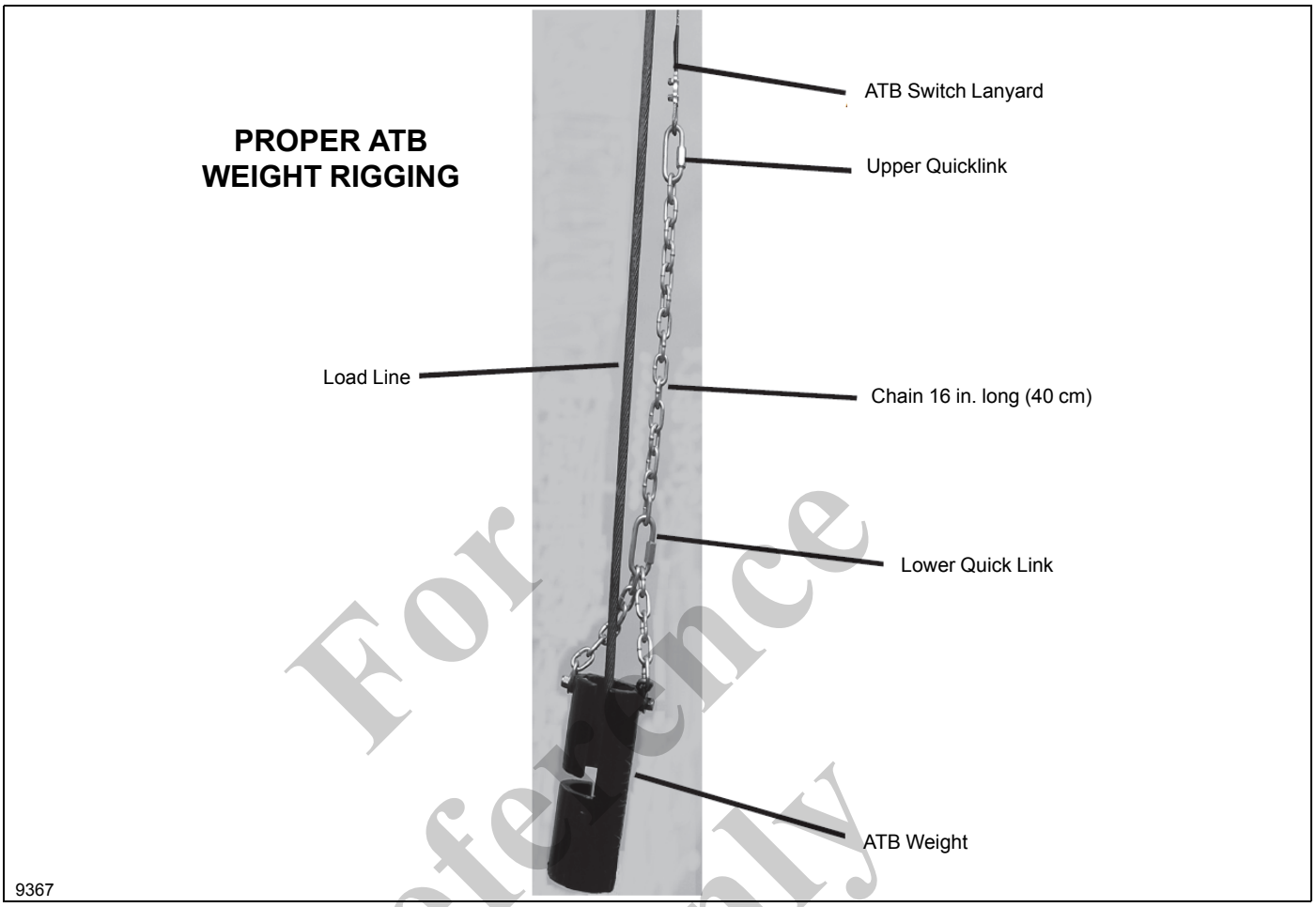
The anti-two-block system provided on your National Crane can help prevent cable damage by sensing the position of the hoist cable end attachments with respect to the sheave case and disabling the functions that can cause a two block condition.

The anti-two-block system consists of normally open, work port unloader valves in the main and hoist control valves. When the cartridge solenoid is energized, the crane functions normally, when de-energized, the oil to the boom extend, boom down, and hoist up crane functions are diverted to tank. These solenoids are controlled by a limit switch, which is attached to the boom or jib sheave case. This switch is held in the closed position by a chain suspended weight. The weight, which is looped around the hoist cable, causes the contacts to remain closed until the hoist cable end attachments contact the weight and release the tension on the switch. At this point the contacts in the switch open, breaking electrical continuity through the circuit provided by the internal anti-two-block cord routed with a reel or through the boom. When this continuity is broken, the unloader cartridges de-energize and divert the function oil to tank.

An audible and visual warning of the two block condition is provided by the display console of the RCL system. See RCL operators handbook for additional information.

If the machine is equipped with an optional Hydraulic Capacity Alert (HCA) system, an indicator light provided on the console will alert the operator when a two block condition is detected.

Normal functioning is restored by hoisting down (or retracting boom) until the weight is once again suspended freely. Occasionally if the hoist up and boom extend functions are operated at maximum speed in the dump mode, the back pressure induced in the circuit will cause the hoist up or boom extend functions to creep slightly (with no load on the hook). Such a condition is not cause for alarm, as the back pressure is not of sufficient magnitude to damage the cable or end connections.






## 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 2-11.

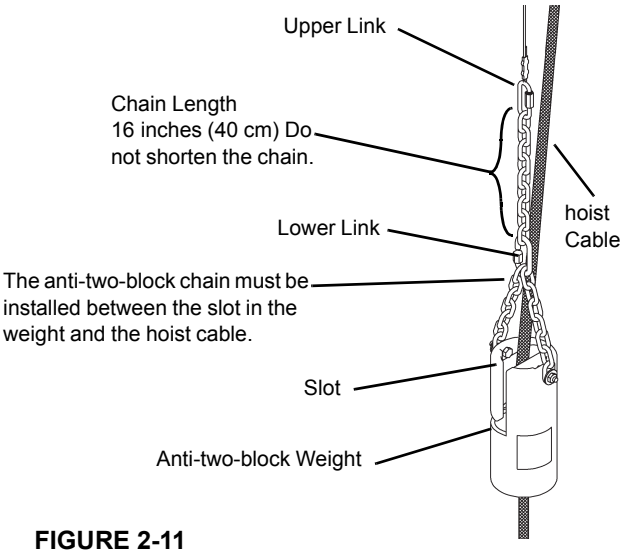



**FIGURE 2-11**

# HYDRAULIC CAPACITY ALERT SYSTEM (OPTIONAL)

## System Description

The hydraulic capacity alert (HCA) system is a hydraulically operated, maximum capacity sensing device that will stop all of the normal crane functions that cause overload when maximum capacity is exceeded. In the event that an over capacity condition occurs, the hydraulic capacity alert system is actuated by sensing excessive pressure in the lift cylinder which causes the boom down, extend out and hoist up functions to become inoperative. These are the functions that increase the over capacity condition. This system allows for continued operation of the hoist down, boom up and boom retract functions, the functions that normally allow the operator to bring the load to a shorter operating radius or set the load down in order to eliminate an over capacity condition. Once the excessive cylinder pressure has been reduced by bringing the load to a shorter radius or setting the load down, normal operation can be resumed. This hydraulic capacity alert system uses the work port unloader solenoids in the anti-two-block system as the hydraulic system dump circuit.

The hydraulic capacity alert system has an override switch or button located on the operator's console that momentarily overrides the hydraulic capacity alert and anti-two-block systems and restores power to crane functions. Two indicator lights located near the override alert the operator of function power loss and discriminate between the hydraulic capacity alert and the anti-two-block systems as the cause of power loss. If crane is equipped with optional audible alert, an audible alarm will sound in an overload condition. **Do not use the override to continue lifting operations in an overload or two blocked condition**.

HYDRAULIC CAPACITY ALERT
ANTI-TWO-BLOCK
OVERRIDE

**⚠ DANGER**

HOLDING THIS OVERRIDE TO
INCREASE LOADING OR TWO BLOCK
THE CRANE WILL RESULT IN
**DEATH OR SERIOUS INJURY**
TO CORRECT THE CONDITION CAUSING
THE CRANE SHUTDOWN REFER
TO OWNERS MANUAL

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The hydraulic capacity alert system provides a load range gauge at each operator station. This gauge has three colors on the dial face: (1) Green - OK; (2) Yellow - Caution; and (3) Red - Overload. The gauge is plumbed directly to the lift cylinder and the indicator position can be used as an aid in determining the load condition of the crane. The lift control lever must be moved from boom up position to the neutral position to get the most accurate reading when using load range gauge. **Do not use the load range gauge with a jib or personnel basket**.

## System Operation

The capacity alert system will operate as stated in the System Description Section. Once an over-capacity condition is reached, the system will not allow the operator to move the load to a greater radius. The truck may have to be repositioned closer to the load in order to set the load at the desired location.

When trip pressure is reached, the pressure sensing switch breaks electrical continuity to the work port unloader solenoid in the main control valve. When power is removed from this solenoid, the unloader valves allow the oil flowing to hoist up, telescope out and boom down to flow to tank. This path to tank will prevent further operation of these functions. When the overload condition is corrected by hoisting down, retracting the boom, or raising the boom, the pressure sensing switch allows the work port unloader solenoids to be powered thereby allowing the crane to function normally.

During the operation at near capacity loads, care must be taken to operate the controls smoothly or the system may be shocked into the dump mode prematurely.

Caution should be exercised when operating near 80° of boom elevation. If the boom lift cylinder is fully extended and pressurized above trip pressure, the system solenoid will deactivate and the boom will remain locked at 80°. To correct this condition, momentarily actuate the override switch and boom down approximately 5°. Some units may be equipped with a Manual Reset Valve Option that can be used to unlock the unit from 80°. See Controls & Hydraulics Section for additional description of this system.

On older models, the override system consists of a key switch and a momentary push button switch. The key switch provides power to the momentary push button switch located on the console. To momentarily override, activate key switch and depress push button on console. This will activate the anti-two-block solenoid and return power to hoist up, telescope out, and boom down functions. The override switch is not to be used during normal use of the crane or as an aid in using the crane in an overload or anti-two blocked condition.

On newer models, the override key switch and momentary override button operate independently. The override key switch (Figure 2-12) overrides the HCA and ATB systems continuously, restoring power to crane functions so long as the key in the activated position. The momentary override button (Figure 2-13) overrides the systems only so long as the button is depressed.

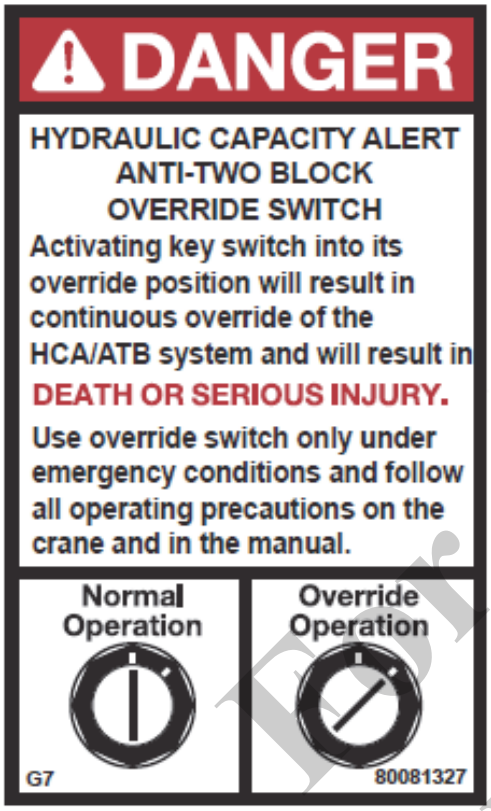


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**FIGURE 2-12**

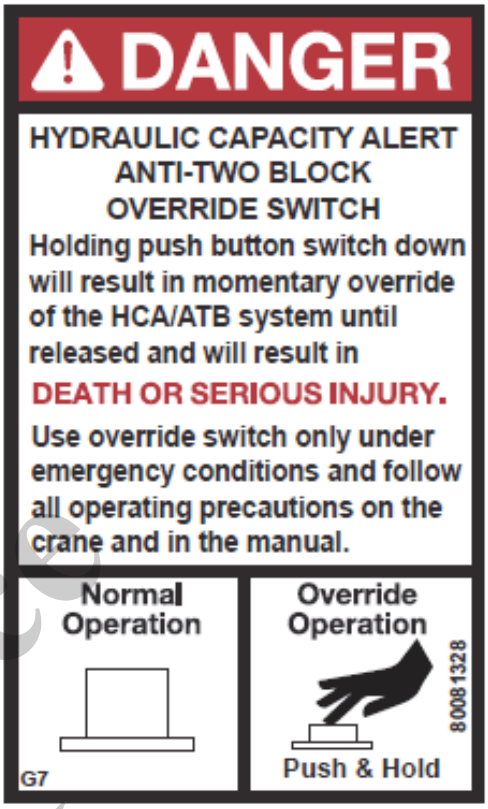


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**FIGURE 2-13**

The load range gauge is provided to aid the operator when operating near the rated capacity of the crane. The gauge only provides accurate indication when the lift control lever is in neutral. The gauge movement is not proportional to the load on the hook. It is not unusual for the indicator to be in the red area at less than rated load condition when operating the lift control, especially during boom down operation.

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**⚠CAUTION**

The RCL or (optional) Hydraulic Capacity Alert Systems are intended to be used as aids to prevent most overload conditions. **Do not use the RCL or (optional) Hydraulic Capacity Alert System as substitutes for safe operating practices as outlined in the "*Safety Information*" section of this manual.**

**Do not expect the RCL or (optional) Hydraulic Capacity Alert System to detect all possible overload conditions.** They **will not** prevent structural or stability overloads to the crane or winch caused by:

1. Freely swinging loads or operating in an out-of-level condition which will result in excessive side loading.
2. Side loading due to pulling sideways on the boom with boom rotation or load hoist. Load must always be directly under boom tip.
3. Sudden load movements from erratic operation of the crane functions which will result in excessive shock loading.
4. Improper loadline reeving for loads larger than single line pull capacity.
5. Extending the boom without first paying out the loadline which can result in deadheading (two blocking) the loadline against the boom tip.
6. Loads in excess of capacity when operating with a jib deployed.
7. Loads with lift cylinder fully retracted.
8. Excessive induced loading during auger system operation.
9. Operation without outriggers and stabilizers fully deployed or inadequate footing for the outriggers and stabilizers.

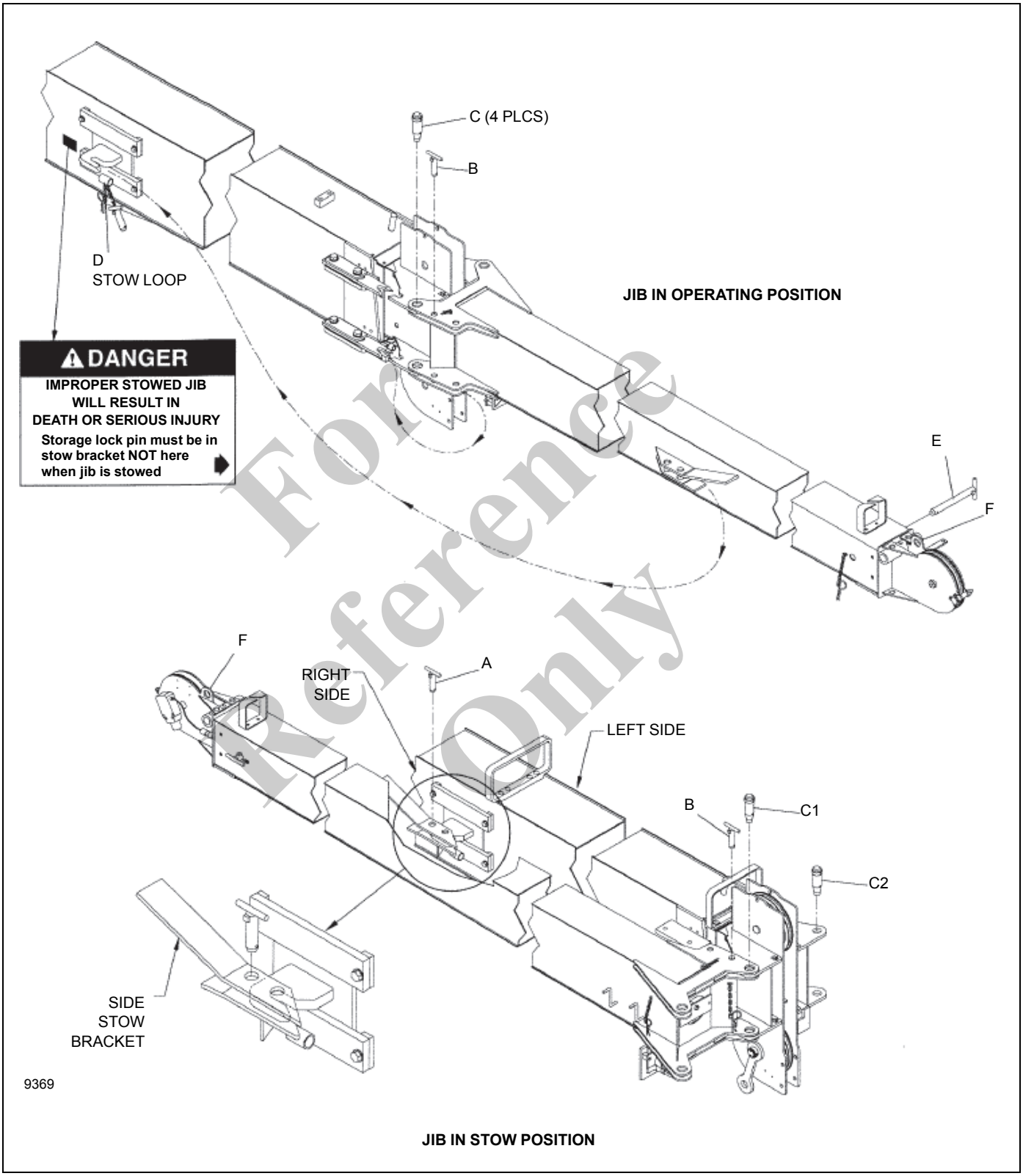
**Note: The 800D must have an RCL system if equipped with jib or personnel platform options.**

**⚠DANGER**

## JIB OPERATIONS

**The Capacity Alert System does not provide accurate indication of overload conditions when operating with a jib deployed. Reliance upon the system to warn of overload with the jib deployed** (or other excepted overload conditions) **can result in structural damage, instability, injury and death. The operator must always know the weight of the load to be lifted, insure that the loadline reeving is correct for the size of the load, and operate the machine within its rated capacity in a safe, smooth manner according to the instructions outlined in the "*JIB Safety and Operation*" section of this manual**

## JIB SAFETY AND OPERATION



## Safety Tips For Jib Operation

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.
4. When radius is between points listed on capacity chart, the load shown at the next longer radius shall be used.
5. Operate with jib by boom angle when main boom is not fully extended. Do not exceed rated jib capacities at any reduced boom lengths.
6. When angle is between points listed on capacity chart, the load shown at next lower boom angle shall be used.
7. Ensure jib is stowed correctly.
8. Removal of swing around pins, C, without proper installation of stow pin A and pin B, may allow jib to fall off.
9. Extending boom with jib stowed and failure to remove swing pin, C, will damage unit upon extension.
10. Attempt to only the swing jib to working or stowed position when boom is horizontal, stow pin A and pin B, are removed and swing pins, C, are in place. Jib could swing uncontrollably if boom is not horizontal.
11. Crane shall be fully set-up according to proper set-up procedures outlined previously when stowing or unstowing jib.
12. Operate boom and turn functions very slowly and carefully when using jib since jibs can increase boom length by 50%.
13. Area where jib swings around must be clear of obstructions and power lines when stowing and unstowing jib.
14. Use safety glasses when pounding pins with hammer.
15. Do not extend/retract boom unless boom is horizontal when stow pin A and pin B are removed during stowing or unstowing procedures.
16. Always put spring clips in pins to ensure that they will stay in place.
17. When the jib is stowed, the boom can not be fully retracted if a boom tip attachment option is installed.

**⚠ CAUTION**

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

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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 1 st section jib when pin, E, is removed. Keep personnel clear of area.

## Side Folding-swing Around Jib Operation

**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.

**Deployment Procedure**

1. Using boom telescope function, fully retract boom.
2. Using lift function, lower boom to allow for easier access to jib deployment pins C1 and C2.
3. Install pins C1 in upper and lower jib ears. Install retainer spring clips. These pins will be 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 t-handle Pin B from top ear of jib.
6. Remove stow Pin A from ramp/bracket assembly on jib and stow in Stow Loop D and install spring clip.
7. Using lift function, raise boom to a horizontal position.
8. Attach tag line to sheave case end of jib.
9. Using telescope function, slowly extend boom approximately one foot. This procedure will pull the jib out of the stow bracket.

**⚠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 keeper. 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 keeper.
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 weight/chain assembly from boom tip switch and install on jib tip 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 pin B and keeper into jib ears.
19. Unwrap ATB cord on side of jib to allow manually extending jibs to be deployed without damage to the cord.
20. For manually extendable jibs, pull extension retention 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 and keeper.
21. Make ATB cord connections as required.

**Stowing Procedure**

1. Using lift function, lower boom so that jib tip is close to the ground.
2. For manually extendable jibs, pull extension retention 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 attachment point F on the jib sheave case. Slowly activate the hoist up function until the 2nd section is fully retracted
3. Reinstall extension retention 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 anti-two-block weight assembly to boom tip switch.
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 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. Utilization of the jib jack at this time will aid in pin hole alignment to facilitate pin removal.
9. Using lift function, raise boom to a horizontal position.
10. Using extend function, extend boom approximately 1 foot.
11. Using tag line attached to jib sheave case, slowly swing jib into stow position (parallel with 1 st 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.**

12. Install t-handle pin B through jib ear and boom sheave case holes. This pin will keep the jib assembly in line (parallel) with the 1st section boom. Pin B **does not** retain the jib in its stowed position on the 1st section boom.
13. Using boom telescope function, slowly retract boom. The ramp/bracket assembly on the side of the 1 st section jib will engage the hook on the side of the 1st section boom, first lifting the jib and then engaging the jib stow bracket and the boom hook completely upon full retraction of the boom.
14. Install stow pin A with spring clip into the ramp/ bracket assembly on the jib. Complete engagement of stow brackets and proper installation of pin A is critical for secure jib stow attachment.
15. 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.
16. Reinstall loadline over boom sheave case.

**⚠CAUTION**

**Visually check all pin positions to assure jib is fully retracted into stow brackets, jib stow attachment is secure, and all pins and safety clips are in their proper locations.**

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

- **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.**

## Jib Maintenance

1. Lubricate sheave pin on jib with grease gun containing chassis grease weekly.
2. Check for free rotation of jib sheave daily when using jib.

## Jib Jack

## Operation

The jib pin alignment device consists of a hydraulic jack mounted horizontally on the underside of the jib. A handle for the jack is provided and is installed above the jack on the side of the jib.

The purpose of the jib pin alignment device is to aid in installing the fourth or “last” jib pin when setting up a jib. This device has been designed to line up the bottom jib pin hole on the left side of the crane.

To use the device, follow the proper procedure outlined in the Owner’s Manual to install both jib pins on the right side of crane and the top pin on the left side. Next remove jack handle and using the flattened end, close jack release valve by turning handle clockwise until it is firmly closed. Insert the round end of the handle into the handle sleeve and pump jack until ram contacts boom sheave case. Continue to pump slowly until jib pin hole is exactly aligned with hole in boom ear. At this time the final jib pin can be easily tapped into position.

If hole alignment is “over shot” due to jacking too far, the jack can simply be relieved and the process repeated. To relieve the jack, use the flattened end of jack handle to slowly turn relief valve counter-clockwise no more than one full turn.

After all jib pins are installed, relieve jack. The jib pin alignment device is also useful when removing the “fourth” pin. Use the jib jack to relieve jib weight induced pressure on the “fourth” pin and it will be much easier to remove.

Once the jib has been erected or stowed, it is important that the jack handle be properly placed back on its stowage hooks and that the cotter key be properly placed in the stowage hook to retain the handle on the hook.

**Important: Avoid “shock loads” created by quickly opening and closing the release while jack is under load. This may result in overloading of the hydraulic circuit and possible damage to the jack.**

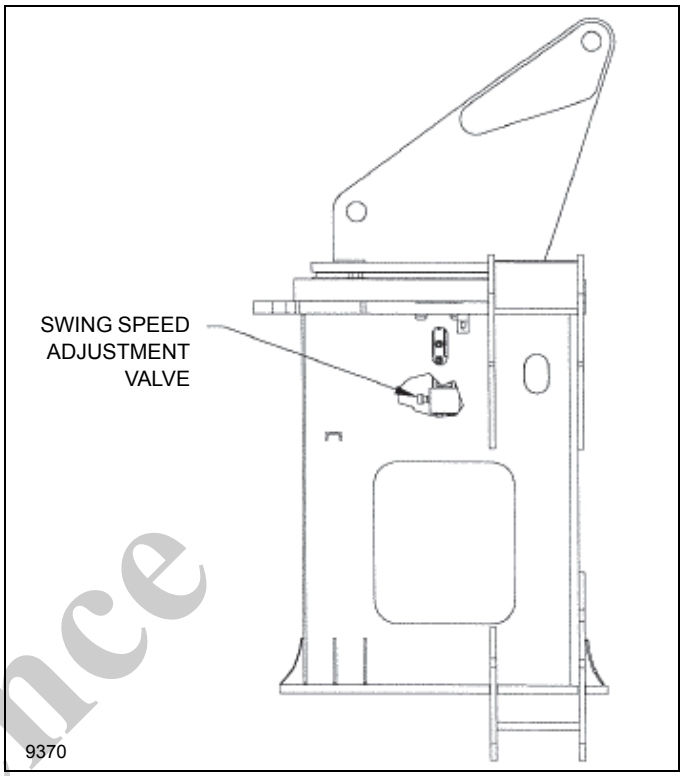
When jib is stowed on side of crane, always leave ram and handle sleeve pushed all the way down to reduce exposure to rusting.

## ADJUSTABLE SWING SPEED VALVE

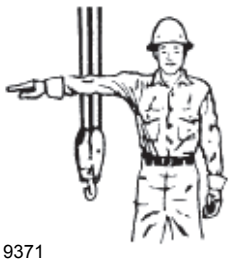
The Series 800D is equipped with an adjustable swing speed valve. This valve allows the operator to limit the maximum swing speed of the machine to suit operator preference or varying applications.

An adjustment dial is located on the swing holding valve mounted on the swing motor inside the crane frame. The valve has an adjustment screw with a lock collar. Loosen the lock collar when adjusting the speed, then tighten the lock collar to maintain swing speed limit setting. Turning the knob counter-clockwise reduces the rotation speed. The adjustment dial allows the maximum swing speed to be reduced as follows:

| Number of Turns | Approximate Max. Swing Speed (375° Rotation) | Percent Full Speed |
|---|---|---|
| Closed | 45 sec | 100% |
| 1 | 48 sec | 90% |
| 2 | 53 sec | 80% |
| 3 | 61 sec | 70% |
| 4 | 89 sec | 50% |

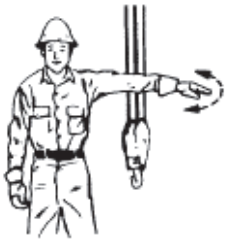


# STANDARD HAND SIGNALS FOR CONTROLLING CRANE OPERATIONS

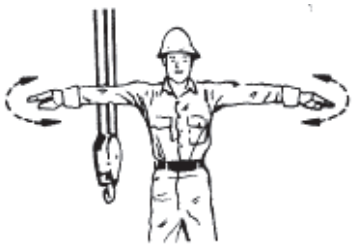


9371

**SWING.** Arm extended, point with finger in direction of swing of boom.



**STOP.** Arm extended, palm down, move arm back and forth horizontally.



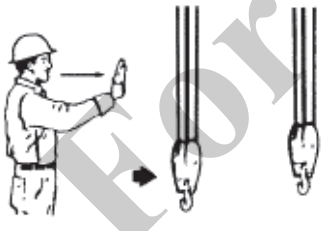
**EMERGENCY STOP.** Both arms extended, palms down, move arms back and forth horizontally.

**HOIST.** With forearm vertical, forefinger pointing up, move hand in small horizontal circle.

**LOWER.** With arm extended downward, forefinger pointing down, move hand in small horizontal circle.

9372

**USE MAIN HOIST.** Tap fist on head; then use regular signals.

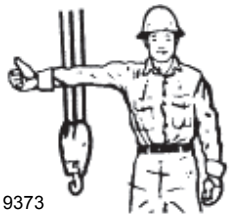


**TRAVEL.** Arm extended forward, hand open and slightly raised, making pushing motion in direction of travel.

**DOG EVERYTHING.** Clasp hands in front of body.

**TRAVEL (Both Tracks).** Use both fists in front of body, making a circular motion about each other, indicating direction of travel, forward or backward. (For land cranes only.)

**USE WHIPLINE (Auxiliary Hoist).** Tap elbow with one hand; then use regular signals,

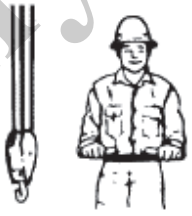


9373

**RAISE BOOM.** Arm extended, fingers closed, thumb pointing upward.

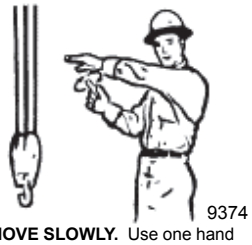
**LOWER BOOM.** Arm extended, fingers closed, thumb pointing downward.

**TRAVEL (One Track).** Lock the track on side indicated by raised fist. Travel opposite track in direction indicated by circular motion of other fist, rotated vertically in front of body. (For land cranes only)



**RETRACT BOOM (Telescoping Booms).** Both fists in front of body with thumbs pointing toward each other.

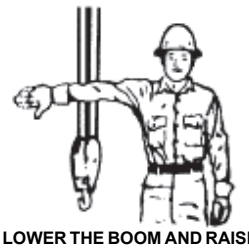
**EXTEND BOOM (Telescoping Booms).** Both fists in front of body with thumbs pointing outward,



9374

**MOVE SLOWLY.** Use one hand to give any motion signal and place other hand motionless in front of hand giving the motion signal. (Hoist slowly shown as example.)

**RAISE THE BOOM AND LOWER THE LOAD.** With arm extended, thumb pointing up, flex fingers in and out as long as load movement is desired.



**LOWER THE BOOM AND RAISE THE LOAD.** With arm extended, thumb pointing down, flex fingers in and out as long as load movement is desired.

**EXTRACTED FROM ANSI STANDARD ASME B30.5 - 2000 THIS COMPLIES WITH OSHA STANDARDS**

# SECTION 3
# MAINTENANCE

## SECTION CONTENTS





## INSPECTION AND MAINTENANCE

A regular schedule of inspection and maintenance is essential to keep your unit in peak operating efficiency. Operators or service personnel responsible for the care of the unit must be completely familiar with the type and frequency of inspections and maintenance operations. The following pages outline the inspections and maintenance required to keep the crane in proper operating condition.

### Inspection

The following pages list inspections which are to be conducted on your unit to help assure it is operating properly and safely. Check all items listed at the frequency listed and make necessary repairs prior to operating. Use applicable torque table requirements for missing or loose fasteners.

The inspections are separated into the following frequency classifications:

- **Daily Inspections-**These items should be visually inspected each day by the operator prior to using the unit.
- **Weekly Inspections-**These items should be visually inspected weekly by the operator.
- **Monthly Inspections-**These inspections are to be performed monthly by the personnel responsible for maintenance and service of the crane.
- **Periodic Inspections-**This inspection is a thorough inspection conducted at least every three months and includes all items listed under Daily, Weekly, and Monthly Inspection in addition to those items listed under periodic inspection. Federal Laws through OSHA and ANSI B30.5 require that dated and signed records of these periodic inspections be kept. A crane inspection log book is available from National Crane to assist you in keeping records.

### 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.
6. Condition of tires and suspension.
7. Condition of loadline and end attachment for corrosion, severe kinking, crushing, cutting, or slippage of cable clamps or wedge socket.
8. Loose parts or damage to loadline centering blocks.
9. Position of loadline with guides and on sheaves.
10. Free turning of sheaves.
11. Lubrication of points required by Lubrication Chart For more information, see *Lubrication Chart*, page 4-4.
12. Evidence of oil leak from hoses, gearboxes or swivel.
13. Hand and foot controls for malfunction or misadjustment.
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 overload and anti-two-block operator aid system to include switch, weight and chain at boom tip (and jib tip if equipped), power cords and indicator lights on console. Cycle slowly to check for proper operation.
18. Presence and proper operation of load hook safety latch.
19. All drain holes at rear of first section boom are clear of all obstructions.
20. All fasteners retaining loadline centering block are in place and tight.
21. All safety covers for proper installation.

## Weekly Inspections

Check the following items:

1. Battery water level.
2. Tire pressure.
3. Lubrication of points required by *Lubrication Chart*, page 4-4.
4. Boom lift and outrigger holding valves for proper operation.
5. Torque mounting bolts during first month of operation of machine and then during periodic inspections thereafter.
6. Hoist brake for proper operation at hoist capacity load.
7. Torque boom wear pad retaining bolts during first month of operation, then monthly thereafter.
8. Check to see that crane Owner's Manual is with the unit. If not, obtain serial number of unit and order manual immediately.

### Monthly Inspections

Check the following items:

1. All cylinders and valves for signs of leaks.
2. Lubrication of points required by *Lubrication Chart*, page 4-4.
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 (129 Nm).
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 rope maintenance procedure.

## Periodic 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 overfull range.
5. Hydraulic systems for proper operating pressure.
6. Lift and outrigger/stabilizer cylinders for drift caused by oil leaking around piston.
7. Cylinders for:

a. Damaged rods

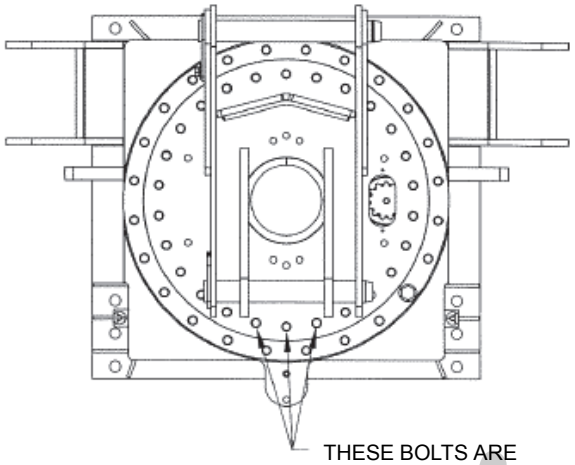
b. Dented barrels

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). The three turret to rotation bearing capscrews at the front edge cannot be torqued without a special tool or removal of the lift cylinder. These should be torqued anytime that the lift cylinder is removed for service. It is not required to torque the bolts at these three locations

as part of the periodic inspection, although an end wrench should be used to verify that they are tight.




## Other

1. Stability of unit throughout working area. Check stability procedure in Installation Section annually or when any change is made to crane or truck.
2. If the boom has not been disassembled and inspected in the last seven years or 3,000 hours of use, the boom is to be completely torn down to allow a thorough inspection of the extend and retract cables, sheaves, and pins.

# HOIST CABLE INSPECTION AND MAINTENANCE

**⚠ 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.

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

**NOTE:** Wire rope may be purchased through Manitowoc Crane Care.

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

## Keeping Records

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

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

## Environmental Conditions

The life expectancy of wire rope may vary due to the degree of environmental hostility and other conditions to which these mechanical devices are subjected. Variation in temperature, continuous excessive moisture levels, exposure to corrosive chemicals or vapors or subjecting the wire rope to abrasive material may shorten normal wire rope life. Frequent/periodic inspections and maintenance of wire rope is recommended for preventing premature wear and to insure long-term satisfactory performance.

**NOTE:** Refer to *Wire Rope Lubrication*, page 4-3 for wire rope lubrication requirements.

## Dynamic Shock Loads

Subjecting wire rope to abnormal loads beyond the endurance limit will shorten the wire rope life expectancy. Examples of this type of loading are listed below.

- High velocity movement, for example; hoisting or swinging of a load followed by abrupt stops.
- Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
- Lifting a load that is beyond the rated capacity of the lifting mechanism, such as overloading.

## Precautions and Recommendations During Inspection

- Always use safety glasses for eye protection.
- Wear protective clothing, gloves, and safety shoes as appropriate.
- Measure the rope's diameter across crowns of the strands when determining if rope has become damaged, refer to Figure 3-1.

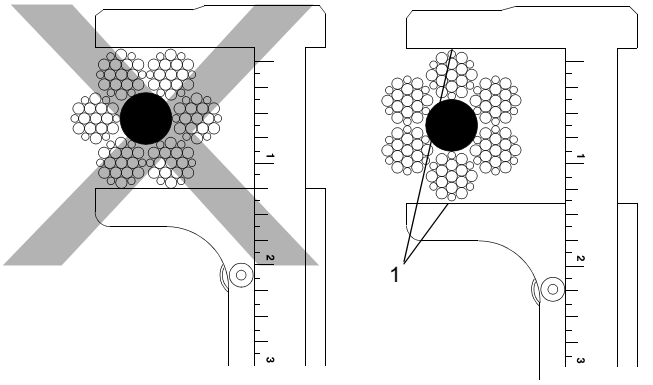



FIGURE 3-1

## Inspection

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.
- Significant 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.
- Significantly corroded, cracked, bent, or worn end connections.

Inspect only the outer surface of a cable. Never attempt to open the cable.

Pay particular attention to areas of the rope where wear and other damage is likely to occur:

- Pick-up Points: Sections of wire rope that are repeatedly stressed during each lift, such as those sections in contact with sheaves.
- End Attachments: The point where a fitting is attached to the wire rope or the point where the wire rope is attached to the hoist drum.
- Abuse Points: The point where the wire rope is subjected to abnormal scuffing and scraping.

### *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*

Wire rope should be inspected periodically/annually, or at a shorter time interval, if necessitated by environmental or other adverse conditions, and shall cover the entire length of the wire rope. Periodic inspection should include all previous items listed under *Inspection*, plus the following:

- Inspect for severely corroded or broken wires at end connections.
- Inspect wire rope in areas subjected to rapid deterioration such as:
  - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.
  - Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
- Inspect boom nose sheaves, hook block sheaves, boom extension/extension sheaves, auxiliary boom nose sheaves, and hoist drums for wear. Damaged sheaves or hoist drums can accelerate wear and cause rapid deterioration of the wire rope.

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.

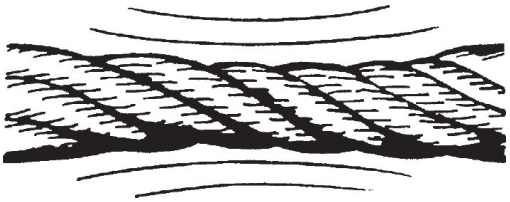
## Wire Rope Replacement

No precise rules can be given for determination of the exact time for replacement of wire rope since many variable factors are involved. Determination regarding continued use or replacement of wire rope depends largely upon the good judgment of an appointed and qualified person who evaluates the remaining strength in a used rope after allowance for any deterioration disclosed by inspection.

Wire rope replacement should be determined by the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies and as recommended by National Crane. All wire rope will eventually deteriorate to a point where it is no longer usable.

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

- In rotation resistant ropes: two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- Severe corrosion as evidenced by pitting
- 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 5%.
- One outer wire broken at its point of contact with the core of the rope which has worked its way out of, and protrudes or loops out from the rope structure.
- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
- National Crane recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- National Crane recommends that boom extension cables be replaced every seven (7) years.

## Adjustments and Repairs

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

1. A warning tag should be placed in a conspicuous place at the controls stating that the machine requires adjustment or repair before it can be operated.
2. The crane should be placed where it will cause the least interference with other equipment or operations in the area.
3. All controls at the OFF position and all operating features secured from inadvertent motion by brakes or other means.
4. All methods used to start the truck's engine rendered inoperative.
5. Power plant stopped or disconnected at take off.
6. Boom lowered to the ground or otherwise secured against dropping.
7. Load block lowered to ground or otherwise secured against dropping.
8. Relieve hydraulic oil pressure from all hydraulic circuits before loosening or removing hydraulic components.

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

Any hazardous conditions disclosed by the inspection requirements listed above shall be corrected before operation of the crane is resumed. Adjustments and repairs shall be done only by designated personnel who are properly trained. Use only National Crane supplied parts to repair the crane.

## Seizing Wire Rope

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

The two preferred methods for seizing wire ropes are:

***Method 1***

Using a length of soft annealed wire Figure 3-2, place one end in the groove between two strands of the wire rope. Turn the long end of the annealed wire at right angles to the wire and wrap it tightly over the portion in the groove.

The two ends of the annealed wire should be twisted together tightly. Cut off the excess wire and pound the twist flat against the wire rope.

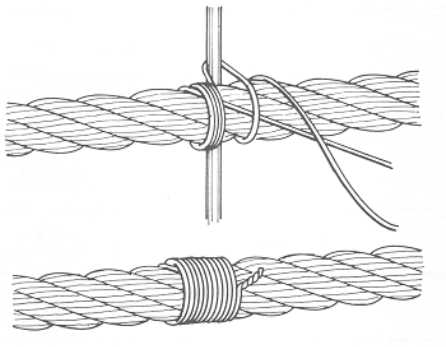


**FIGURE 3-2**

***Method 2***

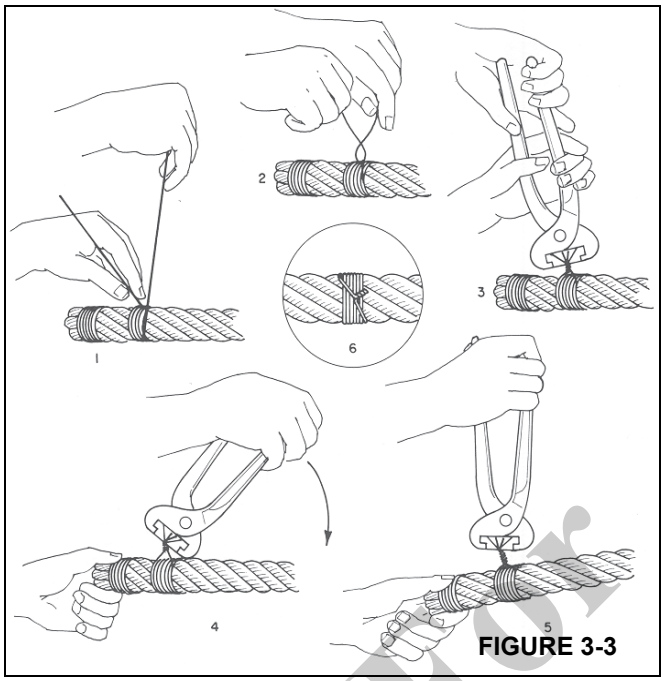



**FIGURE 3-3**

Wind a length of soft annealed wire Figure 3-3 around the wire rope at least seven times. The two ends should be twisted together in the center of the seizing. Tighten the seizing by alternately prying and twisting. Cut off both ends of the wire and pound the twist flat against the rope.

**NOTE:** Non-preformed wire rope (1) Figure 3-4 should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

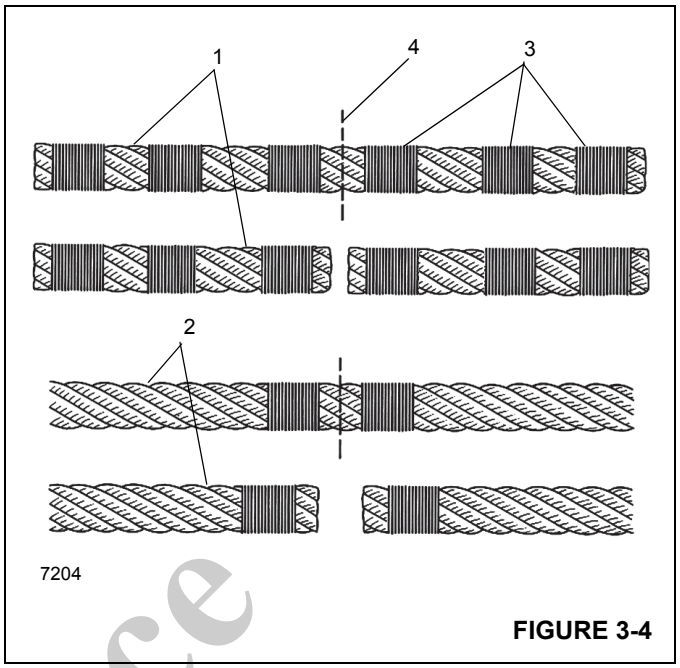



**FIGURE 3-4**

## 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.

## 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 pressures.

**TIRE LOAD AND INFLATION TABLES**

Tire and Rim Association Standard Tire Loads At Various Inflation Pressures.
Load Range Letters and Corresponding Ply Rating

**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**

**TIRES FOR TRUCKS IN NORMAL HIGHWAY SERVICE**
**(TIRES MOUNTED ON 15° DROP CENTER RIMS)**

| TIRE SIZE DESIG-NATION | USAGE | TIRE LOAD LIMITS, LB (kg), AT VARIOUS COLD INFLATION PRESSURES, PSI (kPa) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RADIAL PLY | | | | | | | | | | | | |
| | | 60 (414) | 65 (448) | 70 (483) | 75 (517) | 80 (552) | 85 (586) | 90 (621) | 95 (655) | 100 (690) | 105 (724) | 110 (758) | 115 (793) | 120 (827) |
| 9*22.5 | DUAL | 2960 (1343) | 3120 (1415) | 3270 (1483) | 3410 (1547) | ***3550 (E) (1610) (E)*** | 3690 (1674) | 3820 (1738) | ***3950 (E) (1792) (E)*** | 4070 (1846) | 4200 (1905) | ***4320 (G) (1960) (G)*** | | |
| | SINGLE | 3010 (1365) | 3190 (1447) | 3370 (1529) | 3560 (1615) | 3730 (1692) | 3890 (1764) | ***4050 (E) (1837) (E)*** | 4210 (1910) | 4350 (1973) | ***4500 (F) (2041) (F)*** | 4640 (2105) | 4790 (2173) | ***4920 (G) (2232) (G)*** |
| 10*22.5 | DUAL | 3510 (1592) | 3690 (1674) | 3870 (1755) | ***4040 (E) (1833) (E)*** | 4200 (1905) | 4360 (1978) | ***4520 (F) (2050) (F)*** | 4670 (2118) | 4820 (2186) | ***4970 (G) (2254) (G)*** | | | |
| | SINGLE | 3560 (1615) | 3770 (1710) | 4000 (1814) | 4210 (1910) | 4410 (2000) | ***4610 (E) (2091) (E)*** | 4790 (2173) | 4970 (2254) | ***5150 (F) (2336) (F)*** | 5320 (2413) | 5490 (2490) | ***5670 (G) (2572) (G)*** | |
| 11*22.5 | DUAL | | | 4380 (1987) | 4580 (2077) | ***4760 (F) (2159) (F)*** | 4950 (2245) | 5120 (2322) | ***5300 (G) (2404) (G)*** | 5470 (2481) | 5630 (2554) | ***5800 (H) (2631) (H)*** | | |
| | SINGLE | | | 4530 (2055) | 4770 (2164) | 4990 (2263) | 5220 (2368) | ***5430 (F) (2463) (F)*** | 5640 (2558) | 5840 (2649) | ***6040 (G) (2740) (G)*** | 6240 (2830) | 6430 (2917) | ***6610 (H) (2998) (H)*** |
| 11*24.5 | DUAL | | | 4660 (2114) | 4870 (2209) | ***5070 (F) (2300) (F)*** | 5260 (2386) | 5450 (2472) | ***5640 (G) (2558) (G)*** | 5820 (2640) | 6000 (2722) | ***6170 (H) (2799) (H)*** | | |
| | SINGLE | | | 4820 (2186) | 5070 (2300) | 5310 (2409) | 5550 (2517) | ***5780 (F) (2622) (F)*** | 6000 (2722) | 6210 (2817) | ***6430 (G) (2917) (G)*** | 6630 (3007) | 6840 (3103) | ***7030 (H) (3189) (H)*** |
| 12*22.5 | DUAL | | | 4780 (2168) | 4990 (2263) | ***5190 (F) (2354) (F)*** | 5390 (2445) | 5590 (2536) | ***5780 (G) (2622) (G)*** | 5960 (2703) | 6150 (2790) | ***6320 (H) (2867) (H)*** | | |
| | SINGLE | | | 4940 (2241) | 5200 (2359) | 5450 (2472) | 5690 (2581) | ***5920 (F) (2685) (F)*** | 6140 (2785) | 6370 (2889) | ***6590 (G) (2989) (G)*** | 6790 (3080) | 7010 (3180) | ***7200 (H) (3266) (H)*** |
| 12*24.5 | DUAL | | | 5080 (2304) | 5300 (2404) | ***5520 (F) (2504) (F)*** | 5730 (2599) | 5940 (2694) | ***6140 (G) (2785) (G)*** | 6330 (2871) | 6530 (2962) | ***6720 (H) (3048) (H)*** | | |
| | SINGLE | | | 5240 (2377) | 5520 (2504) | 5790 (2626) | 6040 (2740) | ***6290 (F) (2583) (F)*** | 6530 (2962) | 6770 (3071) | ***7000 (G) (3175) (G)*** | 7220 (3275) | 7440 (3375) | ***7660 (H) (3475) (H)*** |

** Tire size designation will include “R” (Radial Ply)*
*NOTE: Letters in parentheses denote Load Range for which Bold Face Loads are maximum*

## WIDE BASE RADIAL TIRES FOR TRUCKS IN NORMAL HIGHWAY SERVICE
### (TIRES USED AS SINGLES)

| TIRE SIZE DESIGNATION | TIRE LOAD LIMITS, LB (kg), AT VARIOUS COLD INFLATION PRESSURES, PSI (kPa) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 70 (483) | 75 (517) | 80 (552) | 85 (586) | 90 (621) | 95 (655) | 100 (690) | 105 (724) | 110 (758) | 115 (793) | 120 (827) |
| 445/65R19.5 | 7540 (3420) | 7930 (3597) | 8270 (3751) | 8680 (3937) | 9040 (4101) | 9370 (4250) | 9730 (4413) | 10,100 (4581) | ***10,500 (J) (4763) (J)*** | | |
| 385/65R22.5 | 6380 (2894) | 6710 (3044) | 7040 (3193) | 7350 (3334) | 7650 (3470) | 7950 (3606) | 8230 (3733) | 8510 (3860) | 8790 (3987) | 9050 (4105) | ***9370 (J) (4250) (J)*** |
| 425/65R22.5 | 7590 (3443) | 7990 (3624) | 8370 (3797) | 8740 (3964) | 9100 (4128) | 9450 (4286) | 9790 (4441) | 10,100 (4581) | 10,500 (4763) | | |
| 445/65R22.5 | 8280 (3756) | 8710 (3951) | 9120 (4137) | 9540 (4327) | 9930 (4504) | 10,300 (4672) | 10,700 (4853) | 11,000 (4990) | ***11,400 (J) (5171) (J)*** | 11,700 (5307) | ***12,300 (J) (5579) (J)*** |

*NOTE: Letters in parentheses denote Load Range for which Bold Face Loads are maximum.*

## TIRES FOR TRUCKS IN NORMAL HIGHWAY SERVICE
### (TIRES MOUNTED ON FLAT BASE RIMS)

| TIRE SIZE DESIGNATION | USAGE | TIRE LOAD LIMITS, LB (kg), AT VARIOUS COLD INFLATION PRESSURES, PSI (kPa) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RADIAL PLY | | | | | | | | | | |
| | | 70 (483) | 75 (517) | 80 (552) | 85 (586) | 90 (621) | 95 (655) | 100 (690) | 105 (724) | 110 (758) | 115 (793) | 120 (827) |
| 10.00*20 | DUAL | 4380 (1987) | 4580 (2077) | ***4760(F) (2159) (F)*** | 4950 (2245) | 5120 (2322) | ***5300(G) (2404) (G)*** | 5470 (2481) | 5630 (2554) | ***5800 (H) (2631) (H)*** | | |
| | SINGLE | 4530 (2055) | 4770 (2164) | 4990 (2263) | 5220 (2368) | ***5430(F) (2463) (F)*** | 5640 (2558) | 5840 (2649) | ***6040 (G) (2740) (G)*** | 6240 (2830) | 6430 (2917) | ***6610(H) (2998) (H)*** |
| 10.00*22 | DUAL | 4660 (2114) | 4870 (2209) | ***5070(F) (2300) (F)*** | 5260 (2386) | 5450 (2472) | ***5640(G) (2558) (G)*** | 5820 (2640) | 6000 (2722) | ***6170(H) (2799) (H)*** | | |
| | SINGLE | 4820 (2186) | 5070 (2300) | 5310 (2409) | 5550 (2517) | ***5780(F) (2622) (F)*** | 6000 (2722) | 6210 (2817) | ***6430(G) (2917) (G)*** | 6630 (3007) | 6840 (3103) | ***7030 (H) (3189) (H)*** |
| 11.00*20 | DUAL | 4780 (2168) | 4990 (2263) | ***5190(F) (2354) (F)*** | 5390 (2445) | 5590 (2536) | ***5780(G) (2622) (G)*** | 5960 (2703) | 6150 (2790) | ***6320(H) (2867) (H)*** | | |
| | SINGLE | 4940 (2241) | 5200 (2359) | 5450 (2472) | 5690 (2581) | ***5920(F) (2685) (F)*** | 6140 (2785) | 6370 (2889) | ***6590(G) (2989) (G)*** | 6790 (3080) | 7010 (3180) | ***7200(H) (3266) (H)*** |
| 11.00*22 | DUAL | 5080 (2304) | 5300 (2404) | ***5520(F) (2504) (F)*** | 5730 (2599) | 5940 (2694) | ***6140 (G) (2785) (G)*** | 6330 (2871) | 6530 (2962) | ***6720 (H) (3048) (H)*** | | |
| | SINGLE | 5240 (2377) | 5520 (2504) | 5790 (2626) | 6040 (2740) | ***6290(F) (2853) (F)*** | 6530 (2962) | 6770 (3071) | ***7000 (G) (3175) (G)*** | 7220 (3275) | 7440 (3375) | ***7660(H) (3475) (H)*** |
| 11.00*24 | DUAL | 5390 (2445) | 5630 (2554) | ***5860(F) (2658) (F)*** | 6090 (2762) | 6310 (2862) | ***6520(G) (2957) (G)*** | 6730 (3053) | 6930 (3143) | ***7130 (H) (3234) (H)*** | | |
| | SINGLE | 5570 (2527) | 5860 (2658) | 6140 (2785) | 6420 (2912) | ***6680(F) (3030) (F)*** | 6940 (3148) | 7190 (3261) | ***7430(G) (3370) (G)*** | 7670 (3479) | 7900 (3583) | ***8130 (H) (3688) (H)*** |
| 12.00*20 | DUAL | 5440 (2468) | 5680 (2576) | 5910 (2681) | ***6140(G) (2785) (G)*** | 6360 (2885) | 6580 (2985) | ***6790(H) (3080) (H)*** | 7000 (3175) | ***7200 (J) (3266) (J)*** | | |
| | SINGLE | 5620 (2549) | 5920 (2685) | 6200 (2812) | 6480 (2939) | 6740 (3057) | ***7000(G) (3175) (G)*** | 7250 (3289) | 7500 (3402) | 7740(H) (3511) (H) | 7980 (3620) | ***8210 (J) (3724) (J)*** |
| 12.00*24 | DUAL | 6120 (2776) | 6390 (2898) | 6650 (3016) | ***6910(G) (3134) (G)*** | 7160 (3248) | 7410 (3361) | ***7640 (H) (3465) (H)*** | 7870 (3570) | ***8100 (J) (3674) (J)*** | | |
| | SINGLE | 6330 (2871) | 6660 (3021) | 6980 (3166) | 7280 (3302) | 7580 (3438) | ***7880(G) (3574) (G)*** | 8160 (3701) | 8450 (3833) | 8710 (H) (3951) (H) | 8970 (4069) | ***9230 (J) (4187) (J)*** |

** Tire size designation will include "R" (Radial Ply)*
*NOTE: Letters in parentheses denote Load Range for which Bold Face Loads are maximum*

**TIRES FOR TRUCKS IN NORMAL HIGHWAY SERVICE**
**(TIRES MOUNTED ON 15° DROP CENTER RIMS)**

| TIRE SIZE DESIGNATION | USAGE | TIRE LOAD LIMITS, LB (kg), AT VARIOUS COLD INFLATION PRESSURES, PSI (kPa) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RADIAL PLY | | | | | | | | | | | |
| | | 65 (448) | 70 (483) | 75 (517) | 80 (552) | 85 (586) | 90 (621) | 95 (655) | 100 (690) | 105 (724) | 110 (758) | 115 (793) | 120 (827) |
| 225/70R19.5 | DUAL | ***2600(D) (1179) (D)*** | 2720 (1234) | 2860 (1297) | ***3000 (E) (1361) (E)*** | 3115 (1413) | 3245 (1472) | ***3415 (F) (1549) (F)*** | 3490 (1583) | 3615 (1640) | ***3750 (G) (1701) (G)*** | | |
| | SINGLE | ***2755(D) (1250) (D)*** | 2895 (1313) | 3040 (1379) | ***3195 (E) (1449) (E)*** | 3315 (1504) | 3450 (1565) | ***3640 (F) (1651) (F)*** | 3715 (1685) | 3845 (1744) | ***3970 (G) (1801) (G)*** | | |
| 245/70R19.5 | DUAL | | | | 3415 (1549) | 3515 (1594) | 3655 (1658) | ***3860 (F) (1751) (F)*** | 3940 (1787) | 4075 (1848) | ***4300 (G) (1950) (G)*** | 4345 (1971) | ***4540 (H) (2059) (H)*** |
| | SINGLE | | | | 3640 (1651) | 3740 (1969) | 3890 (1764) | ***4080 (F) (1851) (F)*** | 4190 (1901) | 4335 (1966) | ***4540 (G) (2059) (G)*** | 4620 (2096) | ***4805 (H) (2180) (H)*** |
| 265/70R19.5 | DUAL | | | | 3750 (1701) | 3930 (1783) | 4095 (1857) | 4300 (1950) | 4405 (1998) | 4415 (2003) | ***4675 (G) (2121) (G)*** | | |
| | SINGLE | | | | 3970 (1801) | 4180 (1896) | 4355 (1975) | 4540 (2059) | 4685 (2125) | 4850 (2200) | ***5070 (G) (2300) (G)*** | | |
| 305/70R19.5 | DUAL | | | | 4540 (2059) | 4670 (2118) | 4860 (2204) | 5070 (2300) | 5230 (2372) | 5410 (2454) | ***5675 (H) (2574) (H)*** | 5770 (2617) | ***6005 (J) (2724) (J)*** |
| | SINGLE | | | | 4940 (2241) | 5130 (2327) | 5340 (2422) | 5510 (2499) | 5745 (2606) | 5945 (2697) | ***6175 (H) (2801) (H)*** | 6340 (2876) | ***6610 (J) (2998) (J)*** |
| 255/70R22.5 | DUAL | | | | 3970 (1801) | 4110 (1864) | 4275 (1939) | 4410 (2000) | 4455 (2021) | 4610 (2091) | ***4675 (G) (2121) (G)*** | 4915 (2229) | ***5070 (H) (2300) (H)*** |
| | SINGLE | | | | 4190 (1901) | 4370 (1982) | 4550 (2064) | 4675 (2121) | 4895 (2220) | 5065 (2297) | ***5205 (G) (2361) (G)*** | 5400 (2449) | ***5510 (H) (2499) (H)*** |
| 305/75R22.5 | DUAL | | | | | | | 5840 (2649) | 6025 (2733) | 6235 (2828) | 6610 (2998) | 6640 (3012) | ***6940 (J) (3148) (J)*** |
| | SINGLE | | | | | | | 6395 (2901) | 6620 (3003) | 6850 (3107) | 7160 (3248) | 7300 (3311) | ***7610 (J) (3452) (J)*** |
| 305/85R22.5 | DUAL | | | | 5355 (2429) | 5550 (2517) | 5780 (2622) | 6005 (2724) | 6215 (2819) | 6435 (2919) | ***6780 (H) (3075) (H)*** | | |
| | SINGLE | | | | 5840 (2649) | 6100 (2767) | 6350 (2880) | 6610 (2998) | 6830 (3098) | 7070 (3207) | ***7390 (H) (3352) (H)*** | | |

*NOTE: Letters in parentheses denote Load Range for which Bold Face Loads are maximum*

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# SECTION 4
# LUBRICATION

## SECTION CONTENTS





## LUBRICATION PROCEDURES AND CHARTS

Following the designated lubrication procedures is important in ensuring maximum crane lifetime and utilization. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information. The information included in this section does not include lubrication requirements for the truck chassis. Refer to appropriate truck manufacturer's 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 service representative or the National Crane Product Support Department.

### 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, refer to the component manufacturer's manual and a reliable supplier.

***Chassis Grease.*** 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.

***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 -°F (°C) |
|---|---|
| 75 W | - 40 (-40) |
| 80 W | - 15 (-26) |
| 85 W | +10 (-12) |
| 90 | +20 (-7) |
| 140 | +40 (+5) |
| 250 | +50 (+10) |

***Open Gear Lubricant.*** This is a special adhesive lubricant of heavy consistency for protection of wire rope and exposed gears where provision is not made for continuous lubricant replenishment. Select the viscosity that gives best protection and lubrication without peeling, scaling, or excessive throw off.

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

***Coupling Lube Spline Lubricant.*** Coupling Lube Spline Lubricant is a synthetic-blend, heavy duty, antiwear, extreme pressure coupling grease recommended for the lubrication of pump shaft/PTO splines when the pump is mounted directly to the PTO. It exhibits excellent reduced wear characteristics and has exceptional serviceability over a wide range of temperatures. It is available from Schaeffer Manufacturing Company, 102 Barton Street, St. Louis, Missouri.

## 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 antiwear additives.

***Viscosity.*** The oil must have proper viscosity to provide a lubricating film at system operating temperature.

Oil viscosity is important because it has a direct bearing on efficient transmission of power. An oil must flow readily through the system with a minimum of pressure and flow loss. Positive lubrication depends on viscosity. The oil must be sufficiently light to get between the components machined surfaces and maintain a lubricating film at system operating temperatures. Oil too light may cause the following conditions in the system.

1. Excessive leakage.
2. Lower volumetric efficiency of the pump.
3. Increased component wear.
4. Loss of system pressure.
5. Lack of positive hydraulic control.
6. Lower overall efficiency.

Oil too heavy may cause the following conditions in the system:

1. System pressure drop.
2. Increases system temperature.
3. Sluggish system operation.
4. Low mechanical efficiency.
5. Higher power consumption.

The following oil viscosity characteristics are recommended:

- 80 to 180 SUS optimum at system operating temperature.
- 60 SUS minimum at system operating temperature.
- 7500 SUS maximum at starting temperature.
- 90 Viscosity Index (VI) minimum.

**Note:** On units equipped with self-leveling platforms, low temperature service oils are necessary to provide proper boom functions at temperatures below +10°F(-12°C).

Regardless of temperature and oil viscosity, always use suitable start-up procedures to ensure adequate lubrication during system warm up.

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

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

***Standard Hydraulic Oil.*** (32°F to 100°F) (0°C to 38°C) The factory fill standard hydraulic oil is Exxon Mobil 424 10W-30. This fluid is acceptable for operating temperatures above -9°C (15°F).

***Intermediate Hydraulic Oil.*** (-10°F to 80°F) (-23°C to 27°C) For colder operating environments, the standard fluid may be replaced with a Low Service Temperature Multi Viscosity Hydraulic Oil with High Viscosity Index 175+. Typical fluids are ESSO UNIVIS N-22 and CHEVRON RYKON PREMIUM Oil MV or equivalents.

***Wide Range Intermediate Hydraulic Oil.*** (-30°F to 80°F) (-34°C to 27°C) For even colder operating conditions, the standard fluid may be replaced with a petroleum based fluid developed especially for colder environments. A typical fluid is Petro Canada Premium Plus All Season Hydraulic Oil or equivalent.

***Arctic Hydraulic Oil.*** (-10°F and below) (-23°C and below). In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results. However, certain fluids, such as hologenated hydrocarbons, nitro hydrocabons and phosphate ester hydraulic fluids might not be compatible with hydraulic system seals and wear bands. A typical fluid is Texaco Aircraft Hydraulic Oil 15 or equivalent. This hydraulic oil is not recommended for service in ambient temperatures above 32°F (0°C).

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

## Lubrication Points

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

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 will definitely lead to a shorter lifetime.

Grease fittings that are worn and will not hold the 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 relubricate to ensure complete lubrication of the entire wear area.

## Wire Rope Lubrication

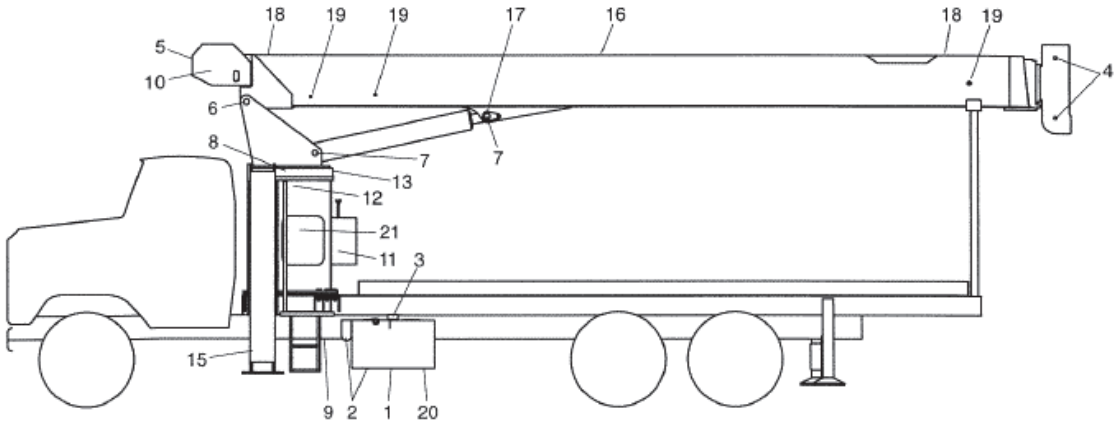
Wire rope is lubricated during manufacturing so the strands, and individual wires in strands, may move and adjust as the rope moves and bends. A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added periodically throughout the life of a rope to replace factory lubricant which is used or lost.

The surface of some ropes may become covered with dirt, rock dust, or other material during their operation. This covering can prevent field applied lubricants from properly penetrating into the rope. Therefore, these ropes should be cleaned before being lubricated.

The lubricant applied should be light bodied enough to penetrate to the core of the rope. Lubricant may be applied effectively by various methods. It may be dripped on, sprayed on, or put on by brushing, but in any case it should be applied at a place where the rope is being bent, such as at a sheave. It should be applied at the top of the bend, because at that point the strands are spread by bending and are more easily penetrated. The service life of rope will be directly proportional to the effectiveness of the method used and amount of lubricant reaching the working parts of the rope.

A proper lubricant must reduce friction, protect against corrosion, adhere to every wire and be pliable and not crack or separate when cold and yet not drip when warm.

# Lubrication Chart

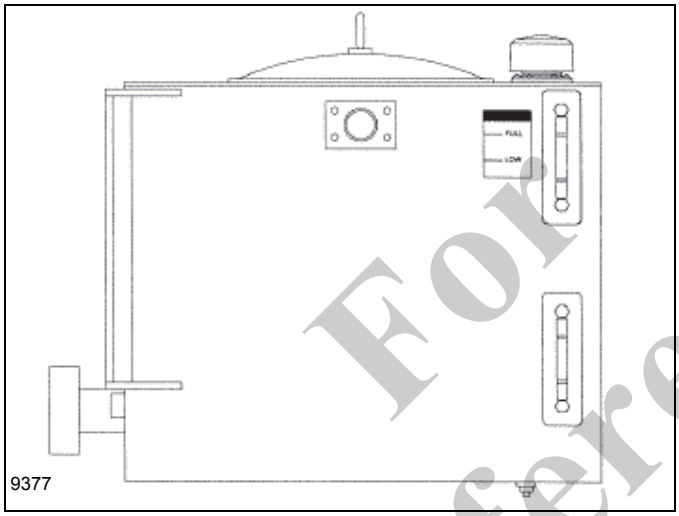



| APPLICATION | RECOMMENDED LUBRICANT | PROCEDURE | FREQUENCY |
|---|---|---|---|
| 1. Hydraulic Oil Reservoir | Hydraulic Oil | Check & Fill<br>Change *(See "Hydraulic Oil Reservoir Level" on page 4-5)* | Weekly<br>Semi-Annually |
| 2. Oil Filter, Magnetic Plug | | Change or Clean | After First 40 Hours then Quarterly |
| 3. Reservoir Breather | | Clean | Monthly |
| 4. Sheave Pins/Boom-3, Jib-1 | Chassis Grease | Grease Gun | Weekly |
| 5. Loadline - Wire Rope | Open Gear Lube | Brush or Spray | Semi-Annually |
| 6. Boom Pivot Pin | Chassis Grease | Grease Gun | Monthly |
| 7. Lift Cylinder Pins 2 ea. | Chassis Grease | Grease Gun | Monthly |
| 8. Turntable Bearing | Chassis Grease | Grease until lubricant appears at seal while rotating crane | Monthly |
| 9. Pump Drive U-Joint 2 ea. or Pump Spline Shaft (Direct Mount) | Chassis Grease<br>Coupling Lube Spline Lubricant | Grease Gun<br>Remove Pump and Apply to Shaft or Zerk Provided on PTO Housing Shaft | Monthly<br>Semi-Annually |
| 10. Hoist Drive | Refer to Hoist Manual for Oil Recommendation on Hoist | Check & Fill<br>Change | Weekly<br>Semi-Annually |
| 11. Control Linkage | SAE-10W | Oil Can | Quarterly |
| 12. Swing Drive Gearbox<br><br><br><br><br>Swing Gearbox, Upper Bearing | EPGL<br><br><br><br><br>Chassis Grease | Change<br><br>Check & Fill<br>Change<br><br>Grease Gun | After First 50 Operating Hours<br>Weekly<br><br>Semi-Annually<br><br>Monthly |
| 13. Swing Gear Teeth | Open Gear Lube | Grease Gun | Monthly |
| 14. Boom Extension<br>Sides<br>Bottom | See Boom Maintenance Section | | |
| 15. Outrigger Beams | Low Temp Chassis Grease | Brush or Roller | Monthly |
| 16. Wire Rope Cables & Boom | Open Gear Lube | Brush or Spray | Anytime Boom is Disassembled |
| 17. Pin Joints | Penetrating Oil | Spray | Monthly |
| 18. Boom Top Wear Pads | See Boom Pad Lubrication | | |
| 19. Sheave Bearings | Chassis Grease | Grease Gun with Nozzle Tip-See Boom Maintenance Section | Semi-Annually |
| 20. Diffuser | | Clean | Semi-Annually with oil change |
| 21. Optional Continuous Rot. Swivel | Chassis Grease | Grease Gun | Monthly |

## HYDRAULIC OIL RESERVOIR LEVEL

The hydraulic oil reservoir has a sight gauge located on the side of the reservoir. The hydraulic reservoir is full when the oil level is level with the **FULL** bar on the adjacent decal with the crane parked on a level surface in the transport condition and while the oil is cold.

If the oil level is below the **LOW** bar on the decal add the recommended type of hydraulic oil until the oil level is back at the **FULL** marker. If the oil level is above the top of the sight gauge, oil should be removed until the oil level is even with the **FULL** marker.




## CARWELL© RUST INHIBITOR

### Protecting Cranes From Corrosion

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

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

Carwell© T32-CP-90 is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CFR19-10.1200. 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, cased 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 Crane, Manitowoc Crane Care recommends washing the crane at

least monthly to remove all foreign matter. More frequent cleaning may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

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

**CAUTION**

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

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

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

## Inspection and Repair

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

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

**CAUTION**

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

- For scratches and marks in highly visible areas:
- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect, then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat 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©.

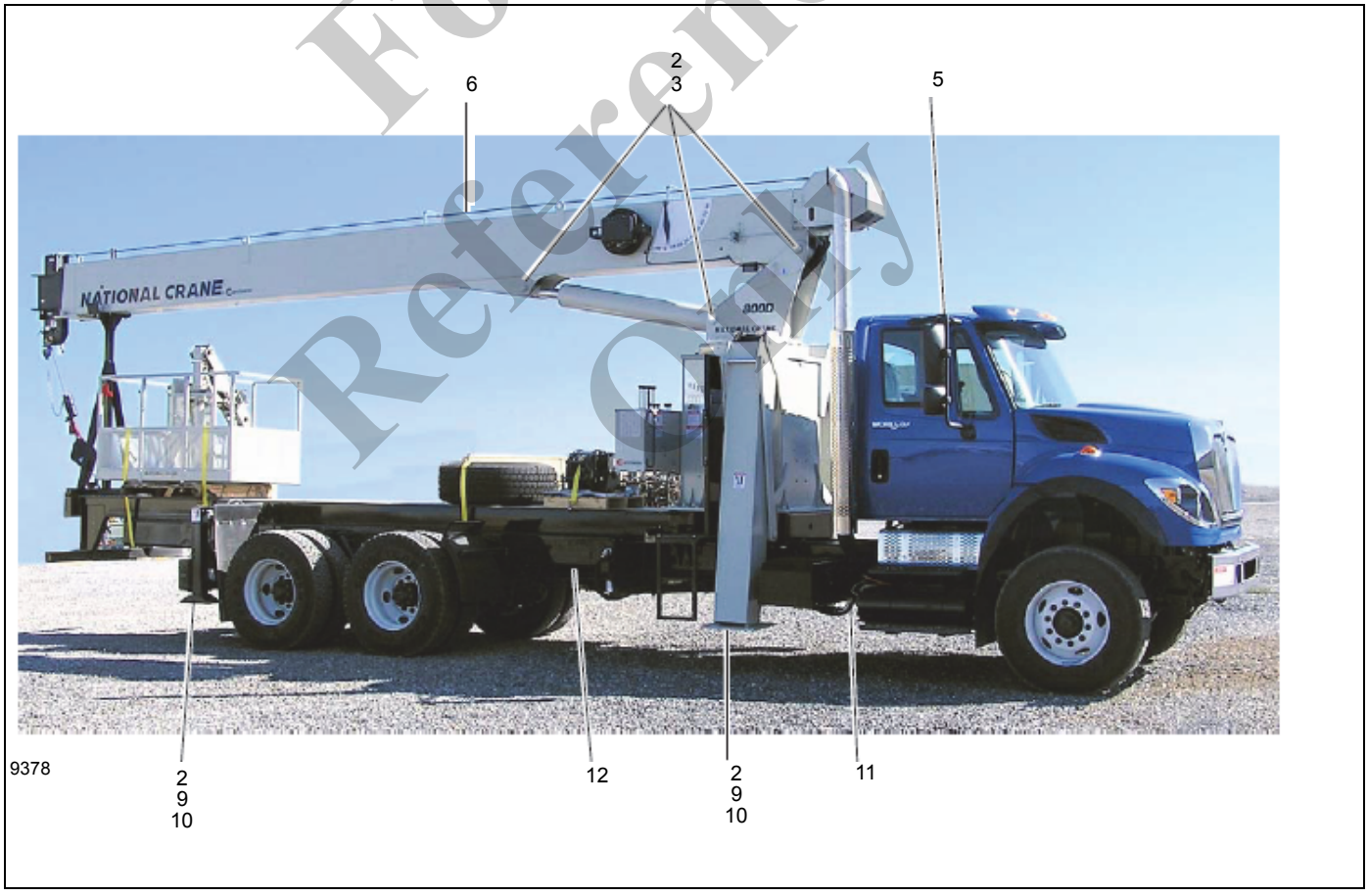
**NOTE:** Unit must be completely dry before applying Carwell©.

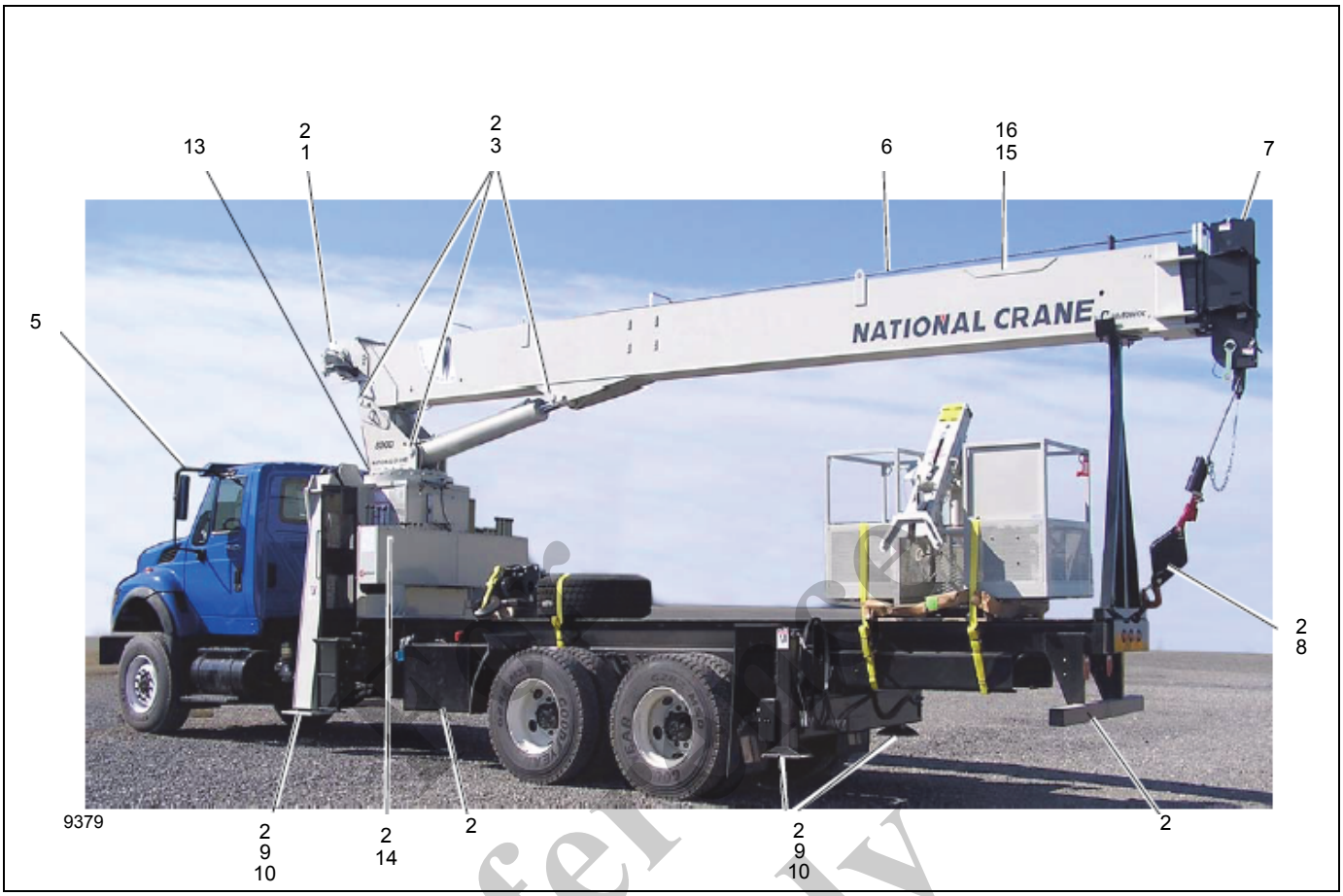
- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of Carwell©, the product needs to be fogged on the unit.
- Use of pressure pots to apply the Carwell© to the unit being processed 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, drive lines, 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 | All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips |
| 3 | Pivot Shaft |
| 4 | Hose Connections |
| 5 | Mirror Mounting Hardware |
| 6 | Wire Rope |
| 7 | Boom Nose Pins, Clips |

| Item | Description |
|---|---|
| 8 | Hook Block/Headache Ball |
| 9 | O/R Hose Connections |
| 10 | O/R Pins, Clips |
| 11 | Power Train Hardware |
| 12 | Entire underside of unit |
| 13 | Turntable Bearing Fasteners, Pins |
| 14 | Valve Bank, Hose Connections |
| 15 | Clips for Optional Jib |
| 16 | Hanger Hardware for Optional Jib |

# SECTION 5
# SERVICE

## SECTION CONTENTS





## SERVICE AND REPAIR

The information supplied in this section of the manual is designed to assist you in service and repair of your National Crane. Inspection, lubrication and general maintenance information are found in two previous sections of this manual. Before attempting to perform any service work, the machine must be shut down as outlined under Maintenance Procedure in the Maintenance section of this book.

Generally, a study of the hydraulic schematics in conjunction with a systematic procedure to locate and correct the problem will enable a skilled mechanic to determine the problem and correct it. If at any time you cannot find or correct the problem, contact your National Crane distributor or Manitowoc Crane Care. ***Be sure you have your parts and service book, model number and serial number at hand when you call***. This information is on the serial number placard located on the crane frame.

The following general suggestions should be helpful in analyzing and servicing your crane. Use the following systematic approach should be helpful in finding and fixing problems:

1. Determine the problem.
2. List possible causes.
3. Devise checks.
4. Conduct checks in a logical order to determine the cause.
5. Consider the remaining service life of components against the cost of parts and labor necessary to replace them.
6. Make the necessary repair.
7. Recheck to ensure that nothing has been overlooked.
8. Functionally test the new part in its system.

**Note: Your safety and that of others is always the number one consideration when working around cranes. Safety is a matter of thoroughly understanding the job to be done and the application of good common**

**sense. It is not just a matter of “Do's” and “Don'ts”. Stay clear of all moving parts.**

## 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.

## Cleanliness

An important item in preserving the long life of the crane is keeping dirt out of working parts. Enclosed compartments, seals, and filters have been provided to keep the supply of air, fuel and lubricants clean. It is important that these enclosures be maintained.

Whenever hydraulic, fuel, lubricating oil lines are disconnected, clean the adjacent area as well as the point of disconnect. As soon as the disconnection is made, cap, plug or tape each line or opening to prevent entry of foreign material. The same recommendation for cleaning and covering apply when access covers or inspection plates are removed.

Clean and inspect all parts. Be sure all passages and holes are open. Cover all parts to keep them clean. Be sure parts are clean when they are installed. Leave new parts in their containers until ready for assembly.

## Hydraulic Systems

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

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

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

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

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

### Label Parts When Disassembling

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

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

## Hydraulic Oil Recommendations

For the hydraulic oil specifications, Reference *Lubrication*, page 4-1.

## Draining and Flushing

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

1. Remove the reservoir drain plug. Allow about three minutes after hydraulic oil stops flowing from the drain port for the side walls to drain.
2. Clean and install the reservoir plug and fill the reservoir with a 50/50 mixture of fuel oil and clean hydraulic oil.
3. Cycle the crane through all functions several times. Then return the crane to its stowed position and turn the front and rear wheels to the extreme left. Shut down the engine.
4. Remove the reservoir drain plug and drain the reservoir. Clean and install the drain plug and fill the reservoir with clean hydraulic oil.

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

Draining the various components will be aided by connecting a drain line in place of the disconnected return line.

5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.
6. Connect the cylinder return line and lower the boom to its stowed position. Replenish the reservoir hydraulic oil level as required.
7. Disconnect the return line from an outrigger extension cylinder and fully extend the outrigger.
8. Connect the outrigger return line and retract the outrigger. Replenish the reservoir hydraulic oil level as necessary.
9. Repeat Steps 7 and 8 for the remaining outriggers.

**CAUTION**

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

10. Disconnect the return lines from a pair of outrigger jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.
14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from steer cylinders and turn the wheels to the extreme right.
16. Connect the return lines and turn the wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.
17. Raise the crane on outriggers.
18. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
19. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
20. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
21. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

**CAUTION**

When hydraulic oils are changed or added, ensure that hydraulic oils of different manufacturers are of the same specifications, however, discoloration (milkiness) may occur. Mixing incompatible hydraulic oils may result in improper operation or damage to the machine.

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted.

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

## Removing Air From the Hydraulic System

Air entering the hydraulic oil will normally be removed automatically by passage of the hydraulic oil over the baffles in the hydraulic reservoir. If a component has been replaced, the reservoir level is too low, or a leak develops in the suction lines to the pumps, air can enter the system. If air becomes entrapped in the hydraulic oil, it may be detectable in pumps and motor operated components such as the swing mechanism and hoist(s), because it can cause these units to become noisy during operation. If noisy operation occurs, first check the level of the hydraulic reservoir and replenish as necessary. Then inspect for leaks in the suction lines leading to the pumps.

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

- Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 0.138 to 0.276 bar (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.
- This action should return any entrapped air to the reservoir where it can be removed from the hydraulic oil by the baffles.

**CAUTION**

Always locate the machine on a firm supporting surface, extend the outriggers and level the machine and position the boom over the front to extend the boom at low angles. Injury or damage to the machine may result if this caution is not followed.

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

**CAUTION**

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

Extreme care must be used when removing any plugs or restrictions from a hydraulic system suspected to have entrapped air that may be pressurized. Moderate to minor injury may result from pressurized air in a hydraulic system.

- Entrapped air may be removed from cylinders having wet rods by cycling. On certain cylinders, a plugged port is provided on the rod end to bleed off entrapped air.
- In the event that air entrapment should persist, bleeding of air by loosening various clamp and screw type fittings may become necessary.
- If the above procedures fail to eliminate air entrapment, contact your authorized National Crane distributor.

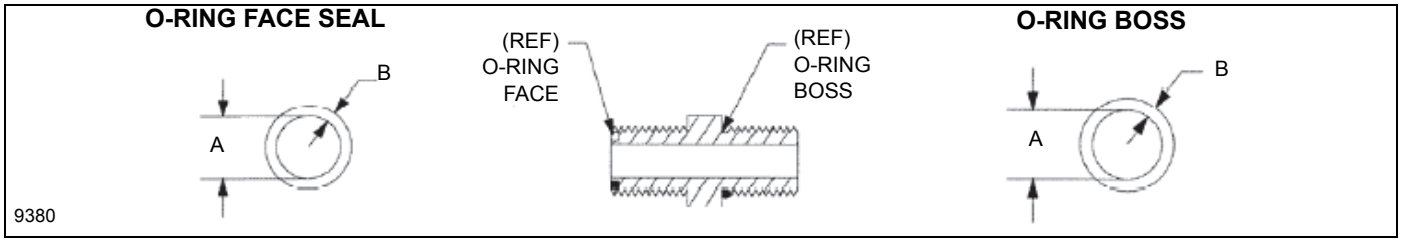
## Welding Precautions

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

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



## National Crane Fitting O-ring Part Numbers



| O-RING FACE SEAL | | | | FITTING SIZE | | O-RING BOSS | | | |
|---|---|---|---|---|---|---|---|---|---|
| NATIONAL CRANE PART NO. | THREAD SIZE | B inch (mm) | A inch (mm) | TUBE O.D. | MFGR'S SIZE CODE | A inch (mm) | B inch (mm) | THREAD SIZE | NATIONAL CRANE PART NO. |
| **897063 | 9/16-18 | 0.07 (1,78) | 0.301 (7,64) | 0.250 | 4 | 0.351 (8,92) | 0.072 (1,83) | 7/16-20 | 888412* |
| **897064 | 11/16-16 | 0.07 (1,78) | 0.364 (9,24) | 0.375 | 6 | 0.458 (11,63) | 0.078 (1,98) | 9/16-18 | 888414* |
| “897065 | 13/16-16 | 0.07 (1,78) | 0.489 (12,42) | 0.500 | 8 | 0.644 (16,36) | 0.087 (2,21) | 3/4-16 | 888415* |
| **897066 | 1-14 | 0.07 (1,78) | 0.614 (15,60) | 0.625 | 10 | 0.755 (19,18) | 0.097 (2,46) | 7/8-14 | 888416* |
| “897067 | 1 3/16-12 | 0.07 (1,78) | 0.739 (18,77) | 0.750 | 12 | 0.924 (23,47) | 0.116 (2,95) | 1 1/16-12 | 888417* |
| **897068 | 1 7/16-12 | 0.07 (1,78) | 0.926 (23,52) | 1.000 | 16 | 1.171 (29,74) | 0.116 (2,95) | 1 5/16-12 | 888419* |
| **897069 | 1 11/16-12 | 0.07 (1,78) | 1.176 (29,87) | 1.250 | 20 | 1.475 (37,46) | 0.118 (3,00) | 1 5/8-12 | 888420* |
| **897070 | 2-12 | 0.07 (1,78) | 1.489 (37,82) | 1.500 | 24 | 1.720 (43,69) | 0.118 (3,00) | 1 7/8-12 | 888421* |

* 888422 O-Ring Boss Seal Kit (12 EA)

** 897234 O-Ring Face Seal Kit (12 EA)

### *Fatigue of Welded Structures*

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

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

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

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

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

## Loctite®

**⚠ CAUTION**

**Skin and/or Eye Hazard!**

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

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

### *Application of Medium Strength Loctite®*

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

The following procedure covers the proper application and curing method for medium strength Loctite® adhesive/sealant (Loctite® No. 243).

1. Ensure the threaded surface, both male and female, is clean of contaminants and free of dirt and oil.

**Adhesive/Sealant Application**

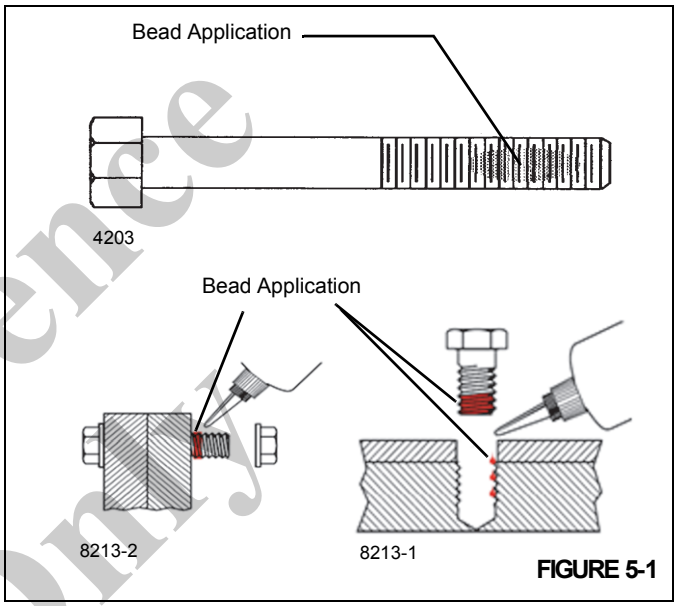



**FIGURE 5-1**

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 5-1).
2. In a blind hole application, a bead of several drops of adhesive should be applied into the bottom of the hole to be hydraulically forced up during engagement.
3. After application and engagement of mated threads, fixturing will occur within five (5) minutes. Time required to achieve full strength is 24 hours.

## FASTENERS AND TORQUE VALUES

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

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

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

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

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

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

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

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

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

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

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

## *Torque Wrenches*

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

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

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

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

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

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

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

## *Torque Values*

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

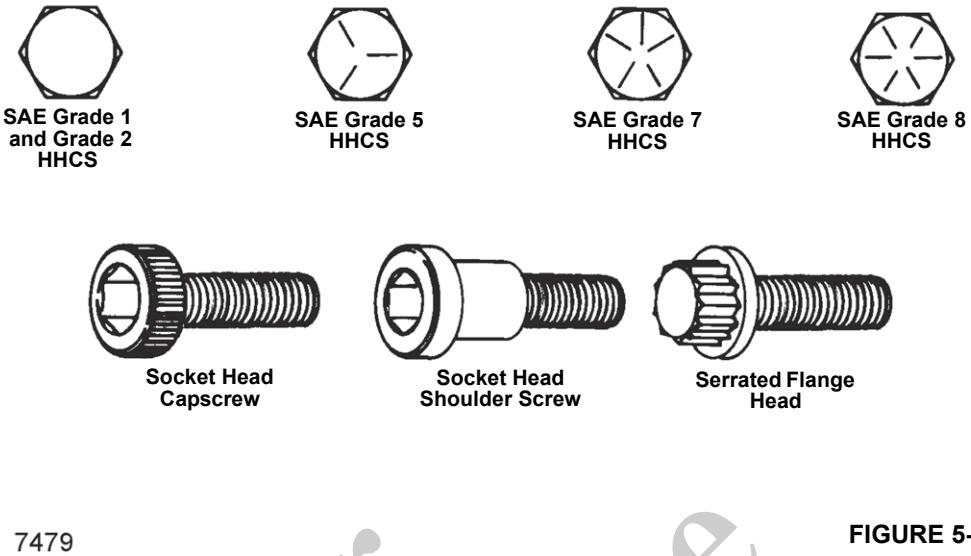



**FIGURE 5-2**

**Table 5-1Inch Series with Coarse Threads (UNC) – Zinc Flake Coated**

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

**Table 5-2 Inch Series with Fine Threads (UNF) – Zinc Flake Coated**

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

**Table 5-3 Metric Series with Coarse Threads – Zinc Flake Coated**

| Nominal Size, Threads per Inch, and Series Designation | Property Class | Torque (Nm) | | |
|---|---|---|---|---|
| | | Maximum | Nominal | Minimum |
| M4x0.7 | 10.9 | 3.6 | 3.5 | 3.4 |
| | 12.9 | 4.2 | 4.1 | 4.0 |
| M5x0.8 | 10.9 | 7.2 | 7.0 | 6.8 |
| | 12.9 | 8.4 | 8.2 | 8.0 |
| M6x1.0 | 8.8 | 8.3 | 8.1 | 7.9 |
| | 10.9 | 12.2 | 11.9 | 11.6 |
| | 12.9 | 14.3 | 13.9 | 13.6 |
| M8x1.25 | 8.8 | 20.2 | 19.7 | 19.2 |
| | 10.9 | 29.6 | 28.9 | 28.2 |
| | 12.9 | 34.7 | 33.8 | 33.0 |
| M10x1.5 | 8.8 | 40.0 | 39.0 | 38.0 |
| | 10.9 | 58.7 | 57.2 | 55.8 |
| | 12.9 | 68.7 | 67.0 | 65.3 |
| M12x1.75 | 8.8 | 69.7 | 68.0 | 66.2 |
| | 10.9 | 102.4 | 99.8 | 97.2 |
| | 12.9 | 119.8 | 116.8 | 113.8 |
| M14x2 | 8.8 | 111.4 | 108.6 | 105.8 |
| | 10.9 | 163.6 | 159.5 | 155.4 |
| | 12.9 | 191.5 | 186.7 | 181.9 |
| M16x2 | 8.8 | 172.8 | 168.5 | 164.1 |
| | 10.9 | 253.8 | 247.4 | 241.1 |
| | 12.9 | 296.9 | 289.5 | 282.1 |
| M18x2.5 | 8.8 | 246.2 | 240.1 | 233.9 |
| | 10.9 | 350.7 | 341.9 | 333.2 |
| | 12.9 | 410.4 | 400.1 | 389.9 |
| M20x2.5 | 8.8 | 348.0 | 339.3 | 330.6 |
| | 10.9 | 495.6 | 483.2 | 470.8 |
| | 12.9 | 580.0 | 565.5 | 551.0 |
| M22x2.5 | 8.8 | 474.4 | 462.6 | 450.7 |
| | 10.9 | 675.7 | 658.8 | 641.9 |
| | 12.9 | 790.7 | 770.9 | 751.2 |
| M24x3 | 8.8 | 601.3 | 586.3 | 571.3 |
| | 10.9 | 856.4 | 835.0 | 813.6 |
| | 12.9 | 1002.2 | 977.1 | 952.1 |

| Nominal Size, Threads per Inch, and Series Designation | Property Class | Torque (Nm) | | |
|---|---|---|---|---|
| | | Maximum | Nominal | Minimum |
| M27x3 | 8.8 | 881.6 | 859.6 | 837.5 |
| | 10.9 | 1255.7 | 1224.3 | 1192.9 |
| | 12.9 | 1469.4 | 1432.7 | 1395.9 |
| M30x3.5 | 8.8 | 1195.3 | 1165.5 | 1135.6 |
| | 10.9 | 1702.5 | 1659.9 | 1617.3 |
| | 12.9 | 1992.3 | 1942.4 | 1892.6 |
| M36x4 | 8.8 | 2089.8 | 2037.6 | 1985.3 |
| | 10.9 | 2976.4 | 2902.0 | 2827.6 |
| | 12.9 | 3483.0 | 3395.9 | 3308.9 |

**Table 5-4 Metric Series with Fine Threads – Zinc Flake Coated**

| Nominal Size, Threads per Inch, and Series Designation | Property Class | Torque (Nm) | | |
|---|---|---|---|---|
| | | Maximum | Nominal | Minimum |
| M8x1.0 | 8.8 | 21.6 | 21.1 | 20.5 |
| | 10.9 | 31.7 | 30.9 | 30.1 |
| | 12.9 | 37.1 | 36.2 | 35.3 |
| M10x.75 | 8.8 | 46.8 | 45.6 | 44.4 |
| | 10.9 | 68.7 | 67.0 | 65.3 |
| | 12.9 | 80.4 | 78.4 | 76.4 |
| M10x1.25 | 8.8 | 42.2 | 41.1 | 40.1 |
| | 10.9 | 62.0 | 60.4 | 58.9 |
| | 12.9 | 72.5 | 70.7 | 68.9 |
| M12x1.0 | 8.8 | 79.5 | 77.5 | 75.5 |
| | 10.9 | 116.7 | 113.8 | 110.9 |
| | 12.9 | 136.6 | 133.2 | 129.8 |
| M12x1.25 | 8.8 | 76.2 | 74.2 | 72.3 |
| | 10.9 | 111.8 | 109.0 | 106.3 |
| | 12.9 | 130.9 | 127.6 | 124.3 |
| M12x1.5 | 8.8 | 72.9 | 71.1 | 69.2 |
| | 10.9 | 107.1 | 104.4 | 101.7 |
| | 12.9 | 125.3 | 122.1 | 119.0 |
| M14x1.5 | 8.8 | 120.2 | 117.2 | 114.2 |
| | 10.9 | 176.5 | 172.1 | 167.7 |
| | 12.9 | 206.6 | 201.4 | 196.2 |
| M16x1.5 | 8.8 | 184.4 | 179.8 | 175.2 |
| | 10.9 | 270.9 | 264.1 | 257.3 |
| | 12.9 | 317.0 | 309.1 | 301.2 |
| M18x1.5 | 8.8 | 276.6 | 269.7 | 262.8 |
| | 10.9 | 394.0 | 384.2 | 374.3 |
| | 12.9 | 461.1 | 449.6 | 438.0 |
| M20x1 | 8.8 | 405.7 | 395.5 | 385.4 |
| | 10.9 | 577.8 | 563.3 | 548.9 |
| | 12.9 | 676.1 | 659.2 | 642.3 |
| M20x1.5 | 8.8 | 386.0 | 376.3 | 366.7 |
| | 10.9 | 549.7 | 535.9 | 522.2 |
| | 12.9 | 643.3 | 627.2 | 611.1 |
| M22x1.5 | 8.8 | 520.8 | 507.8 | 494.8 |
| | 10.9 | 741.7 | 723.2 | 704.7 |
| | 12.9 | 868.0 | 846.3 | 824.6 |

| Nominal Size, Threads per Inch, and Series Designation | Property Class | Torque (Nm) | | |
|---|---|---|---|---|
| | | Maximum | Nominal | Minimum |
| M24x2 | 8.8 | 655.8 | 639.4 | 623.0 |
| | 10.9 | 934.0 | 910.6 | 887.3 |
| | 12.9 | 1092.9 | 1065.6 | 1038.3 |
| M27x2 | 8.8 | 951.4 | 927.6 | 903.8 |
| | 10.9 | 1355.0 | 1321.1 | 1287.2 |
| | 12.9 | 1585.6 | 1546.0 | 1506.3 |
| M30x1.5 | 8.8 | 1369.2 | 1334.9 | 1300.7 |
| | 10.9 | 1950.0 | 1901.3 | 1852.5 |
| | 12.9 | 2281.9 | 2224.9 | 2167.8 |
| M30x2 | 8.8 | 1324.6 | 1291.5 | 1258.4 |
| | 10.9 | 1886.6 | 1839.4 | 1792.2 |
| | 12.9 | 2207.7 | 2152.5 | 2097.3 |
| M33x2 | 8.8 | 1784.5 | 1739.9 | 1695.3 |
| | 10.9 | 2541.6 | 2478.0 | 2414.5 |
| | 12.9 | 2974.2 | 2899.8 | 2825.4 |
| M36x2 | 8.8 | 2340.1 | 2281.6 | 2223.1 |
| | 10.9 | 3332.8 | 3249.5 | 3166.2 |
| | 12.9 | 3900.2 | 3802.6 | 3705.1 |

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

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

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

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

**Table 5-6 Inch Series Screws of STAINLESS STEEL 300 (18-8) with Coarse Threads**

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

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

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

**Table 5-7 Inch Series Bearing Bolts – Untreated (black finish)**

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

**Table 5-8 Metric Series Bearing Bolts– Untreated (black finish)**

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

**Table 5-9 Inch Series with Coarse Threads (UNC) – Untreated (black finish)**

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

**Table 5-10 Inch Series with Fine Threads (UNF) – Untreated (black finish)**

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

**Table 5-11 Metric Series with Coarse Threads – Untreated (black finish)**

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

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

**Table 5-12 Metric Series with Fine Threads – Untreated (black finish)**

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

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

## Weld Studs

Unless otherwise specified the following grade 2 torque values (± 10%) apply.

**Table 5-13: Weld Stud Torque Values**

| Stud Size | Torque |
|---|---|
| No. 10 | 20 lb-in |
| 1/4 in | 4 lb-ft |
| 5/16 in - 18 | 9 lb-ft |
| 5/16 in - 24 | 10 lb-ft |
| 3/8 in | 14 lb-ft |
| 1/2 in | 35 lb-ft |
| 5/8 in | 70 lb-ft |

## Using Torque Wrench Extensions

1. Torque wrench extensions are designed to extend the range or versatility of torque wrenches. Torque wrench scale readings or limit settings shall be computed with the following formulas when an extension handle is employed. The sketch below shows which formula is to be used, adding “A” or subtracting “A” when calculating the torque wrench setting.

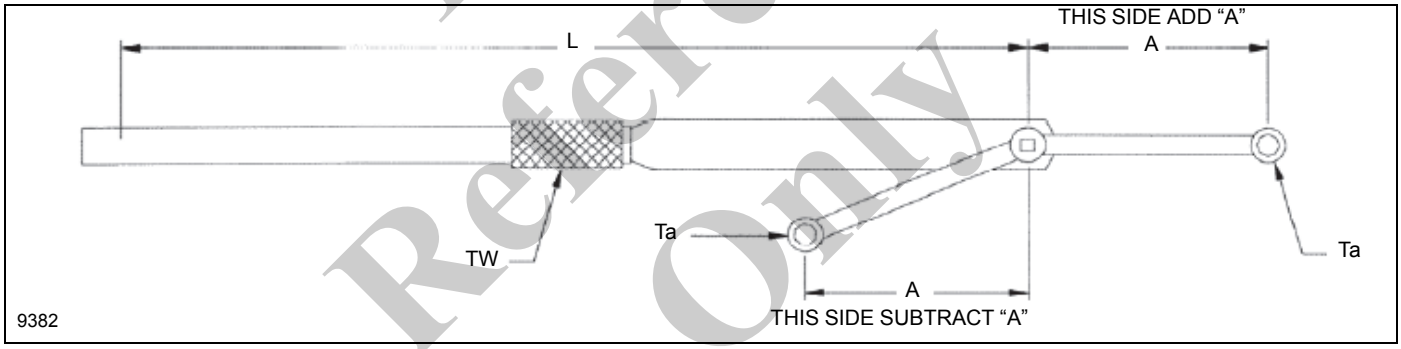
$$TW = \frac{Ta \times L}{L + A} \quad \text{or} \quad TW = \frac{Ta \times L}{L - A}$$

Ta = Torque required (specified)

TW = Wrench scale reading or limit setting of torque wrench

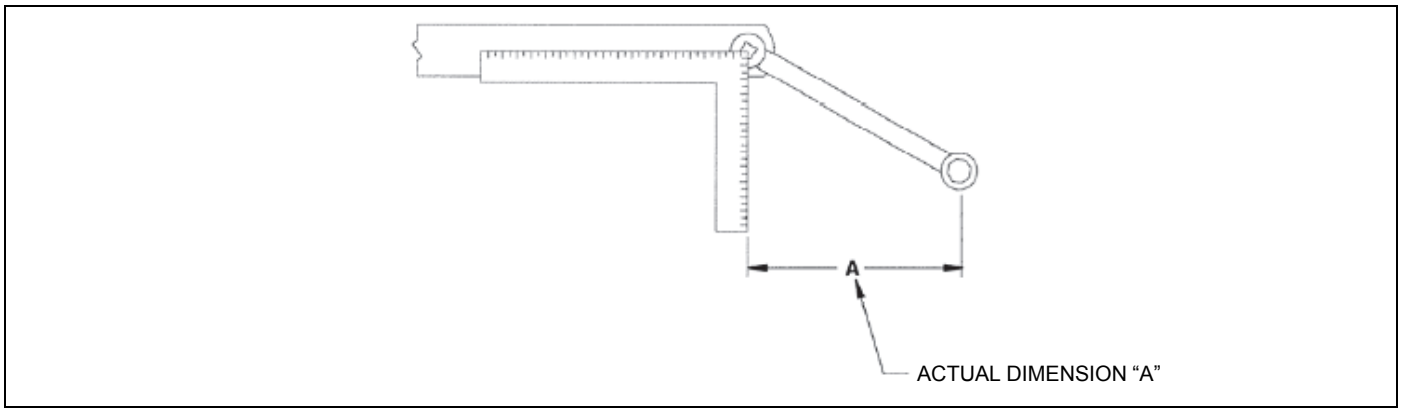
L = Length of torque wrench in inches (center of drive tang to handle pivot pin or center of hand grip - extension handles are considered part of wrench length, when used)

A = Length of adapter extensions in inches.




2. If the offset C/L is not in line with the torque wrench C/L, then you must measure the distance from the C/L of the torque wrench to the C/L of the offset by using a square. Then apply this dimension to the torque wrench setting formula. See sketch below.

3. If offset is positioned at right angles to the torque wrench, then the offset will not change the effective length. Therefore, TW-wrench setting and Ta- applied torque, will be the same value as if no offset were used.



## TROUBLE DIAGNOSIS

The following chart lists malfunctions which may occur during equipment operation, followed immediately by possible cause and possible 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** | • Load too heavy.<br>• PTO not engaged.<br>• Low hydraulic fluid supply.<br>• Suction line blocked.<br>• Broken hydraulic pressure line.<br>• Defective hydraulic pump.<br>• Incorrect relief valve setting.<br>• Relief valve sticking. | • Check Capacity Chart.<br>• Engage PTO.<br>• Check and fill as required.<br>• Drain tank and hose and remove blockage.<br>• Replace as required.<br>• See Pump Service Manual.<br>• Adjust relief.<br>• Clean relief. |
| **Poor hydraulic system performance** | • Pump not operating at proper speed.<br>• Low hydraulic fluid supply.<br>• Relief valve sticking.<br>• Relief setting too low.<br>• Worn pump, motor or cylinder.<br>• Plugged filter.<br>• Valve spools not fully open.<br>• Boom holding valves out of adjustment.<br>• Oil temperature too high.<br>• Hydraulic oil too cold or dirty.<br>• Line restricted.<br>• Internal control valve crack.<br>• Load too heavy. | • Check PTO ratio, pump size and engine speed for proper oil flow.<br>• Check and fill as required.<br>• Remove and clean.<br>• Readjust to proper setting.<br>• Replace bad part.<br>• Change filter.<br>• Adjust linkage so valve has full throw.<br>• Adjust or clean as required.<br>• Reduce engine speed, slow cycle time to cool oil or add oil cooler option.<br>• Warm oil or use less viscous oil.<br>• Check lines; clean and repair as necessary.<br>• Replace valve.<br>• Check Capacity Chart and reduce load. |
| **Swing moves erratic or loosely** | • Loose turntable bearing.<br>• Loose swing gearbox mounting bolts.<br>• Worn gears or bearing.<br>• Operator control of lever too erratic.<br>• Motor counterbalance valves dirty or not set properly.<br>• Brake not holding properly.<br>• Brake releasing at wrong time or erratically. | • Torque bearing mounting bolts.<br>• Tighten bolts.<br>• Replace worn parts or adjust gearbox spacing.<br>• Operate controls smoothly.<br>• Clean or replace counterbalance valves not set at 600 psi.<br>• Check for no pressure in brake pilot line when turn is in neutral.<br>• Replace worn brake parts or shim brake to proper torque.<br>• Bleed air from brake with bleed screw on side of brake. |

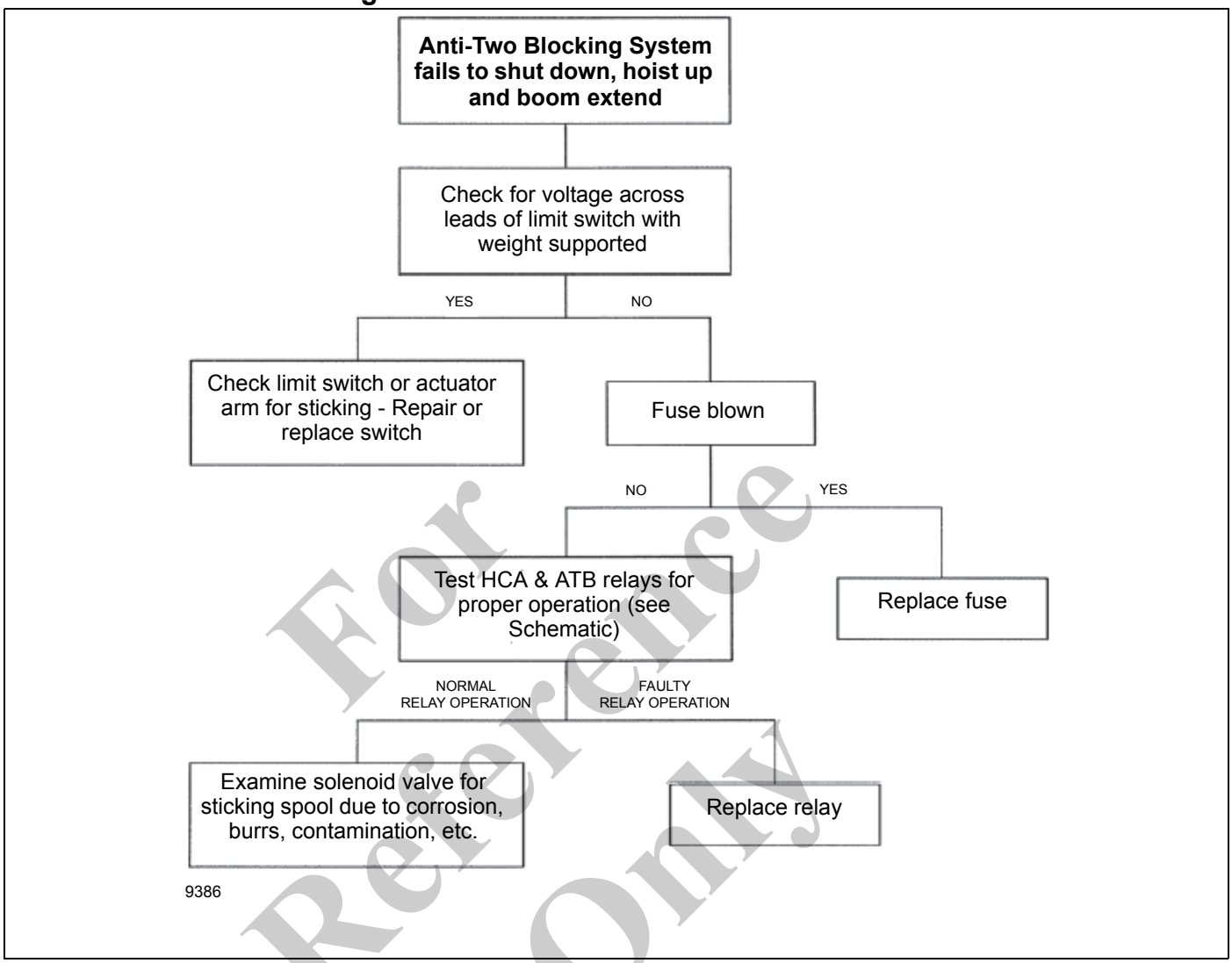
**TROUBLE DIAGNOSIS (continued)**

| CONDITION | POSSIBLE CAUSE | POSSIBLE SOLUTION |
|---|---|---|
| **Swing will not turn** | • Attempting to swing up too much of incline.<br>• Turn circuit relief valves sticking.<br>• Turntable bearing drag.<br>• Brake not releasing properly. | • Level machine.<br>• Clean and check circuit pressure.<br>• Lubricate thoroughly as rotating boom.<br>• Check for 200 + PSI brake pilot pressure. Clean pilot line or adjust motor counterbalance valves.<br>• Adjust or clean brake for proper release. |
| **Excessive pump noise during operation** | • Excessive pump speed.<br>• Low oil temperature.<br>• Low hydraulic oil supply.<br>• Suction line kinked, collapsed or blocked.<br>• Hydraulic oil too thick.<br>• Relief valve chattering.<br>• Hydraulic tubing vibration.<br>• Tank breather plugged. | • Adjust foot throttle or check for too high PTO ratio.<br>• Allow unit to warm up.<br>• Check and fill.<br>• Clear blockage.<br>• Warm oil or use oil more applicable to environment.<br>• Dirt in relief valve or damaged relief.<br>• Check for loose tubing.<br>• Clean breather. |
| **Cylinders drift** | • Not getting oil to cylinders.<br>• Worn or damaged piston seals.<br>• Air in hydraulic oil.<br>• Loose holding valve.<br>• Dirt in holding or check valve. | • Clean and replace as required.<br>• Replace as required.<br>• Cycle operate crane cylinder to remove air.<br>• Tighten valve.<br>• Clean valve. |
| **Hoist will not lift or hold load** | • Load too heavy.<br>• Relief valve setting too low.<br>• Motor worn excessively.<br>• Counterbalance valve defective or leaking.<br>• Anti-two-block system defective.<br>• Brake worn out. | • Check load and change to applicable multipart reeving.<br>• Check and adjust if required.<br>• Replace motor.<br>• Clean and replace as necessary.<br>• Repair anti-two-block system.<br>• Repair or replace brake. |
| **Hoist gearbox heats** | • Gearbox grease low.<br>• Duty cycle too high. | • Check and fill as required.<br>• Reduce cycle time or speed of hoist. |
| **Truck engine will not start** | • Kill switch on crane control console depressed. | • Pull up kill switch.<br>• Check all other normal motor vehicle systems as outlined by normal practice. |

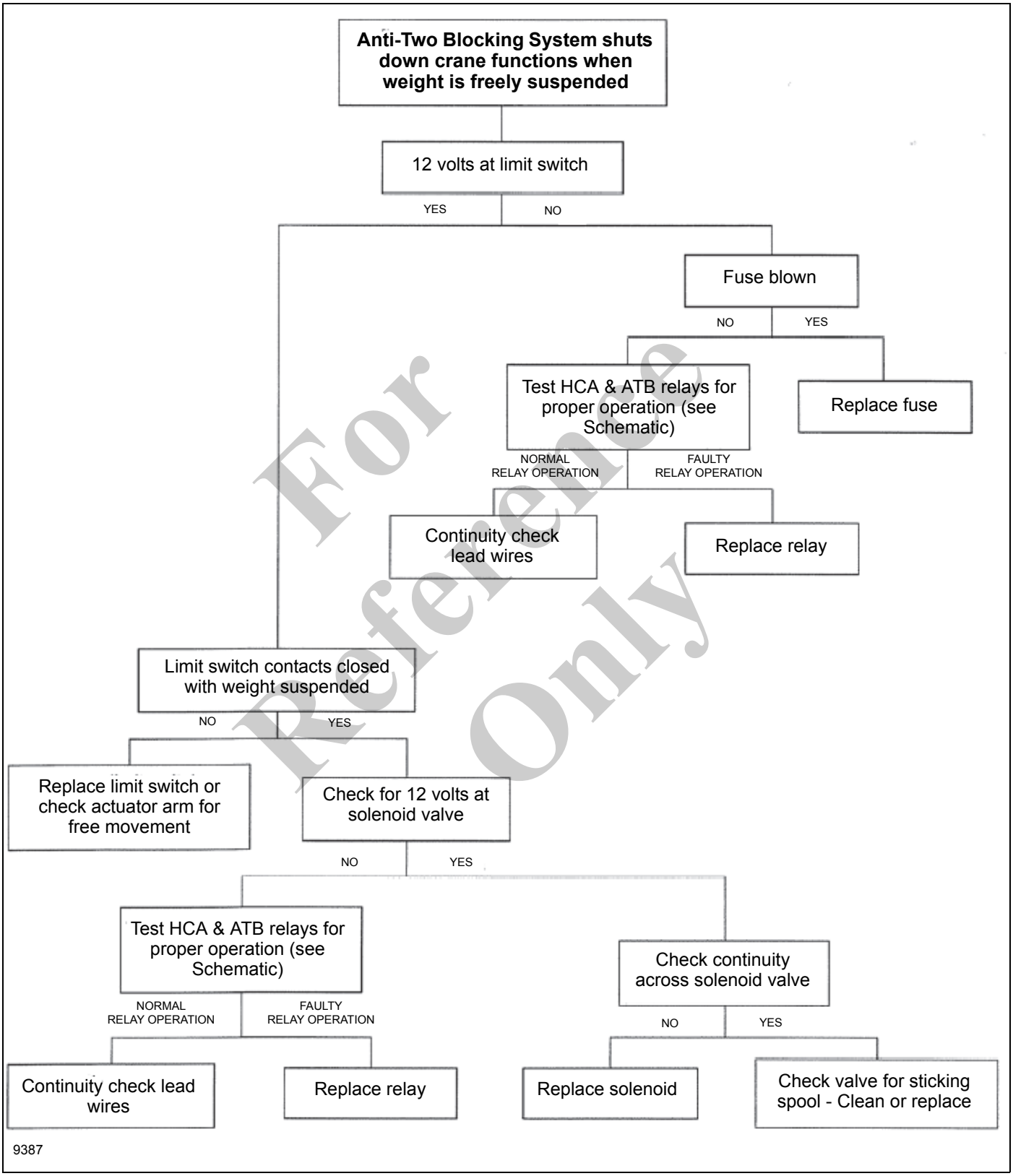
**TROUBLE DIAGNOSIS (continued)**

| CONDITION | POSSIBLE CAUSE | POSSIBLE SOLUTION |
|---|---|---|
| **Boom chatters during extension/ retraction or doesn't proportion properly** | • Boom sections need lubrication.<br>• Wear pads not shimmed correctly.<br>• Worn wear pads.<br>• Extension cables out of adjustment.<br>• Extend or retract cables broken. | • Grease boom.<br>• Reshim as described in boom assembly section.<br>• Replace pads.<br>• Readjust cables and tension properly.<br>• Disassemble and inspect and replace cables. |
| **Boom will not extend** | • Proportioning cables not attached.<br>• Anti-two-block system shut down.<br>• Defective anti-two-block system. | • Reconnect, replace and/or adjust cables.<br>• Lower hook, and extend load.<br>• Check anti-two-block system; repair if defective. |

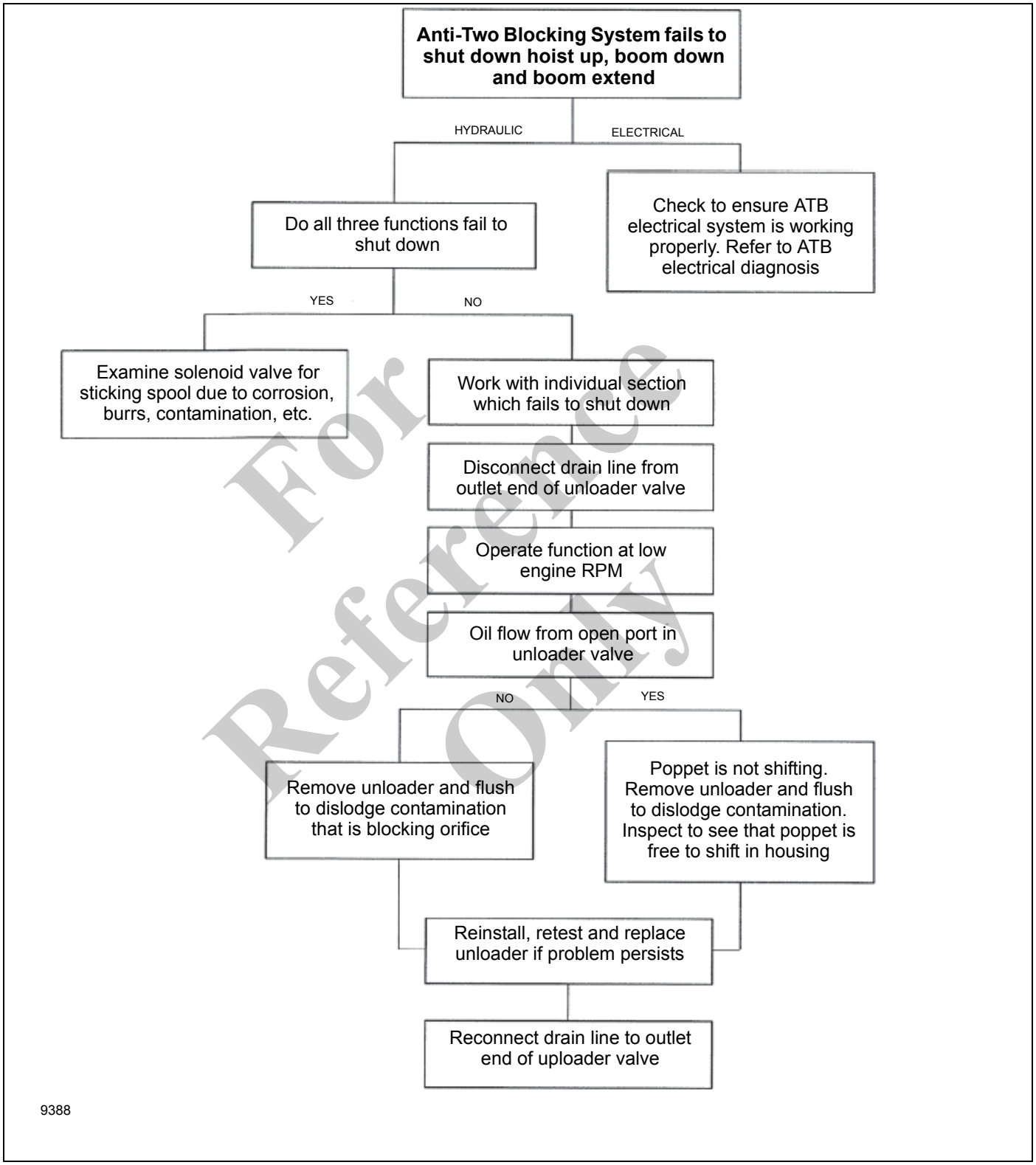
## Anti-two Block Trouble Diagnosis — Electrical



## Anti-two Block Trouble Diagnosis – Electrical (Continued)



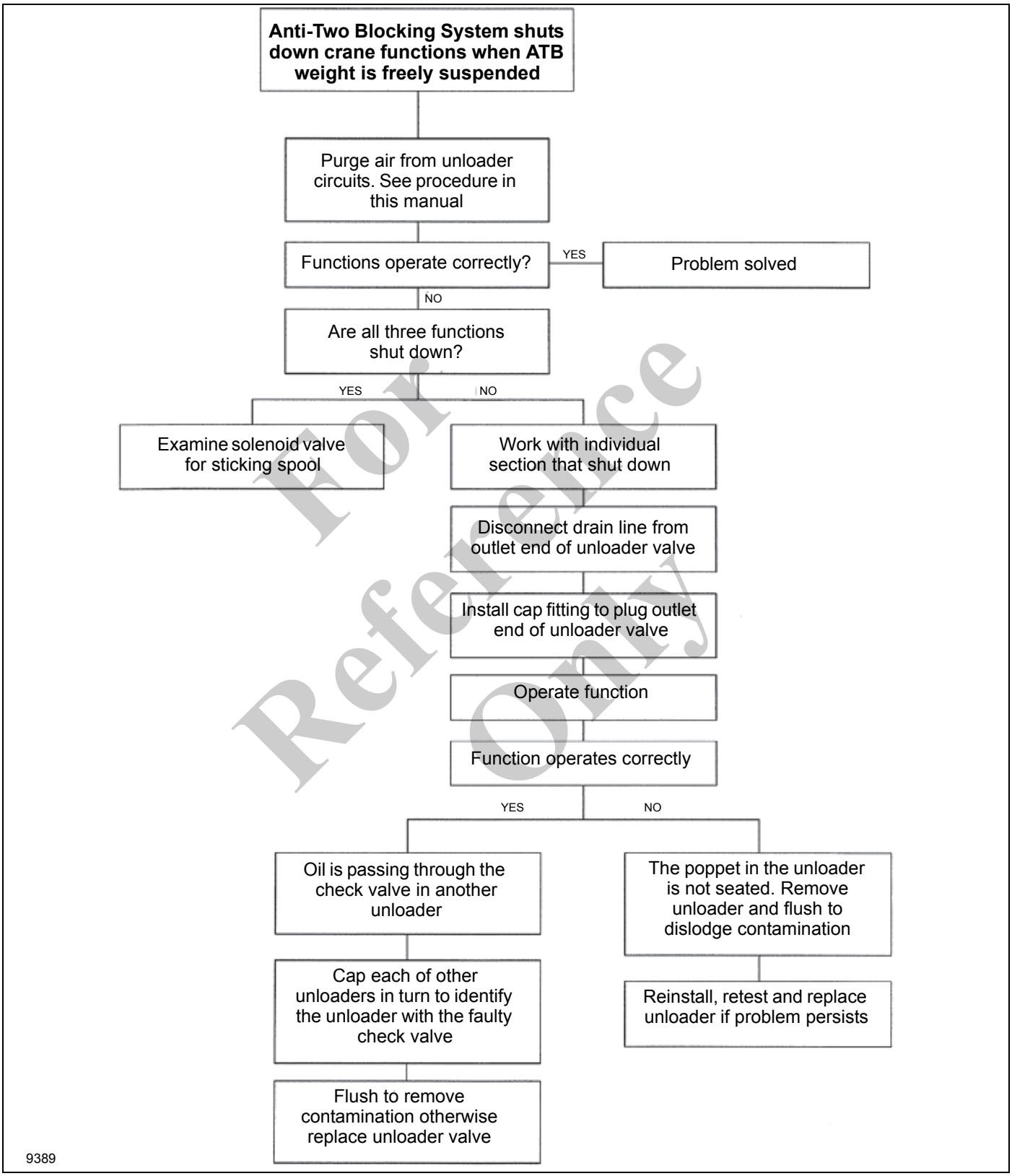
## Anti-two Block Trouble Diagnosis — Hydraulic






**Note: None of the internal parts of the unloader valves are serviceable.**

## ANTI-TWO BLOCK TROUBLE DIAGNOSIS - HYDRAULIC (CONTINUED)






**Note: None of the internal parts of the unloader valves are serviceable.**

## ANTI-TWO-BLOCK INTERNAL WIRE SYSTEM/FOUR SECTION BOOM (CABLE ON TOP OF SECTIONS)

### Operation

The internal anti-two-block wire system is routed through the boom in two stages. The first stage, 1/2, runs between the top plates of the first and second sections on a traveling block. The 1/2 and 2/3/4 sections are joined with a Weather-Pack connector. The second stage, 2/3/4, is anchored at the back of the second section, passes over the sheave at the end of the telescoping cylinder and is then anchored at the hoist end of the fourth section. After running the length of the boom inside of the fourth section, it is connected to the anti-two-block switch mounted on the side of the sheave case.

### Maintenance

In the event of a break in continuity of the anti-two-block wire, the hydraulic portion of the system will be disabled and make certain crane functions inoperative. Before repair or replacement of either of the two stages, check for continuity loss at the anti-two-block switch, connector damage or corrosion, and overall system condition. Due to the environmental exposure of the system, a thorough check of the circuit should be performed.

If the internal wire has lost continuity it will probably be necessary to replace only one of the two stages in the circuit, the 1/2 or the 2/3/4 stage. A simple continuity test of both stages should identify which one contains the failure.

1. Unplug the Weather-Pack connector linking the two stages together at the hoist end of the second boom section.
2. With the anti-two-block switch in its closed position (weight suspended from switch or overridden with the red flag), check continuity across the Weather-Pack terminals on the 2/3/4 stage. If there is no continuity in the 2/3/4 stage, recheck continuity of the anti-two-block switch on its own and recheck continuity of the 2/3/4 wire to ensure the wire is the problem. If continuity exists, the problem is in the 1/2 stage.
3. If the fault is suspected in the 1/2 stage, unplug the connector at the turret. Install a jumper wire across the terminals of one of the connectors and check for continuity at the opposite connector.

After determining which wire stage contains the fault, refer to the following procedures for replacement.

## 1/2 STAGE ANTI-TWO BLOCK WIRE REPLACEMENT

The 1/2 stage anti-two-block wire is located between the top plates of the 1st and 2nd boom sections, riding on a traveling block. The maintenance of this wire can be accomplished with the boom fully assembled but would be simplified if the 2/3/4 boom assembly was removed from the first section.

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

### Disassembly Of 1/2 Stage

**Alternative No. 1**

This procedure pulls the replacement wire through the boom following the path of the defective wire.

Special tools or equipment:

- Two end-to-end electrical butt connectors
- Shrink tube or electrical tape

1. Retract boom completely.
2. Unplug Weather-Pack connector between 1/2 and 2/3/4 stage, located at rear of second boom section.
3. Unplug connector in turret and disconnect wire from cushion clamp on bottom of first boom section.
4. Measure the amount of wire from the retaining plates to the connectors on both ends of the 1/2 wire. Record these numbers for later use.
5. Remove capscrews and retaining plates from the top backs of the first and second sections.
6. Attach replacement anti-two-block wire to damaged wire with a “temporary splice”, securing the conductors with end-to-end butt connectors and shrink tube or electrical tape. This connection must be secured well enough to pull the new wire through the boom.
7. Slowly pull the new wire into the boom by pulling on the opposite end of the damaged wire. If this method fails, Alternative No. 2 should be used.
8. Once enough new wire has been pulled past the retaining plate location, remove temporary splice, reattach the retaining plate and install the connector on that end of the wire. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 2/3/4 wire.
9. Loosely attach the retaining plate on the other end of the new wire.
10. While pulling on the new wire with a tension of about 15-25 lb (7-11 kg), tighten the capscrews on the retaining plate.
11. Using the length recorded earlier, measure the cord and attach the connector. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 2/3/4 wire.

12. Install a jumper across the terminals of one of the connectors and check for continuity at the opposite connector. If the new wire does not have continuity, check the terminals to ensure they have been attached correctly.
13. Do not proceed until this wire shows continuity.
14. Visually inspect interior routing of anti-two-block wire for excess slack in wire, inaccurate routing of wire, etc. Correct any problems before boom operation.
15. Make all wire connections, reattach the wire to the cushion clamp on the bottom of the boom and check system for correct operation.
16. Slowly cycle the boom while checking for proper wire operation.

**Alternative No. 2**

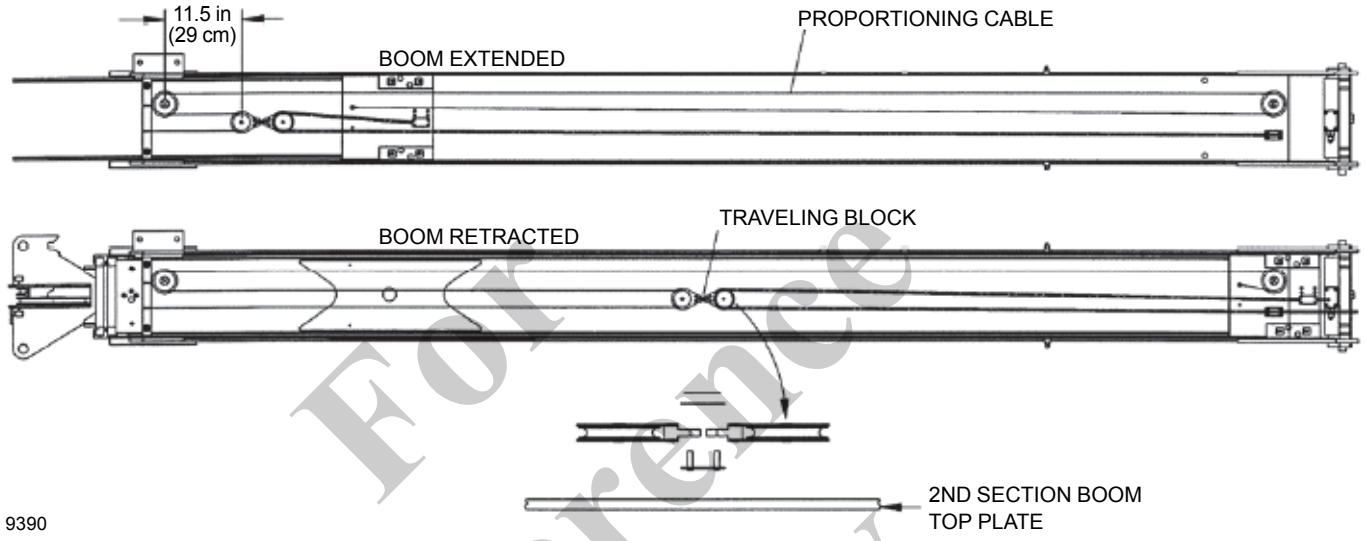
This procedure is used for anti-two-block wire replacement in the event of a complete separation of the wire or the inability to access one or both ends of the damaged wire outside of the boom assembly.

Specials tools or equipment

- •Electrical tape
- •Installation tools

1. Retract boom completely.
2. Measure the lengths of the two ends of the anti-two-block wires that are outside of the clamps on the first and second boom sections. Record these dimensions.
3. Remove capscrews and retaining plates from the top plates of the first and second sections. Remove both ends of the damaged anti-two-block cord from the boom.
4. Extend the boom until the reinforcing plate on the top of the second section is outside of the first section by about 24 in (61 cm).
5. At the sheave case end of the boom, remove the two capscrews and washer from the spacer bar under the bottom of the first section top plate.
6. Using the anchor button on the steel cable, which drives the anti-two-block wire, remove the spacer bar and pull the traveling blocks out of the boom.
7. Inspect the steel cable for damage or defects.
8. Extend the boom to maximum extension. This provides the least amount of overlap between the two sections and makes it easier to hook an installation tool at the back of the second section.
9. Using No. 9 wire or another stiff yet bendable material, make two tools which are about 72 in (183 cm) in length with a hook at one end which has an opening of 0.5 in (1,3 cm).
10. Insert the hooked end of the two “tools” into the space between the tops of the first and second sections and run them back until the tools hook over the top plate of the second section.
11. Run the replacement wire through the open sheave (one sheave will have the steel cable routed through it already) of the traveling block and temporarily attach each end of the new wire to the two tools. You have now made a big loop with the two tools and the new wire routed through the sheave.
12. Slowly retract the boom maintaining tension on the new wire, both sides of the loop, and the steel proportioning cable. At the time when the reinforcing plate is about 24 in (61 cm) outside of the first section, you need to allow the traveling block to pass back into the first section.
13. While still maintaining tension on both sides of the loop of the new wire and a little tension on the steel proportioning cable, retract the boom to full retraction. Do not allow the retention button on the steel cable to go inside of the boom.
14. At the hoist end of the boom, reach inside of the boom and draw out the two tools hooked over the top plate of the second section.
15. At the sheave case end of the boom, reinstall the spacer plate between the top front of the first and second sections. Make sure that the steel cable is still running through the slot in the spacer bar.
16. At the hoist end of the boom, draw the two ends of the new wire out of the boom until the retention button on the steel cable is drawn against the spacer bar.
17. Run the new wire back and forth through the traveling block sheave to make sure it runs freely. Do this by alternately pulling on one end or the other of the new wire while maintaining slight tension on the other end of the wire.
18. Loosely replace the retention clamps on the wire after measuring out one end to ensure the correct wire length for the connector.
19. Tighten the clamp on the measured end of the wire and replace the connector. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 2/3/4 wire.
20. While pulling on the new wire with a tension of about 15-25 lb (7-11 kg), tighten the capscrews on the second retaining plate.
21. Using the length recorded earlier, measure the cord and attach the connector. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 2/3/4 wire.

22. Install a jumper across the terminals of one of the connectors and check for continuity at the opposite connector. If the new wire does not have continuity, check the terminals to ensure they have been attached correctly.
23. Do not proceed until this wire shows continuity.
24. Visually inspect interior routing of anti-two-block wire for excess slack in wire, inaccurate routing of wire, etc. Correct any problems before boom operation.
25. Make all wire connections, reattach the wire to the cushion clamp on the bottom of the boom and check system for correct operation.
26. Slowly cycle the boom while checking for proper wire operation.




**1/2 WIRE ROUTING**

## 2/3/4 STAGE ANTI-TWO BLOCK WIRE REPLACEMENT

The procedure for removal and reinstallation of the 2/3/4 stage anti-two-block wire can be accomplished using two different methods depending on the severity of the damage. Alternative No. 1 should be used if the wire has experienced a continuity failure in the conductors but the rubber jacket of the wire is still intact. Alternative No. 2 is to be used if the wire has been completely cut or either end of the wire is not accessible.

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

**Alternative No. 1**

This procedure pulls the replacement wire through the boom following the path of the defective wire.

Special tools or equipment:

- Two end-to-end butt connectors
- Shrink tube or electrical tape

1. Retract boom completely.
2. Loosen and remove capscrew and cable clamp from sheave case attachment point. Remove connector from wire, measure and record pigtail length from attachment point, and pull end of wire through the side plates of the boom to align the end with the wire routing over the telescope cylinder.
3. Attach replacement anti-two-block wire to the damaged wire using the end-to-end butt connectors and tape or shrink tube. This connection must be secured well enough to pull the new wire through the boom.
4. At the hoist mount end of the boom, reach into the rear of the boom and loosen the capscrew on the anti-two-block cable clamp enough to let the cable run around it with minimal effort. This clamp is located on the extend cable anchor at the back bottom of the fourth section.
5. Disassemble capscrew attaching cord grip/spring/anti-two-block wire to the extend cable anchor on the 2nd boom section at the hoist mount end of the boom.
6. Slowly pull the damaged wire from the hoist mount end of the boom. The splice on the end of the replacement wire may need help moving around the cable clamp at

the bottom back end of the fourth section. If excessive force is needed to pull the wire through, observe the routing for obstructions and make adjustments to avoid breaking the splice. If the splice fails Alternative No. 2 may need to be used.

7. Pull the wire through the boom until enough wire is left on the sheave case end of the boom to attach the connector and route and anchor the wire. Refer to measurement taken earlier.
8. Tighten the clamp at the back bottom of the fourth section.
9. Apply about 15-25 lb (7-11 kg) of tension to the wire at the sheave case end of the boom. Tighten the clamp on the wire in the sheave case.
10. Reattach the connector to the wire and make the connection between the new wire and the anti-two-block switch. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 1/2 wire.
11. Cut the splice from the new wire and slide the cord grip to its approximate final position.
12. Reattach spring to cord grip and reassemble the parts at the cable anchor on the back of the second boom section. Slide cord grip up anti-two-block wire into boom to increase spring tension on moving length of anti-two-block wire. Approximately 2 in (51 mm) of spring extension tension should be adequate for proper operation.
13. Reattach the connector to the wire and make the connection between the new wire and the anti-two-block switch. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 1/2 wire.
14. Visually inspect interior routing of anti-two-block wire for excess slack in wire, wrong routing of wire, etc. Correct any problems before boom operation.

Alternative No. 2

This procedure is to be used for anti-two-block wire replacement in the event of a complete separation of the wire, or the inability to access one or both ends of the damaged wire. This procedure routes a new anti- two-block wire through the boom without having an existing wire to pull it through (Alternative No. 1).

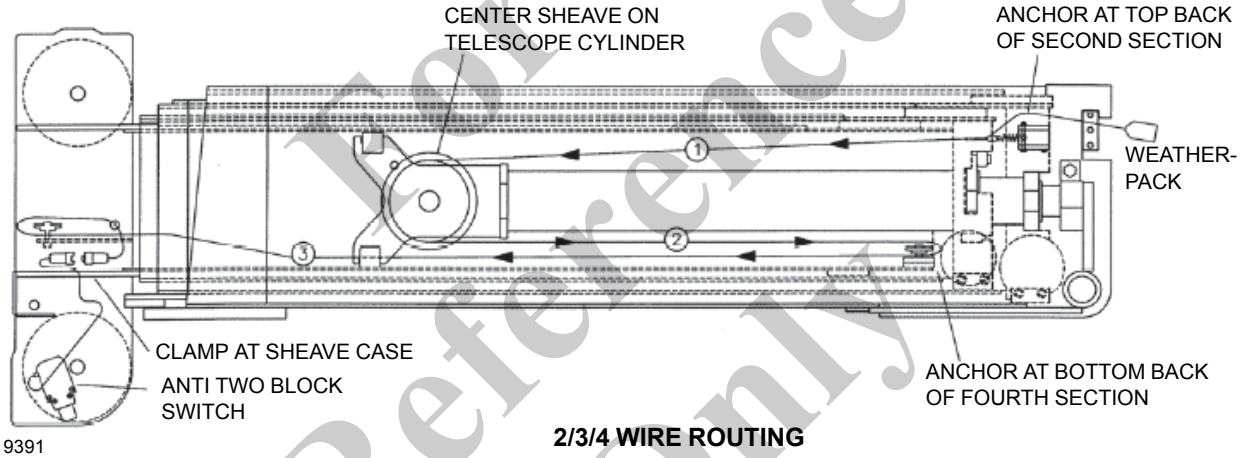
Special tools or equipment:

- Electrical tape
- Installation tool

To route the wire the entire length of the boom, a long tube, to be used as an installation tool, must be utilized to transport the end of the new anti-two-block wire from one end of the boom assembly to the other. A telescopic grease applicator for the boom, hydraulic tubing or electrical conduit are all possibilities for use as an installation tool. The installation tool should be at a minimum 2 ft (0,5 m) longer than the retracted boom length.

1. Retract the boom completely.
2. 2.Loosen and remove the anti-two-block clamp from the sheave case and fourth section extend cable anchor.
3. Remove the capscrew from extend cable anchor at the back of the second boom section.
4. Remove the connector from the wire at the sheave case end of the boom. Measure and record the length of the pigtail from the cable clamp to the connector.
5. Remove all damaged wire from the boom. Visually inspect the interior of the boom to make sure all of the damaged wire is removed. Inspect sheave at the end of the telescope cylinder to make sure it is not damaged.
6. Start installation of the replacement at the sheave case end of the boom. Tape one end of the new wire to one end of the installation tool.
7. Insert installation tool and wire into the sheave case in the center open area between the sheave case side plates. Visually guide the wire and installation tool over the center sheave on the telescope cylinder sheave case.
8. Push installation tool and wire until it can be pulled through the hoist end of the boom. Detach wire from tool and pull tool back out the sheave case end of the boom.
9. Attach the other end of the wire to the tool and again insert the tool into the boom between the sheave case side plates. This time guide the tool into the boom and under the center sheave of the telescope cylinder.
10. Push tool and attached wire through the boom until it can be grasped from hoist end. Do not detach wire at this time.
11. Apply tension to both ends of the new wire. This will draw the new wire into the groove of the center sheave of the telescope cylinder sheave case.
12. From the sheave case end of the boom, verify that the wire is in the groove of the center sheave. If the wire is not properly aligned, a 5 ft (1,5 m) piece of stiff wire may have to be used to guide the wire into the groove.
13. At the hoist mount end of the boom, assemble the clamp attached to the extend anchor at the bottom back of the fourth boom section.
14. Loop the wire that is still taped to the tool around the clamp and slowly draw the tool back out of the sheave case end of the boom.

15. The routing of the new wire is now complete and the tool can be detached from the wire. Visually inspect the wire routing to make sure that it is correctly routed.
16. Pull the wire from either the sheave case or hoist end of the boom to get the end lengths closer to what is required.
17. Tighten the clamp at the bottom back of the fourth section.
18. Reassemble the clamp at the sheave case and while applying 15-25 lb (7-11 kg) of tension to the new wire, tighten the clamp. Measure the length of pigtail required and reassemble the connector onto the wire. Route the connector through the sheave case and make the connection with the anti-two-block switch. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 1/2 wire.
19. At the hoist end of the boom, install the cord grip and spring onto the new wire at the approximate final position inside of the boom. Install the capscrew into the spring and cable anchor. While applying tension to the wire, slide the cord grip out the wire until there is approximately 2 in (50 mm) of spring extension for proper operation.
20. Attach connector to wire. The connectors on this cable are two separate styles. Make sure the Weather-Pack connector is on the end that will attach to the 1/2 wire.
21. Visually inspect routing and anchors for correct assembly, excessive slack and/or capscrew torque, etc. Verify continuity of new anti-two-block wire.



9391

**2/3/4 WIRE ROUTING**



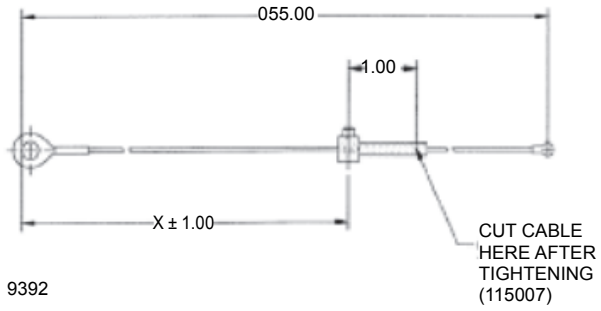
## REPLACEMENT OF PROPORTIONING CABLE FOR 1/2 STAGE OF ANTI-TWO BLOCK WIRE

### Operation

The 1/2 stage of the anti-two-block wire is driven by a small diameter steel proportioning cable. This cable drives the traveling block, which carries the live wire of the system. The location of the traveling block at full extension and retraction is critical to the proper operation of this system. If the traveling block is not located correctly, it could either fall off of the back of the second section during boom extension or be pinched between the first and second section top plates by the reinforcing plate on the second sector during boom retraction.

### Maintenance

The wire can be replaced with the boom assembled. If the wire has separated and become lodged in the boom extend and/or retract sheaves, boom disassembly will probably be required. There are two alternatives to the steel cables' replacement. Alternative will deal with an intact cable and alternative No. 2 will deal with a cable that has been cut into two pieces. The replacement cable supplied through National Crane part department works for several different lengths of booms. It will have to be installed and cut to the correct length during assembly.




| MODEL | LENGTH (X) |
|---|---|
| 8100D | USE CABLE AS IS |
| 890D | 605.00 |
| 880D | 545.00 |
| 685D | 555.50 |
| 680D | 525.00 |
| 649D | 339.50 |

Alternative No. 1

Special Tools:

- •Electrical tape
- •Short Cord or Wire

1. Retract the boom completely.
2. At the hoist mount end of the boom, remove the 5/16-18NC grade 5 capscrew through the slot on the lop plate of the first boom section.
3. Pull the end of the cable out of the back of the boom and connect a short piece of wire or cord through the loop. Anchor the cord in order to keep control of the end of tho cable.
4. At the sheave case end of tho boom. Remove the two capscrews and spacer bar from the top front end of the first boom section. As the spacer bar is removed, pull the steel cable along with the bar. The cord on the opposite end of the steel cable will allow some length of cable to be pulled from the boom. Do not pull hard enough lo break the hoist end of the cable loose.
5. Remove the cable stop from the end of the old proportioning cable and fasten the eyelet end of the new wire to the old cable with electrical tape
6. While maintaining some amount of tension on the new wire pull the old wire out of the boom at the hoist end of the boom assembly. When the eyelet of the new wire becomes visible at the hoist end of the boom, stop pulling on the wire
7. Detach the old and new wires. Insert the eyelet of the new wire into the space between the top plates of the first and second sections. Reattach the wire to the top plate of the second section with the 5/16-18NC grade 5 capscrew that was removed earlier.
8. At the sheave case end of the boom, install the spacer and capscrews in the top front of the first section. Make sure that the new anti-two-block wire is routed through the slot in the spacer bar.
9. Visually inspect the routing of the proportioning cable to make sure that it is properly seated in the sheave grooves.
10. Cut off the excess wire from the new wire that is sticking out of the first section leaving a length to about 24 in (61 cm). This will allow a short amount of wire to use to apply tension and for the installation of the cable stop and shrink tube without dealing with a lot of extra wire
11. Slide the cable stop onto the end of the wire sticking out of the end of the first section and run it up against the spacer bar. While pulling on the steel cable with a tension of about 15-25 lb (7-11 kg), tighten the screw in the cable stop.
12. Slide a new piece of shrink tube onto the end to the wire, run it up against the cable stop, and apply heat to shrink the tube. This will prevent the end of the wire from fraying.
13. Cut off the excess wire leaving about 1 in (25 mm) of wire with shrink tube sticking out of the cable stop.
14. Slowly operate the boom to make sure the sheaves turn and the cable runs correctly.

Alternative No. 2

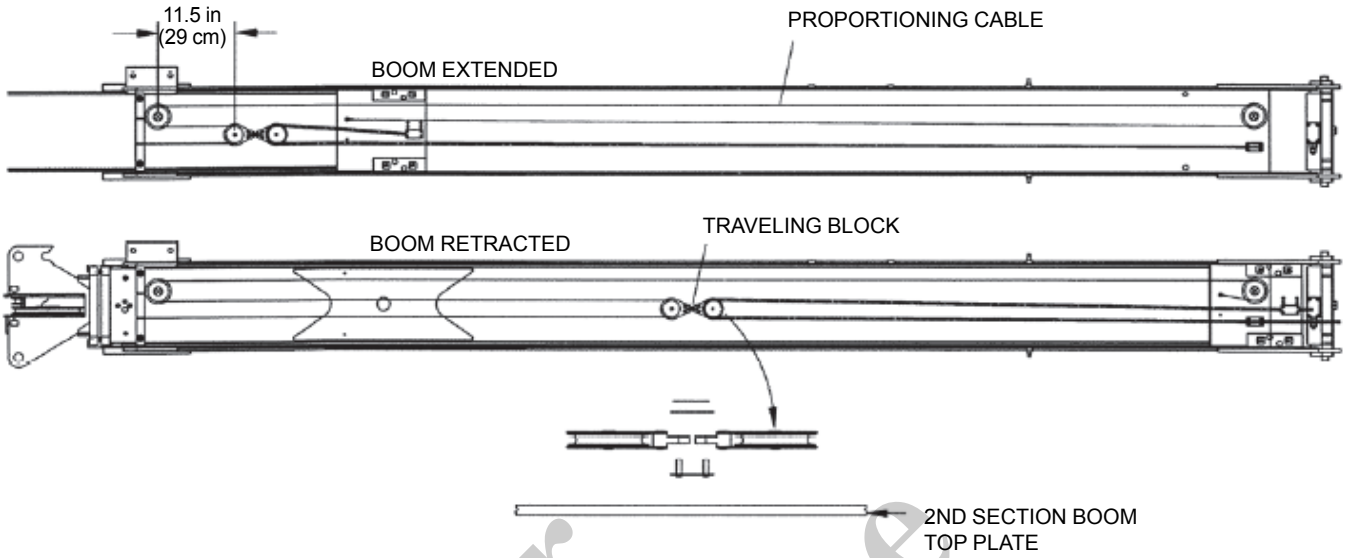
This is the method to be used in the event the proportioning cable has been cut during use. In this method a long installation tool is used to run the new wire from one end of the boom to the other.

Special tools:

- •Electrical tape
- •Installation tool

1. Retract the boom completely.
2. At the hoist end of the boom, remove the 5/16- 18NC capscrew from the top plate of the second section. This capscrew is accessible through a slot in the top plate of the first section.
3. Remove the old wire from the boom.
4. Extend the boom until the reinforcing plate on the second section is extended about 24 in (61 cm) out of the first section.
5. At the sheave case end of the boom, remove the two capscrews and the spacer plate from the front top of the first section. As the spacer plate is pulled from the boom, bring the old wire out of the boom.

6. Extend the boom completely.
7. Use a piece of No. 9 wire as an installation tool. Make a hook with an opening of about 1/2 in (13 mm) on one end. With the other end of the No. 9 wire, run the wire through the eyelet on the new wire and bend the wire over to make a hook. Tape the No. 9 wire and new proportioning cable to make sure these parts stay together as the cable is installed. The new wire is now attached to the installation tool.
8. Insert the tool into the space between the top plates of the first and second sections and hook it over the back of the top plate on the second section.
9. Slowly retract the boom while maintaining tension on the new steel cable.
10. When the boom is fully retracted, reach into the boom and pull the tool on out of the back of the boom. Detach the tool from the new proportioning cable. Route the end of the new wire around the sheave at the back of the first section and align the eyelet of the cable with the hole in the top plate of the second section. Loosely install the 5/16-18 NC capscrew.
11. On the power circuit side of the anti-two-block system, disconnect the connectors in the turret and remove the cushion clamp at the bottom of the boom. Loosen the cable clamp on the top hoist end of the first section. Loosening this wire will allow the traveling block to be drawn out of the front end of the boom assembly.
12. While the new steel proportioning cable is being held and guided to prevent damage, extend the boom until it is fully extended.
13. Again using the No. 9 wire, reach into the space between the first and second sections and hook and pull the traveling block out of the boom assembly. Inspect the traveling block for damage.
14. Route the proportioning cable around the sheave mounted to the top plate of the first section. Then run the new steel cable through the open sheave of the traveling block. Visually inspect to ensure the wire is routed correctly.
15. At the hoist end of the boom, slowly pull the circuit wire back out of the back of the boom until it reaches its original location. A crimped area on the jacket of the wire should be visible and line up with the clamp plate. Loosely tighten the retaining plate capscrews.
16. If the parts are properly aligned, the center pin of the sheave on the sheave case end of the traveling block should be about 11-1/2 in (29 cm) behind the center of the sheave bolted to the top plate of the first section. If the traveling block is not located correctly, it will be damaged during boom extension or retraction.
17. Tighten the 5/16-18NC capscrew at the top hoist end of the second section. Tighten the capscrews in the retaining plate at the hoist end of the first section.
18. At the sheave case end of the boom, install the spacer and capscrews in the top front of the first section. Make sure that the new anti-two-block proportioning cable is routed through the slot in the spacer bar.
19. Visually inspect the routing of the proportioning cable to make sure that it is properly seated in the sheave grooves.
20. Cut off the excess wire from the new wire that is sticking out of the first section leaving a length of about 24 in (61 cm). This will allow a short amount of wire to use to apply tension and for the installation of the cable stop and shrink tube without dealing with a lot of extra wire.
21. Slide the cable stop onto the end of the wire sticking out of the end of the first section and run it up against the spacer bar. While pulling on the steel cable with a tension of about 15-25 lb (7-11 kg), tighten the screw in the cable stop.
22. Slide a new piece of shrink tube onto the end of the wire, run it up against the cable stop, and apply heat to shrink the tube. This will prevent the end of the wire from fraying.
23. Cut off the excess wire leaving about 1 in (25 mm) of wire with shrink tube sticking out of the cable stop.
24. Slowly operate the boom to make sure the sheaves turn and the cable runs correctly.




**1/2 WIRE ROUTING**

## ANTI-TWO-BLOCK INTERNAL WIRE SYSTEM/THREE SECTION BOOM

### Operation

The internal anti-two-block wire is routed from the control console to the hoist mount end of the boom, following the path of the extend cables to the rear of the 3rd section boom. This is the length of the wire that proportions in and out with the boom length, similar to the route of the extend cables. At this point at the rear of the 3rd section, the wire loops around and anchors at the anti-two-block cable clamp on the extend cable anchor. The anti-two-block wire, now attached at the rear of the 3rd, runs the length of the section and attaches to the 3rd section sheave case. The wire then loops around the clamp arrangement on the sheave case and routes through access holes in the side plate of the boom. The wire terminates at a quick connect two conductor plug designed for anti-two-block switch or jib interface.

### Maintenance

In the event of a break in continuity of the anti-two-block wire routed internally in the boom, the anti-two-block hydraulic system will sense a problem and make certain crane functions inoperative. Before repair or replacement of internal wire, check for continuity loss at the anti-two-block switch, damaged, missing, or corroded connectors and overall system condition. Due to the environmental exposure of the system, a thorough check of the circuit should be performed.

The procedure for removal and reinstallation of the anti-two-block wire can be accomplished using two different methods depending on the severity of the damage. Alternative No. 1 should be used if the wire has experienced a continuity failure in one or both of the conductors, but the rubber jacket of the wire is still intact. Alternative No. 2 is to be used if the wire has been completely cut or either end of the wire is inaccessible.

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

Alternative No. 1

This procedure pulls the replacement wire through the boom, following the path of the defective wire.

Special tools or equipment:

- Two end-to-end electrical butt connectors
- Shrink tube or electrical tape

1. Retract boom completely.
2. Loosen and remove capscrew and cable clamp arrangement from sheave case attachment point of anti-two-block wire. Remove quick connect plug on anti-two-block wire by unscrewing base of plug and disconnecting individual wires from connections. Note pigtail length at this time and wire/terminal number location for proper reassembly.
3. Pull end of anti-two-block wire through side plates of 3rd section boom to gain in-line wire path.
4. Attach replacement anti-two-block wire to damaged wire with a “temporary splice”, securing the conductors with end to end butt connectors and shrink tube or electrical tape. This connection must be secured well enough to pull the new wire through the boom.

5. At the hoist mount end, reach into the rear of the boom and loosen the capscrew on the anti-two-block cable clamp enough to let the cable run around it with minimal effort. This clamp is located on the extend cable anchor.
6. Disassemble spade bolt anchor attaching anti-two-block wire to the extend cable plate on the hoist mount end of the boom.
7. Pull wire from hoist mount end. Replacement wire “temporary splice” may need assistance reeving around anti-two-block cable clamp in rear of 3rd section. If excessive force is needed to pull wire through, observe wire routing and make adjustments as needed to avoid breaking “temporary splice”. If splice fails at this point, wire routing Alternative No. 2 should be used.
8. Pull wire through boom, leaving enough wire on sheave case end to properly attach and terminate wire.
9. Tighten anti-two-block wire clamp located in rear of 3rd section.
10. Route sheave case end of anti-two-block wire around clamp in sheave case, and through holes in side plates. Pulling on this end will tension the static length of anti-two-block wire clamped in the 3rd. Approximately 15-25 lb (6-11 kg) will be sufficient to provide proper operation. Tighten sheave case anti-two-block wire clamp.
11. Reassemble quick disconnect plug to anti-two-block wire. Proper wire attachment is critical for proper anti-two-block system operation. Consult electrical schematic in this book for proper connector wiring.
12. Temporary splice” should now be approximately 10 ft (3 m) past the hoist mount end of the boom. Break “splice” and slide strain relief/cord grip onto wire into approximate position inside the boom.
13. Assemble spring and spade bolt to cord grip and reassemble anchor components to extend cable anchor plate on the hoist mount. Slide cord grip up anti-two-block wire into boom to increase spring tension on moving length of anti-two-block wire. Approximately 2 in (50 mm) of spring extension tension should be adequate for proper operation.
14. Visually inspect interior routing of anti-two-block wire for excess slack in wire, inaccurate routing of wire, etc. Correct any problems before boom operation.

**Alternative No. 2**

This procedure is to be used for anti-two-block wire replacement in the event of a complete separation of the wire, or the inability to access one or both of the ends outside the boom assembly. This procedure routes a new anti-two-block wire through the boom without having an existing wire to pull it through (Alternative No. 1).

Special tools or equipment:

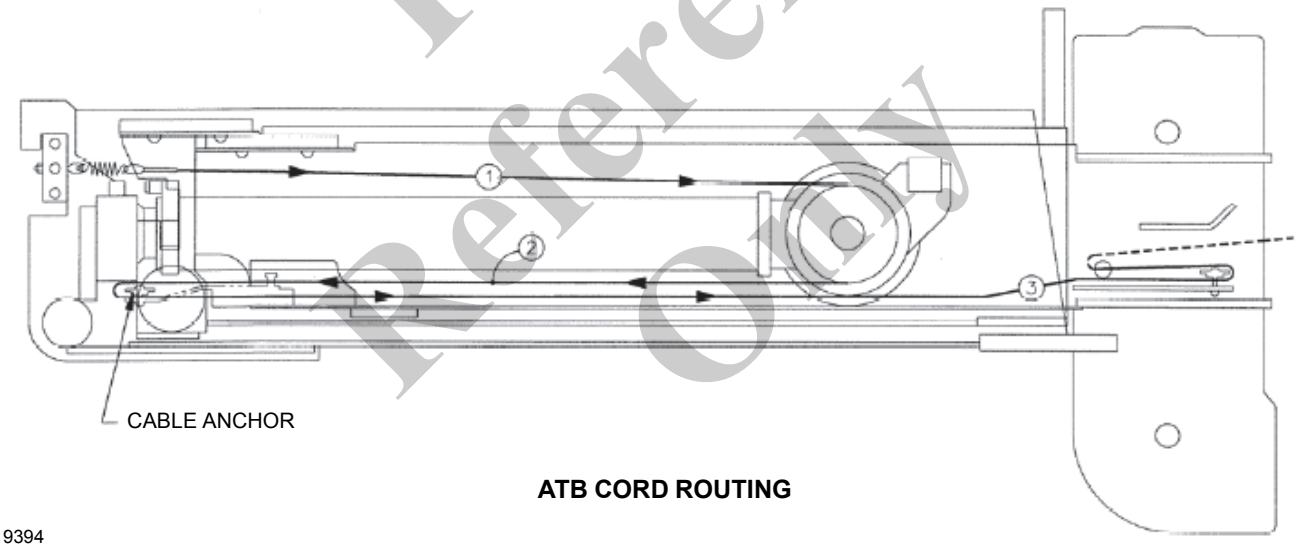
- •Electrical tape
- •Installation tool

To route the wire the entire length of the boom, a long tube, to be used as an installation tool, must be utilized to transport the end of the anti-two-block wire from one end of the boom assembly to the other. A telescopic grease applicator for the boom, hydraulic tubing or electrical conduit are all possibilities for an installation tool. The installation tool should be at a minimum 2 ft (0,5 m) longer than the retracted boom assembly.

1. Retract boom completely.
2. Loosen and remove anti-two-block cable clamp arrangements from sheave case and 3rd section extend anchor. Remove spade bolt anchor from extend cable anchor plate in the hoist mount end of boom.
3. Remove quick disconnect plug on anti-two-block wire by unscrewing base of plug and disconnecting individual wires from connections. Note pigtail length at this time, and wire/terminal number location for proper reassembly.
4. Pull anti-two-block wire out of boom assembly. Visually inspect boom interior from both ends to verify alt the cable has been removed from the boom. Visually inspect center sheave on extend cylinder for damage.
5. Start installation of replacement wire on the sheave case end of the boom assembly. Using electrical tape, attach one end of replacement wire to the end of the installation tool.
6. Insert installation tool and wire into sheave case in the center open area between the sheave case side plates. Visually guide the wire and installation tool over the center sheave on the extend cylinder sheave case.
7. Push installation tool and wire through boom until it appears at the hoist mount end, detach wire from installation tool, route wire through open top of hoist mount and temporarily tie off to a convenient anchor point. Pull installation tool out sheave case end of boom.
8. From sheave case end of boom, attach other end of replacement wire to installation tool with electrical tape. Insert installation tool and wire into the boom sheave case, in the open area between the sheave case side plates. Visually guide this end under the center sheave on the extend cylinder sheave case.
9. Push installation tool and wire through boom until it appears at the hoist mount end. Do not detach wire from installation tool.
10. From hoist mount end of boom, locate installation tool and attached wire, and pull the wire out of the boom section, removing the slack loop from the sheave case end of the boom. This will place the wire close to, if not on, the center sheave of the extend cylinder.

11. Move to the sheave case end of the boom. Visually determine if the wire has properly located itself onto the sheave. If not, manipulate the wire placement through the end of the boom and place the wire on the sheave. A 5 ft (1,50 m) long access tool (hook end) will simplify this procedure greatly.
12. From the hoist mount end of the boom, assemble the anti-two-block wire clamp on the extend cable anchor in the rear of the 3rd section. Loop anti-two-block wire around clamp and lightly tighten capscrew holding clamp together. Keeping a slight amount of tension on the wire at this point will keep the wire properly located on the sheave.
13. From the sheave case end, pull the installation tool and wire end out of the boom. The route of the anti-two-block wire in the boom is now complete.
14. Pull wire at either end of boom to adjust length of wire on sheave case end to properly attach and terminate wire.
15. Tighten anti-two-block wire clamp located in rear of 3rd section.
16. Route sheave case end of anti-two-block wire around clamp in sheave case and through holes in side plates. Pulling on this end will tension the static length of anti-two-block wire clamped in the 3rd. Approximately 15-25 lb (7-11 kg) will be sufficient to provide proper operation. Tighten sheave case anti-two-block wire clamp.
17. Reassemble quick disconnect plug to anti-two-block wire. Proper wire attachment is critical for proper anti-two-block system operation. Consult electrical schematic in this book for proper connector wiring
18. From hoist mount end of boom, slide strain relief/cord grip onto wire, into approximately position inside the boom.
19. Assemble spring and spade bolt to cord grip and reassemble anchor components to extend cable anchor plate on the hoist mount. Slide cord grip up anti-two-block wire into boom to increase spring tension on moving length of anti-two-block wire. Approximately 2 in (50 mm) of spring extension tension should be adequate for proper operation.
20. Visually inspect interior routing of anti-two-block wire for excess slack in wire, inaccurate routing of wire, etc. Correct any problems before boom operation.






**ATB CORD ROUTING**

9394

## ANTI-TWO-BLOCK WIRE WITH EXTERNAL REEL

### Operation

Boom is equipped with an anti-two-block utilizing a reel on the outside of the boom. As the boom extends, the wire pays off of the reel and is routed through a sheave on the hoist end of the boom. The wire is then routed through roller guides attached at the hoist end of the 2nd and 3rd boom sections. The wire is then anchored at both ends of the 4th boom section. A switch at the sheave case on the 4th section controls switching of the signal. Three and four section booms differ only in number of roller guides.

### Maintenance

In the event of a break in continuity of the anti-two-block wire, the hydraulic portion of the system will be disabled and make certain crane functions inoperative. Before replacement of the wire, check for continuity loss at the anti-two-block switch, connector damage or corrosion, and overall system condition. Due to the environmental exposure of the system,

a thorough check of the circuit should be performed. If the wire on the reel is determined to be faulty, replace the wire.

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

### *Alternative No. 1*

This method pulls the replacement wire through the boom using the defective wire as the installation tool.

Special tools and equipment

- •Two end-to-end electrical butt connectors
- •40 ft (12,2 m) flexible wire or light cord

1. Retract boom completely.
2. Unplug electrical connector at sheave case end of boom.
3. Remove electrical connector from the anti-two-block wire running to the reel.
4. Remove the capscrew, anchoring the anti-two-block wire at the hoist end of the 4th section.
5. Remove the capscrew, washers and nut, anchoring the anti-two-block wire at the sheave case end of the 4th section.
6. Pull the wire about 2 ft (0,6 m) out the sheave case end of the boom.
7. Cut the thimble off of the wire.
8. Attach the 40 ft (12,2 m) length of flexible wire or light cord to the end of the anti-two-block wire using the end-to-end electrical butt connector.
9. Let the spring tension on the reel slowly pull the wire or cord back through the boom.
10. Remove old wire from reel and replace with new anti-two-block wire.
11. Route the new wire through the sheave at the hoist end of the boom and attach the end of the anti-two-block wire to the end of the wire routed through the boom using the second end-to-end butt connector.
12. Draw all of the light cord or flexible wire through the boom plus an additional length of anti-two-block wire long enough to install the first thimble for the sheave case end of the boom. Install thimble per instructions.
13. Draw enough additional anti-two-block wire to install the other two thimbles on the anti-two-block wire. Refer to drawing. Install thimbles per instructions.
14. Allow the reel to retract the two thimbles back into the boom.
15. At the hoist end of the boom, attach the two thimbles to the 4th boom section making sure that the thimbles point in opposite directions and that the loop in the cord is at the top of the anchor. Tighten the capscrew until it bottoms out in the threads.
16. At the sheave case end of the boom, attach the thimble in the slot and pull it towards the open end of the boom to tension the anti-two-block wire.
17. Attach the electrical connector and connect to the switch.
18. Slowly operate the boom to make sure that the anti-two-block wire runs freely in the boom and that the cable reel runs properly.
19. Test the anti-two-block circuit for proper operation and hydraulic circuit cut out.

### *Alternative No. 2*

This method requires pushing a long rod through the boom to pull the new anti-two-block wire through the boom. This method is required in the event the anti-two-block wire is severed.

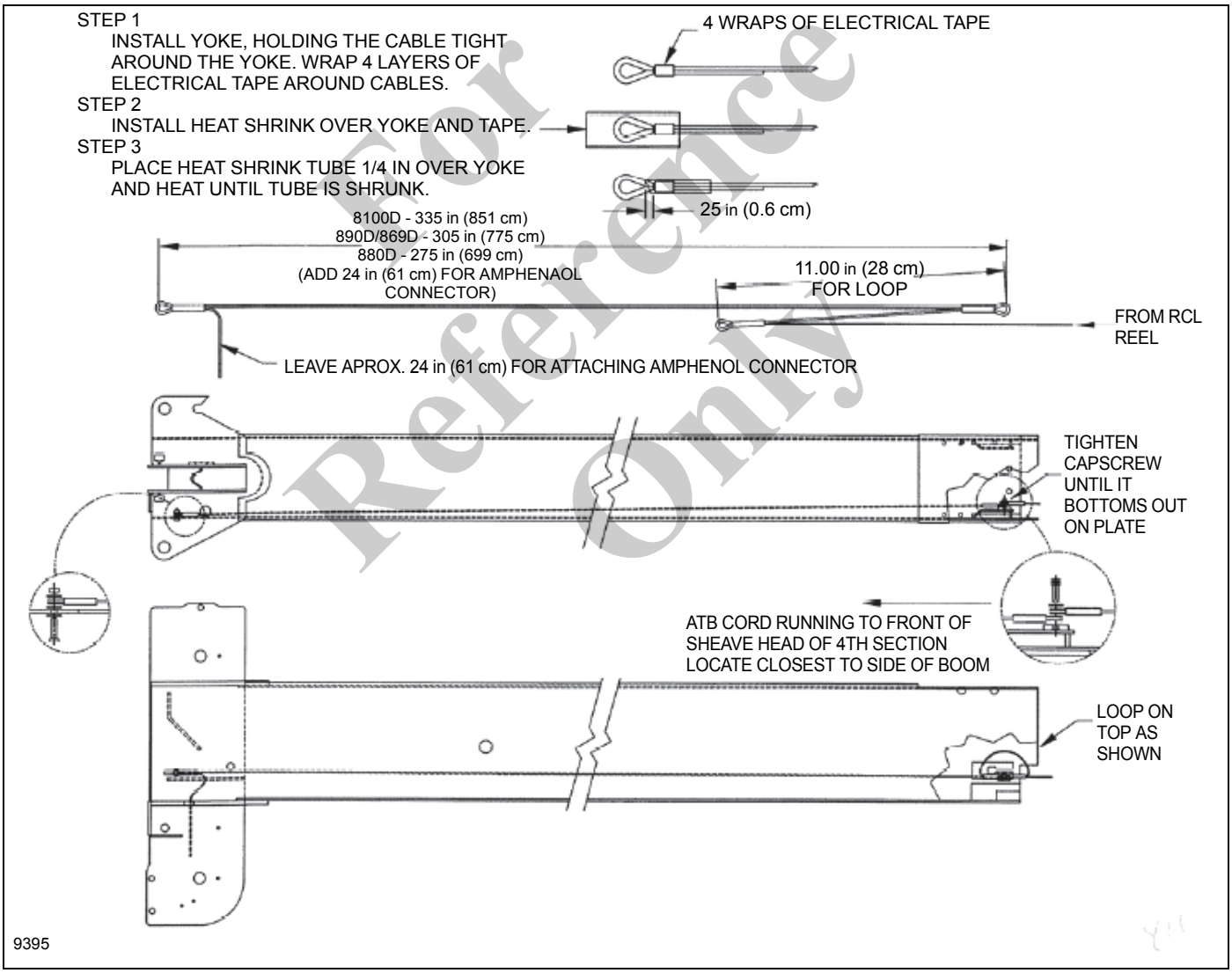
Special tools and equipment:

- •Electrical tape
- •Rod or electrical conduit 30 ft (9.1 m)

1. Retract boom completely.
2. Unplug electrical connector at sheave case end of boom.
3. Remove electrical connector from the anti-two-block wire running to the reel.
4. Remove the capscrew, anchoring the anti-two-block wire at the hoist end of the 4th section.
5. Remove the capscrew, washers and nut, anchoring the anti-two-block wire at the sheave case end of the 4th section.
6. Cut the shrink tube at each thimble connection in order to reuse the thimbles.
7. Insert the rod or conduit into the sheave case end of the boom and push through the full length of the boom.
8. At the hoist end of the boom, the rod or conduit will be below the roller guides at the backs of the extending sections.
9. Lift the rod or conduit and pull it out the back end of the boom about 1 ft (0.3 m).
10. Install the new anti-two-block wire on the reel.
11. Route the new wire through the sheave case at the hoist end of the boom and through the roller guides on the back end of each extending section.
12. Pull the anti-two-block wire out the hoist mount end of the boom and tape securely to the rod or electrical

conduit. This will still leave the anti- two-block wire routed through the roller guides.

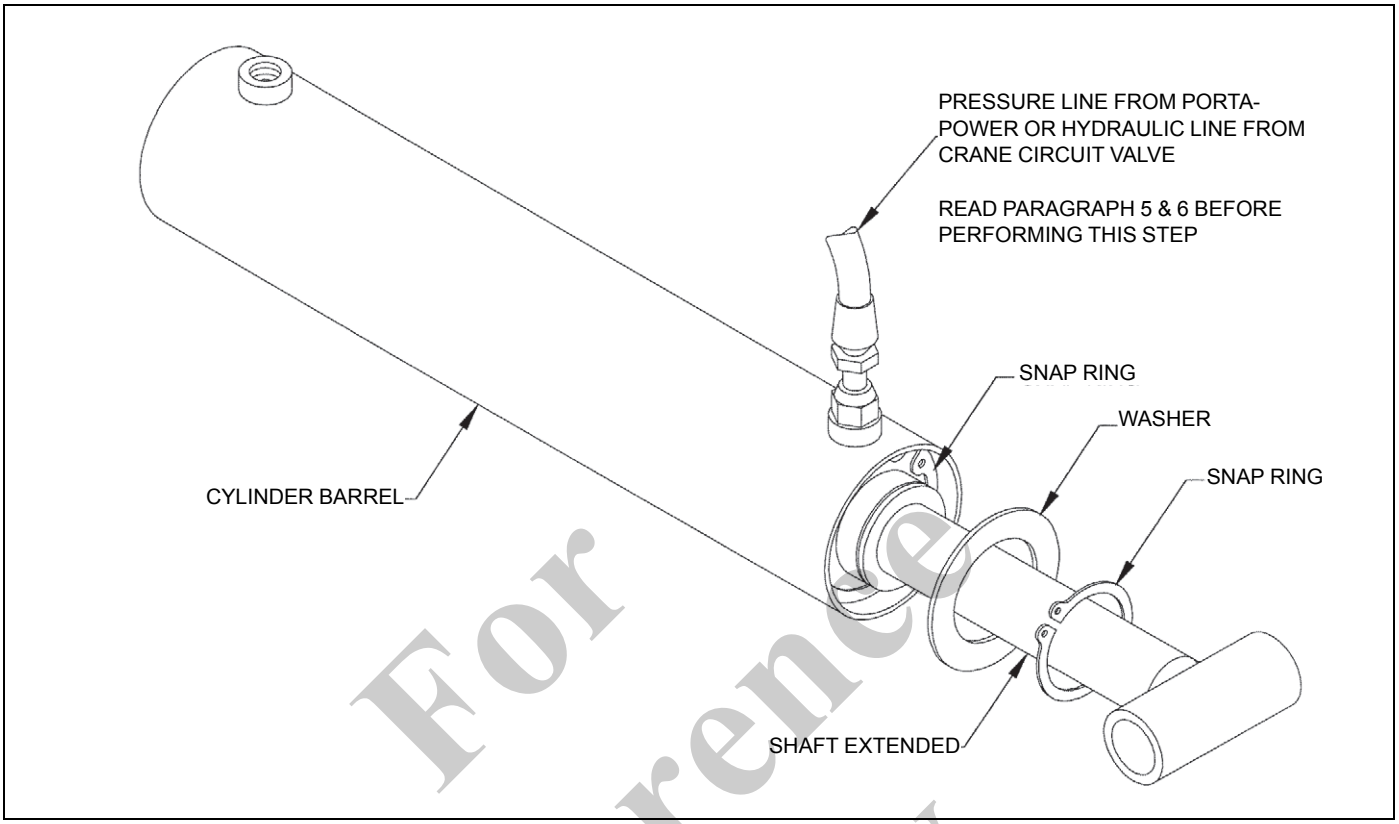
13. Draw the rod or electrical conduit plus an additional length of anti-two-block wire long enough to install the first thimble from the sheave case end of the boom. Install thimble per instructions out of the sheave case end of the boom.
14. Draw enough additional anti-two-block wire to install the other two thimbles on the anti-two-block wire. Refer to drawing. The correct length is specific to each boom length. Install thimbles per instructions.
15. Allow the reel to retract the two thimbles back into the boom.
16. At the hoist end of the boom, attach the two thimbles to the 4th boom section making sure that the thimbles point in opposite directions and that the loop in the cord is at the top of the anchor. Tighten the capscrew until it bottoms out in the threads.
17. At the sheave case end of the boom, attach the thimble in the slot and pull it towards the open end of the boom to tension the anti-two-block wire.
18. Attach the electrical connector and connect to the switch.
19. Slowly operate the boom to make sure that the anti-two-block wire runs freely in the boom and that the cable reel runs properly.
20. Test the anti-two-block circuit for proper operation and hydraulic circuit cut out.



# SECTION 6
# REPAIR

## SECTION CONTENTS

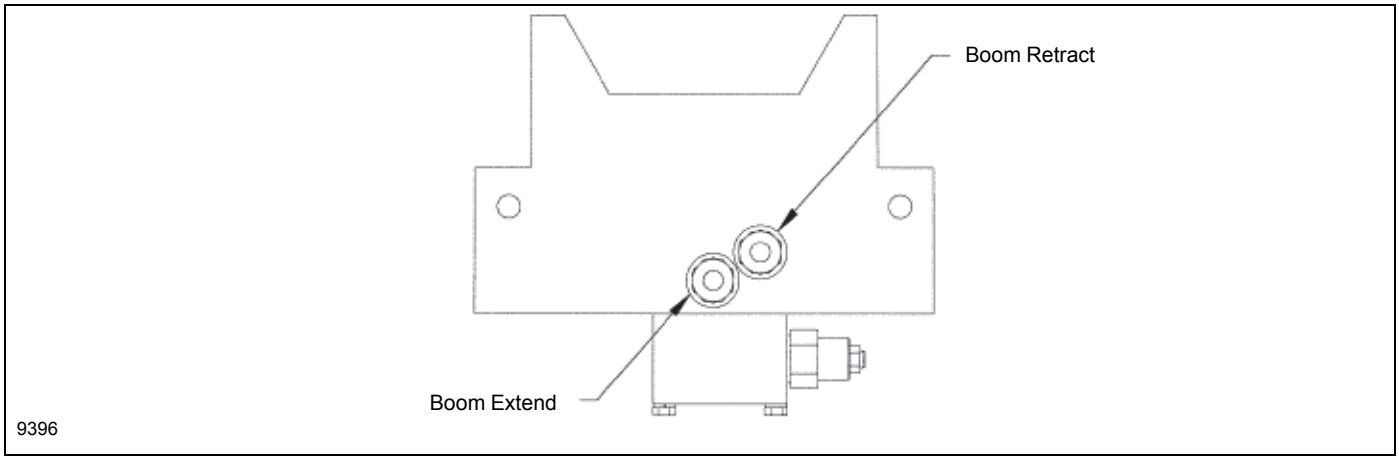
## CYLINDER DISASSEMBLY AND REPAIR






1. Disconnect shaft end of cylinder from machine.
2. Retract cylinder shaft with oil from the hydraulic system until about 12 in (30 cm) of shaft is extended. The barrel must be filled with oil to prevent a compressed air chamber being formed which could result in injury at disassembly.
3. Remove the cylinder from the machine and place on supports with an oil pan directly beneath the cylinder head area.
4. Using the proper size of internal snap ring pliers, compress the snap ring completely and remove from groove.
5. Attach a porta power hand pump or hydraulic line from crane circuit valve to the shaft end of the cylinder. Debur snap ring groove edge. Failure to do so will damage barrel or packing gland.
6. Operate hand pump or crane circuit valve, preferably the boom telescope circuit, to force packing gland out of barrel.
7. Remove the shaft and piston assembly by hand.
8. Disassemble the piston set by removing nut, replace worn or damaged parts. Note: Loctite® 680 is used during original assembly to secure nut to shaft. If necessary, heat nut to 400-500°F (204-260°C) to facilitate removal. If heat is necessary for removal, discard nut and replace with new equivalent nut as well as worn or damaged parts.
9. Wipe and inspect cylinder barrel for internal damage.
10. Wipe and inspect cylinder shaft for damage.
11. Remove shaft packing by removal of internal snap ring from packing gland. If spiral rings are used, they will have to be replaced each time they are removed. Replace parts as required.
12. Lubricate piston head snap ring at O-ring seal area removing all nicks that have been formed at the snap ring area that would damage the O-ring before installation.
13. Reassemble shaft and piston set assembly. Apply Loctite® to nut and onto shaft using type 680 according to Loctite® recommendations.
14. Reinstall shaft and head assembly being sure that snap ring expands completely and properly into the snap ring head groove.

## TELESCOPE CYLINDER




### Telescope Cylinder Disassembly

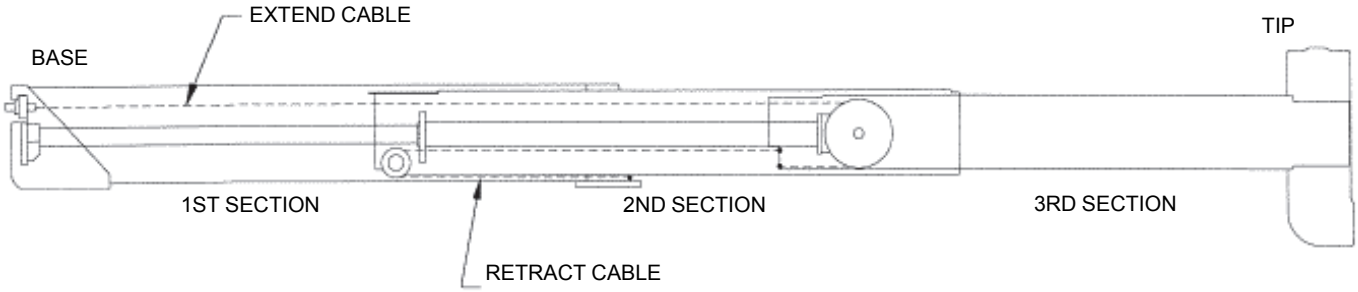
1. After cylinder has been removed from boom, place on supports and place drain pan under holding valve and cylinder head area.
2. Using hydraulic power (porta power or crane circuit) extend cylinder approximately 12 in (30 cm). Relieve any trapped hydraulic pressure which might remain in the cylinder.
3. Using a special drive tool, drive the packing gland into the barrel assembly to expose the round cross section retaining ring. Then use a small needle nose locking plier to clamp the round cross section retaining ring to prevent from rotating in the groove. Use two straight blade screw drivers; one to pry the end of the ring out of the groove and the other to pry the ring out of the barrel assembly.
4. Deburring groove edge. Failure to do so will damage packing gland and or barrel assembly when packing gland is removed.
5. Plug retract port in the cylinder holding valve with SAE #8 O-Ring boss plug and pull on the rod assembly to force packing gland out of the barrel assembly.
6. If step 5 fails to break packing gland loose from the barrel assembly, remove the plug from the retract port and plug the extend port in the cylinder holding valve (SAE #8 O-Ring boss). Apply retract pressure to cylinder to break packing gland loose. Remove pressure and pull packing gland out by hand.
7. As soon as the packing gland is sufficiently loosened, properly support the rod assembly and carefully remove it. Place rod assembly on supports. Caution must be exercised in the support and removal of the rod assembly as damage to the chrome surface will necessitate rod assembly replacement.
8. Remove the two locking setscrews from piston.
9. Using proper spanner wrench loosen and remove threaded piston.
10. Remove piston, stop tube, packing gland and round ring. Replace any damaged or worn metal parts.
11. Replace all seals and bearings.
12. Wipe and inspect all cylinder internal and external surfaces for damage.
13. Inspect wear pad on barrel assembly and replace as required.

### Telescope Cylinder Assembly

1. Debur ring groove edge in barrel assembly and inspect all internal and external surfaces for damage.
2. Reassemble round ring, packing gland and stop tube on shaft assembly.
3. Install piston on shaft assembly and torque piston to 200 lb-ft (271 Nm). **Loctite® should not be used on threaded piston.**
4. Apply Loctite® 243 to two setscrews and install in piston. Torque setscrews to 8 lb-ft (11 Nm).
5. Grease piston assembly and install the shaft assembly with piston, stop tube, packing gland and round ring into barrel assembly.
6. Using special drive tool, drive the packing gland into the barrel assembly.
7. Insert one end of round ring into groove in barrel assembly and spiral ring into groove with straight blade screw driver.
8. Cycle test cylinder to ensure no leaks exist. Support end of cylinder as it extends and retracts.

## THREE SECTION BOOM OPERATION

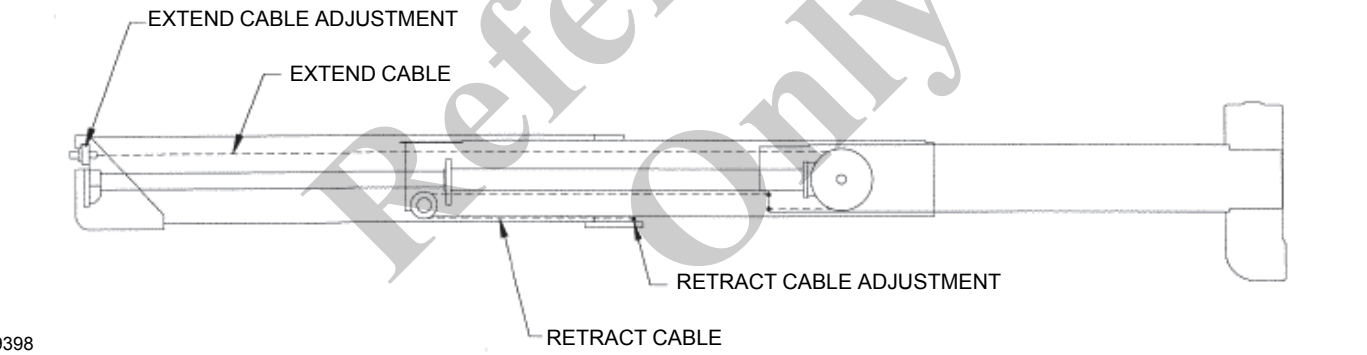
*The boom service and maintenance section of this manual includes both the three and four section boom information. Use appropriate information for your particular boom length.*



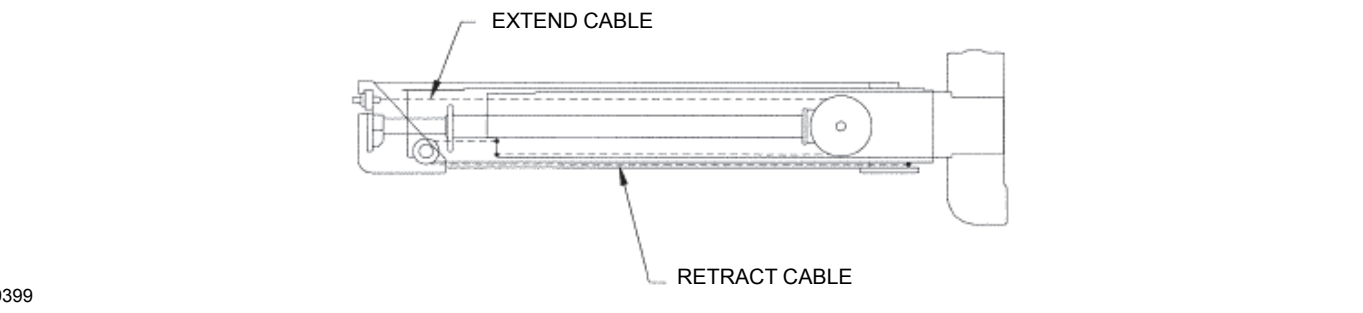

A rod-fed, double-acting cylinder, attached to the 1st and 2nd boom sections, supports and propels the 2nd boom section. The extend cables attach to the base end of the 1st boom section, are reeved around sheaves attached to the cylinder, and attach to the base end of the 3rd boom section, therefore providing support and extension of the 3rd boom section. The retract cables attach to the tip end of the 1st boom section, are reeved around sheaves attached to the 2nd boom section, and attach to the base end of the 3rd boom section, therefore providing retraction of the 3rd boom section. This type of boom operation provides that the 2nd and 3rd section booms extend and retract equally. Proper service and maintenance is required to insure smooth and proper operation.

## BOOM ILLUSTRATIONS

### Boom Extended




### Boom Retracted



## THREE SECTION BOOM MAINTENANCE

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

### Internal Cable Sheave Lubrication

***Special Tools:*** Nozzle or needle grease gun fitting. The lubrication points on the sheaves are not equipped with grease fittings (zerks), therefore a 0.25 in (6.35 mm) diameter nozzle grease gun tip will be required. Contact the National Crane Product Support Department to obtain this nozzle tip, or numerous variations of the nozzle tip can be purchased at local hardware or auto parts retail outlets.

**NOTE: Observation through the sheave case for the extend sheaves and the hoist mount for retract sheaves will visually determine the amount of grease necessary for proper lubrication. A slight amount of grease extrusion around the pin joint is adequate for proper lubrication.**

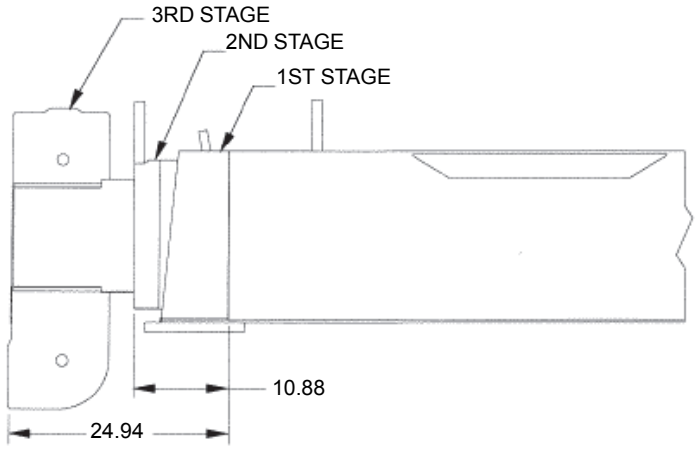
Lubrication of the extend cable sheaves located on the boom tip end of the extend cylinder, and the retract cable sheaves located on the inside rear of the 2nd section are accomplished as follows:

1. Extend boom until grease access hole becomes visible in side plate of 2nd section as it extends out of 1 st section.
2. Visually check alignment between the 2nd section access hole and the access hole in 3rd section. When these holes become aligned, the end of the retract cable sheave pins will be visible and accessible for lubrication.
3. This boom extended position will coincide with proper alignment of the access hole in the rear of the 1st section for lubrication of the retract sheaves attached to the rear of the 2nd section.
4. The sheaves located on the boom tip end at the telescope cylinder can be greased while the boom is fully retracted. Access to the grease holes on either end of the pin is through holes in the boom side plates.

### Three Section Cable Tensioning

After boom reassembly or from time to time if interior proportioning cables appear loose, cable tensioning may be required. Tensioning must be done with the boom horizontal.

1. Slightly tighten all cables. Then cycle the boom approximately 4 ft (120 cm) out and in a few times to equalize the extend and retract cable/ boom section sequence positioning.
2. Fully retract boom. Do not induce and hold hydraulic pressure. At full retraction, observing through the hoist mount end of the boom, the second section should be bottomed on the telescope cylinder butt plate, and the third section should be bottomed on the thick vertical side plates welded to the inside of the second section. (See reference dimensions below)
3. It is important to achieve these boom section positions before torquing. If the boom sections do not bottom out as specified (boom is out of sequence), adjust cables to achieve proper section positioning.
4. Torque retract cables to 14 lb-ft (19 Nm). Cable adjustment point is located at the sheave case end of the boom, on the bottom of the 1st section. Use the flats at the front of the cable ends to keep the cables from turning while torquing retainer nuts.
5. Torque extend cables to 20 lb-ft (27 Nm). Cable adjustment point is located at the rear of the boom on the cable anchor bar going through the hoist mount.
6. Repeat steps 4 and 5. Torque the retract cables to 14 lb-ft (19 Nm). Torque the extend cables to 40 lb-ft (54 Nm).
7. Cycle the boom fully, check that all cables are torqued properly and that all sections are retracted completely, then add jam nuts to all cables. All threaded cable ends must be equipped with retainer nuts, jam nuts and cable protectors.



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## THREE SECTION BOOM SERVICE

### Boom Removal

| Boom Length | Boom Weight | CG from pivot point |
|---|---|---|
| 69 ft | 7050 lb (3198 kg) | 146 in (3.71 m) |

1. Extend and set machine outriggers. Boom must be completely retracted and stowed in the boom rest.
2. If equipped, remove swing around jib according to procedures outlined in the “Safety & Operation” section.
3. Remove hook block or downhaul weight, wind up rope on hoist drum and stow wedge socket on pegs provided on 1 st section. Shut down truck engine.
4. Attach a lifting device to rod end of lift cylinder, remove boom lift cylinder pin keeper and pin from bottom of the 1 st section boom. Lower lift cylinder to a suitable support.
5. Tag and disconnect telescope cylinder lines and hoist hydraulic lines. Cap all open lines and ports.
6. Attach a lifting device to provide even weight distribution and raise the boom until weight is removed from the boom pivot pin. Remove boom pivot pin keeper and boom pivot pin. Lift boom free of turret.

### Boom Disassembly

The 800D boom can be disassembled by using two different methods. Alternative #1 disassembles the boom in the conventional manner. Alternative #2 removes the telescope cylinder from the rear of the boom, after removal of the hoist. This feature facilitates cylinder service without complete boom teardown.

For reference, the front of the boom refers to the sheave case end, the rear of the boom is the hoist mount end. Left and right are viewed from front to rear.

If the boom is to be unpinned from the turret of the crane structure, please refer to the “Boom Removal Procedure” section in this book. If the required service procedure is to be performed on the boom while still pinned to the turret, please follow these directions.

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

1. Extend and set the outriggers.
2. Fully retract the boom and place in a horizontal position.
3. Hoist removal optional.

### *Boom Disassembly Alternative #1*

1. Gaining access through rear of boom, loosen capscrews retaining the keeper plates holding the extend cable anchor and retract cables in the rear of the 3rd section, remove keeper plates. Loosen capscrew on the anti-two-block wire clamp on the anchor assembly.
2. Extend boom 24 in (61 cm). Loosen and remove the nuts which secure the extend cables to the cable anchor plate. Remove nut from anti- two-block spade bolt. Tag and disconnect hydraulic lines to the telescope cylinder.
3. Drape extend cables and anti-two-block cable inside boom, and slide cable anchor plate out of the side of the hoist mount if hoist has been removed from boom.
4. Loosen and remove two capscrews, lockwashers and spacers which anchor the telescope cylinder rod butt plate to the rear of the 1st section.
5. Loosen and remove two capscrews and lockwashers securing spacer bar to the inside top of the front of the 1st section. Remove spacer bar.
6. Loosen and remove four capscrews securing wear pads to the bottom of the 1st section. Removal of side wear pads is optional. Adequate clearance exists between adjoining section side pads for boom disassembly. If side pad removal is required, tag all pads, shims, and corresponding locations for proper reassembly.
7. Support 2nd-3rd assembly at the front with an appropriate lifting method. Raise the 2nd-3rd assembly inside the 1st section to allow for front bottom pad removal. Remove bottom wear pads.
8. With the 2nd-3rd assembly supported, slide assembly out of the 1st. Relocation of the sling point on the 2nd-3rd assembly will be necessary for proper balancing of the assembly as it slides out of the 1st section. Keep tension on retract cables as the assembly is pulled out of the 1st, to minimize the chance of retract cable damage.
9. Place 2nd-3rd assembly on a suitable horizontal surface. Take care not to pinch or crush retract cables while lifting or supporting assembly.
10. Remove top rear wear pads on the 2nd section. They will lift off the cam plate easily. Do not remove or loosen the capscrews holding the cam plate to the section. This will affect side clearance during re-assembly.
11. Loosen and remove four capscrews securing the rear bottom wear pads on the 2nd section. This pad serves as a bottom and side pad as well as the retract cable keeper under the retract sheaves. Removal of this pad will allow the retract cables to uncoil off the retract sheaves. Place retract cable ends in a location to minimize the possibility of damage.
12. Loosen and remove six capscrews securing retract sheave pin and retract sheaves to 2nd section. Remove sheaves and pins.
13. Loosen and remove two capscrews functioning as upper retract cable keepers. Remove retract cables.
14. Loosen and remove two capscrews securing lock bar to the telescope cylinder collar. This bar constrains the

vertical movement of the telescope cylinder. Remove bar.

15. Loosen capscrews retaining extend cable anchor to back of the 3rd section. Total removal of the capscrews will allow the cable anchor to be completely disassembled, backing capscrews out approximately 0.50 in (12 mm) will allow the anchor assembly to slide rearward out of the section as the telescope cylinder is removed.
16. Support telescope cylinder with an appropriate lifting device and pull the telescope cylinder out of the boom while keeping the extend cables and anti-two-block wire tensioned slightly by hand to minimize the possibility of damage to the cables. Pull cylinder to within 3 ft (91 cm) of complete removal from the boom sections.
17. Reach into the rear of the 3rd section and loosen and remove the anti-two-block cable clamp on the extend cable anchor. Pull the extend cable anchor out from its retaining pocket on the bottom of the 3rd section. A slight angle applied to the anchor as it's being pulled to the rear will permit easier removal through the 2nd section.
18. Remove the telescope cylinder from the boom. Remove extend cables. Place cylinder and cables in suitable area to prevent possible damage.
19. Anti-two-block wire can be removed if necessary by disassembly of the clamp arrangement at the sheave case and pulling wire through boom.
20. Loosen and remove two capscrews, cable guide, wear pad and spacer bar from the front top of the second section.
21. Loosen and remove six capscrews attaching the bottom pad plate to the second section. Slightly lift third section, and remove pad plate.
22. Slide 3rd section out of 2nd section. Removal of side pads is optional, as the side pads have adequate clearance for boom disassembly. If removal of side pads is required, tag all shims, pads and corresponding locations for proper reassembly.
23. Loosen and remove all remaining capscrews and wear pads from boom sections.

### *Boom Disassembly Alternative #2*

The 800D boom design allows for removal of the telescope cylinder from the rear of the boom without complete disassembly of the boom sections. This procedure allows quick access to the cylinder, retract cables, and various internal boom components for service or replacement.

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

1. Remove hoist.
2. Gaining access through rear of boom, loosen and remove capscrews retaining the keeper plates holding the extend cable anchor in the rear of the 3rd section as well as the anti-two-block wire clamp on the anchor assembly. Loosen and remove two capscrews retaining lock bar to telescope cylinder. Remove lock bar
3. Extend boom 24 in (61 cm). Loosen and remove the nuts which secure the extend cables to the cable anchor plate. Remove nut from anti- two-block spade bolt.
4. Drape extend cables and anti-two-block wire inside boom, and slide cable anchor plate out of the side of the hoist mount.
5. Loosen and remove two capscrews, lockwashers and spacers which anchor the telescope cylinder rod butt plate to the rear of the 1 st section.
6. Using appropriate lifting device, lift telescope cylinder up and out of retaining slot on rear of 2nd section. Retracting cylinder with an external hydraulic power source during this step may be necessary.
7. Pull cylinder out through rear of boom assembly approximately one-half the length of the cylinder. Turning of the butt plate and rod 90 degrees may aid in sliding cylinder through hoist mount area. Keep extend cables tight to minimize the possibility of damage.
8. Lift telescope cylinder up until it contacts inside of boom section. Remove anti-two-block wire clamp from extend cable anchor. Remove anchor by pulling anchor and cables out rear of boom. A slight angle applied to the anchor as it's being pulled to the rear will permit easier removal.
9. Continue to pull telescope cylinder and cables out of rear of boom. Remove extend cables and store in an area to minimize the possibility of damage.

## Additional Maintenance, Disassembled Boom

1. Clean all boom sections and inspect for wear, dents, bent or bowed boom sections, gouged metal, broken welds or any abnormal conditions. Repair or replace as required.
2. Inspect all sheaves for excessive groove wear or abnormal rim wear. Replace as required.
3. Inspect all sheave bearings for excessive wear or cut liner material. If installed bearing diameter is 0.015 in (0.38 mm) larger than the pin diameter, bearing must be replaced. Any cut or gouge which causes the bearing liner to be distorted is cause for bearing replacement.
4. Clean and inspect all cable assemblies according to the "Wire Rope Inspection Procedures" in this section. Pay particular attention to any wire breakage within 6 ft (180 cm) of the end connections. Replace cable assemblies

as required. Lubricate all cable assemblies before reinstalling them in the boom.

5. Inspect all sheave pins for nicks, gouges or pitting due to rust in the bearing surface area. Replace if any damage is evident.
6. Inspect anti-two-block wire full length for damage, check for electrical continuity.

## THREE SECTION BOOM ASSEMBLY

*This procedure includes assembling internal anti-two-block wire*

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

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

1. Assemble sheaves into 3rd section sheave case. Top sheave is to be installed to the left hand side of the boom with the spacer to the right hand side.
2. Attach rear wear pads on bottom of 3rd section. Using Loctite® 243 blue, Loctite® all wear pad mounting capscrews.
3. Install 3rd section boom into 2nd section. Slide together approximately 5 ft (150 cm).
4. Assemble bottom front wear pads for 2nd section and Teflon™ plugs. Attach pads to pad plate.
5. Using appropriate lifting device, lift 3rd section to allow for wear pad/pad plate installation in front of 2nd. Install wear pad/pad plate assembly. Slide sections together within 12 in (30 cm) of full retraction.
6. Install front side wear pads with appropriate shims, between 3rd and 2nd sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used. If locations are in question, refer to shim calibration section in this book.
7. Route anti-two-block wire through 3rd section, keeping bulk of wire at the rear of the boom sections. Routing can be accomplished using an installation tool, such as a telescopic boom grease applicator, electrical conduit, or hydraulic tubing. Route anti-two-block wire between sheave case side plates.
8. Uncoil retract cable assemblies, and insert button end into anchors in back of the 3rd section. Place uncoiled cable in area that will minimize the potential for damage.
9. Assemble retract sheaves and retract sheave pins in rear of 2nd section. Coat surfaces of bearings with grease before assembly.
10. Place retract cables overtop of retract sheaves. Install keeper capscrew above sheave to hold retract cables in place.
11. Reeve cables over retract sheave and install keeper/ wear pad to bottom rear of 2nd section. This pad acts as a side pad, bottom pad, and a cable retainer.
12. Assemble exterior telescope cylinder components. Install and center sheave pin in sheave case end of telescope cylinder. If boom is equipped with internal anti-two-block wire routing make sure the sheave and spacer are installed on pin. Install bearings into extend cable sheaves. Coat surface of bearings with grease and assemble extend sheaves on sheave pin. Install snap rings.
13. Wrap approximately 10 ft (300 cm) of each 3/4 in (19.0 mm) diameter extend cable around extend sheaves and install extend cable anchor. Do not tighten capscrews clamping anchor together completely. These capscrews if tightened completely will not allow cable anchor to install into 3rd section. Route anti-two-block cable over center sheave on telescope cylinder.
14. Install wear pad over telescope cylinder sheave side plates. This serves as a wear pad to keep the end of the telescope cylinder centered in the boom, as well as an extend cable retainer.
15. Slide telescope cylinder /extend cables into 2nd-3rd boom assembly enough to assemble extend cable anchor into bottom rear of 3rd section. Route anti-two-block cable over extend cable anchor as anchor slides into 3rd section. Be aware of extend and anti-two-block cable location when inserting cylinder into boom sections, inadvertent crushing or other damage to cables will warrant replacement.
16. Tighten capscrews clamping extend anchor together. Install keeper plates to retain the extend cable anchor and retract cables into the rear of the 3rd section.
17. Loop anti-two-block cable at the extend cable anchor in the 3rd and install anti-two-block cable clamp. Do not completely tighten clamp capscrew.
18. Assemble anti-two-block clamp in the sheave case. Reeve anti-two-block cable around anchor and through holes in side plate of sheave case. Pull approx. 2 ft (60 cm) of cable out the end of the boom for proper routing and termination.
19. Tighten anti-two-block clamp on the extend cable anchor in the rear of the boom. Tension anti-two-block cable from the sheave case end of the boom, and tighten anti-two-block clamp located in sheave case.
20. Visually verify that the extend and anti-two-block cables are properly routed on their sheaves and continue to slide the telescope cylinder and cables into the boom sections. Keep extend and anti-two-block cables supported and slightly tensioned during insertion of cylinder, to maintain proper cable placement.

21. As the telescope cylinder keeper plate nears the 2nd section, adjust the height of the cylinder to allow the cylinder to access the cylinder keeper cutouts in the doubler plates on the sides of the 2nd section.
22. Drop the cylinder down into the vertical cutouts in the doubler plates on the sides of the 2nd section.
23. Install lock bar and capscrews to the telescope cylinder.
24. Position 2nd/3rd cylinder assembly in position to be inserted into 1st section. Lay retract cables out under 2nd/3rd cylinder to allow easy installation as the booms are assembled.
25. Slide 2nd/3rd cylinder assembly into 1st section boom approx. 2 ft (60 cm). Use caution during this step to keep retract cables straight and on the correct side of the boom assembly as the sections are assembled.
26. Continue to slide 2nd/3rd cylinder assembly into 1st until it is approximately halfway into 1st.
27. Assemble bottom front wear pads in 1st section, trapping ends of retract cables in slots on bottom of 1st section. Lift 2nd/3rd cylinder assembly up to ease installation.
28. Slide boom together to within 12 in (30 cm) of complete retraction. Install upper front spacer bar in 1st section and upper front wear bar and cable guide assembly to 2nd.
29. Retract boom completely, using proper hardware and spacers, connect telescope cylinder butt plate to the hoist mount. Hydraulic power source can be utilized at this time if slight cylinder length adjustment is necessary.
30. Slide extend cable anchor into position in hoist mount. Push threaded ends of 5/8 in (15.88 mm) extend cables through holes in anchor and assemble hex nuts onto threaded ends.
31. Assemble top rear wear pads and plates to the top of the 2nd and 3rd boom sections. These assemblies can be inserted from the hoist mount end of the boom. The cam plates have an eccentric hole which allows the wear pads to be positioned at different widths. Install the cam plates in the wear pads so that the wear pads are tight against the boom side plates. These plates function as rear side clearance adjustment.
32. Approximately 10 ft (300 cm) of anti-two-block cable will be available on the hoist mount end of the boom to route and hookup to the control console wiring. Find the end of this cable and slide the cord grip/strain relief hookup onto it and slide it up the cable into approximate position inside the boom.
33. Assemble the extension spring and spade bolt to the cord grip. Assemble the spade bolt through the telescope cylinder anchor with a hex nut. Adjust tension on anti-two-block cable by sliding cord grip down cable into the boom. Approximately 2 in (5 cm) of spring extension should be adequate for proper boom operation.
34. Visually check each end of boom for proper extend, retract and anti-two-block cable routing and placement. Make certain anti-two-block cable is correctly on sheave. Inspect from sheave case end.
35. Adjust slack out of extend and retract cables at hex nut adjustment points. Slowly cycle boom in and out several times. Torque cables per procedure located elsewhere in this book.

## THREE SECTION TOP/BOTTOM PAD REPLACEMENT ASSEMBLED BOOM

Inspect top and bottom wear pads periodically for signs of abrasion or excessive wear. Excessive is defined as 3/16 of an inch (4.76 mm) from the original pad thickness. Top rear pad thickness 0.75 in (19 mm), bottom front 1st section 1 in (25 mm), bottom front 2nd section 0.50 in (13 mm). Uneven pad wear of 3/32 in (2 mm) from side to side on the wear pad would be considered excessive as well. If any of these conditions exist, the top and bottom pads can be replaced without complete disassembly of the boom.

### Top Rear Pad Replacement

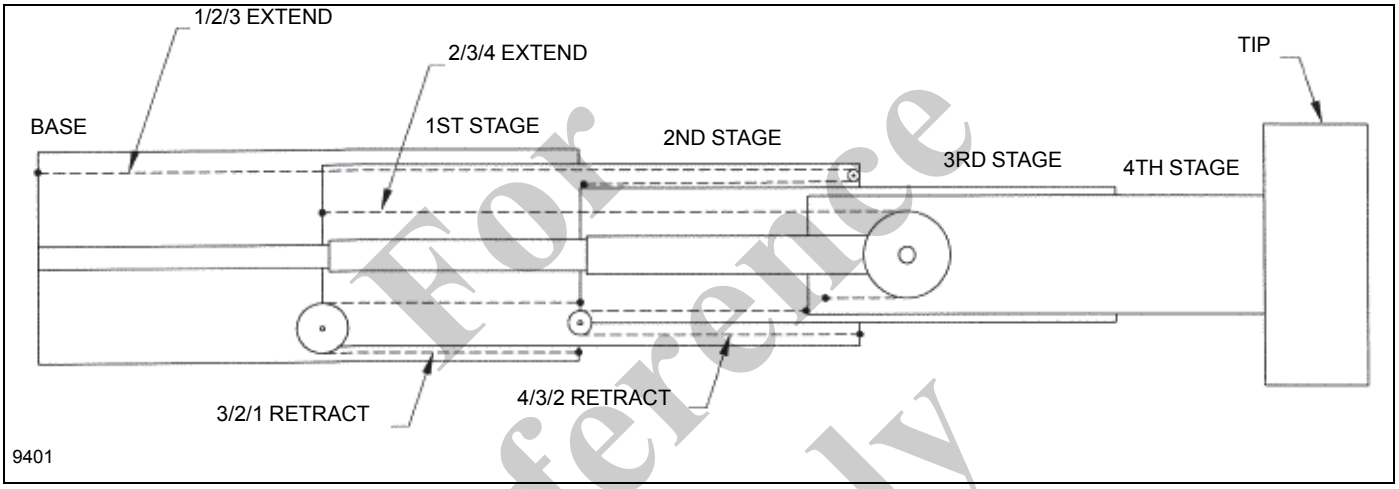
1. Retract boom completely.
2. Remove capscrews through access holes on top rear of sections.
3. Remove wear pads and cam plates from the rear of the boom through open hoist mount end.
4. Note all pad locations and tag accordingly.
5. Inspect pads for wear using previously mentioned inspection criteria.
6. Assemble new wear pads with the cam plates and install through the hoist mount end of the boom. Install capscrews through holes in outer boom sections.
7. The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16 in (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plates independently. This is possible because the holes in these parts are offset from the center. The holes are 0.06 in (1.5 mm) off center in the plate and 0.03 in (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.
8. Adjust pads until they are within 0.03 in (0.8 mm) or less of the side plates of the outer boom section.
9. Torque retainer capscrews to 110 lb-ft (149 Nm) Failure to properly torque capscrews will cause loss of preload and cause excessive side clearance between sections.

## Front Bottom Pad Replacement

1. Extend boom approximately 4 feet (120 cm) out.
2. Using an appropriate lifting device, sling around the 3rd section boom and lift it up until weight is removed from the bottom pads in the front of the 2nd and 1st boom sections.
3. Loosen and remove the six capscrews holding the pad doubler plate in between the 3rd and 2nd sections, remove plate, remove pads from this plate. Note all pad locations and tag accordingly.
4. Loosen and remove the four capscrews holding the bottom front wear pads to the 1st section, remove pads. Retract cable adjustment ends may have to be loosened during this step. Note all pad locations and tag accordingly.
5. Replace all wear pads, wear pad plate and retorque retract cables if disassembly of cables was required.

## FOUR SECTION BOOM OPERATION

*The boom service and maintenance section of this manual includes both the three and four section boom information. Use appropriate information for your particular boom length.*




A rod-fed, two-stage double-acting cylinder, attached to the 1st, 2nd and 3rd boom sections, supports and propels the 2nd and 3rd boom sections. The extend cables attach to the base end of the 2nd boom section, are reeved around sheaves attached to the cylinder, and attach to the base end of the 4th boom section, therefore providing support and extension of the 4th boom section. The 3rd section retract cables attach to the tip end of the 1st boom section, are reeved around sheaves attached to the 2nd boom section, and attach to the base end of the 3rd boom section, therefore providing retraction of the 3rd boom section. The 4th section retract cables attach to the tip end of the 2nd boom section, are reeved around sheaves attached to the 3rd boom section, and attach to the base end of the 4th boom section, therefore providing retraction of the 4th boom section. A proportioning cable attached to the rear of the 1st section, reeved around a sheave at the tip of the 2nd section, and anchored to the rear of the 3rd section maintain proper cylinder extension proportion, therefore maintaining equal boom section proportion Detailed service and maintenance is required to insure smooth and proper operation.

## FOUR SECTION BOOM MAINTENANCE

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

### Internal Cable Sheave Lubrication

***Special Tools:*** Nozzle or needle grease gun fitting. The lubrication points on the sheaves are not equipped with grease fittings (zerks), therefore a 0.25 in (6.35 mm) diameter nozzle grease gun tip will be required. Contact the National Crane Product Support Department to obtain this nozzle tip (NCC Part No. 955047), or numerous variations of the nozzle tip can be purchased at local hardware or auto parts retail outlets.

**NOTE: Observation through the sheave case for the extend sheaves and the hoist mount for retract sheaves will visually determine the amount of grease necessary for proper lubrication. A slight amount of grease extrusion around the pin joint is adequate for proper lubrication.**

Lubrication of the extend cable sheaves located on the boom tip end of the telescope cylinder, and the retract cable sheaves located on the inside rear of the 2nd and 3rd section

and the extend cable sheave attached to the bottom of the top plate of the second section at the sheave case end of the boom, are accomplished as follows:

1. Extend boom until grease access hole becomes visible in side plate of 2nd section as it extends out of 1st section.
2. Visually check alignment between the 2nd section access hole and the access holes in 3rd and 4th section. When these holes become aligned, the end of the retract cable sheave pins will be visible and accessible for lubrication.
3. This boom extended position will coincide with proper alignment of the access holes in the rear of the 1st section for lubrication of the retract sheaves attached to the rear of the 2nd and 3rd section.
4. The extend cable sheave located on the bottom of the top plate of the 2nd section at the sheave case end of the boom can be accessed at any boom length for lubrication.
5. The sheaves located on the boom tip end of the telescope cylinder can be greased while the boom is fully retracted. Access to the grease holes on either end of the pin is through holes in the boom side plates.

## Four Section Cable Tensioning

After boom reassembly or from time to time if interior proportioning cables appear loose, cable tensioning may be required. Tensioning must be done with the boom horizontal.

1. Slightly tighten all cables. Then cycle the boom approximately 4 ft (120 cm) out and in a few times to equalize the extend and retract cable/ boom section sequence positioning.
2. Fully retract boom. Do not induce and hold hydraulic pressure. At full retraction, observing through the hoist mount end of the boom, the second section should be bottomed on the telescope cylinder butt plate, the third section should be bottomed on the thick vertical side plates welded to the inside of the second section, the fourth section should be bottomed on the thick vertical side plates welded to the inside of the third section.
3. It is important to achieve these boom section positions before torquing. If the boom sections do not bottom out as specified (boom is out of sequence), adjust cables to achieve proper section positioning. After proper section position has been established, a scribe mark on all the sections at the boom tip end to identify proper section position relative to each other may be helpful during the tensioning process.
4. Torque 4-3-2 retract cables to 8 lb-ft (11 Nm). Cable adjustment point is located at the sheave case end of the boom, on the bottom of the 2nd section. Use the flats at the front of the cable ends to keep the cables from turning while torquing retainer nuts.
5. Torque large extend cables to 20 lb-ft (27 Nm). Cable adjustment point is located at the rear of the boom on the cable anchor located in the rear of the 2nd section
6. Torque 3-2-1 retract cables to 14 lb-ft (19 Nm) Cable adjustment point is located at the sheave case end of the boom, on the bottom of the 1 st section. Use the flats at the front of the cable ends to keep the cables from turning while torquing retainer nuts.
7. Torque 1-2-3 extend cable to 14 lb-ft (19 Nm) Cable adjustment point is located at rear of boom, on the hoist crossbar spanning the 1st section
8. Repeat steps 4, 5, 6, and 7 torquing the 4-3-2 retract cables to 8 lb-ft (11 Nm). Torque the large extend cables to 40 lb-ft (54 Nm). The 3-2-1 retract cables to 14 lb-ft (20 Nm) and the 1-2-3 extend cable to 14 lb-ft (20 Nm)
9. Cycle the boom fully, check that all cables are torqued properly and that all sections are retracted completely, utilizing scribe marks or bottoming position of boom sections then add jam nuts to all cables. All threaded cable ends must be equipped with retainer nuts, jam nuts and cable protectors.

# FOUR SECTION BOOM SERVICE

## Boom Removal

| Boom Length | Boom Weight | CG from pivot point |
|---|---|---|
| 100 ft | 9340 lb (4237 kg) | 156 in (3.96 m) |
| 90 ft | 8615 lb (3908 kg) | 144 in (3.66 m) |
| 80 ft | 7985 lb (3622 kg) | 129.5 in (3.29 m) |

1. Extend and set machine outriggers. Boom must be completely retracted and stowed in the boom rest.
2. If equipped, remove swing around jib according to procedures outlined in the “Safety & Operation” section.
3. Remove hook block or downhaul weight, wind up rope on hoist drum and stow wedge socket on pegs provided on 1st section. Shut down truck engine.
4. Attach a lifting device to rod end of lift cylinder, remove boom lift cylinder pin keeper and pin from bottom of the 1st section boom. Lower lift cylinder to a suitable support.
5. Tag and disconnect telescope cylinder lines and hoist hydraulic lines. Cap all open lines and ports.
6. Attach a lifting device to provide even weight distribution and raise the boom until weight is removed from the boom pivot pin. Remove boom pivot pin keeper and boom pivot pin. Lift boom free of turret.

## Boom Disassembly

The 800D boom can be disassembled by using two different methods. Alternative #1 disassembles the boom in the

conventional manner. Alternative #2 removes the telescope cylinder from the rear of the boom, after removal of the hoist. This feature facilitates cylinder service without complete boom teardown.

For reference, the front of the boom refers to the sheave case end, the rear of the boom is the hoist mount end. Left and right are viewed from front to rear.

If the boom is to be unpinned from the turret of the crane structure, please refer to the Boom Removal Procedure section in this book. If the required service procedure is to be performed on the boom while still pinned to the turret, please follow these directions.

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

1. Extend and set the outriggers.
2. Fully retract the boom and place in a horizontal position.
3. Hoist removal optional.

### *Boom Disassembly Alternative #1*

1. Gaining access through rear of boom, loosen capscrews retaining the keeper plates holding the extend cable anchor and retract cables in the rear of the 3rd section, remove keeper plates.
2. Extend boom 24 in (60 cm). Loosen and remove the nuts which secure the extend cables to the cable anchor plate. Tag and disconnect hydraulic lines to the telescope cylinder.
3. Drape extend cables and slide cable anchor plate out of the side of the hoist mount if hoist has been removed from boom.
4. Loosen and remove two capscrews, lockwashers and spacers which anchor the telescope cylinder rod butt plate to the rear of the 1st section.
5. Loosen and remove two capscrews and lockwashers securing spacer bar to the inside top of the front of the 1st section. Remove spacer bar.
6. Loosen and remove four capscrews securing wear pads to the bottom of the 1st section. Removal of side wear pads is optional. Adequate clearance exists between adjoining section side pads for boom disassembly. If side pad removal is required, tag all pads, shims, and corresponding locations for proper reassembly.
7. Support 2nd-3rd-4th assembly at the front with an appropriate lifting method. Raise the 2nd-3rd-4th assembly inside the 1st section to allow for front bottom pad removal. Remove bottom wear pads.
8. With the 2nd-3rd-4th assembly supported, slide assembly out of the 1st. Relocation of the sling point on the 2nd-3rd-4th assembly will be necessary for proper balancing of the assembly as it slides out of the 1st section. Keep tension on retract cables as the assembly is pulled out of the 1st to minimize the chance of retract cable damage.
9. Place 2nd-3rd-4th assembly on a suitable horizontal surface. Take care not to pinch or crush retract cables while lifting or supporting assembly.
10. Remove top rear wear pads on the 2nd section. They will lift off the cam plates easily. Do not remove or loosen the capscrews holding the cam plate to the section. This will affect side clearance during re-assembly. Note orientation of pad as it is removed. The hole in the bottom is offset for adjustment purposes. Replacing the wear pad in the same orientation is required to keep the boom straight.
11. Loosen and remove four capscrews securing the rear bottom wear pads on the 2nd section. This pad serves as a bottom and side pad as well as the retract cable keeper under the retract sheaves. Removal of this pad will allow the retract cables to uncoil off the retract sheaves. Place retract cable ends in a location to minimize the possibility of damage.
12. Loosen and remove six capscrews securing retract sheave pins and sheaves to 2nd section. Remove sheaves and pins.
13. Loosen and remove two capscrews functioning as upper retract cable keepers. Remove retract cables.
14. Loosen and remove two capscrews securing lock bar to the telescope cylinder collar. This bar constrains the vertical movement of the telescope cylinder. Remove bar.
15. Loosen capscrews retaining extend cable anchor to back of the 4th section. Total removal of the capscrews will allow the cable anchor to be completely disassembled, backing capscrews out approximately 0.50 in (12 mm) will allow the anchor assembly to slide rearward out of the section as the telescope cylinder is removed.
16. Support telescope cylinder with an appropriate lifting device and pull the cylinder out of the boom while keeping the extend cables tensioned slightly by hand to minimize the possibility of damage to the cables. Pull cylinder to within 3 ft (91 cm) of complete removal from the boom sections.
17. Pull the extend cable anchor out from its retaining pocket on the bottom of the 4th section. A slight angle applied to the anchor as it's being pulled to the rear will permit easier removal through the 2nd and 3rd sections.
18. Remove the telescope cylinder from the boom. Remove extend cables. Place cylinder and cables in suitable area to prevent possible damage.
19. Loosen and remove four capscrews, cable guide, wear pad and spacer bars from the front top of the second section.

20. Loosen and remove six capscrews attaching the bottom pad plate to the second section. Slightly lift third section, and remove pad plate.
21. Slide 3rd section out of 2nd section. Removal of side pads is optional, as the side pads have adequate clearance for boom disassembly. If removal of side pads is required, tag all shims, pads and corresponding locations for proper reassembly.
22. Loosen and remove all remaining capscrews and wear pads from boom sections.

### *Boom Disassembly Alternative #2*

The 800D boom design allows for removal of the telescope cylinder from the rear of the boom without complete disassembly of the boom sections. This procedure allows quick access to the cylinder, retract cables, and various internal boom components for service or replacement. If this procedure is used for disassembly, reverse procedure for reassembly, or locate the appropriate step in the assembly procedure in this manual to start reassembly from.

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

1. Remove hoist.
2. Gaining access through rear of boom, loosen and remove capscrews retaining the extend cable anchor in the rear of the 4th section. Loosen and remove two capscrews retaining lock bar to telescope cylinder. Remove lock bar
3. Loosen and remove the nuts which secure the extend cables to the extend cable anchor in the back of the second section, remove capscrews from keeper plates holding extend anchor in place, remove keepers. Remove anchor.
4. Drape extend cables and slide cable anchor plate out of the side of the hoist mount.
5. Loosen and remove two capscrews, lockwashers and spacers which anchor the telescope cylinder rod butt plate to the rear of the 1st section.
6. Using appropriate lifting device, lift telescope cylinder up and out of retaining slots on rear of 2nd and 3rd sections. Retracting cylinder with an external hydraulic power source during this step may be necessary.
7. Pull cylinder out through rear of boom assembly approximately one-half the length of the cylinder. Turning of the butt plate and rod 90 degrees may aid in sliding cylinder through hoist mount area. Keep extend cables tight to minimize the possibility of damage.

## FOUR SECTION BOOM ASSEMBLY

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

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

1. Assemble sheaves into 4th section sheave case. Top sheave is to be installed to the left hand side of the boom with the spacer to the right hand side.
2. Attach rear wear pads on bottom of 4th section. Using Loctite® 243 blue, Loctite® all wear pad mounting capscrews.
3. Install 4th section boom into 3rd section. Slide together approximately 5 ft (150 cm).
4. Assemble bottom front wear pads for 3rd section and Teflon plugs. Attach pads to pad plate.
5. Using appropriate lifting device, lift 4th section to allow for wear pad/pad plate installation in front of 3rd. Install wear pad/pad plate assembly. Slide sections together within 12 in (30 cm) of full retraction.
6. Install cable guide and upper spacer to front of 3rd section
7. Install front side wear pads with appropriate shims, between 4th and 3rd sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used. If locations are in question, refer to shim calibration section in this book. Slide boom sections completely together.
8. Assemble new wear pads with the cam plates and install through the hoist mount end of the boom. Install capscrews through holes in outer boom sections.

   The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16 in (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 0.06 in (1.5 mm) off center in the plate and 0.03 in (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.
9. Uncoil 4/3/2 retract cable assemblies, and insert button end into anchors in back of the 4th section. Place uncoiled cable in area that will minimize the potential for damage.
10. Uncoil 1/2/3 retract cable assemblies, and insert button end into cable anchor pockets in back of the 3rd section. Place uncoiled cable in area that will minimize the potential for damage. Assemble retract sheaves and retract sheave pins in rear of 3rd section. Coat surfaces of bearings and keeper plates with grease before assembly.
11. Place retract cables anchored to 4th over the top of the retract sheaves on the 3rd. Install keeper capscrew above sheave to hold retract cables in place.

12. Reeve cables over retract sheave and install keeper/ wear pad to bottom rear of 3rd section. This pad acts as a side pad, bottom pad, and a cable retainer. Loctite® rear wear pad hardware on bottom of 3rd section with Loctite® 243 blue. Loctite® all wear pad mounting capscrews.
13. Loop the 1/2/3 extend cable in half and place it on the top of the 3rd section, with the loop end towards the sheave case end and the threaded and button end towards the rear of the section.
14. Install clamp plate and capscrews with the button end of the cable installed in the anchor slot on the rear top of the 3rd section.
15. Place sheave pin and sheave for the 1/2/3 extend cable in position on the sheave case end of the boom, inside the loop of cable
16. Install 3rd and 4th section boom assembly into 2nd section. Slide together approximately 5 ft (150 cm). Use caution as retract cables and upper extend cable attached to the 4th-3rd section assembly slide into the 2nd section to prevent damage or crossing of cables.
17. Assemble bottom front wear pads for 2nd section and Teflon plugs. Attach pads to pad plate.
18. Using appropriate lifting device, lift 3rd and 4th section assembly to allow for wear pad/pad plate installation in front of 2nd. Install wear pad/pad plate assembly. Slide sections together within 12 in (30 cm) of full retraction.
19. Install cable guide and spacer to top of 2nd section
20. Install front side wear pads with appropriate shims between 3rd and 2nd sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used. If locations are in question, refer to shim calibration section in this book. Slide sections fully together
21. Assemble new wear pads with the cam plates and install through the hoist mount end of the boom. Install capscrews through holes in outer boom sections.

    The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16 in (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 0.06 in (1.5 mm) off center in the plate and 0.03 in (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.
22. Position sheave and sheave pin located in cable loop on top of 3rd to allow capscrew installation, through top plate of 2nd. Install capscrews and torque to specification, clamping sheave pin and sheave to the bottom of the 2nd section top plate.
23. Assemble retract sheaves, retract sheave pins and cable keeper plates in rear of 2nd section. Coat surfaces of bearings with grease before assembly.
24. Place retract cables anchored to 3rd over top of retract sheaves attached to rear of 2nd. Install keeper capscrew above sheave to hold retract cables in place.
25. Reeve cables over retract sheave and install keeper/ wear pad to bottom rear of 2nd section. This pad acts as a side pad, bottom pad, and a cable retainer.
26. Assemble exterior telescope cylinder components. Install and center sheave pin into sheave case end of telescope cylinder. Install bearings into extend cable sheaves. Make sure spacers and sheave are in place for anti-two-block wire if equipped. Coat surface of bearings with grease and assemble extend sheaves on sheave pin. Install snap rings.
27. Wrap approximately 10 ft (300 cm) of each 3/4 in (19.0 mm) diameter 2/3/4 extend cable around extend sheaves and install 4th section extend cable anchor around cables at button end. Do not tighten capscrews clamping anchor together completely. These capscrews if tightened completely will not allow cable anchor to install into 4th section.
28. Install wear pad over telescope cylinder sheave side plates. This serves as a wear pad to keep the end of the telescope cylinder centered in the boom, as well as an extend cable retainer.
29. Slide telescope cylinder/extend cables into 2nd/ 3rd/4th boom assembly enough to assemble extend cable anchor into bottom rear of 4th section. Be aware of extend cable location when inserting cylinder into boom sections, inadvertent crushing or other damage to cables will warrant replacement.
30. Tighten capscrews clamping extend cable anchor together. This will also lock anchor in place in the anchor cutouts in the 4th section.
31. Visually verify that the extend cables are properly routed on their sheaves and continue to slide with the telescope cylinder and cables into the boom sections. Keep extend cables supported and slightly tensioned during insertion of cylinder to maintain proper cable placement.
32. As the telescope cylinder nears complete insertion into the 2nd/3rd/4th section assembly, adjust the height of the cylinder to allow the cylinder anchor collars to access the cylinder keeper cutouts in the doubler plates on the sides of the 2nd and 3rd sections.
33. Drop the cylinder down into the vertical cutouts in the doubler plates on the sides of the 2nd and 3rd sections. Cylinder length or boom section placement may have to be adjusted to allow cylinder collars to drop into their proper position.
34. Install lock bar and capscrews to the telescope cylinder collar in the 3rd section.

35. Install large extend cable anchor into anchor cutouts in the doubler plates in the rear of the 2nd by routing the 3/4 in (19.0 mm) extend cables through the anchor and the small 3/8 in (9.53 mm) cable over the anchor. Slide anchor fully into cutout.
36. Install keeper plates and hardware. This keeper plate retains both the horizontal movement of the extend anchor and the vertical movement of the telescope cylinder.
37. Install 2/3/4 section boom assembly into 1st section boom, use caution when sliding sections together, 3rd retract cables must maintain their position to prevent damage, do not let boom rest on cables. Damage will result.
38. Assemble bottom front wear pads for 1st section and Teflon plugs.
39. Using appropriate lifting device, lift 2/3/4 section assembly to allow for wear pad installation in front of 1st. Install wear pads. Slide sections together within 12 in (30 cm) of full retraction.
40. Install upper spacer to front of 1st section.
41. Install front side wear pads with appropriate shims between 2nd and 1st sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used. If locations are in question, refer to shim calibration section in this book.
42. Push boom together until telescope cylinder butt plate makes contact with the rear cylinder anchor plates in the rear of the 1st section. Install spacers, washers and capscrews, attaching cylinder to 1st section boom. If cylinder is misaligned with anchor points, cylinder butt plate can be rotated to achieve proper alignment (holding valve up, parallel with boom top plate).
43. Assemble new wear pads with the cam plates and install through the hoist mount end of the boom. Install capscrews through holes in outer boom sections.

    The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16 in (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 0.06 in (1.5 mm) off center in the plate and 0.03 in (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.
44. Install thick hoist attachment bar through hoist mount. This bar anchors the 3/8 in (9.53 mm) extend cable and serves as the upper hoist attachment point. Hold this bar up in its slot with a spacer on each side. This will facilitate easier assembly.
45. Install the threaded end of the 3/8 in (9.53 mm) extend cable through hole in center of the hoist attachment bar.
46. Slightly tighten all cables. Cycle boom slowly to assure proper operation before torquing cables. Refer to the “Four Section Cable Tensioning” section to properly torque the cables in the extend system. Cables must be torqued to proper specifications for proper boom operation.
47. Install hoist.

## FOUR SECTION TOP/BOTTOM PAD REPLACEMENT ASSEMBLED BOOM

Inspect top and bottom wear pads periodically for signs of abrasion or excessive wear. Excessive is defined as 3/16 of an in (4.76 mm) from the original pad thickness, top rear pad thickness 0.75 in (19 mm), bottom front 1st section 1 in (25 mm), bottom front 2nd and 3rd section 0.44 in (13 mm). Uneven pad wear of 3/32 in (2 mm) from side to side on the wear pad would be considered excessive as well. If any of these conditions exist, the top and bottom pads can be replaced without complete disassembly of the boom.

### Top Rear Pad Replacement

Pad maintenance on the four section can be made easier by removal of the hoist and or removal of the hoist mounting bar spanning the end of the 1st section. Additional clearance can be achieved by loosening the large extend cables and removing the extend cable anchor located in the 2nd section.

1. Retract boom completely.
2. Remove capscrews through access holes on top rear of sections.
3. Remove wear pads, shims, and cam plates from the rear of the boom through open hoist mount end.
4. Note all pad locations and tag accordingly.
5. Inspect pads for wear using previously mentioned inspection criteria.
6. Assemble new wear pads with the cam plates and install through the hoist mount end of the boom. Install capscrews through holes in outer boom sections.
7. The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16 in (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are0.06 in (1.5 mm) off center in the plate and 0.03 in (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.
8. Torque retainer capscrews to 110 lb-ft (149 Nm) Failure to properly torque capscrews will cause loss of preload, allowing pad cam to rotate and cause excessive side clearance between sections.

## Front Bottom Pad Replacement

1. Extend boom approximately 4 ft (120 cm) out.
2. Remove cable guides and upper spacer bars from front of boom sections
3. Loosen and remove hex nuts on retract cables on the front of the 1st and 2nd sections
4. Using an appropriate lifting device, sling around the 4th section boom and lift it up until weight is removed from the bottom pads in the front of the 3rd, 2nd, and 1st boom sections.
5. Loosen and remove the four capscrews holding the pad doubler plate in between the 4th and 3rd sections. Remove plate. Remove pads from this plate. Note all pad locations and tag accordingly.
6. Loosen and remove the four capscrews holding the pad doubler plate in between the 3rd and 2nd sections. Remove plate. Remove pads from this plate. Note all pad locations and tag accordingly.
7. Loosen and remove the four capscrews holding the pads in between the 2nd and 1st sections. Remove pads. Note all pad locations and tag accordingly.
8. Inspect pads for wear using previously mentioned inspection criteria.
9. Install new pads with Teflon inserts on plates or boom sections. Reassemble plates in boom in proper locations.

## BOOM CABLE TENSIONING

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

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

A single stage cylinder will control first extendable section.

A dual stage cylinder will control second extendable section.

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

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

## Cable Tensioning

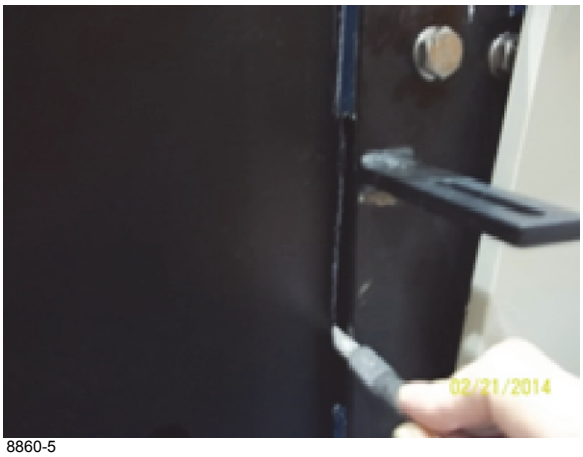
### *Tensioning Setup Procedure*

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

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

Ensure boom is completely assembled and fully retracted.

1. Mark the front of each section with a chalk line as indicated in Figure 6-1.
2. Extend and retract boom several times to establish working state of cables.
3. Extend boom so scribed lines are exposed by approximately 12 inches.
4. Measure the extension gaps between each boom section and scribed line and note values.
5. Retract boom so that the scribed lines are exposed by approximately 6 inches.
6. Measure the retraction gaps between each boom section and scribed line and note values.
7. Extend and retract the boom a few times and then repeat measuring the extension gaps.
8. Adjust all corresponding cables according to ***Cable Tightening Sequence*** instructions.



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8860-6

FIGURE 6-1

## Cable Tension Sequence

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

Cable tensioning (See Figure 6-2) to be in the following order:

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

### *Four section boom with two stage cylinder.*

Cable tensioning to be in the following order:

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

### *Four section boom with one stage cylinder.*

Cable tensioning to be in the following order:

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

### *Three section boom with one stage cylinder.*

Cable tensioning to be in the following order:

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

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

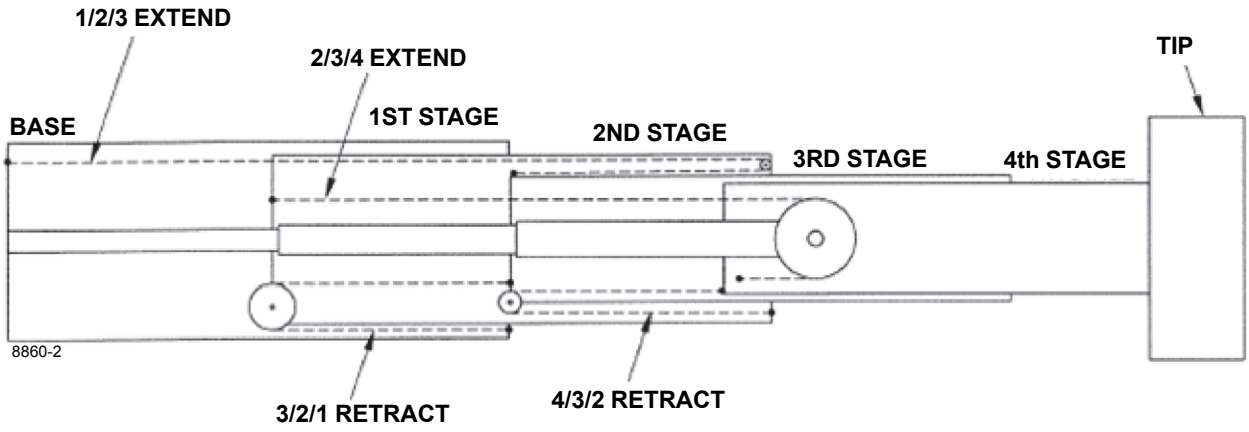



FIGURE 6-2

### *Cable Tightening Sequence 4 Section Boom with Two Stage Extend Cylinder*

Boom must be in horizontal position when adjusting cable tension (See Figure 6-2.) Retract boom fully ensuring sections are bottomed out on section stops. Ensure all sections are fully bottomed out and do not spring back.(Reference Tensioning Setup Procedure)

### *321 and 123 cable balancing*

**Extension**

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

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

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

The second section should have moved out.

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

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

**Retraction**

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

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

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

The third section should have moved out.

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

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

### *234 and 432 cable balancing*

**Extension**

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

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

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

The fourth section should have moved out.

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

**Retraction**

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

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

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

The fourth section should have moved in.

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

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

## 4- Section Boom w/ 1 Stage Cylinder Cable Positioning

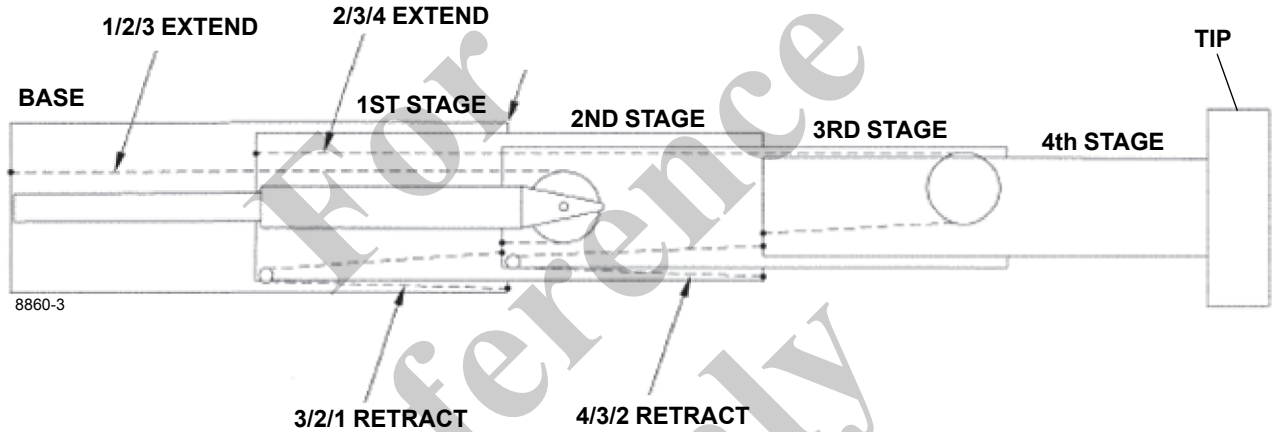



FIGURE 6-3

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

Boom must be in horizontal position when adjusting cable tension (See Figure 6-3.) Retract boom fully ensuring sections are bottomed out on section stops. Ensure all sections are fully bottomed out and do not spring back.(Reference Tensioning Setup Procedure)

### *321 and 123 cable balancing*

**Extension**

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

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

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

The third section should have moved out.

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

**Retraction**

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

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

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

The third section should have moved in.

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

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

### *234 and 432 cable balancing*

**Extension**

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

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

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

The fourth section should have moved out.

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

**Retraction**

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

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

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

The fourth section should have moved in.

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

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

## 3- Section Boom w/ 1 Stage Cylinder Cable Positioning

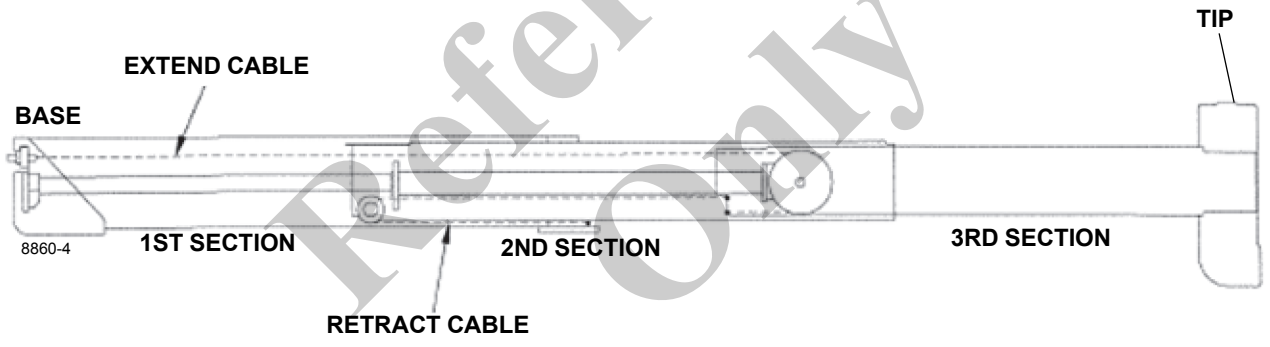



FIGURE 6-4

### *Cable Tightening Sequence 3 Section Boom with (1) Stage Extend Cylinder*

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

### *321 and 123 cable balancing*

**Extension**

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

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

2. Tighten **123** extend cable located at the back top of the base section the difference in the extension gap measurements.

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

The third section should have moved out.

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

**Retraction**

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

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

2. Tighten the **321** retract cable located at the front bottom of the base section the difference in the retraction gap measurements.

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

The third section should have moved in.

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

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

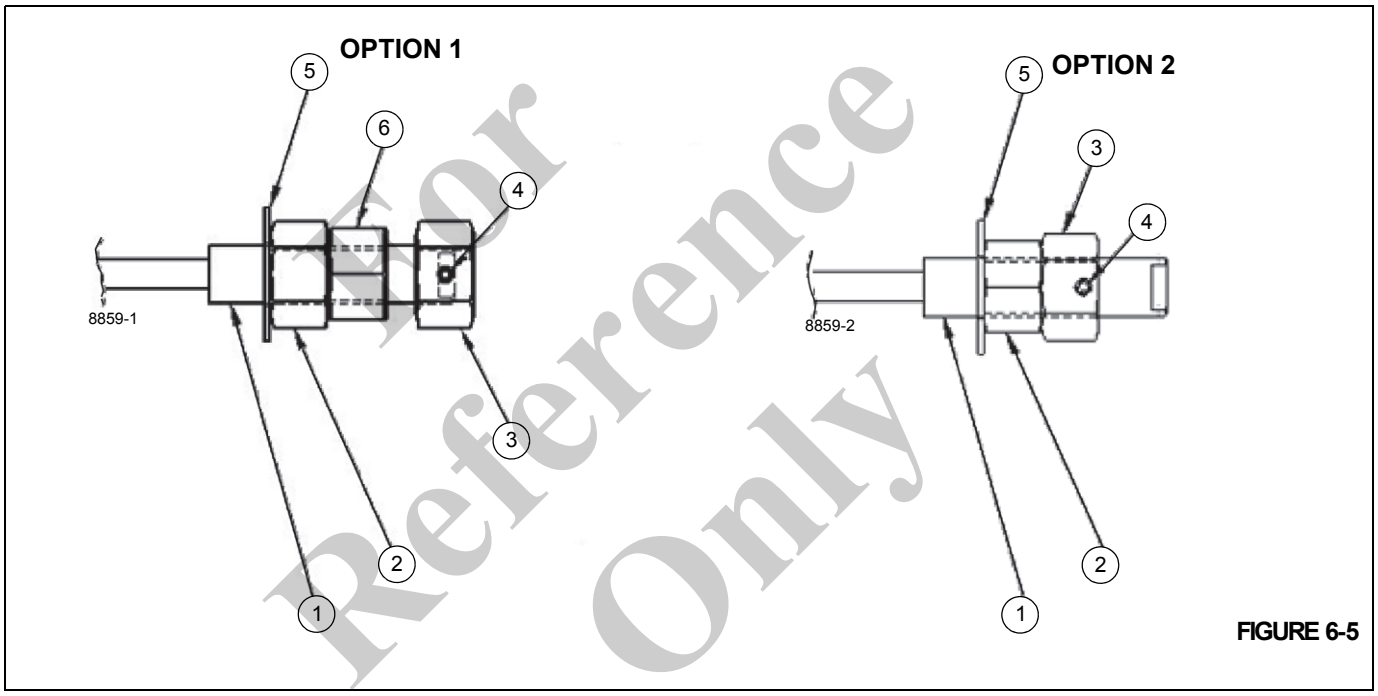



FIGURE 6-5



## Cable Retention

Cable Retention Hardware

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

Nut configuration (see Figure 6-5) will be First Nut (ADJUSTMENT) and Second Nut (TORQUED).

**NOTE:** (**OPTION 2**) method used ONLY when space constraints prevent **OPTION 1** usage.

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

After the cable adjustment procedure is completed for the entire boom assembly. The second (torqued) nut must be installed on all retract and extend cables.

The second nut should be hand tightened until it comes in contact with the back of the first nut.

Hold the first (adjustment) nut stationary and a torque wrench to tighten the second (torqued) nut against the first (adjustment) nut to the values indicated in TORQUE VALUES for Second Nut

Third (positive lock) nut installation is to be placed on each of the extend cables. The retract cables do not require the third (positive lock) nut.

The third nut should be hand tightened until the tapped hole for the set screw is tangent to the end face of the wrench flat.

Install set screw into Third nut and tighten.

(**OPTION 2**) method used ONLY when space constraints prevent **OPTION 1** usage (see Figure 6-5).

## *TORQUE VALUES for Second Nut*

Inch Series with Coarse Threads (UNC)

| Cable end Thread Size | Minimum Nut Strength GRADE | Nut Type | TORQUE ft lb |
|---|---|---|---|
| 1/2-13 | SAE 2 | Hex Jam (HALF) | 12 |
| 5/8-11 | SAE 2 | Hex Jam (HALF) | 31 |
| 3/4-10 | SAE 2 | Hex Jam (HALF) | 47 |
| 7/8-9 | SAE 2 | Hex Jam (HALF) | 63 |
| 1-8 | SAE 2 | Hex Jam (HALF) | 199 |
| 1 ¼-7 | SAE 2 | Hex Jam (HALF) | 203 |
| 1 ½-6 | SAE 5 | Hex Jam (FULL) | 250 |
| 1 ¾-5 | ASTM B | Hex Jam (FULL) | 250 |

Metric Series with Coarse Threads

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

# SECTION 7
# SIDE SHIMMING OF BOOM SECTIONS

## SECTION CONTENTS





**Center inner boom section in outer boom section.**

$X_1 = X_2$

**Calculate shims required.**

Gaps $X_1 = X_2 = 0.56$ in (14.3 mm).

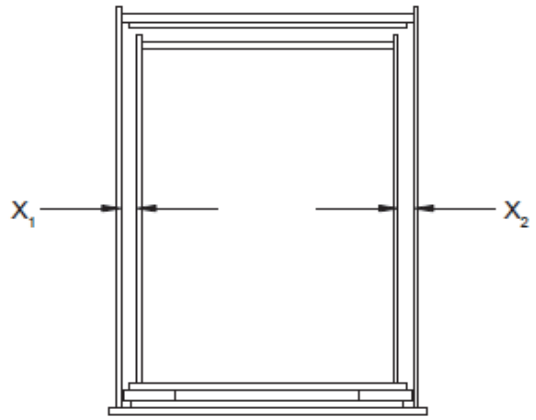
Wear pad thickness ($t_{wp}$) = 0.44 in (11.1 mm).

Add shims as required [each shim is 0.03 in (0.8 mm)] to tighten the pads so that there is 0.03 in - 0.09 in (0.8 mm - 2.4 mm) total clearance between the sections. In some cases it will be necessary to have an unequal number of shims behind the pads at the top and bottom side pad locations.

| | |
|---|---|
| X1 = | 0.56 in (14.3 mm) |
| - $t_{wp}$ = | 0.44 in (11.1 mm) |
| clearance before shims | 0.12 in (3.2 mm) |
| Add shims | 0.03 in (0.8 mm) |
| | 0.06 in (1.6 mm) |
| Final clearance | 0.03 in (0.8 mm) |

At each pad location add qty-1 0.06 in (1.6 mm) and qty-1.03 in (0.8 mm) shim for a total clearance of 0.03 in (0.76 mm).

**FRONT SIDE PAD SHIMS**



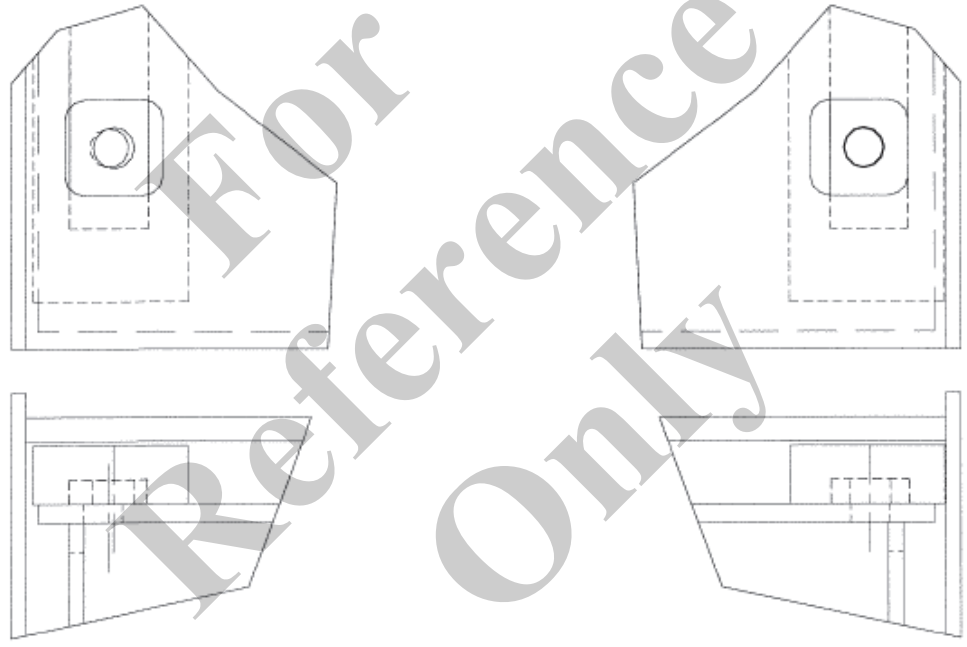

9402

## TOP/REAR SIDE PAD ADJUSTMENT

With the inner boom section fully retracted, center the inner boom in the outer boom by prying the inner boom section from side to side.

Assemble the top/rear wear pads and plates. The top/rear wear pads on this boom are adjustable to account for lateral tolerances that occur during the manufacturing process of the boom sections. The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16 in (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 0.06 in (1.6 mm) off center in the plate and 0.03 in (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.

Once the boom is located, the wear pad and plate combinations can be inserted into the space between the boom sections and aligned over the holes in the sections. If the holes in the plate are not centered over the holes in the sections, the wear pads and plates have to be removed and adjusted either towards or away from the side plate of the next larger section until the holes will align. When properly aligned the wear pad should be tight against the side plate of the outer boom section.



9403



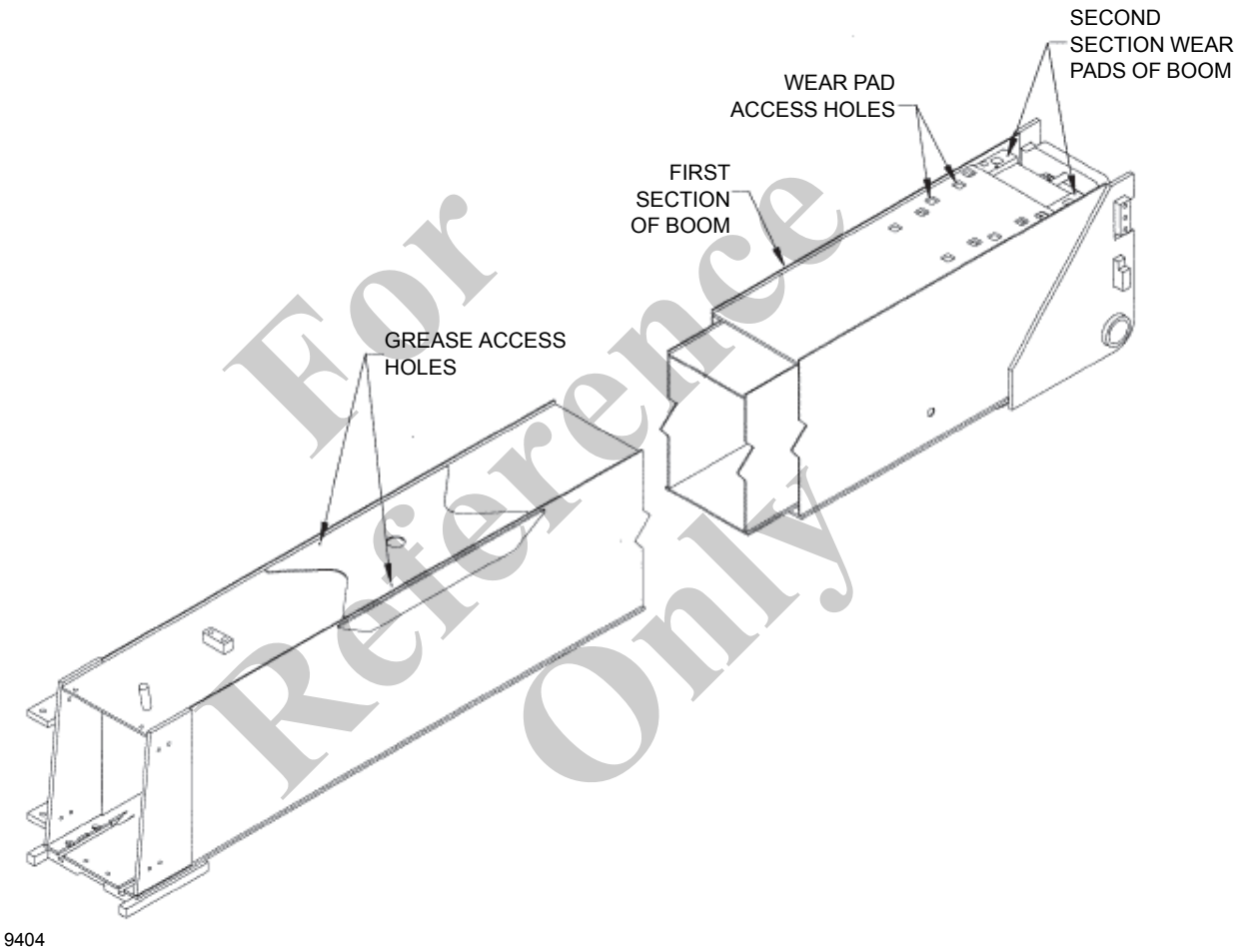
**Needs adjustment.** The capscrews cannot be installed and there is a gap between the wear pad and side plate of the larger boom section.

**Properly aligned and adjusted wear pad.** The holes in the cam plate are concentric with the threaded holes in the smaller boom section and the wear pad is tight against the side plate of the larger boom section.

When wear pads are properly aligned and adjusted, install capscrew and torque to 110 ft-lb (149 N·m).

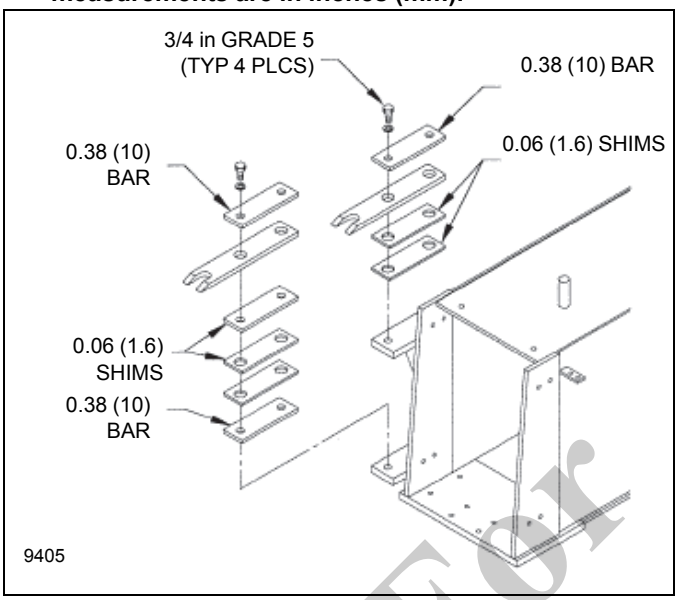
## INNER BOOM PAD LUBRICATION

1. With the boom fully retracted, fill upper rear pad retention pockets (pad retainers) with grease. Access pockets through holes in rear of boom top plate.
2. Extend boom to full extension at this time. The upper rear pad retention pockets will be under the 1/4 in grease access holes in the butterfly plates on the top of the boom sections.
3. Using a 1/4 in diameter nozzle grease gun adapter, fill pad retention pockets with grease.
4. Retract boom. This should apply grease to the pad bearing area of the top plates of the boom sections.
5. These steps can be repeated as many times as necessary if unacceptable boom noise or chatter persists.

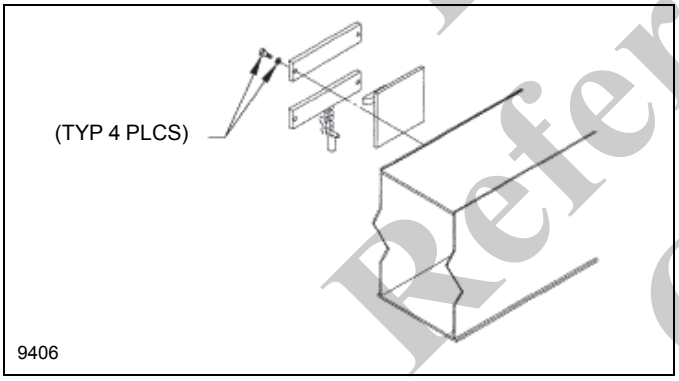


## JIB INSTALLATION AND ADJUSTMENT

1. Loosely bolt the two ear assemblies with shims and bars as shown to the side of the first boom section. **Note: All measurements are in inches (mm).**

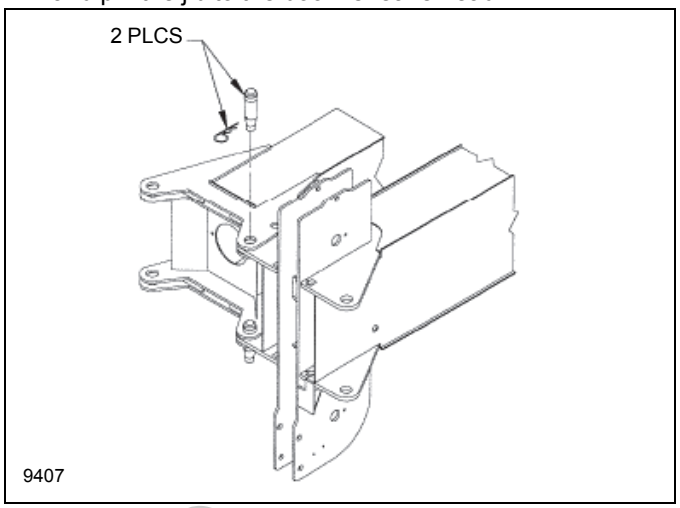



2. Loosely bolt the hook assembly to the side of the first boom section.

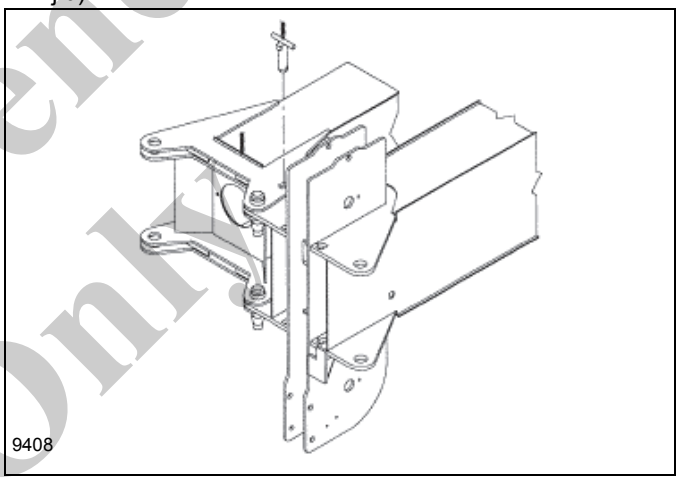



3. Extend the boom approximately one foot (300 mm).

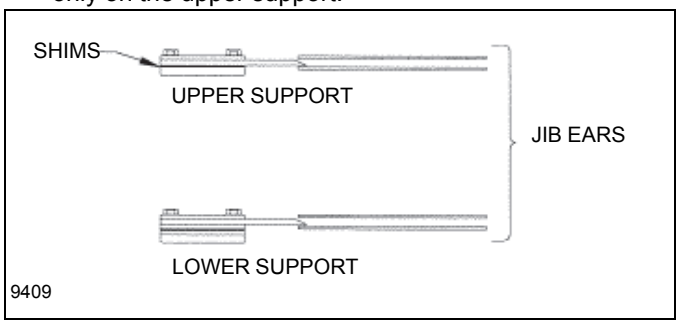
4. Using an overhead hoist, lift the jib assembly and align and pin the jib to the boom sheave head.




5. With jib pinned to the sheave head, swing the jib parallel to the boom and install the pin which keeps the jib from swinging (the pin is welded to a chain on the end of the jib).

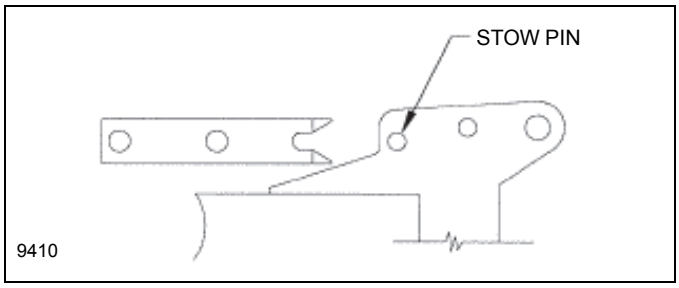



6. Slowly retract the boom until the jib ears are within 0.50 in (13 mm) of the ear assemblies on the first section. Observe the vertical alignment of the jib ears and ear assemblies and add or remove shims until the jib is supported by the jib ears. The jib will typically rest only on the upper support.

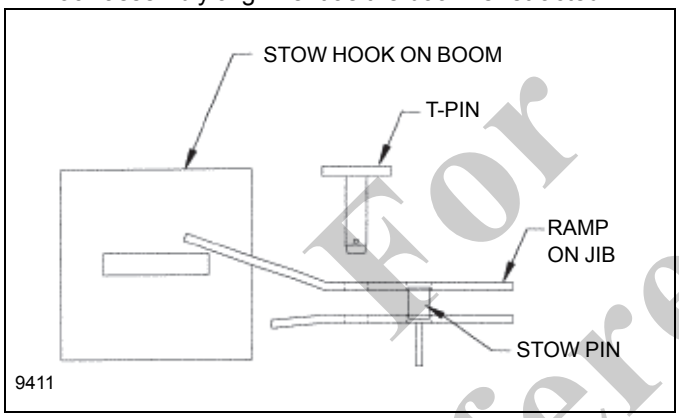



7. Observe the horizontal alignment of the slot in the ear assemblies and the stow pin in the jib. Horizontal adjustment of the stow ears is provided by oversize bolt

holes in the stow ear. Move the ears in or out to achieve proper alignment. Position the top ear so it holds the top of the jib in toward the boom and the bottom ear so that it holds the bottom of the jib away from the bottom of the boom.



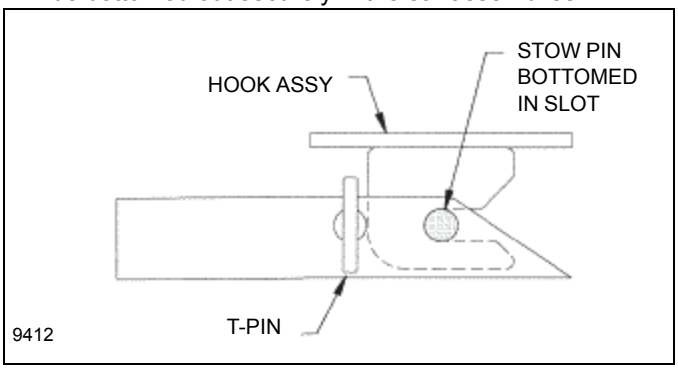

8. Retract the boom slowly. Observe the stow hook and lock assembly alignment as the boom is retracted.

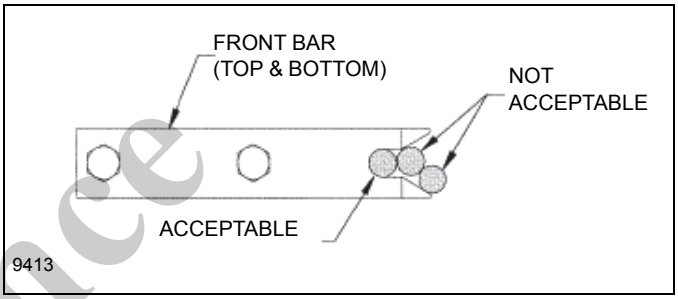



**⚠CAUTION**

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

9. When the boom is fully retracted, the jib stow pins must be bottomed out securely in the ear assemblies.




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

10. Try to remove the jib pins. If the pins are too tight, the stow hook assembly or front bars will have to be adjusted.
11. Torque all capscrews to their specified torque value (see table in Service & Maintenance Section). Install stow pin in lock assembly and remove the jib pins.
12. Extend and retract boom to insure proper alignment of jib pins.
13. Install jib pins and remove the stow pins.
14. Extend and retract the boom and jib to ensure proper alignment of jib stow brackets.
15. Install jib stow pins and remove jib pins.

Always save shims to allow future adjustment of jib stow if required.

## JIB JACK SERVICE & 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

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

## Changing Oil

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

## Lubrication

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

## Rust Prevention

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

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

# TROUBLESHOOTING

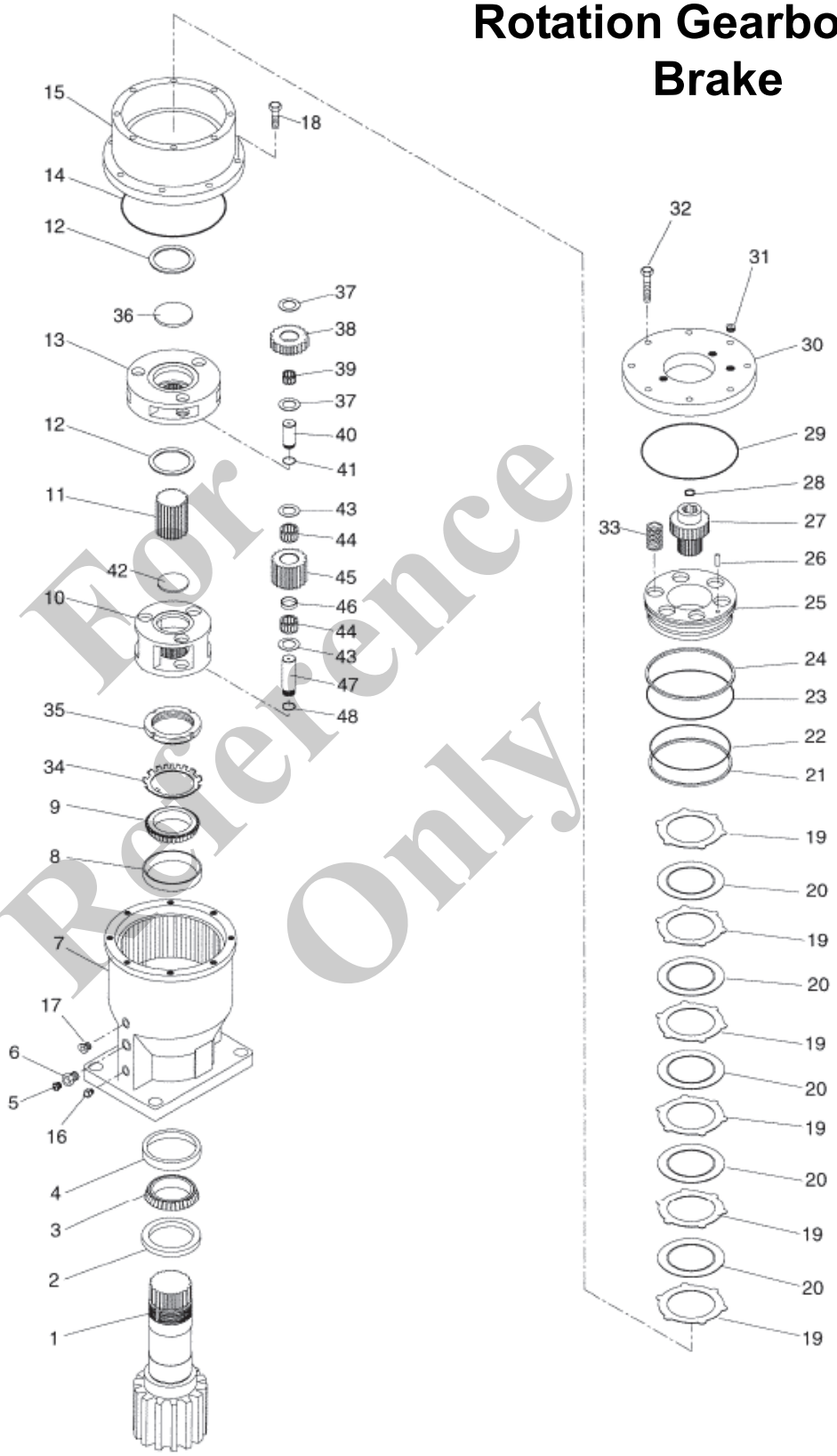
| Symptom | Possible Cause(s) | Corrective Action |
|---|---|---|
| Will not lift load | 1. No oil in system<br>2. Release valve not closed | 1. Add oil to reservoir tank through oil filler hole<br>2. Turn handle clockwise tightly |
| Will lift load only part way | Oil level low | Add oil to reservoir tank through oil filler hole |
| Will lift load but will not hold | 1. The following valve or valves leaking:<br>a. Suction valve<br>b. Delivery valve<br>c. Release valve<br>4. Packings worn out or defective | 1. Replace jack<br>2. Replace jack |
| Jack will not lower | Release valve stuck, probably dirt or foreign matter | Transfer load then replace dirty oil, flush oil reservoir with kerosene |
| Poor lifting | 1. Dirty oil<br>2. Air in hydraulic system | 1. Change hydraulic oil<br>2. Purge air from system |
| Poor pumping action | Oil seal for pump unit worn out or defective | Replace jack |

# (OPTIONAL) OIL COOLER SERVICE & MAINTENANCE

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

Frequent inspection and tightening of hose clamp line connections will eliminate the possibility of end connection failure due to back pressure from cold startup. If cooler system fails to provide adequate performance, reduced air or oil flow through the heat exchanger is the probable cause. The cooling fan should be inspected for proper operation (see Specifications). Any obstructions in airflow should be corrected (cooler too close to other truck components, foreign matter in heat exchanger fins, etc.) All hydraulic lines should be periodically checked for obstructions, hose kinks or other flow restrictions.

# Rotation Gearbox and Brake






9414

FIGURE 7-1

# SWING DRIVE SERVICE

## Lubrication and Maintenance

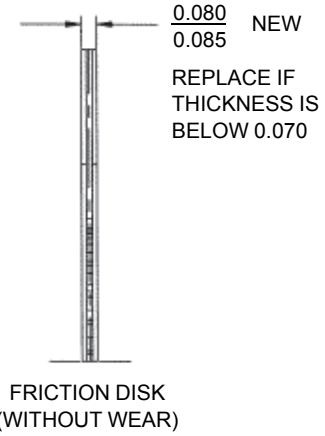
Manufacturer recommends changing oil after first 50 hours of operation. Oil should be changed at 500-hour intervals thereafter. All gearboxes require GL-5 grade EP 80/90 gear oil for lubrication. Some units may be equipped with a grease fitting for lubrication of the output shaft bearings (pinion up applications). The shaft bearings should be greased sparingly at every 50 operating hours with a lithium or GP bearing lube. In pinion down applications, gearbox oil will lubricate Shaft bearings.

**Oil Capacities**

70 oz (9.64 kg)

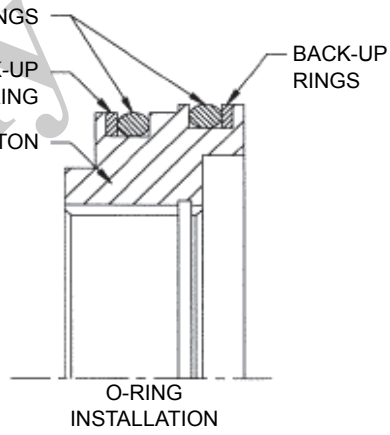
## Disassembly Procedure

1. Remove drive from vehicle and drain gearbox lubricant by removing the drain plug (**31,** Figure 7-1).
2. Remove the motor from the motor adapter (**30**).
3. Remove the brake assembly from the gear housing assembly (**7**) by removing eight sockethead capscrews (**18**). NOTE: Notice the position of the brake port in conjunction with the drain and fill holes in the housing for reassembly.
4. Separate the motor adapter (**30**) from the brake housing (**15**) by removing eight capscrews (**32**). NOTE: Notice the position of the motor mounting hole in relation to the brake release port for re-assembly. CAUTION: The motor adapter is spring-loaded and the capscrews should be loosened in a sequence that will allow an even load distribution on the motor adapter.
5. Inspect the motor adapter o-ring (**29**) for damage. Replace if necessary.
6. Remove the six springs (**33**), piston (**25**), and brake driver (**27**) from brake housing (**15**). NOTE: Notice the position of the dowel-pin hole in piston with respect to the brake release port for re-assembly. NOTE: A port-a-power can be used to assist in the removal of piston by slowly pressurizing the brake release port until piston clears the top of housing (**15**). Remove statorplates (**19**) and friction discs (**20**) from the brake housing (**15**). Inspect stator plates for excessive grooving or burn spots. Also, inspect friction discs for wear. Replace as required. *(Ref.* Figure 7-2*)*
7. Remove stator plates (**19**) and friction discs (**20**) from the brake housing (**15**). Inspect stator plates for excessive grooving or burn spots. Also, inspect friction discs for wear. Replace as required. *(Ref.* Figure 7-2*)*.




9415 **FIGURE 7-2**

8. Inspect the piston o-rings (**22** & **23**) and the back-up rings (**21** & **24**) for damage, replace if necessary. *(*Figure 7-3*)*




9416 **FIGURE 7-3**

9. If applicable remove 2nd piston (**36**) from the brake housing (**15**), inspect o-rings (**37** & **38**) and back-up rings (**39** & **40**) for damage, replace if necessary. *(*Figure 7-3*)* Inspect bearing (**41**) in brake housing (**15**) replace if necessary.

10. Remove race (**12**) from input planet set (**13**).
11. Remove input planet set (**13**) from gear housing (**7**) by pulling straight up and out of the housing.
12. Remove retaining ring (**41**), press out the planet pins (**40**), remove the planet gear (**38**), and needle bearings (**39**), inspect for unusual wear. Replace as required.
13. Remove race (**12**) from output planet set (**10**).
14. Remove the output sun gear (**11**), from the output planet carrier (**10**). Lift the output planet set out of the housing (**7**).
15. Remove the retaining ring (**48**). Press out the planet pins (**47**); remove the planet gear (**45**) and needle bearings (**44**). Inspect for unusual wear. Replace as required.
16. Remove bearing lock nut (**35**) and lock washer (**34**).
17. Remove the pinion shaft (**1**) from the housing (**7**) inspect the pinion shaft, seal, and bearing for wear and replace if necessary. Remove the inboard bearing (**9**) and inspect for wear.
18. Remove outboard seal (**2**) and bearing (**3**) Inspect for wear and replace if necessary.

## Assembly Procedure

1. Press the inboard and outboard bearing cup (4 & 8, Figure 7-1) into the gear housing (7) if replaced.
2. Grease pack the bearing cones (9 & 3) with EP-2 before installation.
3. Install the outboard cone (**3**) into the outboard cup (**4**). Press the seal (**2**) into the gear housing (**7**) from the outboard side.
4. Slide the output pinion (**1**) into the housing (**7**) from the outside.
5. Install the inboard bearing cone (**9**).
6. Apply Loctite® to pinion shaft and locknut.
7. Install the bearing lockwasher (**34**) then the bearing locknut (**35**). Torque locknut to 50 lb-ft. Loosen and rotate pinion 90 degrees, re-torque locknut to 50 lb-ft. (repeat this process 4 times) then re-tighten locknut to 20 lb-ft. If the locknut is between tabs on the lockwasher always tighten until tabs align with slots in locknut. Secure locknut by bending tabs on lockwasher so that it engages locknut to prevent locknut from backing off. NOTE: Install a 5/8-11 bolt into the end of the pinion shaft on the outboard side and check the rolling torque. Preload of the bearing torque should be 50-75 lb-in.
8. Install the output carrier (**10**) into the gear housing (**7**). Install sun gear (**11**) and then the race (**12**) into output carrier (**10**).
9. Install the input carrier section (**13**) with race (**12**).
10. Assemble the brake section by first installing the o- ring (**14**) on the brake housing (**15**). Install eight capscrews (**18**) to the brake housing (**15**) and torque to 10 ft. lbs. NOTE: Notice the position of the brake port in conjunction with the drain and fill holes in the housing.
11. If applicable install piston (**36**) into brake housing (**15**). NOTE: Apply a slight film of oil on the o-rings and back-up rings before installation.
12. Insert the brake driver (**27**) into the assembled brake housing (**15**).
13. Install the stator plates (**19**) and friction disks (**20**) starting with one stator plate and alternating between friction disk and stator plate until six stator plates and five friction disks are used. NOTE: Soak friction disk in EP-90 oil before installation.
14. Carefully press the assembled piston (**25**) into the brake housing (**15**), taking care not to damage the o- rings. NOTE: Notice the position of the dowel pin hole in piston with the brake release port for correct assembly.
15. Install six springs (**33**) into the holes in the piston (**25**).
16. Mount the motor adapter (**30**) to the brake housing (**15**) with eight caps crews (**32**) checking to make sure the roll pin (**26**) is in line with the dowel hole in piston (**25**).

**NOTE:** Notice the position of the motor mounting hole in relation to the brake release port for correct re-assembly.

17. Mount the motor to the adapter (**30**).
18. Fill the gearbox to desired level with EP-90 gear lube.

## ROTATION STOP-MECHANICAL

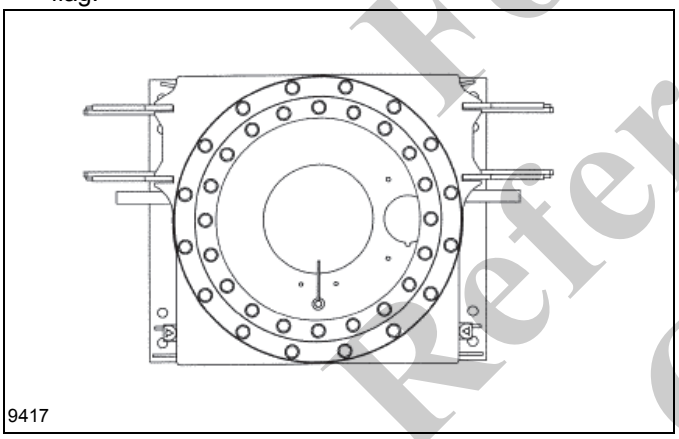
The rotation stop system is designed to stop crane rotation beyond 375 degrees in the clockwise or counter-clockwise directions. This is accomplished by mechanically returning the control valve to the centered position as full rotation is approached. The operator will feel the control lever begin to pull in the opposite direction as full rotation is approached. The operator should not resist this counteracting force, but permit the rotation stop system to return the lever to neutral. If a load cannot be reached or placed due to the available rotation, the crane must be re-positioned. Attempting to override the rotation stop system will result in damage to the crane and possible injury to the operator.

### Adjustment Procedure

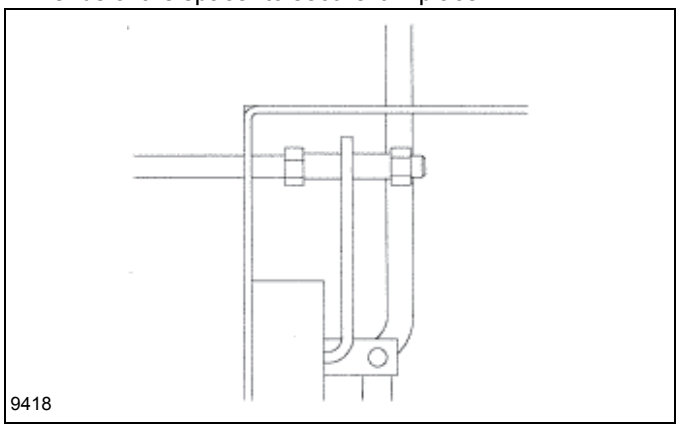
There are two methods that can be used for adjusting the rotation stop system.

#### *Method 1*

1. From inside of the frame, rotate the flag rod until it is centered between the two stop pins on either side of the flag.


9417

2. Make certain that the turn lever is vertically aligned. If not, adjust the lever at the clevis connecting it to the control valve.
3. With the turn lever vertically adjusted, verify that the spacer is centered in the turn control rod tab.
4. If it is not centered, loosen the two nuts, one on either side of the spacer. Turn the nuts in the same direction until the spacer is centered. Tighten the nuts against the ends of the spacer to secure it in place.


9418

5. Verify that the flag is still centered between the stop pins.

#### *Method 2*

1. Follow the crane set-up procedures in this manual to set outriggers and stabilizers and level the machine.See “Proper Leveling of the Crane” on page 10.
2. With the crane properly set-up, raise the boom to near full boom angle (75-80 degrees). This must be done with the boom fully retracted and with no load attached to the loadline.
3. Slowly rotate the boom until is directly over the front of the truck (behind cab mounting). With the boom directly over the front, place a mark at the top of the frame aligned with the center of the lift cylinder.
4. Rotate the crane clockwise, or counter-clockwise until the rotation stop system centers the control lever.
5. Again make a mark at the crane frame aligned with the center of the lift cylinder.
6. Now rotate the crane in the opposite direction until the rotation stop system centers the control lever.
7. Make another mark on the crane frame aligned with the center of the lift cylinder.
8. If the rotation stop system is properly adjusted, the distance should be the same from the first mark made to the second mark, as it is from the first mark to the third mark.
9. If not, loosen the nut on either side of the spacer on the flag rod actuator rod and adjust the position of the spacer. Tighten the two nuts and repeat steps 3 through 7 above until proper adjustment is achieved.

## SERVICING THE CONTROL VALVES

### Disassembly and Reassembly of Control Valves to Replace Seals

**NOTE: For clarification, we shall call the inlet cover containing the main relief the left side of the valve assembly.**

1. Before disassembly, it is suggested that each valve section be marked numerically to avoid incorrect reassembly.
2. Remove three assembly stud nuts from the end section using a 9/16 in thin wall socket.
3. Remove valve sections by sliding from assembly studs.
4. If valve sections are to be added or removed, use the proper length assembly stud.

**NOTE: Use assembly nuts, three required, with all assembly studs. No lockwashers! All studs are stress-proof material and should be replaced only with original equipment replacement parts.**

5. Thoroughly clean O-ring counterbores and ground surfaces of each section.
6. Replace the four O-rings for crane valve and three O-rings for hoist valve, two seals per section. Buna-N seals are standard.
7. Replace valve sections on assembly studs in the same order in which they were removed.

**NOTE: Use care in replacing valve sections to avoid dislodging o-rings from counterbores.**

8. When all valve sections are positioned on assembly studs, replace stud nuts and tighten evenly to 32 lb-ft (43 Nm) torque for crane valve and 25 lb-ft (34 Nm) torque for hoist valve.

**NOTE: If stud nuts are not tightened to the proper torque, valve spools may bind or stick, or cause section seals to extrude.**

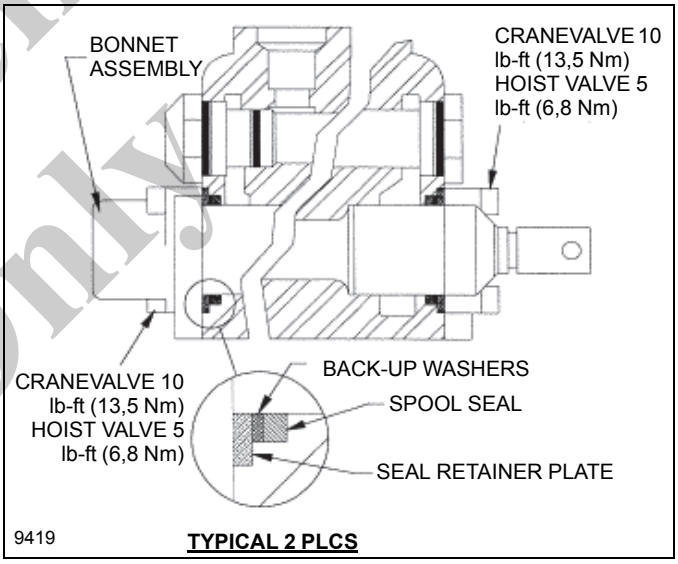
### Replacing Spool Seals

Valve sections and covers are identified by numbers cast into the body.

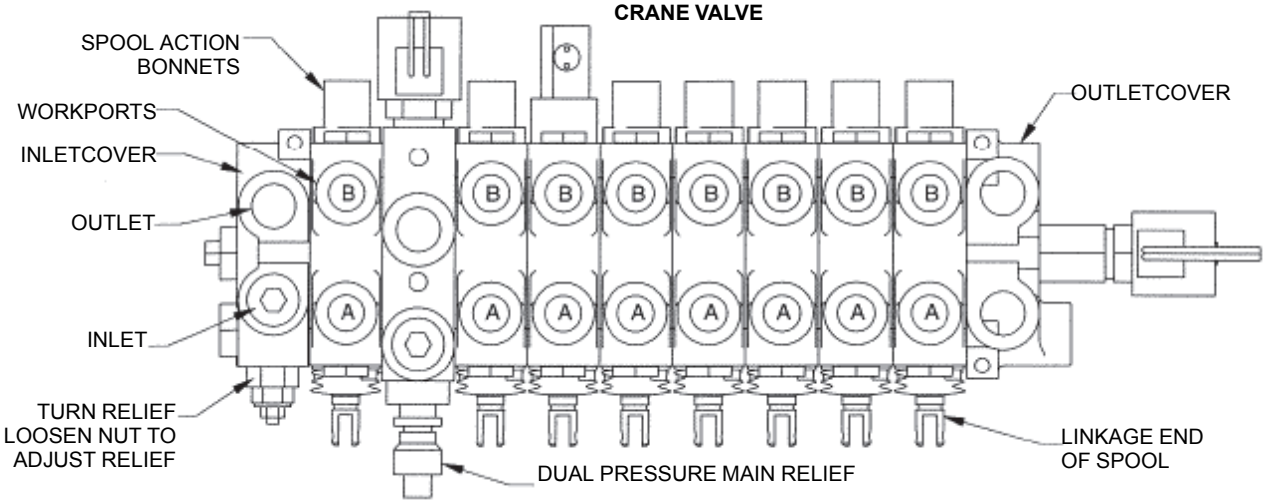
1. Remove bonnet assembly parts from back of valves and keep in order of disassembly.
2. Remove all parts connected to the spool on the front of the valve.

**NOTE: Do not remove the spool as the seals can be replaced externally. Prevent spool from turning or moving by inserting a screw driver through clevis slot, or running a rod through the pin hole and using a handle. Do not hold the spool with a wrench. This will destroy the finish. Always replace all spool seal parts with parts included in spool seal replacement kit.**

3. Remove boot retainer plate, seal retainer plate washers, back-up washers and spool seals.
4. Thoroughly clean counterbore.
5. Lightly oil new seals. Slide over valve spool and insert in seal counterbore.



TYPICAL 2 PLCS




## UNLOADER VALVE SERVICE

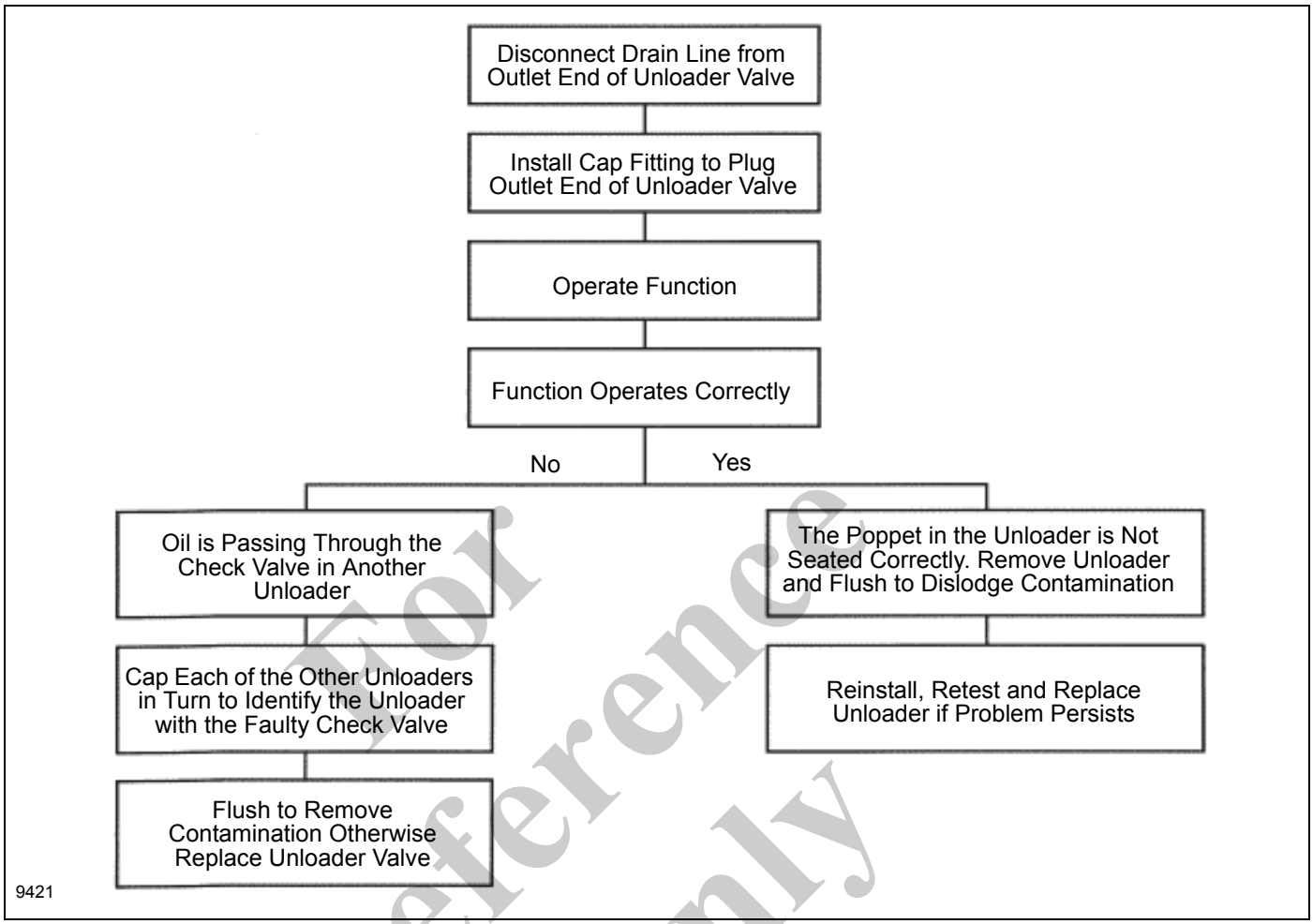
*Refer to ATB System Diagnosis if an electrical problem has occurred.*

This crane has three work sections equipped with unloader (dump) valves. The functions connected to the unloader valves are hoist up, boom down and boom extend. The purpose of these unloaders is to stop control oil from reaching the functions in the event of a two-blocking occurrence or an overload condition. Hydraulic lines extend between the unloader valve on each of these sections to a single solenoid (dump) valve. The hydraulic oil in these lines can drain out over a period of time, when the pump is not engaged, or may be lost during servicing the unit. Air may enter these lines at such a time. If the unloader hydraulic lines have air in them, these three functions may not operate or may exhibit a delay in their operation. **Note: None of the internal parts of the unloader valves are serviceable**.

In the event that one of these three functions will not operate or operates with a delay and the crane is not overloaded or two-blocked, the following air purging procedure should be followed. If no improvement is seen after completing the following procedure twice, follow the troubleshooting steps outlined for checking and inspecting the solenoid valve and unloaders in this hydraulic circuit outlined below.

1. Purposely trip the ATB switch to open the solenoid (dump) valve.
2. Operate hoist up, boom down and boom extend separately for about a minute, longer if the oil is cold.
3. Operate all three functions simultaneously.
4. Release the ATB switch.
5. Check the operation of each function.
6. Repeat procedure if necessary.

In the event that one of these three functions will not operate and the crane is not overloaded or two- blocked, the following procedure is used to diagnose the problem.






## CONTROL VALVE RELIEF ADJUSTMENT

The control valves supplied on this crane are equipped with adjustable relief valves. After some time of use, it may be necessary to make some adjustment in pressure because of spring weakening, etc. The relief valves are adjustable only through a specific pressure range.

Both the inlet of the main control valve and inlet of the hoist valve have screw adjustable main relief valves. Turning the relief in increases pressure relief setting; turning the relief out decreases pressure relief setting.

The turn circuit pressure can be checked by plugging a port on the turn motor with a pressure gauge. The pressure on the main control valve stack should be checked by booming the lift cylinder down against the end of the cylinder stroke. The hoist circuit pressure can be checked by plugging a port on the hoist motor with a pressure gauge.

The mid-inlet relief in the main control valve is a dual-pressure relief. Adjustment is detailed below.

### Mid-inlet Relief Adjustment

**Relief Cartridge Adjustment:** Refer to the “Specifications” section for correct standard pressure setting.

**Adjusting the relief valve for the standard pressure setting.**

1. Remove the fitting from the relief valve at C.
2. Loosen jam nut A1 and with a wrench on the body at A2 either screw the body in or out. Screwing the body in increases the pressure setting. Screwing the body out reduces the pressure setting. The pressure can be read on the gauge on the console during adjustment.
3. Once the correct pressure is attained, tighten jam nut A1 while holding the body with the wrench at A2.
4. Recheck the pressure on the console gauge to ensure that tightening the jam nut has not changed the pressure setting. ***Never set pressure above recommendations***.
5. Reinstall the fitting at C.

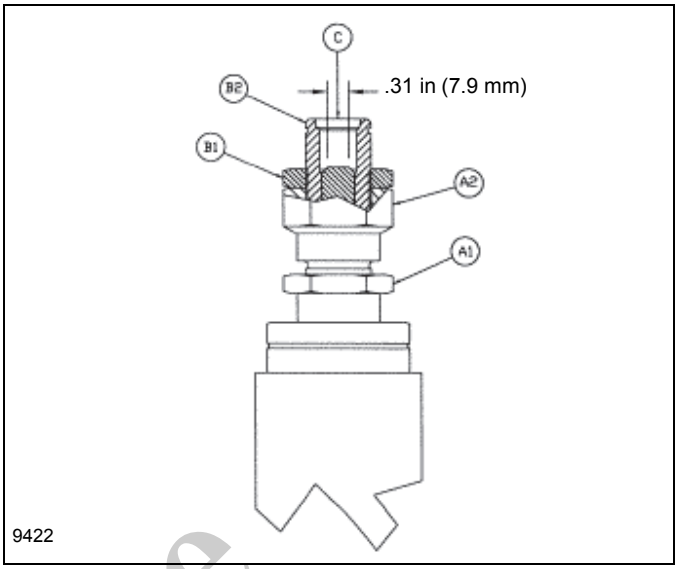
Adjusting the relief valve for the secondary pressure setting.

1. Disconnect the hose from one of the outrigger sections and plug the port. This function can be used to test the system pressure without the hoses or cylinder seeing the higher pressure.
2. Remove the fitting from the relief valve at C.
3. Insert a plug with a diameter of 0.31 in (7.9 mm) and a length of 0.31 in (7.9 mm) in the cavity at C.
4. Screw a SAE -4 fitting into the port at C until it is tight.
5. Loosen jam nut B1 and with a wrench on the two wrench flats at B2 either screw the threaded body in or out. Screwing the body in increases the pressure setting. Screwing the body out reduces the pressure setting. The pressure can be read on the gauge on the console during adjustment. Correct pressure is listed above.
6. Once the correct pressure is attained, tighten jam nut B1 while holding the body with the wrench at B2.
7. Recheck the pressure on the console gauge to ensure that tightening the jam nut has not changed the pressure setting. ***Never set pressure above recommendations.***
8. Remove the SAE -4 fitting and plug from location C.
9. Reattach the hydraulic line at C and check for leaks.
10. Reconnect hose to outrigger function.

Some valve sections include work port reliefs. The work port reliefs are shim adjustable. Adjustment is made by adding or taking out shims. Adding a 0.010 shim will increase pressure 100 psi (0.68 MPa). See “Specifications” section for correct pressure settings. ***Never set pressure above recommendations***.

**⚠CAUTION**

**If the machine does not perform properly at these pressures, the problem is not the relief valve and no attempt should be made to readjust the setting. If the relief valves are set to higher pressures than those listed above, the warranty on the machine is void. Also the machine could operate in a manner such as to endanger personnel safety.**




## UNLOADER DUMP VALVE – AIR PURGING INSTRUCTION

When a crane sits for a long period, the oil can drain back to the reservoir and air could get into the pilot lines of the unloader dump valves. This is likely to be more of a problem in colder weather as the oil will not flow back into the unloaders as easily when the crane is started. If the unloader pilot tubes have air in them, the dump functions will not work correctly. They might appear to be dumping the flow even though the ATB or overload switch has not been tripped. If this is suspected when checking the systems during start-up, first try to purge any air that may be in the system.

Purposely trip the ATB switch to open the dump solenoid. Engage each function that is being dumped (telescope out, hoist up, and boom down) separately at full throttle for about a minute, longer if the oil is cold. Then engage all three simultaneously. Remove the two-block condition and check performance of each function. If there is no change, the procedure may be repeated. If again there is no improvement, follow the troubleshooting steps outlined for checking and inspecting the ATB solenoid and work port unloaders.

## HYDRAULIC SYSTEM DESCRIPTION

The hydraulic system of this machine is an open center type consisting of a fixed displacement three section high pressure pump which supplies oil to a main control valve and a hoist control valve. The main control valve is equipped with a main inlet and a mid inlet. The main inlet supplies oil to the turn function, the mid inlet supplies the remainder of the crane function requirements. The main control valves contain inlet section reliefs or port reliefs which limit pressure in the hydraulic system to acceptable levels and control

crane movements. See Specification Section for pressure settings.

The large single section control valve supplies oil to hoist up and down. The inlet section contains a screw adjustable main relief. The first work section of the multi-section main control valve controls turn right and left. This work section is supplied oil by the main inlet section which contains a screw adjustable relief valve. The remaining work sections are boom telescope, boom lift, and outrigger functions in that order. The oil to these sections is supplied by the mid inlet section which also contains a main relief valve. The hoist and the main circuits are all connected through shuttles to a pressure gauge located on the control console.

This system provides additional hydraulic pressure to the lift cylinder to raise the boom from a negative angle back to zero degrees. When the boom is below zero degrees and the lever is thrown to provide oil to the bore side of the lift cylinder the system relief cartridge in the main control valve is shifted to provide a higher pressure to the control valve. The relief valve in the mid-inlet of the control is designed to have two pressure settings. These pressures are listed in the “Specifications” section in the front of the Owner’s Manual.

The hydraulic oil is supplied by a truck frame mounted oil reservoir, which is equipped with a replaceable canister type return oil filter. The truck power take off driven hydraulic pump is sized to supply oil to the hoist circuit, the boom lift and telescope circuits and the turn function at specified pump shaft speed. Higher pump speeds may result in excessive heat generation in the hydraulic system. The pump is not bi-directional and can be used when the shaft rotates only in the proper direction. If you need to verify or change pump rotation, contact your National Crane distributor or Manitowoc Crane Care.

The crane hydraulic system includes a Rated Capacity Limiter (RCL) system. This system monitors lift cylinder pressure. As the pressure in the lift cylinder approaches a maximum predetermined level, which can be monitored on the RCL display console, a signal is sent to a solenoid which dumps oil flowing to crane functions which increase the over capacity condition.

All load bearing cylinders on this machine are protected from inadvertent movement or collapse due to hose failure by pilot operated check valves or by pilot operated counterbalance valves if overhung loads must be controlled.

The standard swing gearbox is locked in place by an integrally mounted spring applied brake and a dual counterbalance motor holding valve. The swing brake and counterbalances are piloted open and closed by operating swing left or right and are automatically reapplied by ceasing the swing function. Maximum swing speed can be limited using the swing speed adjustment valve.

See “Specifications” section for system pressures and flows.

## OPTIONAL HYDRAULIC CAPACITY ALERT SYSTEM

### System Adjustment

The hydraulic capacity alert system should be checked for proper adjustment during initial crane startup and quarterly thereafter. The procedure for proper adjustment should be performed as follows: Trapped air must be bled from the system before adjustments are made.

1. Remove the console cover depending on crane model.

**⚠DANGER**

**Before loosening any fittings, support the boom.**

2. Start the truck and set the crane up for operation as prescribed in the “Safety and Operation” Section.
3. Select a test weight that is equal to crane capacity at an intermediate boom length and radius. Work with loads which have loaded boom angles near 30°. Starting with the boom at the chosen reference angle and a radius less than the chosen radius, pick the weight up with the hoist and begin extending the boom. As the boom is extending, lower the load with the hoist to keep the load near the ground. Monitor the load range gauge located in the console as the boom is extending. The gauge is plumbed directly into the lift cylinder pilot line and the pressure reading should increase to what is defined as capacity load pressure as the selected intermediate boom length and radius is reached. The intermediate boom length is determined by a line and corresponding dimension decal on the side of the second section boom. The chosen radius is measured from the centerline of rotation to the loadline.

   If the gauge reading does not increase while extending, lower the load to the ground and check the system plumbing according to the hydraulic schematic. Replumb the system according to the schematic and illustrated parts page or replace faulty pressure gauge.

**⚠DANGER**

**Before loosening any fittings, support the boom.**

   When the pressure reaches capacity load pressure, the overload system should activate and boom extension will stop. This is defined as trip pressure. This point should be at or very close to the red/yellow color change on the load range gauge.

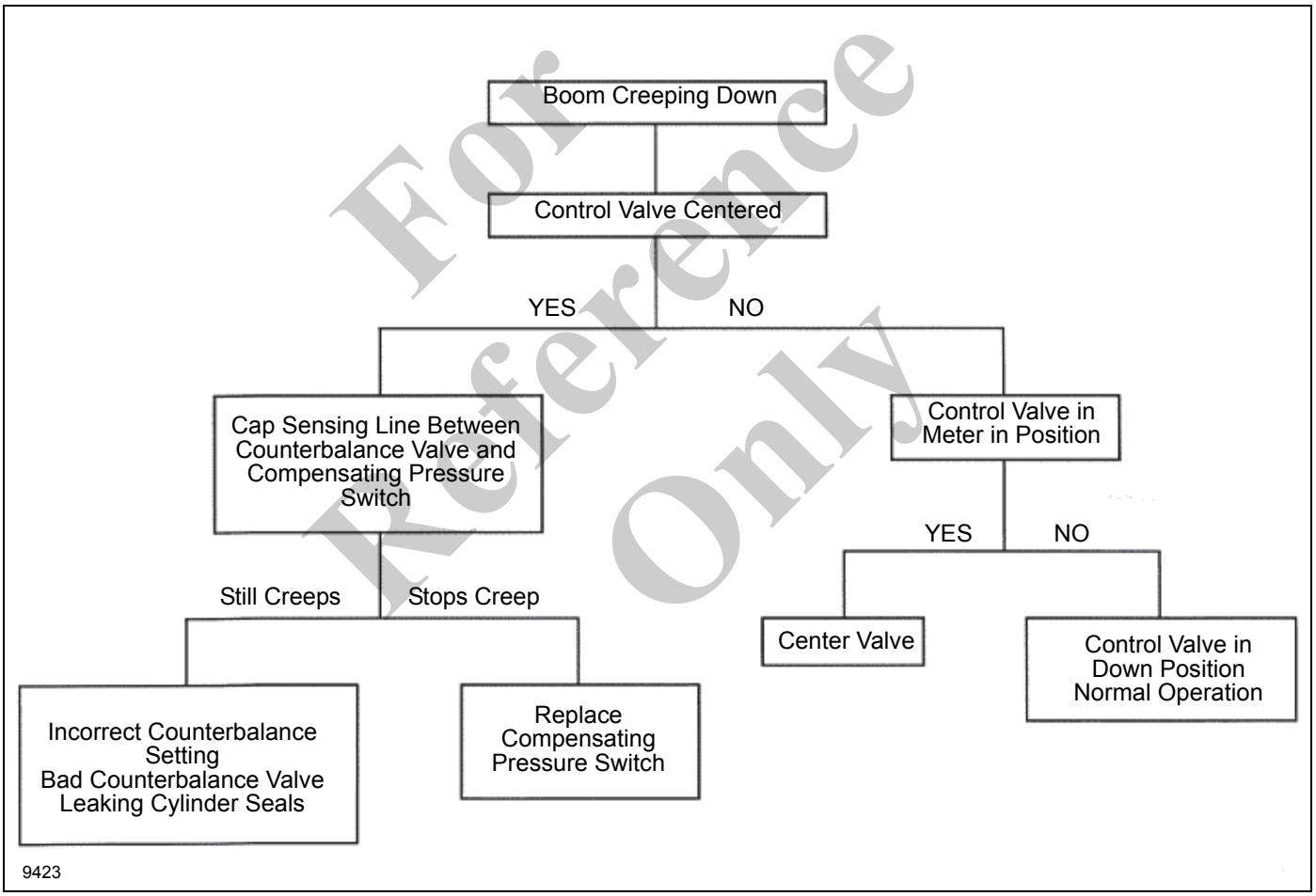
4. Trip pressure should be reached as the boom extension reaches the chosen radius. If the overload system trips

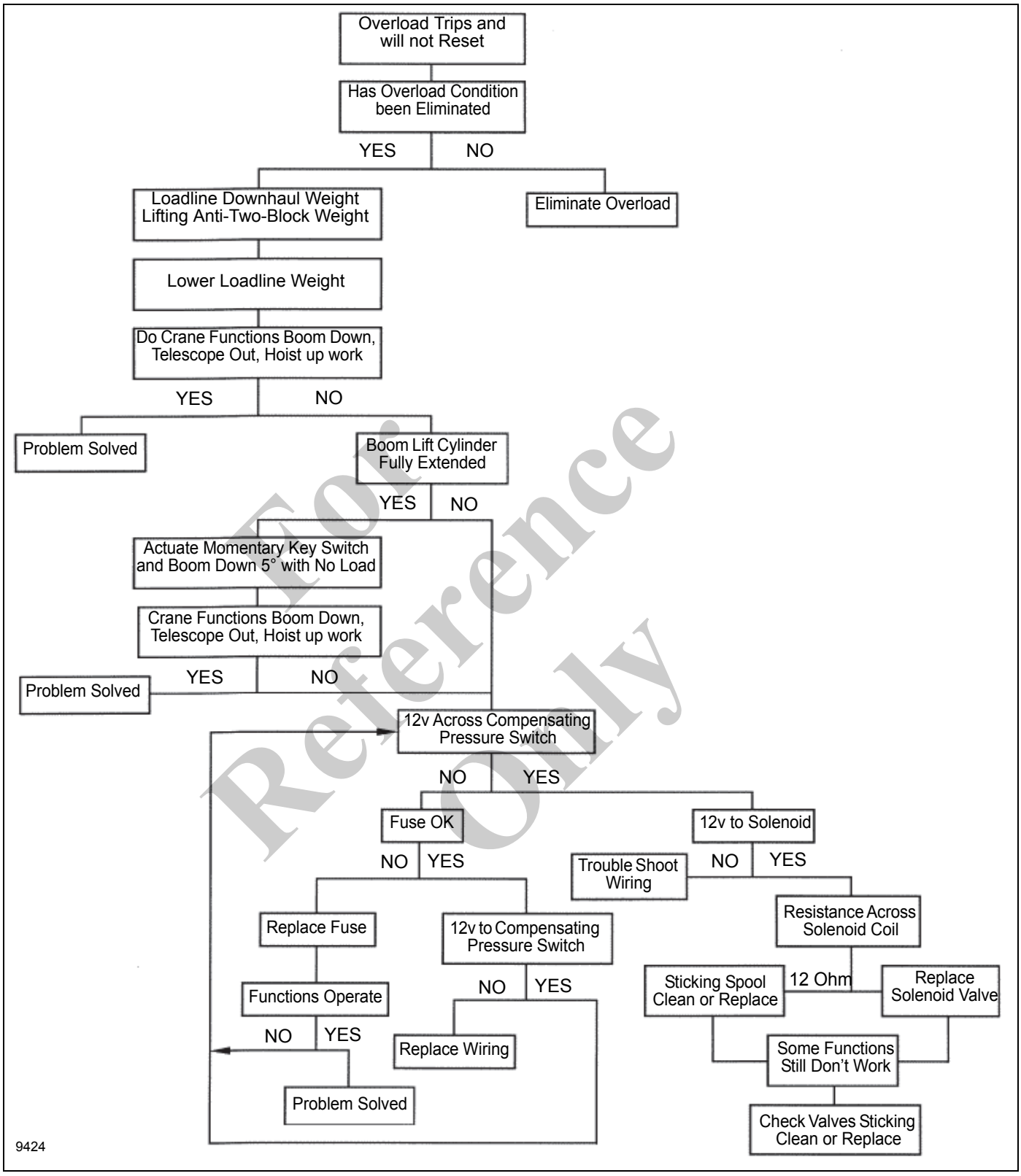
before the chosen radius is reached or allows extension beyond the chosen radius, adjustment is required. If the system is activated before trip pressure is reached, lower the load, remove acorn nut and loosen the locking nut on the compensating pressure switch and turn the setscrew clockwise to increase trip pressure.

5. When the gauge reaches trip pressure, turn the setscrew counter-clockwise until the system solenoid is deactivated and tighten the locking nut. Retract the boom until the pilot pressure is reduced enough to reactivate the system solenoid. The hydraulic capacity alert indicator light will go out when the solenoid is reactivated. Check the trip pressure setting by extending the load until the chosen radius is reached. As the chosen radius is reached, the system solenoid should be deactivated and the indicator light should come on. Readjust switch head if trip pressure is not correct.
6. Once proper adjustment is verified, return the boom to a firmly supported position, stop the truck engine and replace covers.

## TROUBLESHOOTING

The following step-by-step analysis will be helpful in isolating and correcting almost every service problem if followed in a step-by-step systematic manner. Use this information with the Hydraulic Schematic and the Illustrated Parts Catalog to identify parts and follow flow paths. Start at top box and work downward step by step - don't try to start in the middle or skip steps.





## MAINTENANCE & REPAIR

1. Refer to Hydraulic Schematic and System Description to gain a thorough understanding of the capacity alert system before proceeding with any maintenance.
2. System adjustment must be checked every three months for accuracy. Refer to the preceding section on System Adjustment.
3. Always be sure the boom is adequately supported and no hydraulic pressure remains in the lines before the pilot pressure line fittings are loosened.

# SECTION 8
# SPECIFICATIONS
## (DIMENSIONAL SPECIFICATION)

| | G | DRY WEIGHT* | W/OIL WEIGHT * |
|---|---|---|---|
| 851D | 28 in [71 cm] | 13,700 lb [6214 kg] | 14,215 lb [6448 kg] |
| 860D | 46 in [117 cm] | 14,270 lb [6472 kg] | 14,790 lb [6709 kg] |
| 869D | 63 in [160 cm] | 14,830 lb [6727 kg] | 15,350 lb [6963 kg] |
| 880D | 56 in [142 cm] | 15,500 lb [7031 kg] | 16,020 lb [7266 kg] |
| 890D | 68 in [173 cm] | 16,465 lb [7468 kg] | 16,985 lb [7704 kg] |
| 8100D | 79 in [201 cm] | 17,190 lb [7797 kg] | 17,710 lb [8033 kg] |

* - ABOVE WEIGHTS DO NOT INCLUDE SUBBASE, RESERVOIR, FRONT OR REAR STABILIZERS, JIBS, PTO, PUMP, BED, BOOM RESTS, REAR BUMPER, OR ANY OTHER MOUNTING OR CRANE OPTIONS.

| SUBBASE | WEIGHT | C. G. |
|---|---|---|
| 851D-TM | 2500 lb [1134 kg] | *5.75 in [14.6 cm] |
| STANDARD 18 ft | 2975 lb [1349 kg] | 108.25 in [275 cm] |
| STANDARD 20 ft | 3175 lb [1440 kg] | 120.50 in [306 cm] |
| STANDARD 22 ft | 3445 lb [1563 kg] | 143.25 in [364 cm] |

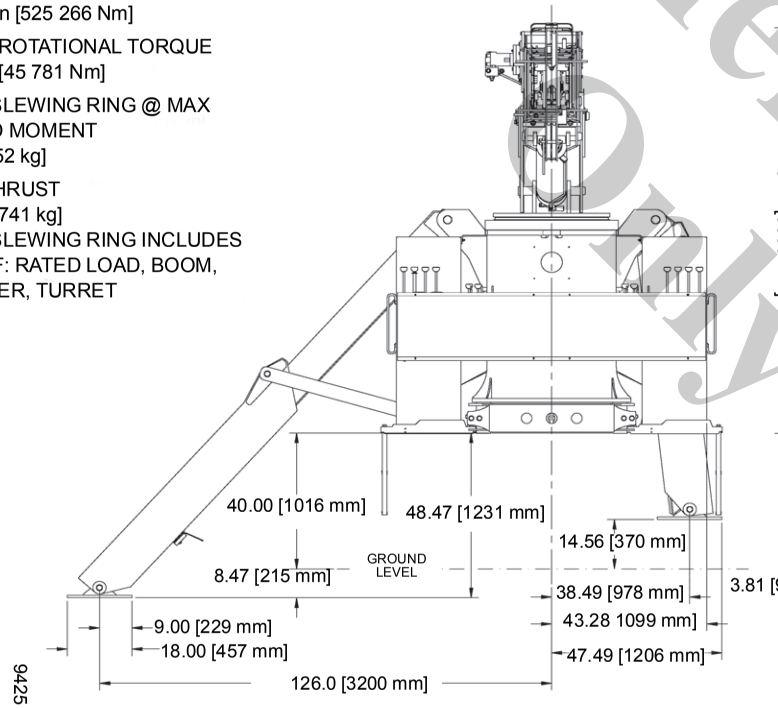
SUBBASE C. G. ARE LOCATED FROM THE CENTERLINE OF ROTATION.
*851D-TM C. G. LOCATED ON O/RIG SIDE OF CENTERLINE OF ROTATION.
16 ft [4,87 m] SPAN RSOD 1300 lb [590 kg]
**[851D]** 14' [4.26M] SPAM RSOD-TM 1,300 LB. [590 kg]

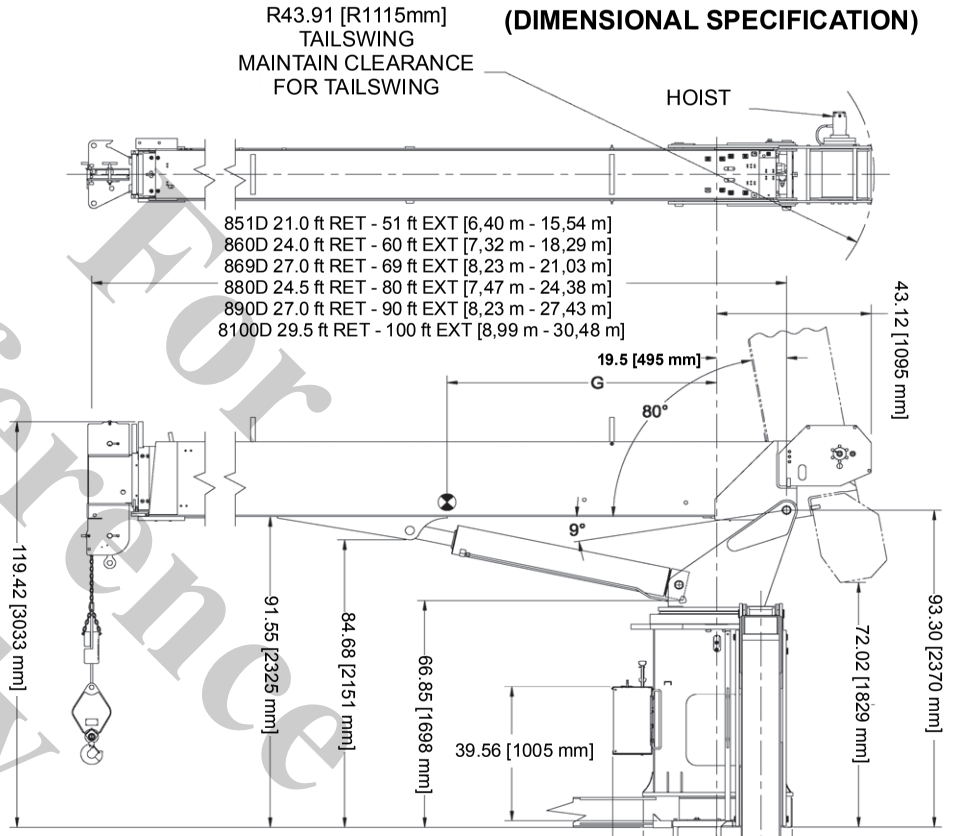
MAX RATED LOAD MOMENT
4,649,000 lb-in [525 266 Nm]

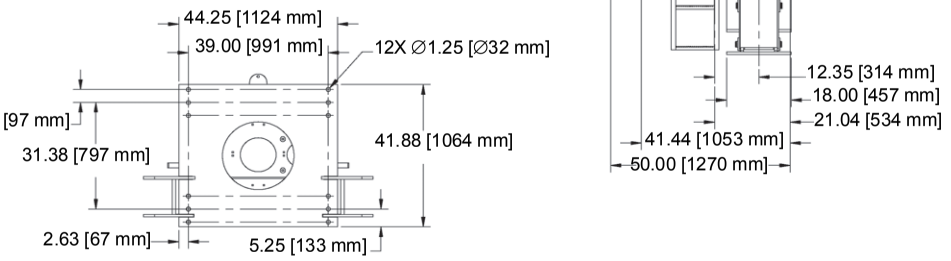
MAX RATED ROTATIONAL TORQUE
405,200 lb-in [45 781 Nm]

THRUST @ SLEWING RING @ MAX RATED LOAD MOMENT
12,020 lb [5452 kg]

MAXIMUM THRUST
56,750 lb [25 741 kg]
THRUST @ SLEWING RING INCLUDES WEIGHTS OF: RATED LOAD, BOOM, LIFT CYLINDER, TURRET




BOTTOM VIEW
SOME COMPONENTS
REMOVED FOR CLARITY

# SPECIFICATIONS

## Hydraulic Pump

Pump Speed . . . . . 2500 RPM

Displacements

Section PI . . . . . 18 GPM (68.1 LPM) at 3900 psi +100/-000 {26.89 MPa)

Section PZ. . . . . 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 l/min), 3350 psi +100/-000 (23.09 MPa)
Boom System Below 0° . . . . . Secondary pressure, 3900 psi + 100/-000 (26.89 MPa)
Telescope Extend . . . . . 18 gpm (68 l/min), 2500 psi +50/-50 (17.24 MPa)
Telescope Retract . . . . . 18 gpm (68 l/min), 2950 psi +100/-000 (20.34 MPa)
Hoist System. . . . . 34 gpm (128 l/min), 3300 psi +100/-000 (22.75 MPa)
Turn . . . . . 10 gpm (38 l/min), 2600 psi +100/-000 (15.17 MPa)
Reservoir Capacity . . . . . 66 gal (249 l)
System Capacity . . . . . 88 gal (333 l)
Filtration . . . . . 10 Micron Return

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

## Hoist System

Wire Rope . . . . . ***Standard***

325 ft (99.1 m) of 9/16 in (14.3 mm) dia.

Rotation Resistant

Nominal Breaking Strength - 38,500 lb (17 463 kg)

Hoist Performance (with 1 part of line)

| Layer | Hoist Pull | | Hoist Speed | | BOS Hoist Speed | |
|---|---|---|---|---|---|---|
| | lb | (kg) | ft/min | (m/min) | ft/min | (m/min) |
| 1 | 10,200 | (4626) | 111 | (34) | 169 | (51) |
| 2 | 9200 | (4173) | 123 | (37) | 188 | (57) |
| 3 | 8400 | (3810) | 135 | (41) | 206 | (63) |
| 4 | 7700 | (3492) | 147 | (45) | 224 | (68) |
| 5 | 7100 | (3220) | 159 | (48) | 243 | (74) |

All ratings based on 34 gpm at 3300 psi. (128.7 l/min at 22.75 MPa)

Burst of Speed maximum line pull + 3000 lb (1361 kg)

**Crane Operating speeds**

Rotation, 375° . . . . . 45 sec., ± 7 sec.
Lift Up, (-10° to 80°) . . . . . 33 sec., ± 5 sec.
Lift Down, (-10° to 80°) . . . . . 24 sec., ± 5 sec.
Telescope Extend
3 Section . . . . . 31 ft/min, ± 5 ft/min (9.45 m/min ± 1.5 m/min)
4 Section . . . . . 33 ft/min, ± 5 ft/min (10.06 m/min ±1.5 m/min)
Telescope Retract
3 Section . . . . . 39 ft/min, ± 6 ft/min (11.89 m/min ± 1.83 m/min)
4 Section . . . . . 40 ft/min, ± 6 ft/min (12.19 m/min ± 1.83 m/min)

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# SECTION 9
# INSTALLATION

## SECTION CONTENTS



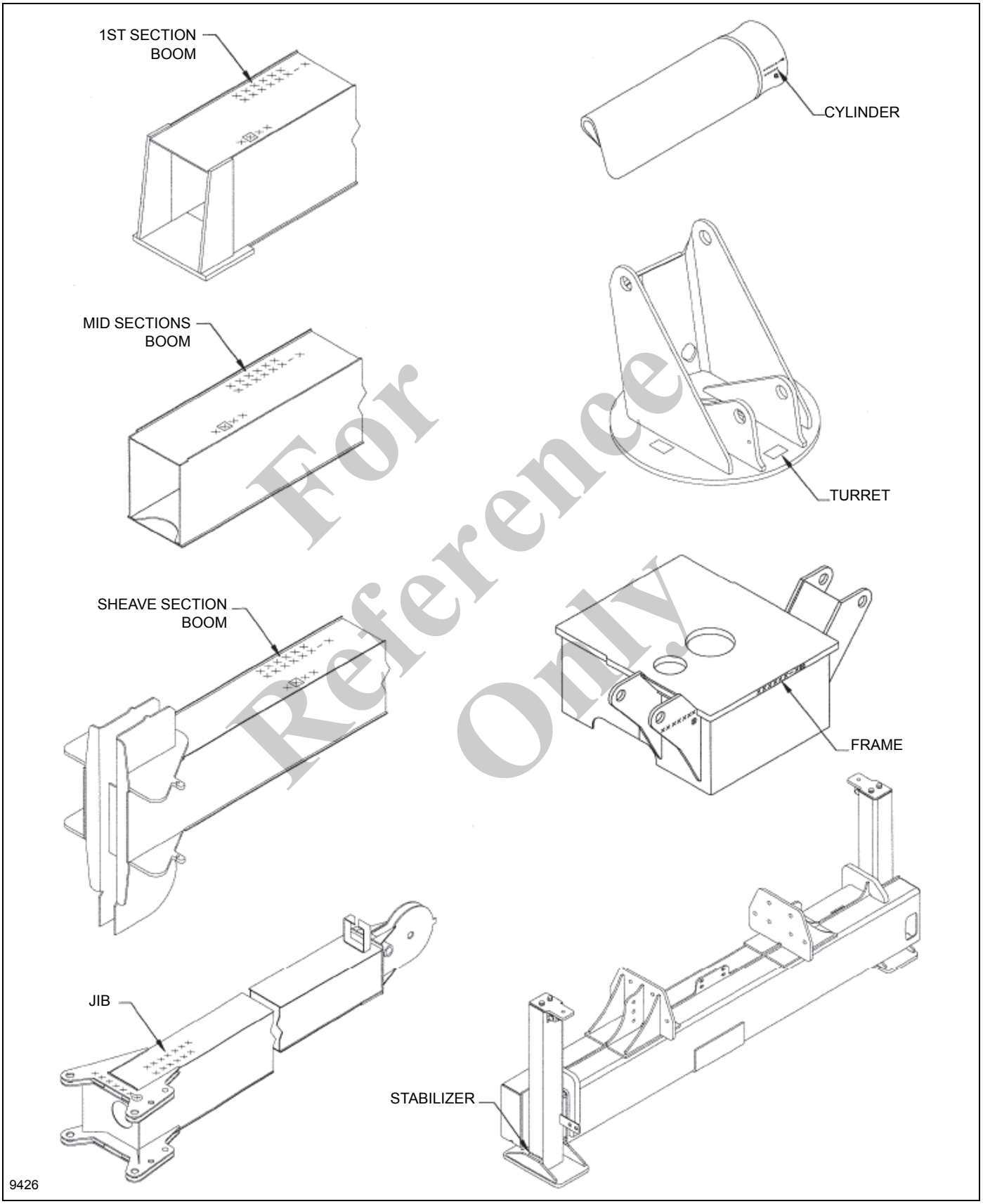


This installation section provides information for mounting and initial check out of the crane. One of the most important elements in good long lasting crane performance is proper mounting. Improper mounting can cause permanent damage to the truck, i.e. frame or transmission, and the crane, i.e. pump or nonstability. Also Federal Department of Transportation Laws relating to vehicle manufacture and modification such as lights, brakes and axle loads must be met as well as State vehicle laws relating to weights and dimensional restrictions such as overall length, overhang, etc. This section is organized by first presenting detailed information relating to truck requirements and mounting configurations followed by a step-by-step installation procedure including PTO selection, Pump rotation selection, reinforcement, crane and stabilizer installation, counterweighting, boom rests and stability testing. The final manufacturer of the vehicle must certify that the axle ratings have not been exceeded with all permanently attached equipment including a full load of fuel and men [at 200 lb (90 kg) each].

National cranes should meet ASME/ANSI B30.5 (latest) when completed as cranes and ASME/ANSI B30.23 (latest) when completed as a personnel lifting system. These standards require welds to meet AWS D14.3 or AWS D1.1 respectively. Therefore any work done in mounting should be done in compliance with these codes.

**NOTE:** The following page lists the typical locations for the Serial Number identification tags that are fastened to the main components of the crane. Before proceeding with the installation, verify that the number on the serial number plates on the major components match the main serial number which is found on the crane frame. If the serial numbers do not match, contact the factory before proceeding. Matching the serial number plates insures that accurate warranty information will be recorded at the factory and will aid in dispensing service bulletins and other pertinent information.

# TYPICAL LOCATIONS / SERIAL NUMBER IDENTIFICATION



## MINIMUM TRUCK REQUIREMENTS

Many factors must be considered in the selection of a proper truck for a 800D series crane. Items which must be considered are:

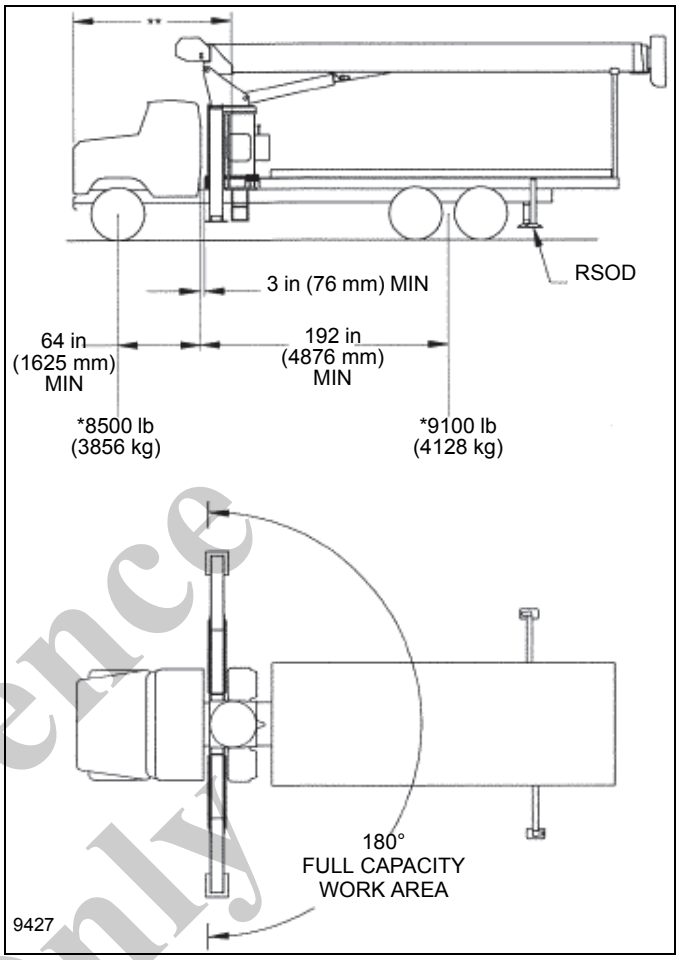
1. **Axle Rating.** Axle ratings are determined by the axles, tires, rims, springs, brakes, steering and frame strength of the truck. If any one of these components is below the required rating, the gross axle rating is reduced to its weakest component value.
2. **Wheelbase, Cab-to-Axle (CA).** The wheelbase and CA required are in part determined by the mounting configuration but also by the boom length and the platform length of the particular unit. Match the platform length to the retracted boom length so that the boom doesn't overhang the rear of the bed by more than that required by legal regulations where the unit will be operated. The truck cab-to-axle dimension is then determined by the length of the bed (the bed should be approximately centered over the rear axle) and the mounting space that the crane frame takes up between the cab and the bed.
3. **Truck Frame.** Try to select a truck frame that will minimize or eliminate frame reinforcement or extension of the after frame (AF). Many frames are available that have the necessary after frame (AF) section modulus (S.M.) and resistance to bending moment (RBM) so that reinforcing is not required. The front hydraulic jack is used for a 360 degree working range around the truck. The frame under the cab through the front suspension must have the minimum S.M. and RBM because reinforcing through the front suspension is often difficult because of engine, radiator mounts and steering mechanics. See "Truck Requirements" and "Frame Strength" pages for the necessary section modulus and resistance to bending moment values.
4. **Additional Equipment.** In addition to the axle ratings, wheelbase, cab-to-axle requirements and frame, it is recommended that the truck is equipped with electronic engine control, increased cooling and a transmission with a PTO opening available with an extra heavy duty PTO. See "PTO Selection" pages. A conventional cab truck should be used for standard crane mounts.
5. **Neutral Start Switch.** If equipped with optional remote controls or remote start at the controls, the chassis must be equipped with a switch that prevents operation of the engine starter when the transmission is in gear.

# MOUNTING CONFIGURATIONS

The Series 800D is a versatile machine and its versatility can be enhanced by the manner in which it is mounted. Following is a brief description of the mounting configurations and the advantages of each. The minimum weights listed below the front and rear axles for each configuration are estimated minimum front and rear axle weights for an 85% stability factor before the crane, stabilizers and subbase, if required, are installed on the chassis. Truck chassis that do not meet these minimum stability weights may require counterweight. These weights include the permanently attached equipment on the chassis, such as pumps, PTO's, reinforcing, chassis mounted options, bed and counterweight. Before placing this unit in service, a final stability check as outlined in this section must be performed. The maximum weights listed below the front and rear axles for each configuration are estimated maximum front and rear axle weights for not exceeding axle capacities before the crane, stabilizers, and subbase, if required, are installed on the chassis.

## Configuration 1 — 8100D

This configuration allows the installation of the Series 8100D on a chassis by using the sub-base for a 22 ft bed. In most cases, the chassis will not require reinforcing.



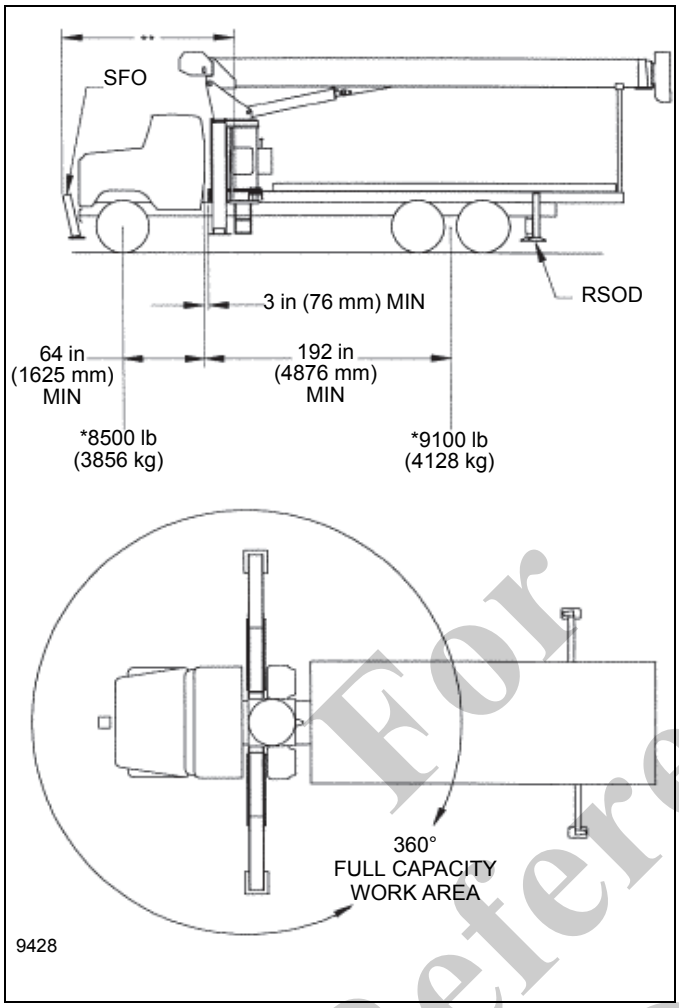

Requires 16,000 lb (7257 kg) GAWRF, 34,000 lb (15 422 kg) GAWRR, 50,000 lb (22 679 kg) GVWR, RSOD rear stabilizers and sub-base for 22 ft bed. Full capacity work area is rear 180° of vehicle from outrigger to outrigger. Truck frame must have or be capable of being reinforced to 15.9 $in^3$ S.M. (260 $cm^3$) and 1,749,000 lb-in (197 610 Nm) RBM under the crane, spring hang Oerto spring hanger.

*Actual scale weights prior to installation of crane, sub-base and stabilizers.

**If the distance from the front bumper (SFO) to center of rotation exceeds 144 in (366 cm), the 40 ft (12.19 m) overall truck length restriction will be exceeded. Overall length restrictions vary from state to state. In some states it is legal to be more than 40 ft (12.19 m) in length and some states allow overlength permits.

## Configuration 2 — 8100D

This mount requires front stabilizer for full capacity 360° around the truck. Front stabilizer gives the machine a solid base helping the operator control loads.



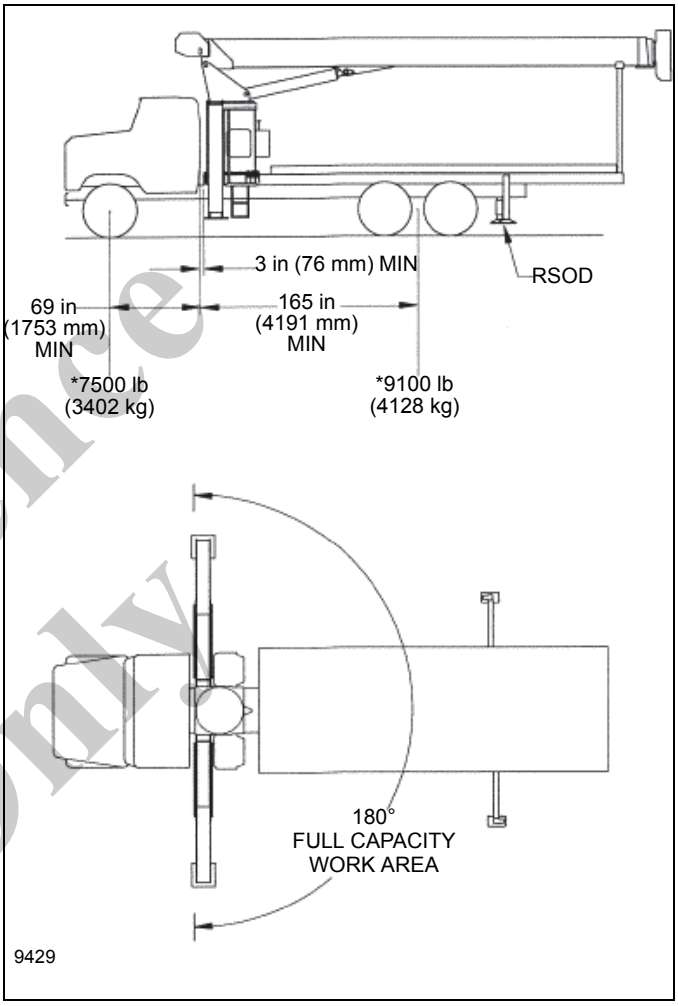

Requires 16,000 lb (7257 kg) GAWRF, 34,000 lb (15 422 kg) GAWRR, 50,000 lb (22 679 kg) GVWR, standard sub-base for 22 ft bed, SFO and RSOD rear stabilizers. Truck must have 20.0 $in^3$ (327 $cm^3$) section modulus and 2,200,000 lb-in (248 566 N-m) RBM or be capable of being reinforced to this strength under the crane frame through to the front suspension. Normally a tapered frame cannot be reinforced to this requirement. Additional truck frame requirements must be met from the crane frame through the front suspension to the SFO attachment point (See “Truck Frame and Mounting Bolt Requirements for Front Stabilizer” in this section).

*Actual axle scale weights prior to installation of crane, torsion box and stabilizers.

**If the distance from the front bumper (SFO) to center of rotation exceeds 144 in (366 cm), the 40 ft (12.19 m) overall truck length restriction will be exceeded. Overall length restrictions vary from state to state. In some states it is legal to be more than 40 ft (12.19 m) in length and some states allow overlength permits.

## Configuration 3 — 800D (all booms other than 8100D)

This configuration allows the installation of the Series 800D on a chassis with a sub-base and bed combination which best fits the boom length. Depending on the boom length, the bed can be 18 ft, 20 ft or 22 ft. Not all bed lengths can be used with each boom due to rear overhang limits.

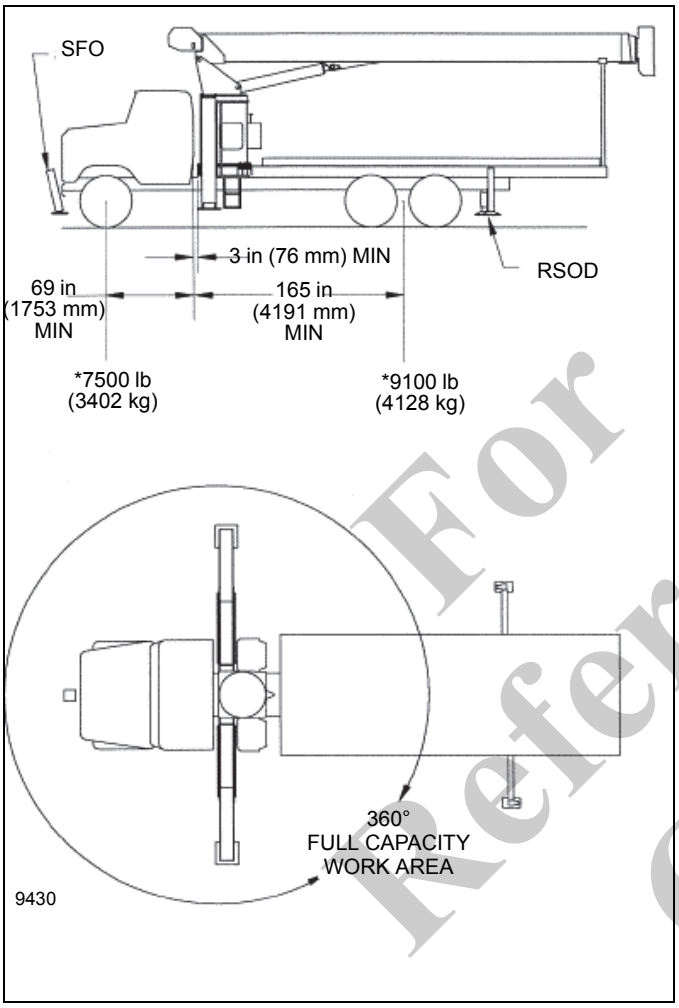



Requires 16,000 lb (7257 kg) GAWRF, 34,000 lb (15 422 kg) GAWRR, 50,000 lb (22 679 kg) GVWR, RSOD rear stabilizers and sub-base for 18 ft, 20 ft or 22 ft bed. Full capacity work area is rear 180° of vehicle from outrigger to outrigger. Truck frame must have or be capable of being reinforced to 15.9 $in^3$ S.M. (260 $cm^3$) and 1,749,000 lb-in (197 610 Nm) RBM under the crane, spring hanger to spring hanger.

*Actual scale weights prior to installation of crane, sub-base and stabilizers.

## Configuration 4 — 800D (all booms other than 8100D)

This mount requires front stabilizer for full capacity 360° around the truck. Front stabilizer gives the machine a solid base helping the operator control loads.



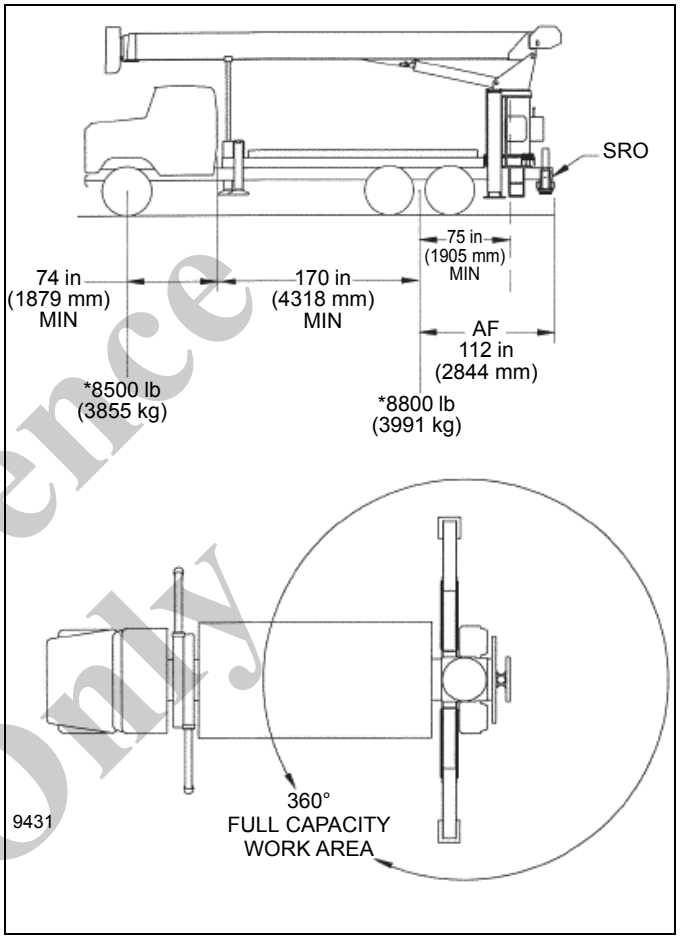

Requires 16,000 lb (7257 kg) GAWRF, 34,000 lb (15 422 kg) GAWRR, 50,000 lb (22 679 kg) GVWR, standard sub-base for 18 ft, 20 ft or 22 ft bed, SFO and RSOD rear stabilizers.

Truck must have 20.0 $in^3$ (327 $cm^3$) section modulus and 2,200,000 lb-in (248 566 Nm) RBM or be capable of being reinforced to this strength under the crane frame through to the front suspension. Normally a tapered frame cannot be reinforced to this requirement. Additional truck frame requirements must be met from the crane frame through the front suspension to the SFO attachment point (See “Truck Frame and Mounting Bolt Requirements for Front Stabilizer” in this section).

*Actual axle scale weights prior to installation of crane, torsion box and stabilizers.

## Configuration 5 — Rear Mount

This configuration allows the rear mount installation of the Series 800D. This configuration is 360° stable and allows the effective use of close working area to lift the heavier capacity loads.




Requires a 16,000 lb (7257 kg) GAWRF, 40,000 lb (18 143 kg) GAWRR and 56,000 lb (25 401 kg) GVWR, overframe outriggers, rear stabilizer, and heavy duty rear mount sub-base. The maximum bed length is 16 ft (4,87 m). Counterweight may have to be added to ensure unit stability if the truck does not meet minimum weight requirements.

Truck frame must have 15.9 $in^3$ (260 $cm^3$) section modulus and 1,749,000 in-lb (197 610 Nm) RBM from rear of crane through the front outriggers. Truck frame must have or be capable of being lengthened to an AF of 112 in (2844 mm).

*Actual scale weights prior to installation of crane, heavy duty sub-base and behind cab stabilizers.

# PTO HORSEPOWER REQUIREMENTS

A three pump hydraulic system is furnished with this crane. The unit is equipped with a three section pump that will supply 34 gpm (128 l/min) to the hoist, 18 gpm (68 l/min) to the boom and outriggers and 10 gpm (37 l/min) to the swing (turn) circuit. To provide these flows, the pump shaft must turn at 2500 RPM. The PTO requirement is a torque rating of at least 200 lb-ft (271 Nm) or 40 HP (30 KW) per 1000 RPM of PTO shaft speed.

## Direct Mount Pump To PTO

Most pump installations can be direct mounted to the PTO using adapter assemblies available from the PTO supplier. If the pump is direct mounted, its weight should be supported by a strap between the pump and the transmission. The splined shaft coupling in a direct mount pump installation requires lubrication. Coupling Lube Spline Lubricant should be applied to the shaft during original installation and reapplied to the shaft or zerk provided on PTO housing shaft semi-annually thereafter. It is available from Schaeffer Manufacturing Company, 102 Barton Street, St. Louis, Missouri.

## Pump Rotation

It is imperative that the three section hydraulic pump installed in a 800D application be the correct pump rotation configuration for the truck drive train/power take off rotation direction. Make certain which direction the power take off output shaft rotates before selecting a clockwise (cw) or counter-clockwise (ccw) rotation hydraulic pump. Either cw or ccw rotation pumps are available, and are marked clearly with a directional arrow on the pump housing.

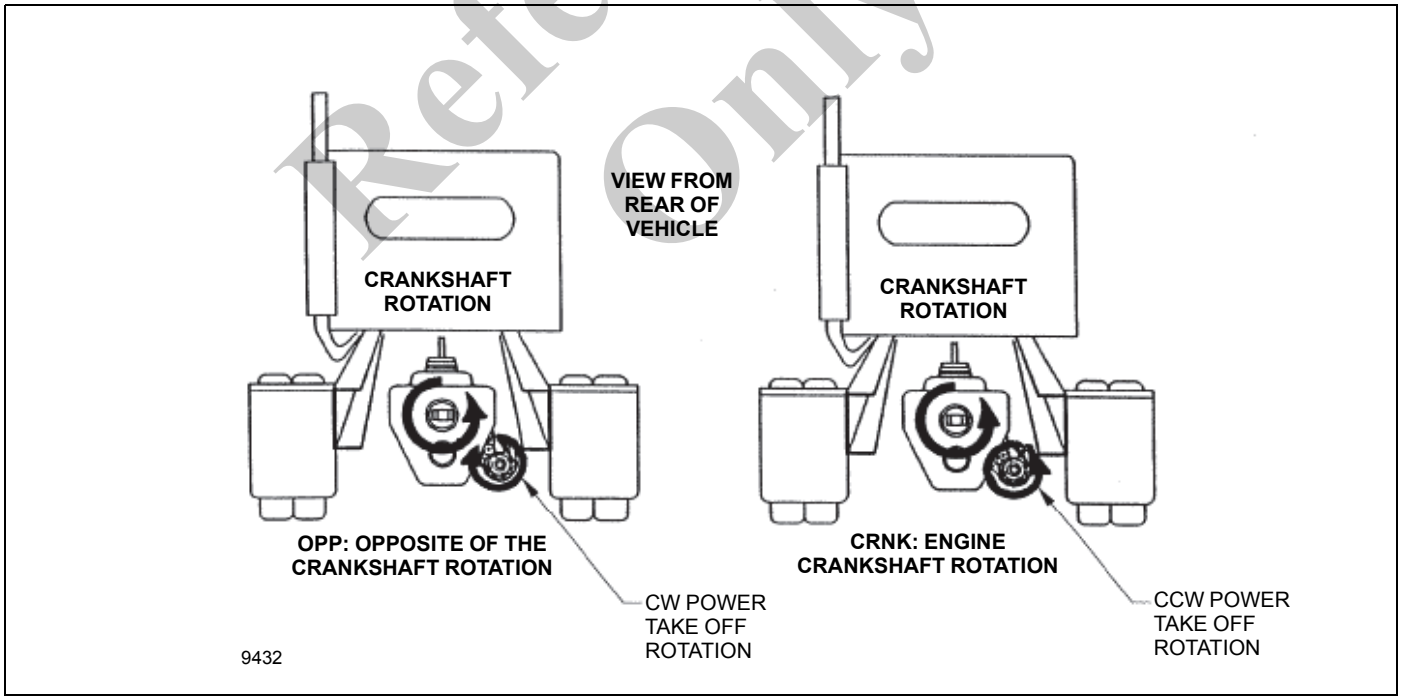
**Do not attempt to turn pump in the opposite direction of the indicating arrow on the pump housing. Pump failure will result.**

Do not confuse engine crankshaft rotation with power take off rotation. If the power take off shaft rotates opposite the engine crankshaft, it is turning in a clockwise (cw) direction when viewed from the rear of the truck. If the power take off shaft rotates the same as the engine crankshaft, it is turning in a counter-clock- wise (ccw) direction when viewed from the rear of the truck. See illustration below.

## Auger System

Units equipped with an auger system use a valving system that combines the 34 gpm (128 l/min) hoist and 18 gpm (68 l/min) crane function pump flows at full system pressure during auger operation. Digging operations at these combined flow/pressure conditions increase the output hp (kW) and duty cycle requirements of the PTO. A PTO with a torque rating of 350 lb-ft (479 Nm) or 65 hp (48 kW) per 1000 rpm PTO shaft speed is recommended for auger unit installations.





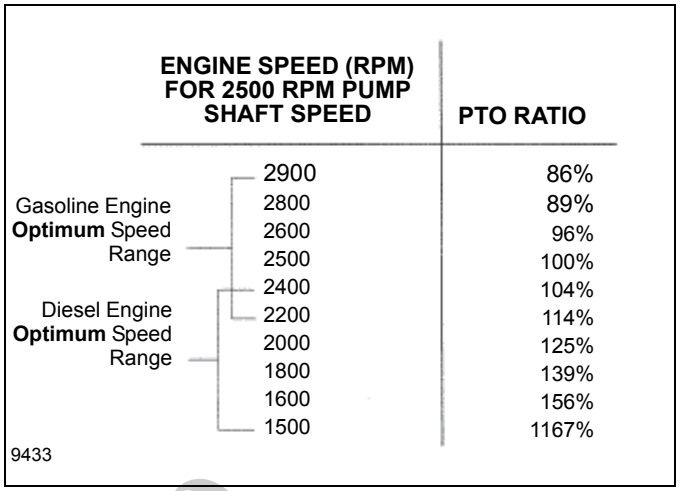
## PTO SELECTION

Operating speeds and performance of the crane are based on proper pump outputs to the hoist, lift, telescope and swing circuits. A triple pump system is standard equipment on the 800D. This pump supplies 34 (128), 18 (68) and 10 (37) gpm (l/min) to the appropriate crane circuits when operating at 2500 RPM.

The speeds shown below are optimum operating speeds. The engine must be operated at a speed such that the horsepower developed is adequate to pull the pumps under pressure.

**Do not attempt to turn pump in the opposite direction of the indicating arrow on the pump housing, pump failure will result.**

See pump rotation section to determine correct pump for your application.




## TRUCK FRAME STRENGTH

In order for a truck frame to be suitable for accepting a Series 800D size crane, the truck frame must have a requirement for rigidity so as not to allow excessive boom movement due to truck frame deflection, and it must be strong enough to resist the loading induced by the crane so as not to permanently bend or deform. Section Modulus (S.M.) is a measurement of the area of the truck frame and determines the rigidity of the frame. Resistance to bending moment (RBM) is a measurement of strength and is determined by multiplying the section modulus of each frame rail by the yield strength of the rail material.

For a standard, behind-the-cab mount, 180° stability, the Series 800D crane requires a minimum of 1,749,000 lb-in (197 610 Nm) RBM and 15.9 $in^3$ (260 $cm^3$) S.M. under the crane frame between the front and rear springs with 1,430,000 lb-in (161 568 Nm) RBM and 13.0 $in^3$ (213 $cm^3$) S.M. through suspension to rear stabilizers on each truck frame rail. For 360° stability the truck frame must have a 20.0 $in^3$ (327 $cm^3$) section modulus [2,200,000 lb-in (248 566 Nm) RBM] minimum under the crane frame, 11.0 $in^3$ (180 $cm^3$) section modulus [1,210,000 lb-in [136 711 Nm] RBM) at the front spring rear hanger, 7.5 $in^3$ (123 $cm^3$) section modulus [825 000 lb-in (93 212 Nm) RBM] through the front spring and 2 $in^3$ (33 $cm^3$) section modulus [220,000 lb-in (24 856 N·m) RBM] at the stabilizer attachment point on each truck frame rail. Listed below is a table showing the commonly used truck frame and reinforcing materials and the section modulus required for each material to ensure adequate strength and rigidity. In all cases, the minimum requirements for section modulus and RBM must be met.



| | Truck Frame or Reinforcing Material | Min. Section Modulus Under Crane | Min. Section Modulus Thru Rear Suspension | RBM Under Crane | RBM Thru Suspension |
|---|---|---|---|---|---|
| **180° Stability** | 110,000 PSI (758 MPa) | 15.9 $in^3$ (260 $cm^3$) | 13.0 $in^3$ (213 $cm^3$) | 1,749,000 lb-in (197 610 Nm) | 1,430,000 lb-in (161 568 Nm) |
| **360° Stability** | 110,000 PSI (758 MPa) | 20.0 $in^3$ (327 $cm^3$) | 13.0 $in^3$ (213 $cm^3$) | 2,200,000 lb-in (248 566 Nm) | 1,430,000 lb-in (161 568 Nm) |

# SECTION MODULUS TABLES

The following tables will determine the section modulus of the truck frame. Always measure the truck frame and check the tables to be sure that any truck factory listed section modulus is correct.

1. **Channel** (Table A). Table A provides the section modulus of channel frames in thicknesses of 3/16 in (4.76 mm), 1/4 in (6.35 mm), 5/16 in (7.94 mm), and 3/8 in (9.52 mm) with each grouping a flange width and web depth column. When the depth of frame channel and flange width is known, the point at which these two lines intersect is the section modulus from that particular channel.

   If the section modulus of the channel does not meet the requirements, the channel should be reinforced in the most applicable method following.

2. **Channel Reinforcement** (Table A). In order to provide more strength, a channel of suitable thickness can be added to the existing frame. The depth and flange width of this channel should be chosen so it fits over the existing frame. The section modulus of the needed channel is obtained from Table A and should be added to the section modulus obtained from the truck frame.

3. **Angle Reinforcement** (Table B). If the truck is reinforced with an angle, refer to Table B for the data on the added strength provided by the angle. Add this to the section modulus of the channel obtained from Table A.

4. **Fish Plate Reinforcement** (Table C). The frame can be strengthened by adding a fish plate of suitable thickness and depth equal to the frame. The section modulus of the fish plate can be obtained from Table C and this must be added to the section modulus of the frame to obtain the total section modulus.

5. **Angle Under Reinforcement** (Table D). This table lists the section modulus of an angle with the flange under the truck frame that is added to a frame with an angle reinforcement already added. Add the section modulus from Table D to the section modulus obtained from tables A and B to determine total section modulus.

The edges of the reinforcing angles or channels are to be flush with the edges of the frame.

**Welding.** Two rows of 1 in (25.4 mm) diameter plug welds are to be placed in a staggered pattern of the web; the rows to be spaced 5 in (127 mm) apart with welds at an interval of 4 in (102 mm). Do not weld on the flanges.

Where thickness, depth or flange width vary, interpolation between tables or variables within a given table will provide the strength for the section.

If you have any questions concerning frame strength or reinforcing, contact National Crane before proceeding.

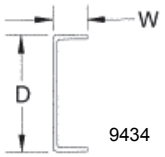



**TABLE A**

**Section Modulus in$^3$ (cm$^3$)**

**THICKNESS 3/16 in (4.76 mm)**

| W in. (mm) / D in (mm) | 2½ (64) | 3 (76) | 3½ (89) | 4 (102) |
|---|---|---|---|---|
| 8 (203) | 5.3 (87) | 6.0 (98) | 6.7 (110) | 7.5 (123) |
| 9 (229) | 6.3 (103) | 7.1 (116) | 7.9 (130) | 8.7 (143) |
| 10 (254) | 7.3 (120) | 8.2 (134) | 9.1 (149) | 10.0 (164) |
| 11 (279) | 8.4 (138) | 9.4 (154) | 10.4 (170) | 11.4 (187) |
| 12 (305) | 9.5 (156) | 10.6 (174) | 11.7 (192) | 12.8 (210) |
| 13 (330) | 10.8 (177) | 11.9 (195) | 13.1 (215) | 14.3 (234) |
| 14 (356) | 12.0 (197) | 13.3 (218) | 14.6 (239) | 15.9 (261) |
| 15 (381) | 13.4 (220) | 14.7 (241) | 16.1 (264) | 17.5 (287) |

**THICKNESS 1/4 in (6.35 mm)**

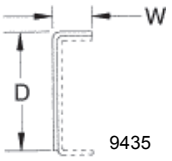
| W in (mm) / D in (mm) | 2½ (64) | 3 (76) | 3½ (89) | 4 (102) |
|---|---|---|---|---|
| 8 (203) | 6.9 (113) | 7.8 (128) | 8.8 (144) | 9.7 (159) |
| 9 (229) | 8.2 (134) | 9.2 (151) | 10.3 (169) | 11.4 (187) |
| 10 (254) | 9.5 (156) | 10.7 (175) | 11.9 (195) | 13.1 (215) |
| 11 (279) | 11.0 (180) | 12.3 (202) | 13.6 (223) | 14.9 (244) |
| 12 (305) | 12.5 (205) | 13.9 (228) | 15.3 (251) | 16.8 (275) |
| 13 (330) | 14.1 (231) | 15.6 (256) | 17.2 (282) | 18.8 (3.8) |
| 14 (356) | 15.8 (259) | 17.5 (287) | 19.1 (313) | 20.8 (341) |
| 15 (381) | 17.5 (287) | 19.3 (316) | 21.2 (348) | 23.0 (377) |

**THICKNESS 5/16 in (7.94 mm)**

**THICKNESS 3/8 in (9.52 mm)**

| W in (mm) / D in (mm) | 2½ (64) | 3 (76) | 3½ (89) | 4 (102) |
|---|---|---|---|---|
| 8 (203) | 8.4 (138) | 9.5 (156) | 10.7 (175) | 11.9 (195) |
| 9 (229) | 10.0 (164) | 11.3 (185) | 12.6 (206) | 13.9 (228) |
| 10 (254) | 11.6 (190) | 13.1 (215) | 14.6 (239) | 16.0 (262) |
| 11 (279) | 13.4 (220) | 15.0 (246) | 16.6 (272) | 18.3 (300) |
| 12 (305) | 15.3 (251) | 17.1 (280) | 18.8 (308) | 20.6 (338) |
| 13 (330) | 17.3 (284) | 19.2 (315) | 21.1 (346) | 23.1 (379) |
| 14 (356) | 19.4 (318) | 21.4 (351) | 23.5 (385) | 25.6 (420) |
| 15 (381) | 21.6 (354) | 23.8 (390) | 26.0 (426) | 28.3 (464) |

| W in (mm) / D in (mm) | 2½ (64) | 3 (76) | 3½ (89) | 4 (102) |
|---|---|---|---|---|
| 8 (203) | 9.8 (161) | 11.2 (184) | 12.5 (205) | 13.9 (228) |
| 9 (229) | 11.7 (192) | 13.2 (216) | 14.8 (243) | 16.3 (267) |
| 10 (254) | 13.6 (223) | 15.4 (252) | 17.1 (280) | 18.8 (308) |
| 11 (279) | 15.7 (257) | 17.7 (290) | 19.6 (321) | 21.5 (352) |
| 12 (305) | 18.0 (295) | 20.1 (329) | 22.2 (364) | 24.3 (398) |
| 13 (330) | 20.3 (333) | 22.6 (370) | 24.9 (408) | 27.2 (446) |
| 14 (356) | 22.8 (374) | 25.3 (415) | 27.8 (456) | 30.3 (497) |
| 15 (381) | 25.4 (416) | 28.1 (461) | 30.8 (505) | 35.5 (582) |




## TABLE B

### Section Modulus in$^3$ (cm$^3$)

**THICKNESS 3/16 in (4.76 mm)**

| W in. (mm) / D in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|
| 7½ (191) | 2.2 (36) | 2.3 (38) | 2.3 (38) | 2.4 (39) |
| 8½ (216) | 2.8 (46) | 2.9 (48) | 3.0 (49) | 3.0 (49) |
| 9½ (241) | 3.4 (56) | 3.5 (57) | 3.6 (59) | 3.7 (61) |
| 10½ (267) | 4.1 (67) | 4.3 (70) | 4.4 (72) | 4.5 (74) |
| 11½ (292) | 4.9 (80) | 5.1 (84) | 5.2 (85) | 5.4 (88) |
| 12½ (318) | 5.8 (95) | 6.0 (98) | 6.1 (100) | 6.3 (103) |
| 13½ (343) | 6.7 (110) | 6.9 (113) | 7.1 (116) | 7.3 (120) |
| 14½ (368) | 7.6 (124) | 7.9 (129) | 8.1 (133) | 8.3 (136) |

**THICKNESS 1/4 in (6.35 mm)**

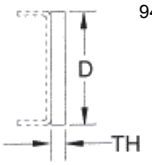
| W in (mm) / D in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|
| 7½ (191) | 2.9 (48) | 3.0 (49) | 3.1 (51) | 3.2 (52) |
| 8½ (216) | 3.7 (61) | 3.8 (62) | 3.9 (64) | 4.0 (66) |
| 9½ (241) | 4.5 (74) | 4.7 (77) | 4.8 (79) | 5.0 (82) |
| 10½ (267) | 5.5 (90) | 5.7 (93) | 5.8 (95) | 6.0 (98) |
| 11½ (292) | 6.5 (106) | 6.7 (110) | 6.9 (113) | 7.1 (116) |
| 12½ (318) | 7.6 (124) | 7.9 (129) | 8.1 (133) | 8.3 (136) |
| 13½ (343) | 8.8 (144) | 9.1 (149) | 9.4 (154) | 9.6 (157) |
| 14½ (368) | 10.1 (166) | 10.5 (172) | 10.7 (175) | 11.0 (180) |

**THICKNESS 5/16 in (7.94 mm)**

| W in. (mm) / D in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|
| 7½ (191) | 3.6 (59) | 3.7 (61) | 3.9 (64) | 4.0 (66) |
| 8½ (216) | 4.6 (75) | 4.7 (77) | 4.9 (80) | 5.0 (82) |
| 9½ (241) | 5.6 (92) | 5.8 (95) | 6.0 (98) | 6.2 (102) |
| 10½ (267) | 6.8 (111) | 7.1 (116) | 7.3 (120) | 7.5 (123) |
| 11½ (292) | 8.1 (133) | 8.4 (138) | 8.6 (141) | 8.9 (146) |
| 12½ (318) | 9.5 (156) | 9.8 (161) | 10.1 (166) | 10.4 (170) |
| 13½ (343) | 11.0 (180) | 11.4 (187) | 11.7 (192) | 12.0 (197) |
| 14½ (368) | 12.6 (206) | 13.0 (213) | 13.4 (220) | 13.7 (224) |

**THICKNESS 3/8 in (9.52 mm)**

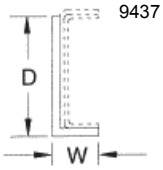
| W in (mm) / D in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|
| 7½ (191) | 4.3 (70) | 4.5 (74) | 4.6 (75) | 4.8 (79) |
| 8½ (216) | 5.5 (90) | 5.7 (93) | 5.9 (97) | 6.0 (98) |
| 9½ (241) | 6.7 (110) | 7.0 (115) | 7.2 (118) | 7.4 (121) |
| 10½ (267) | 8.1 (133) | 8.4 (138) | 8.7 (143) | 8.9 (146) |
| 11½ (292) | 9.7 (159) | 10.0 (164) | 10.3 (169) | 10.6 (174) |
| 12½ (318) | 11.3 (185) | 11.7 (192) | 12.1 (198) | 12.4 (203) |
| 13½ (343) | 13.1 (215) | 13.6 (223) | 14.0 (229) | 14.3 (234) |
| 14½ (368) | 15.1 (247) | 15.5 (254) | 16.0 (262) | 16.4 (269) |




## TABLE C

### Section Modulus in$^3$ (cm$^3$)

| W in (mm) / D in (mm) | 8 (203) | 9 (229) | 10 (254) | 11 (279) | 12 (305) | 13 (330) | 14 (356) | 15 (381) | 16 (406) |
|---|---|---|---|---|---|---|---|---|---|
| 3/16 (4.76) | 2.0 (33) | 2.51 (41) | 3.10 (51) | 3.75 (61) | 4.46 (73) | 5.24 (86) | 6.08 (100) | 6.98 (114) | 7.94 (130) |
| 1/4 (6.35) | 2.66 (44) | 3.37 (55) | 4.16 (68) | 5.03 (82) | 5.99 (98) | 7.03 (115) | 8.15 (134) | 9.36 (153) | 10.5 (172) |
| 5/16 (7.94) | 3.33 (55) | 4.21 (69) | 5.20 (85) | 6.29 (103) | 7.49 (123) | 8.79 (144) | 10.19 (167) | 11.7 (192) | 13.31 (218) |
| 3/8 (9.52) | 4.0 (66) | 5.06 (83) | 6.25 (102) | 7.56 (124) | 9.00 (148) | 10.56 (173) | 12.25 (201) | 14.06 (230) | 16.0 (262) |
| 7/16 (11.11) | 4.67 (76) | 5.9 (97) | 7.29 (119) | 8.82 (144) | 10.5 (172) | 12.32 (202) | 14.29 (234) | 16.4 (269) | 18.66 (306) |




## TABLE D

### Section Modulus in$^3$ (cm$^3$)

**THICKNESS 3/16 in (4.76 mm)**

| D in (mm) \ W in (mm) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
|---|---|---|---|---|
| 8½ (216) | 5.7 (93) | 6.4 (105) | 7.0 (115) | 7.7 (126) |
| 9½ (241) | 6.7 (110) | 7.4 (121) | 8.1 (133) | 8.9 (146) |
| 10½ (267) | 7.7 (126) | 8.5 (139) | 9.3 (152) | 10.1 (166) |
| 11½ (292) | 8.8 (144) | 9.7 (159) | 10.6 (174) | 11.4 (187) |
| 12½ (318) | 10.0 (164) | 10.9 (179) | 11.9 (195) | 12.8 (210) |
| 13½ (343) | 11.2 (184) | 12.2 (200) | 13.2 (216) | 14.3 (234) |
| 14½ (368) | 12.5 (205) | 13.6 (223) | 14.6 (239) | 15.7 (257) |
| 15½ (394) | 13.8 (226) | 15.0 (246) | 16.1 (264) | 17.3 (284) |

**THICKNESS 1/4 in (6.35 mm)**

| D in (mm) \ W in (mm) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
|---|---|---|---|---|
| 8½ (216) | 7.7 (126) | 8.6 (141) | 9.4 (154) | 10.3 (169) |
| 9½ (241) | 9.1 (149) | 10.0 (164) | 10.9 (179) | 11.9 (195) |
| 10½ (267) | 10.5 (172) | 11.5 (188) | 12.5 (205) | 13.6 (223) |
| 11½ (292) | 11.9 (195) | 13.1 (215) | 14.2 (233) | 15.4 (252) |
| 12½ (318) | 13.5 (221) | 14.7 (241) | 16.0 (262) | 17.2 (282) |
| 13½ (343) | 15.2 (249) | 16.5 (270) | 17.8 (292) | 19.2 (315) |
| 14½ (368) | 16.9 (277) | 18.3 (300) | 19.7 (323) | 21.2 (347) |
| 15½ (394) | 18.7 (306) | 20.2 (331) | 21.7 (356) | 23.3 (382) |

**THICKNESS 5/16 in (7.94 mm)**

| D in (mm) \ W in (mm) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
|---|---|---|---|---|
| 8½ (216) | 9.8 (161) | 10.8 (177) | 11.9 (195) | 12.9 (211) |
| 9½ (241) | 11.5 (188) | 12.6 (206) | 13.8 (226) | 15.0 (246) |
| 10½ (267) | 13.3 (218) | 14.5 (238) | 15.8 (259) | 17.1 (280) |
| 11½ (292) | 15.1 (247) | 16.5 (271) | 18.0 (295) | 19.4 (318) |
| 12½ (318) | 17.1 (280) | 18.6 (305) | 20.2 (331) | 21.7 (356) |
| 13½ (343) | 19.2 (315) | 20.8 (341) | 22.5 (369) | 24.2 (397) |
| 14½ (368) | 21.4 (351) | 23.1 (379) | 24.9 (408) | 26.7 (438) |
| 15½ (394) | 23.7 (388) | 25.5 (418) | 27.4 (449) | 29.4 (482) |

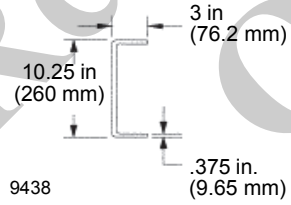
**THICKNESS 3/8 in (9.52 mm)**

| D in (mm) \ W in (mm) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
|---|---|---|---|---|
| 8½ (216) | 11.9 (195) | 13.2 (216) | 14.4 (236) | 15.6 (256) |
| 9½ (241) | 14.0 (229) | 15.3 (251) | 16.7 (274) | 18.1 (297) |
| 10½ (267) | 16.2 (266) | 17.7 (290) | 19.2 (315) | 20.7 (339) |
| 11½ (292) | 18.4 (302) | 20.1 (329) | 21.8 (357) | 23.5 (385) |
| 12½ (318) | 20.9 (342) | 22.6 (370) | 24.5 (402) | 26.3 (431) |
| 13½ (343) | 23.4 (384) | 25.3 (415) | 27.3 (447) | 29.3 (480) |
| 14½ (368) | 26.0 (426) | 28.1 (461) | 30.2 (495) | 32.4 (531) |
| 15½ (394) | 28.8 (472) | 31.0 (508) | 33.3 (546) | 35.6 (583) |



**EXAMPLE:**

A truck frame of 110,000 psi (758 MPa) yield strength steel has the following dimensions: 3/8 in (9.65 mm) thick, 3 in (76.2 mm) flanges and is 10.25 in (260 mm) deep. To find the frame section modulus:




1. From Table A, 3/8 in (9.65 mm) thickness, W (width) = 3 in (76.2 mm), D (depth) = 10 in (254 mm) section modulus = 15.4 in$^3$ (252 cm$^3$).
2. From Table A, 3/8 in (9.65 mm) thickness, W = 3 in (76.2 mm), D = 11 in (279 mm), Section Modulus = 17.7 in$^3$ (290 cm$^3$).
3. Interpolating between the two values:

   10 in (254 mm) deep channel

   = 15.4 in$^3$ (252 cm$^3$)

   11 in (279 mm) deep channel

   = 17.7 in$^3$ (290 cm$^3$)

   10.5 in (267 mm) deep channel

   $$= \frac{15.4\ in^3 + 17.7\ in^3}{2} = 16.55\ in^3$$

   $$= \frac{252\ cm^3 + 290\ cm^3}{2} = 271\ cm^3$$

4. Now interpolate between a 10 in (254 mm) deep channel and a 10.5 in (267 mm) deep channel to get the section modulus of a 10.25 in (260 mm) deep channel.

   10 in (254 mm) deep channel

   = 15.4 in$^3$ (252 cm$^3$)

   10.5 in (267 mm) deep channel

   = 16.55 in$^3$ (271 cm$^3$)

   10.25 in (260 mm) deep channel

   $$= \frac{15.4\ in^3 + 16.55\ in^3}{2} = 15.98\ in^3$$

   $$= \frac{252\ cm^3 + 271\ cm^3}{2} = 262\ cm^3$$

   A 3/8 in (9.65 mm) x 3 in (76.2 mm) x 10.25 in (260 mm) truck frame has a 15.98 in$^3$ (262 cm$^3$) Section Modulus and RBM of 110,000 psi x 15.98 in$^3$ = 1,757,800 lb-in (758 MPa x 262 cm$^3$ = 198,596 Nm)

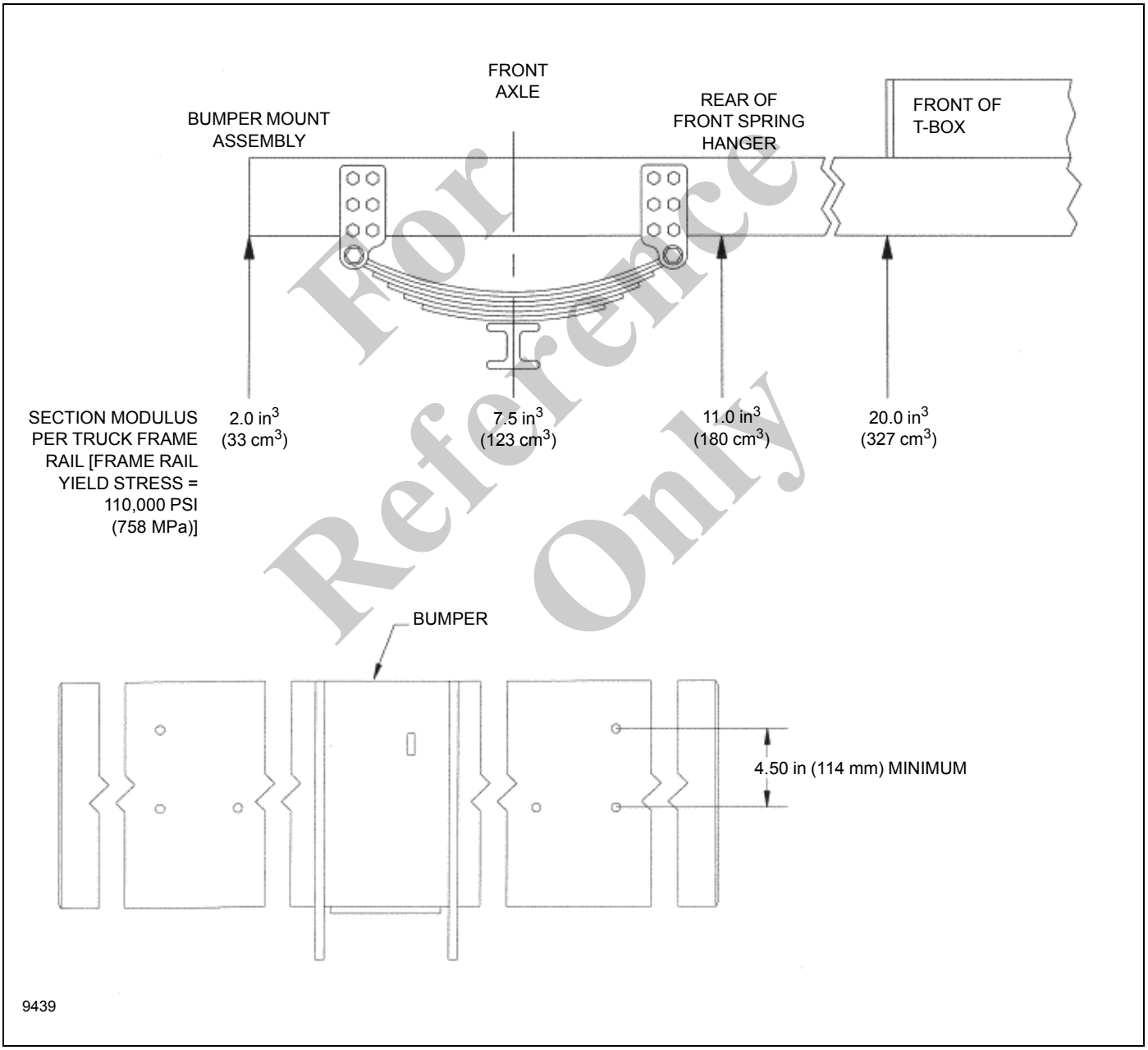
5. 15.98 in$^3$ (262 cm$^3$) Section Modulus, 110,000 psi (758 MPa) steel is adequate for a standard mount with a torsion box.

### Truck Frame Requirements For Optional Front Stabilizer

The truck frame must have adequate strength from under the crane frame through the front suspension to the bumper assembly for front stabilizer installation. A truck frame yield strength of 110,000 psi (758 MPa) is required.

The following diagram shows the required section modulus at various stations along the front end of the truck frame for a standard behind-the-cab mount with torsion box.

In order to safely mount a front stabilizer in place of the normal front bumper, a minimum bolt pattern as shown is required. The bracket must be capable of supporting 0.50 in (12.7 mm) DIA. Grade 8 bolts to their nominal breaking strength. Torque the mounting bolts supplied with the front stabilizer to 110 lb-ft (149 Nm). **Do not use spacers between the bumper bracket and the front stabilizer bumper assembly**. If the bumper bracket and front of the truck frame do not meet these specifications, an extended frame truck must be used. Contact factory for details. Details for mounting a stabilizer on an extended frame truck are included in that installation instruction. However, the Section Modulus requirements outlined below do apply.



### Section Modulus Tables

Use Table E and Table F below along with Tables A through D in the preceding section of this manual for determining the section modulus of the truck frame.

Always measure the truck frame and check the tables to be sure that any truck factory listed section modulus is correct. It is also necessary to measure the frame and check the section modulus wherever the depth and/or flange width changes.

1. **Channel** (Table E). Table E supplements Table A for narrower truck frame flanges. Use the width of the narrow flanges for “W” to find the section modulus from Table E.
2. **Angle** (Table F). Use Table F for an angle section such as when a flange and part of the web of a truck frame channel is removed.

Where thickness, depth or flange width vary, interpolation between tables or variables within a given table will provide the strength for the section.

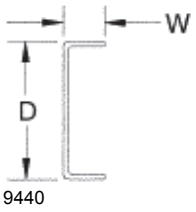
If you have any questions concerning frame strength or reinforcing, contact National Crane before proceeding.

Where thickness, depth or flange width vary, interpolation between tables or variables within a given table will provide the strength for the section.

If you have any questions concerning frame strength or reinforcing, contact National crane before proceeding.

**TABLE E**

**Section Modulus in$^3$ (cm$^3$)**



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**THICKNESS 3/16 in (4.76 mm)**

| D in (mm) \ W in (mm) | 1 (25) | 1½ (38) | 2 (51) |
|---|---|---|---|
| 8 (203) | 3.2 (52) | 3.9 (64) | 4.6 (75) |
| 9 (229) | 3.8 (62) | 4.7 (77) | 5.5 (90) |
| 10 (254) | 4.6 (75) | 5.5 (90) | 6.4 (105) |
| 11 (279) | 5.4 (88) | 6.4 (105) | 7.4 (121) |
| 12 (305) | 6.3 (103) | 7.4 (121) | 8.5 (139) |
| 13 (330) | 7.2 (118) | 8.4 (138) | 9.6 (157) |
| 14 (356) | 8.2 (134) | 9.5 (156) | 10.8 (177) |
| 15 (381) | 9.3 (152) | 10.6 (174) | 12.0 (197) |

**THICKNESS 1/4 in (6.35 mm)**

| D in (mm) \ W in (mm) | 1 (25) | 1½ (38) | 2 (51) |
|---|---|---|---|
| 8 (203) | 4.1 (67) | 5.0 (82) | 5.9 (97) |
| 9 (229) | 5.0 (82) | 6.0 (98) | 7.1 (116) |
| 10 (254) | 5.9 (97) | 7.1 (116) | 8.3 (136) |
| 11 (279) | 7.0 (115) | 8.3 (136) | 9.6 (157) |
| 12 (305) | 8.2 (134) | 9.6 (157) | 11.0 (180) |
| 13 (330) | 9.4 (154) | 10.9 (179) | 12.5 (205) |
| 14 (356) | 10.7 (175) | 12.4 (203) | 14.1 (231) |
| 15 (381) | 12.1 (198) | 13.9 (228) | 15.7 (257) |

**THICKNESS 5/16 in (7.94 mm)**

| D in (mm) \ W in (mm) | 1 (25) | 1½ (38) | 2 (51) |
|---|---|---|---|
| 8 (203) | 4.9 (80) | 6.1 (100) | 7.2 (118) |
| 9 (229) | 6.0 (98) | 7.3 (120) | 8.6 (141) |
| 10 (254) | 7.2 (118) | 8.7 (142) | 10.1 (166) |
| 11 (279) | 8.5 (139) | 10.1 (166) | 11.8 (193) |
| 12 (305) | 9.9 (162) | 11.7 (192) | 13.5 (221) |
| 13 (330) | 11.5 (188) | 13.4 (220) | 15.3 (251) |
| 14 (356) | 13.1 (215) | 15.2 (249) | 17.3 (284) |
| 15 (381) | 14.8 (242) | 17.1 (280) | 19.3 (316) |

**THICKNESS 3/8 in (9.52 mm)**

| D in (mm) \ W in (mm) | 1 (25) | 1½ (38) | 2 (51) |
|---|---|---|---|
| 8 (203) | 5.7 (93) | 7.1 (116) | 8.4 (138) |
| 9 (229) | 7.0 (115) | 8.6 (141) | 10.1 (166) |
| 10 (254) | 8.4 (138) | 10.2 (167) | 12.0 (197) |
| 11 (279) | 10.0 (164) | 11.9 (195) | 13.8 (226) |
| 12 (305) | 11.6 (190) | 13.8 (226) | 15.9 (261) |
| 13 (330) | 13.4 (220) | 15.7 (257) | 18.0 (295) |
| 14 (356) | 15.4 (252) | 17.8 (292) | 20.3 (333) |
| 15 (381) | 17.4 (285) | 20.1 (329) | 22.8 (374) |

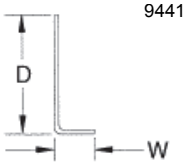

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**TABLE F**

**Section Modulus in$^3$ (cm$^3$)**

**THICKNESS 3/16 in (4.76 mm)**

| D in (mm) \ W in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|

**THICKNESS 1/4 in (6.35 mm)**

| D in (mm) \ W in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 3½ (89) | 0.6 (10) | 0.6 (10) | 0.6 (10) | 0.6 (10) |
| 4½ (114) | 0.9 (15) | 1.0 (16) | 1.0 (16) | 1.0 (16) |
| 5½ (140) | 1.4 (23) | 1.4 (23) | 1.4 (23) | 1.5 (25) |
| 6½ (165) | 1.8 (30) | 1.9 (31) | 2.0 (33) | 2.0 (33) |
| 7½ (191) | 2.2 (36) | 2.3 (38) | 2.3 (38) | 2.4 (39) |
| 8½ (216) | 2.8 (46) | 2.9 (48) | 3.0 (49) | 3.0 (49) |
| 9½ (241) | 3.4 (56) | 3.5 (57) | 3.6 (59) | 3.7 (61) |
| 10½ (267) | 4.1 (67) | 4.3 (70) | 4.4 (72) | 4.5 (74) |
| 11½ (292) | 4.9 (80) | 5.1 (84) | 5.2 (85) | 5.4 (88) |
| 12½ (318) | 5.8 (95) | 6.0 (98) | 6.1 (100) | 6.3 (103) |
| 13½ (343) | 6.7 (110) | 6.9 (113) | 7.1 (116) | 7.3 (120) |
| 14½ (368) | 7.6 (124) | 7.9 (129) | 8.1 (133) | 8.3 (136) |

| | | | | |
|---|---|---|---|---|
| 3½ (89) | 0.8 (13) | 0.8 (13) | 0.8 (13) | 0.8 (13) |
| 4½ (114) | 1.2 (20) | 1.3 (21) | 1.3 (21) | 1.3 (21) |
| 5½ (140) | 1.8 (30) | 1.8 (30) | 1.9 (31) | 1.9 (31) |
| 6½ (165) | 2.4 (39) | 2.5 (41) | 2.6 (43) | 2.6 (43) |
| 7½ (191) | 2.9 (48) | 3.0 (49) | 3.1 (51) | 3.2 (52) |
| 8½ (216) | 3.7 (61) | 3.8 (62) | 3.9 (64) | 4.0 (66) |
| 9½ (241) | 4.5 (74) | 4.7 (77) | 4.8 (79) | 5.0 (82) |
| 10½ (267) | 5.5 (90) | 5.7 (93) | 5.8 (95) | 6.0 (98) |
| 11½ (292) | 6.5 (106) | 6.7 (110) | 6.9 (113) | 7.1 (116) |
| 12½ (318) | 7.6 (124) | 7.9 (129) | 8.1 (133) | 8.3 (136) |
| 13½ (343) | 8.8 (144) | 9.1 (149) | 9.4 (154) | 9.6 (157) |
| 14½ (368) | 10.1 (166) | 10.5 (172) | 10.7 (175) | 11.0 (180) |

**THICKNESS 5/16 in (7.94 mm)**

| W in (mm) / D in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|
| 3½ (89) | 0.9 (15) | 1.0 (16) | 1.0 (16) | 1.0 (16) |
| 4½ (114) | 1.5 (25) | 1.5 (25) | 1.6 (26) | 1.6 (26) |
| 5½ (140) | 2.2 (36) | 2.3 (38) | 2.3 (38) | 2.4 (39) |
| 6½ (165) | 3.0 (49) | 3.1 (51) | 3.2 (52) | 3.2 (52) |
| 7½ (191) | 3.6 (59) | 3.7 (61) | 3.9 (64) | 4.0 (66) |
| 8½ (216) | 4.6 (75) | 4.7 (77) | 4.9 (80) | 5.0 (82) |
| 9½ (241) | 5.6 (92) | 5.8 (95) | 6.0 (98) | 6.2 (102) |
| 10½ (267) | 6.8 (111) | 7.1 (116) | 7.3 (120) | 7.5 (123) |
| 11½ (292) | 8.1 (133) | 8.4 (138) | 8.6 (141) | 8.9 (146) |
| 12½ (318) | 9.5 (156) | 9.8 (161) | 10.1 (166) | 10.4 (170) |
| 13½ (343) | 11.0 (180) | 11.4 (187) | 11.7 (192) | 12.0 (197) |
| 14½ (368) | 12.6 (206) | 13.0 (213) | 13.4 (220) | 13.7 (224) |

**THICKNESS 3/8 in (9.52 mm)**

| W in (mm) / D in (mm) | 2¾ (70) | 3¼ (83) | 3¾ (95) | 4¼ (108) |
|---|---|---|---|---|
| 3½ (89) | 1.1 (18) | 1.1 (18) | 1.1 (18) | 1.2 (20) |
| 4½ (114) | 1.8 (30) | 1.8 (30) | 1.9 (31) | 1.9 (31) |
| 5½ (140) | 2.6 (43) | 2.7 (44) | 2.7 (44) | 2.8 (46) |
| 6½ (165) | 3.5 (57) | 3.7 (61) | 3.8 (62) | 3.8 (62) |
| 7½ (191) | 4.3 (70) | 4.5 (74) | 4.6 (75) | 4.8 (79) |
| 8½ (216) | 5.5 (90) | 5.7 (93) | 5.9 (97) | 6.0 (98) |
| 9½ (241) | 6.7 (110) | 7.0 (115) | 7.2 (118) | 7.4 (121) |
| 10½ (267) | 8.1 (133) | 8.4 (138) | 8.7 (143) | 8.9 (146) |
| 11½ (292) | 9.7 (159) | 10.0 (164) | 10.3 (169) | 10.6 (174) |
| 12½ (318) | 11.3 (185) | 11.7 (192) | 12.1 (198) | 12.4 (203) |
| 13½ (343) | 13.1 (215) | 13.6 (223) | 14.0 (229) | 14.3 (234) |
| 14½ (368) | 15.1 (247) | 15.5 (254) | 16.0 (262) | 16.4 (269) |

**EXAMPLE:**

Refer to the sample truck frame cross sections in Table E. Truck frame yield strength is 110,000 psi (758 MPa) with the following dimensions at the front axle location: 3/8 in (9.65 mm) thick, 1.50 in (38.1 mm) top flange, 3 in (76.2 mm) bottom flange, 10.25 in (260 mm) deep. To find the frame section modulus:

1. Use a channel with 1.50 (38.1 mm) flanges since in (38.1 mm) is the smaller flange width.
2. From Table E, 3/8 in (9.65 mm) thickness, W (width) = 1.50 in (38.1 mm), D (depth) = 10.0 in (254 mm) Section Modulus = 10.2 $in^3$ (167 $cm^3$).
3. From Table E, 3/8 in (9.65 mm) thickness, W = 1.50 in (38.1 mm), D = 11.0 in (279 mm) Section Modulus = 11.9 $in^3$ (195 $cm^3$).
4. Interpolate between the two values:

   10 in (254 mm) deep channel

   = 10.2 $in^3$ (167 $cm^3$)

   11 in (279 mm) deep channel

   = 11.9 $in^3$ (195 $cm^3$)

   10.5 in (267 mm) deep channel

   $$= \frac{10.2\ in^3 + 11.9\ in^3}{2} = 11.0\ in^3$$

   $$= \frac{167\ cm^3 + 195\ cm^3}{2} = 181\ cm^3$$

5. Now interpolate between a 10.0 in (254 mm) deep channel and a 10.5 in (267 mm) deep channel to get the section modulus of a 10.25 in (260 mm) deep channel

   10.0 in (254 mm) deep channel

   = 10.2 $in^3$ (167 $cm^3$)

   10.5 in (267 mm) deep channel

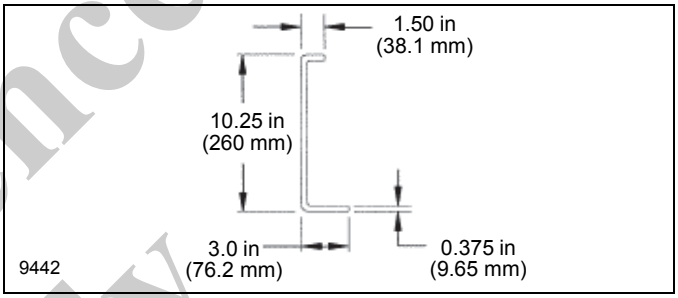
   = 11.0 $in^3$ (181 $cm^3$)

   10.25 in (260 mm) deep channel

   $$= \frac{10.2\ in^3 + 11.0\ in^3}{2} = 10.6\ in^3$$

   $$= \frac{167\ cm^3 + 181\ cm^3}{2} = 174\ cm^3$$

Frame Section Modulus at the front axle location is 10.6 $in^3$ (174 $cm^3$). This is greater than the 7.5 $in^3$ (123 $in^3$) required so the truck frame is strong enough at this location.



# TRUCK PREPARATION

Plan installation completely before any work is done. Plan the location of the crane for the final front and rear axle weights and boom overhang. Check final weight (see Counterweighting Section to verify that final truck weight with crane, reinforcement, counterweight and options such as jib, etc. complies with the appropriate laws).

## Welding Precautions

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

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

## Positioning Crane on Truck

The final user of the crane must be aware of all state axle and length laws in force at the time of crane mounting and position the crane on the truck accordingly. Following are items which must be considered.

1. **Overall Length:** Most states have a maximum straight truck length limit of 40 ft (12.19 m). Using too long a WB truck could cause the unit to exceed this limit.
2. **Axle Weights:** All states allow 20,000 lb (9072 kg) single axle weight and 34,000 lb (15 422 kg) tandem axle weights on primary roads, however, some states restrict axle weight to less on secondary roads or at certain times throughout the year. Be aware of your state's axle laws and the roads the machine will operate on for weight restrictions due to secondary roads, bridges, winter driving conditions, etc.
3. **Overhang:** The most restrictive overhang laws call for a maximum of 3 ft (0.91 m) in front of the truck. Many states have a maximum of 4 ft (122 cm) overhang in back of the truck. Check on your state requirements.
4. **Federal Bridge Law.** The Federal Bridge Law in effect currently states that in order to carry 54,000 lb (24 494 kg) on a three axle truck, the extremes of any group of axles must be at least 23.5 ft (7.16 m) apart. This equates to a truck with a wheelbase of at least 258 in (655 cm) with a minimum length of 24 in (60.96 cm) from the center of tandems to the center of the rear axle.

## PTO, Pump, Reservoir

1. Select the PTO according to the PTO Selection pages shown earlier in this section. PTOs are not furnished by the factory.
2. Install the PTO and PTO shifting mechanism according to the PTO manufacturer's instructions. If PTO has a reverse gear, it must be blocked out. Pump must not run backwards.
3. If PTO integral mount flanges are to be used, the pump can be mounted directly to the PTO. Direct mount pumps require lubrication of the spline shaft coupling. See "Service and Maintenance" Section for lubrication information. Be sure adequate clearance exists for this type of pump mount. Sometimes the pump is powered through a drive line with the pump located no more than 42 in (107 cm) from the PTO. The drive line should not exceed a 15° angle. The drive line U-joint yokes on both ends of the drive shaft must be parallel with each other. Drive lines should be sized so they can safely carry the maximum pump horsepower requirements. See "PTO Selection" pages. Drive lines are not normally furnished by the factory.
4. Plan the location of the pump mounting bracket and drive line, if used, so that ample clearance is maintained between pump and truck drive shaft or exhaust system. Pump should be situated so that hydraulic lines can be connected without sharp bends especially the large suction line from the reservoir. Pump mounting brackets may be attached to existing frame cross-members or a 6 in (15 cm) channel cross-member can be made and installed.
5. Install pump mounting bracket (if used) securely to frame. Attach pump to pump mounting plate or to PTO using capscrews provided. Install the support bar at the rear of the pump and bolt or weld the upper end to a crossmember if the pump is mounted with a drive line or install the support bar to a transmission bolt if the pump is direct mounted to the PTO.

**Note: Some of the pipe fittings used are sealed by means of two threaded tapered sections, one male and one female. When these two tapers meet, you will note a sudden increase in the force required to screw the fittings together. This is true of all tapered pipe threads. Further tightening will not only fail to increase the pressure tightness of the joint, but may ruin the connections and make correct assembly impossible.**

**Other fittings are of the o-ring boss type. These are installed by first screwing the lock nut flush to the upper thread land and installing fitting into port until the nut contacts the surface of the port. Adjust fitting to desired direction. Tighten locknut.**

**Most pressure fittings are the O-ring face seal types. A small O-ring is compressed between the male and the female fittings of the joint. Be sure the O-ring is present on the fitting and seated properly in its groove before the fittings are tightened.**

6. Remove the dust covers from the pump inlet and outlet and determine that the suction and pressure sides of the pump are correct while rotating the pump in the same direction as the PTO. Rotate the pump in the mounting

bracket so suction side is toward the reservoir suction port. An arrow is cast into the rear pump housing to identify rotation. Make sure pump is correct rotation.

7. If using a drive shaft type of mount, connect PTO drive shaft to pump and PTO. Drill a 0.31 in (7.87 mm) dia. x 0.12 in (3 mm) deep hole on the flat of the hex shaft at the fixed yoke end of the drive shaft to engage the yoke set screw. A small flat area should be ground in the O.D. of the splined pump shaft to engage the pump yoke set screw. Apply Loctite® and tighten the shaft setscrews. Grease the PTO universal joints.

## Reinforcing/After Frame Extension

1. Refer to “Truck Frame Strength” and “Section Modulus” tables. Determine section modulus by actual measurement of the truck frame. If reinforcing is required, always use at least 110,000 psi (758 MPa) steel to minimize the amount of reinforcing required. Use Grade 90 weld material for any welding to be done.
2. Strip the frame of obstructions in the area to be reinforced or extended, one side at a time. If the truck frame crossmembers are bolted in, remove the bolts. Do not attempt to remove any rivets.
3. Place the reinforcing on the truck frame and clamp in place. Mark the location of any rivets by striking the outside of the reinforcing over the rivet area so that the rivets make an impression on the inside of the reinforcing. Mark the approximate location of the crane mounting anchors so that no obstructions exist. Remove the reinforcing and drill or torch cut clearance holes for bolts or rivets. See Figure A.

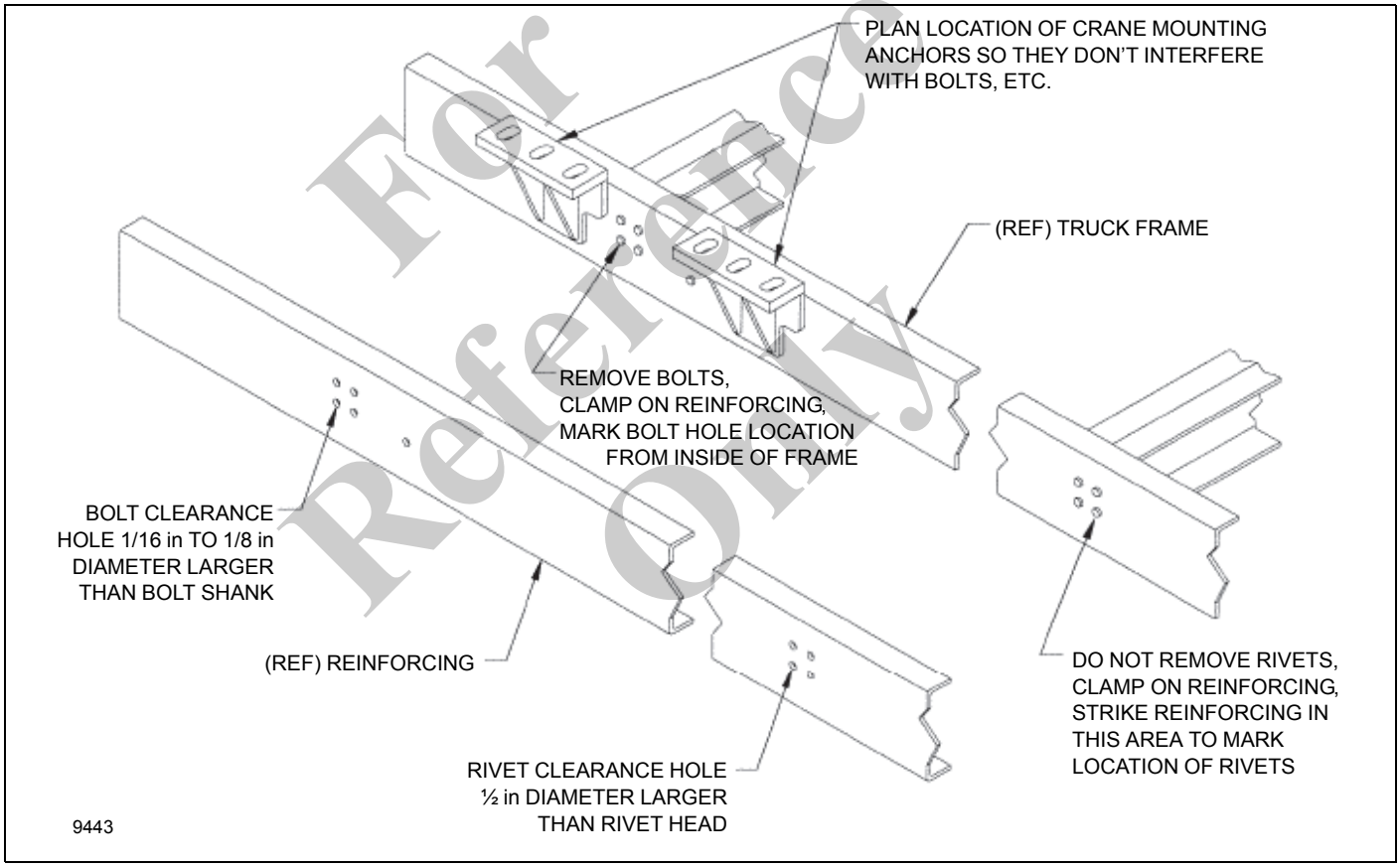



**FIGURE A**

4. If reinforcing is to be welded on, torch cut hole pattern in reinforcing being careful to clear crane mounting anchors. Install reinforcing, clamp in place, install any crossmember bolts that were previously removed and weld to truck frame as shown in Figure B.

   In some cases, because of customer stipulation or truck manufacturer voiding their warranty, bolt- on reinforcing is required. In these cases, install the reinforcing, clamp in place, install any crossmember bolts that were previously removed, then drill through reinforcing and truck frame being careful to clear crane mounting anchors and bolt reinforcing in place. See Figure C for recommended drilling and bolting procedure. Use 5/8, Grade 8 bolts, drill holes to 39/64 diameter, drive fit bolts and torque according to Torque Chart in Maintenance Section.

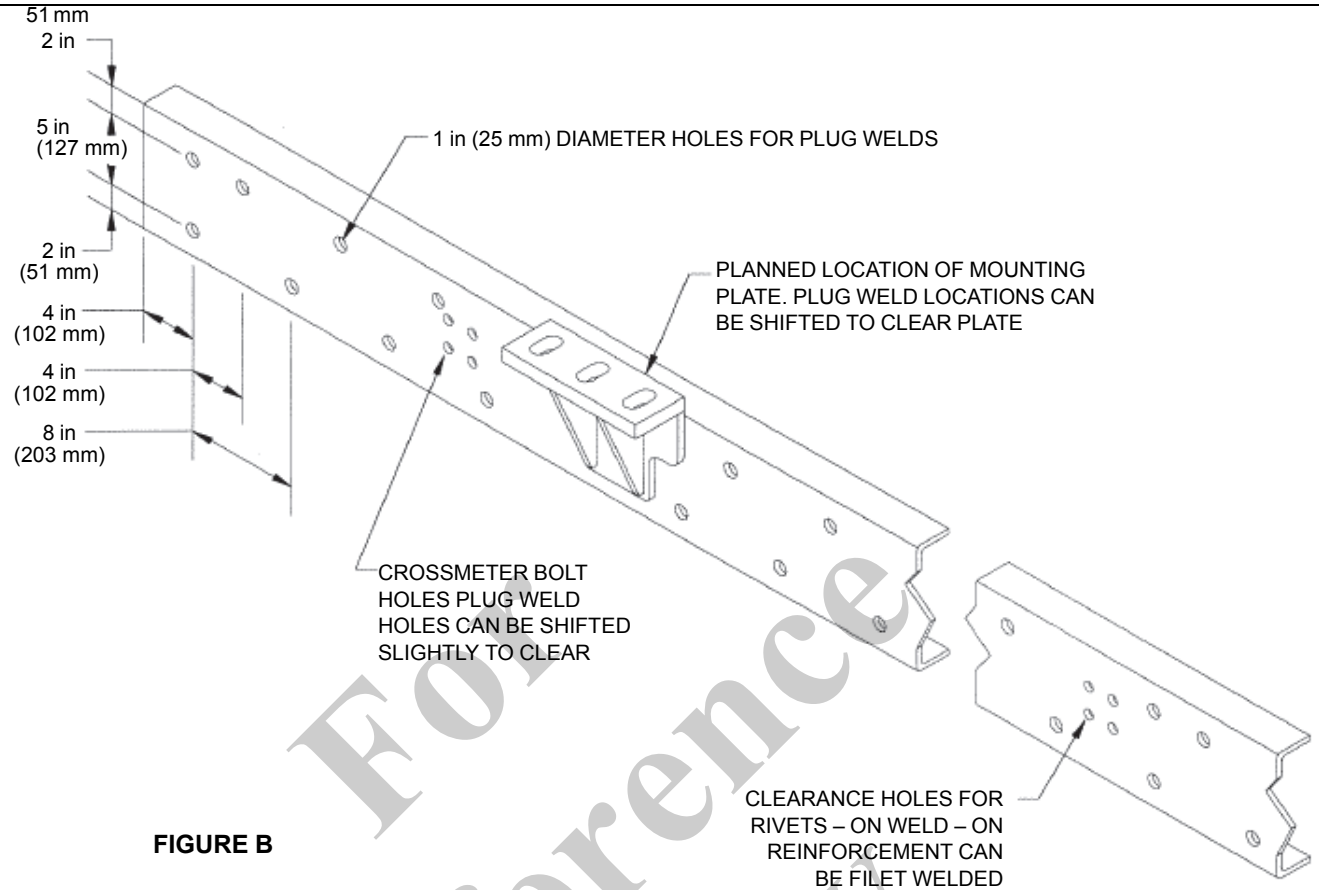



**FIGURE B**

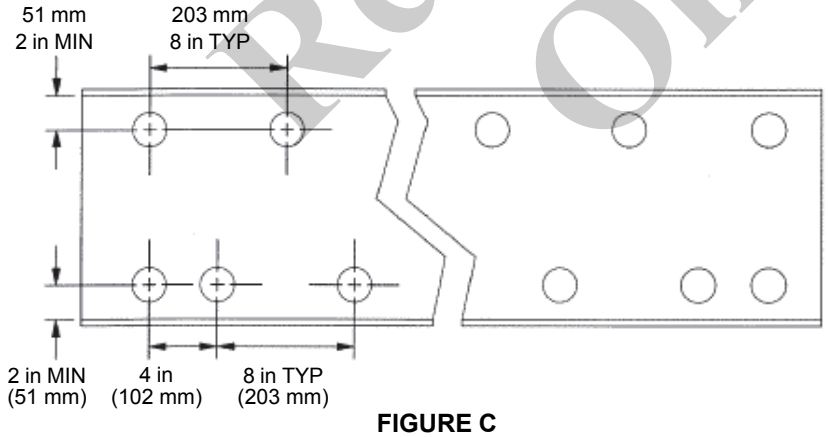



**FIGURE C**

9444

5. If the frame through the rear suspension doesn't meet minimum specifications for RBM and section modulus as shown on "Truck Frame Strength" table, it can be reinforced by adding an angle type of reinforcing as in Figure D. See "Section Modulus tables, Table B for the required size of reinforcing. Strip all easily removable equipment from the frame through the suspension such as spring stops, etc. Butt the reinforcing angle up against the reinforcing forward of the suspension and mark the areas that will require cutting so that the angle will slide up around the spring hangers and against the existing truck frame and forward reinforcing. Torch out the marked areas in the long leg of the angle deep enough so that the lip of the angle can be slid up from the underneath the frame to contact either existing truck frame or spring hanger brackets (if they extend down below the existing truck frame). If reinforcing angle is to be welded to truck frame, cut out plug weld hole pattern as in Figure B. Slide the reinforcing angle up from the bottom, butt it to existing forward reinforcing and weld rear suspension reinforcing to forward reinforcing. Replace as much of the spring hanger cut out areas as possible and butt weld these pieces in.

   If reinforcing angle is to be bolted on, drill hole pattern and install bolts according to Figure C. Reinforce spring hanger cut outs and the weld area, suspension reinforcing to forward reinforcing by adding bars under these areas. The bars should be of the same thickness, width and yield strength as the reinforcing angle lip, and should be long enough to extend at least 6 in (152 mm) beyond either side of the weld or cut out areas. Weld these reinforcing bars to the underside of the reinforcing with length-wise welds. ***Do not weld across the flanges***. Replace any equipment that had been removed.

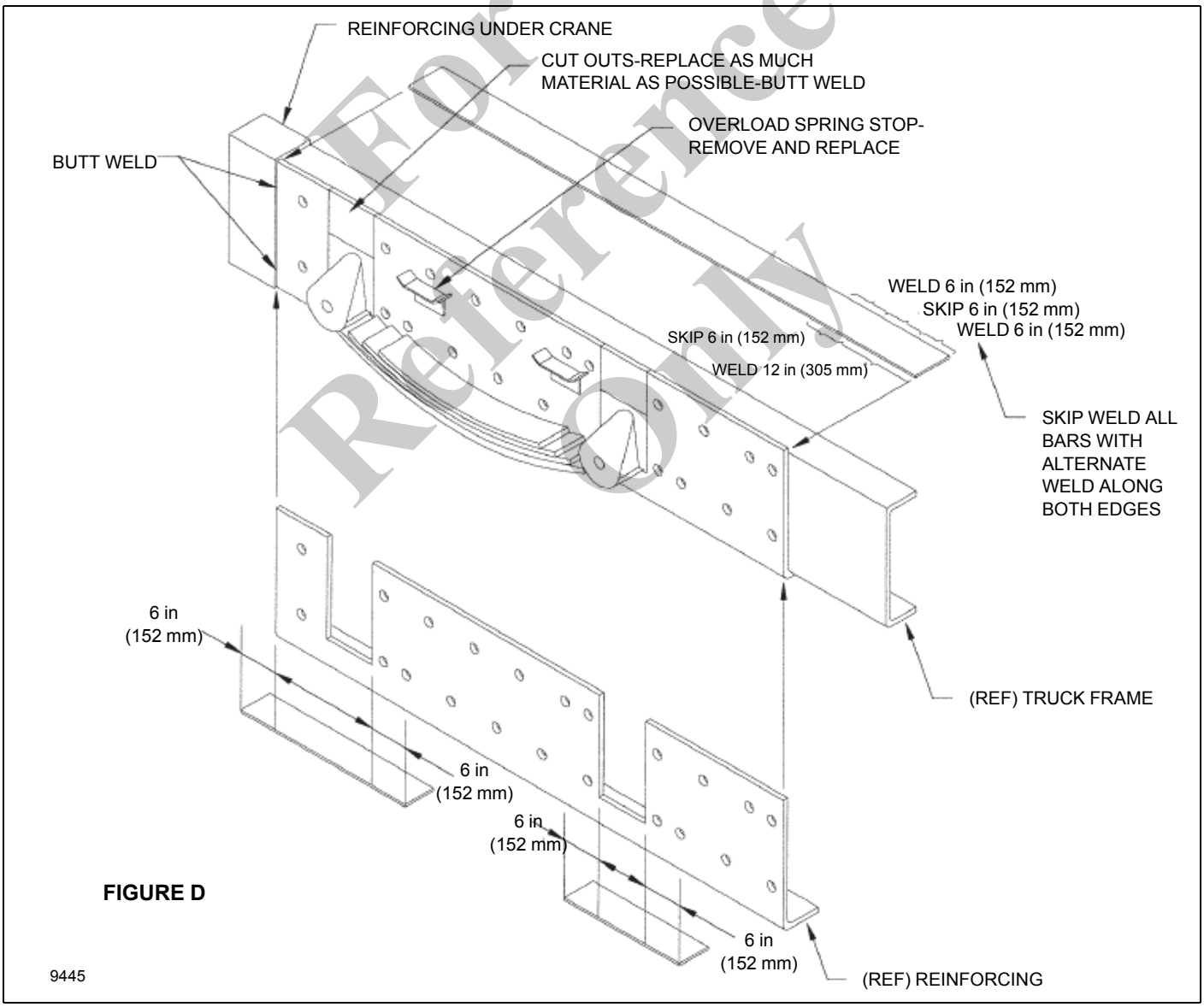



**FIGURE D**

## AFTER FRAME MODIFICATION

If additional suspension reinforcing is required, as may be the case with a truck frame that tapers down to approximately 6 in (15.24 cm) deep through the suspension, a channel may be fabricated through the suspension for additional strength. To do this, install the angle as described in the previous step, making sure that the long leg of the angle extends to the top of the truck frame. A bar of the same material strength, thickness, length and flange width as the reinforcing angle is then added to the top of the truck frame. The bar is butt welded to the top of the forward reinforcing, then skip-welded with 6 in (15.24 cm) of weld, 6 in (15.24 cm) no weld, etc., along both edges of the bar, front to back.

Length of after frame (AF) may have to be modified for crane installation. If AF is too long, cut off excess and remove any cross members from back of truck frame. If AF is too short, the frame will have to be lengthened. Use channels fabricated from 100,000 psi (758 MPa) yield material that are the same size as the truck frame. Weld these channels to the ends of the existing truck frame channels. Bevel the ends of the channels to get 100% weld joints with Grade 90 weld material. Fabricate an inner channel of the same thickness as the truck frame channels to span the weld joint for at least 12 in (30 cm) on each side of joint. Plug weld this channel to the inside of the truck frame, then skip weld the inside edge of the top and bottom flanges to the truck frame flanges.

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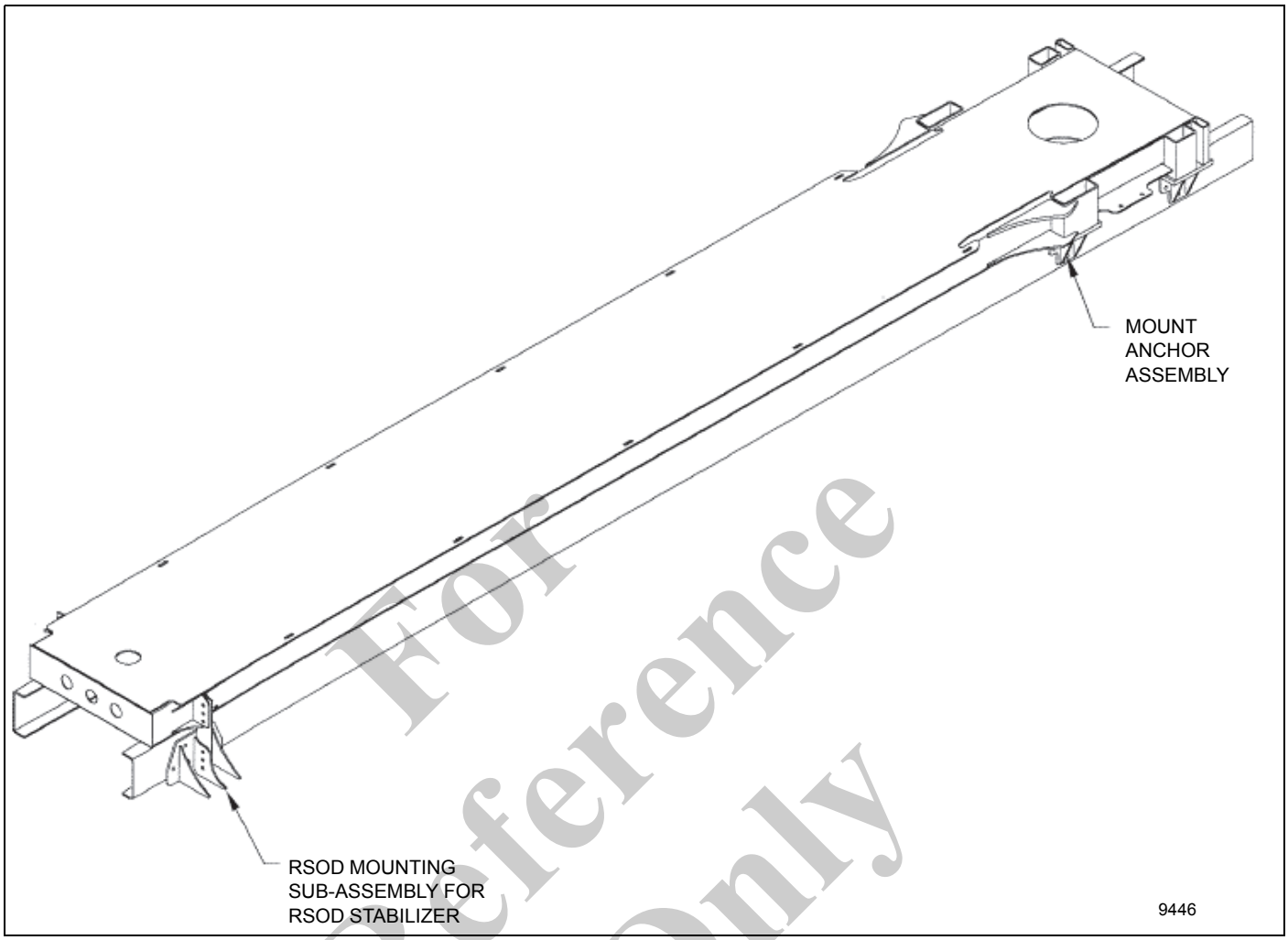
# SECTION 10
# CRANE INSTALLATION

## SECTION CONTENTS

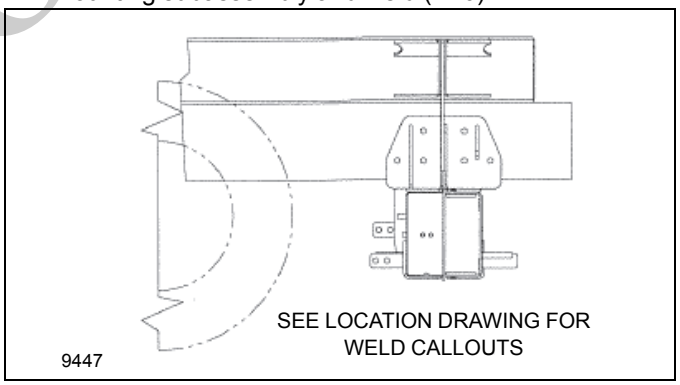


1. Determine installation position for the crane considering the operating area of the crane, space for saddle tanks, truck frame crossmembers, or anything that might affect installation and be sure the frame is clear of any obstructions that might interfere with proper installation.
2. Center the subbase on the chassis at the proper location. Loosely assemble two mount anchor assemblies per side to subbase and look for interference with truck crossmembers.
3. If subbase does not fit tightly on truck frame at all locations, do not force them together to remove gaps since they will not affect the unit's stiffness or strength. Add spacers as required to level truck bed before attaching it to the torsion box.
4. Drill four 3/4 in diameter holes through the truck frame at each mounting plate using the holes in the mount anchor assembly as pilot holes. Install 3/4 in diameter Grade 8 bolts, washers and nuts in mounting plates.
5. With RSOD stabilizers retracted, determine the distance from the top of the stabilizer frame cross tube to ground level that will give you approximately 14 in (35 cm) of ground clearance to the bottom of the stabilizer foot. This will give approximately 11 in (27 mm) of stabilizer penetration. Before final mounting the RSOD brackets make sure that the tops of the stabilizer vertical cylinder are below the top of the torsion box. Keep in mind that the truck frame may settle slightly with the addition of the crane frame, boom, bed and payload. Using this determined vertical dimension, position the RSOD mounting sub-assembly approximately 12 in (30 cm) behind the rear tires. Check for truck frame bolt or rivet interference. Cut clearance holes for rivet heads. Mark and drill six 3/4 in bolt holes as specified through RSOD mounting sub-assembly and truck frame and install six 3/4 in Grade 8 bolts, washers and nuts. Tighten to proper torque.




6. Loosely assemble flex plate and two anchor ears as shown. Locate flex plate anchor ears to torsion box and RSOD anchor plate as specified and tack in place. If proper ground clearance cannot be obtained, see location drawing for further instructions. Remove flex plate and weld (E70) ears to torsion box and anchor plate as specified. Install flex plate with six 5/8 in Grade 8 bolts, washers and nuts. Tighten to proper torque. Repeat flex plate installation procedure on other side.

Raise and locate the RSOD frame to the RSOD mounting subassembly and weld (E70).




7. Set the crane frame on the subbase and install the three 1-1/8 in diameter Grade 8 mounting bolts at each corner. Bolt the crane to mounting anchors through tubes in the subbase and mounting anchors to truck frame. Tighten mounting bolts to the proper torque.

8. Find a location for and install hydraulic oil reservoir. Mounting brackets may be bolted to the truck frame. Before placing reservoir in service, remove cleanout cover and inspect to ensure proper installation of diffuser. Connect 1/4 in hoist drain line to coupling in back side of reservoir and 2-1/2 in suction line from pump before filling with oil.

9. Install the return line from the crane frame to the filter on the side of the reservoir. Be careful to avoid damaging the filter housing when installing the 4 bolt flange connection. Snug each capscrew, then tighten to proper torque in a diagonal torquing pattern. Clamp return hose to filter flange then check for leaks. Engage PTO and run the pump to circulate the oil.

   **Important: The weight of suction and return hose and plumbing must be supported to prevent damage to the reservoir. Install support brackets and clamp or tie hoses up to eliminate strain on reservoir connections. Also ensure that the hydraulic hoses do not contact the truck drive shaft.**

10. Install outriggers on crane frame as shown in illustrated parts pages. Attach the appropriate hoses to the outrigger cylinders. Cycle the outriggers to fill with oil completely and install the latch plate to hold outriggers in place during travel.

11. Important: Before attempting to assemble the boom and lift cylinder to the frame, see “Hose Routing” page in “Controls & Hydraulics” Section and “Pin Bearing Inspection and Installation” and “Anti-Two-Block System Installation” pages in this section. Before connecting hoses, boom must be opposite (180°) the rotation stop to minimize hose twist.

    Pin lift cylinder barrel in position in the turret. Pin boom pivot to turret. (It will be necessary to use an overhead hoist for lifting boom and lift cylinder.) The boom, telescope, and hoist hoses need to be routed through nylon covers, per the parts pages, prior to routing through the frame and turret. Connect the 1/2 in R12 hoses to the lift cylinder. Support outer end of boom securely and use the overhead hoist to position the lift cylinder with the control valve to pin the cylinder to the boom ears. Torque pin keeper capscrews to proper torque. Grease the three pin joints with gun grease and operate the boom and lift cylinder through several complete cycles before placing machine in operation.

12. Route the 1/2 inch R12 telescope hoses over the turret back plate and to the back side of the boom. Connect the telescope cylinder connections at the back of the boom.

13. Route the 3/4 inch R12 hoist hoses and the 1/4 in R1 hoist drain hose through the turret then through the holes in the side of the hoist side plates and connect to the hoist fittings.

14. If loadline has been installed at factory, skip to Step 21 Unspool approximately 15 ft (8 m) of cable and route the cable through the boom cable guides from the front of the boom to the hoist.

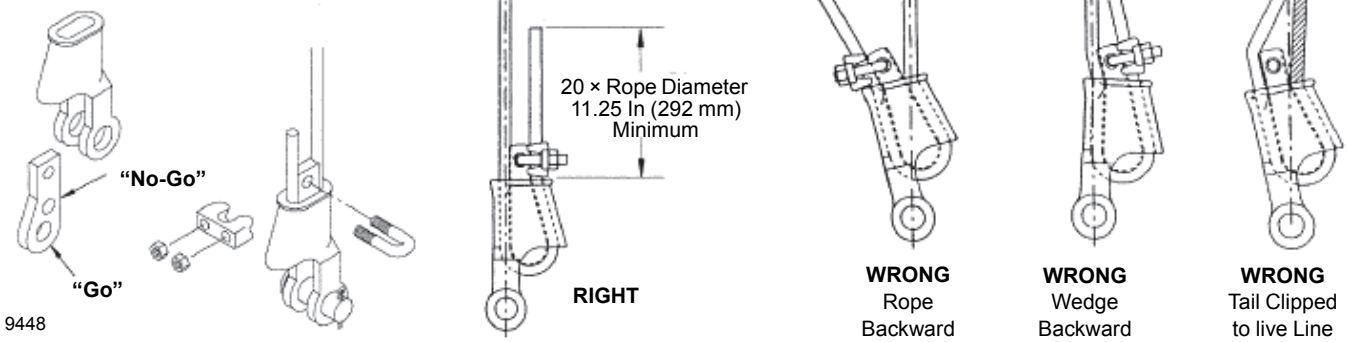
15. Install one end of the loadline cable into the hoist drum using the wedge socket provided. See “Hoist Service Manual” in the Service and Maintenance Section for proper placement of the wedge socket with 9/16 in diameter wire rope.

16. Remove the cable keeper T-handle pin from the sheave case and lay the cable over the top sheave. Replace the top cable keeper pin.

17. Unspool the remainder of the cable out from the back of the truck being sure the cable is straight and without kinks. Attach downhaul weight, wedge socket, hook and cable clamp to the end of cable as shown in Loadline Section. Torque cable clamp (clip) to 95 lb-ft (128.8 Nm). This torque must be rechecked after initial operation of the crane. Be sure cable clamp is attached to the free end of the cable only. If equipped with optional 2/3 part block, omit downhaul weight and assemble as shown in Loadline Section. Special care should be taken to reeve the cable through the wedge socket as shown below.

18. Spool the loadline onto the hoist drum while maintaining approximately 500 lb (250 kg) of tension on the cable (attaching a small vehicle to the end of the loadline with another person lightly riding the vehicle brakes while the cable is spooling on the drum will accomplish this). While the first half of the hoist bare drum is filling, it will be necessary to force the cable to wrap tightly against the preceding wrap by pounding the cable against the preceding wrap with a rubber mallet until at least half of the drum is full. The remaining half of the drum should wrap tightly because the fleet angle of the cable will tend to pull the cable to the center of the drum thus wrapping tightly.

**Terminator Type Wedge Installation**




| Rope size | 3/8 | 7/16 | 1/2 | 9/16 | 5/8 | 3/4 | 7/8 | 1 | 1-1/8 | 1-1/4 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Torque lb-ft (Nm) | 45 (61) | 65 (88) | 65 (88) | 95 (128.8) | 95 (128.8) | 130 (176) | 225 (305) | 225 (305) | 225 (305) | 360 (488) |
| * The tightening torque values shown are based upon the threads being clean, dry, and free of lubrication. | | | | | | | | | | |

- Properly match 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.
- Align live end of rope, with center line of pin.
- Secure dead end section of rope.
- Tighten nuts on clip to recommended torque. (See Table)
- Do not attach dead end to live end or install wedge backwards.
- Use a hammer to seat Wedge and Rope as deep into socket as possible before applying first load.

FIGURE L

19. Continue winding the cable on the second, third and fourth layer of the drum. Keep the cable paying in straight to the boom to avoid side loading the boom. The preceding layers will wrap smoothly guided by the first layer wrapping.
20. After cable is completely wrapped on drum, replace remaining cable keeper bolts on the sheave case.

    Attach wedge socket and cable clip to end of cable per illustration in Loadline Section of parts manual and torque cable clip bolts to 95 lb-ft (128.8 Nm) for 9/16 inch cable.
21. Check for hoist mount tail swing clearance at top of cab. Any equipment that extends above the truck cab such as exhaust stacks or air horns may interfere with the hoist mount when the boom is elevated and rotated. Shorten exhaust stacks or move air horns, etc. to ensure clearance.
22. If crane is to be repainted, mask all decals prior to final paint or install all new decals in accordance with location drawings and illustrated parts catalog over final paint.
23. After installation, check all oil and lubricant levels and lubricate unit according to "Lubrication Chart" on page 4 in Service and Maintenance Section.

# PIN BEARING INSPECTION AND INSTALLATION PROCEDURE

## Pin Inspection

1. Remove the protective covering from pins and inspect each pin for nicks, gouges or deep wide scratches. A small nick or gouge up to 1/8 in (3 mm) diameter can be repaired by dressing the edges of the imperfection with a file so that no metal protrudes above the circular surface of the pin.
2. A circular scratch of up to 1/16 in (1.5 mm) wide or deep can be repaired as in 1 above.
3. A lengthwise scratch on the pin of up to 1/32 in (0.8 mm) wide or deep can be repaired as in 1 above.
4. Pins with defects larger than those listed in 1, 2 or 3 should be replaced.

## Bearing Inspection

1. The bearings furnished with this machine are made up of a tough epoxy impregnated wound glass backing shell with a thin inner layer of filament wound bearing material. The outer bearing material should be visually checked for imperfections. Bearings with cracks or gouges larger than 1/4 in (6 mm) diameter on the outside diameter should be replaced.
2. Inspect the inner diameter surface of the bearing. any scratches, cut or gouges which have penetrated through the inner liner may cause premature failure of the bearing. The bearing should be replaced.

## Trunnion Inspection

1. The trunnion bore should either have a machined step or have a spring spacer installed to prevent inward movement of the bearing. If equipped with a spring spacer, check to make sure the opening is positioned over the grease hole.

## Installation

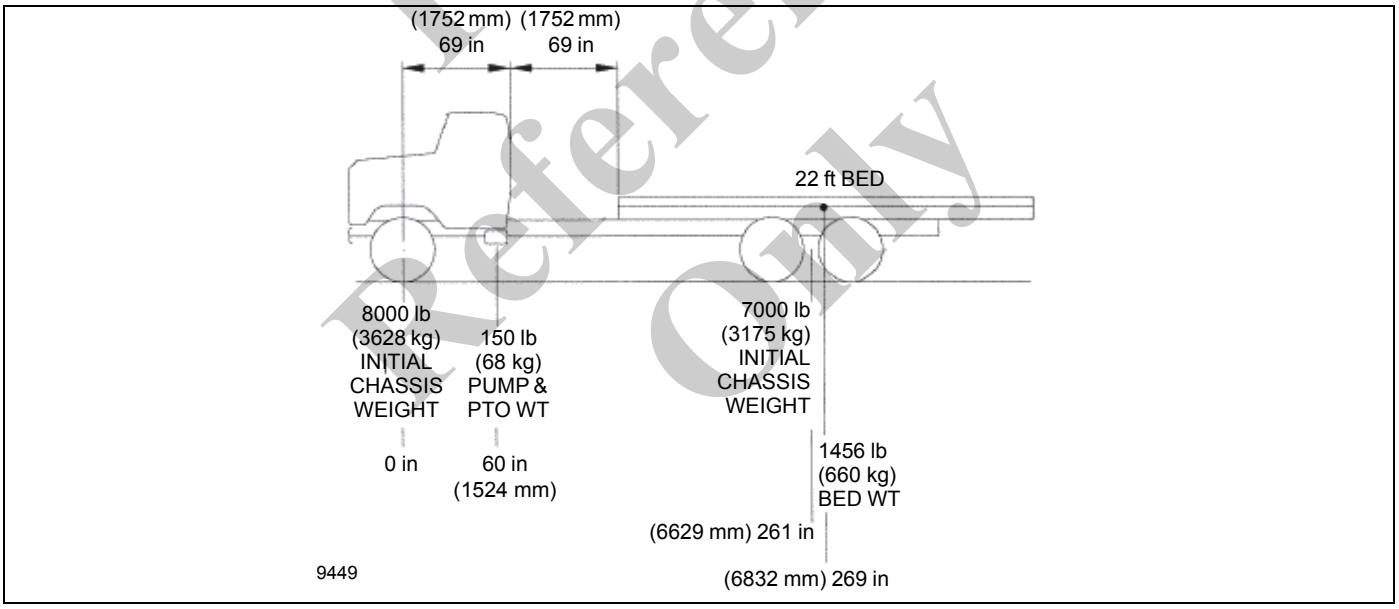
1. Two bearings are to be installed in the boom pivot trunnion located directly below the hoist and the remaining four bearings are to be installed in the lift cylinder, two at each side of the rod end of the cylinder and two at each side of the butt end of the cylinder.
2. The bearings should be started in their respective bores by rotating the bearing while applying inward pressure with the hand. Once the bearing has been started squarely into its bore, it can be driven to its full counterbored depth by tapping lightly with a rubber mallet. The head diameter of the mallet should exceed the outside diameter of the bearing to ensure that the bearing is not damaged during assembly into the bore.
3. If the bearing appears to be loose in the bore (if it can be pushed in with hand pressure alone), it is permissible to tighten the bearing by center punching the bore diameter in approximately 50 places around and throughout the 2 in (51 mm) deep bored area. Center punching will raise the metal around the edge of the punch mark and this raised metal will hold the bearing firmly in place during machine operation.
4. After all bearings have been installed and before attempting to assemble the machine, insert the pins through both bearings in each end of the lift cylinder and through the boom pivot bearings to insure alignment and fit are correct. Also check the two sets of pin holes in the turret and the pin holes in the boom ears to ensure that the pins will slide freely through the leading hole and start in the opposite hole. If a pin starts to bind through the leading hole, do not force the pin any further to avoid damaging the pin surface finish. Remove the pin and clean any corrosion of burrs out of the holes with a round file or emery cloth.
5. When pinning the boom to the turret, and the lift cylinder to the turret and boom, use a round smooth bar of approximately 1-1/2 in (38 mm) diameter as a pry bar to align the pin holes. A pry bar with a sharp edge, such as a crowbar, can gouge or cut bearing and this may lead to premature bearing failure.

## COUNTERWEIGHTING

1. Refer to “Mounting Configuration” pages in this section. The amount of counterweight and its location is dependent upon the stability working area (180° behind the truck or 360° around the truck), the weight of the truck and all permanently attached equipment. Permanently attached equipment which can be considered as counterweight includes the bed, reinforcing, PTOs and pumps, tool boxes, etc. The torsion resisting subbase and rear stabilizers are considered part of this crane and not part of the counterweight. Additional counterweight is usually added to the underside of the bed and/or to the torsion resisting subbase. On some trucks, a heavy front bumper may also be required for stability around the rear.
2. The 85% tipping factor as outlined in OSHA and ANSI specifications means that when lifting the full capacity loads most likely to cause the truck (with outriggers and stabilizer set) to overturn, the unit is at 85% of tipping over. Increasing this full capacity load by 117.6% (overloading) will cause the unit to tip over.
3. In order to determine the amount of counterweight required, it is necessary to add up the weight that each permanently attached piece of equipment will place on the front and rear axles of the truck along with the initial truck chassis weight and then compare the total front and rear axle weights with the weights listed on the “Mounting Configuration” (Installation Section) pages to determine the amount and location of counterweight required.

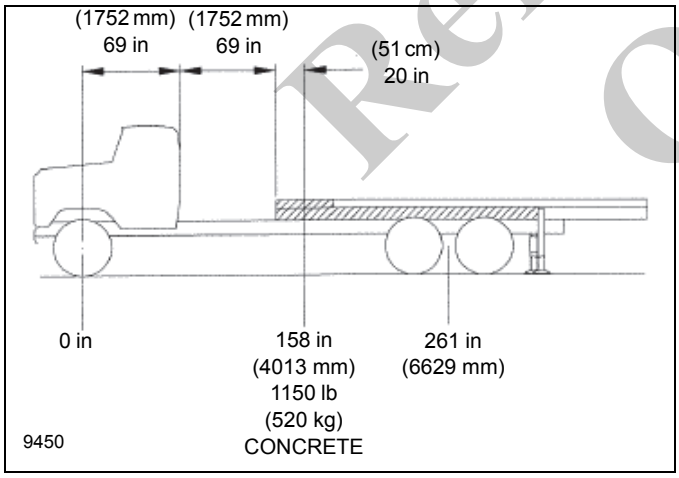
**Example**

A typical truck is shown below with all the permanently attached equipment also shown. A Series 8100D crane will be mounted on this truck and a 180° stability working area around the rear of the truck is desired as in “Configuration 1” (See ““Configuration 1 — 8100D” on page 4”.



| | REAR: (Weight) × (Distance From Front Axle) / Wheel Base = Rear Axle Weight | | Front: Weight − Rear Axle Weight = Front Axle Weight | |
|---|---|---|---|---|
| | **Rear Axle Weight** | | **Front Axle Weight** | |
| 1. Initial front axle wt. | (8000) × 0 / 261 = 0 lb | *(3628) × 0 / 6629 = 0 kg* | 8000 - 0 = 8000 lb | *3628 - 0 = 3628 kg* |
| 2. Pump & PTO's | (150) × 60 / 261 = 34 lb | *(68) × 1524 / 6629 = 15 kg* | 150 - 34 = 116 lb | *68 - 15 = 53 kg* |
| 3. Initial rear axle wt. | (7000) × 261 / 261 = 7000 lb | *(3175) × 6629 / 6629 = 3175 kg* | 7000 - 7000 = 0 lb | *3175 - 3175 = 0 kg* |
| 4. Bed wt. | (1456) × 269 / 261 = 1500 lb | *(660) × 6832 / 6629 = 680 kg* | 1456 - 1500 = – 44 lb | *660 - 680 = – 20 kg* |
| 5. Add front and rear axle wts. | 8534 lb | *3870 kg* | 8072 lb | *3661 kg* |
| 6. Compare with wt. required for this type of mount from "Mounting Configuration I" | 9100 lb | *4128 kg* | 8500 lb | *3856 kg* |
| **Difference** | **566 lb** | ***258 kg*** | 428 lb | ***195 kg*** |

4. Two methods of counterweighting may be used: (A) a heavy front bumper and concrete in the bed or (B) concrete in the bed only. The easiest and most economical method is usually concrete in bed only. The amount of counterweight required will be 566 + 428 = 994 lb (258 + 195 = 453 kg). Use 1150 lb (520 kg) of concrete poured in the front of the bed. See "Counterweighting for 180° Stability" in this section.

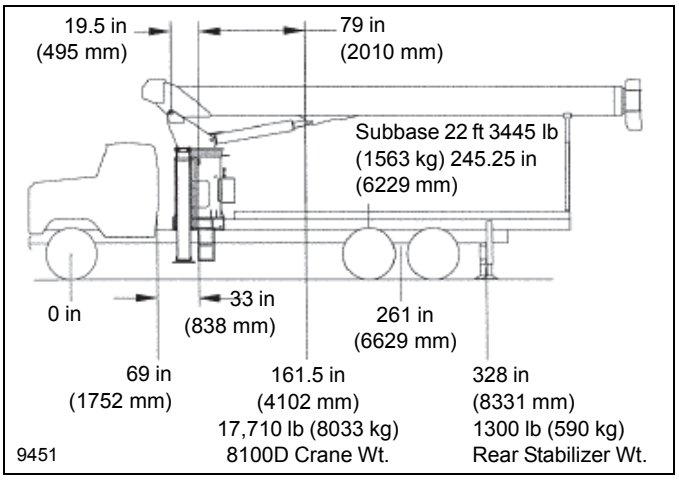



5. Determine axle weights added by the counterweight by using the same method as used before. Figure the center of the counterweight to determine where the weight acts. If the counterweight is oddly shaped, figure the center and weight of each regular shape. Weights ahead of the front axle require using a negative (-) distance in calculations.

| | Rear Axle Weight | Front Axle Weight |
|---|---|---|
| 1150 lb (520 kg) | (1150) × 158 / 261 = 696 lb | (1150) - 696 = 454 lb |
| Bed Concrete | *(520) × 4013 / 6629 = 315 kg* | *(520) - 315 = 205 kg* |
| Required Counterweight Weights | 566 lb<br>*258 kg* | 428 lb<br>*195 kg* |
| **Difference** | **130 lb**<br>***(57 kg)*** | **26 lb**<br>***(10 kg)*** |

The rear axle weight is 130 lb (57 kg) heavier than required and the front axle weight is 26 lb (10 kg) heavier than required.

6. Check the final weight of the unit with crane installed. See "Specifications Section" for weight of 8100D and center of gravity. Note that this weight does not include weight of RSOD stabilizers [1300 pounds (590 kg)]-

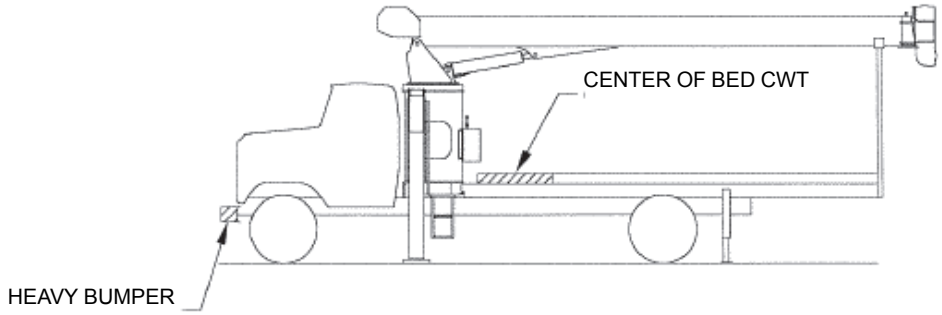


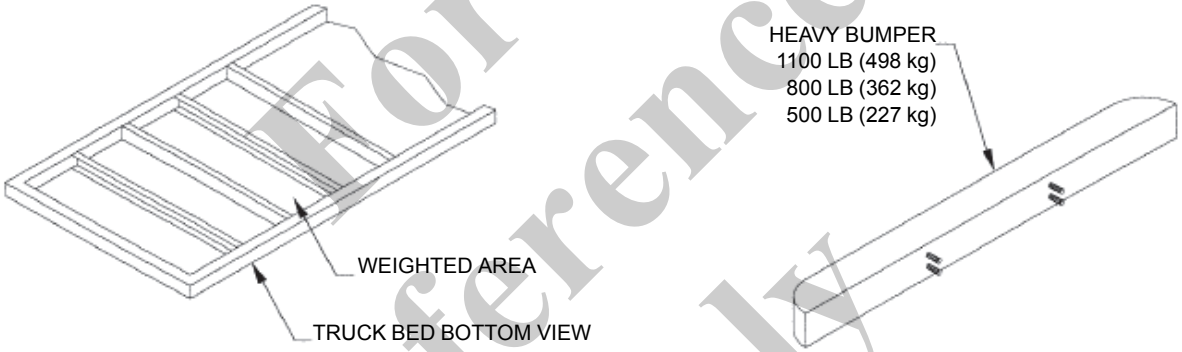

| | | Rear Axle Weight | Front Axle Weight |
|---|---|---|---|
| Base Unit | | 8534 lb | 8072 lb |
| | | 3870 kg | 3661 kg |
| Counterweight | | 696 lb | 454 lb |
| | | *315 kg* | *205 kg* |
| Add Crane Weight | $\frac{(17{,}710) \times 161.5}{261}$ | = 10,958 lb | (17,710) - 10,958 = 6752 lb |
| | $\frac{(8033) \times 4102}{6629}$ | = *4970 kg* | *(8033) - 4970 = 3063 kg* |
| Rear Stabilizer Weight | $\frac{(1300) \times 328}{261}$ | = 1633 lb | (1300) - 1633 = -333 lb |
| | $\frac{(590) \times 8331}{6629}$ | = *741 kg* | *(590) - 741 = -151 kg* |
| 22 ft Sub-bass | $\frac{(3445) \times 245.25}{261}$ | = 3237 lb | (3445) - 3237 = 208 lb |
| | $\frac{(1563) \times 6229}{6629}$ | = *1469 kg* | *(1563) - 1469 = 94 kg* |
| **Total** | | **25,058 lb** | **15,153 lb** |
| | | ***11 365 kg*** | ***6873 kg*** |

Add any other required mounting or crane options. Check the final unit weight with a full load of diesel [@ 7.3 lb per gallon (0,87 kg per liter)] and men (@ 200 lb (90 kg) per man) to ensure that the axle ratings have not been exceeded so that DOT certification requirements can be met.

After the unit is completely assembled, the stability test must be run in accordance with “Stability Test Procedure” page at the end of this section to verify crane stability.

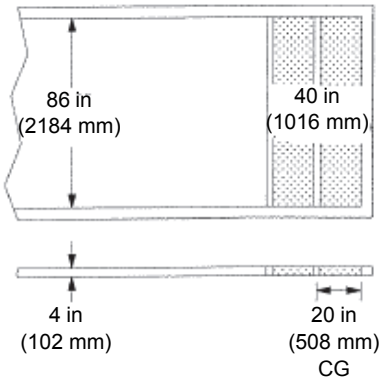
# COUNTERWEIGHTING METHODS FOR STABILITY AROUND THE REAR 180°



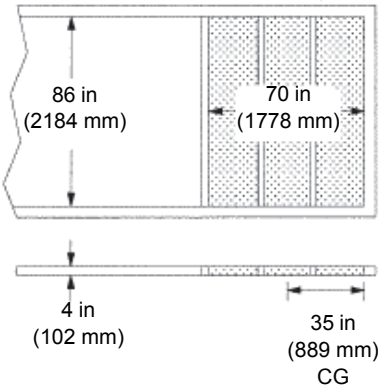





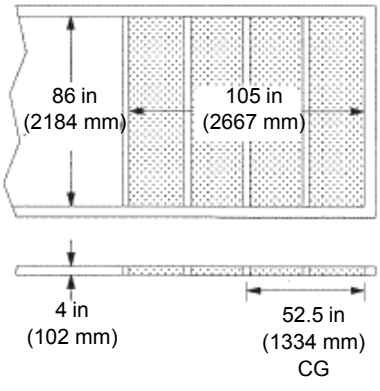

BED COUNTERWEIGHTING FOR 1150 LB (520 kg)




BED COUNTERWEIGHTING FOR 2000 LB (910 kg)




BED COUNTERWEIGHTING FOR 3000 LB (1360 kg)

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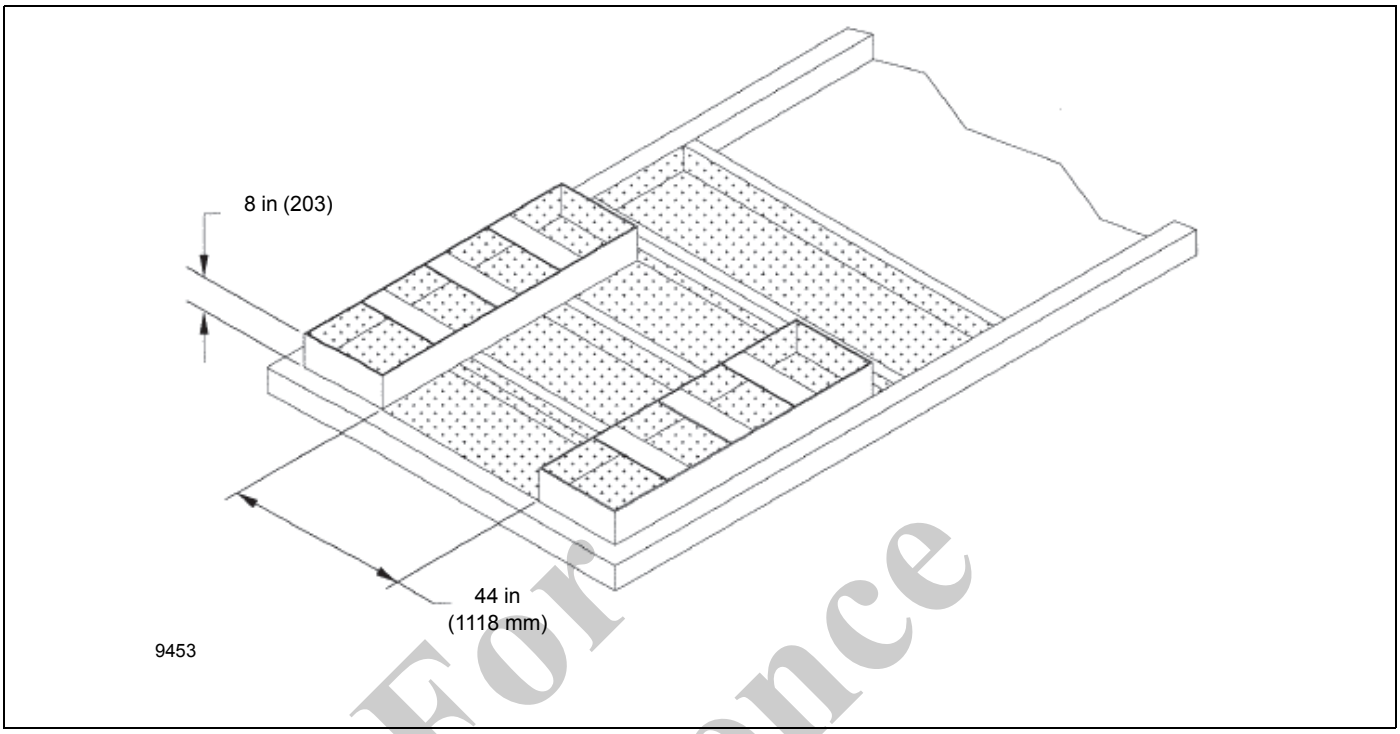
**NOTE: SHADED AREAS INDICATE CONCRETE**




The method shown above can be use do shift more weight to the front of the crane than the previous methods will. When using this method check for interference with hydraulic reservoir and truck tires. Bed attachment to truck should be planned in advance. If the bed is attached to torsion box by bolting through slots in torsion box, leave open area in concrete counterweight for hardware access. The weight of the concrete can be determined by multiplying the volume in cubic inches by 0.083 lb per cubic inch.

**Example**

Concrete poured in the bed measures 4 in (10.16 cm) deep by 86 in (218.44 cm) wide by 70 in (177.80 cm) long. The weight of the concrete is 4 × 86 × 70 × 0.083 = 2000 lb (907 kg). The center of this weight will be in the center of the concrete slab.

# ANTI-TWO-BLOCK RATED CAPACITY LIMITER INSTALLATION AND FUNCTION VERIFICATION

1. 800D model cranes equipped with DS160 RCL systems have the RCL reel length cable routed inside the boom. The cable has been installed and pretensioned at the factory. If cable tension adjustment is required, rotate the reel counter-clockwise (in the direction of payout) and wrap the length cable back onto the reel. At the hoist end of the boom, disconnect the thimbles from the back end of the fourth section and rotate the thimbles and loop counter-clockwise. Reattach the thimbles to the fourth section. Disconnect the length cable at the boom tip and rotate the length cable clockwise to remove twist. Length transducer must be zeroed after doing this (see step 10).

**⚠DANGER**

**Do not allow reel to unwind uncontrolled. The signal cable will be damaged.**

2. Insert cord plug from the boom cable reel into the mating connector located in the frame coming from the CPU. (See Illustrated Parts Pages.) Check cable routing to ensure cable is unobstructed through complete range of boom angle and rotation. Secure excess cable as needed using nylon ties.
3. Install ATB weight assembly around loadline and attach to switch at boom tip. The length of chain used to attach the weight can be adjusted to permit maximum crane working height and allow securing the boom with the loadline in the transport position. Extra chain should be retained for use if additional loadline rigging attachments are added.
4. Route hydraulic hoses from transducers inside frame to the lift cylinder. Connect hose with the small 90° drop to swivel on holding valve located at base of lift cylinder (piston side). Connect hose with larger 90° drop to tee located at base of lift cylinder (rod side).
5. Bleed air from hydraulic hoses connecting to transducers. Operate crane slowly while following this procedure. It is not required to lift boom from boom rest during bleeding procedure. With boom in boom rest, loosen bleeder on bulkhead fitting piston side transducer and install clear plastic hose and route to catch pan. Slowly actuate boom up lever generating flow and permitting air to escape and when air ceases to escape tighten bleeder. With boom still in boom rest loosen bleeder on bulkhead fitting rod side transducer and install clear plastic hose and route to catch pan. Slowly actuate boom down lever generating flow and permitting air to escape and when air ceases to escape tighten bleeder.
6. Route the two conductor cord to a convenient location in the truck cab. Install the RCL power switch and indicator light. A mounting plate is provided or the switch and light may be installed in the dash. Install the label decals adjacent to the switch. Refer to illustrated parts section for item numbers and decal placement.
7. To ensure RCL calibration is correct, the serial numbers of the frame, boom, and lift cylinder must match. If they do not, the system will not work properly. If serial numbers do not match, contact National Crane immediately.
8. The components of this system are pre-calibrated, however, there is an initial setup that needs to take place to ensure proper communication between the sensors and the processor. If the system has not yet been set up, the maintenance screen will appear when the RCL system is powered up. The maintenance screen will have the options CALIBRATE SENSORS, SENSOR OUTPUTS & EXIT.
9. The pressure transducers have been zeroed at the factory. This step is only required if replacing or changing the pressure transducers. Support boom and release pressure from lift cylinder. Remove hoses from pressure transducers.

**⚠CAUTION**

**Ensure there is no pressure in the hydraulic lines when disconnecting the hoses from pressure transducers.**

Using the UP & DOWN keys to scroll, select “PIS” or “ROD” and press “OK”. The screen will read BOOM DOWN COMPLETELY AND DISCONNECT HYDR, OK, & EXIT. Press “OK” button to zero the selected pressure transducer. The rod and piston side pressure transducers must be zeroed individually; therefore you must complete this procedure for both piston and rod side pressure transducers.

Press “EXIT” to leave calibration or select “CALIBRATE SENSORS” to calibrate another sensor.

After zeroing both pressure transducers, reconnect the hydraulic lines to the pressure transducers. Operate the lift cylinder in both directions, then support the boom and bleed any air from the hydraulic lines (using procedure in step 5).

10. Remove cable reel cover. Fully retract main boom. Confirm length sensor is set by rotating center screw in large gear counter-clockwise to a soft stop.
11. After selecting “CALIBRATE SENSORS” select “ANG” to begin angle sensor calibration. Using a calibrated

inclinometer (measures to within 0.1°, Example: SMARTTOOL DIGITAL LEVEL) adjust boom angle to 0° (range -0.5° - +0.5°) and mechanically adjust the angle sensor so that the system reads the angle to ±0.0 deg. of the measured angle. Press “OK” when the sensor is mechanically set, this confirms the mechanical adjustment.

The display should now read BOOM TO 40.0 DEG, XX.X DEG, EXIT. Raise boom to approx. 40° (range 35° to 45°). When the boom angle is within the calibration range, the screen will add “CHANGE” & “OK” text. Measure the boom angle with the inclinometer. Compare this with the displayed angle and select “CHANGE” and press “OK”. Use the “UP” & “DOWN” arrow buttons to adjust the displayed angle to match the measured angle. Once the display shows the correct angle press “OK”.

The display will now define a mid correction angle, 65 DEG. Raise boom to approx. 65° and repeat above steps.

The display will then define a high correction angle, 75 DEG. Raise boom to approx. 75° and repeat above steps.

After pressing “OK” the system will request the angle sensor calibration be saved. Select “YES” then press “OK” to confirm calibration.

Press “EXIT” to leave calibration or select “CALIBRATE SENSORS” to calibrate another sensor.

12. After selecting “CALIBRATE SENSORS” select “LEN” to begin length sensor calibration. Screen will read FULLY RETRACT MAIN BOOM XX.X ft., OK & EXIT. Refer to load chart and elevate the boom to an angle that allows boom to be fully extended. Verify the retracted boom length is correct and press “OK”. The screen will now read FULLY EXTENDED MAINBOOM XX.X ft. OK & EXIT. Fully extend the main boom and press “OK”. NOTE: The RCL system measures boom length from the pivot pin to the center of the boom tip sheave. This varies slightly from length indicated on Load Chart (see table below).

    After pressing “OK”, the system will request the length sensor calibration be saved. Selected “YES” then press “OK” to confirm calibration.

    Press “EXIT” to leave calibration.

    Verify length and angle indication are accurate and replace cable reel cover.

13. Load indicating accuracy is verified by lifting known loads. Select one or more known test loads that will load the crane to full capacity, preferably a load that can fully load the crane at more than one rated boom length. The test loads including blocks, slings, etc. are to be known accurate within ±1%.

    Starting with a rated boom length and a short radius (high boom angle), lift a load that is somewhat lower than rated capacity at this condition. Increase the radius slowly by decreasing the boom angle until the limit signal is activated. Measure and record radius along with the test load. Complete this for each test condition. If you have selected a test load that is within the crane’s capacity at the next longer rated boom length (closer load radius at higher boom angle), you can reposition the same test load for an additional test condition. A minimum of four tests with one or more at full boom extension are recommended.

    For each test condition, refer to the Load Capacity Chart and determine the rated load for the measured radius condition. If the measured radius is between those listed on the Capacity Chart, the rated load (for this test work only) shall be determined by linear interpolation.

    The load indicating accuracy is determined by this formula:

    TEST LOAD/RATED LOAD x 100 = % of Rated Load

    The actual test load which activates the limit signal is not to be less than 90% of the rated load nor more than 100% of the rated load for the corresponding actual load radius.

| MODEL | CAP. CHART RETRACT | CAP. CHART EXTEND | RCL RETRACT | RCL EXTEND |
|---|---|---|---|---|
| 869D | 27 ft | 69 ft | 26.6 ft | 68.6 ft |
| 880D | 24.5 ft | 80 ft | 24.1 ft | 79.6 ft |
| 890D | 27 ft | 90 ft | 26.6 ft | 89.6 ft |
| 8100D | 29 ft | 100 ft | 29.1 ft | 99.6 ft |
| The RCL system measures boom length from the pivot pin to the center of the boom tip sheave. This varies slightly from length indicated on Load Chart. | | | | |

## INITIAL CRANE RUN IN PROCEDURE

1. With the unit in an open area for testing that will permit full operation of all its functions, engage the PTO and run the truck engine at idle to activate the pump (approximately 600 rpm). Turn the crane power switch on and operate the crane and outriggers though all of their functions at least six (6) times to purge cylinders of air. Operate the control valves slowly with the truck engine at idle and cycle each cylinder through its complete stroke each time. Check to see that movement of outriggers and boom correspond with direction indicated on switches and levers. Refer to hydraulic or electrical schematic and parts pages to correct any problems.

**Note: Add oil to reservoir as required to keep air from reentering the system.**

2. Set throttle according to engine RPM and PTO ratio to get 2500 RPM pump shaft speed.
3. When all cylinders have operated through complete cycles, stow crane and place the outriggers in the up position. The oil level should be visible near the top of the sight gage.
4. Lift and stability test must now be performed on the unit. (See “Stability Test” page.) Hoist and crane tests should be conducted to insure proper performance.
5. After testing is completed, the mounting bolts and all cable clamp bolts should be retorqued to specifications.

Upon completion, overall height of crane vehicle combination must be measured and posted inside of cab informing driver of overall height.

## BOOM RESTS

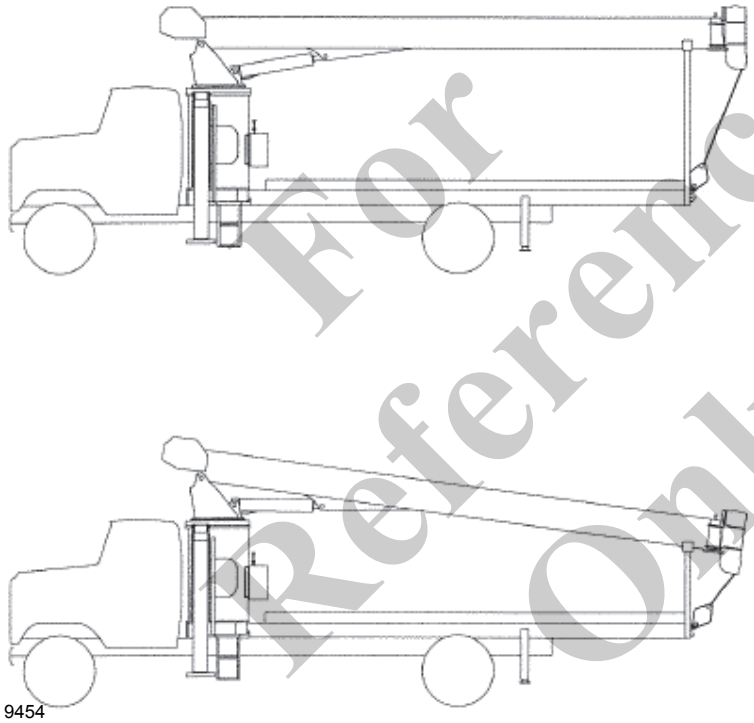
Before the mounting of a crane is complete, a boom rest must be installed. A rest must be supplied for transport to reduce vibratory stress on the crane and truck and protect rotation system from transient damage.

Below are shown configurations to meet application of the user. All of these configurations are available at your National Crane distributor.

The loadline shall be hooked to some point on the bed, truck frame, etc. to secure the hook weight during transport. Install tie down point low enough to allow room for anti-two-block weight. Do not shorten chain.

The boom rest should be positioned to support the 1st section boom. Be careful to avoid contacting the boom at or near the end where the retract cables are located. Contact with these cables will result in costly repairs.

The boom rest saddle provided is designed to support the 1st section boom. It will be necessary to modify the saddle to make it narrower and reposition the support cushions under the boom side plates if the boom is extended to reach the boom rest.



HORIZONTAL OR REMOVEABLE MOUNT FOR GREATER LOAD SPACE

LOW PROFILE REAR BED MOUNT FOR LOWER CENTER OF GRAVITY

9454

# STABILITY CHECK

The chassis weight, before the crane is mounted, is intended for use only as a guideline in determining the total weight required for the unit to be stable with an 85% tipping factor (i.e. when lifting capacity load, the unit is at 85% of tipping or less).

In order to ensure the stability of the unit with an 85% tipping factor, a live load stability test must be performed on each completed unit. Proceed as follows:

1. Test the unit for stability on a firm level surface. See “Proper Leveling of the Crane” on page 10.
2. A Series 800D crane requires RSOD stabilizers for stability. With the boom stowed, set the unit up level on the outriggers and stabilizers.
3. When stability testing this unit, select the load from the capacity chart that at the longest boom extension matches the radius listed below:

| Model | Boom Length | Loaded Angle | Loaded Radius |
|---|---|---|---|
| 851D | 51 ft (15.54 m) | 37° | 40 ft (12.19 m) |
| 869D | 69 ft (21.03 m) | 36.5° | 55 ft (16.76 m) |
| 880D | 80 ft (24.38 m) | 28° | 70 ft (21.34 m) |
| 890D | 90 ft (27.43 m) | 33.5° | 75 ft (22.86 m) |
| 8100D | 100 ft (30.48 m) | 32° | 85 ft (25.91 m) |

The stability test load will be 1.18 times the load chosen from the load rating area of the capacity chart.

**Example: 8100D**

Boom Length:100 ft (30.48 m)

Loaded Radius: 85 ft (25.91 m)

Load Rating:1050 lb (476.27 kg)

Stability Test Load: 1.18 x 1050 lb (476.27 kg) =1239 lb (562 kg)

(Includes weights of slings and downhaul blocks.)

Be sure the stability test weight is accurate. A 1% increase in stability test weight will mean up to a 10% increase in counterweight. Extend the boom to the maximum boom length and hoist the stability load off the ground. Slowly boom the load down so the load will swing out, until the loaded radius is reached. As the boom is lowered keep hoisting the load up to keep it about 6 in off the ground.

**Do not exceed loaded radius.**

Slowly rotate the boom throughout the work area. As the boom is rotated, the boom will have to be raised and/or lowered to maintain the loaded radius because of subbase flexure.

On Front Mounted Cranes that are not equipped with front stabilizers, tipping from stabilizer support to front wheel support will occur as the load or boom is swung around the front. Do not attempt to lift rated loads around the front of the truck unless the unit is equipped with a front stabilizer. **(Except on cranes with a Rear Mounted configuration.)**

**NOTE: Weights of accessories installed on the boom or loadline (including downhaul weight) must be deducted from the calculated load when checking stability**

4. If slight tipping occurs, but load can be kept from coming in contact with ground by hoisting the load up, unit is stable. If not, counterweighting will have to be added to get unit in a stable condition or decal must be added to define areas of full stability and areas of reduced capacity because of stability. If the unit is equipped with a jib, the stability test should be repeated. Use the fully extended jib capacity multiplied times 1.18 at the lowest angle that the jib is rated fully extended.
5. When adding counterweight to the vehicle, it is usually most effective when added as close to the crane as possible. After adding counterweight, the above procedure must be repeated to insure the added counterweight is adequate.
6. If unit is not stable 360° around the truck, a decal must be added showing the working area according to stability.

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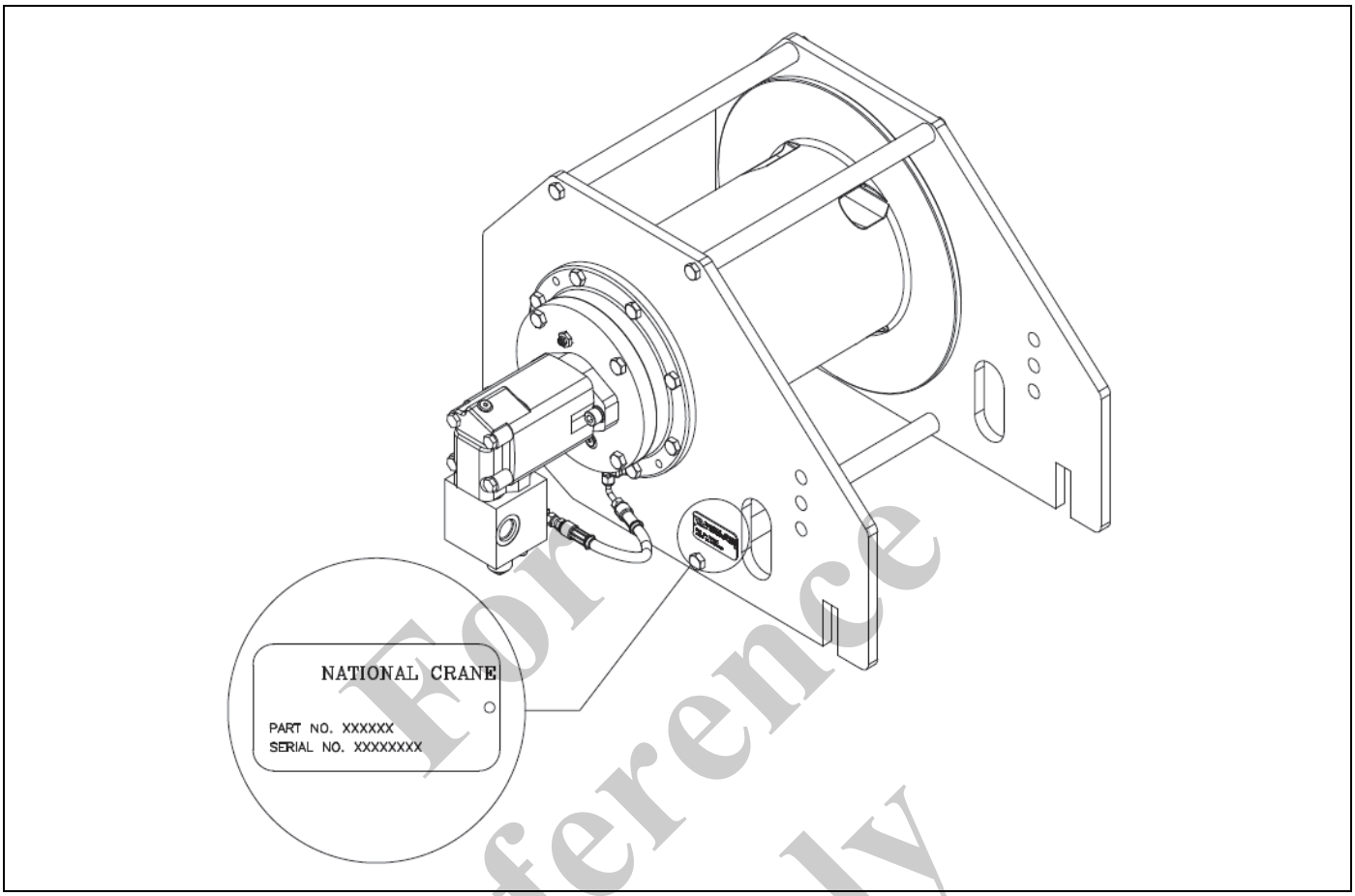
# SECTION 11
# HOIST

## SECTION CONTENTS



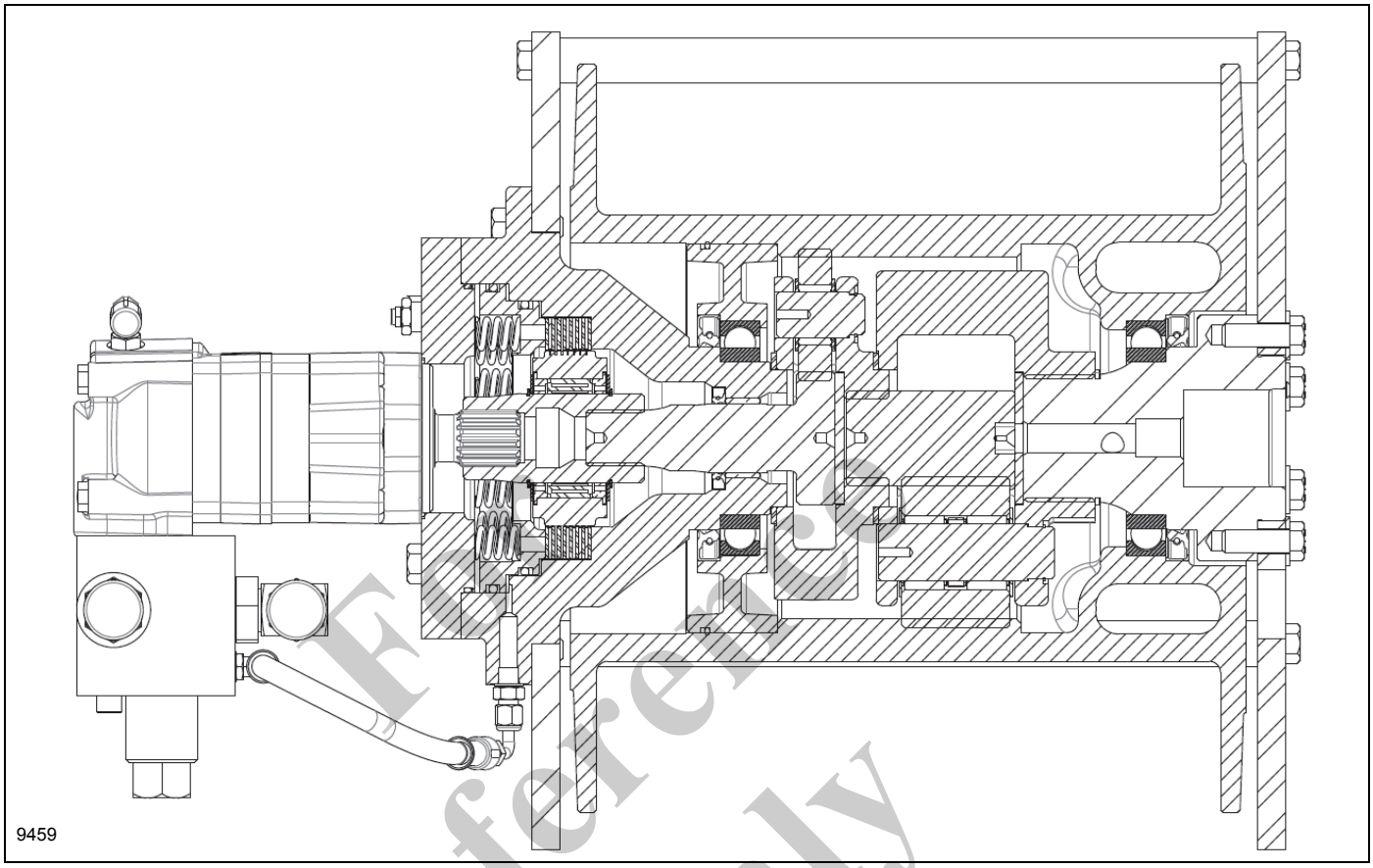



**WARNING**

Failure to heed the following warnings may result in serious injury or death!

- Operators must be trained in the proper, safe operation of the hoist.
- Hoists are not to be used to lift, raise, or move people. If your task involves lifting or moving people, you must use the proper equipment, not this hoist.
- Cable anchors on hoists are not designed to hold the rated load of the hoist. You must keep at least five (5) wraps of cable on the drum to ensure that the cable doesn't come loose.
- Stay clear of suspended loads and of cable under tension. A broken cable or dropped load can cause serious injury or death.
- Avoid shock loads. This type of load imposes a strain on the hoist many times the actual weight of the load and can cause failure of the cable or the hoist.
- Make sure that all equipment, including the hoist and cable, are maintained properly.

## INTRODUCTION AND THEORY OF OPERATION

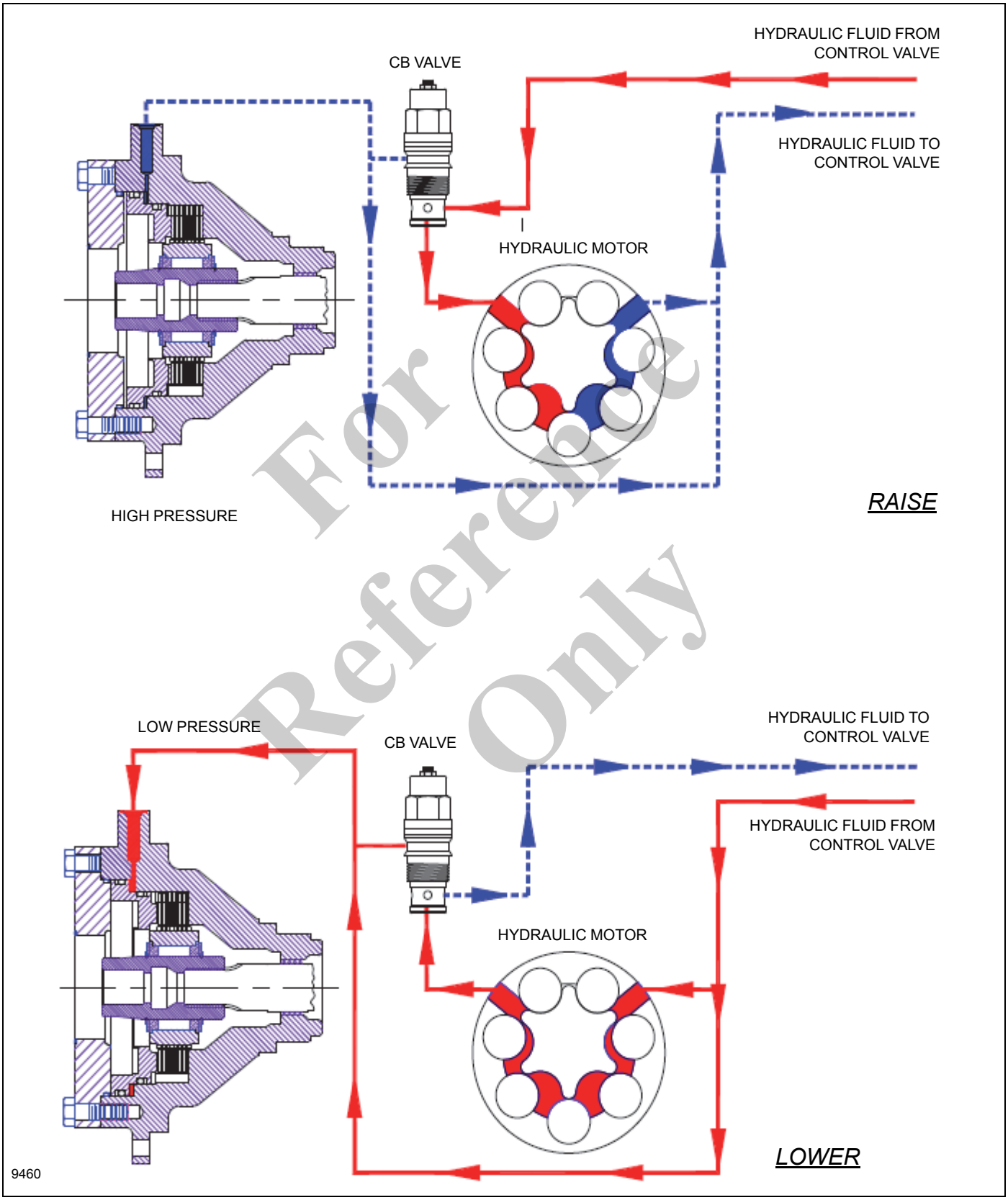



The planetary hoist is designed to utilize a geroler, gear, or piston motor, driving through a multiple-disc oil brake, through a pair of planetary gearsets to the cable drum.

The multiple-disc oil brake is spring applied and hydraulically released through a port in the brake housing. During inhaul, the brake is not released, since the load is driven through a one-way cam clutch, bypassing the brake. When the load comes to a stop, the cam clutch locks up and the brake prevents the load from moving.

During payout, a brake valve is used to prevent the load from moving faster than desired. This brake valve partially blocks the main line from the motor back to the directional control valve, allowing only a limited amount of hydraulic fluid through the motor. The brake valve is then modulated by sensing pressure on the other main line, the line from the directional control valve to the motor. Additionally, any time there is sufficient pressure (225 PSI ±10%) to modulate the brake valve; this same pressure releases the brake.

## HYDRAULIC SCHEMATIC



## MAINTENANCE AND SERVICE

For safe and consistent operation of this hoist a regular program of preventive maintenance is strongly recommended. Regular oil changes with the correct oil for the ambient temperature conditions and an annual inspection of the wear components will help ensure a long life for your planetary geared products.

### Maintenance Scheduling

The owner is to ensure proper inspection intervals, in compliance with the API RP 2D Section 4 requirements or the ANSI B30.5, 5-2.3, and will review hoist usage categories on a periodic basis. A Qualified Inspector should perform all maintenance and inspections.

- For hoists in occasional use, less than 10 hours per month, API RP 2D recommends a pre-use inspection and an annual 12-month inspection based on average use over a quarter.
- For hoists in moderate use, more than 10 but less than 50 hours per month, API RP 2D recommends a pre-use inspection, quarterly inspection, and an annual 12-month inspection based on average use over a quarter.
- For hoists in heavy use, more than 50 hours per month, API RP 2D recommends a pre-use inspection, monthly inspection, quarterly inspection, and an annual 12-month inspection.

### Oil Level Maintenance

The oil level in the gearbox and brake housing be checked and adjusted as part of the pre-use inspection. If the oil level drops frequently or oil leakage is detected during an inspection, maintenance should be performed to correct any problems.

### Oil Change Interval

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.

### 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 11-1) 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 11-1), 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.

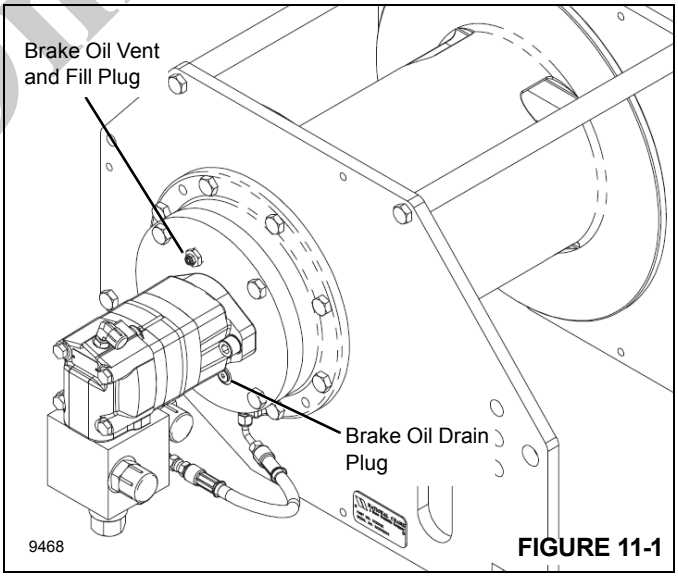



**FIGURE 11-1**

## Hoist Gearbox Oil

### *Hoist Gearbox Oil Change*

Gearbox oil is drained by first removing the drain plug (*33,* Figure 11-2) 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 in 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 EP-90 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*, page 11-5. *See Recommended Oil*, page 11-6 *for recommended oil type and grade for your application*.

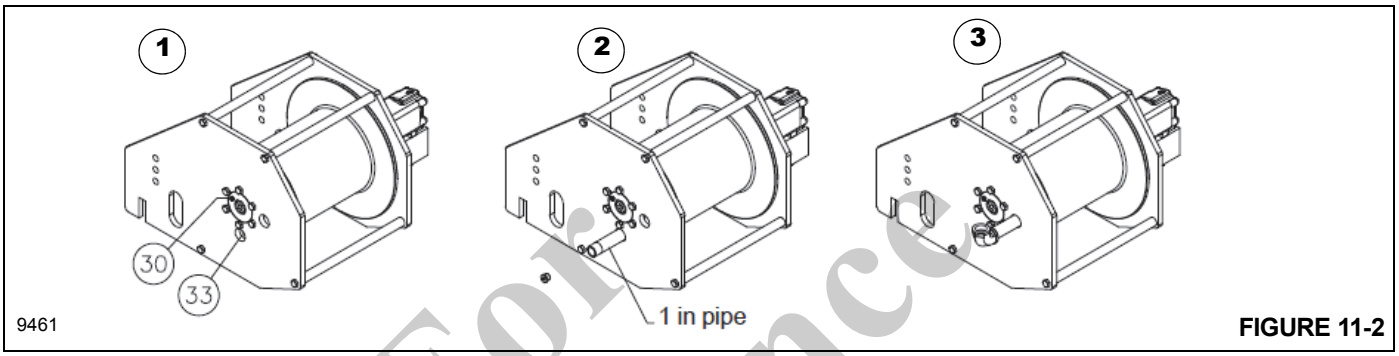



**FIGURE 11-2**

## RECOMMENDED OIL

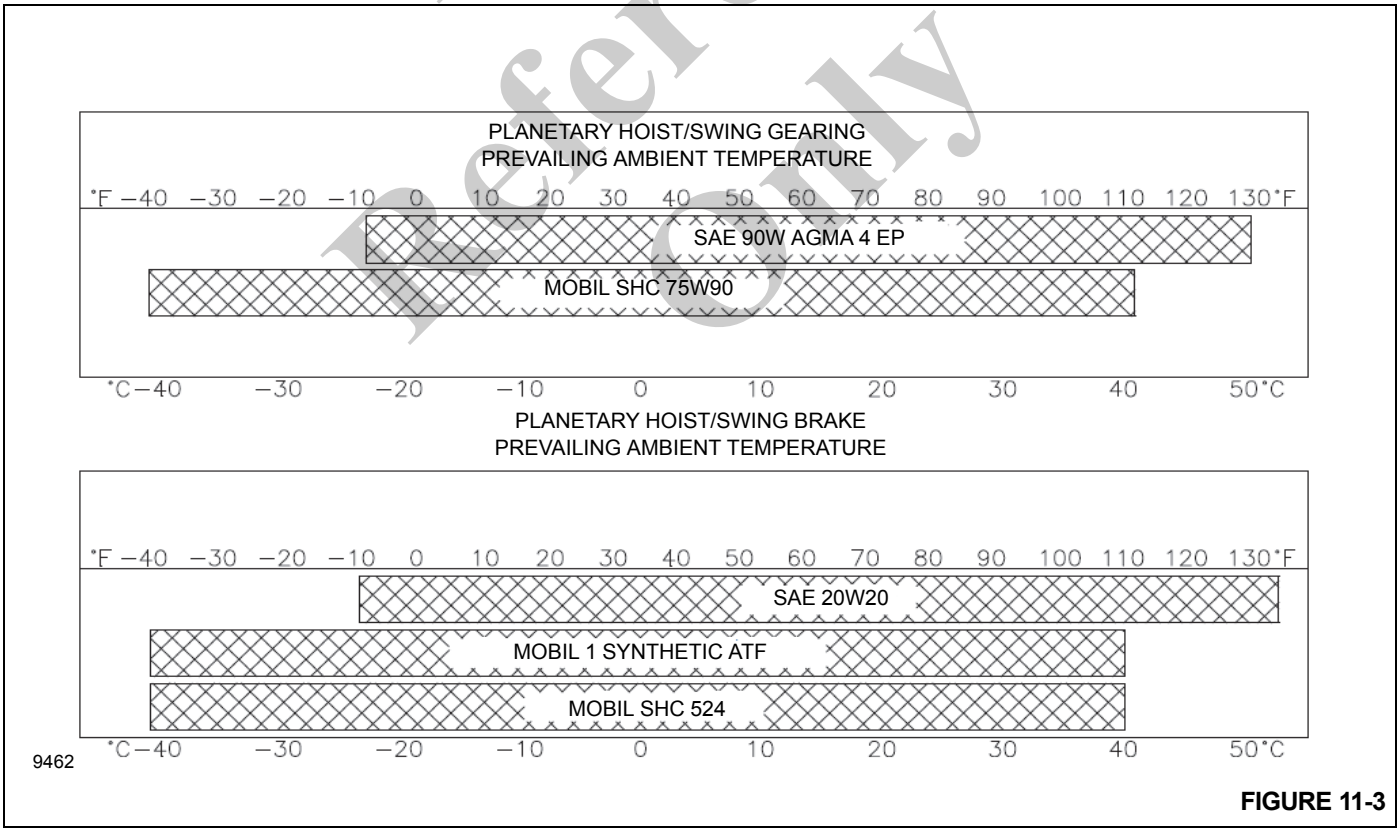



**FIGURE 11-3**

**NOTE:** All oils must meet MIL-PRF2105E. Substitution from a reputable manufacturer is allowed as long as type and grade are maintained.

| OIL CAPACITY | |
|---|---|
| GEARBOX | 1.42 liter (1.50 qt) |
| BRAKE | 0.23liter (0.25 qt) |

**WARNING**

Do not use EP type gear lubes in the brake section of this hoist. EP lubes may prevent the clutch from locking up, which, in turn causes the load to fall, resulting in property damage, personal injury, or death.

The hydraulic system should use only high quality hydraulic fluid from reputable suppliers. These oils should contain additives to prevent foaming and oxidation in the system. All hoist hydraulic systems should be equipped with a return line filter capable of filtering 10 micron particles from the system.

Hoists are shipped from the factory with SAE 90 Extreme Pressure (EP) gear lube in the gearbox and lightweight non-EP oil in the brake section. This oil and gear lube should be satisfactory for operation in ambient temperatures from -10°F (-23°C) to +130°F (+55°C).

## DISASSEMBLY

1. Drain the oil from the gearbox and brake sections using the instructions in *Hoist Brake Oil*, page 11-5 and *Hoist Gearbox Oil*, page 11-6.
2. Stand the hoist on its end with the motor pointing up.
3. Disconnect the hose (46) connected to the brake housing (21). Remove the motor and counterbalance valve assembly from the hoist by removing two capscrews (51) and washers (52). See *Servicing the Motor*, page 11-10 for motor and counterbalance valve disassembly.
4. Remove the brake subassembly from the hoist by removing eight capscrews (9) holding the brake housing to the side plate (1). Reinstall two of these capscrews into the two extra tapped holes and tighten them evenly until the brake housing comes loose from the side plate. See *Servicing the Brake*, page 11-11 for brake repair.
5. Remove the side plate (1) by removing four capscrews (2).
6. Lift the bearing carrier (26) out of the drum (5). Inspect the bearing (28) for signs of pitting or spalling and if necessary, replace the bearing and seal (7-4).
7. Remove the thrust washer (6) and input sun gear (8) from the input planet gearset (36). Inspect for damage and replace if needed.
8. Remove the input planet gearset (36) from the drum. Inspect the gearset for wear and repair as needed. See *Servicing the Planetary Sets*, page 11-12 for disassembly and repair.
9. Remove the thrust washer (6) and output sun gear (16). Inspect for damage and replace if needed.
10. Remove the output planet gearset (4) from the drum (5). Inspect the gearset for wear and repair as needed. See *Servicing the Planetary Sets*, page 11-12 for disassembly and repair.
11. Remove the drum (5) by lifting straight up and off of the output shaft (32). Inspect the gear teeth for excessive wear and replace if necessary. Inspect the bearing (28) for signs of spalling or pitting and, if necessary, replace the bearing and seal (7-4).
12. Inspect the retaining ring (3) on the output shaft to ensure that it is still in the groove and is not bent, and replace if necessary.
13. Inspect the output shaft (32) for wear or damage and, if necessary, remove it from the side plate (50) by removing six capscrews (9).

## ASSEMBLY

1. Thoroughly clean all parts. Replace those that show wear or damage.
2. Inspect the drum (5) for structural integrity and the gear teeth for excessive wear, then replace if necessary.
3. Attach the output shaft (32) to the side plate (50) with six capscrews (9), making sure the vent (30) is oriented properly, then torque them to specification (see *Hoist Torque Specifications Chart*, page 11-15).
4. Install the retaining ring (3) onto the output shaft (32).
5. Attach the rods (43) to the side plate (50) with four capscrews (2). Torque to specification (see *Hoist Torque Specifications Chart*, page 11-15).
6. If necessary, install a new bearing (28) and oil seal (7-4) into the drum.
7. Lay the unit down so that the rods (43) are pointing up. Set the drum (5) onto the output shaft (32) being careful not to damage the seal (7-4), seating the drum on the bearing (28).
8. Install the output planet gearset (4) into the drum (5), making sure it's installed correctly onto the output shaft (32).
9. Put a light coating of grease on the thrust washer (6) to keep it in place. Install the thrust washer into the output gearset (4), and then insert the output sun gear (16). The slot in the sun gear must be installed facing the output shaft.

10. Install the input planet gearset (36) into the drum (5), making sure it's installed correctly onto the output sun gear (16).
11. Put a light coating of grease on the thrust washer (6) to keep it in place. Install the thrust washer into the input gearset (36), and then insert the input sun gear (8).
12. Install a new o-ring (7-10) and, if necessary, a new bearing (28) and seal (7-4) into the bearing carrier (26). Grease the o-ring and seal and install the bearing carrier into the drum.
13. Position the side plate (1) on top of the rods (43). Attach the side plate with four capscrews (2). Torque to specification (see *Hoist Torque Specifications Chart*, page 11-15).
14. Install the brake subassembly into the side plate (1), making sure that the pilot of the brake housing (21) aligns with the bearing (28) and seal (7-4) in the bearing carrier (26) and that the holes for the motor are in the correct orientation. Also, make sure that the level and vent plugs in the cover are properly oriented. Install eight capscrews (9) and torque them to specification (see *Hoist Torque Specifications Chart*, page 11-15).
15. Install a new o-ring (7-2) on the face of the motor and re-install the motor/counterbalance valve assembly. Install two capscrews (51) and washers (52) and torque them to specification (see *Hoist Torque Specifications Chart*, page 11-15).
16. Reconnect the hose (46) to the brake housing (21).
17. Fill both the gearbox and the brake section with the proper amount and type of lubricants as instructed in the *Recommended Oil*, page 11-6.

## 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.

1. Position the cable over the boom nose sheave and route to the hoist drum.
2. Position the hoist drum with the cable anchor slot on top.
3. Insert the cable through the slot and position around the anchor wedge (1) Figure 11-4.

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

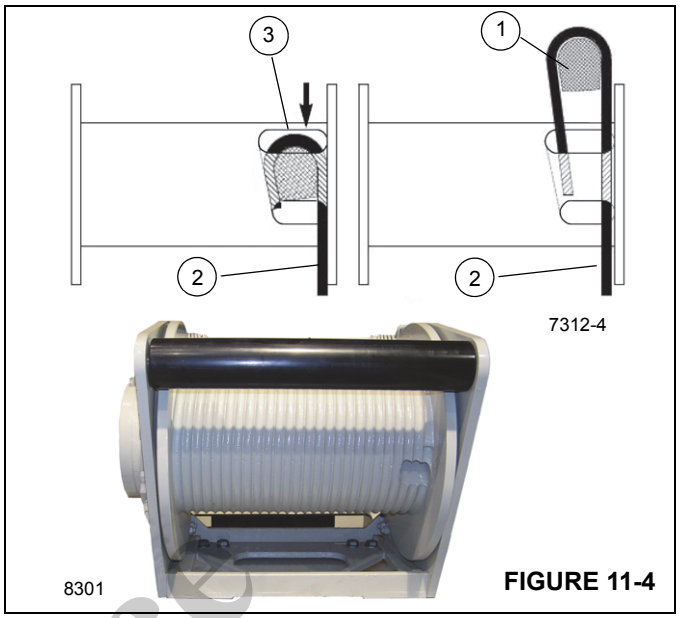



**FIGURE 11-4**

4. 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.


5. Slowly rotate the drum, ensuring the first layer of cable is evenly wound onto the drum.
6. Install the remainder of the cable, as applicable.

### 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 *Hoist Cable Inspection and Maintenance*, page 3-3 for wire rope procedures.
3. Make sure the live-end (Figure 11-5) 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.

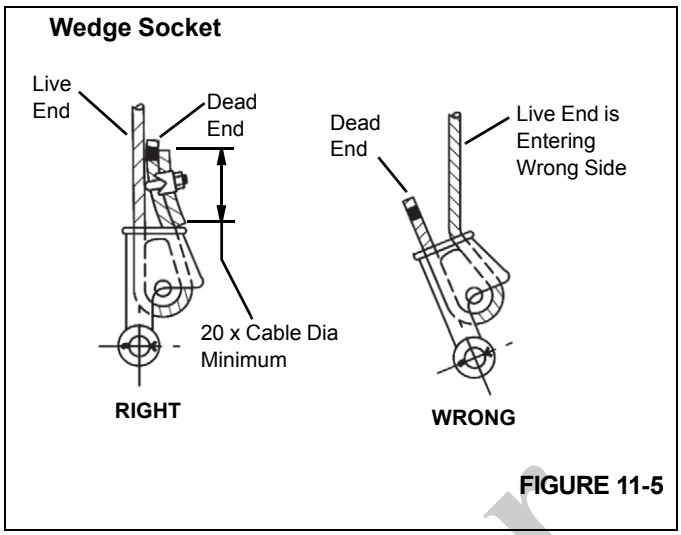



FIGURE 11-5

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 11-5) to protrude from the socket. Ensure the dead-end of the rope is of sufficient length to apply end treatment to the dead-end after the wedge has been seated.
5. Insert the wedge into the loop and pull the live-end of the rope until the wedge and rope are snug inside the socket. It is recommended that the wedge be seated inside the socket to properly secure the wire rope by using the crane's hoist to first apply a light load to the live-end.
6. After final pin connections are made, increase the loads gradually until the wedge is properly seated.
7. The wire rope and wedge must be properly secured inside the socket before placing the crane into lifting service. It is the wedge that secures the wire rope inside the socket. The dead-end treatment is used to restrain the wedge from becoming dislodged from the socket should the rope suddenly become unloaded due to the headache ball or hook block striking the ground, etc; refer to *Dead-end Rigging*, page 11-9.

## Dead-end Rigging

Sketches A through F (Figure 11-6) 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.

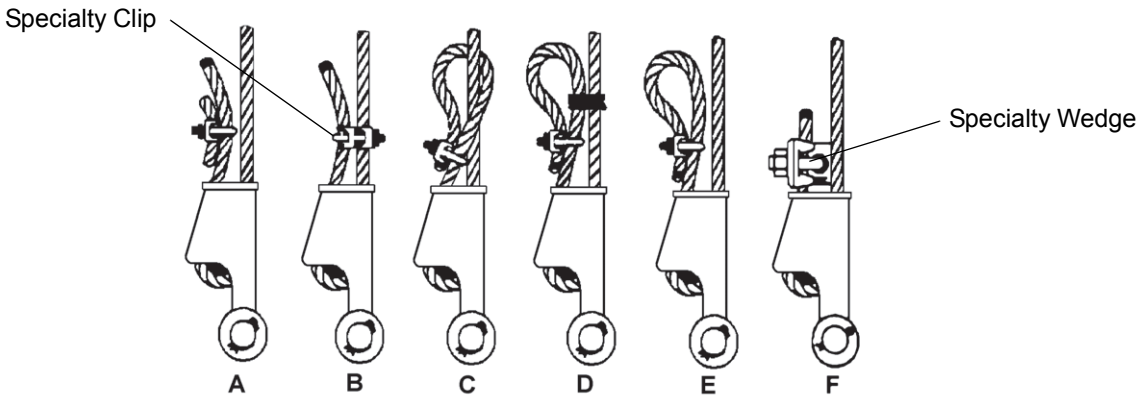
Of the methods shown below, National Crane prefers that method A or F be used, i.e., clipping a short piece of wire rope to the dead-end or using a commercially available specialty wedge. Typically, it is recommended that the tail length of the dead-end should be a minimum of 6 rope diameters but not 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 11-1).

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 11-1

| 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 11-6**

## SERVICING THE MOTOR

1. Remove the hose (46, Figure 11-7) and counterbalance block (42) from the motor assembly.
2. Remove the counterbalance valve (58) from the block (42) and inspect the small metering hole located on the side of the valve to make sure it is not obstructed. Also, inspect the o-rings for damage and replace if necessary.
3. Motors and counterbalance valves are not serviceable in the field. Return them to an authorized National Crane distributor for service.



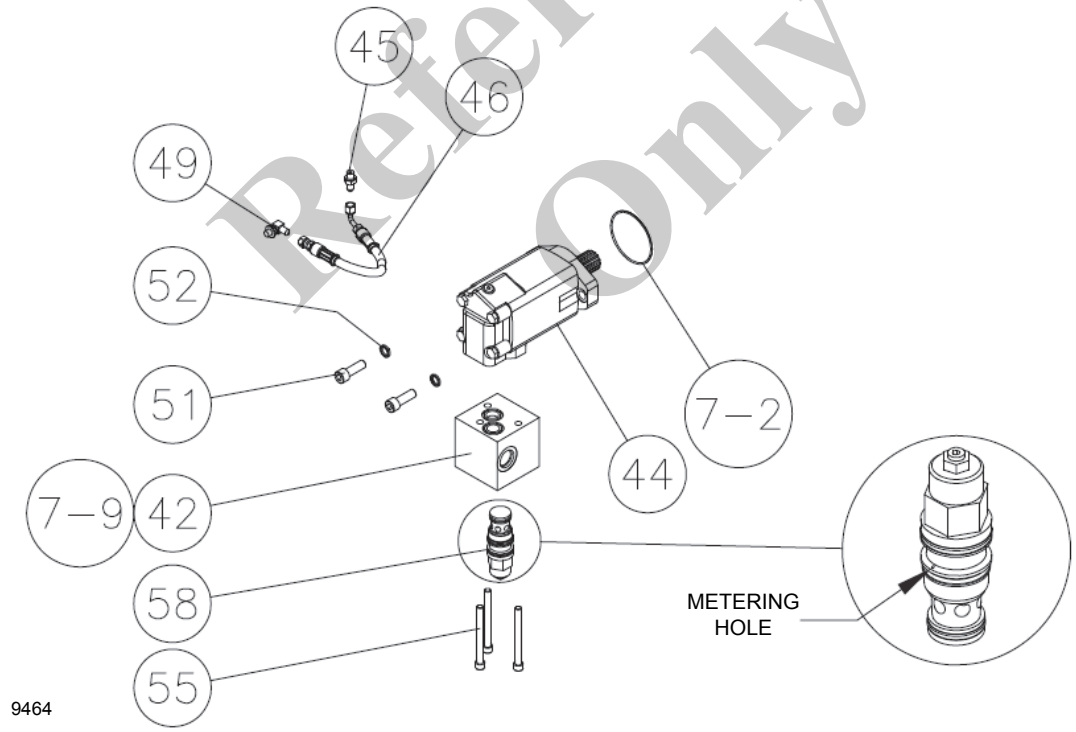



**FIGURE 11-7**

## SERVICING THE BRAKE

1. Evenly remove the four capscrews (11, Figure 11-8) holding the brake cover (20) in place. Spring pressure will raise the cover as the capscrews are loosened. Remove the cover from the brake housing.
2. Remove the springs (24) from the piston and check the free height. Each spring should measure at least 1.200 in with no force on them.
3. Remove the brake piston (10) by installing two pieces of 3/8 in-16NC all-thread in the bottom of two spring pockets. Using jam nuts, screw the all-thread pieces in evenly until the piston is clear of the housing. An alternate way of removing the piston is to use a portable power unit or shop air to slowly pressurize the brake cavity until the piston is out of the bore.
4. Remove the brake driver/clutch assembly (13, 14, 15, 17, 34, and 38) from the brake housing (21).
5. Remove the stator plates (19) and friction discs (18) from the brake housing and check them for excessive wear, then replace if necessary. Additionally, check the top stator plate for scoring caused by the removal tools and polish if necessary. Friction discs should measure no less than 0.055 in thick and stator plates should measure no less than 0.064 inches thick.
6. If necessary, with a hook wire or pry bar, remove the seal (7-5) from the brake housing.
7. Examine the bushing (39) in the brake housing for wear and, if worn, replace it.
8. If the brake housing (21) is removed from the hoist, examine the journal on the brake housing where the seal (7-4) runs for wear. If severely worn, replace the brake housing.
9. Carefully disassemble the brake driver/clutch and note the side in which the markings on the clutch (34) are facing. The clutch assembly must be re-assembled with the markings facing the proper direction in order for the hoist to function properly. Inspect the surface on the input and brake drivers (13 & 38) where the clutch (34) runs. If there is any pitting or spalling on the drivers then both it and the clutch must be replaced.
10. Re-assemble the driver/clutch assembly, making sure that the clutch is installed properly.
11. Install a new seal (7-5) into the brake housing. If the brake housing is removed from the hoist, temporarily install the input sun gear (8) into the brake housing and slide the driver/clutch assembly onto the sun gear spline.
12. Install the stator plates (19) and friction discs (Item 18) into the brake housing starting with a stator and alternating friction discs and stator plates. There is one more stator plate than friction disc so you will finish with a stator plate.
13. Coat the new o-rings and backup rings (7-1, 7-6, 7-7, & 7-8) with light oil and install onto the piston (10). See Figure 11-8 for proper o-ring/backup ring installation.
14. Carefully install the piston (10) into the brake housing (21) and gently tap it down until it is seated.
15. Install the springs (24) into the spring pockets of the piston. If working in a horizontal position, coat the bottom of each spring with chassis lube to keep it in position.
16. Coat the new o-ring (7-3) with light oil and install it into the groove on the brake cover (20).
17. Install the cover (20) onto the brake housing (21) and draw it down evenly, alternating between opposite capscrews (11). Make sure that the cover is aligned properly with the brake housing in order to correctly orient the motor and vent/drain plugs.
18. Check the brake release with a portable hydraulic pump. Full release should be obtained at 225 PSI ±10%.

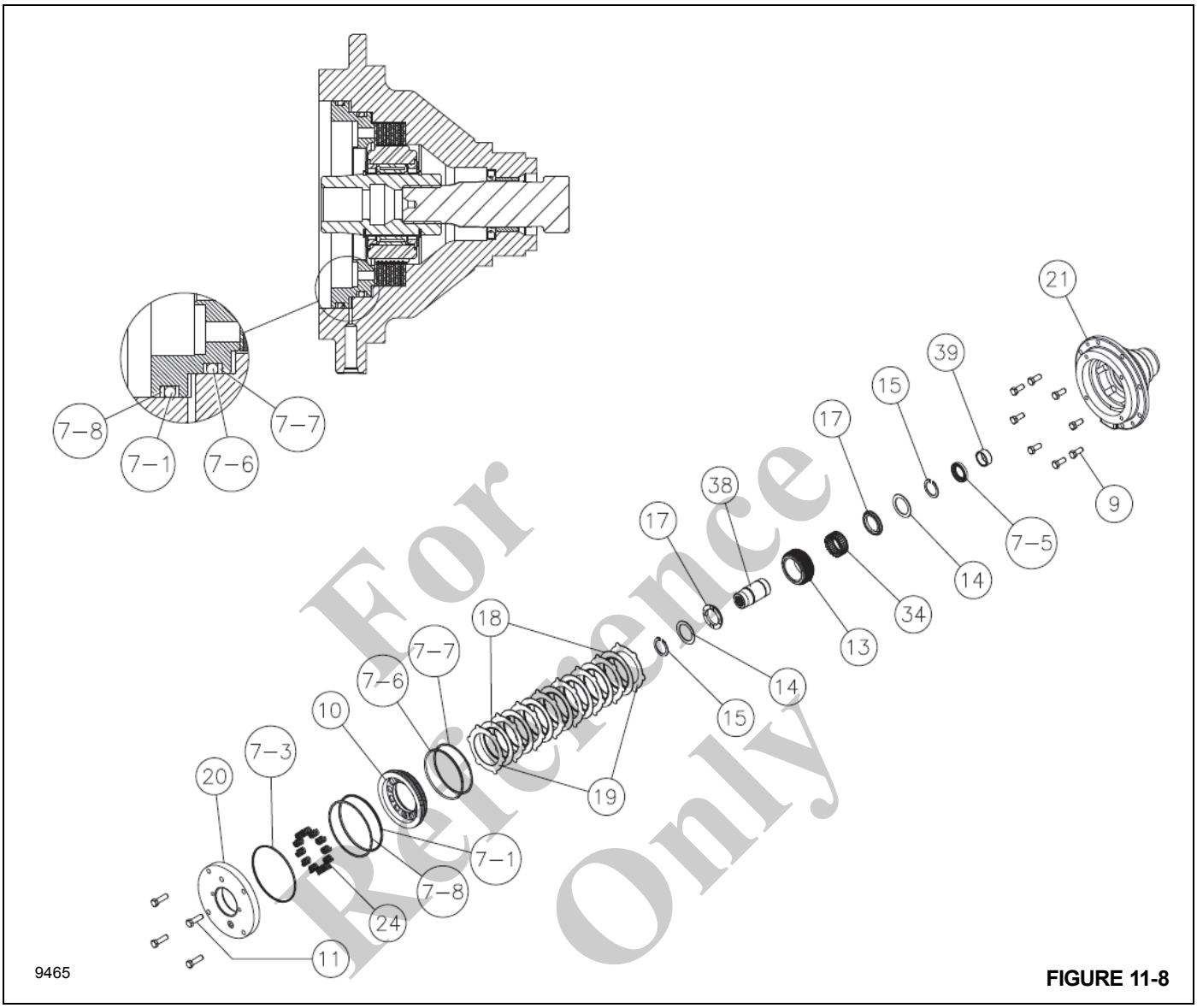



FIGURE 11-8



## SERVICING THE PLANETARY SETS

1. Remove the retaining rings from the planet pins.
2. Remove the pins from the carrier by carefully tapping them out.
3. Remove the planet gears, washers and bearings from the carrier.
4. Inspect the pins, bearings, and gear bores for evidence of wear and replace if necessary.
5. On output planet gearsets, note that two bearings with a spacer between them are used.
6. Before reassembly, be sure to insert the thrust plate into the carrier.
7. To reassemble, be careful to line up the planet pins with the washers and bearings then press the knurled part of the pin into the carrier. If the pins are not lined up properly, the washers can be shattered during the pressing operation.
8. Replace the retaining rings onto the planet pins.

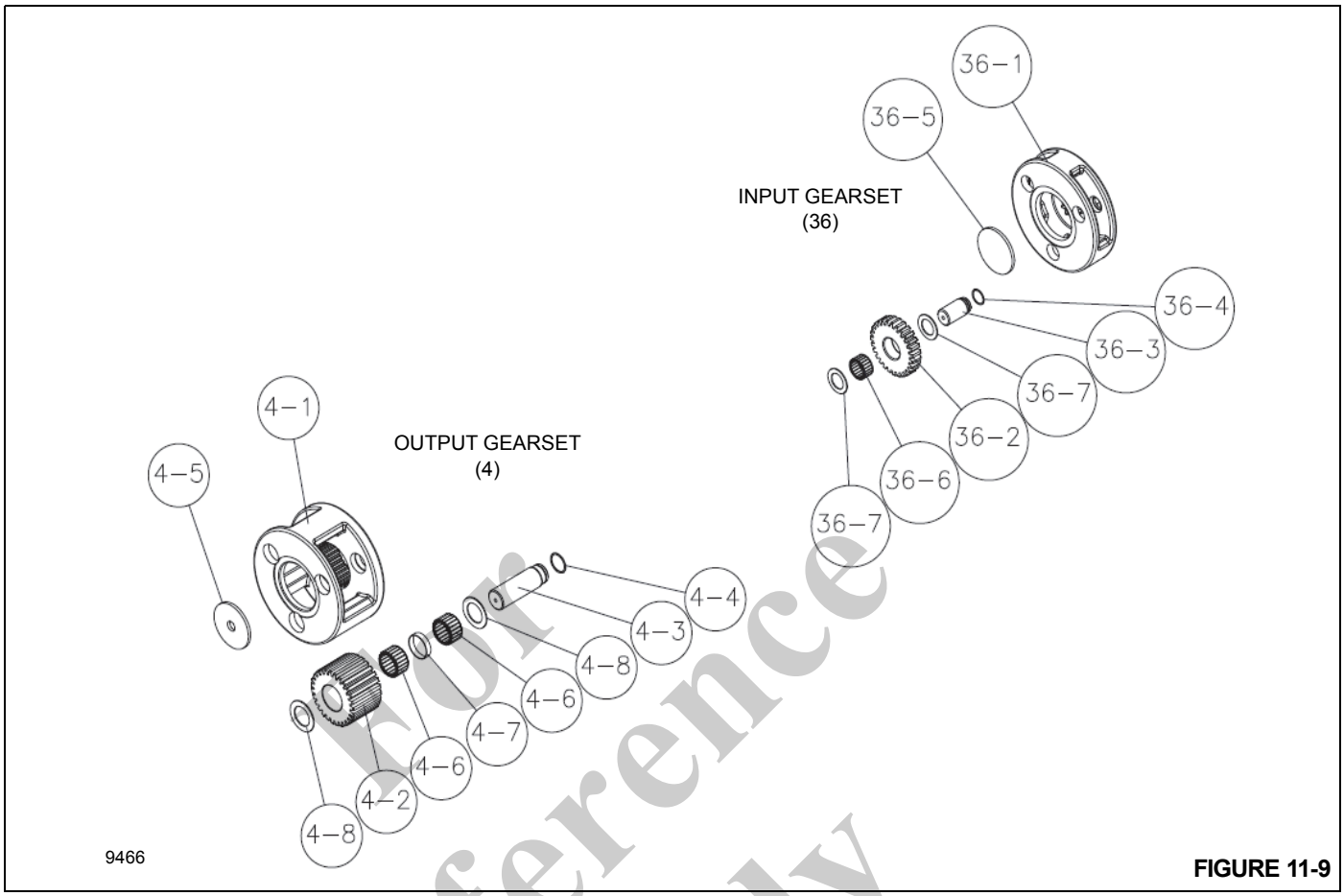



FIGURE 11-9

## TROUBLESHOOTING

### Hoist won't hold load

#### *Possible Solutions:*

1. There is excessive back pressure in the hydraulic system. Check the system for line restrictions and reduce the back pressure.
2. The brake discs are worn. Replace the brake discs. Friction discs should measure no less than 0.055 in thick and the stator plates should measure at least 0.068 in thick.
3. The brake clutch is slipping due to wear of either driver and/or clutch. Inspect the driver components for wear and replace if necessary.

### Hoist unable to lift load

#### *Possible Solutions:*

1. The relief valve setting may be too low to allow proper lifting. Increase the relief pressure setting.
2. The load being lifted may be more than the hoists rating. Verify weight and reduce the load or re-rig it to increase mechanical advantage.

### Hoist unable to lower load

#### *Possible Solutions:*

1. The counterbalance valve cartridge may have a plugged metering hole (see Figure 11-7 for location of metering hole). Remove the cartridge and clean it.

### Oil leaks from motor-side vent

#### *Possible Solutions:*

1. The motor shaft seal may have failed. Replace the seal and reduce the back pressure if that was a cause of the seal failure.
2. The brake pistons o-ring seals may have failed. Service the brake section and replace any worn parts found.

## HOIST TORQUE SPECIFICATIONS CHART

i

| Nominal | Size | Dry SAE Grade 5 Torque *(lb-ft) | Plated SAE Grade 5 Torque *(lb-ft) | Lubricated SAE Grade 5 Torque *(lb-ft) | Dry SAE Grade 8 Torque *(lb-ft) | Plated SAE Grade 8 Torque *(lb-ft) | Lubricated SAE Grade 8 Torque *(lb-ft) |
|---|---|---|---|---|---|---|---|
| **1/4** | **20** | **8** | **6** | **5** | **12** | **9** | **7** |
| **1/4** | **28** | **10** | **7** | **6** | **14** | **10** | **8** |
| **5/16** | **18** | **17** | **13** | **10** | **25** | **18** | **15** |
| **5/16** | **24** | **19** | **14** | **11** | **27** | **20** | **16** |
| **3/8** | **16** | **31** | **23** | **19** | **44** | **33** | **26** |
| **3/8** | **24** | **35** | **26** | **21** | **49** | **37** | **30** |
| **7/16** | **14** | **49** | **37** | **30** | **70** | **53** | **42** |
| **7/16** | **20** | **55** | **41** | **33** | **78** | **58** | **47** |
| **1/2** | **13** | **76** | **57** | **45** | **106** | **80** | **64** |
| **1/2** | **20** | **85** | **64** | **51** | **120** | **90** | **72** |
| **9/16** | **12** | **109** | **82** | **65** | **153** | **115** | **92** |
| **9/16** | **18** | **122** | **91** | **73** | **172** | **129** | **103** |
| **5/8** | **11** | **150** | **113** | **90** | **212** | **159** | **127** |
| **5/8** | **18** | **170** | **128** | **102** | **240** | **180** | **144** |
| **3/4** | **10** | **266** | **200** | **160** | **376** | **282** | **226** |
| **3/4** | **16** | **297** | **223** | **178** | **420** | **315** | **252** |
| **7/8** | **9** | **430** | **322** | **258** | **606** | **454** | **364** |
| **7/8** | **14** | **474** | **355** | **284** | **668** | **501** | **401** |
| **1** | **8** | **644** | **483** | **386** | **909** | **682** | **545** |
| **1** | **14** | **721** | **541** | **433** | **1019** | **764** | **611** |
| **1 1/8** | **7** | **794** | **596** | **475** | **1288** | **966** | **772** |
| **1 1/8** | **12** | **890** | **668** | **534** | **1444** | **1083** | **866** |
| **1 1/4** | **7** | **1120** | **840** | **672** | **1817** | **1363** | **1090** |
| **1 1/4** | **12** | **1241** | **930** | **745** | **2012** | **1509** | **1207** |



T = BOLT TORQUE (lb-ft)**T = (KWD) / 12**

K = TORQUE COEFFICIENT**(K = 0.20 DRYK = 0.15 PLATEDK = 0.12 LUBRICATED)**

W = PRELOAD TENSION

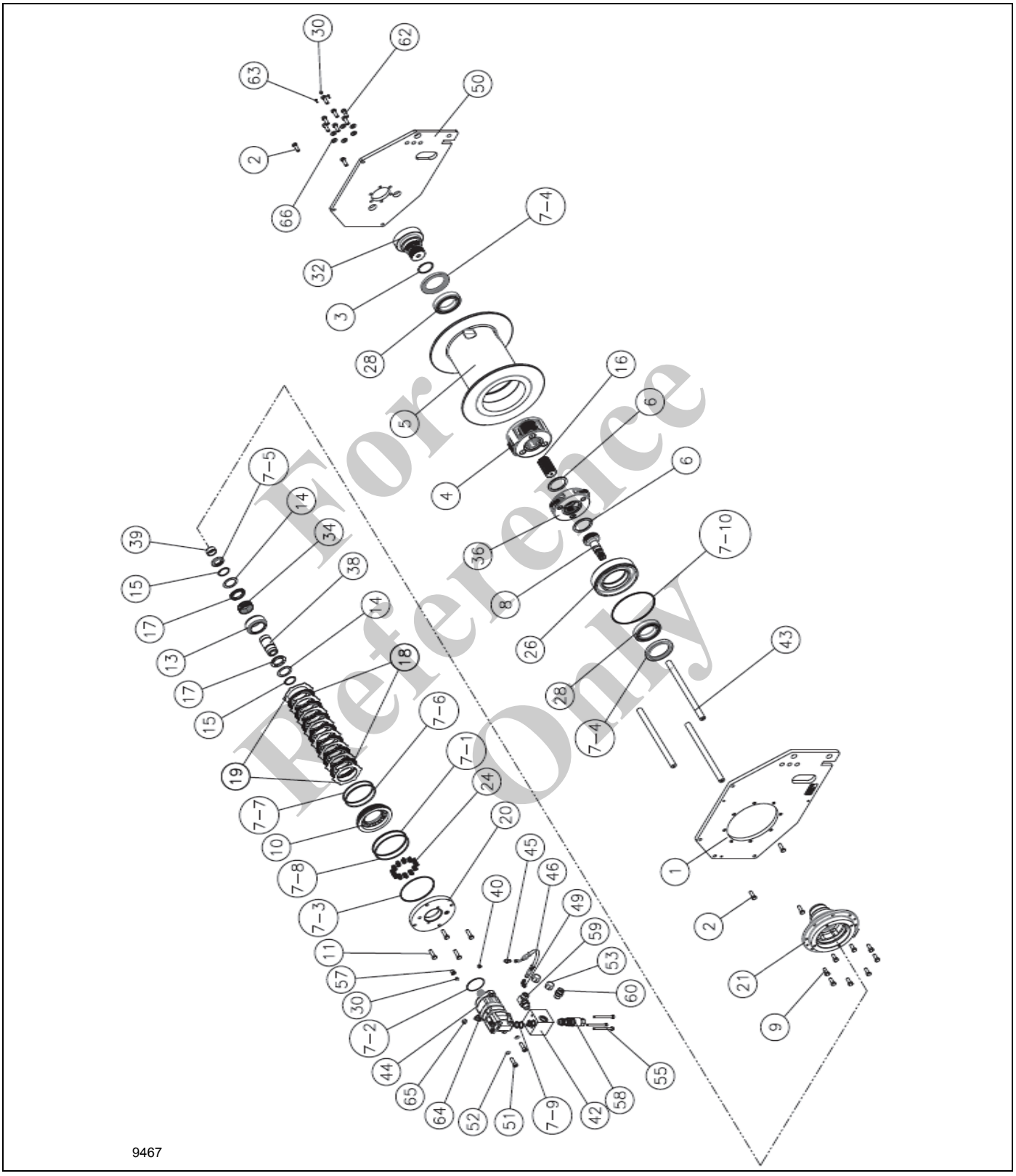
D= NOMINAL BOLT SIZE (IN)***ALL TORQUE VALUE TOLERANCES ARE ± 5%**

## BILL OF MATERIAL

| SEQ | | QTY | | DESCRIPTION |
|---|---|---|---|---|
| **1** | | 1 | | SIDE PLATE |
| **2** | | 8 | | CAPSCREW |
| **3** | | 1 | | RETAINING RING |
| **4** | | 1 | | OUTPUT GEARSET |
| 4-1 | | 1 | | CARRIER |
| 4-2 | | 3 | | OUTPUT PLANET GEAR |
| 4-3 | | 3 | | PLANET PIN |
| 4-4 | | 3 | | RETAINING RING |
| 4-5 | | 1 | | THRUST PLATE |
| 4-6 | | 6 | | BEARING |
| 4-7 | | 3 | | SPACER |
| 4-8 | | 6 | | WASHER |
| **5** | | 1 | | DRUM |
| **6** | | 2 | | RACE |
| **7** | | 1 | | SEAL KIT |
| 7-1 | | 1 | | O-RING |
| 7-2 | | 1 | | O-RING |
| 7-3 | | 1 | | O-RING |
| 7-4 | | 2 | | OIL SEAL |
| 7-5 | | 1 | | OIL SEAL |
| 7-6 | | 1 | | O-RING |
| 7-7 | | 1 | | BACKUP RING |
| 7-8 | | 1 | | BACKUP RING |
| 7-9 | | 2 | | O-RING |
| 7-10 | | 1 | | O-RING |
| **8** | | 1 | | INPUT SUN GEAR |
| **9** | | 14 | | CAPSCREW |
| **10** | | 1 | | BRAKE PISTON |
| **11** | | 4 | | CAPSCREW |
| **13** | | 1 | | BRAKE DRIVER |
| **14** | | 2 | | RACE |
| **15** | | 2 | | RETAINING RING |
| **16** | | 1 | | OUTPUT SUN GEAR |
| **17** | | 2 | | BUSHING |
| **18** | | 7 | | FRICTION DISC |
| **19** | | 8 | | STATOR PLATE |
| **20** | | 1 | | BRAKE COVER |
| **21** | | 1 | | BRAKE HOUSING |
| **24** | | 12 | | BRAKE SPRING |
| **26** | | 1 | | BEARING CARRIER |
| **28** | | 2 | | BEARING |

| SEQ | | QTY | | DESCRIPTION |
|---|---|---|---|---|
| **30** | | 2 | | BREATHER |
| **31** | | 1 | | O-RING PLUG |
| **32** | | 1 | | SHAFT |
| **33** | | 1 | | O-RING PLUG |
| **34** | | 1 | | CAM CLUTCH |
| **36** | | 1 | | INPUT GEARSET |
| 36-1 | | 1 | | CARRIER |
| 36-2 | | 3 | | PLANET GEAR |
| 36-3 | | 3 | | PLANET PIN |
| 36-4 | | 3 | | RETAINING RING |
| 36-5 | | 1 | | THRUST PLATE |
| 36-6 | | 3 | | BEARING |
| 36-7 | | 6 | | WASHER |
| **38** | | 1 | | INPUT DRIVER |
| **39** | | 1 | | BUSHING |
| **40** | | 1 | | O-RING PLUG |
| **42** | | 1 | | COUNTERBALANCE BLOCK |
| **43** | | 4 | | SUPPORT ROD |
| **44** | | 1 | | HYDRAULIC MOTOR |
| **45** | | 2 | | STRAIGHT ADAPTER |
| **46** | | 1 | | HOSE ASSEMBLY |
| **49** | | 1 | | 90 DEGREE ADAPTER |
| **50** | | 1 | | SIDE PLATE |
| **51** | | 2 | | CAPSCREW |
| **52** | | 2 | | LOCKWASHER |
| **55** | | 3 | | CAPSCREW |
| **57** | | 1 | | BUSHING |
| **58** | | 1 | | COUNTERBALANCE VALVE |

## EXPLODED ISOMETRIC ASSEMBLY DRAWING



# SECTION 12
# SCHEMATICS

For your convenience, the latest version of schematics available at the time of printing are placed in this section.

## Alphabetical Index