IPT's CRANE and RIGGING TRAINING MANUAL

RONALD G. GARBY

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by

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SECTION ONE

RIGGING

Wire Rope Parts

Wire rope is typically made of steel wires laid together to form a strand, as shown in Illustration #1. These strands are formed into a rope, usually around a central core of either fiber or wire.

Illustration #1 — Wire Rope Parts

Fiber core and wire core strands are shown in Illustrations #2A and B. However, new types of wire rope designed for specific purposes are being developed.

Compacted strands are shown in Illustration #2C and flattened strands in Illustration #2D.

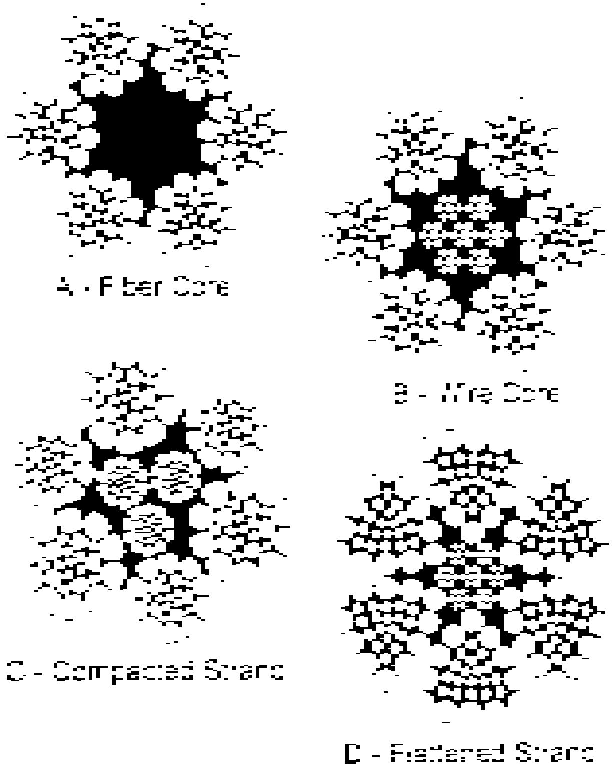

Illustration #2 - Strand Types

Fiber Core

A fiber core is composed of vegetable fiber (manila, sisal, or jute), or a synthetic fiber such as polypropylene. The synthetic fibers offer better resistance to deterioration.

During manufacture the fiber core is impregnated with lubricant, which is released during rope use and helps keep the wires lubricated. A fiber core also helps to cushion the strands during operation.

Wire Core

IWRC is the abbreviation for independent wire rope core. This core, which is actually another strand (and can be called a mini-rope with its own strands and core), has several advantages over the fiber core. It adds about 7 1/2% in strength, and helps resist rope crushing. In an extremely hot working environment a wire core is a requirement as a fiber core might burn or char.

Wire Rope Construction

Wire rope is made up of pre-formed strands. This pre-forming gives the rope strands an equal load distribution, and it helps prevent unravelling when the rope is cut.

The number of strands, number of wires per strand, type or quality of the wire material, and nature of the core will depend on the end use of the wire rope.

A wire rope, with many smaller wires and strands, is more flexible than rope with large diameter wires and fewer strands. Wire rope that is used with sheaves and drums should have a sufficient number of strands to be flexible enough to bend around the sheaves and drums.

The main considerations in the design and construction of wire rope are to impede the conditions that contribute to corrosion, over-tension, wear, crushing, and rotation. The result is many types and sizes of wire rope, with new rope designs continually coming on the market.

Wire Rope Grades

Wire rope manufacturers have many different grades to meet the varying demands for strength and toughness.

Grade 120/130 and 130/140 Extra Extra Improved Plow (EEIPS)

This rope is used when special installations require maximum rope strength, such as mine shaft hoisting. (About 10% stronger than Extra Improved Plow).

Grade 115/125 Extra Improved Plow (EIPS)

This rope is used when the need for higher breaking strength is required. The bending quality of this rope is not as good as Improved Plow (about 15% stronger than Improved Plow).

Grade 110/120 Improved Plow (IPS)

This is the most commonly used wire rope. It has good wear resistance, a high fatigue factor and high tensile strength.

Grade 100/110 Plow

Has lower tensile strength but can be used when strength is secondary to wear resistance.

Grade 90/100 Mild Plow

This rope has high fatigue resistance but is lower in tensile strength. Applications for this rope are limited.

Galvanized Finish

Most wire rope manufacturers supply all grades of rope with several types of galvanized finish. Each type of galvanizing has limits concerning wire diameter and also tensile strength. These limits are often not shown in catalogues due to the changes and improvements with research and new technology.

Corrosion Resistant Wires

Chromium-nickel steel alloyed ropes are usually made of type 302 or type 305 alloy. Both types have military applications.

Phosphor Bronze and Copper Wires

These limited use ropes are corrosion resistant and non-sparking. Their applications are in hazardous industrial plants and marine use.

Note: Check the applicable local authority for wire rope standards pertaining to elevators for construction, repair, and/or rope replacement.

Wire Rope Lays

The term lay refers to the direction of winding of both the wires in the strands and to the actual rope strands. The term also applies to the actual design, of which there are two basic types. These are Regular Lay and Lang Lay, as indicated in illustrations #3 and #5. These in turn can be either right lay, left lay, or a combination. Right or left lay is determined by the rotation of the strands as they recede from the observer. Most wire rope is manufactured right lay.

Regular Lay

The wires in the strands are laid in one direction, while the strands in the rope are laid in the opposite direction. Therefore the wires are able to withstand considerable crushing and distortion due to the short length of exposed wires. See illustrations #3 and #4.

Illustration #3 - Right Regular Lay

Illustration #4 – Left Regular Lay

Lang Lay

The wires in the strands, and the strands in the rope, are laid in the same direction. Lang Lay rope should not be used for single part hoisting due to its tendency to unwind or unravel. Its biggest advantage is its resistance to abrasion. See illustrations #5 and #6.

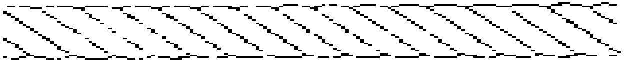

Illustration #5 – Right Lang Lay

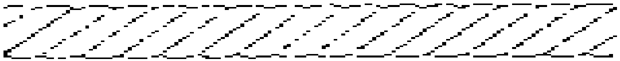

Illustration #6 – Left Lang Lay

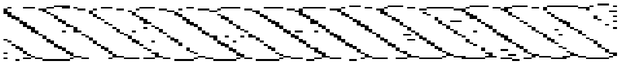

Illustration #7 – Right Alternate Lay

Illustration #7 shows a right lay rope made of alternating strands of right regular lay and right lang lay.

Rotation-Resistant

There are several categories of this type of rope, but basically the outer layer and the inner layer of strands are laid in the opposite direction. The opposing torque from the right hand lay and the left hand lay helps to prevent rope rotation under load. See illustration #8.

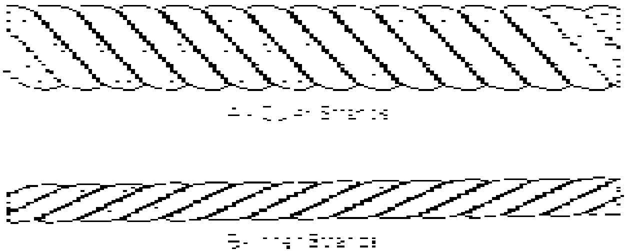

Illustration #8 – Rotation-Resistance

Strand Classification

Strands are grouped according to the number of wires per strand. The number of wires and the pattern defines the rope's characteristics. The wires in the strands can all be the same size or a mixture of sizes.

There are many different strand pattern design classifications. Table #1 shows four common wire rope classifications. In all cases the number of strands is given, followed by the number of wires in each strand. The wires per strand indicate that a rope may be chosen in one particular classification, 6 x 19, for example, but in that classification the individual strand could have from 15 to 26 wires depending on the use.

Table #2 shows several wire rope classifications and their common uses.

Classification	No. of Strands	Wires Per Strand
6 x 7	6	3 to 14
6 x 19	6	15 to 26
6 x 37	6	27 to 49
8 x 19	8	15 to 26

Table #1 – Wire Rope Classification Examples

Strand Examples

Seale

One layer of wires is laid over a number of small wires, with the same length and direction of lay. The wires on the outer layers are supported in the valleys between the wires of the inner layers. See illustration #9.

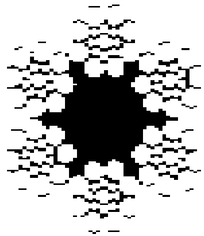

Illustration #9 – Seale

Warrington

One layer of wires is composed of alternating large and small wires. The length of lay and number of wires in each layer are equal. See Illustration #10.

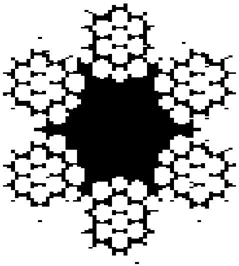

Illustration #10 – Warrington

Filler Construction

The outer wires are supported by half the number of main inner wires with an equal number of smaller filler wires. See Illustration #11.

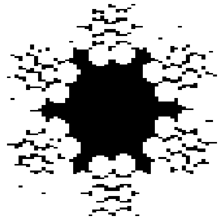

Illustration #11 – Filler

Ordinary

All the wires are the same size. See Illustration #12.

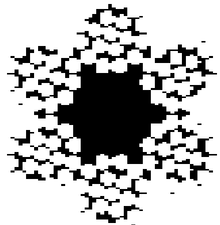

Illustration #12 – Ordinary

Strand Classification Examples

- 6 x 7 - This rope has large wires and is not very flexible but has good abrasion resistant qualities. It should be used on large diameter sheaves and on drums. It is used for permanent guy-lines, ski tows and tramways.

- 6 x 19 - This rope has the most diverse use. The wide range of wire arrangements give it excellent combinations for both flexibility and abrasive wear. There can be from 8 to 12 outer wires in each strand, and up to 26 total wires in each strand. The more wires in a strand, the more flexible the wire rope.
- 6 x 37 - This rope will have 31 to 49 wires per strand. It is the most flexible, and therefore is commonly used on high-speed cranes, multiple reeving hoists, and also power shovels and draglines. It is not commonly used where multiple drum layers are required because of the tendency for wire crushing.
- 8 x 19 - This rope is more flexible than the 6 strand rope, but has poor abrasion resistance, and it crushes and distorts easily. It is used on high-speed cranes with multiple reeving.
- 8 x 19 is available in spin-resistant designs for applications such as tower cranes where reverse bends and small sheaves exclude the use of non-rotating rope and usually require a higher design (safety) factor.

Classification	Common Use
6 x 7	Regular lay — guy lines
6 x 19	Seale, regular lay — mines, including hoists
6 x 19	Filler wire, regular lay — misc. hoists devices, cranes, tackle blocks, mine hoists, elevators
6 x 37	Regular lay — hoists traction elevators
8 x 19	Spin resistant — hoists having single line suspension

Table #2 — Common Wire Rope Uses

Rotation Resistant Wire Rope

There are a wide variety of designs available for this type of rope, and each has its benefits and drawbacks.

Several of the general classifications are: 3 strand - torque balanced, 8 strand - spin resistant, 19 strand - rotation resistant, 35 strand - non-rotating. For each classification, there are a number of strand combinations. The principle is that rope rotation is lessened, or prevented, as the inner and outer strand layers are laid in opposite directions (left lay - right lay). See illustration #13.

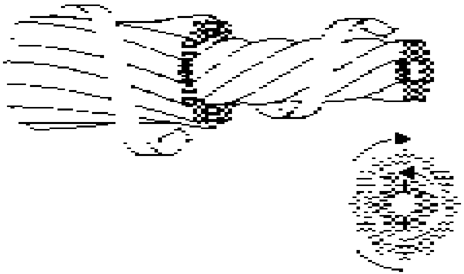

Illustration #13 – Rotation-Resistant Characteristics

The advantages of rotation resistant rope may be offset by some common disadvantages:

- More frequent inspection due to a tendency of inner wire breakage.
- Probably a lower listed strength.
- Strength affected by rotation. Rotation under load can cause rope core slippage where one layer of strands tighter (become shorter) while the other loosens (gets longer). Therefore one strand layer carries more load. See illustration #14.

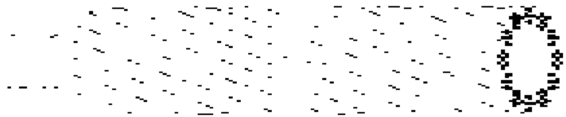

Illustration #14 – Rotation-Resistant Core Slippage

- A higher design (safety) factor needed.
- More crushing from multi-layer drum spooling.
- Check with the rope manufacturer concerning brazing or tightly seizing ends to prevent strand or core disturbance.
- Wedge sockets can cause rope core slippage due to their short bend radius.

The following precautions are also needed:

- Avoid disturbing the lay length.
- Avoid inducing twist into rope during handling and installation. Rope twist can be caused by improper fleet angle, sheave misalignment, poor spooling or improper reeving.
- Avoid high loads with small diameter sheaves.
- Maintain a tight rope on the drum by keeping tension on payoff reel when spooling.
- Break in a new rope by running it through several cycles with a light load.

Design (Safety) Factor

Note: For cranes equipped with rotation resistant wire rope, ANSI and most other safety standards and regulations require a minimum design (safety) factor of 5:1. This doubles to 10:1 when hoisting personnel. By comparison, when using IPS or EIPS (extra improved plow), the factor is 3.5:1, and 7:1 for hoisting personnel.

Some jurisdictions or companies may have a higher design factor requirement.

Many types of rotation resistant rope are rated at approximately 85% tensile strength of an equivalent size 6 x 19 improved plow rope. To be sure, check the rope being used with the manufacturers data. The combination of a higher design factor and a lower tensile strength, reduces the working load limit (SWL).

Note: Rotation resistant rope must be replaced if there are two randomly distributed broken wires in six rope diameters of length; or four randomly distributed broken wires in thirty rope diameters; or one outer wire broken at the interior contact point with the core and is protruding from the rope.

Open Swivels

Generally, the 35 strand classification is the only one where the continuous use of a swivel is satisfactory for either single or multiple part hoisting.

For safety reasons, swivels can be used for single line hoisting with 6 x 19, 19 x 7, and 19 x 19 wire rope. However they must be properly used, have an adequate design factor and be inspected daily. Swivels are sometimes used to relieve rope twist caused by installation and then removed. They can be attached periodically to relieve rope twist accumulated during operation and then removed.

Consult the Manufacturer

It is difficult to determine which type of rotation resistant rope if any may be best for single line or multiple line hoisting. Instructions from a manufacturer or distributor should be followed when selecting a rope and making end connections.

Plastic-Enhanced Wire Rope

Wire rope deterioration from broken wires has been reduced considerably in recent years by placing a layer of plastic between the outer and inner layers of strands. This eliminates or reduces the metal to metal contact produced from the rope being repeatedly bent around sheaves. Earlier types of plastic deteriorated quite quickly. However, research into new types of plastic has resulted in some rope manufacturers using a plastic that could double the number of rope usage cycles.

This enhanced plastic protects the inner strand wires while supporting and protecting the outer strand wires. See Illustration #15.

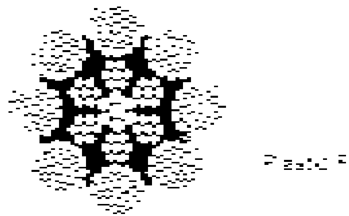

Illustration #15 – Plastic-Enhanced Wire Rope Cross Section

Drum Crushing Resistant Wire Rope

Continuous winding of wire rope on and off a drum results in excessive rope wear due to crushing from multiple layers, cross winding, and improper tensioning.

Some wire rope manufacturers have new ropes using individual specifically shaped wires and triangular shaped strands. They are designed to considerably reduce rope wear from drums and sheaves. See illustration #18.

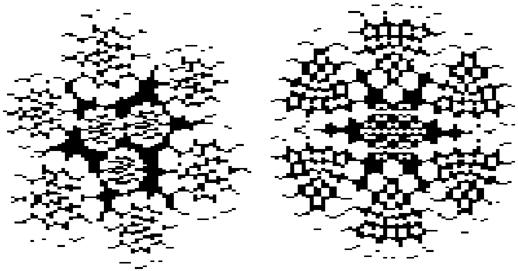

Illustration #18 – Drum Crushing Resistant Wire Rope Cross Sections

Wire Rope Inspection

Checking wire rope is one of the most important aspects of rigging equipment inspection. Inspection serves several purposes:

- it ensures safety.
- it ensures that components will be replaced only when necessary.
- and it provides advance warning before something breaks resulting in severe damage.

Problems such as wear, metal fatigue, abrasion, corrosion, kinks, and improper block reeving could have more influence on dictating the life of a wire rope than the breaking strength factor based on new rope condition.

All wire rope should be inspected regularly. The frequency will depend on the service conditions. Wire rope in continuous service or severe conditions should be inspected weekly (in some cases it should be inspected daily), and also observed during normal operation. For most other services it should have at least a monthly inspection.

The preferred method is to have one person do the inspection and keep an inspection log listing dates, length of service, and any defects, as part of the regular routine.

The decision on when to remove a wire rope from service will always vary because of the working conditions. However items to consider are:

- The size, type, and frequency of lifts.
- The consequences of rope breakage including injury and damage.
- The next inspection date.

The inspector must determine if the rope deterioration has reduced the rope strength enough to cause a safety hazard. In continuous service conditions where metal fatigue could be a factor, it may be beneficial to replace the wire rope on a regular basis regardless of external appearance.

A wire rope must be totally inspected as wear and deterioration could very well be in a localized area. For example, a rope cycling back and forth on a sheave not properly aligned will show localized wear.

Wire Rope Lay Length

The lay length of a wire rope is the straight linear distance of one strand as it takes a complete revolution. Mark one strand on top of the rope, follow it around and mark the strand again as it comes around to the top. The straight point to point distance is the lay length. See Illustration #17. Determining lay length is one method used to check a rope for stretching.

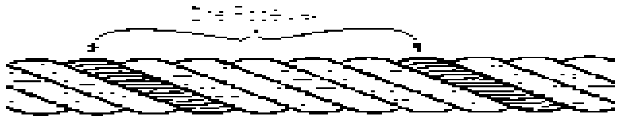

Illustration #17 – One Lay Length

Lay length is also used when the bending arc of a wire rope around an object is measured in a certain number of lay lengths.

Wire Rope Stretch – Any new wire rope will stretch when the initial load is applied. A new rope is slightly oversize and this initial "constructional stretch" will bring it down to its approximate correct nominal size. This stretch is ½% to ¾% for 6 strand fiber core, and ¼% to ½% for 6 strand wire core.

After the initial stretch, and a slight stretching over time during normal wear, the rope will stretch at a quicker rate, which means it is approaching the time for replacement. See illustration #18

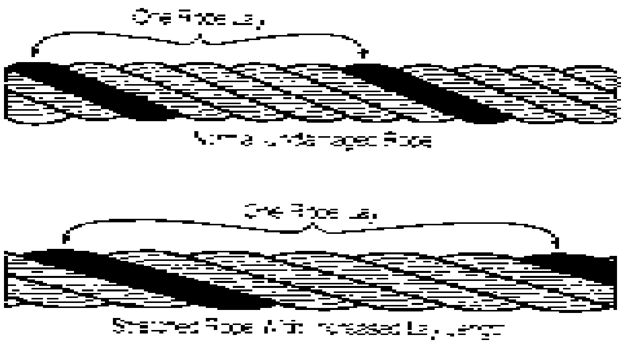

Illustration #18 – Wire Rope Stretching

Wire Rope Sizing

A wire rope is measured across the diameter at its widest point. This is called measuring across the "crowns". Do not measure across the "flats". It is advisable to make three such measurements on a 6 strand rope and four on an 8 strand rope. The correct and incorrect methods are indicated in illustration #19.

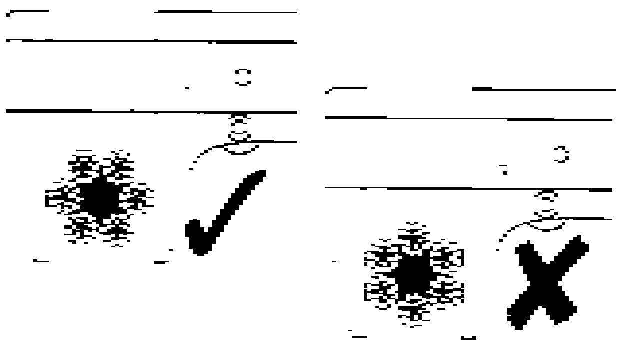

Illustration #19 – Wire Rope Diameter Measuring

Diameter Reduction – Any noticeable reduction in diameter is a serious deterioration problem. Diameter reduction could result from one, or a combination of several faults. See illustration #20.

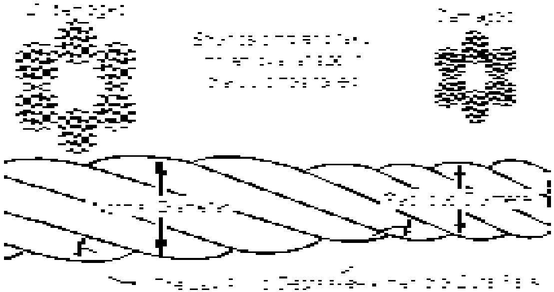

Illustration #20 – Wire Rope Diameter Reduction

The maximum wear for general purposes, as well as EOT and mobile crane wire ropes is:

Up to [illegible] — [illegible]
[illegible] to [illegible] — [illegible]
[illegible] to [illegible] — [illegible]
[illegible] to [illegible] — [illegible]
[illegible] to 1 [illegible] — [illegible]

Broken Wires - The required removal of a rope from service because of broken wires will depend on how that particular rope is being used. Finding one broken wire for several widely spread) is usually not a problem. Numerous breaks are a cause for concern and require a closer inspection.

See illustration #21 for inspection of wire rope. The guidelines for rope replacement are shown in table #3.

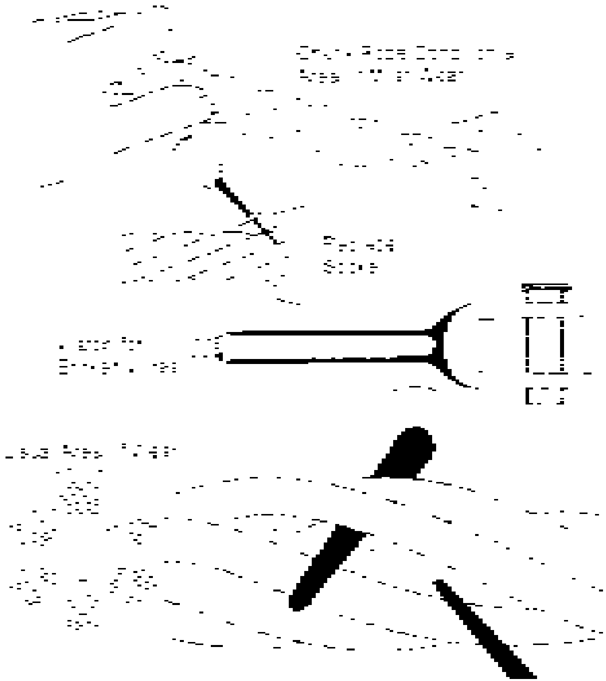

Illustration #21 – Inspecting For Wire Breaks

When To Replace Wire Rope - Based On Number Of Broken Wires

ANSI Standard	Equipment	Number Broken Wires in Running Ropes: In One Rope Lay	Number Broken Wires in Running Ropes: In One Strand	Number Broken Wires in Standing Ropes: In One Rope Lay	Number Broken Wires in Standing Ropes: At End Connection or Adjacent
B30.2	Overhead and Gantry Cranes	12	4	Not Specified	
B30.3	Tower Cranes	12	4	3	2
B30.4	Portal, Tower and Pillar Cranes	6	3	3	2
B30.5	Crawler, Locomotive & Truck Cranes	6	3	3	2
B30.6	Derricks	6	3	3	2
B30.7	Base Mounted Drum Hoists	5	3	3	2
B30.8	Floating Cranes and Derricks	5	3	3	2
B30.16	Overhead Hoists	12	4	Not Specified	
A10.4	Personnel Hoists	6**	3	2**	2
A10.5	Material Hoists	6**	Not Specified	Not Specified	

**Also remove for 1 valley break.

Table #3 — Wire Rope Broken Wires

Broken wires are listed in four general categories which are:

- Running ropes (exterior)
- Standing ropes (pendants, guylines)
- Standing ropes (near fittings)
- Running ropes (valley breaks). Any sign of breakage in the valley indicates an abnormal problem and the rope must be replaced.

3/6 Rule: A commonly followed practice for rope replacement is the 3/6 rule, which is: three broken wires in one strand, or six broken wires randomly distributed among all strands, all within one lay length.

The problem with this rule is that a rope subjected to repeated bending cycles could have far more broken wires in the interior part of the strands or in the core, than the rope exterior. This is due to the metal to metal contact between the inner portion of the strands and the core.

Abrasion – Wire rope winding over drums or through sheaves will wear. The rope must be replaced if the wear reduces the diameter to the limits specified on page 16 under "Diameter Reduction". Watch for localized wear shown in illustration #22

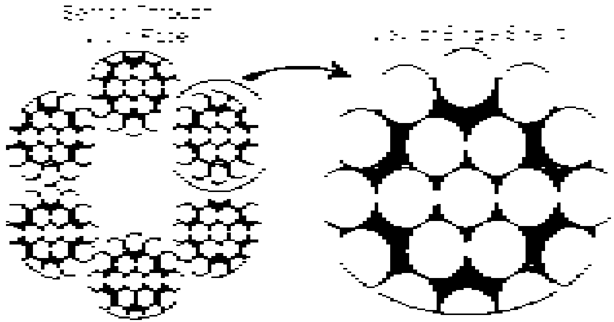

Illustration #22 – Wire Rope Localized Wear

Note: Replace rope if wire diameter wear is 1/3 or more.

Crushed Strands – This condition is a result of too many layers of rope wrapped on a drum. The general recommendation is to have no more than two layers on the drum, especially if the rope is a type with many small wires, for example a 6 x 37. If more layers are required, the rope should be a type which has fewer but larger wires and is more resistant to crushing, such as a 6 x 19; however the drum diameter should be increased as the rope is less flexible. Strand crushing is also caused by cross winding, which is a result of poor winding procedures when the rope is wound in a pile in the middle of a drum. See illustration #23.

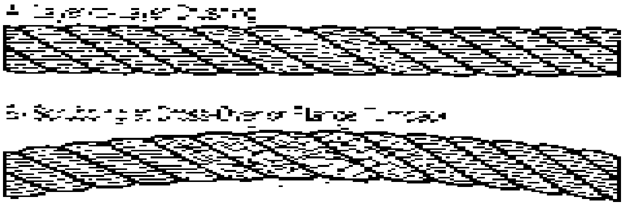

Illustration #23 – Wire Rope Damage From Drums

Some rope manufacturers are now making wire rope with strands designed to be more resistant to drum crushing.

Corrosion – This problem is difficult to evaluate, and it can be more serious than normal wear as corrosion will often start inside the rope before it shows on the outside. A lack of lubrication is usually the cause. Wire pitting or severe rusting should mean immediate replacement. Broken wires and corrosion can be determined by magnetic particle testing.

Kinks – Kinks are permanent distortions. After a wire rope has been kinked it is impossible to straighten the rope enough to return it to its original strength. The strands will not have an equal load distribution at the straightened kink. See illustration #24.

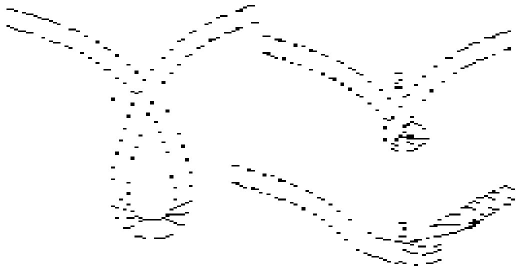

Illustration #24 – Wire Rope Kinking

Electric Arc – Wire rope that has been accidentally (or purposely) used as a welding ground, or has been in contact with a live power line could have fused or annealed wires and must be removed from service immediately.

Metal Fatigue – This wire rope problem is usually caused by bending stress from repeated passes over sheaves, or from vibration that may be encountered on crane pendants. Fatigue fractures can be either external or internal. A larger sheave or drum size, or using a more flexible rope may increase the rope life.

Bird Caging – This torsional imbalance is a result of mistreatment such as pulling through tight sheaves, wound on too small a drum, or sudden stops.
A sudden release of tension and rebound of the rope from an overload condition results in the strands not returning to their original positions. See illustration #25.

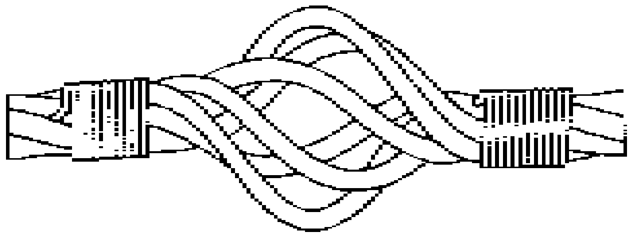

Illustration #25 – Wire Rope Bird Caging

Scrubbing – This is a wearing or displacement of wires resulting from rubbing against something.

Protruding Core – Any rope damage resulting in a spreading of the strands with the core bulging out means the rope should be replaced. See Illustration #26.

Illustration #26 – Wire Rope Popped-Core

Localized Wear – This condition can be reduced with suitable cut-off practice. See Illustration #27.

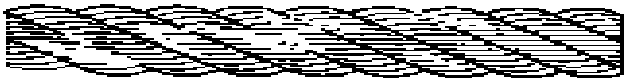

Illustration #27 – Wire Rope Localized Wear

Bending Fatigue – Repeated bending over sheaves results in fatigue breaks in the individual wires. These breaks are square and are usually on the crown of the strand. See illustration #28A.

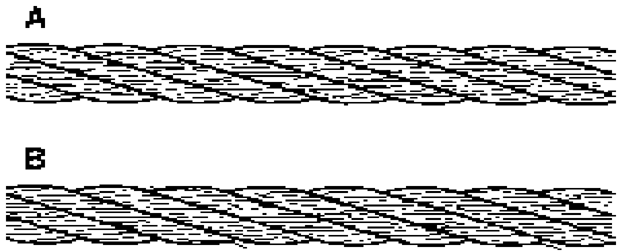

Illustration #28 – Wire Rope Bending Fatigue

A wire rope subjected to heavy loads over small sheaves results in the usual crown breaks accompanied by breaks in the valleys between the strands. The latter breaks are caused by strand nicking. See illustration #28B.

Diagnostic Guide To Common Wire Rope Degradation

Mode	Symptoms	Possible Causes
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table 4 – Wire Rope Diagnostic

Wire Rope Lubrication

A wire rope is lubricated during the manufacturing process. This provides the rope with protection for a reasonable time if the rope is stored under proper conditions. When the wire rope is in service the initial lubrication will not be sufficient to last the lifetime of the rope.

Depending on the type of service and the environment, at some point it is usually necessary to apply a lubricant to a wire rope under working conditions. A light mineral oil can be used for lubrication. Never use old crankcase oil. Several application methods are shown in illustration #29.

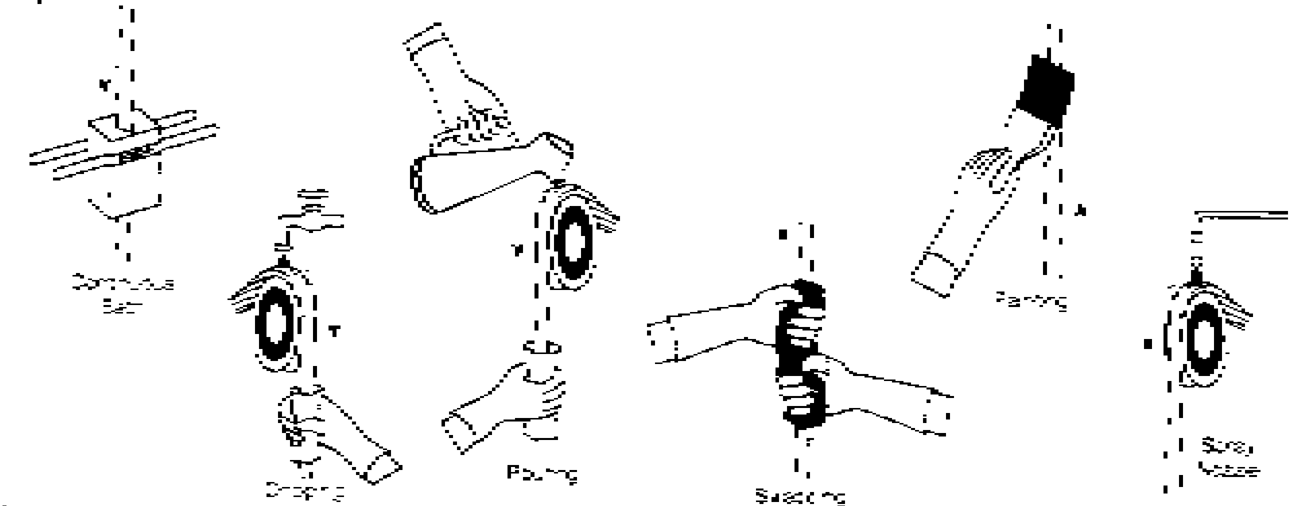

Illustration #29 – Wire Rope Lubrication

Wire Rope Precautions

1. Match the wire rope to the use, and inspect it regularly.
2. Always apply the necessary design (safety) factor to any wire rope use.
3. Do not overload the rope and minimize shock loading, especially in cold weather.
4. Exercise caution and increase the design (safety) factor when there is a danger to personnel, the conditions are abnormal, or the exact load weight is not known.
5. Use softeners on the corners of steel edges, and do not drag a rope from under a load.
6. Do not let a slack loop be pulled tight into a kink. A kink creates permanent damage.
7. Never use damaged wire rope.
8. The drums and sheaves must be of sufficient diameter. The rope must spool properly on the drum. Do not put excessive wire rope layers on any drum.
9. Sheaves with worn or scored grooves, broken rims, or faulty bearings should be replaced. Use the correct fleet angle. Match the sheave with the rope size. Try to avoid reverse bends.
10. Premature wear at a localized area is a common occurrence. This problem can be reduced by regularly moving the rope away from the wear point. On a drum, cutting a short section off the drum end of the rope can change cross-winding points and can also change an area of localized wear caused by a sheave. Another option is to reverse the rope. Cutting off a short section of a rope and reconnecting it to a fitting can repair a rope with broken wires near that fitting.

Wire Rope Seizing

Seizing is a method of binding the end of a wire rope to prevent the wires and strands from unraveling. See illustration #30.

Number of Seizings

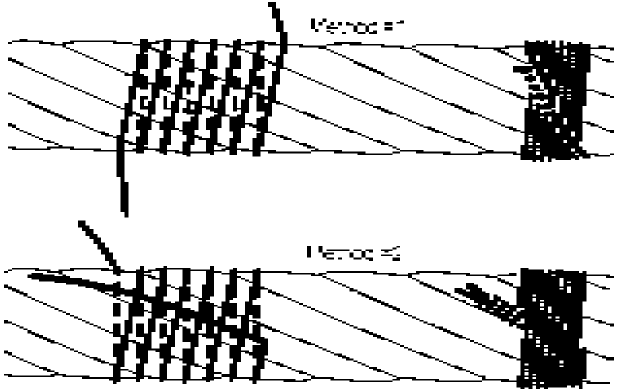

Illustration #30 – Wire Rope Seizing

The number of seizings to be applied equals approximately three times the diameter of the rope in inches to the next whole number.

Seizing Size/Spacing

The length of each seizing should be between 1 and 1½ times the rope diameter.

The space between the seizing should be two times the diameter of the rope.

Replacing Wire Rope

When replacing an old rope, contact the wire rope distributor or manufacturer. The new wire rope can be damaged if the proper method and procedure is not followed.

Be aware that recent studies by wire rope manufacturers have shown that several of the previously accepted replacement methods may result in the old rope faults, such as rope twisting and jumped sheaves, being transferred to the new rope. New methods of joining the old and new rope for replacement purposes are being developed to eliminate this problem.

Wire Rope Unreeling

Unreeling and Uncoiling

The best way to lift a reel of wire rope is to place an approved lifting device through the center hole of the reel and connect the slings and a suitable hoist.

When removing wire rope from the shipping reel or coil, it is essential that the reel or coil rotate as the rope unwinds. Attempting to remove a rope from a stationary reel or coil will almost inevitably result in a tangled mess. This easily results in a kinked rope, and the rope will be injured beyond repair at that point. The correct methods are indicated in illustration #31.

Note: For information on wire rope and drum spooling see pages 115 to 123

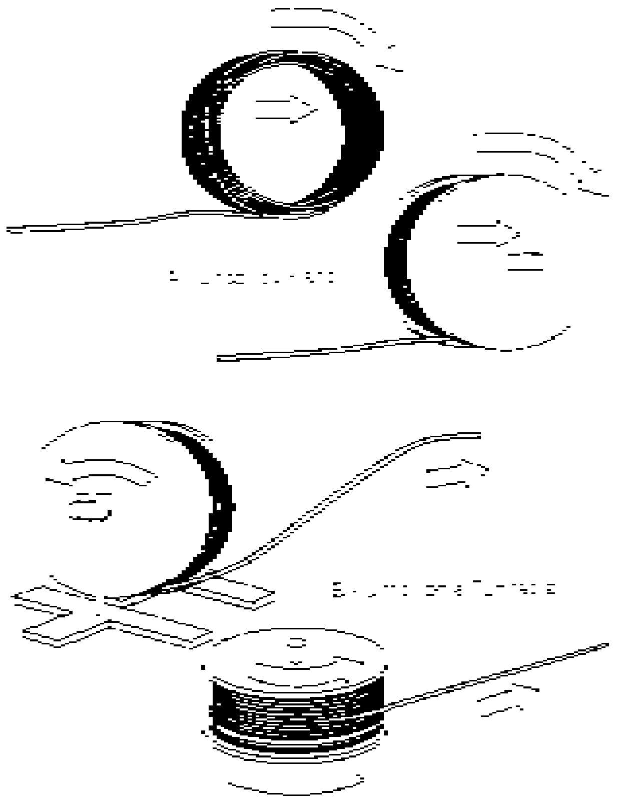

Illustration #31 – Unspooling Wire Rope

Wire Rope Ultimate Load (Breaking Strength) Formulas

One of the most important requirements to consider when selecting a wire rope is the ultimate load (breaking strength). See table #5. If a chart is not available a "rule of thumb" formula can be used to give a close approximation.

Ultimate Load
Rule of Thumb Formula

Diameter squared multiplied by the ultimate load (BS) of a one-inch diameter rope.

D^2 x Ultimate Load (BS) of 1 inch wire rope

D^2 x 42 (fiber core - improved plow)

6 x 19 x 1 inch fiber core rope has an ultimate load (breaking strength) of 42 tons.

(chart reading = 41.7 tons - IPS).

D^2 x 45 (wire core - improved plow)

6 x 19 x 1 inch independent wire core rope (IWRC) has an ultimate load (breaking strength) of 45 tons. (chart rating 44.8 tons IPS).

Ultimate Load Examples

1. Fiber Rope Core
   - $\frac{1}{2}$ inch fiber rope core
   - D^2 x 42 = Ultimate Load
   - $\frac{1}{2} \times \frac{1}{2} \times 42 = \frac{42}{4} = 10.5$
   - Ultimate Load = 10.5 tons
   - (chart value = 10.7 tons IPS)

2. Independent Wire Rope Core
   - $\frac{1}{2}$ inch independent wire rope core
   - D^2 x 45 = Ultimate Load
   - $\frac{1}{2} \times \frac{1}{2} \times 45 = \frac{45}{4} = 11.25$ tons
   - Ultimate Load = 11.25 tons
   - (chart value = 11.5 tons IPS)

All ultimate load formulas are based on a diameter of one inch and in a tonnage ratio.

Note: Remember rule of thumb formulas can only give a close approximation, not the exact value and only apply to new or undamaged rope.

Nominal Strengths Of Wire Rope 6 x 19 Classification, IWRC

Nominal Diameter		Approximate Mass		Nominal Strength			
				Improved Plow		Extra Imp. Plow	
inches	mm	lb/ft	kg/m	tons	Metric tonnes	tons	Metric tonnes
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table #5 — Wire Rope Nominal Strengths

Working Load Limit (WLL) or Safe Working Load (SWL)

Most hoisting jobs use a Working Load Limit (Safe Working Load) based on a 5:1 design (safety) factor of the wire rope breaking strength. The 5:1 factor also applies to most rigging hardware when calculating the load weight and equipment required for a hoisting job. This factor should go higher if there is a possibility of injury or death due to breakage. For example elevators, which are usually based on a 20:1 factor. Critical lifts with a danger to personnel should be calculated on a 10:1 factor. If using an ultimate load (breaking strength) chart calculate the WLL (SWL) as follows:

$$WLL (SWL) = \frac{\text{Ultimate (Breaking) Strength}}{\text{Design (Safety) Factor}}$$

For example, a one inch IPS core wire rope has an ultimate load of 45 tons

The design (safety) factor is 5:1.

45 tons ÷ 5 = 9 tons WLL (SWL)

Note: See table #6 for an example of a safe working load chart.

Note: Mobile Crane Design (Safety) Factors: The various wire ropes on mobile cranes generally have different factors applied to them than the usual 5:1 (or higher) factor applied to the slings and hardware on the actual load. These crane factors are specified as a minimum by ANSI, OSHA, and CSA. Cranes operating under various jurisdictions or requirements may have to be equipped with higher factor wire rope.

The minimum factors for cranes are:

- *Conventional type boom when boom being raised from horizontal:*
  3:1 for boom hoist line;
  2.5:1 for pendant lines.
- *Conventional type boom with load:*
  3.5:1 for boom hoist line;
  3:1 for pendant lines;
  3.5:1 for main load hoist line and jib or whip line.
- *Hydraulic boom with load:*
  3:1 for standing boom or jib lines;
  3.5:1 for main load hoist line, jib or whip line.
- *For rotation resistant wire rope used on live or running lines, the minimum design factor is 5:1.*

Maximum WWL (SWL) in tons
Design Safety Factor = 5

Rope Diameter (inches)	Grade 100/110 Plow		Grade 110/120 Plow Improved	
	Fibre Core	Steel Core	Fibre Core	Steel Core
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]

Table #[illegible] – Wire Rope Working Load Limits (SWL)

WLL Rule of Thumb

A rule of thumb formula can be used to find the approximate WLL (SWL) for IWRC rope.

The general rule of thumb formula is:

$D^2 \times 45 \div 5$ = load in tons

This load is based on a Design (Safety) Factor of 5

Example 1:

½ inch wire rope

$\frac{1}{2} \times \frac{1}{2} \times 45 \div 5$

$= \frac{9}{4} = 2\frac{1}{4}$ tons WLL (SWL)

Example 2:

¾ inch wire rope

$\frac{3}{4} \times \frac{3}{4} \times 45 \div 5$

$= \frac{9}{16} \times 9 = \frac{81}{16} = 5.1$ tons WLL (SWL)

Note: These formulas cannot be used with metric measurements.

Wire Rope Efficiency

A wire rope that bends around a sheave has less strength compared to a straight pull rope. The larger the bending diameter, the more strength or efficiency the rope will have. The efficiency for most 6 x 19 and 6 x 37 rope is shown in table #7. The same condition applies to a wire rope sling bent around the hook of a crane block, a shackle, or a pipe.

Divide the sheave, hook, or pipe diameter by the rope diameter to find a ratio (D/d). Then find the closest ratio in table #7. If the ratio that is worked out doesn't match the table, use the next smallest table ratio number.

Example:

8 inch snatch block

⅞ inch wire rope

Ratio = 8 inch ÷ $\frac{7}{8}$ = 9.14

The ratio is 9.14.

The closest table #7 ratio is 8, and the wire rope strength, or efficiency, is 83%.

Wire Rope Bending Efficiency

D/d ratio sheave/rope diameter	% of Strength Efficiency compared to Catalog Strength
40	95
30	93
20	91
15	89
10	86
8	83
6	79
4	75
2	65
1	50

Table #7 - Rope Bending Efficiency

From table #5, a 1 inch improved plow rope is rated at 34.6 tons. With an efficiency of 83%, the rating is lowered to 28.7 tons.

A ratio of 1, which means a wire rope bent around an equal size diameter (such as a 1 inch sling and a 1 inch shackle pin) reduces the rope efficiency to 50%.

In comparison, a ratio of 40 (a 1 inch rope around a 40 inch sheave) has an efficiency of 95%. Wire rope manufacturers indicate that any bend will cause a strength reduction. Therefore with anything other than a straight pull, the maximum rope strength will never be rated at 100%.

***Note:** The working load limit (SWL) of wire rope is shown in table #6. The ultimate load (breaking strength) of IWRC rope is shown in table #5.*

Sling Identification Tags

In 2001 it became a requirement that all slings including wire rope, synthetics, metal mesh, or chain, manufactured under ANSI/ASME guidelines, must have an identification tag. This tag must include the following:

- Name or trademark of the manufacturer
- Diameter or size of the sling
- Type of material used
- Rated load for a given type of hitch
- Lift angle upon which the load rating is based

Note: Sling characteristics are regulated by ANSI B30.9 and CSA.

Note: In the USA, users of alloy chain, wire rope, metal mesh, and ALL types of synthetic slings should refer to ANSI B30.9 for training parameters. These include sling selection, inspection, cautions to personnel, effects of environment, and rigging practices, effective in 2003.

Note: When referring to slings, the "Rated Load" is the maximum allowable working load established by the sling manufacturer. The terms "Rated Capacity" and "Working Load Limit" are commonly used to describe Rated Load in place of the older terminology of "Safe Working Load".

Sling Design (Safety) Factor

As a result of the excessive abuse of slings due to overloading, abrasion, crushing, kinking, and impact loading, a design (safety) factor must be applied to every lift. A common factor is 5:1, although this can vary depending upon the application.

Some specific engineered lifts may have a design (safety) factor lower than 5:1, however most factors that are not 5:1 will be higher. Design (safety) factors that are 8:1, 8:1, 10:1 or higher are not uncommon.

Rule of Thumb WLL (SWL)

The rule of thumb formula to find the working load limit (safe working load) for a wire rope sling is:

$D^2 \times 45 \div 5$ = WLL (SWL) (in tons)

Example: $\frac{1}{2}$ inch WRC sling

$\frac{1}{2} \times \frac{1}{2} \times 45 \div 5 = 2.25$ tons WLL (SWL)

This is based on a 5:1 design (safety) factor, however be aware that many sling chart numbers are based on a 5:1 factor, and wire rope sling charts should be based on 95% of the actual rope ultimate strength.

Types of Sling Hitches

Single Vertical Hitch

The total weight of the load is supported by a single sling leg, therefore the load weight can equal the working load limit (safe working load) of the sling, as shown in illustration #32. The load might need a tag line for control.

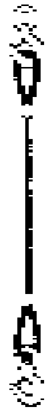


Illustration #32 – Single Vertical Hitch

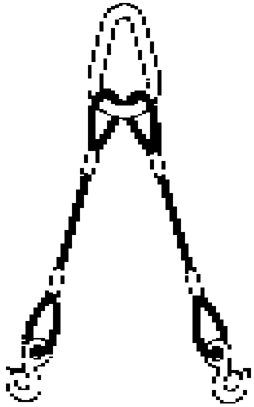


Illustration #33 – 2 Leg Bridle Hitch

Bridle Hitch

A bridle hitch can be made up of a number of legs, usually 2, 3 or 4. See illustration #33 for a two leg bridle.

A bridle hook-up with 2 legs can be straight-forward. However a non-symmetrical load, as shown in illustration #34, requires the hook to be positioned over the center of gravity.

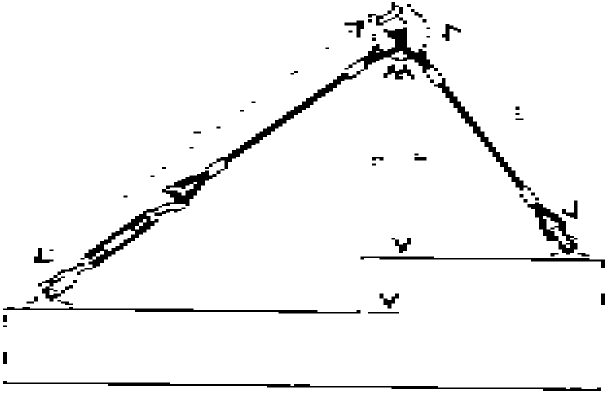


Illustration #35 – Non-Symmetrical Bridle Hitch

Some type of adjustment method is needed to increase or decrease one leg length to keep the load level.

On lighter loads a turnbuckle, come-a-long, or chain fall can be used, however the last two are not recommended as a number of factors including shock loading, extreme sling lifting angles, or unknown weights could overload the hardware. Getting the proper adjustment is usually not easy.

Note: Some companies require a full length back up sling for a sling leg with an adjuster.

Note: When using a multi-branch sling, the rating shown for the single sling shall not be exceeded for any branch of the multiple branch sling bridle hitch.

A bridle with 3 legs will result in uneven sling leg loading if not properly hooked. See illustration #35.

If the pickup points are not evenly spaced and the sling legs are not the same length, the load distribution will have the majority of the load on two legs while the third leg will only act as a balance.

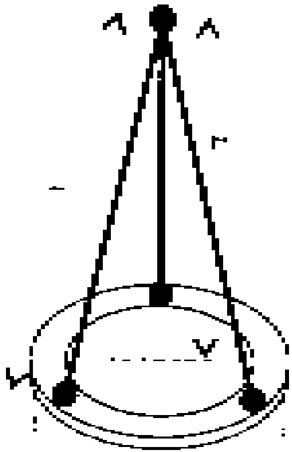


Illustration #35 – 3 Leg Bridle Hitch

A bridle with four sling legs, as shown in illustration #36, is usually not as simple as it appears. Several factors can often apply to make equal leg loading difficult or impossible. It is not unusual to have three legs (or possibly only two) carrying the weight while the third (or third and fourth) balance the load. Sling manufacturers may rate a four leg bridle the same as a three leg, or a two leg

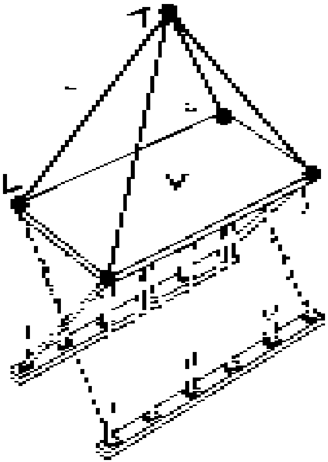


Illustration #36 – 4 Leg Bridle Hitch

Factors such as different sling leg lengths, stretched sling legs, position of lifting lugs, position of sling eyes in the lifting hook, and a twisted, warped or uneven structure, can change the loading of sling legs.

See tables #8, #9, #10 for bridle sling example capacities based on improved plow wire rope.

Note: If using a four leg bridle, OSHA/OH&S standards require the load to be calculated using three legs.

Note: Multiple loads (e.g. structural steel components) are not permitted during one lift without using an approved hoisting assembly. (Check with the local OSHA/OH&S office).

Note: Angles shown in tables #8, #9, #10 are horizontal angles.

Note: Sling WLL (SWL) in tables #8, #9, #10 is based on 6 to 1 design (safety) factor.

Two Part Bridle Sling

Rope Dia. Inches	60° S.W.L. 2 Legs Pounds	45° S.W.L. 2 legs Pounds	30° S.W.L. 2 Legs Pounds
1/4	1,600	1,300	920
3/8	3,500	2,860	2,020
1/2	6,490	5,270	3,740
5/8	9,740	7,910	5,600
3/4	14,020	11,450	8,080
7/8	18,920	15,450	10,900
1	24,600	20,080	14,160
1 1/8	29,900	23,500	16,560
1 1/4	36,000	29,260	20,740
1 3/8	43,980	35,840	25,340
1 1/2	53,040	43,300	30,620
1 5/8	62,160	50,760	35,900
1 3/4	71,280	58,200	41,170
1 7/8	83,560	68,220	48,320
2	91,380	74,600	52,760

Table #8 – Two Part Bridle Sling Working Load Limits

Three Part Bridle Sling

Rope Dia. Inches	60° S.W.L. 3 Legs Pounds	45° S.W.L. 3 Legs Pounds	30° S.W.L. 3 Legs Pounds
1/4	2,400	1,950	1,380
3/8	5,250	4,290	3,030
1/2	9,730	7,900	5,600
5/8	14,610	11,860	8,400
3/4	21,030	17,190	12,100
7/8	28,380	23,220	16,380
1	36,900	30,100	21,300
1 1/8	43,350	35,250	25,000
1 1/4	54,000	43,900	31,100
1 3/8	65,820	53,700	38,000
1 1/2	79,560	64,900	45,900
1 3/4	106,920	87,300	61,700

Table #9 – Three Part Bridle Sling Working Load Limits

Four Part Bridle Sling

Rope Dia. Inches	60° S.W.L. 4 Legs Pounds	45° S.W.L. 4 Legs Pounds	30° S.W.L. 4 Legs Pounds
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Table #1[illegible] – Four Part Bridle Sling Working Load Limits

Basket Hitch

A basket hitch for supporting a load is shown in illustration #37A. The D/d ratio is the load diameter divided by the sling (wire rope) diameter. To have the full basket hitch sling load rating, the D/d ratio must be 25:1 for improved plow and extra improved plow wire ropes, or 20:1 for extra-extra improved plow.

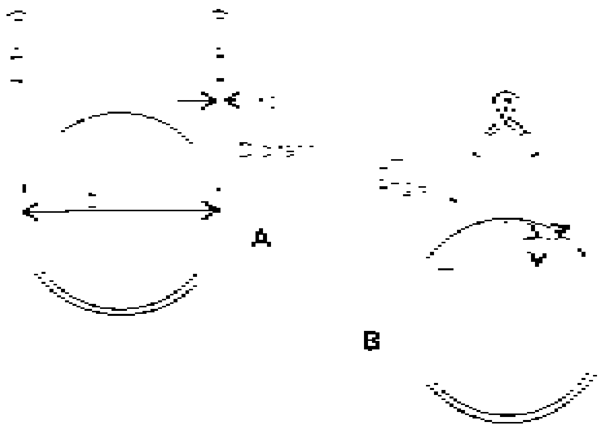


Illustration #37 – Basket Hitch

With the proper D/d ratio, and the sling legs vertical, the efficiency of a basket hitch is rated by sling manufacturers at twice that of a single vertical hitch.

If the sling legs are both attached to one hook, as shown in illustration #37B, the basket capacity is reduced, depending on the lift angle, as shown in table #11.

Angle	Single Leg Capacity
90°	200%
60°	170%
45°	140%
30°	100%

Table #11 - Basket Hitch Capacity

Note: 95% Efficiency – Be aware that wire rope manufacturers state that the maximum efficiency of any wire rope going around a bend is 95% or less. For example, a wire rope hooked around an object of equal diameter (D/d of 1:1) has a strength rating of 50%, and as the D/d increases the strength efficiency increases. For more information, see page 31 and table #7 on Wire Rope Efficiency.

Note: Sling tables rate a basket hitch with the proper D/d at twice that of a single vertical hitch. See table #12.

	Rope Diameter Inches	Basket Hitch Pounds	Vertical Lift Pounds
6 x 19 IWRC	1/4	1,840	920
	3/8	4,040	2,020
	1/2	7,470	3,740
	5/8	11,210	5,600
	3/4	16,160	8,080
	7/8	21,730	10,900
	1	28,360	14,150
6 x 37 IWRC	1 1/8	33,320	16,660
	1 1/4	41,480	20,740
	1 3/8	50,680	25,340
	1 1/2	61,240	30,620
	1 5/8	71,800	35,900
	1 3/4	82,330	41,170
	1 7/8	96,640	48,320
	2	105,520	52,760

Table #12 - Vertical Sling & Basket Hitch Safe Working Loads

Note: *Table #12 load limits are calculated on improved plow steel 6 x 19 I.W.R.C. from 1/4" diameter to 1" diameter inclusive and improved plow steel 6 x 37 I.W.R.C. from 1 1/8" diameter to 2" diameter inclusive.*

Determining Basket Hitch Values

Most sling chart tables give three basic values, which are a single vertical hitch, a basket hitch, and a choker hitch. The vertical hitch capacity is the basis for the other two. A vertical hitch (illustration #38A) is rated at 100%, a basket hitch (illustration #38B) is

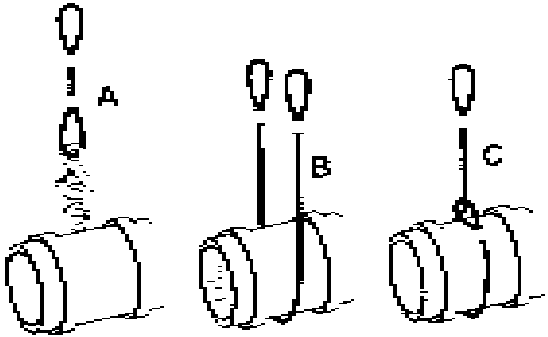


Illustration #38 – Vertical, Basket and Choker Values

rated at 200% if the legs are vertical and the D/d ratio is 25:1 (or 20:1 depending on the material grade), and the choker hitch is rated up to 75% (depending on the choke angle). What load condition applies to a basket to give the full 200% rating?

The answer to this is often somewhat distorted, as depending on the load, a true basket shape is often not being utilized. For example, a sling wrapped around a rectangular load with square corners is not a true basket as the load corners cause a shearing effect on the sling. A true basket also requires a full 180 degree support from the half circle of the load and it must have a sufficient D/d ratio.

The use of flat synthetic or chain slings makes the basket D/d ratio difficult to establish, as the flat synthetic or chain sling capacity would have to be compared to an equivalent capacity wire rope sling. Then the equivalent wire rope diameter is divided by the load diameter to get a D/d ratio.

Note: Always remember, the tighter the bending radius, the less capacity the sling will have.

Double Basket Hitch

This is a method of supporting a load using two single basket hitches. Do not use this hitch on loads that are difficult to balance as the load could shift and slip out of the sling (see illustration #39).

Do not spread the slings too far apart as the angle will create extra load on the sling legs.

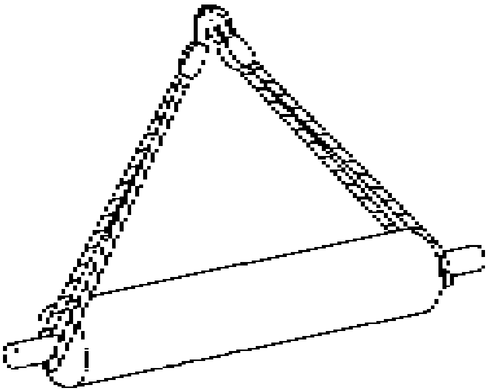


Illustration #39 – Double Basket Hitch

Double Wrap Basket Hitch

This basket hitch is wrapped completely around the load, rather than just supporting it.

It is excellent for pipe and tubing as it exerts a full 360 degree contact and pulls the load together. See illustration #40 for an example of two double wrapped basket hitches.

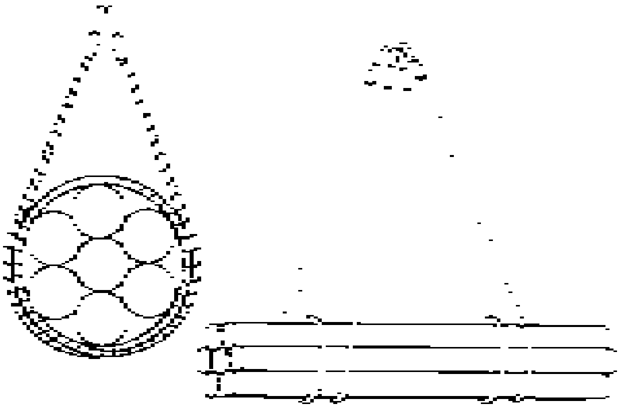


Illustration #40 – Two Double Wrapped Basket Hitches

Choker Hitch

A choker hitch is rated at 75% of a single vertical hitch. However the capacity could be less than 75% depending upon the angle of choke. See illustration #41 and table #13

Illustration #41 – Choker Hitch

Angle of Choke	Sling Leg Capacity of Single Vertical Hitch
120° - 180°	75%
90° - 120°	65%
60° - 90°	55%
30° - 60°	40%

Table #13 – Choker Hitch Capacity

Single Choker Hitch

A choker hitch tightens somewhat as the load is lifted due to the noose formed at the point of choke. See illustration #42. However the single choker hitch does not provide full 360 degree contact with the load and should not be used to lift loose bundles. A more secure method is a double wrap choker, where the choker hitch is in full contact with the load as the sling end is wrapped completely around the load before it is hooked into the vertical part of the sling. A double wrap choker is more suitable when lifting a bundle of loose material.

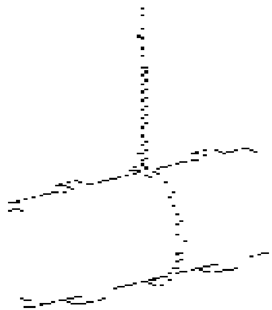


Illustration #42 – Single Choker Hitch

Double Choker Hitches

The double choker hitch is made up of two single chokers that are spread out and attached to the load, making the load more stable. See illustration #43A.

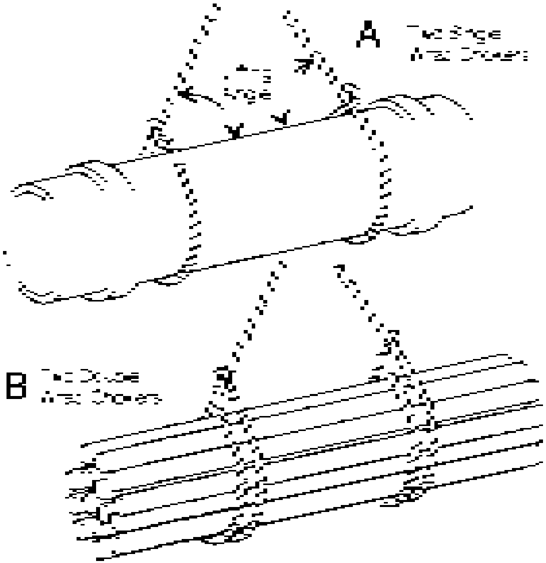


Illustration #43 – Double Choker Hitch

The double choker hitch does not provide full 360 degree contact with the load and should not be used to lift loose bundles.

An extra wrap around the load, creating two double wrap chokers should be used when lifting long bundles of loose material, such as pipe or tubing (see illustration #43B).

Note: Two slings in a double choker hitch configuration (illustration #43) will have a reduced lifting capacity as compared to two choker hitches each lifting straight up. The reduced capacity depends upon the lifting angle.

Hooking Back on Choked Slings

Hooking back when choking a load with one sling should be avoided as it creates extra localized stress in the sling.

When a load is choked and tension is applied to the sling the two portions of the choker coming off the load have a natural tendency to lift up to as high an angle as possible. See illustration #44A.

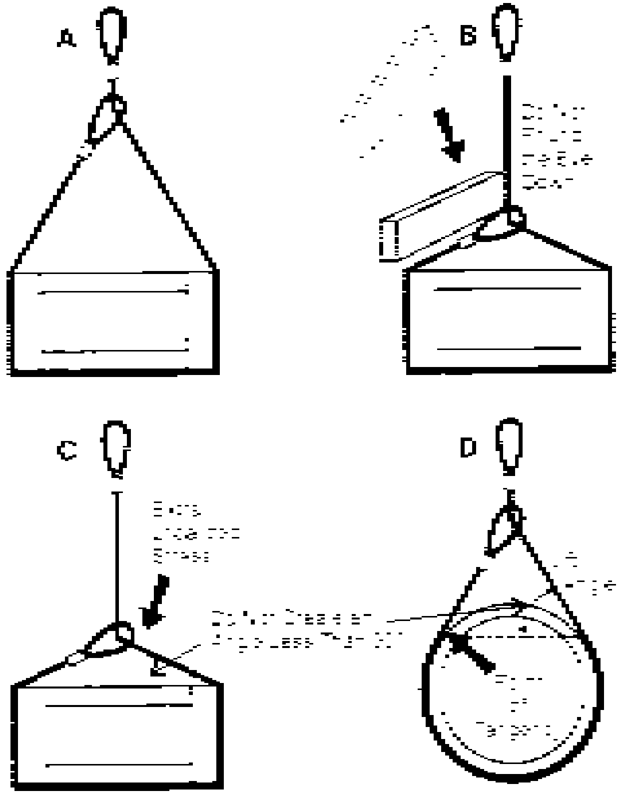


Illustration #44 – Hooking Back with Chokers

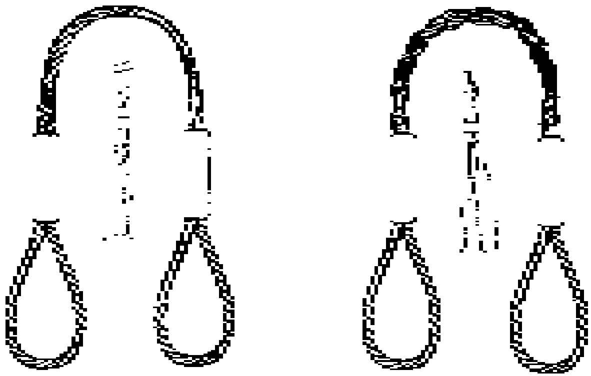
A very common occurrence for the person hooking up the load is to grab whatever is nearby and pound the eye down as close as possible to the load. See illustration #44B. This creates an extremely low sling angle and creates extra localized stress in the sling. See illustration #44C.

A similar situation applies to round loads such as pipe, as the sling angle triangle is also formed from the pipe points of tangency. See illustration #44D.

Note: Do not force the choked eye down close to the load, and never create an angle less than 30 degrees to the horizontal.

Wire Rope Braided Slings

Braided slings are made up of many small diameter wire ropes (usually 6 or 8) braided together to form one large sling. See illustration #45. The sling has greater flexibility than one large diameter rope and does not kink easily. They are used in high capacity lifts.



8-Part Braided Sling 6-Part Braided Sling

Illustration #45 – Braided Slings

Synthetic Slings

Synthetic Web Slings: offer good protection for machined parts, are non-sparking, light weight and flexible. It is a flexible flat sling that has the ability to hug the load and keep it more secure from slippage, as indicated in Illustration #46. This sling is usually made of nylon or polyester, however other materials are available.

Nylon resists most alcohols, aldehydes, alkalis, and hydrocarbons, but it is not recommended for use around acids. Polyester can be used in acidic conditions. Nylon has a 10% stretch factor, while polyester has a lower stretch factor.

Both nylon and polyester can be used in temperatures up to 200 degrees F.

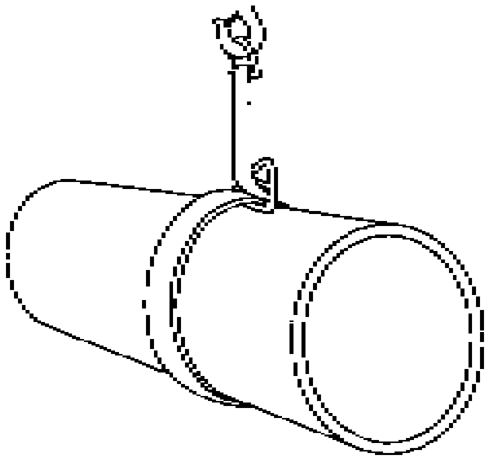


Illustration #46 – Synthetic Web Sling

Rigging hardware, for example rings and shackles, is available to use with web slings (see the hardware section). The flat shape of the hardware is more suited to these slings than the usual curved types. Any folding, bunching or pinching in a standard shackle will reduce the rated load of a synthetic sling.

Note: Check with a reputable safety systems distributor for the proper sling material used with specific hazardous products.

Note: Synthetic slings must be removed from service if any of the following conditions are present: acid or caustic burns; melting or charring of any surface part; snags, punctures, tears, or cuts; broken stitches; distorted fittings; or the colored core warning yarns are showing.

Note: All sling types, including synthetic web sling must have the proper identification to show the name of the manufacturer, the rated load, and the type of material used. See illustration #47.

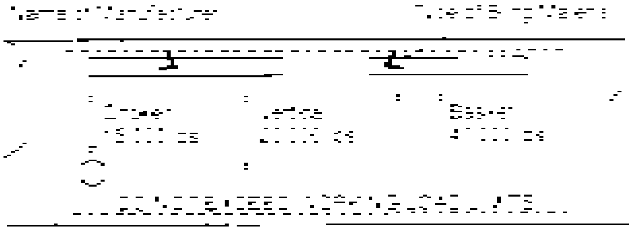


Illustration #47 - Synthetic Sling Identification Example

Note: Synthetic slings are manufactured in single and double ply. The double ply capacity ranges from 140% to 200% that of a single ply, depending upon sling type and hook up.

Edge protectors are available. They are the sewn-on, sliding, and replaceable types.

Synthetic web slings are identified by a Type Number, and they are available in a number of eye configurations. See illustration #48.

See Section Twelve - Appendix for a web sling chart and a metal mesh chart.

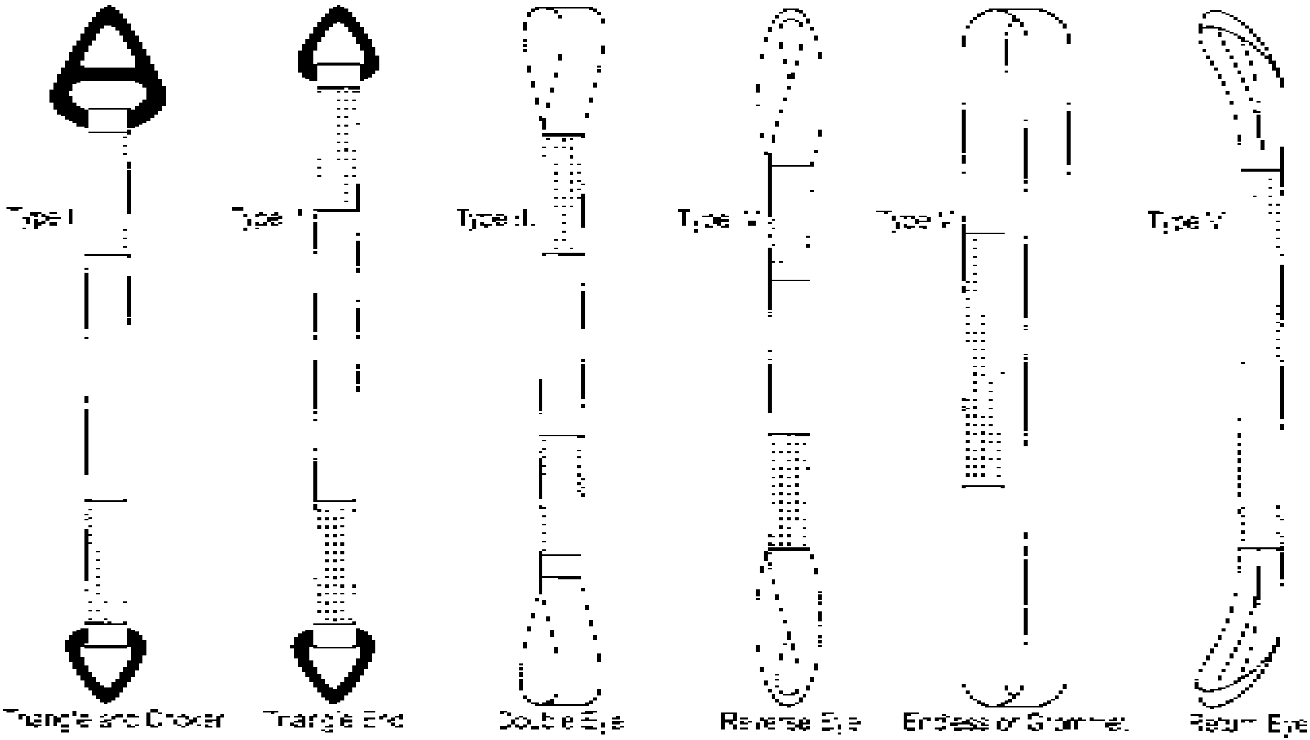


Illustration #48 - Synthetic Web Sling Types

Synthetic Web Sling Grades

Although most web slings look similar to the untrained eye, they can vary in capacity for several reasons.

- Number of plies
- Grade of webbing material
- Efficiency of sewing

Be aware that a double ply web sling may not necessarily have twice the capacity of a single ply.

Web slings are available in three grades of webbing, and the rating is based on the efficiency of the sewing.

The WLL of a sling is based on the formula:

Material breaking strength x efficiency of sewing ÷ design (safety) factor

Note: Always refer to the sling identification tag for the sling capacity. If the tag is missing, do not use the sling.

Synthetic Roundslings: are flexible lightweight slings made up of load carrying fibers covered with a tough, non-load carrying cover. They are very flexible with limited stretch. Normal cover wear does not affect the strength, and wear points can be moved around. A safety feature is that the cover will rip when the sling is overloaded and over-stretched.

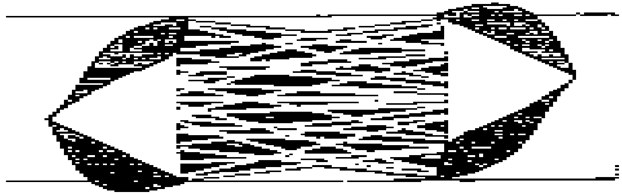


Illustration #45 – Synthetic Roundsling Example

Note: Always refer to the roundsling ID tag. Due to the wide number of manufacturers, there may be discrepancies in sizes and capacities, and color coding of round slings may not be standardized.

New Synthetic Sling Types

Twin Type: is one of the newest designs in slings. It is constructed using two roundsling types encased in an outer cover. See illustration #50 for an end view example.

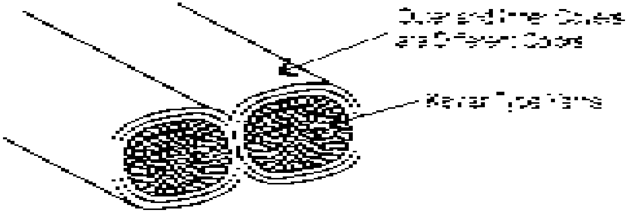


Illustration #50 - Twin-Type Sling

This sling type is made of fibers from a kevlar type material which has a better weight to strength ratio than steel. For comparison purposes, one example is a type of 35 foot endless sling used in a basket configuration that has a capacity of 140,000 pounds.

This sling only weighs about 60 pounds while a wire rope sling of equal capacity weighs approximately 600 pounds.

Some of the other features of this sling type include:

- Fiber-optic tell-tales: installed with both ends near the identification tag. A light shining through one end is visible at the other end. No light coming through could indicate damage and it should be removed from service.
- Load carrying yarns never come in contact with load. Outer cover material about 4 times more durable than polyester.
- Two inner bundles are covered in a different colored material than the outer cover to provide an instant alert for damage.
- Has overload indicator "tails" that are readily seen, but shrink and disappear when the sling is overloaded (Illustration #51).

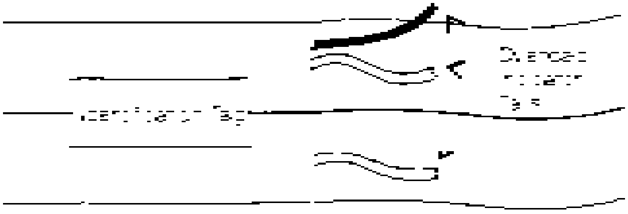


Illustration #51 – Twin-Type Sling

- Should not recoil at break, thereby reducing or eliminating the whiplash effect characteristic of chain, wire rope, and synthetic rope.
- The sling is actually two separate slings in one, with each making its own hook to load connection.
- Available in a continuous loop sling, two leg bridle sling with hardware, and eye and eye sling.

Angles Shown on Sling Tables

Every sling manufacturer creates tables for their product to list the working load limit (safe working load). However, the tables do not all have a consistent format, especially when referring to the angle involved, which may be either the horizontal angle or the vertical angle (see Illustration #52).

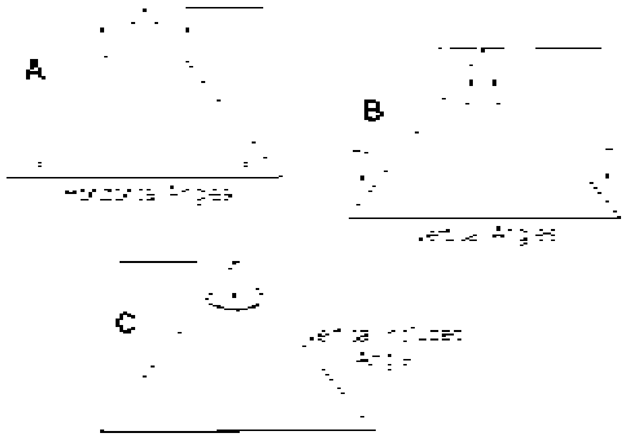


Illustration #52 – Horizontal and Vertical Angles

This can cause confusion, especially with the 60 degree horizontal angle, which is safe; compared to the 30 degree horizontal angle, which is not safe. See illustration #52 for clarification of angles.

A triangle is formed by a line straight down from the hook to the load and a line from the hook out to the sling hook-up point. See illustration #53.

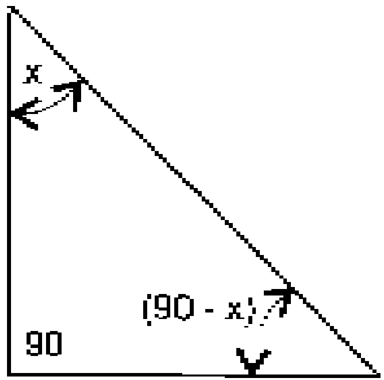


Illustration #53 — Angles in a Triangle

The three included angles of a triangle always add up to 180 degrees. The angle formed by the line straight down from the hook and out to the load will be 90 degrees, while the other two angles combined will be 90 degrees. If one of the angles is known the other can be calculated. If one angle is 45 degrees, then the other must be 45 as well. If one angle is 25 degrees, the other must be 65.

Sling Lifting Angles

The load imposed on each leg of a bridle sling configuration depends upon the angle to the horizontal formed by the legs lifting the load. Two vertical slings lifting a 1000 pound weight will each carry a load of 500 pounds. See illustration #54B.

When the sling legs are pulled together into a common hook, each sling leg will have a load increase. This sling leg load increase is often not realized by the person hooking up the load.

At a 60° angle (illustration #54C), the sling leg load is 115%. When the sling angle lowers to 45°, the sling leg load is increased to 141% (illustration #54D), and at a 30° angle the sling load increases to 200% (illustration #54E). In other words, at 30° the load on each sling leg is equal to the actual load weight.

From this point, the load on each sling leg increases rapidly. If the angle could be lowered to 5°, the load on each sling leg would be 5745 pounds, which is almost 6 times the actual load weight.

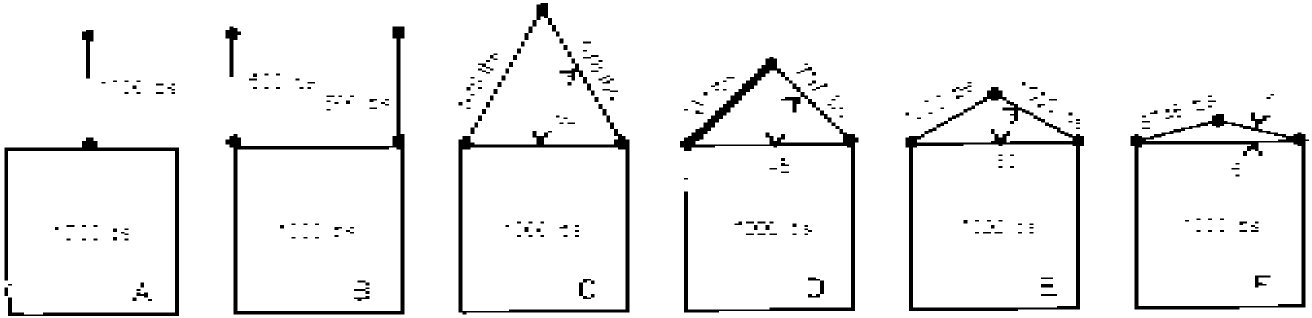


Illustration #54 - Various Sling Angle Loads

Recommended Safe Lifting Angle

The recommended SAFE lifting angle for sling legs is 60° to the horizontal (the minimum lifting angle should be 45° or higher). The 60° angle can be determined by using the actual sling or choker for measuring.

Lifting at a 60° angle creates an equilateral triangle, where all three sides are the same length. See illustration #55.

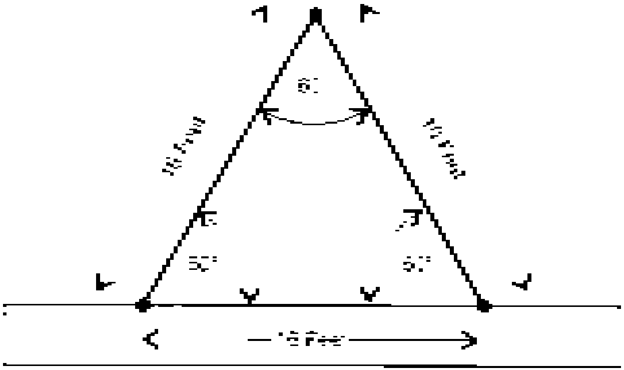


Illustration #55 — Using Sling to Determine Lift Points

The center of the load is determined either by using a tape measure or by laying the sling across the load. Then the two pick up points are marked.

Sling Leg Loading

Illustration #56 shows a 2,000 pound load carried by two vertical slings (only one-half the load and one vertical sling is illustrated).

The loading on one sling leg as it is moved out to different hookup angles is shown. In a vertical lift one sling carries 1,000 lb (one-half the load weight). When the sling is at a 5° horizontal angle the load on one sling leg is 11,490 lb. or nearly 6 times the load weight. Table #14 shows the Load Angle Factor that matches the applicable sling leg lifting angle.

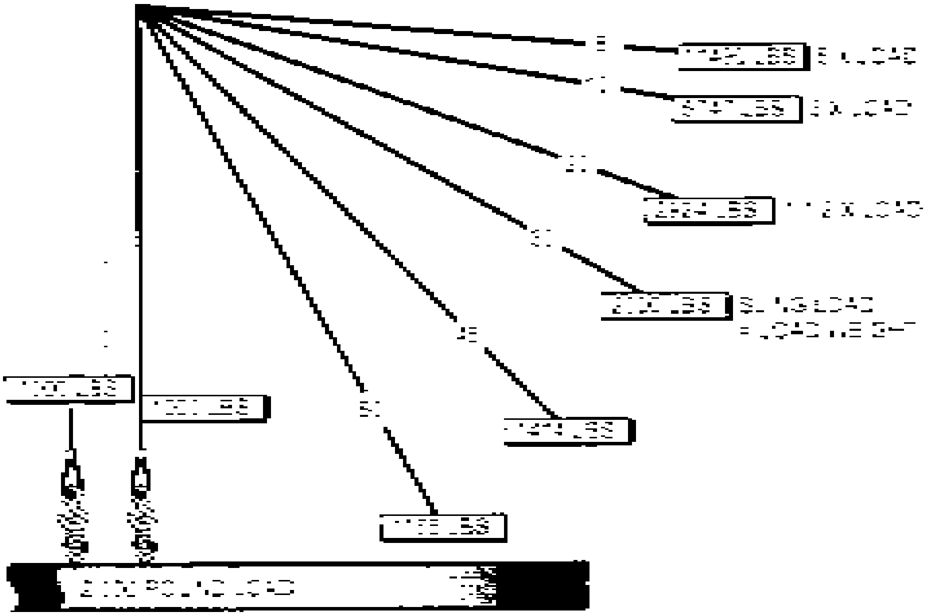


Illustration #56 – Sling Leg Loading Increases

Sling Angle	Load Angle Factor
5°	11.490
10°	5.747
15°	3.861
20°	2.924
25°	2.364
30°	2.000
35°	1.742
40°	1.555
45°	1.414
50°	1.305
55°	1.221
60°	1.155
65°	1.104
70°	1.064
75°	1.035
80°	1.015
85°	1.004
90°	1.000

Table #14 — Horizontal Sling Angle

Calculating Sling Load

Riggers Rule - Formula (1)

With this method, the sling length (L), is divided by the vertical height from the hook to the load (V). See illustration #57. This gives the load angle factor. Multiply the factor by the load weight and divide the answer by two for a two-leg sling. This gives the load on each sling leg. The load angle factors relate to those shown in table #14.

Example:

(a) Sling length = 96 inches.
vertical height = 61 inches.
weight = 9500 pounds.

(b) 96 ÷ 61 = 1.57 factor x 9500 ÷ 2
= 7457 pound (3.7 ton) sling load.

(c) Using a 5 to 1 factor, the required sling size would be 3/4 inch wire rope (page 30, table #6) or the equivalent web sling.

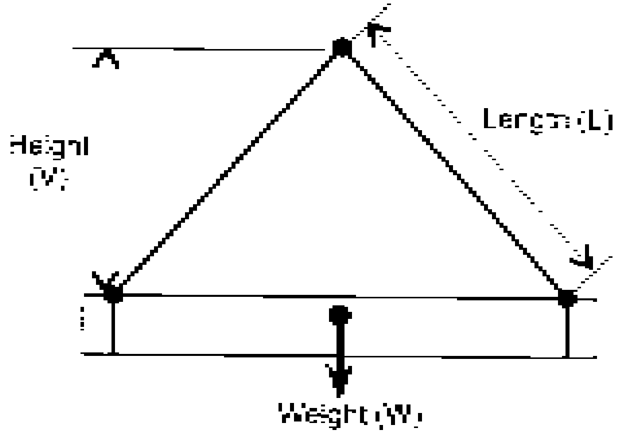


Illustration #57 – Sling Load Formula

Note: Measure the lengths in inches for closer accuracy. If the lengths are measured in feet and rounded off to a half foot the answer will only be approximate.

Riggers Rule - Formula (2)

Another version of this formula is as follows:

$$T = \frac{W}{N} \times \frac{L}{V}$$

T = tension per leg in pounds
W = weight in pounds
N = number of legs
L = sling length in inches (or feet)
V = vertical height in inches (or feet)

Example:

W = weight = 15,000 pounds
N = no. of legs = 2
V = vertical height = 10 feet, 4 inches
L = sling length = 16 feet

$$T = \frac{15000}{2} \text{ lbs} \times \frac{16}{10.33} = \frac{240{,}000}{20.66} = 11{,}600 \text{ lbs}$$

Tension per leg = 11,600 lbs or 5.8 tons

Using a 5 to 1 safety factor, the required sling would be [illegible] inch wire rope or equivalent.

***Note:** The load, the hook-up points, and the sling lengths must be symmetrical for the previous two formulas to be used.*

***Note:** The above two formulas work for any number of sling legs but it is strongly recommended that the formula be only used for two legs, as there is no way of knowing that each leg is carrying an equal share of the load. With an inflexible load and more than two legs, it is possible to have all the weight on only two legs.*

Load Angle Factors

The riggers rule formula (L/V) in which the sling length is divided by the vertical hook to load length (L/V) gives the load angle factor. The factor numbers with the horizontal sling angles are shown in the table #4 portion of illustration #58. By using the table the rigger will know the lifting angle.

Two lift angle examples are shown in illustration #58.

Illustration #58A example:

The sling length is 72 inches, and the vertical height is 60 inches.

Divide 72 by 60 (72 ÷ 60) = 1.2. This is the horizontal load angle factor.

From table #14, factor 1.2 is between 55 and 60 degrees. The lift angle is about 57 degrees, and a safe lifting angle.

Illustration #58B example:

The sling length is 72 inches, and the vertical height is 45 inches.

1. Divide 72 by 45 (72 ÷ 45) = 1.6. This is the horizontal load angle factor.
2. From table #14, factor 1.6 is between 35 and 40 degrees. The lift angle is about 37 degrees, and is considerably less than what is considered a safe angle.

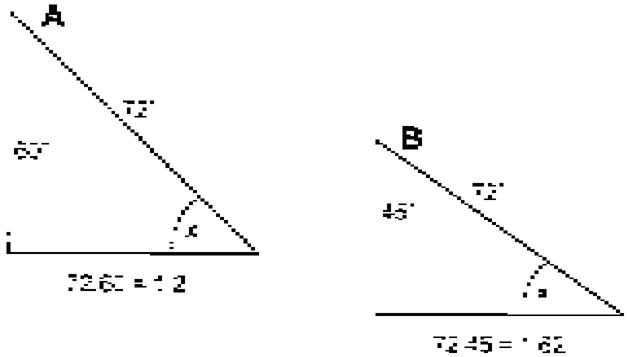


Illustration #58 – Lift Angle Examples

Calculating Sling Load Angles

In a somewhat similar, but more complicated version of formula (1) and formula (2), the load on each sling leg of a symmetrical 2 leg bridle can be found by dividing the distance between hook-up points by the sling length, and then referring to table #15. See illustration #59.

Method A:

1. Divide distance between hook-up points (D) by sling length (L).
2. Look up the answer in table #15 column (X). If the numbers do not match use the next highest number in the chart.
3. Go to the (Y) column and select the number beside the (X) number.
4. Multiply the load weight by the (Y) column number to get the sling leg load.

D/L ratio X	Load Factor Y	Sling Angle (degrees) Z
1.97	2.88	10
1.93	1.93	15
1.88	1.47	20
1.81	1.18	25
1.73	1.00	30
1.64	0.88	35
1.53	0.78	40
1.41	0.71	45
1.29	0.65	50
1.15	0.61	55
1.00	0.58	60
0.85	0.55	65
0.68	0.54	70
0.52	0.52	75
0.35	0.51	80

Table #15 – Sling Load Factors

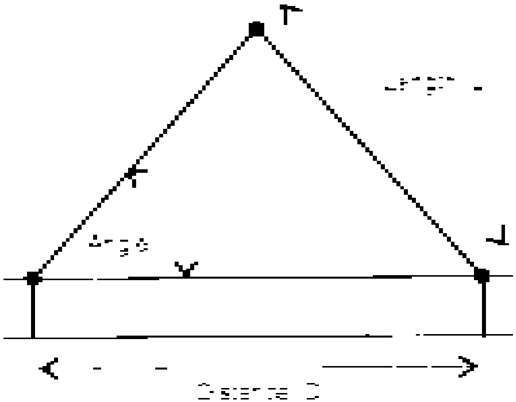


Illustration #55 – Sling Load Calculation

Method B:

1. If the horizontal sling angle is known, look up the angle in column (Z).
2. Go to the (Y) column and select the number beside the (Z) column (sling angle).
3. Multiply the load weight by the (Y) column number to get the sling leg load.

Example 1:

On an 8 ton load, two 14 foot slings are used (distance L), and the hook-up distance between them is 20 feet (distance D).

a. Divide 20 by 14 (20 ÷ 14) = 1.43.

b. Using table #15, look for the closest number to 1.43 in column (X). It is 1.42.

c. Select the number from the (Y) column beside the 1.42. It is 0.71. Multiply 8 tons by 0.71 = 5.68.

Therefore the load on each sling is 5.7 tons, or 11,400 pounds and the horizontal angle is slightly under 45 degrees.

Example 2:

On a 12 ton load, two 10 foot slings are used (distance (L), and the hook-up distance between them is 12 feet (distance D).

Divide 12 by 10 (12 ÷ 10) = 1.2

Using table #15, look for the closest number to 1.2 in column (X). It is between 1.15 and 1.29. Use the higher number, which is 1.29.

Select the number from the (Y) column beside the 1.29. It is 0.66. Multiply 12 tons by 0.66 = 7.92

Therefore the load on each sling is 7.9 tons, or 15,800 pounds and the horizontal (H) angle is slightly more than 50 degrees.

Unequal Sling Lengths

Centering a Load

When selecting slings for a lift, the main considerations are load weight, load size and the center of gravity of the load. Estimate the center of gravity and spot the hook directly over it. See illustration #60.

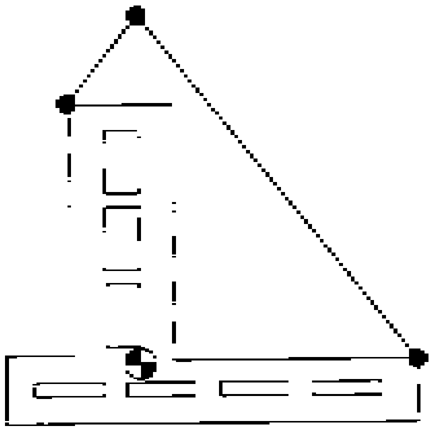


Illustration #60 - Center of Gravity

Note: A load rigged with the hook not positioned directly over the center of gravity will always swing when lifted. This immediately changes the load distribution on the slings. In almost every instance one sling will be carrying more than 50% of the weight. Always attach the slings to the load with the hook directly over the center of gravity. An improperly rigged load could tip or overload one sling.

Center of Gravity (Non-Symmetrical)

A two sling non-symmetrical load example is shown in illustration #61. The sling load will be different on each side and the center of gravity will be off-center.

1. Calculate the size and weight of section A (6.000 lbs.) and its center of gravity (CG1). Then calculate the size and weight of section B (6.000 lbs.) and its center of gravity (CG2).

2. The combined weight is 24,000 lbs. 16,000 divided by 24,000 = 66.7%.
3. A line is drawn joining CG1 and CG2. It measures 10.2 feet. The combined center of gravity is located at a point on this line. The point will be 66.7% of the 10.2 feet, and is 6.8 feet from CG1. Therefore the combined center of gravity is 6.8 feet from CG1. The hook will have to be located above this newly established C of G point.

Finding the center of gravity of an irregular shaped load is usually not easy, but if the hook is not centered over the C of G the load will swing until the C of G is under the hook. This changes the sling loading. The load can be kept horizontal by changing the sling lengths.

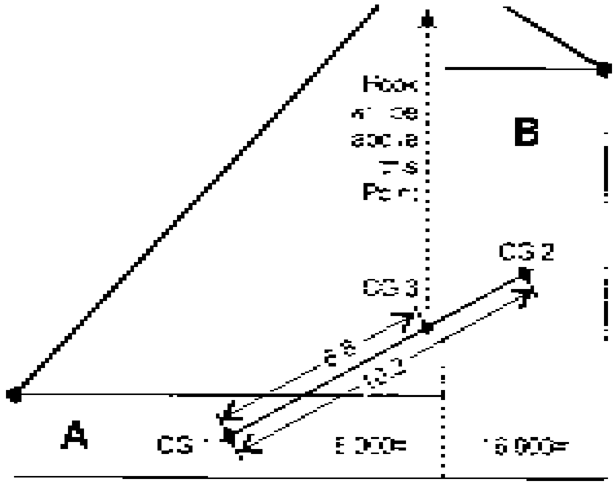


Illustration #61 – Finding Center of Gravity

Incorrect Formula for Non-Symmetrical Slings

Note: Attempts are often made to simplify the sling load calculations for each side of a non-symmetrical load, with one attachment point higher than the other.

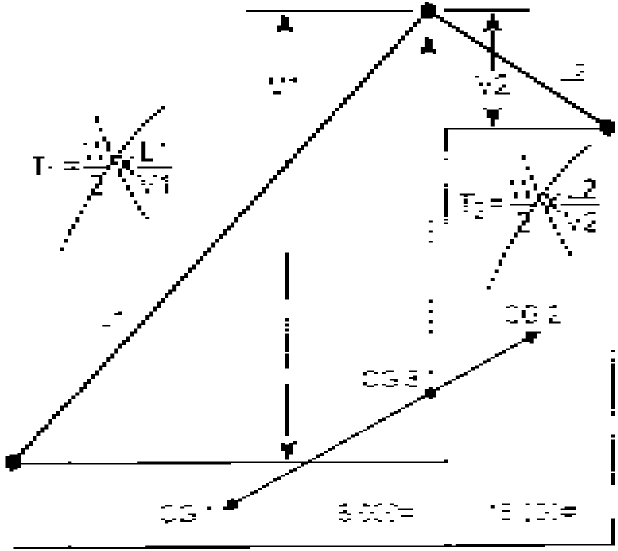


Illustration #62 – Incorrect Sling Load Formula

This is done by using the standard riggers rule formula twice, once for one side and again for the other, using two sets of different sling lengths and heights, see illustration #62. This method is not accurate, especially with extreme load distributions, such as a module with a heavy pressure vessel on one end and only miscellaneous structural steel and piping on the other end.

The other incorrect method uses the two different load angle factors multiplied by a percentage of the load weight (calculated by the center of gravity position).

Correct Non-Symmetrical Sling Formula

A much more accurate formula to calculate sling load is:

- Sling A (T_1) = $\dfrac{Load \times D_2L_1}{D_2H_1 - D_1H_2}$
- Sling B (T_2) = $\dfrac{Load \times D_1L_2}{D_2H_1 - D_1H_2}$

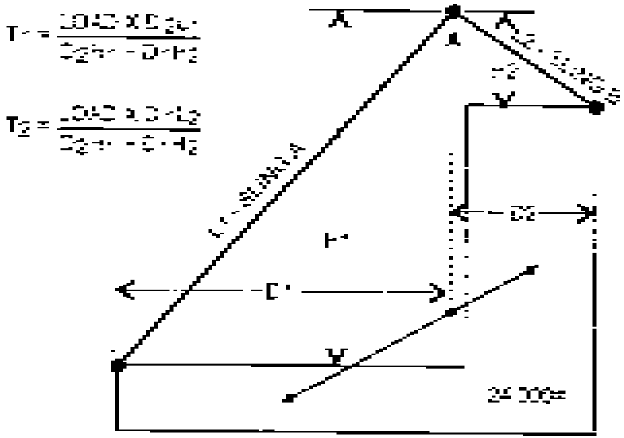


Illustration #63 – Non-Symmetrical Sling Load Formula

Non-Symmetrical Sling Example

Weight = 24,000 pounds

L1 = 29.7 (Sling A) L2 = 12 (Sling B)

D1 = 19 D2 = 5

H1 = 22.8 H2 = 10.9

Sling A = $\dfrac{2400 \times 5 \times 29.7}{5 \times 22.8 - 19 \times 10.9}$

Sling A = $\dfrac{3{,}564{,}000}{321.1}$

Sling A tension = 11,099 lbs

Sling B = $\dfrac{Load \times D_1L_2}{D_2H_1 \times D_1H_2}$

Sling B = $\dfrac{24000 \times 19 \times 12}{5 \times 22.8 - 19 \times 10.9}$

Sling B = $\dfrac{5{,}472{,}000}{321.1}$

Sling B tension = 17,041 lbs

Note: Irregular shaped loads can create unexpected sling loads. Always use a minimum 5:1 safety factor for the rigging.

Sling Shock Loading

When the main hoist line is shock loaded which may happen through rapid lowering and a sudden stop, or by having a load snag on something and then come free, the shock load is magnified in the sling legs. In illustration #64, a 20,000 lbs load is rigged with two slings set at a 30 degree angle. Because of the angle, each sling leg carries 20,000 lbs of load without any shock loading, while the main hoist line still has the 20,000 lbs load.

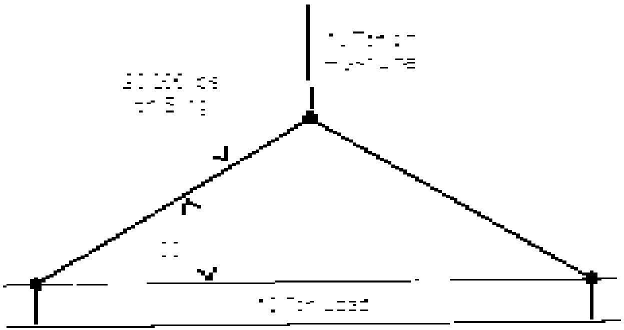


Illustration #64 - Shock Loading on Sling

Sling Shock Load Example

If a 15% shock load is added to the main hoist line, the load is increased from 20,000 lbs to 23,000 lbs. With the sling legs set at a wide angle, a small shock load could be magnified to 40% or more. A 40% increase to the sling legs puts the load at 28,000 lbs each.

If the person who rigged the load was not familiar with sling load increases because of angles, the assumption would be that each sling would carry half the weight and have a 10,000 lb load. A design safety factor of 5:1 applied to the equipment under this misconception would be cut to 2.5:1 with a static load at 20,000 lbs. If the 40% shock load happens, the safety factor for the sling is reduced to 1.7:1. At this point any further miscalculation or faulty equipment could cause a component to be loaded beyond the breaking point.

Note: Always refer to a sling chart to get the proper size sling to match the load and the hook-up configuration.

Hazards of Using High-Lines

A high-line is a method used to position a piece of equipment inside a building that is not accessible by a crane. It consists of lashing wrapped around two building members and a wire rope pulled tight between them. A snatch block on the rope is used to lift the load and move it laterally.

Note: *The use of high-lines is not recommended, but they are used when other lifting methods cannot be readily applied. We are not attempting to promote the use of high-lines, but to point out their hazards.*

Note: *Extreme loads are imposed on the wire rope. High-lines only work effectively when pulled up tight to reduce sag and allow the load to move laterally. A tight high-line has extreme loads similar to sling legs spread out at a wide angle.*

Building structures are not usually designed for unusual side pull, and doing so could damage the building steel, or could even pull the building in.

Note: *In areas where a crane cannot be used, new designs of portable jacking systems may serve the hoisting needs.*

High-Line Example

In illustration #65A, the load weighs 3 tons. This load will require a 3-ton pull (plus friction) if a single sheave is used with a tugger. The total weight supported by the high-line is a minimum 6 tons without friction or shock loads. If the high-line sags to a 10 degree angle, the high-line load approaches 18 tons, which may be an excessive side pull on the building and probably an overload on the wire rope.

Note: *Before using a high-line get engineering advice on the building structure and the loads imposed on the hoisting equipment.*

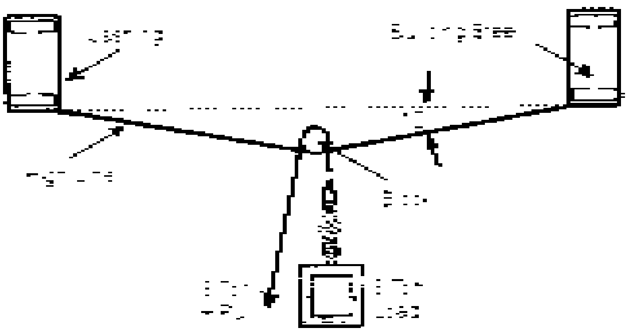


Illustration #55 – High-Line Hazards

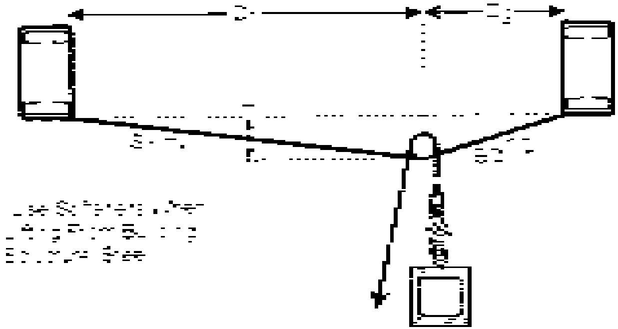


Illustration #56 – High-Line Tension Formula

High-Line Tension by Formula

The total weight is the combined weight of the load plus the hoist line pull. The formula for the line load on each side is:

T_1 = Load x $D_2S_1 \div H(D_1 + D_2)$

T_2 = Load x $D_1S_2 \div H(D_1 + D_2)$

High-Line Formula Example:

Weight = 6,000 lbs P_L = 6,000 lbs

Total Load = 12,000 lbs

$S_1 = 10.1$ $S_2 = 4.1$

$D_1 = 10$ $D_2 = 4$

$H_1 = 1$

T_1 = Load x $D_2S_1 \div H(D_1 + D_2)$

$T_1 = 12{,}000 \times 4 \times 10.1 \div 1(10 + 4)$

$T_1 = 484{,}800 \div 14 = 34{,}628$

The load on the high-line left side is 34,628 lbs

$T_2 = \text{Load} \times D_1S_2 \div H(D_1 + D_2)$

$T_2 = 12{,}000 \times 10 \times 4.1 \div 1(10 + 4)$

$T_2 = 492{,}000 \div 14 = 35{,}143$

The load on the high-line right side is 35,143 lbs.

Chain Fall Load

The tension on two chain falls drifting a load can be enough to extensively overload them. Calculating the tension uses the same method as that used for a high-line.

Chain fall (or come-a-long) tension will vary when a load is lifted, then drifted over to another location. The tension on each chain fall can be worked out by formula for various positions. See illustration #67.

Note: ANSI recommends that chain falls and come-a-longs be used for vertical lifting only. However, if a load must be moved as in illustration #67, ensure that the hardware can withstand any additional load strain.

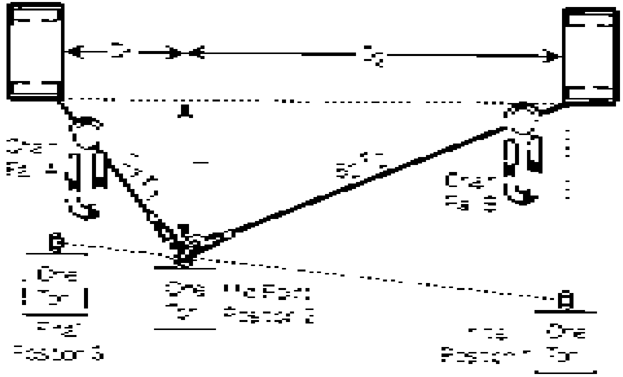


Illustration #67 – Chain Fall Tension Formula

Example Tensions While Drifting a Load

$T_1 = \text{Load} \times D_2S_1 \div H(D_1 + D_2)$

$T_2 = \text{Load} \times D_1S_2 \div H(D_1 + D_2)$

Load on chain fall B
(initial position 1) = 2000 lbs.
Load on chain fall A
(final position 3) = 2000 lbs.

$S_1 = 6.1$ $S_2 = 12.3$

$D_1 = 3.8$ $D_2 = 11.4$

$H = 4.7$

Chain Fall A
(position 2) = Load x D-S. ÷ H(D + D)
Chain Fall A
= 2000 x 11.4 x 6.1 ÷ 4.7(3.8 + 11.4)
The tension on chain fall A
= 139,080 ÷ 71.44 = 1947 lbs.

Chain fall B
(position 2) = Load x D-S ÷ H(D + D)
Chain fall B
2000 x 3.8 x 12.3 ÷ 4.7(3.8 + 11.4)
The tension on chain fall B
= 93,480 ÷ 71.44 = 1308 lbs.

Note: The above formula is based on both chain falls being positioned at the same elevation.

Sling Loading and Center of Gravity

With two slings lifting vertically, the load will be equally shared if the center of gravity of the load is in the middle. For example, with an 18,000 pound weight, 12 feet long, each sling would carry 9,000 pounds. See Illustration #68A.

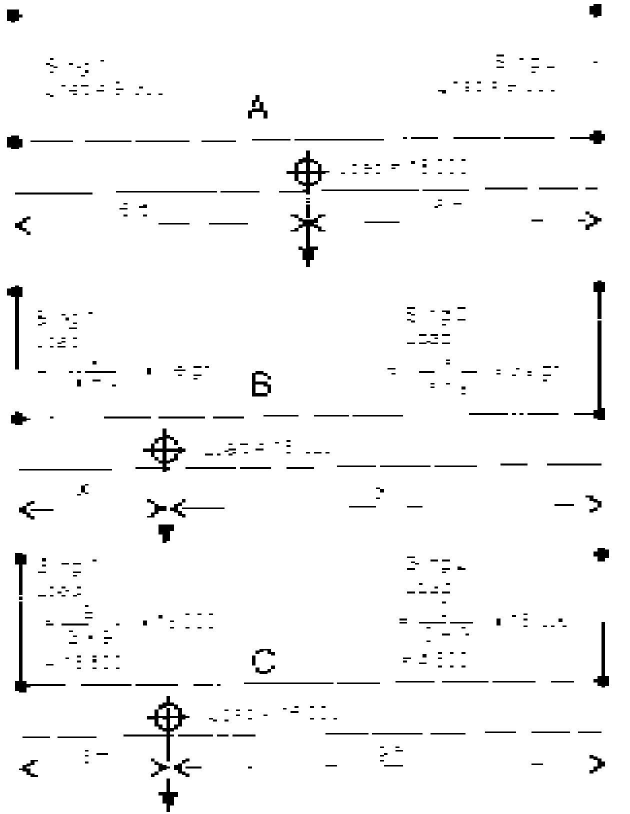


Illustration #68 - Off-Center Sling Loads

If the center of gravity is off-center, the sling loading will not be equal. The sling loading is shown in Illustration #68B.

The formula is:

$$\text{Sling 1 load} = \frac{y}{x + y} \times \text{load weight}$$

$$\text{Sling 2 load} = \frac{x}{x + y} \times \text{load weight}$$

With the same 12 foot, 18,000 pound weight, and with the center of gravity 3 feet from one end, the sling loading is shown in Illustration #68C.

The formula is:

$$\text{Sling 1 load} = \frac{9}{3 + 9} \times 18{,}000 \text{ lbs} = 13{,}500 \text{ lbs}$$

$$\text{Sling 2 load} = \frac{3}{3 + 9} \times 18{,}000 \text{ lbs} = 4{,}500 \text{ lbs}$$

Softeners

All sharp corners should be covered by pads or softeners to prevent the sling from being bent or cut. These softeners can be made from a split pipe section, padding or blocking, see Illustration #69.

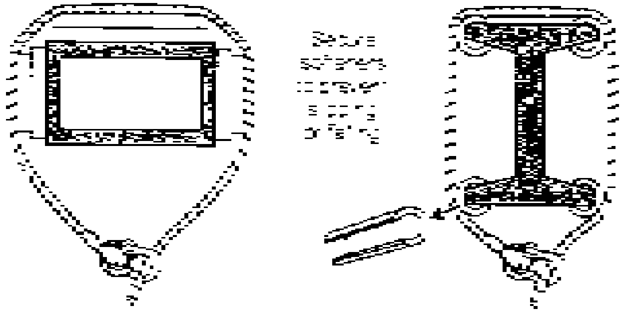


Illustration #69 – Softeners

A good rule to follow is to make sure that the length of contact of the wire rope is equal to one rope lay, or seven times the rope diameter.

Note: see pages 31 and 32 for wire rope efficiency and bending radius.

Rigging Hardware

Note: In the USA, users of all types of rigging hardware should refer to the applicable ANSI standard for pending changes regarding training parameters. These parameters include item selection, inspection, cautions to personnel, effects of environment, and rigging practices.

The standards include:

- *B30.1 for Jacks*
- *B30.9 for Slings*
- *B30.10 for Hooks*
- *B30.20 for Below Hook Devices*
- *B30.26 for Rigging Hardware (new standard in development)*

Implementation date for each standard is not known at this time.

It is extremely important that the proper hardware be selected and inspected before use. Each item must display the correct working load limit (safe working load), not show any wear, cracks, gouges, distortion, stretching or welding arcs. Hardware from a reputable manufacturer or distributor should be embossed with the WLL and a traceable code number. See the applicable pages in this section concerning hardware item information, selection, inspection and use.

Wire Rope Clips

Using wire rope clips is a common method of making an eye or attaching a wire rope to a piece of equipment. There are two main types, which are the U-Bolt and the Fist Grip. See Illustration #70 for clip examples. Clips can develop approximately 80% of the wire rope strength when properly applied, but can drop to 40% or less when improperly applied.

Note: ANSI/OHSA/OH&S regulations prohibit the use of clips to make eyes for slings. Sling eyes must be of a type made with a Flemish splice and a hydraulic pressed swaged fitting.

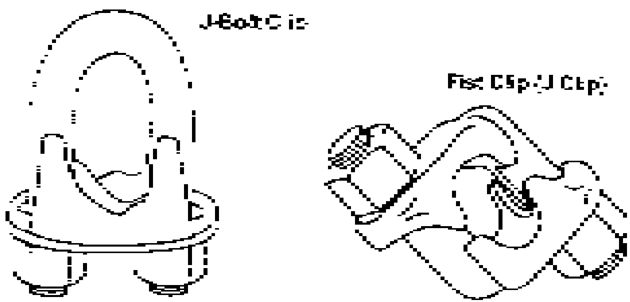


Illustration #70 - Types of Clip

U Bolt Type: When using U-bolt clips, the U section must be on the dead or short end as indicated in illustration #71A.

Fist Grip Type: The fist grip, or J-clip, offers a wide bearing surface for maximum strength and greater holding power as compared to the U-bolt type.

Note: Tighten the clips before tension is placed on the rope. Then re-tighten after a load has been applied to the rope. Clips are usually grooved and it is important to use the correct clip lay grooving to match the lay of the wire rope, otherwise the grooving edges will cut across and damage the rope wires and strands. See illustration #72 for clip installation and Table #16 for manufacturer's chart.

Number of Clips - Rule of Thumb

(use for 7/8" and under)

Number of wire rope clips = the diameter of the rope x 3 + 1 to the next whole number.

Example: 1½ inch wire rope:

D x 3 + 1 (NWN) = clips required

1½ x 3 + 1 (NWN) = 6 clips

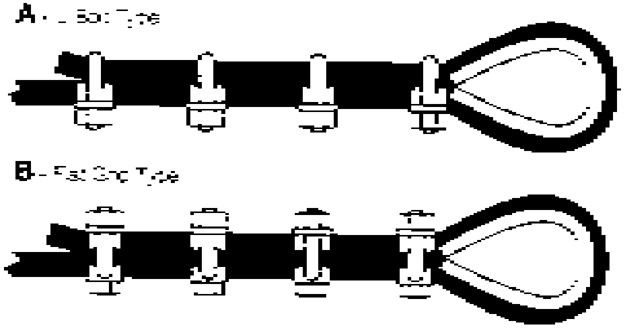


Illustration #71 - Properly Applied Clips

Spacing of Clips - Rule of Thumb

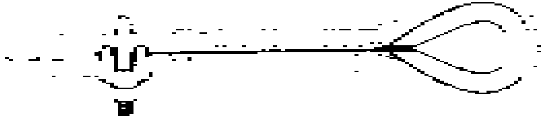
Spacing of wire rope clips
= the diameter of the rope x 6

Example: [illegible] inch wire rope:
clip spacing = D x 6
[illegible] x 6 = 9 inch spacing

Proper Clip Installation

STEP 1

[illegible] Dead End [illegible]

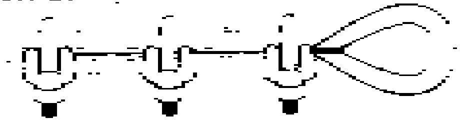


STEP 2

[illegible]
[illegible] **Do Not Tighten**

STEP 3

[illegible]



STEP 4

[illegible]

STEP 5

[illegible]

Illustration #72 - Proper Clip Installation

Rope Diam. Inches	U-Bolt and Saddle Type: Minimum No. of Clips	U-Bolt and Saddle Type: Amount of Rope to turn back in inches from Thimble	U-Bolt and Saddle Type: Torque in lbs Foot	Integral Saddle and Bolt Type: Minimum No. of Clips	Integral Saddle and Bolt Type: Amount of Rope to turn back in inches from Thimble	Integral Saddle and Bolt Type: Torque in lbs Foot
[illegible]	2	[illegible]	—	—	—	—
[illegible]	2	[illegible]	[illegible]	2	[illegible]	30
[illegible]	2	[illegible]	15	2	[illegible]	30
[illegible]	2	[illegible]	30	2	4	30
[illegible]	2	[illegible]	45	2	5	45
[illegible]	2	[illegible]	[illegible]	2	[illegible]	[illegible]
[illegible]	3	[illegible]	[illegible]	3	[illegible]	[illegible]
[illegible]	3	[illegible]	[illegible]	3	[illegible]	[illegible]
[illegible]	3	12	[illegible]	3	8	[illegible]
[illegible]	4	[illegible]	130	3	14	225
[illegible]	4	21 [illegible]	225	4	23	225
1	5	24	225	5	26	225
[illegible]	6	[illegible]	225	5	29	225
[illegible]	7	30	360	6	[illegible]	360
[illegible]	[illegible]	[illegible]	360	6	45	500
[illegible]	8	[illegible]	360	7	[illegible]	500
[illegible]	8	[illegible]	430			
[illegible]	8	45	[illegible]			
2	8	[illegible]	750			

Table #16 - Wire Rope Clip Application

Shackles

The screw pin anchor and the screw pin chain shackle are the most commonly used shackles. The anchor type is better suited for using two slings to lift a load. The working load limit (SWL) of each shackle should be embossed on the bow section and is rated in tons. The shackle is sized by the diameter of the bow section, not the pin diameter.

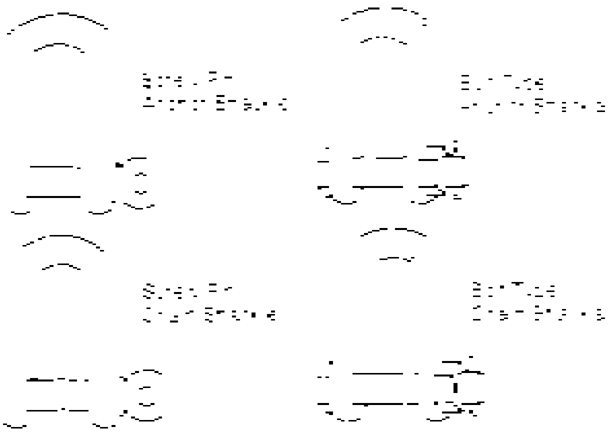


Illustration #73 - Shackle Types

General Shackle Rules

1. Use only a shackle with an embossed rating on the bow.
2. Use only the proper manufacturer's pin, never replace it with a bolt.
3. Never use a screw pin shackle if the pin can roll under load (illustration #74A,C).
4. Always pin the eye of the sling (illustration #74B).
5. Never weld any type of rigging hardware.

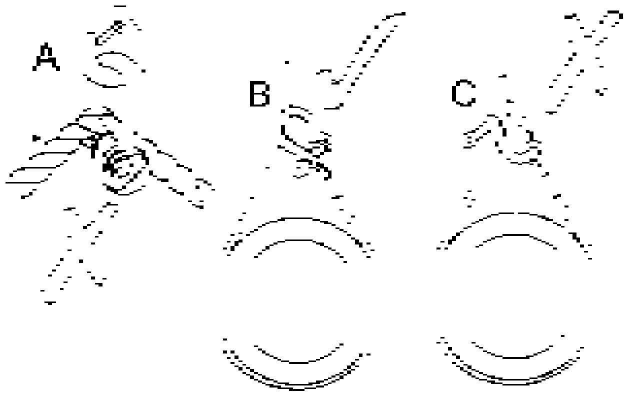
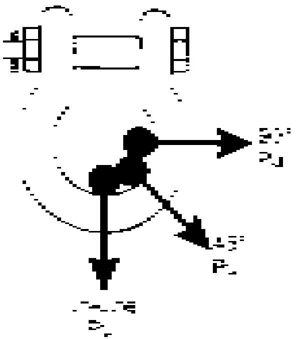


Illustration #74 - Do Not Let Rope Run Over Pin

6. Shackle pins are: 1/16 inch larger in diameter than the bow on sizes up to 7/16 inch; 1/8 inch larger than the bow on sizes 1/2 inch to 1 5/8 inch; 1/4 inch larger than the bow on sizes 1 3/4 and over.
7. Shackles are designed with maximum capacity on a straight pull. See Illustration #75 for capacity reduction on angled loads using screw pin and bolt type shackles. Do not side load a round pin shackle. Use a larger shackle for two slings spreads at a wide included angle.



Side Loading Reduction for Screw Pin and Bolt Type Shackles

Angle from Vertical	Adjusted Working Load Limit
0°	100%
45°	70%
90°	50%

Illustration #75 - Shackle Capacity Reduction

8. The pin of a shackle is usually hung on a hook and the load slings are placed in the body or anchor part. Washers, spacers or a spool provided by the manufacturer can be used on the pin to keep the shackle hanging evenly on a hook (see Illustration #76).

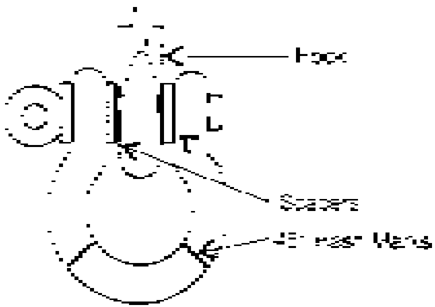


Illustration #76 - Shackle on a Hook

Note: Shackles with 45 degree hash marks on the bow are recommended. These marks indicate that slings hooked up with an included angle greater than 90 degrees have a much reduced capacity.

Shackle Working Load Limits

SHACKLES - Weldless Construction Forged Steel

Stock Diameter (Inches)	Inside Width At Pin (Inches)	Max. Safe Working Load Single Vertical Pull (Pounds)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table #17 – Shackle Working Load Limits

Synthetic Sling Shackles

New types of hardware are available to better fit the shape of synthetic slings. One type of shackle designed for web slings is shown in illustration #77A. The advantages are:

- Increased bow width gives wider sling bearing area to avoid the folding, bunching, or pinching that occurs in standard shackles.
- Increases web sling efficiency by up to 15% which brings the sling closer to its rated capacity.

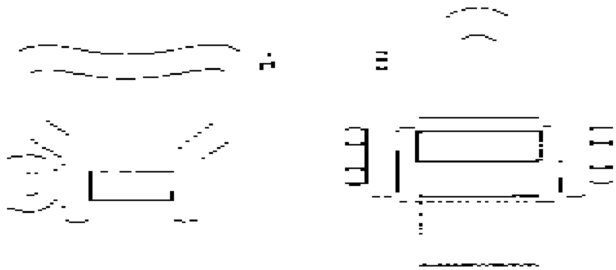


Illustration #77 – Web Sling Shackle and Connector

Another item designed for web slings is the web connector, which is a type of shackle designed for web sling use. See illustration #77B.

Extra Wide Shackle Body

The shackle shown in illustration #78A, designed for higher capacity lifts, has a bow diameter almost twice that of a normal shackle. This increases the D/d ratio (shackle bow diameter to sling diameter), which increases the sling strength efficiency, and reduces the need for a sling thimble. See illustration #78B and #78C for the bow comparison with equal sized pins.

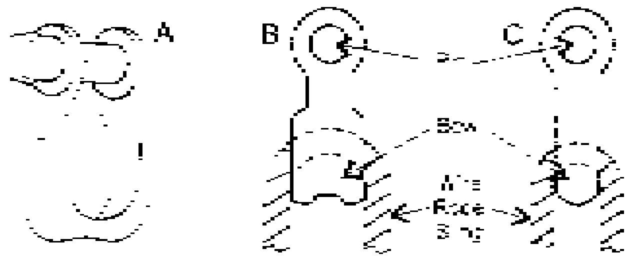


Illustration #78 – Large Bow Diameter Shackle

Hooks

All hooks should be made from forged steel and, except grab and sorting types, they should all be equipped with safety catches.

Forged hooks with the rating embossed on them are the best quality available.

Note: Inspect hooks regularly and look for wear in the saddle and for cracks, nicks, gouges, or corrosion. Check the hook attachment and securement. Make sure the safety latch is not damaged or malfunctioning.

The throat will open if the hook has been over loaded or tip loaded. OH&S OSHA regulations specify a hook should be replaced if the throat has opened 15%, or the body is twisted 10°, however some manufacturers recommend zero distortion. Therefore a safe practise is to destroy the hook if there is any distortion.

Note: *The recommended included safe lifting angle for two slings is 60°. Two slings in a hook with an angle greater than 45° to the vertical (90° included angle) is not recommended. For sling loads greater than 90° included, use an intermediate shackle.*

The load capacity is reduced if the load is applied anywhere between the saddle and tip of the hook, as indicated in illustration #79.

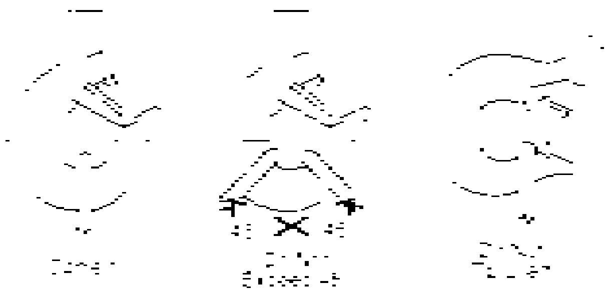


Illustration #79 – Hook Loading

Do not side load, tip load or back load any hook (see illustration #80).

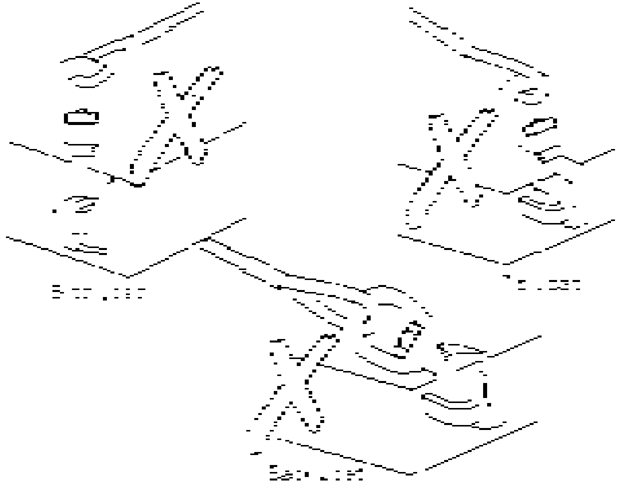


Illustration #80 – Incorrect Hook Loading Practices

Two types of hooks designed for web slings are shown in illustration #81. A standard hook with an eye designed for a web sling is shown in #81A. A slide on hook for web sling choker hitches is shown in illustration #81B.

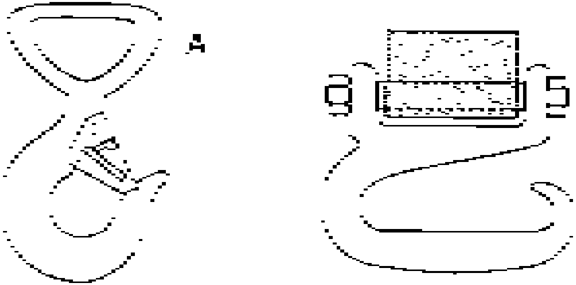
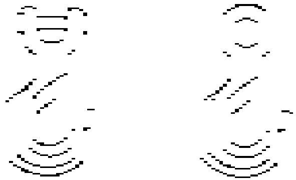


Illustration #81 – Web Sling Hooks

Note: Hook characteristics are regulated by ANSI B30.10

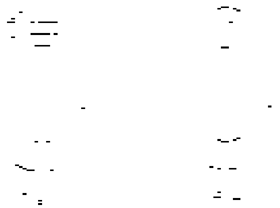
GRAB HOOKS - Clevis Type and Eye Type
Forged Alloy Steel



Throat Opening (Inches)	For Size of Chain (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	[illegible]	2,750
[illegible]	[illegible]	4,300
[illegible]	[illegible]	5,250
[illegible]	[illegible]	7,000
[illegible]	[illegible]	9,000
[illegible]	[illegible]	13,500
[illegible]	[illegible]	18,250
[illegible]	[illegible]	26,000
[illegible]	[illegible]	34,000

Table #13 – Grab Hook Working Load Limits

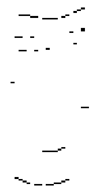
CHAIN SLIP HOOKS - Clevis and Eye Type
Forged Alloy Steel - Safety Factor of 4



Throat Opening (Inches)	For Size of Chain (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	[illegible]	2,750
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]

Table #15 – Clevis Eye Hook Working Load Limits

SLIDING CHOKER HOOKS
Forged Alloy Steel - Safety Factor of 5



Throat Opening (Inches)	For Rope Size (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table #23 – Sliding Hook Working Load Limits

Headache Ball

All crane hooks that are used for lifting should be equipped with swivels and a headache ball. The headache ball must be attached securely so that it cannot slide up and down the line. See illustration #62. The headache ball must be heavy enough to keep the crane hoist line taut when lowering without a load.

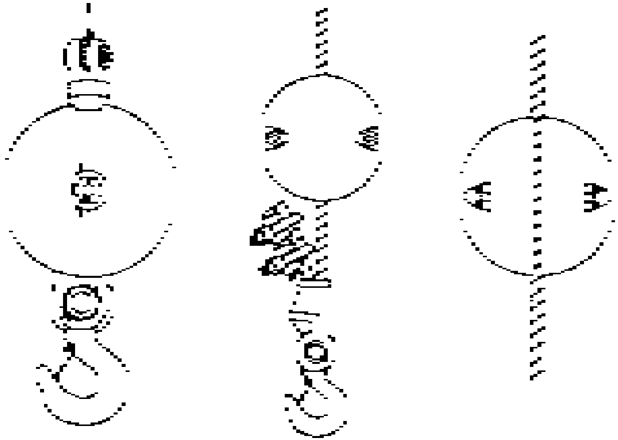


Illustration #62 – Headache Ball

Note: Some cranes may have proprietary parts and components that can only be replaced through the crane manufacturer.

Wedge Sockets

A wedge socket must be attached with the load line pulling in a straight line from the pin. See illustration #83. Due to core slippage, non-rotating rope is not recommended for use with wedge sockets, however because of the non-rotating benefit, it is commonly used in this application.

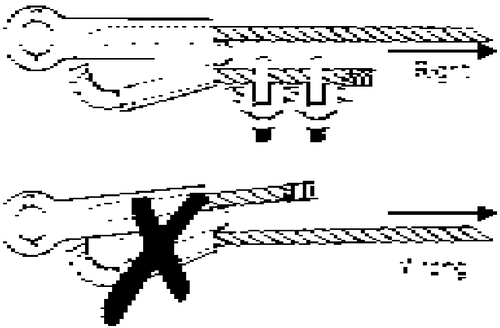


Illustration #83 – Correct Wedge Socket Use

Safety regulations vary concerning the attachment of the dead end line. The two approved methods of securing the dead end are shown in illustrations #84A and #84B.

Illustration #84A is a method shown in many safety regulations, but sometimes cannot be used when the loop is too big and can snag on projections.

Illustration #84B is currently the most popular method. A short stub is clipped to the dead end.

Illustration #84C is a new patented design. It has an extended wedge, allowing the dead end and the wedge to be clipped together.

Clipping the dead end back to the load line is a method that is no longer suggested for use by OHSA or ANSI. This is shown in illustration #84D.

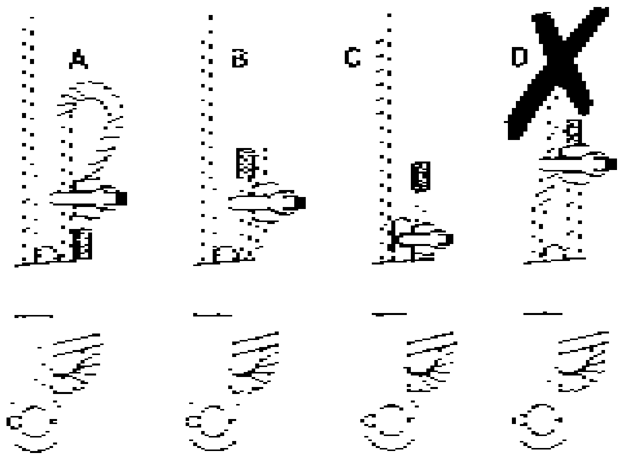


Illustration #84 – Wedge Socket Dead Ends

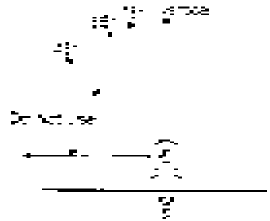
Note: Check with the applicable OH&S/OSHA department concerning wedge socket attachment, as there is a wide discrepancy about which method is permitted in different areas.

Eye Bolts

Do not apply an angular load to a shoulderless eyebolt. For added safety, always use the shoulder type. Eye bolt vertical and angular pull capacity is shown in table #21.

With an angular pull, the capacity drops to 30% of the rated capacity at a 45 degree angle.

Eye Bolt Working Load Limits
- Shoulder Type Only
- Forged Carbon Steel



Shank Diameter	Vertical Pull	60° Pull	45° Pull
[illegible]	650	420	175
[illegible]	1200	750	360
[illegible]	1550	1000	465
[illegible]	2600	1690	780
[illegible]	5200	3380	1560
[illegible]	7200	4680	2160
[illegible]	10 500	6800	3150
1	13 300	8645	3990
1 1/4	21 000	13 500	6300
1 1/2	24 000	15 500	7200

Table #21 – Eye Bolt Working Load Limits

For angular pulls, the eye must be aligned as shown in illustration #85. Shims may be needed to align the eye (limit 3 shims).

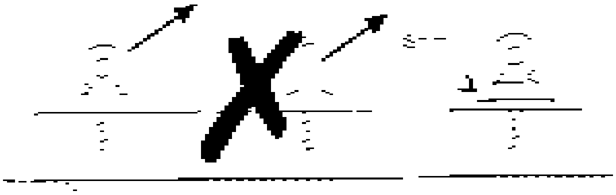


Illustration #85 – Eye Bolt Alignment

Do not insert a hook tip in the eye. Use a shackle. See illustration #86.

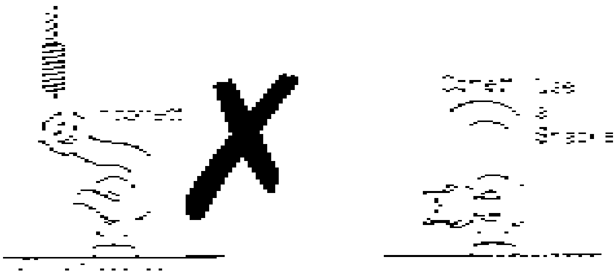


Illustration #86 – Use a Shackle

Note: Never run a sling through a pair of eye bolts. See illustration #87. The resulting sling leg load stress on the eye bolts will be much greater than what it would be if two separate slings were used, as the horizontal portion of the sling will create a compression force on the load.

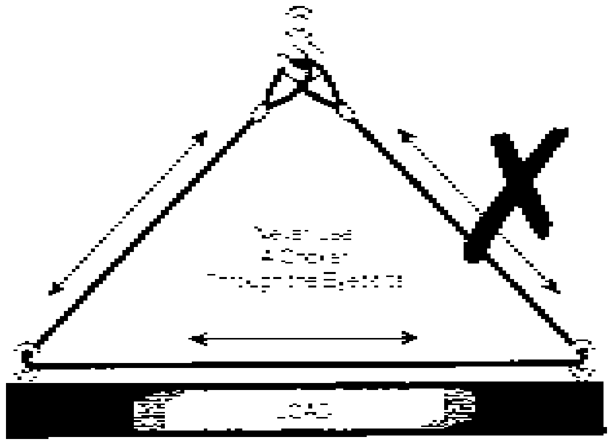


Illustration #87 – DO NOT Run a Sling through Eye Bolts

Swivel Hoist Ring

Swivel rings are a form of eye bolt. The bail (ring) swivels 360 degrees and pivots 180 degrees. In general, the rules concerning eye bolts apply to these rings. They must fit flat against the mounting surface, and be torqued to specification. Never use spacers. Drilled mounting holes must be 90 degrees to the surface. See illustration #88, and table #22.

Illustration #88 – Swivel Hoist Ring

Swivel Ring Data		
Thread Shank Size	Working Load Limit	Torque
inches	lbs	(foot - lbs)
5/16	800	7
3/8	1000	12
1/2	2500	28
5/8	4000	60
3/4	7000	100
7/8	8000	160
1	10,000	230
1 1/4	15,000	470
1 1/2	24,000	800
2	30,000	1100

Table #22 – Swivel Ring Data

Side Pull Hoist Rings

This ring is similar to an eye bolt except it is designed for a 90 degree side pull. It is rated at 100% capacity at 90 degrees. It is used with a shackle for sling attachment. See illustration #89 for an example, and table #23 for side pull ring data.

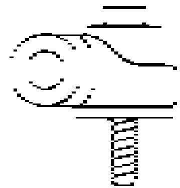


Illustration #89 – Side Pull Ring

Side Pull Ring Data

Bolt Size	Shackle	Working Load Limit	Torque
inches	inches	lbs	(foot - lbs)
[illegible]	[illegible]	850	7
[illegible]	[illegible]	800	12
[illegible]	[illegible]	2500	25
[illegible]	[illegible]	3000	50
[illegible]	[illegible]	5000	100
[illegible]	[illegible]	6500	160
[illegible]	[illegible]	8000	230
[illegible]	[illegible]	14000	470

Table #23 - Side Pull Ring Data

Eye Bolt & Swivel Ring Application

It should be noted that eye bolts lifting at an angle lose capacity, but swivel rings do not. In illustration #90, if two eye bolts were lifting vertically each would lift 4,000 lbs., requiring two 5/8 inch eye bolts. However lifting at 45 degrees creates a 5656 lb. sling load and would require two 1 1/4 inch eye bolts.

For this same lift using swivel rings, two 5/8 inch, 4000 lb. rings would lift the load vertically. However at the 45 degree angle, two 3/4 inch, 7000 lb rings are required.

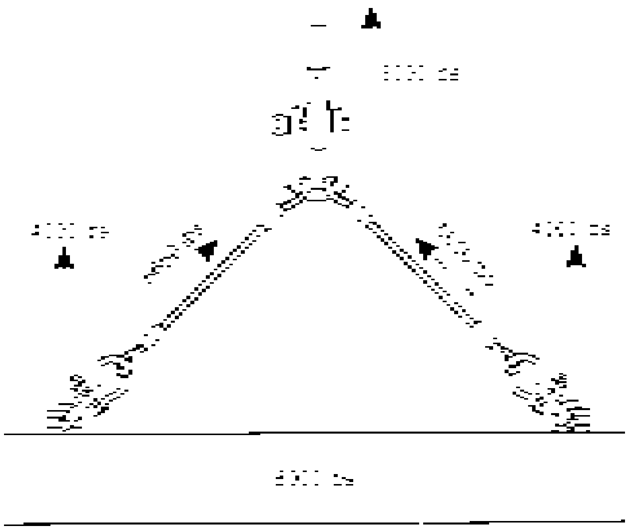


Illustration #90 – Eye Bolt and Swivel Ring Application

Turnbuckles

Turnbuckles should be made of forged alloy steel with no welded components. Several turnbuckle end fittings are indicated in illustration #91.

Note: Do not lubricate turnbuckle threads unless recommended by the manufacturer.

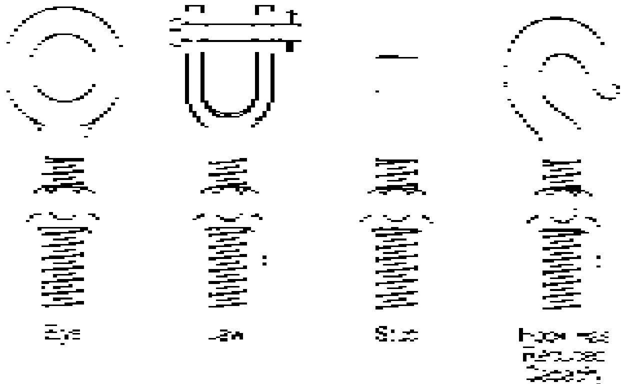


Illustration #91 - Turnbuckle End Fittings

If vibration is present, it is important to lock the frame of the end fitting, as in illustration #92. Do not use jam nuts on turnbuckles that do not come equipped with them as the jam nut will add to the load on the thread.

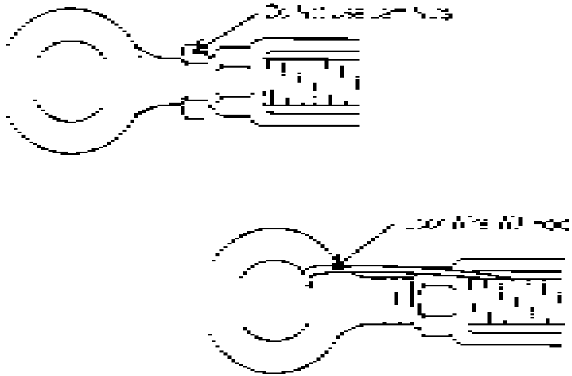


Illustration #92 - Turnbuckle Locking

The safe working load depends on the diameter of the threaded portion. The working load limits of turnbuckles are indicated in table #24.

Turnbuckle Working Load Limits

Stock Diameter (Inches)	Jaw, Eye, Stub, End Fittings (Pounds)	Hook End Fitting (Pounds)
[illegible]	500	400
[illegible]	800	700
[illegible]	1,200	1,000
[illegible]	2,200	1,500
[illegible]	3,500	2,250
[illegible]	5,200	3,000
[illegible]	7,200	4,000
[illegible]	10,000	5,000
[illegible]	15,200	5,000
[illegible]	21,400	7,500
[illegible]	28,000	

Table #24 - Turnbuckle Working Load Limits

Rings & Links

Most rings and links are embossed with their load capacity. Tables #25 to #28 show the working load limits of various types of links.

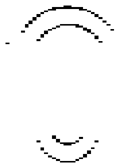
WELDLESS RINGS -

- Forged Steel
- Heat Treated

Stock Diameter (Inches)	Inside Diameter (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	4	7,200
[illegible]	[illegible]	9,600
[illegible]	4	10,800
[illegible]	6	12,400
[illegible]	5	17,000
[illegible]	6	19,000

Table #25 – Ring & Link Working Load Limits

PEAR SHAPED LINKS

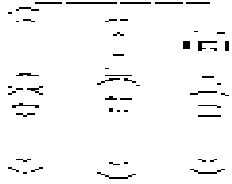


- Weldless Construction
- Forged Alloy Steel

Stock Diameter (Inches)	Inside Length (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	2 [illegible]	1,600
[illegible]	3	2,900
[illegible]	3 [illegible]	4,200
[illegible]	4 [illegible]	6,000
[illegible]	5 [illegible]	8,300
1	6	10,800
1 [illegible]	7 [illegible]	15,750
1 [illegible]	8 [illegible]	22,500

Table #26 – Pear Shaped Link Working Load Limits

SWIVELS



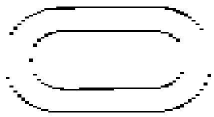
- Weldless Construction
- Forged Alloy Steel

Stock Diameter (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	850
[illegible]	1,250
[illegible]	2,250
[illegible]	3,600
[illegible]	5,200
[illegible]	7,200
[illegible]	10,000
1	12,500
1 [illegible]	15,200
1 [illegible]	18,000
1 [illegible]	45,200

Table #27 – Swivel Working Load Limits

END LINKS

- Weldless Construction
- Forged Alloy Steel

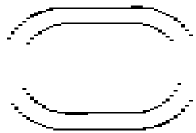


Stock Diameter (Inches)	Inside Width (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	2	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table #28 – End Link Working Load Limits

MASTER LINKS

- Weldless Construction
- Forged Alloy Steel



Stock Diameter (Inches)	Inside Width (Inches)	Maximum WLL (SWL) (Pounds)
[illegible]	[illegible]	[illegible]
[illegible]	3	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	6	[illegible]
2	[illegible]	[illegible]

Table #29 – Master Link Working Load Limits

Spreader Beams

Spreader beams are used to support long, hard to handle loads during lifting. The use of these beams eliminates load tipping, sliding or bending. They also decrease the possibility of unsafe sling angles. See illustration #93.

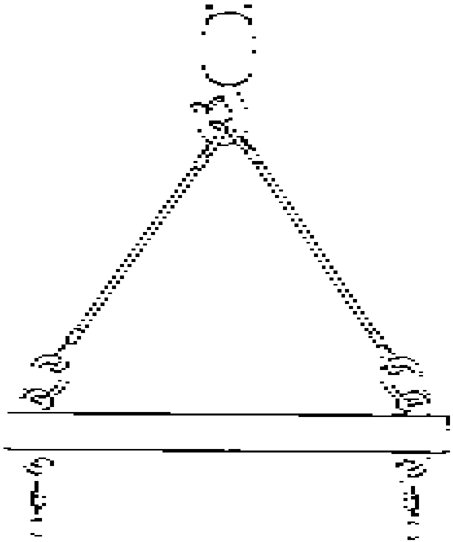


Illustration #93 - Spreader Beam

Equalizer Beams

Equalizer beams are usually used on dual hoist lines to make tandem lifts, but can also be used to equalize the load on sling legs, as in illustration #94.

Note: A custom fabricated lifting beam, or any other lifting device must be designed by an engineer. It should be tested at 125% of rated capacity. The manufacturer, the serial number, the weight and the rated capacity must be clearly indicated on all beams.

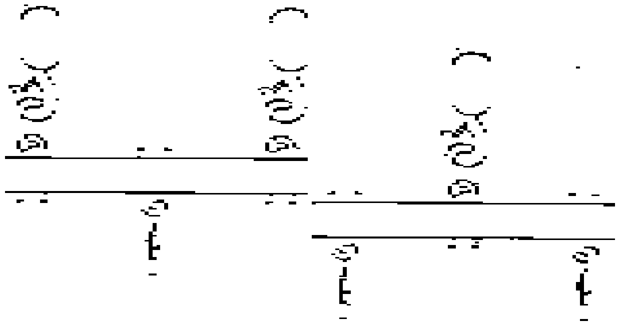


Illustration #94 - Equalizer Beam

Manbasket Safety Requirements

Manbaskets used to hoist personnel have stringent regulations on both design and construction. Illustration #95 shows a manbasket constructed to specifications.

The standard states:

1. A bridle sling used to support the basket must have a master link or shackle to evenly distribute the weight.
2. The bridle sling and any other rigging attachments used for manbasket hoisting shall not be used for any other purpose.
3. A proof test lift at 125% of the basket capacity must be conducted and held suspended for 5 minutes at each new lift site.
4. Before personnel use a basket, trial lifts with the anticipated weight must be made to all lift locations. Trial lifts shall be performed every time the crane is repositioned.

Manbasket Design (Must be Approved by an Engineer)

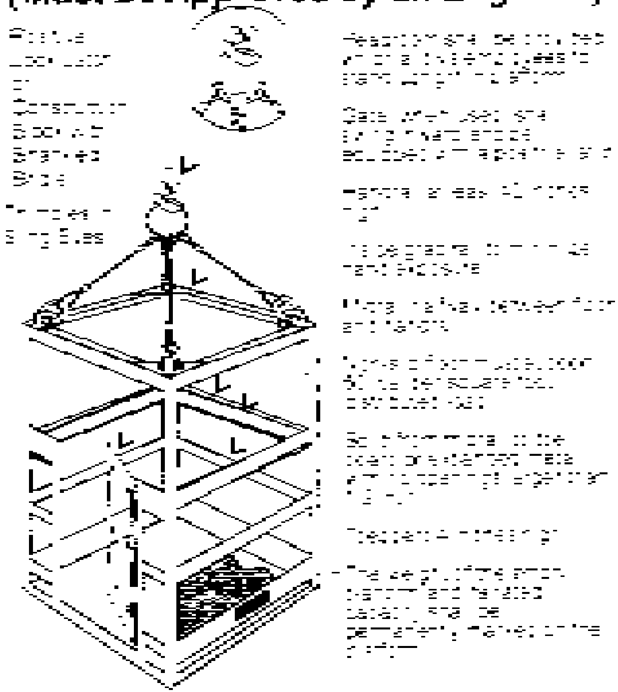


Illustration #95 - Manbasket Design

5. The total weight of the loaded platform and related rigging shall not exceed 50% of the rated capacity for the radius and configuration of the crane.
6. The number of employees occupying the personnel platform shall not exceed the number required for the work being performed.
7. If the hoist line is non-rotating wire rope, the safety factor must be 10:1.
8. The crane must be equipped with an anti-two block device.
9. The crane must have a flip over, positive type hook latch, or a construction block with a shackled bridle assembly.
10. The basket should have a metal nameplate with the basket capacity rating clearly indicated.
11. Some Canadian OH&S regulations require a safety line from the load line above the headache ball to the master ring.

Sheaves

Always check the condition and dimensions of sheave grooves before a new wire rope is placed in service. The bottom of the groove should have an arc of support of at least 120° to 150°, as indicated in illustration #96.

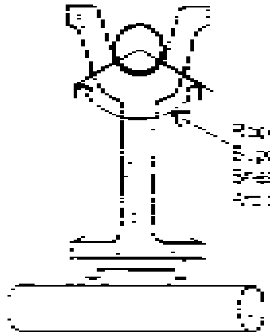
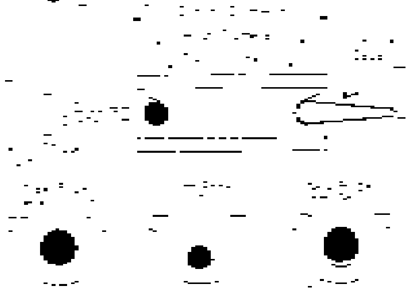


Illustration #96 - Sheave Support

To ensure a long and efficient rope life, the grooves should be smoothly contoured, free of surface defects and have rounded edges.

When the groove diameter is worn to less than the minimum values as indicated on table #30, regroove or replace the sheave.



Nominal Diameter Inches	Amount by which the Groove Diameter should exceed the Rope Diameter (in.) For Minimum Conditions	For New or Regrooved Sheaves or Drums
5/16" and smaller	1/64	1/32
3/8" to 3/4"	1/32	1/16
13/16" to 1 1/8"	3/64	3/32
1 3/16" to 1 1/2"	1/16	1/8
1 9/16" to 2 1/4"	3/32	3/16
2 5/16" and up	1/8	1/4

Table #30 – Sheave Groove Conditions

Sheave Diameter

Do not operate wire rope over a sheave smaller than the "critical" diameter. When using small diameter sheaves, the excessive and repeated bending and straightening of the wires leads to premature failure from metal fatigue. Table #31 shows several examples of minimum and critical diameters for general use sheaves.

Sheave Diameter Table

Rope Construction	Minimum Diameter	Critical Diameter
6 x 19 Seale	34 x D	20 x D
6 x 16 Filler Wire	30 x D	18 x D
6 x 19 Warrington	30 x D	18 x D
6 x 19 Seale	26 x D	16 x D
6 x 19 Filler Wire	26 x D	16 x D
6 x 22 Filler Wire	23 x D	16 x D
8 x 19 Warrington	21 x D	14 x D
8 x 19 Filler Wire	21 x D	14 x D
6 x 37 Seale	18 x D	14 x D

Table # 31 – Sheave Diameters

Construction*	Suggested D/d Ratio**	Minimum D/d Ratio**
6 x 7	72	42
19 x 7 or 18 x 7 Rotation Resistant	51	34
6 x 19 S	51	34
6 x 25 B Flattened Strand	45	30
6 x 27 H Flattened Strand	45	30
6 x 30 G Flattened Strand	45	30
6 x 21 FW	45	30
6 x 26 WS	45	30
6 x 25 FW	39	26
6 x 31 WS	39	26
6 x 37 SFW	39	26
6 x 36 WS	32	26
6 x 43 FWS	35	23
6 x 41 WS	32	21
6 x 41 SWS	32	21
6 x 49 SWS	32	21
6 x 43 FW (2 op)	28	18
6 x 46 SFW	28	18
6 x 46 WS	28	18
8 x 19 S	41	27
8 x 25 FW	32	21
6 x 42 Tiller	21	14

* WS - Warrington Seale
FWS - Filler Wire Seale
SFW - Seale Filler Wire
SWS - Seale Warrington Seale
S - Seale
FW - Filler Wire

**D - tread diameter of sheave
d - nominal diameter of rope

Table #32 – Sheave and Drum Ratios

Sheave Diameter (Rule of Thumb)

The preferred and the minimum D/d ratios suggested by various wire rope manufacturers are shown in table #32. Lacking available manufacturer's guidelines, the suggested critical diameter of a wire rope sheave should be at least 20 times the diameter of the wire rope.

Crane Blocks

Blocks are used when moving heavy objects weighing more than the safe working load of a single wire rope. The sheaves transmit the load imposed by the wire rope to the center pin, then to the side straps and connectors.

Crane blocks have heavy weights on the sides of the blocks to help overhaul the hook when unloaded, as indicated in illustration #97

Note: Some cranes may have proprietary parts and components that can only be replaced by the crane manufacturer.

Note: Never weld on any type of rigging hardware.

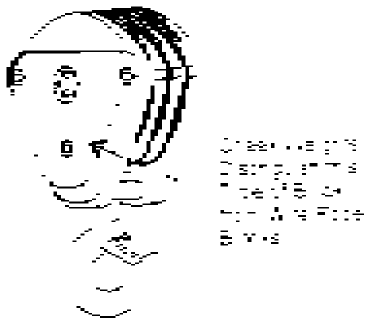


Illustration #97 - Crane Block

Note: Wire rope manufacturers indicate the efficiency, or wire rope strength decreases as it passes over sheaves. Any capacity calculations with wire rope passing over a sheave should be reduced by a minimum 5%. See pages 31 and 32.

The smaller the sheave, the higher the inefficiency. A one inch IWRC rope rated at 44.9 tons should be reduced to 42.6 tons. The reduction is only calculated once, not compounded on multisheave blocks.

Wire Rope Blocks

Depending on the capacity, these blocks are much lighter than hook blocks as they are not subjected to the abuse of hook blocks. They are equipped with cheek straps. The cheek straps provide strength between the end attachments and sheave center pins. Two examples of wire rope blocks are shown in illustration #98.

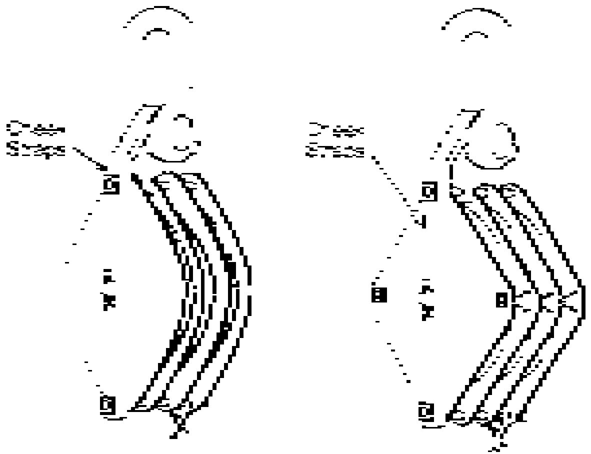


Illustration #98 - Wire Rope Blocks

Block Mechanical Advantage

The mechanical advantage of a machine is the amount by which the machine multiplies the force applied to move a load. Here the machine is a pulley or a combination of pulleys forming a block and tackle system. Usually this system is used to lift, but it can also be used to move a load laterally across a floor.

The top (fixed) sheaves or the block have no other function than to change the direction of the rope. The sheave on the bottom (travelling) block will create a theoretical mechanical advantage of 2:1 for each sheave.

Calculating Mechanical Advantage:
Count the number of lines supporting the load with the exception of the lead line when it comes down over the top block. The lead line pulling down is not counted for mechanical advantage (illustration #99A).

If the lead line comes up to the winch from the traveling block it will be counted as a supporting line and included in the mechanical advantage (illustration #99B).

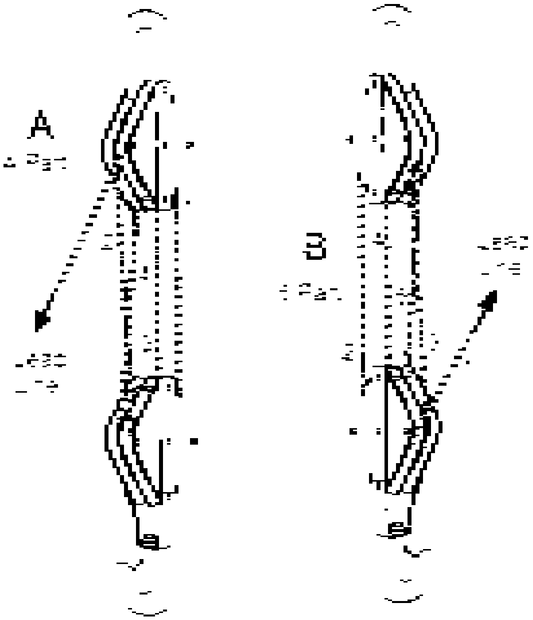


Illustration #99 - Mechanical Advantage of 4 and 5

Block Speed and Distance:

The speed of the traveling block and the distance of load travel is determined by the mechanical advantage. The speed of the traveling block and the load is calculated by dividing the lead line speed by the number of parts of line, or the mechanical advantage (M.A.). Or in other words, using a 5 to 1 M.A. the lead line will travel five feet for every foot the load is lifted, and it will travel five times as fast.

The amount of wire rope needed for the system is determined by measuring the top to traveling block distance and multiplying by the number of parts of line, plus enough wire rope to go to the winch and have at least several full wraps on the winch drum.

Block Friction:

When the load moves, part of the lifting force is lost due to friction in the turning of the sheaves, and the wire rope bending over the sheaves. Therefore the lead line pull must be increased to make up for this loss.

The relationship between a rope sheave and friction is called efficiency, and is usually expressed in terms of percent. Each type of sheave has a different friction percentage, usually based upon the type of bearings in the sheave. The extra load added by friction is calculated progressively on a line to line, sheave-to-sheave basis (see illustration #100 and the example which follows).

Block Friction Example:

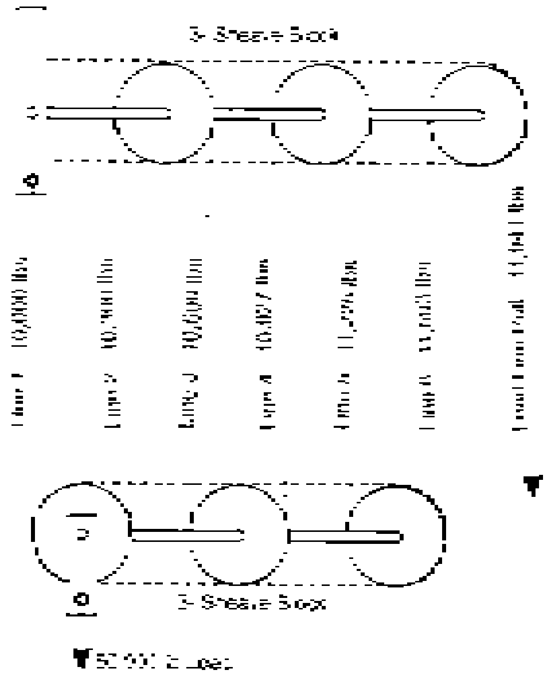


Illustration #100 - Line Friction Example

Load = 60,000 lbs or 30 tons with a 6 part line

Static load on each line equals:

60,000 ÷ 6 = 10,000 lbs load on each line

Roller bearing sheaves used (97% efficient - approximately 3% efficiency loss).

Friction Calculation

Line #1 (becket line): 10,000 lbs

Line #2 10,000 x 1.03 = 10,300 lbs

Line #3 10,300 x 1.03 = 10,609 lbs

Line #4 10,609 x 1.03 = 10,927 lbs

Line #5 10,927 x 1.03 = 11,255 lbs

Line #6 11,255 x 1.03 = 11,593 lbs

Lead line pull = 11,593 x 1.03 = 11,941 lbs

The lead line pull would be 11,941 lbs.

Note: The wire rope 5:1 WLL (SWL) referred to on pages 100-103 does not apply to block systems on cranes.

Block Friction Ratio: Table #33 shows the number of parts of line and the efficiency of three types of sheaves. It includes ratio charts for fiber rope blocks at 10% friction, wire rope bronze bushing sheaves at 5% friction, and wire rope roller bearing sheaves at 3% friction.

Three types of calculations can be made using the block friction ratio table #33. These are:

1. The number of wire, or fiber rope parts of line required to make a lift.
2. Determine the maximum load that can be lifted with a given rigging arrangement.
3. Determine the lead line pull when the load weight and number of parts of line are established or the rope size is known.

Three examples of these calculations are shown below.

Ratio Factors To Account For Friction Loads

# of Parts of Lines	Bronze Bushed Fibre Rope 10%	Bronze Bushed Wire Rope 5%	Rolling Bearing Wire Rope 3%
1	.91	.95	.97
2	1.55	1.92	1.93
3	2.25	2.53	2.75
4	2.74	3.29	3.54
5	3.11	3.91	4.37
6	3.39	4.42	5.00
7	3.61	4.96	5.52
8	3.74	5.41	6.32
9		5.81	6.87
10		6.13	7.21
11		6.43	7.31
12		6.57	8.33
13		6.56	8.64
14		7.00	8.27
15		7.21	8.62
16		7.34	8.94
17		7.42	10.33
18		7.45	10.59
19		7.51	10.50
20		7.55	11.32

Table #33 – Block Friction Ratios

1. Determine Number of Parts of Line Required:

Determine the WLL (SWL) of the wire rope by chart or rule of thumb.

The rule of thumb formula is:
diameter squared x 8 = WLL (SWL).

Determine the weight of the load.

Load weight / WLL = R (ratio).

Find ratio in table =33

The number of parts of line is indicated opposite the applicable ratio number.

Example One – Number of Parts of Line:

Size of wire rope = 1 1/4 inch

Load weight = 75 tons

Type of sheaves = roller bearing

WLL (SWL) of 1 1/4 iron rope
= 1.25 x 1.25 x 8 = 12.5 tons

Total weight of load: 75 tons
75 tons / 12.5 = 6 (ratio)

From the column under Roller Bearing wire rope 3%, we read 6.30 as the next highest number over the calculated answer of 6. The first column indicates 8 parts of line.

2. Determine Maximum Load to be Lifted:

The number of parts of line to be used.

Type of sheaves: 3% for roller bearings, 5% for bronze bushing.

The WLL or safe working load of the wire rope to be used or the maximum lead line pull.

The rule of thumb formula = diameter squared x 8 = WLL (SWL)

Use the ratio from table #33 opposite the number of parts of line.

Calculate the maximum WLL (SWL) of the wire rope or the lead line pull x the ratio of the maximum load.

Example Two – Maximum Load.

14 parts of line

roller bearing sheaves = 3%

¾ inch wire rope

Roller bearing sheaves = 3% loss due to friction.

¾ inch wire rope = .75 x .75 x 8 = 4.5 tons WLL (SWL)

Chart ratio opposite 14 parts of line = 9.27 (table #33)

To calculate the maximum load:

WLL x ratio = load

4.5 x 9.27 = 41.715 or 42 ton maximum load.

3. Calculation to determine the lead line pull and wire rope diameter needed when the load weight and number of parts of line are established.

The type of sheave: 3% for roller bearings. 5% for bronze bushings.

The total weight of the load including lifting equipment.

The number of parts of line to be used.

Calculate the line pull by dividing the load weight by the ratio (opposite the correct number of parts of line from table #33).

Load weight / ratio = lead line pull

Calculate the size of wire rope needed, with a design factor of five from tables #5 and #6, pages 28 and 30.

Example Three - Lead Line Pull & Wire Rope Diameter

bronze bushed sheaves = 5%

load weight = 25 tons

parts of line = 8

Bronze bushed sheave = 5%

Weight of the load = 25 tons

Parts of line to be used = 8

Chart Ratio (opposite 8 parts on table #33) = 5.41

Calculate the lead line pull
= 25 tons / 5.41 ratio = 4.62 tons.

The lead line pull of 4.62 tons x 5 (design factor) = 23.1 tons of ultimate strength required.

Calculate the size of wire rope needed: IWRC improved plow with a design factor of 5; to the next highest number = ¾ inch.

From table #5, ¾ inch = 25.6 tons (ultimate strength), minus 5% = 24.3 tons.

Block Reeving Methods

Following are several tips to help block reeving:

- If the stationary block has more than two sheaves the lead line should be positioned to come off a center sheave to balance the block under load.
- When both blocks have the same number of sheaves, the rope dead end (becket) is attached to the stationary block. When the number of sheaves per block varies, the becket is attached to the block with the fewer sheaves, which will be the travelling block.
- When reeving, the becket end should be led through the blocks starting where the lead line exits, and continued on through toward the becket connection to eliminate pulling all of the wire rope through the blocks.
- Before reeving, position the blocks as close together as possible to give less wire rope to pull through.
- The popular methods of arranging wire rope and sheaves to gain mechanical advantage are lacing, skip reeving and square reeving.

Block Lacing

Lacing is the least complicated method of reeving a set of blocks. See Illustration #101. The wire rope is led through the top outside sheave, goes down to the back of the outside bottom sheave, then progresses from sheave to sheave, from left to right.

The advantages are that it is relatively easy, the blocks will pull quite close together which creates more lifting height, and there are no reverse bends in the rope.

The disadvantage is that the rope and sheave speed is faster on one side. This causes the blocks to tilt together on one end, resulting in the rope wearing against the sheaves. Lacing also tends to rotate the blocks and twist the lines together.

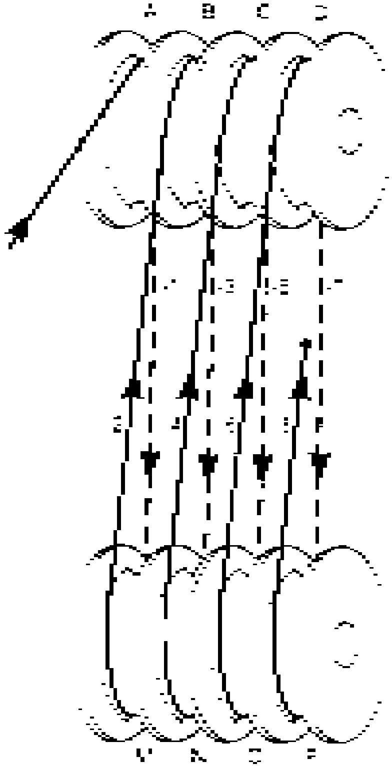


Illustration #121 - Block Lacing

Skip Reeving

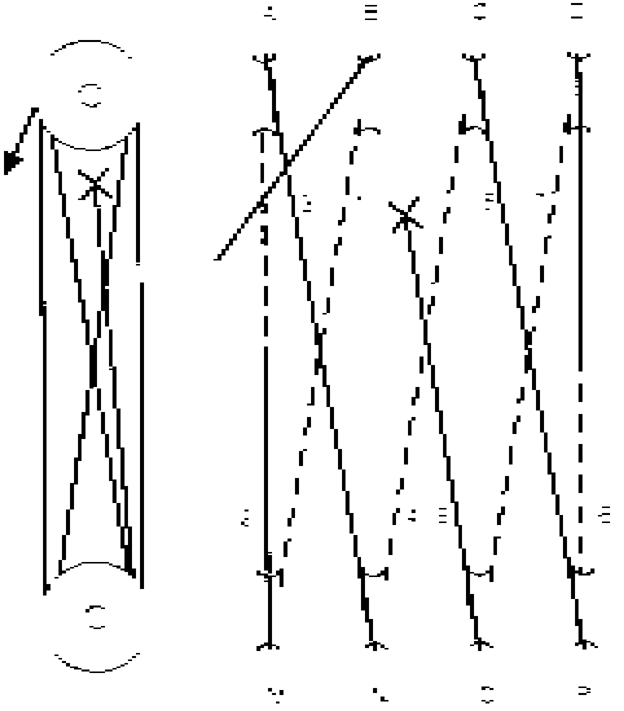
Skip reeving is basically a more complicated method of lacing. An example is shown in illustration #102. Instead of the rope moving progressively sheave to sheave, the rope is fed into a center sheave and a sheave is jumped or skipped as it is fed through from left to right. The rope crosses over from front to rear (or vice versa) on the end sheaves. This creates two reverse bends in the rope, however the line speed is more balanced at each end with the blocks remaining more level.

Square Reeving

The blocks are positioned with one block turned 90 degrees to the other. The main advantage is that the blocks are brought into balance and run smooth and level.

Square reeving has two major disadvantages:

1. The blocks cannot come close together due to the positioning of the blocks and wire rope.



Eight Parts - Two Reverse Bends

Illustration #102 - Skip Reeving

if attempted, it causes the block-to-block lines to come off the sheaves at excessive angles, resulting in line scrub and sheave wear.

2. Wire rope with this square reeve continually goes through reverse bending. Reverse bending in a wire rope will eventually result in premature fatigue.

Most sets of blocks can be square reeved in two types of patterns. The better method has the lead line coming off one of the center sheaves for balance. The other has the lead line coming off an end sheave, however an uneven block pull is partially offset with the next line coming off the sheave on the opposite end. See illustrations #104 to #109 for examples.

Reeving Pattern

For a number of reasons, reeving a set of blocks is never an easy process. One of the difficulties with the blocks spread out is being aware of what sheave to feed the wire rope through.

The following method uses a labeling system to indicate the top, bottom, front, or rear of the blocks.

It is as follows (see illustration #103):

For the top or fixed block, the front of the sheaves are a (tf), and the rear of the sheaves are a (tr). Therefore:

a. The top front sheaves are labeled (tf)A, (tf)B, (tf)C, etc.

b. The top rear sheaves are A(tr), B(tr), C(tr), etc.

For the bottom or traveling block, the front of the sheaves are a (bf), and the rear of the sheaves are a (br).

Therefore:

c. The bottom front sheaves are labeled (bf)M, (bf)N, (bf)O, etc.

d. The bottom rear sheaves are M(br), N(br), O(br), etc.

e. Becket up or becket down indicates whether the wire rope is attached to the top or bottom block.

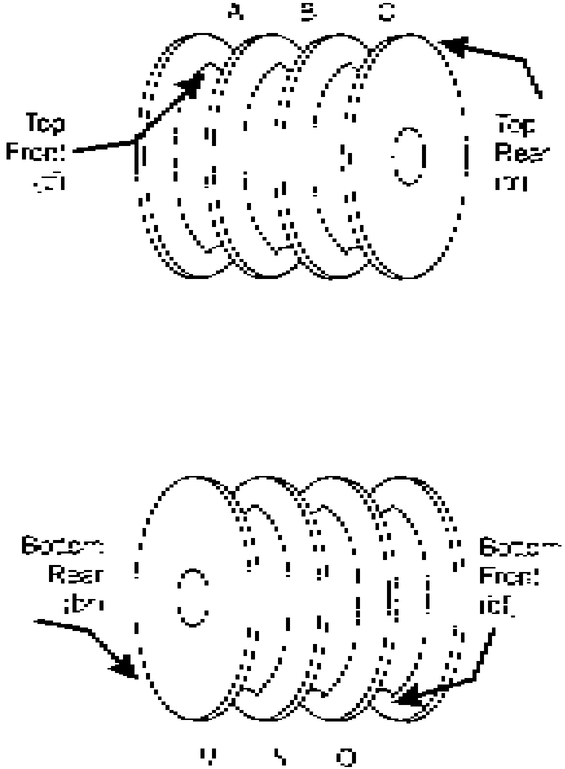


Illustration #103 - Square Reeving

The pattern for three to eight parts of line, and also ten and twelve are listed below.

The lead line enters in the top block in all cases, then follows through to the becket.

Three Part. 3 sheaves laced (top = A, B, bottom = M):

Code is: ***(tf)A, M(br), (tf)B, becket down.***

Four Part. 4 sheaves square reeved (top = A, B, bottom = M, N):

Code is: ***(tf)B, (bf)N, A(tr), M(br), becket up.***

Five Part. 5 sheaves square reeved (top = A, B, C, bottom = M, N):

Code is: ***(tf)B, N(br), C(tr), (bf)M, (tf)A, becket down.***

Six Part. 6 sheaves square reeved (top = A, B, C, bottom = M, N, O):

Code is: ***(tf)B, (bf)O, A(tr), M(br), (tf)C, (bf)N, becket up.***

Seven Part. 7 sheaves square reeved (top = A, B, C, D, bottom = M, N, O):

Code is: ***(tf)C, (bf)N, A(tr), M(br), (tf)D, (bf)O, B(tr), becket down.***

Eight Part. 8 sheaves square reeved (top = A, B, C, D, bottom = M, N, O, P):

Code is: ***(tf)C, (bf)O, A(tr), M(br), (tf)D, (bf)P, B(tr), N(br), becket up.***

Ten Parts. 10 sheaves square reeved (top = A, B, C, D, E, bottom = M, N, O, P, Q):

Code is: ***(tf)C, P(br), D(tr), (bf)N, (tf)B, Q(br), E(tr), (bf)M, (tf)A, O(br), becket up.***

Twelve Parts. 12 sheaves square reeved (top = A, B, C, D, E, F, bottom = M, N, O, P, Q, R):

Code is: ***(tf)D, (bf)P, A(tr), M(br), (tf)F, (bf)R, B(tr), N(br), (tf)E, (bf)Q, C(tr), O(br), becket up.***

Square Reeving Examples

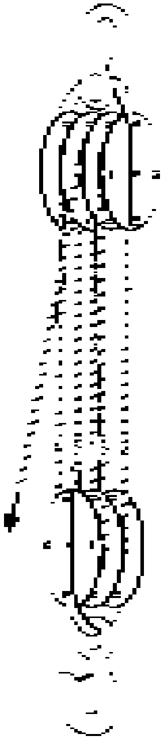


Illustration #104 – Five Part

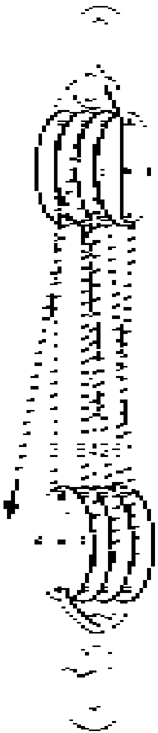


Illustration #105 – Six Part

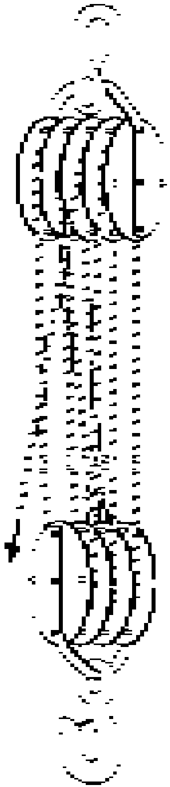


Illustration #106 – Seven Part

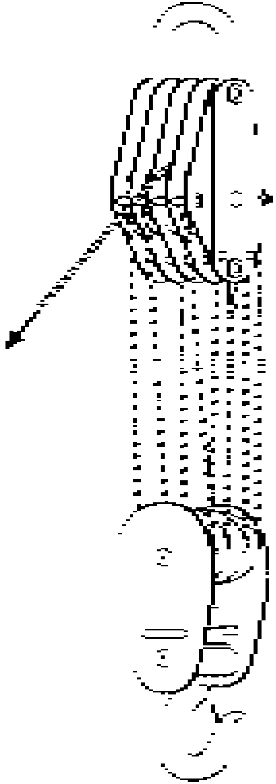


Illustration #107 – Eight Part

Square Reeving Examples

Ten Part Square Reeved

(Illustration #108)

Enter the lead line at the front of the stationary block at sheave C.

Down behind to the traveling block and through sheave P.

Up behind and through D.

Down in front and through N.

Up in front and through B.

Down behind and through O.

Up behind and through E.

Down in front and through M.

Up in front and through A.

Down behind and through O.

Up and becket off on the stationary block for 10 parts.

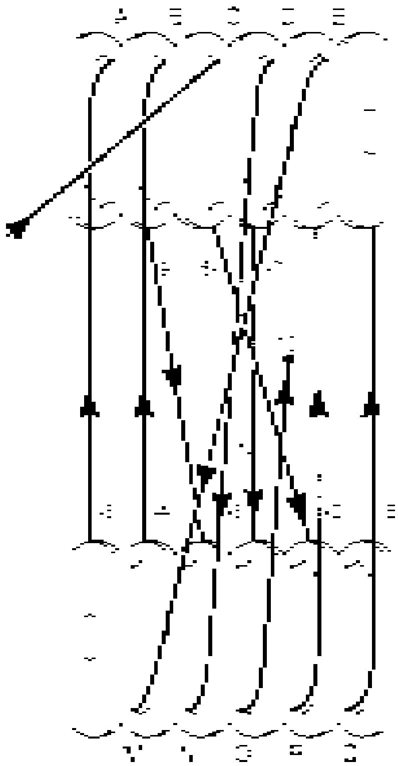


Illustration #108 – Square Reeving Ten Part

Twelve Part Square Reeved (Illustration #109)

Enter the lead line at the front of the stationary block at sheave D.

Down in front of the travelling block and go through P.

Up behind and through A.

Down behind and through M.

Up in front and through F.

Down in front and through R.

Up behind and through B.

Down behind and through N.

Up in front and through E.

Down in front and through Q.

Up behind and through C.

Down behind and through O.

Up to the stationary block and becket off for 12 parts.

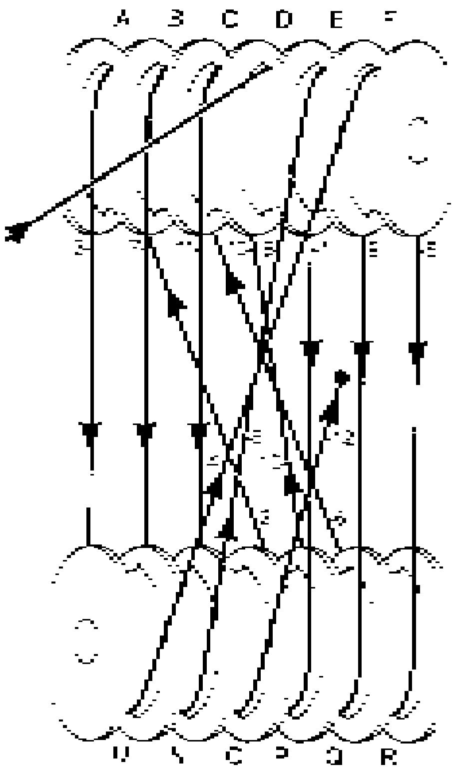


Illustration #109 – Square Reeving Twelve Part

Snatch Blocks

Snatch blocks are used to change line pulling direction of a wire rope. The side opens to allow positioning of the rope without having to feed it through the block. See illustration #110.

Illustration #110 – Snatch Block Side Plate

The load on the snatch block varies with the angle between the lead and load lines. When both the lead and load lines are parallel, the load on the block hook is double the weight of the load plus friction when the load is moving. As the angle opens up, the load on the hook is reduced. To determine the load on a block, multiply the pull on the lead line by the applicable factor from table #34.

Multiplication Factors For Snatch Block Loads

Angle Between Lead and Load Lines	Multiplication Factor
10°	1.99
20°	1.97
30°	1.93
40°	1.87
50°	1.81
60°	1.73
70°	1.64
80°	1.53
90°	1.41
100°	1.29
110°	1.15
120°	1.00
130°	.84
140°	.68
150°	.52
160°	.35
170°	.17
180°	.00

Table #34 – Factors for Snatch Block Loading

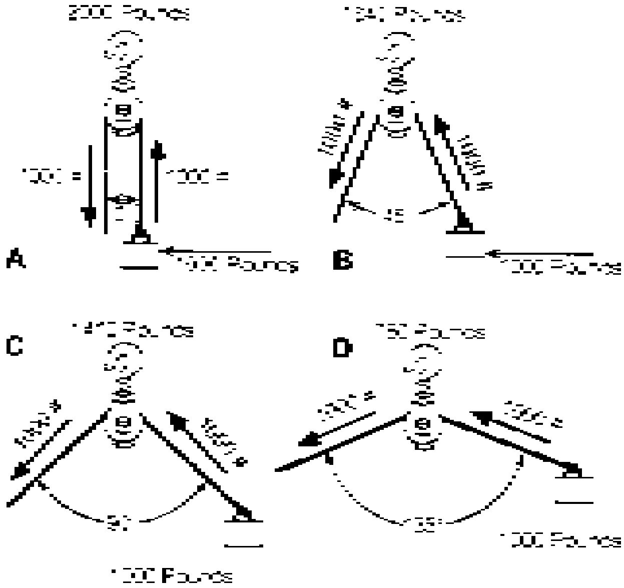


Illustration #111 - Snatch Block Loading

Note: On a straight vertical pull (illustration #111A), the block rigging must hold double the load weight.

Snatch Block Load Example

Illustration #112 shows a 10,000 pound load being lifted using four snatch blocks.

All wire rope changing direction from a sheave loses efficiency to some degree (more pull required).

The efficiency loss depends on the wire rope to sheave size ratio (D/d), the angle of pull on the sheave (illustration #111), and the type of sheave.

A snatch block with a bronze bushing loses approximately 5% on a 0 degree pull (illustration #111A).

In the example shown in illustration #112 sheave A is based on a 5% (1.05) loss, sheave B at 3% (1.03), and 2% (1.02) for sheaves C and D. Sheaves B, C and D have less efficiency loss because the pull angles are more open.

The approximate progressive line pull and sheave pull is:

Line 1		= 5,000
Sheave A	= 5000 x 2	= 10,000
Line 2	= 5000 x 1.05	= 5,250
Line 3	= 5250 x 1.03	= 5,407
Sheave B	= 5407 x 1.41	= 7,624
Line 4	= 5407 x 1.02	= 5,515
Sheave C	= 5515 x 1.00	= 5,515
Line 5	= 5515 x 1.02	= 5,625
Sheave D	= 5625 x 1.00	= 5,625
Hoist Pull		= 5,625

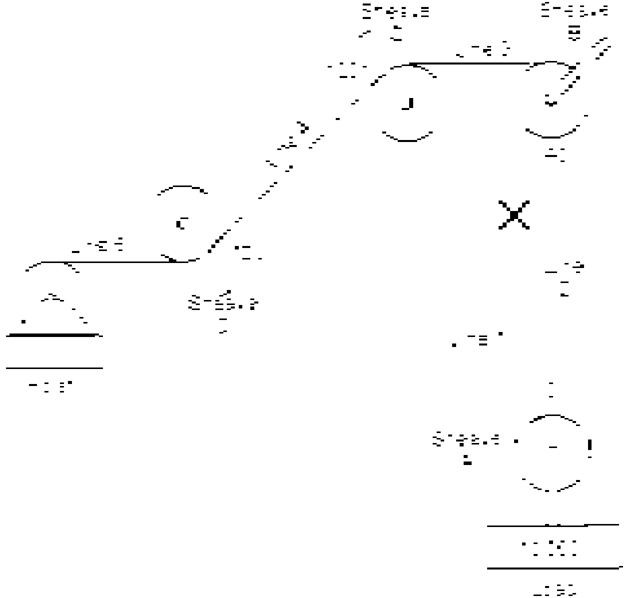


Illustration #112 - Snatch Block Load Example

Wire Rope Drums

When winding wire rope from a storage reel onto another reel or drum, the rope must be reeled correctly to avoid fighting the rope's natural looping and also prevent future winding problems.

The rope must wind from the top of one reel or drum to the top of the other or, from the bottom of one reel or drum to the bottom of the other, as indicated in Illustrations #113A and #113B.

Note: Do not cross wind the wire rope from top to bottom, see illustration #113C.

Winding Wire Rope on a Drum

To properly install a rope on a drum or winch stand behind the drum and face it. The right hand represents Right Lay Rope and the left hand represents Left Lay Rope. Make a fist and extend the index finger.

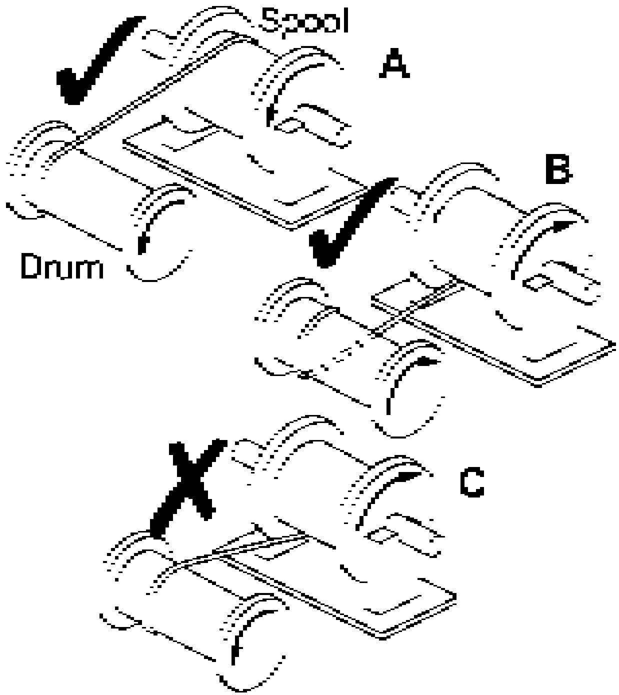


Illustration #113 – Reel To Drum Spooling

If the rope is Right Lay, imagine the right fist as the drum and the index finger as the rope. The wire rope will attach to the drum on the thumb side of the fist. This method is indicated in Illustration #114.

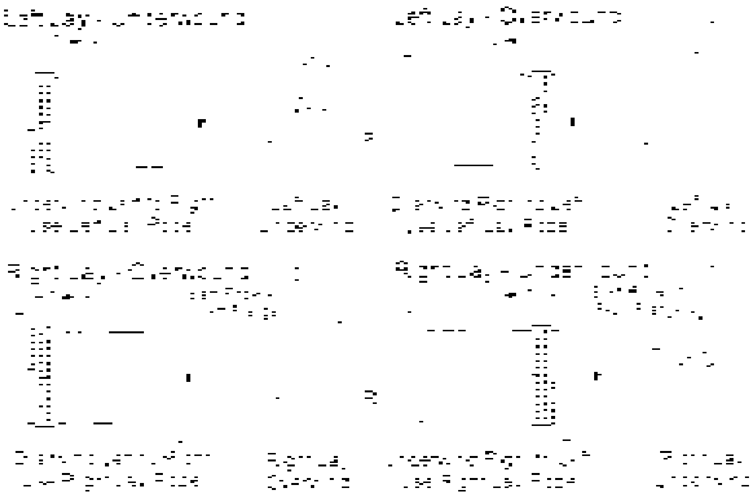


Illustration #114 - Winding Wire Rope on a Drum

Drum Grooves and Wire Rope Lay

In a multi-layer winding, rope lay direction usually does not affect the rope performance. However in a single layer application the general rule is for the drum grooves to be opposite that of the rope lay. That would be left hand drum grooving for a right lay rope. Rope winding is adversely affected with a wide fleet angle.

Fleet Angle and Sheave Alignment

The fleet angle is the off-center angle from the outside wire rope wrap on a drum to the working sheave. As indicated in illustration #115, one line is drawn from the center of the drum to the sheave, and the other line extends from the sheave to the outside wrap on the drum nearest the flange of the drum.

- On a grooved drum the fleet angle should not exceed 2° (30:1 ratio);
- On a smooth drum the fleet angle should not exceed 1½° (40:1 ratio).

- The ratio is based on half the drum width and the distance from the drum out to the sheave.

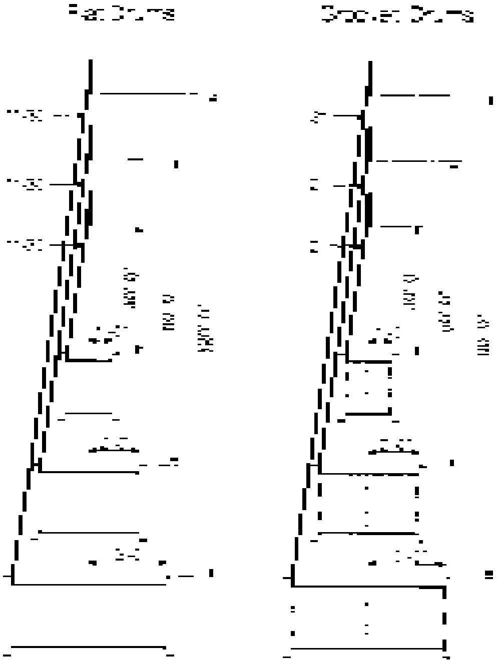


Illustration #115 – Fleet Angles

Wire Rope Drum Capacities

Illustration #116 and table #35 are used to calculate the approximate wire rope capacity of a drum or reel.

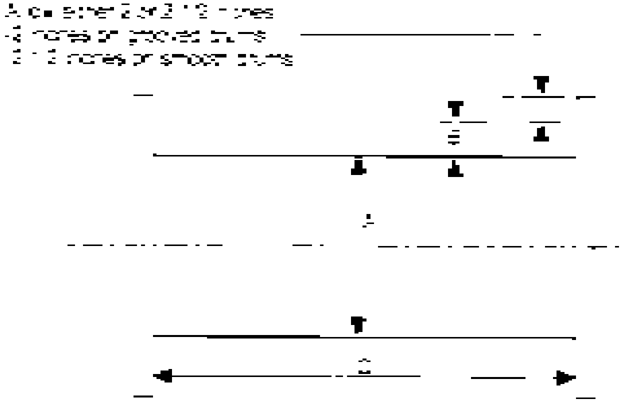


Illustration #116 – Drum Reference Capacities

Nominal Rope Diameter (inches)	Factor
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	0.525
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	0.342
1	0.282
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
2	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Table #36 - Drum and Reel Factors

Formula to find the drum capacity (feet of rope) = (A + B) x B x C x F

Add the diameter of the drum (A) to the depth of the flange (B). Multiply this sum by the depth of the flange (B). Multiply the result by the distance between the drum flanges (C). Multiply this result by the factor of (F) listed in table #36 opposite the diameter of rope to be used.

Drum Capacity Example:

The diameter of the drum is 16 inches
The depth of the flange is 2 inches
The distance between flanges is 24 inches
The drum capacity for one inch is:
(A + B) x B x C x F =
(16 + 2) x 2 x 24 x .282 = 226 feet
(The dimensions are given in inches and the answer is in feet.)

Basic Drum Data

There are a number of different types of wire rope drum, ranging from crane and dragline hoists to a variety of different industrial tuggers.

Check manufacturer's specifications where possible, although in general, at least two full wraps must remain on a drum in all service conditions. Check this number with the local ANSI/OSHA/OH&S regulations as the number of wraps required can be three, or up to five in some areas.

Observe the following conditions:

- The drum end of the rope should be anchored to the drum with a clamp supplied by the manufacturer.
- The flange on a grooved drum should project 2 rope diameters or 2 inches (whichever is larger) beyond the last layer of rope.
- The flange on a flat drum should project 2 rope diameters or 2 1/2 inches (whichever is larger) beyond the last layer of rope.
- Whenever possible, not more than three layers of rope should be on the drum at one time. This will help prevent rope crushing.
- The maximum pull of the hoist occurs on the first layer, and decreases with every following wrap of the wire rope.

See pages 97 to 103 for information on load weight compared to line pull, friction and mechanical advantage.

Drum Hoists (Tuggers)

Base mounted drum hoists (referred to as tuggers) are regulated by ANSI B30.7. This type of hoist can be powered by several methods including: gas or diesel engines, electric motors, compressed air, or hydraulics.

The larger gas or diesel units were often used to lift process plant towers and vessels with a set of gin poles. In most cases they have been replaced by high capacity cranes. However these units are used to power barge derricks.

Drum hoists were commonly used, and are still occasionally used, to power cableway systems (the Hoover Dam construction used a series of cableway systems). Cableways fall under ANSI B30.19.

Smaller tuggers are used for hoisting or lowering loads, or pulling smaller loads laterally across a floor.

Electric or air powered units are often used on construction sites for hoisting small components up through the building steel (see illustration #117).

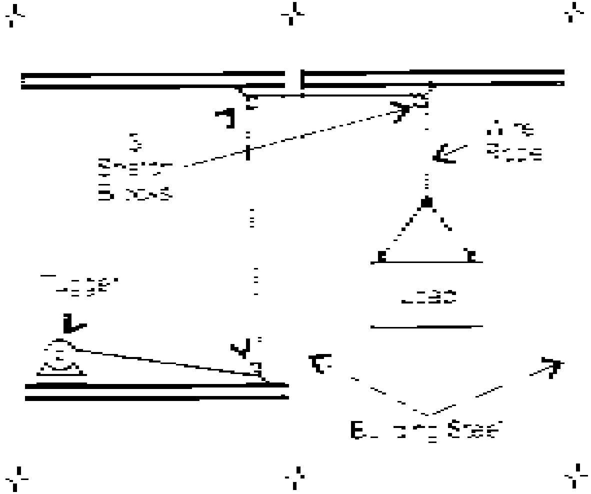


Illustration #117 - Lifting Construction Loads

A typical air tugger is shown in Illustration #118.

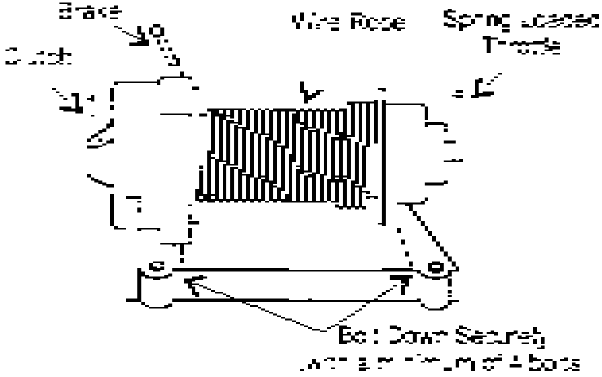


Illustration #118 – Typical Air Tugger

- All hoists must have an identification plate with the following information: load rating; drum size (barrel diameter, barrel length, flange diameter); rope size; rope speed; and rated power supply.
- If air powered, the air hose should be blown out to remove excess moisture before attaching to the hoist.
- The wire rope must be attached to the drum by a method approved by the manufacturer. See Illustration #119A for an example.
- The base must be bolted down securely.
- To maintain proper positioning of the wraps on the drum, the wire rope should be spooled out to a lead sheave aligned with the drum center to maintain the proper fleet angle (Illustration #119B).
- A drum with loads suspended for extended periods must have a ratchet and pawl holding method in addition to the brake.
- Never leave a suspended load unattended.
- The operator or someone giving signals must have a clear view of the load at all times.
- The wire rope and other rigging hardware must meet the normal 5:1 or applicable working load limit (SWL).

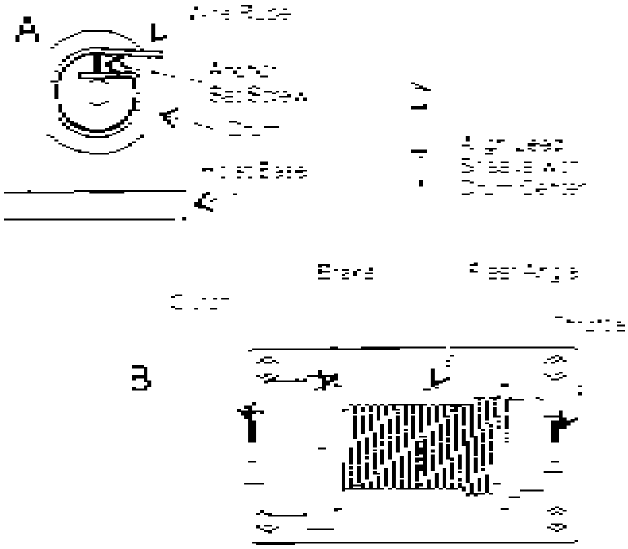


Illustration #119 – Tugger Connections

- Keep hands and clothing clear of the rope and drum when spooling on.
- Throttle controls are usually spring loaded to return to neutral. Modern hoists can often be operated by remote control.
- To lock the drum and prevent rotation, the manual brake control lever is pushed down.
- The clutch control lever is pulled out to disengage. This allows the drum to free-wheel when unwinding the wire rope by hand.
- All hoist components, including base, motor and controls, drum, and wire rope must be inspected regularly for any signs of wear.

Three types of hoists are shown in illustrations #120A,B,C. An air hoist is shown in #120A, an electric hoist in #120B, and a larger three drum gas or diesel hoist in #120C. The swinger drum in #120C may be used to rotate a barge derrick.

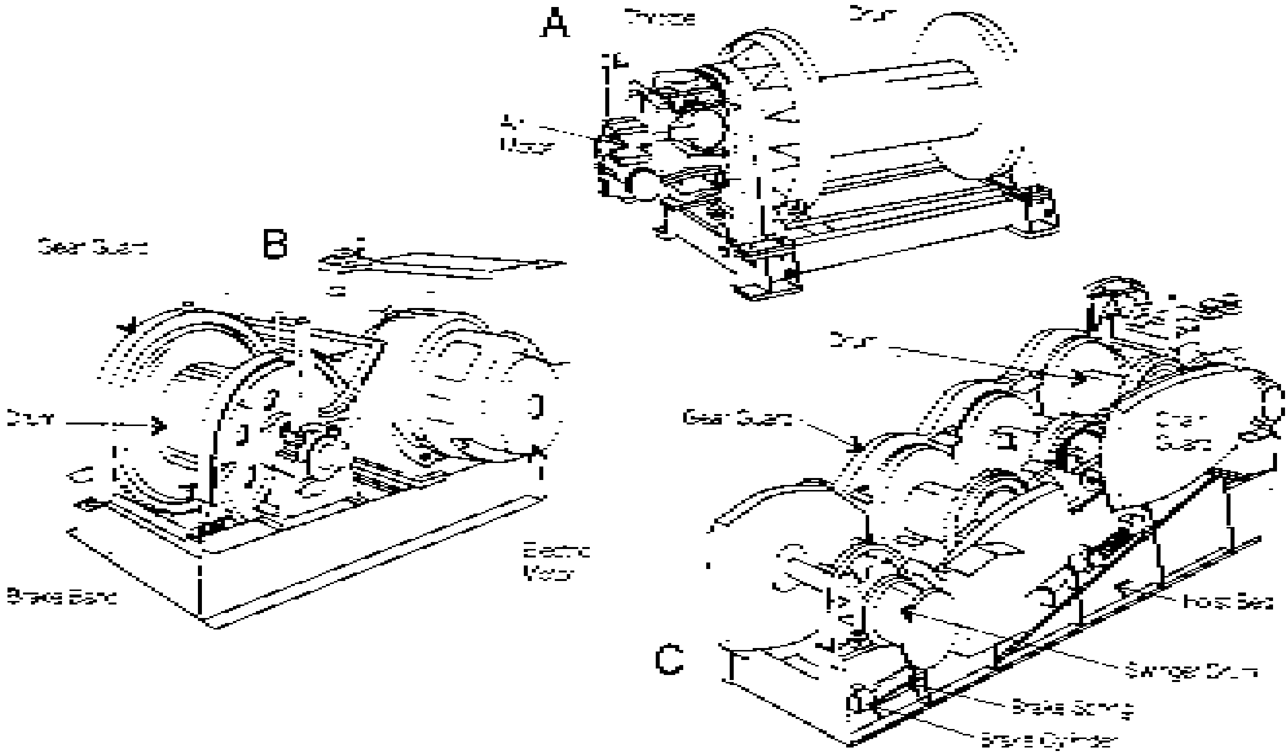


Illustration #120 – Types of Drum Hoist

Chain

Try to avoid using chain whenever it is possible to use synthetic fiber or wire rope. The failure of a single chain link results in the complete failure of the chain, whereas the wire rope is made up of many wires and strands and they must all fail before the rope breaks. Chain usually gives no warning when it is about to break, other than the obvious visible sign of a stretched link or links, whereas a wire rope usually breaks through a progression of snapping wires and strands which can usually be clearly heard.

Chain is not suitable for impact loading as there is no elasticity, and although a wire rope should also not be shock loaded, it does allow a limited amount of flexibility.

Chains are more suitable than wire rope for certain jobs, as they withstand rougher handling, will not kink, and are much more resistant to abrasion and corrosion when used as load slings for such items as heavy castings.

Chain Grade Identification

Chain should have an identifying mark embossed regularly on the links as indicated in illustration #121. Chain quality identification can be confusing as different manufacturers may use their own system of marking. Some of the more common markings for alloy hoisting chain are "A" or a version of the number "8", such as "80" or "800".

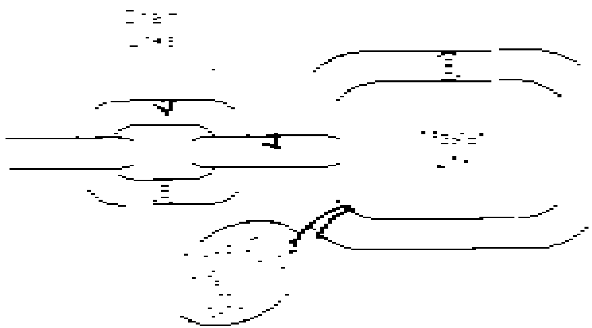


Illustration #121 – Chain Identification

Chain Safety Tips

1. Keep shock loading to a minimum.
2. Never shorten a chain by tying a knot in it, or by bolting two links together. A chain has its maximum strength with the load running in a straight line through the links.
3. Only use alloy hoist slings for lifting a load. Never use decking chain for lifting. Without being familiar with chain identification markings, the strength of a chain will be unknown. For example a chain with 1/4 inch (6.4 mm) links can vary in safe load capacity from 1200 to 3500 pounds, depending upon the grade.
4. Never use homemade links.
5. Never use repair links on alloy chain.
6. Never weld an alloy chain.
7. If the links of a chain bind on each other the chain is overstretched.
8. Always use softeners on the corners of rectangular loads. This reduces the transverse loading that chain is not designed for. See illustration #122.

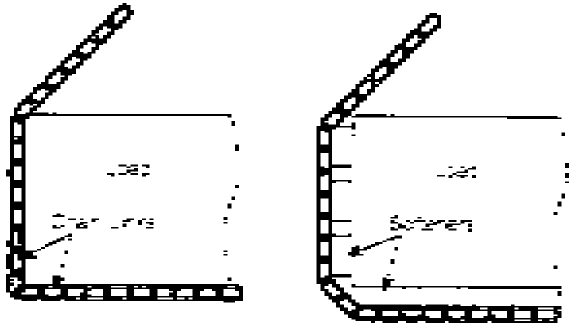


Illustration #122 – Chain Bending Around Corners

Chain Inspection

1. Clean a chain before inspection. Dirt and grease hide nicks and cracks.
2. Inspect for wear. Any portion of the chain worn by 15% should be removed from service immediately. See illustration #123A.

3. Inspect for stretching. Compare the chain with its rated length, or with a new length of chain. Hang a set of slings by the master link and compare the sling leg lengths. Any length increase means wear or stretch. See illustration #123B and C. If the length has increased 3% the chain must be inspected carefully. If it is stretched more than 5% it should be removed from service.

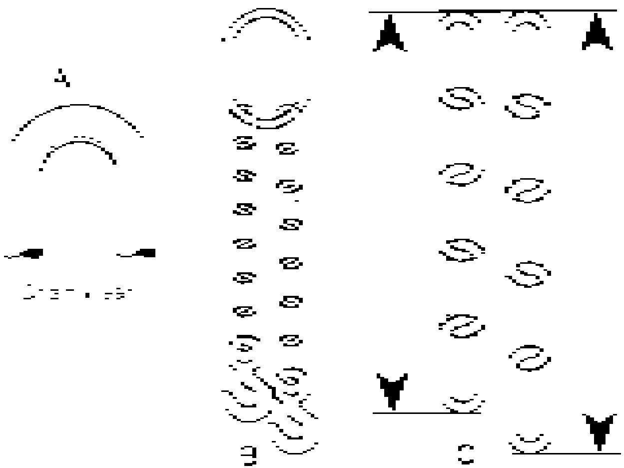


Illustration #123 – Chain Wear and Stretch

4. Inspect for twisted or bent links, and for cuts, gouges, or nicks. See illustration #124.

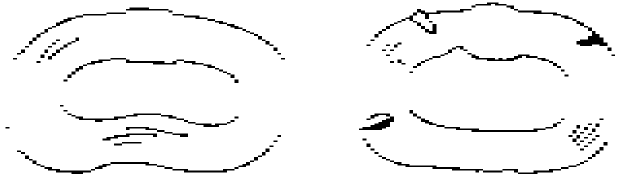


Illustration #124 – Twisted and Gouged Links

5. Inspect for cracks. If any are found, replace the entire chain.

6. Inspect for localized stretching. A chain can be overloaded in one specific area. See illustration #125 for an example.

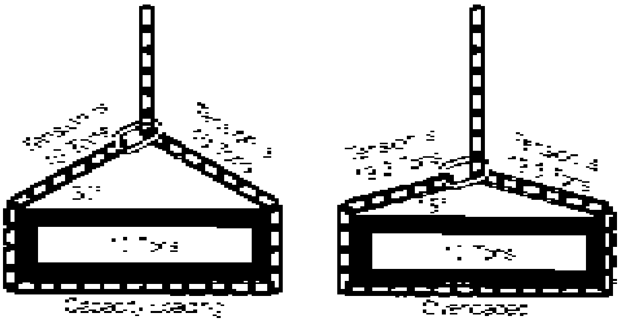


Illustration #125 – Localized Chain Stress

7. Inspect the link welds. Lifted fins at the weld edges signifies overloading. See illustration #126.

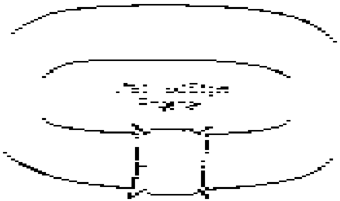


Illustration #126 – Link Weld "Fingernailing"

8. Inspect the chain sling master rings for any wear or stretching. also check the hooks for damage, signs of overloading or cracks.

9. Chain sling hooks should be equipped with safety latches.

10. Temperature - In general, alloy chain is not affected by reasonable low or high temperatures. The manufacturer should be consulted if chains are to be used under extreme temperatures. Most alloy chains should not be used in temperatures over 800°F and if a chain has been exposed to temperatures over 1000°F it must be removed from service.

Chain Wear (Grade 100 Alloy)

Nominal Chain Link Size Inches	mm	Minimum Thickness after Wear inches	mm
[illegible]	5.5	0.189	4.80
[illegible]	7	0.239	6.07
[illegible]	8	0.273	6.93
[illegible]	10	0.342	8.69
[illegible]	13	0.443	11.25
[illegible]	16	0.546	13.87
[illegible]	20	0.687	17.45
[illegible]	22	0.750	19.05
1	26	0.887	22.53
1 [illegible]	32	1.091	27.71

Table #36 – Chain Wear Grade 100

Note: Chain wear gages are available from chain manufacturers and distributors.

Maximum Safe Working Load "A" Type Alloy Steel Chain Single Vertical Sling

Chain Size (Inches)	Capacity (Pounds)
[illegible]	3,250
[illegible]	6,600
[illegible]	11,250
[illegible]	16,500
[illegible]	23,000
[illegible]	28,750
[illegible]	38,750
[illegible]	44,500
[illegible]	57,500
[illegible]	67,000
[illegible]	80,000
[illegible]	100,000

Table #37 – Chain Working Load Limits

Chain WLL Rule of Thumb Formula

Chain slings will have their lifting capacity clearly marked. However the quality of other chain may be unknown in most cases, therefore any rule of thumb formula giving an estimated safe load rating must use the strength rating of lower quality chain.

A rule of thumb formula for the working load limit or safe working load of a lower quality decking chain is:

$(\text{Diameter})^2$ (of link) x 6 = WLL (SWL)

D^2 (of link) x 6 = WLL (SWL)

Example:

$\frac{3}{4}$ inch diameter chain stock:

$\frac{3}{4} \times \frac{3}{4} \times 6 = (9 \times 6) \div 16 = 3.4$ tons

WLL (SWL) = 3.4 tons = 6,800 lbs

Note: Compare the 6,800 pound WLL with the 23,000 WLL shown in table #37 for the same size chain.

Note: Use only Grade 80 or 100 for all hoisting. Grades such as Proofcoil, BBB coil, and Hi-Test are not used for hoisting.

Chain Sling Safety Latches

Note: Safety latches should be standard on all chain sling hooks and the hooks must be of forged steel grade.

CHAIN SLINGS - WLL (SWL) BASED ON GRADE 80 ALLOY 4:1 SF

Nominal Chain Size	Single Chain 90°	Double Chain Slings 60° (30°)	Double Chain Slings 45° (45°)	Double Chain Slings 30° (60°)	Triple & Quad Chain Slings 60° (30°)	Triple & Quad Chain Slings 45° (45°)	Triple & Quad Chain Slings 30° (60°)
inch	lbs	lbs	lbs	lbs	lbs	lbs	lbs
7/32 - 1/4	3 500	6 100	4 900	3 500	9 100	7 400	5 200
3/8	7 100	12 300	10 000	7 100	18 400	15 100	10 600
1/2	12 000	20 800	17 000	12 000	31 200	25 500	18 000
5/8	18 100	31 300	25 600	18 100	47 000	38 400	27 100
3/4	28 300	49 000	40 000	28 300	73 500	60 000	42 400
mm	kg	kg	kg	kg	kg	kg	kg
7	1 500	2 700	2 200	1 500	4 100	3 300	2 400
10	3 200	5 500	4 500	3 200	8 300	6 800	4 800
13	5 400	9 400	7 600	5 400	14 000	11 500	8 100
16	8 200	14 200	11 600	8 200	21 300	17 400	12 300
20	12 800	22 200	18 100	12 800	33 300	27 200	19 200

Notes: 1. Quadruple Sling Rating is the same as Triple Sling Rating because lifting practice may not distribute load uniformly. 2. Angles in parentheses are vertical angles.

Table #36 – Grade 80 Chain Sling Capacities

CHAIN SLINGS - WLL (SWL) BASED ON GRADE 100 ALLOY (4:1 SF)

Nominal Chain Size	Single Chain 90°	Double Chain Slings			Triple and Quad Chain Slings		
		60° (30°)	45° (45°)	30° (60°)	60° (30°)	45° (45°)	30° (60°)
in.	lbs	lbs.	lbs.	lbs.	lbs.	lbs	lbs.
9/32 (1/4)	4300	7500	5100	4300	11,200	9100	6450
3/8	8800	15,200	12,400	8800	22,800	18,600	13,200
1/2	15,000	26,000	21,200	15,000	39,000	31,800	22,500
5/8	22,600	39,100	32,000	22,600	58,700	47,900	33,900
3/4	36,300	61,100	49,900	35,300	91,700	74,900	53,000
mm	kg	kg	kg	kg	kg	kg	kg
7	1950	3400	2700	1900	5100	4100	2900
10	4000	6900	5600	4000	10,300	8400	6000
13	6800	11,800	9600	6800	17,700	14,400	10,200
16	10,200	17,700	14,500	10,200	26,500	21,700	15,400
20	16,000	27,700	22,600	16,000	41,500	34,000	24,000

Notes: 1. Quadruple Sling Rating is the same as Triple Sling Rating because lifting practice may not distribute load uniformly. 2. Angles in parentheses are vertical angles.

Table #39 – Grade 100 Chain Sling Capacities

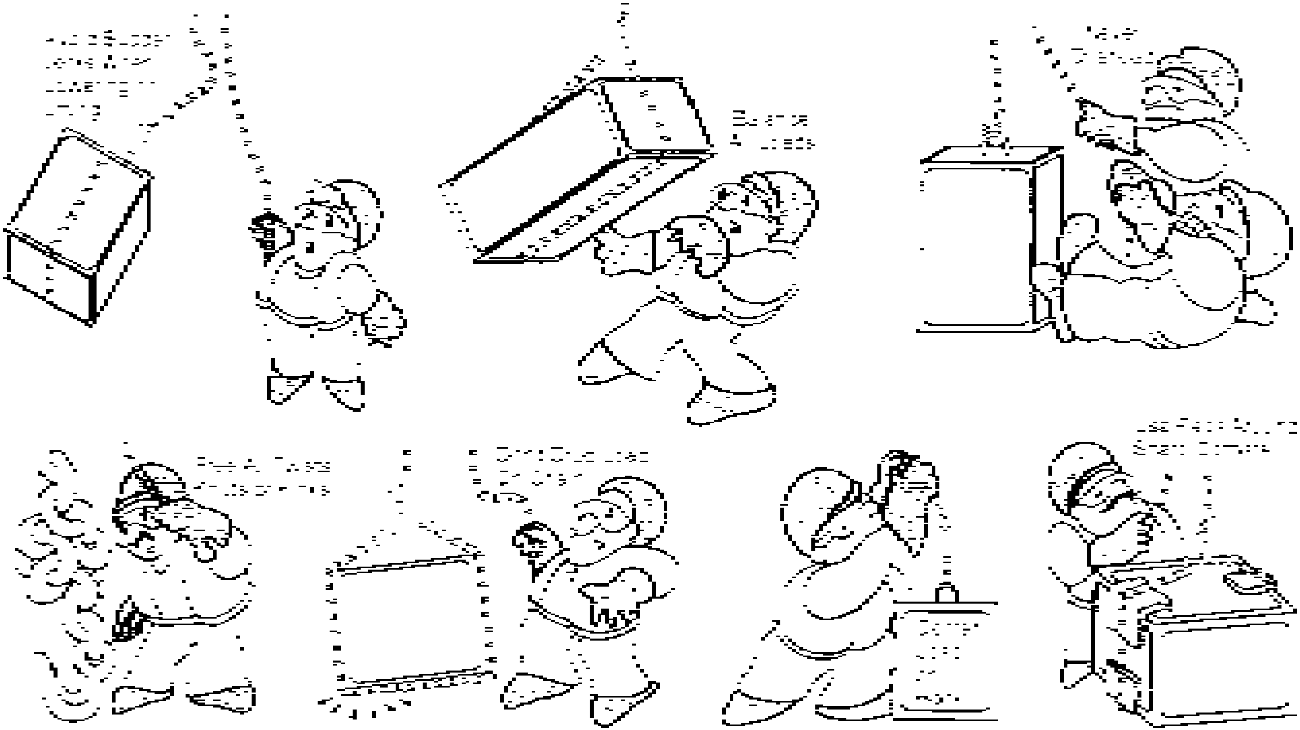


Illustration #127 - Chain Safety Tips

Chain Basket Hitch

Whenever using chain slings for a basket hitch, ensure that it is hooked back to the master link (illustration #128A), not hooked into the chain itself (illustration #128B). If the hook is hooked into the chain the capacity is reduced to 75%.

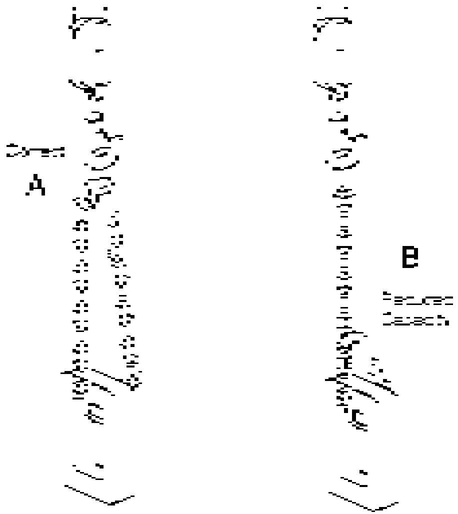


Illustration #128 – Chain Hooked into Master Link

Chain Sling Load Leveller

Chain sling load levellers, or load positioners are available for lifting non-symmetrical loads. The sling lengths are adjustable, and when set, they are locked in position. This type of sling eliminates center of gravity calculations, and the task of getting two proper length slings to balance a load. However sling load calculations are still required. See Illustration #129

Do not lift over the rated capacity.

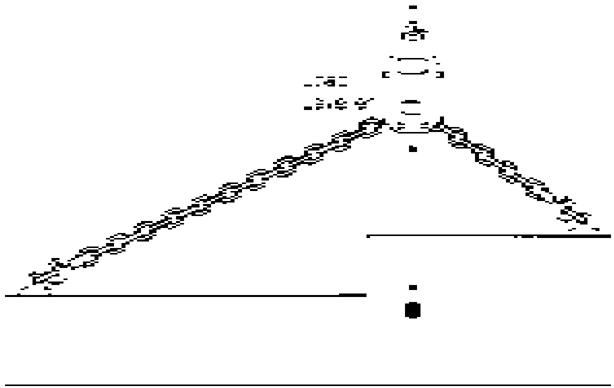


Illustration #129 – Chain Sling Load Leveller

Come-A-Long/Chain Fall

Come-A-Long Safety: A come-a-long is an effective method of lifting or pulling a load. It is also one of the most abused pieces of rigging equipment, generally from severe overloading.

These hoists are factory tested at 150% of capacity. Most of these hoists take less than 100 pounds of pull on the lever to lift the rated load. Therefore two average sized workers hanging off the handle could be trying to lift a load 3 or 4 times heavier than what the hoist is rated for, and also beyond its built in safety factor. See illustration #130 for a typical come-a-long, and illustration #132D for a bad come-a-long practice.

Illustration #130 - Typical Come-a-Long

Note: On some come-a-long hoists the handle will flex when overloaded. This is meant to be a warning to back off, not to put a snipe or cheater over the handle for more leverage.

Chain Fall Safety: A chain fall can easily be overloaded because of the gearing system. As the Chain Pull To Lift Full Load numbers in table #41 indicate, the pull to lift any capacity up to 10 tons takes less than 100 pounds. Two people pulling on the hoist chain will be trying to lift far more than the hoist is rated for. See illustration #131 for two types of chain falls.

Illustration #131 - Typical Chain Fall

Typical Come-A-Long Specifications

Max. Capacity (Tons)	¾	1 ½	3	6
Standard Lift (ft)	5	5	5	5
Pull on Std. lever to lift Full Load (lbs)	58	53	[illegible]	[illegible]
Net Weight (lbs)	[illegible]	24	34	65
Shipping Weight (lbs)	16	26	37	74
Minimum Distance Between Hooks (in.)	10 ¾	14 ½	17	21 ⅝
Lever Length (in.)	21 ¼	21 ¼	21 ¼	21 ¼
Standard length of Chain	5' 6"	5' 6"	11' 3"	22' 9"
Chain Size (in.)	[illegible]	[illegible]	[illegible]	[illegible]

Table #40 – Come-a-Long Data

Typical Chain Fall Specification

Maximum Capacity (Tons)	½	1	1 ½	2	3	4	5	6	8	10
Standard Lift (ft)	8	8	8	8	8	8	8	8	8	8
Net Weight (lbs)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	122	[illegible]	[illegible]	219
Shipping Weight (lbs)	[illegible]	[illegible]	63	[illegible]	[illegible]	[illegible]	128	134	[illegible]	[illegible]
Shortest Distance Between Hooks (in.)	[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	24	25 ¼	[illegible]	36
Chain Overhauled To Lift Load One Foot (ft)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chain Pull To Lift Full Load (lbs)	[illegible]	[illegible]	[illegible]	[illegible]	83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table #41 – Chain Fall Data

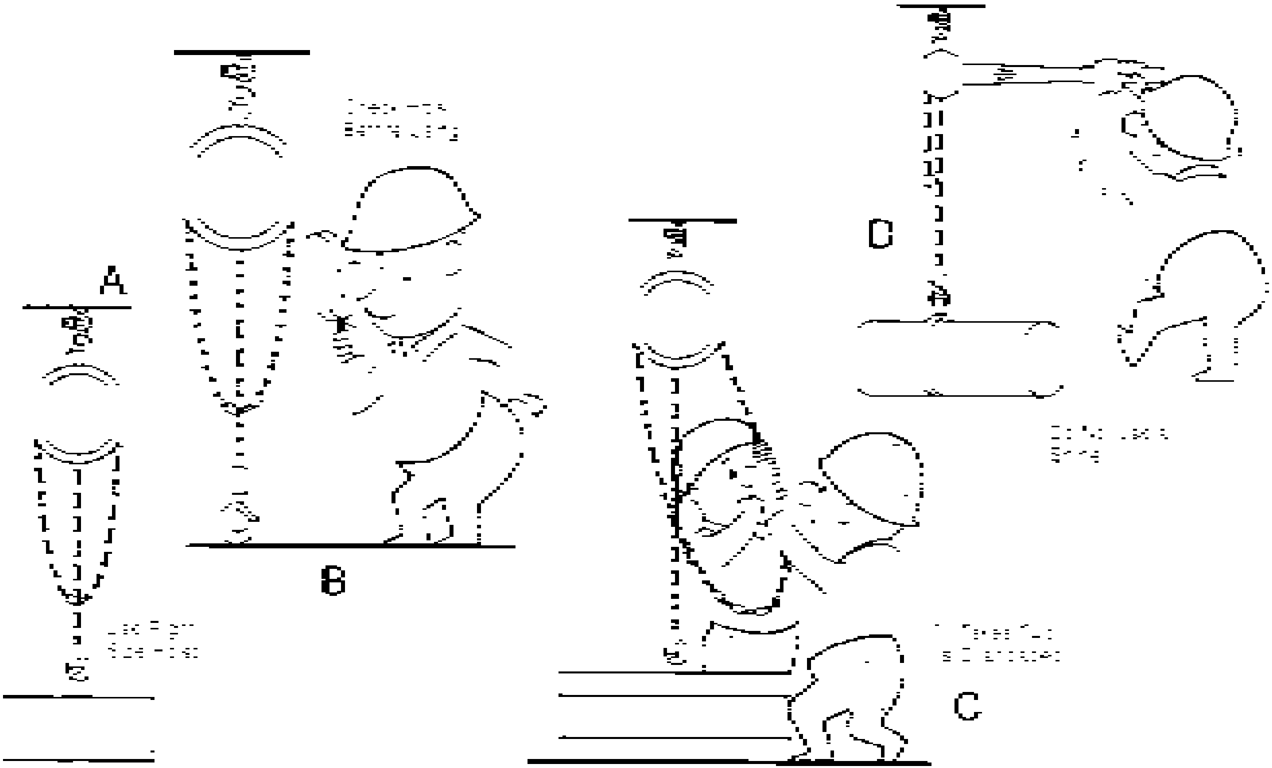


Illustration # 32 - Chain Fall and Come-a-Long Safety

Gantry Hoist: These smaller over-the-floor gantry hoists, as shown in illustration #133, and also monorail hoists are ANSI, OSHA and OH&S regulated concerning design, operation, and inspection. These hoists are usually electric powered, but can be pneumatic or have a hand chain.

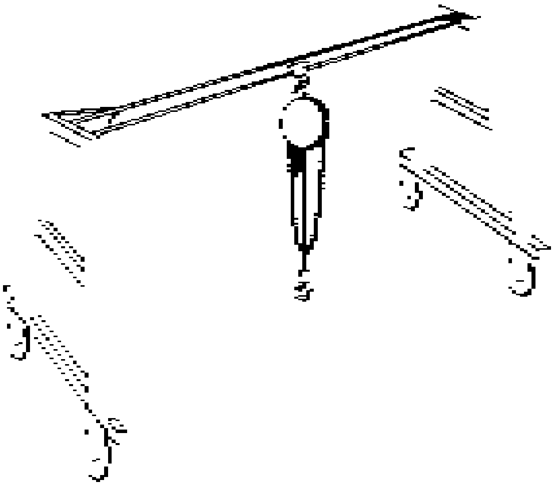


Illustration #133 – Typical Over-the-Floor Gantry with Chain Hoist

General guidelines for their use are listed below:

1. Check the hoist before use and service it regularly.
2. Use the hoist properly. This means the hook is seated correctly, the hoist and load are free, the load will lift in a straight line, the swivel is free, and the load is safely rigged.
3. Keep everybody clear of a moving load.
4. Do not wrap the hoist load chain around a load as a sling.
5. Do not ride on moving loads.
6. Do not hotrod with a powered hoist. This means not jerking or shock loading the hoist, traveling too fast, allowing the load to swing, or bumping into objects.

For further information see Section Eleven - Overhead Cranes.

Load Binder (Boomer) Safety

A standard binder and a ratchet binder are shown in Illustration #134. Load binder information is shown in tables #42 and #43.

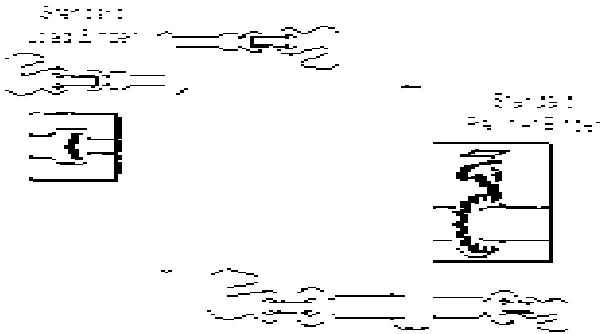


Illustration #135 – Standard Binder, Standard Ratchet Binder

1. Hook the binder so it can be tightened while standing on the ground, pulling the lever downward. Have secure footing.
2. Manufacturers recommend against using a snipe (handle extension) for more leverage. Use a ratchet type instead.
3. Using a snipe can overload the chain and damage the load. It can also fly dangerously if it slips.
4. After tightening, check that the handle is in the down position. Secure the handle by wrapping it with the load chain or a wire.
5. Keep well clear when releasing a loaded binder. Never use a snipe over the handle; use a bar and pry under the handle. When releasing by hand, push upwards with an open palm.
6. Routinely lubricate the binder moving parts.
7. Routinely check all parts for wear, bends, or cracks.
8. Be familiar with any regulations concerning the size or number of load securing systems on trucks.
9. Be aware of the position of other personnel when tightening or releasing a binder.

Standard Load Binder

Min.-Max. Chain Size (in)	Handle Length (in)	Take-Up (in)	Working Load Limit (lbs)	Proof Load (lbs)	Minimum Ultimate Strength (lbs)	Weight (lbs)
[illegible]	16	4 [illegible]	5400	10,800	19,000	6.70
[illegible]	19 [illegible]	4 [illegible]	9200	18,400	26,000	11.50
[illegible]	21	4 [illegible]	11,500	23,000	37,000	13.70

Table #42 – Standard Binder Data

Standard Ratchet Load Binder

Min.-Max. Chain Size (in)	Handle Length (in)	Barrel Length (in)	Take-Up (in)	Working Load Limit (lbs)	Proof Load (lbs)	Minimum Ultimate Strength (lbs)	Weight (lbs)
[illegible]	14	10	8	5400	10,800	19,000	10.60
[illegible]	14	10	8	9200	18,400	33,000	12.90
[illegible]	14	10	8	13,000	16,000	46,000	14.38

Table #43 – Standard Ratchet Binder Data

Rigging Over the Floor

Rigging over the floor is the movement of a piece of heavy equipment laterally from one location to another by a method other than lifting and moving with a crane.

This usually occurs inside a building with no overhead crane, or not enough room for a mobile crane to operate. The process involves lifting the load off the floor, usually with two or more jacks, placing rollers, dollies, roller skids, or compressed air castors under the load, and then moving the load to a new location.

Jacks can be either ratchet, screw or hydraulic. See illustration #135 for several types.

Note: Jacks are regulated under ANSI standard B30.1.

Note: Advanced Hydraulic Lifting Systems – Combined with over the floor rigging, new designs of hydraulic jacking or telescoping gantry systems are becoming widely used for hoisting heavy equipment inside buildings or in areas difficult for cranes.

They are capable of lifting hundreds of tons to a considerable height using either a single two-legged gantry or a pair (4 legs) for hoisting longer horizontal loads. The base of the legs can be solidly placed on the ground and secured, or self-propelled on tires or track wheels. If mobile, the ground and track preparation must be extensive to ensure it is level and solid enough to hold the weight. An example is shown in the Mobile Cranes Section Four, Illustration #195.

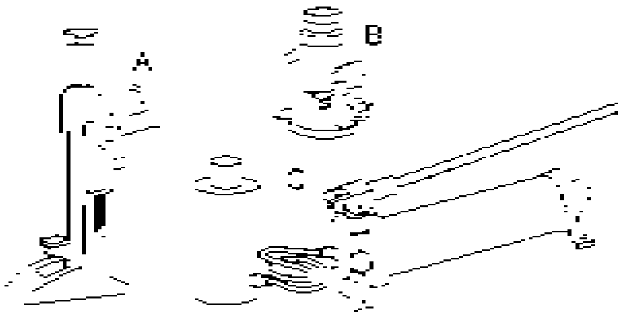


Illustration #135 – Ratchet, Screw and Hydraulic Jacks

Jacking Safety Points

1. Always keep the jacks vertical.
2. For stability, avoid using only one jack.
3. All jacks should be of the same type and capacity.
4. Use a piece of hardwood between the jack and the load.
5. If lifting outside on the ground, do not place the jack directly on the ground. See illustration #136.

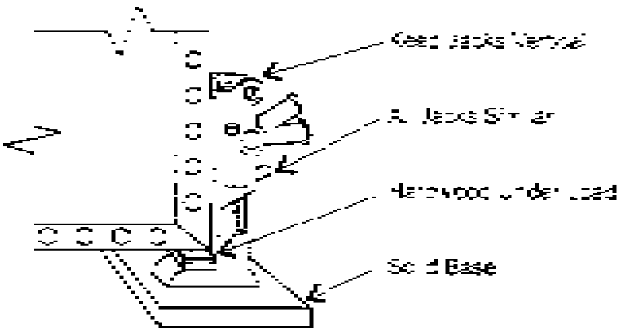


Illustration #136 – Jack Safety

Jacking Process

1. When lifting one end or side, or all four corners, the jacks should be operated simultaneously.
2. After each jacking sequence, use temporary blocking timbers under the load (1 x 6, 2 x 10, 4 x 4, 6 x 6, etc.).
3. Do not overload a jack by using a cheater (extra long lever) bar for extra lift.
4. For safety, always remove the jacking handle when not performing the jacking process.
5. Do not leave the load on jacks for extended period. Use blocking or cribbing.

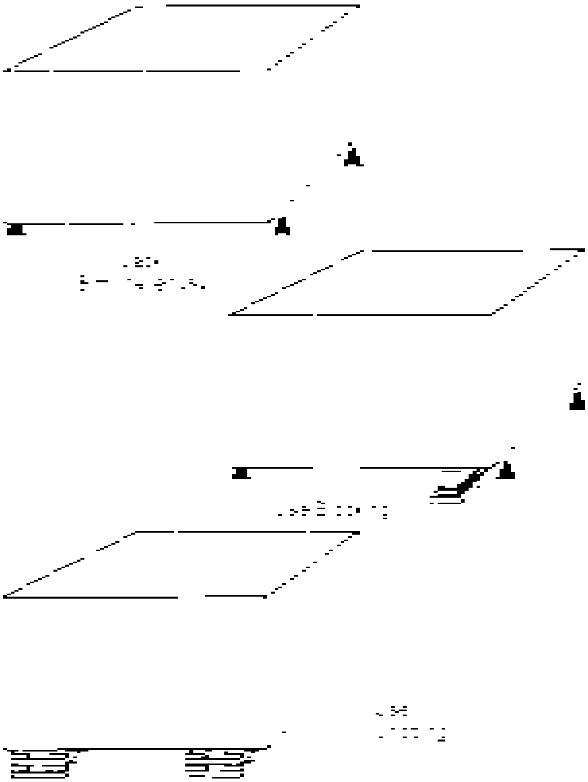


Illustration #137 – Jacking Process

Use of Rollers

1. Jack one end high enough to place a roller 1/3 of the distance from the end (Illustration #138A).
2. Chock the roller, then jack the other end, placing rollers midway and 1/3 from the other end (Illustration #138B).
3. Place a roller in front of load so it will go under the load as it moves (Illustration #138C).
4. As a roller becomes free, move it to the front (Illustration #138D).
5. Use caution to avoid getting hands or feet caught under the rollers.
6. Use a sledge hammer to move all rollers an equal amount for a direction change (Illustration #138E).
7. Use 2 x 10 planks under the rollers on an uneven surface (Illustration #138F).
8. Chock the rollers when not moving the load (Illustration #138G).

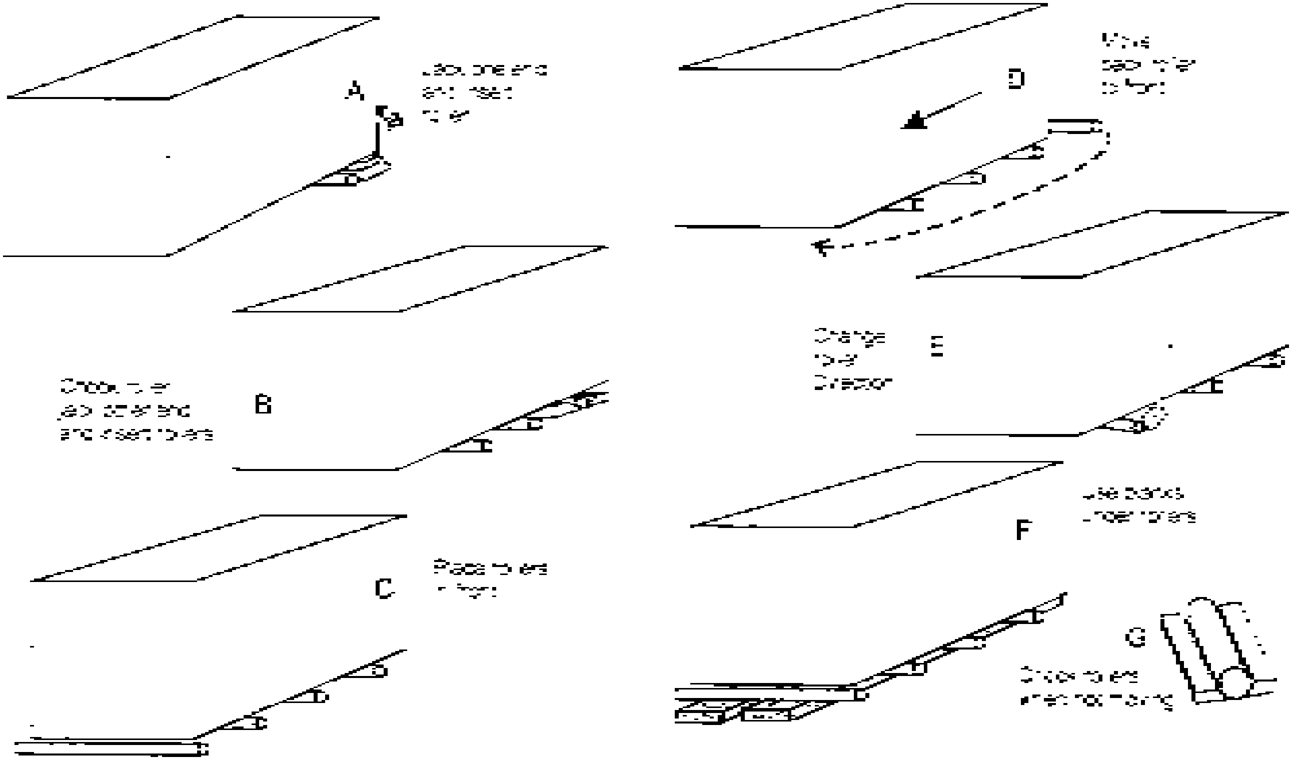


Illustration #138 – Use of Rollers

Roller Skids & Steel Dollies

Two other types of rollers are rollers skids or skates (illustration 139A) and steel dollies. With the roller skid, use hardwood between the skid and the load to prevent slipping, and use a 6 x 6 or 8 x 8 cross tie for the steel dollies (illustration #139B). Wedge the cross tie in firmly to prevent movement. The roller skid may be the straight line type or swivel type, while steel dollies are usually the swivel type.

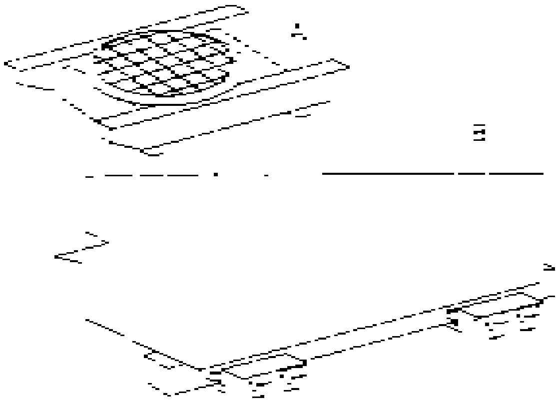


Illustration #139 – Roller Skid and Steel Dolly

Air Castors

Another method of moving a load is the use of air castors. See illustration #140. The load is supported on a thin layer of compressed air, similar to a hovercraft. The benefit is that the friction is minimal, thereby requiring very little push or pull to move the load. Damage to the floor is also reduced or eliminated. If the floor is uneven or has cracks, plywood can be laid down to create a flat surface. Tape the plywood seams to prevent air loss.

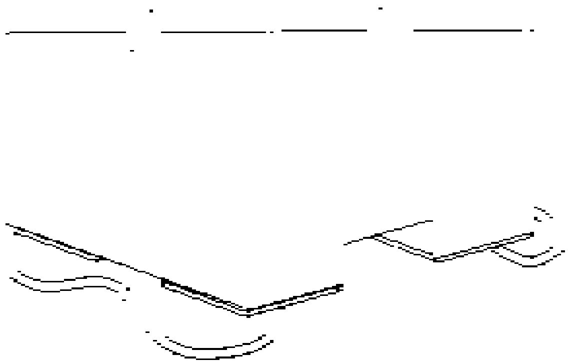


Illustration #140 – Air Castor

Moving a Load

Heavy loads may be moved by several methods including a motorized tug bar (illustration #141A), a forklift (illustration #141B), or a winch (air tugger) along with a snatch block attached to the load (illustration #141C).

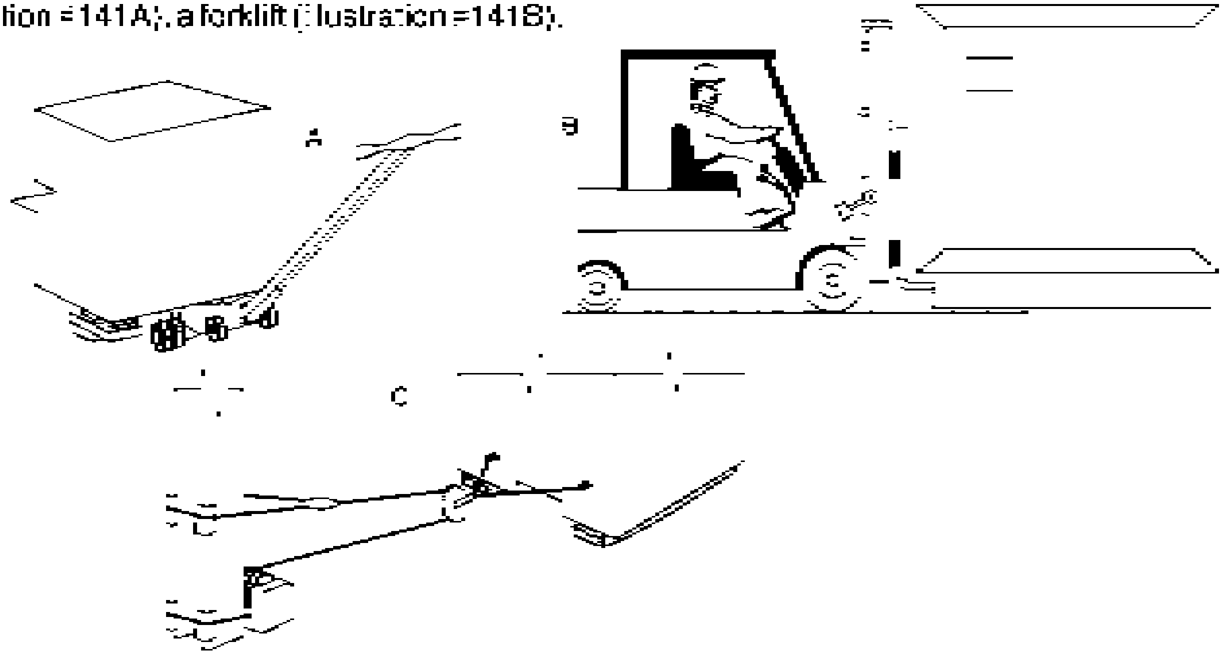


Illustration #141 – Load Moving Methods

Coefficients of Friction

To move a load laterally across a floor, the pull required compared to the load weight depends on the amount of friction between the two surfaces. This ratio is the coefficient of friction.

To find the amount of effort required to move a load, the load weight is multiplied by the coefficient factor (table #44).

For example steel on steel slides quite easily, and the coefficient number is only 0.10. Therefore a 1000 pound steel object on a steel floor would require a push or pull of:

1000 x 0.10 = 100 pounds

However concrete sliding over concrete has a coefficient number of 0.65. Therefore a 1000 pound concrete block sliding over a concrete floor would require a push or pull of:

1000 x 0.65 = 650 pounds.

Coefficients of Friction

Concrete on Concrete	0.65
Metal on Concrete	0.60
Wood on Wood	0.50
Wood on Concrete	0.45
Leather on Metal	0.40
Wood on Metal	0.30
Cast Iron on Steel	0.25
Continuous Lubrication	0.15
Steel on Steel	0.10
On Wheels	0.05

Pull required is load weight x coefficient

Table #44 – Coefficient of Friction

Natural & Synthetic Fiber Rope

Fiber Rope: Fiber rope can be made from either natural or synthetic fibers. Natural fiber rope is derived from plants and synthetic rope is made from chemical compounds.

Natural Fiber Rope: The length of the fibers in natural fiber rope is at most a few feet and the effectiveness in this state is very limited. The fibers are first twisted into yarns, which are laid up into strands, and finally three or more strands are formed into a rope, as in illustration #142.

Manila Rope: The only type of natural fiber rope that is used in the construction industry is Number One Grade Manila. Other types of natural fiber rope are not strong enough or deteriorate too quickly.

Number One Natural Manila is strong and durable. It is recognized by its light yellow color. As the grade and strength decreases, the color darkens. A low grade Manila is dark brown. The minimum breaking strength of a one inch diameter manila rope is 9,000 pounds (4,082 kg).

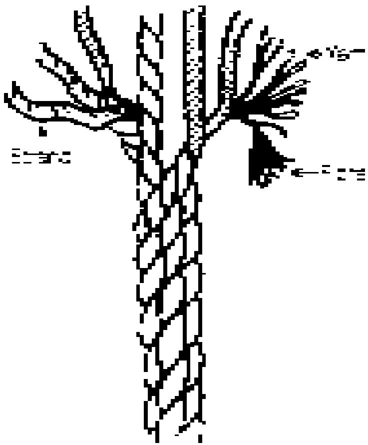


Illustration #142 – Fiber Rope Construction

The following types of natural fibre rope are not used in the construction industry due to various undesirable qualities:

1. Hemp: It is the strongest of the natural fiber ropes, however it deteriorates quickly when wet.
2. Sisal: It is approximately 75% the strength of untarred hemp, and will stand exposure to sea water.
3. Coir: It is made from coconut husk fibers. Very elastic, about one-quarter the strength of hemp, and will float.
4. Cotton: It is approximately 50% as strong as hemp.

Synthetic Fiber Rope: Synthetic ropes have individual threads and fibers that run continuously through the rope. All synthetic ropes have a common characteristic and that is a resistance to rot, mildew, and more strength than natural fiber rope.

Nylon: Other than the Kelvar type materials Nylon is the strongest rope available. It will absorb greater shock load than any other rope, and outlast all natural fiber ropes by a wide margin. Nylon is flexible, has high abrasion resistance, can be stored wet, resists most alkalis and organic solvents, and will not rot. Nylon rope is ideal for anchor lines, couplers, hawsers, tie-up lines, safety and mountaineering ropes. It is also widely used in commercial fishing.

Polyester (terylene): Polyester is not as strong as Nylon, but is twice the strength of Manila and stretches far less than Nylon but slightly more than Manila. It has excellent resistance to abrasion, chemicals and weathering. Polyester ropes are recommended wherever minimum stretch, high strength and durability are needed.

Polypropylene: Polypropylene is the lightest, most economical and widely used rope on the market. Strength is far greater than Manila. Other characteristics are long life, ease of handling, flexibility in cold temperatures, excellent resistance to most acids and alkalis and very good impact loading. And it floats! It is supplied in many colors and color combinations.

Polyethylene: Polyethylene is 50% as strong as nylon and resists acids and alkalis.

Uncoiling and Coiling Rope

A new coil of rope should be laid flat, with the inside rope end on the floor. Reach down inside and pull the rope up through, unwinding it in a counter clockwise direction, as in illustration #143.

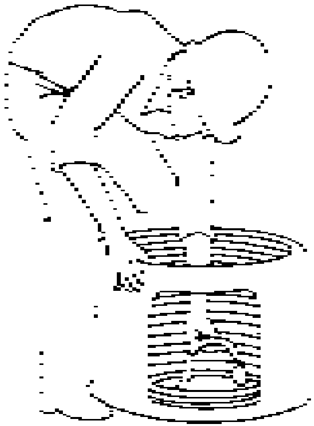


Illustration #143 – Proper Rope Uncoiling

Even when a rope is properly uncoiled, loops and kinks could form. These must be removed to prevent damage.

After use, recoil a rope in a clockwise direction. Loop the rope over your arm and tie with two half hitches. Leave a short end for carrying or hanging from a peg, as in illustration #144.

Illustration #144 – Proper Rope Coiling

Rope Ends

Whipping Natural Fiber Rope: When cutting a natural fiber rope, the ends must be taped, or whipped with a small twine to prevent the rope from untwisting. See Illustration #145.

Melting Synthetic Fiber Rope: As whipping will not stay in position on synthetic fiber rope, the common practice is to melt the strands ends together, after cutting, with a torch or lighter to keep the end from untwisting and fraying.

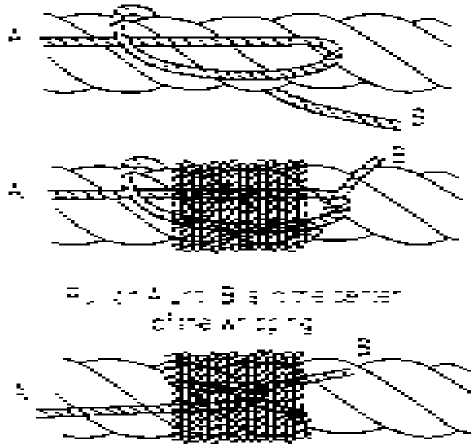


Illustration #145 – Fiber Rope Whipping

Fiber Rope Inspection

Every foot of a rope should be inspected as it is only as strong as its weakest part. Inspect the outer surface for broken yarns or fibers. Then untwist the strands and observe the inside.

On manila rope, look for a bright yellow color to indicate good quality. Broken fibers or powder inside a rope indicates the rope has been overloaded. The interior yarns of an overloaded rope will fail first.

With a natural fiber rope, pull out a fiber and try to break it. If it breaks easily the rope has been overloaded or affected by mildew or dry rot.

In northern regions, be careful not to allow natural or synthetic fiber rope to freeze. This causes the separation of yarns and fibers. A frozen rope should not be disturbed until it has thawed. Exposure to sunlight will eventually deteriorate a natural fiber rope.

Fiber Rope Factors & Reductions

Fiber rope used for rope falls, or hoisting personal has a working load limit (safety factor) of 10. For other uses the factor is 5.

As the fibers in a Manila rope are short and intertwined, they will pull apart under a continuous load. If loaded to 50% of its breaking strength a Manila rope will fail in several hours, due to fiber creepage, and if loaded to 75% of breaking strength, it will fail in minutes.

- Knots tied in fiber rope reduce the strength by approximately 50%.
- An eye splice reduces the strength of fiber rope by 15 - 20%.
- Fiber rope bent over sharp edges such as structural steel, reduces the ropes strength by 50%.
- Fiber ropes bent around each other in a U reduces the strength by 50%.
- Manila rope guy-lines should be slackened off if they become wet as manila swells and becomes shorter.
- See table #45 for the WLL (SWL) of fiber rope.

Approximate WLL (SWL) of New Fibre Rope (3-Strand Ropes)
Design (Safety) Factor of 5

Rope Diameter		Manila		Nylon		Polypropylene		Polyester		Polyethylene	
Inch	(mm)	lbs	kg	lbs	kg	lbs	kg	lbs	kg	lbs	kg
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Table #15 – Fiber Rope Safe Working Loads

Fiber Rope Splices & Knots

- ***Short Splice:*** As a short splice doubles the diameter, it is only used when the rope does not have to pass through a sheave. A short splice is 85% as strong as the original fiber rope.
- Unlay both ends for approximately eight turns. Whip or tape the strand ends, bring them together so they interlock with a strand from one rope between two strands of the other rope (illustration #146A).
- Apply temporary seizing or tape to both ropes after they have been brought closely together.
- Take any one strand and pass it over the strand nearest and tuck it under the next (illustration #146C).
- Tuck all six strands in both ropes at least three times for natural fiber, five times for synthetic. The ends can now be feathered out with several more tucks, then roll the splice to smooth it out (illustration #146E).

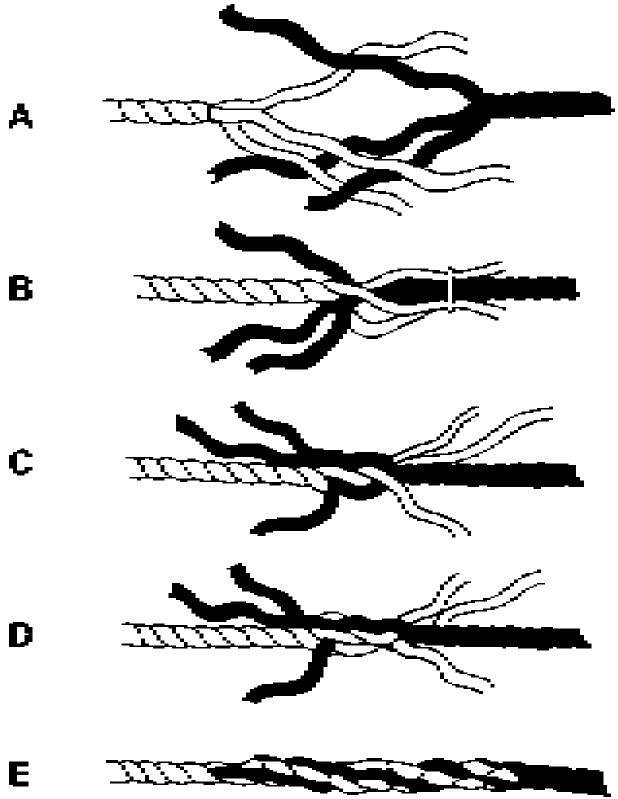


Illustration #146 – Short Splice

Eye or Side Splice: An eye or side splice is used to make eyes in fiber rope. All eye splices used for lifting should have a metal or nylon thimble.

- Manila rope should be seized or taped six turns from the end (nine for synthetic rope).
- The rope is then untwisted to the seizing.
- Tuck the middle strand, #2, under #5 (illustration #147A).
- Tuck strand #1 under strand #4 (illustration #147B).
- Turn over the partially completed splice and lock the eye in by tucking strand #3 through the last remaining strand on the rope, #6 (illustration #147C).
- The remaining rounds of tucks are made by passing each protruding strand over and under the next strand, usually three times for manila and five times for synthetic. Cut away the remaining strands and roll the splice on the floor underfoot to smoothen out (illustration #147D).

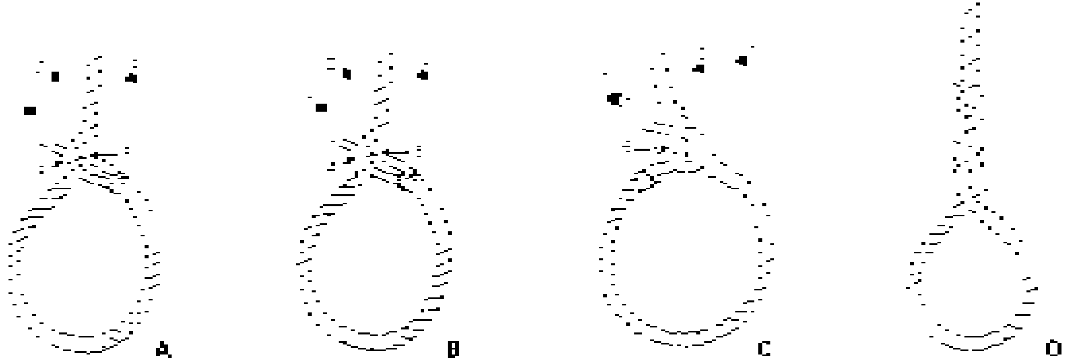


Illustration #147 – Side Splice

Bowline: The bowline is one of the most popular knots. It never jams or slips under load and is easily untied. See illustration #148.

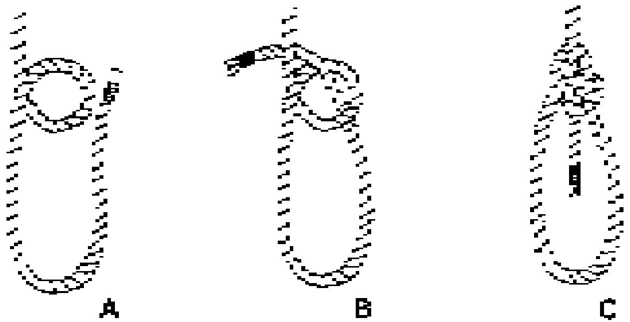


Illustration #148 – Bowline

Bowline on the Bight: The bowline on the bight is used to form a non slipping eye in the middle of a rope. See illustration #149.

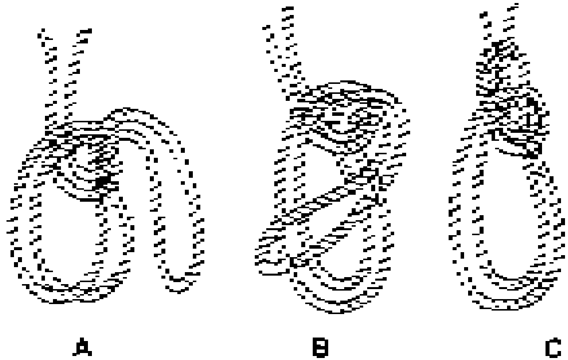


Illustration #149 – Bowline on the Bight

Spanish Bowline: The Spanish bowline can be tied at any point in a line where it is doubled up. Like all bowlines, it will not slip and is easily untied. See illustration #150.

Note: Use for a rescue knot only as a last resort.

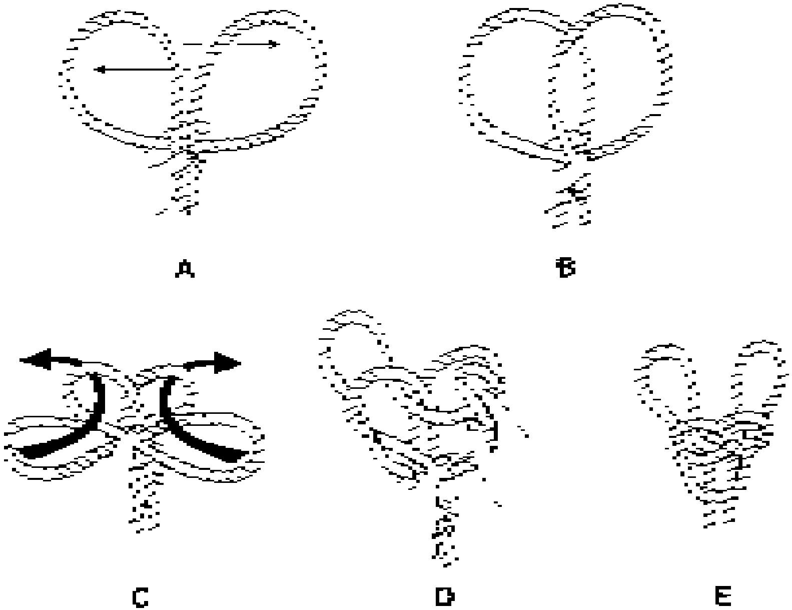
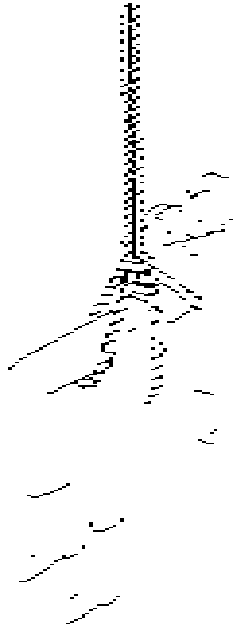


Illustration #150 – Spanish Bowline



Self-Centering Bowline:
The self-centering bowline is useful when a knot must be tied to center a load with equal load distribution. It compliments a scaffold or barrel hitch, which is shown in illustration #151.

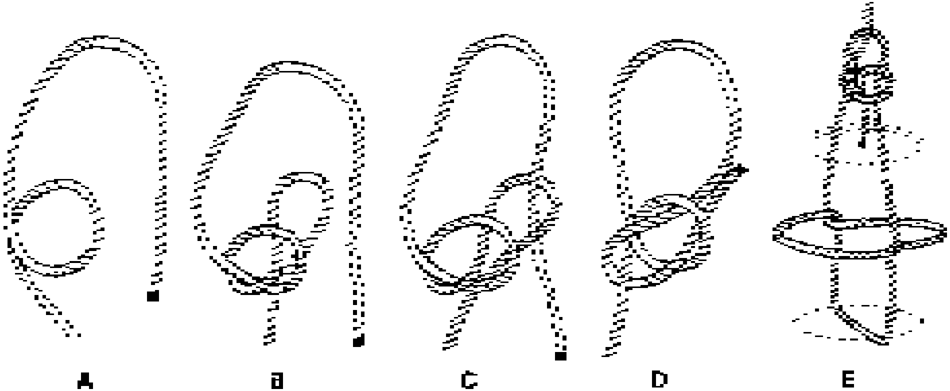


Illustration #151 – Self-Centering Bowline

Running Bowline:
The running bowline is used to provide a choker type sling at the end of a single line. The knot is made around the standing part of the rope and runs freely. See Illustration #152.

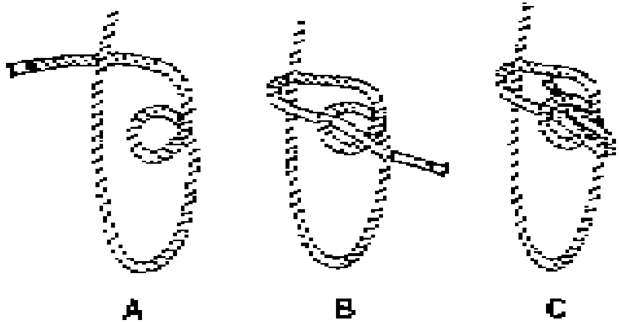


Illustration #152 – Running Bowline

Clove Hitch: The clove hitch is used to tie a rope to a pipe or post. It can be tied in position or slipped over the end. See illustration #153. To prevent loosening it should be finished with a half hitch.

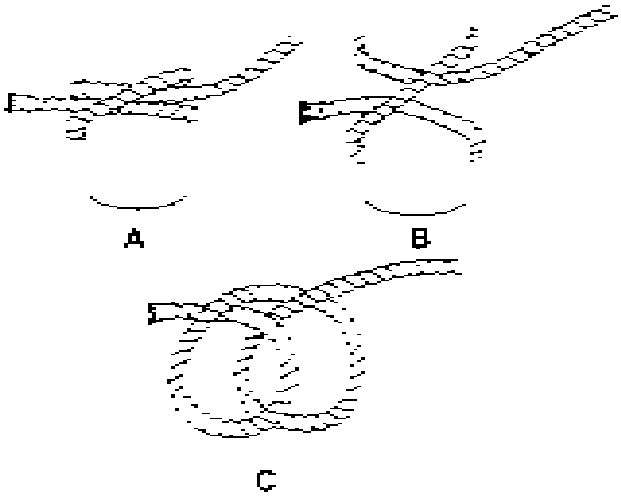


Illustration #153 - Clove Hitch

Becket Hitch: A becket is the end connection of a block for connecting a rope while reeving the block. A becket hitch is used to secure the end of a rope to the becket on a set of rope falls. See illustration #154.

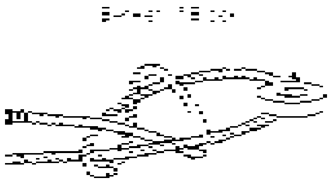


Illustration #154 - Becket Hitch

Timber Hitch: A timber hitch is used for moving planks, pipes, etc. The load must have a steady pull as any slack will release the hitch. It should be used with several half hitches. See illustration #155.

Barrel Hitch: A barrel hitch is used to support a barrel vertically. A self-centering bowline is used to complete the knot. See illustration #156.

Note: The use of the timber and barrel hitches may be prohibited on some construction sites. Check with OH&S/OSHA.

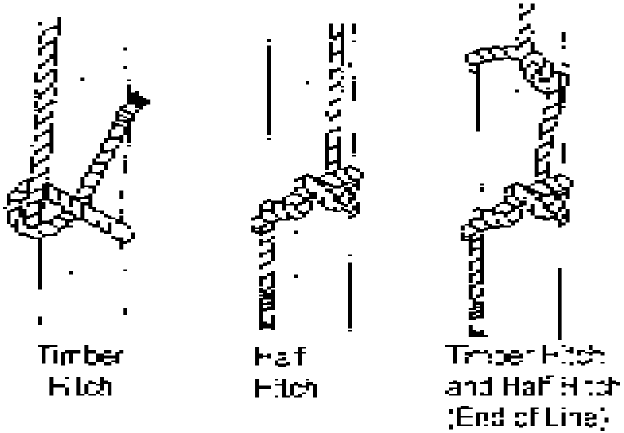


Illustration #155 – Timber Hitch

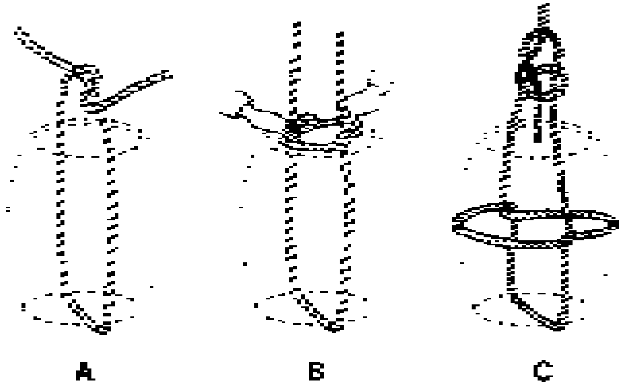


Illustration #156 – Barrel Hitch

Reef Knot: A reef knot is also referred to as a square knot. See illustration #157.

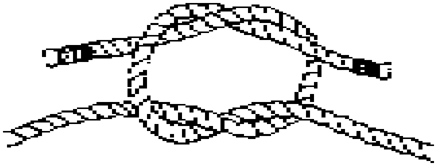


Illustration #157 – Reef (Deadman's) Knot

Note: This knot is often misused or is not tied properly. It is sometimes referred to as a "killer" knot. It must only be used to tie the two ends of a rope together. Do not use it as a bend for joining two ropes.

Sheet Bend: A sheet bend is used for tying two ropes of unequal diameter together. It is not used on large diameter rope. See illustration #158.

Illustration #158 – Double Sheet Bend

Carrick Bend: A carrick bend is used to tie large diameter ropes together. It will draw up tightly but will not jamb. See illustration #159.

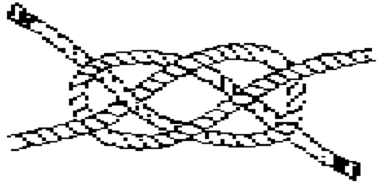


Illustration #159 – Carrick Bend

Catspaw: A catspaw is used to attach a rope to a hook. It is especially useful if the center of the rope is used. See illustration #160.

Illustration #160 – Catspaw

Strength of Knots, Bends, Hitches

- Straight lengths of rope without knots or splices represent 100% of its strength.
- When a knot is tied in a rope it loses approximately 50% of its original strength.

Illustration #161 – Knots = 50% Efficiency

- A rope loses 50% of its strength with a bend.

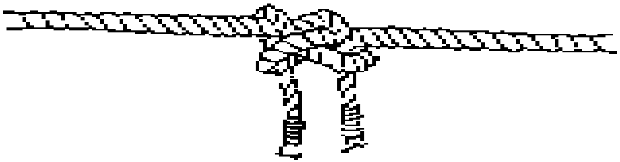


Illustration #162 – Bend = 50% Efficiency

- A rope loses 25% of its strength with a hitch.

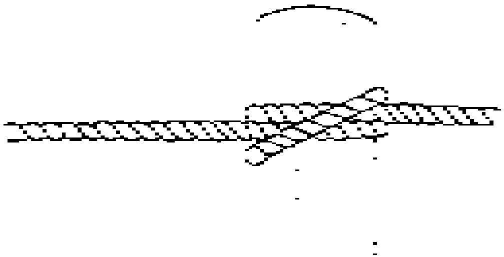


Illustration #163 – Hitch = 75% Efficiency

- A rope loses 15% of its strength with an eye splice or a short splice.

Illustration #164 – Splice = 85% Efficiency

Fiber Rope Tackle Blocks

When reeving a pair of blocks that have more than two sheaves, the hoisting rope should lead from one of the center sheaves on the upper block. The hoist line pull is then placed on the center of the block. This prevents the block from tipping and damaging the fiber rope. The two blocks should be positioned with the sheaves in the upper block at right angles to those in the lower block. See illustration #155.

Note: It is good practice to use the shackle block as the upper block and a hook block as the lower travelling block. A shackle is stronger than a hook of the same size, and the total load on the upper block is considerably more than the lower block load. The lower block supports only the load whereas the upper block carries the load as well as the sheave friction and the lead line pull.

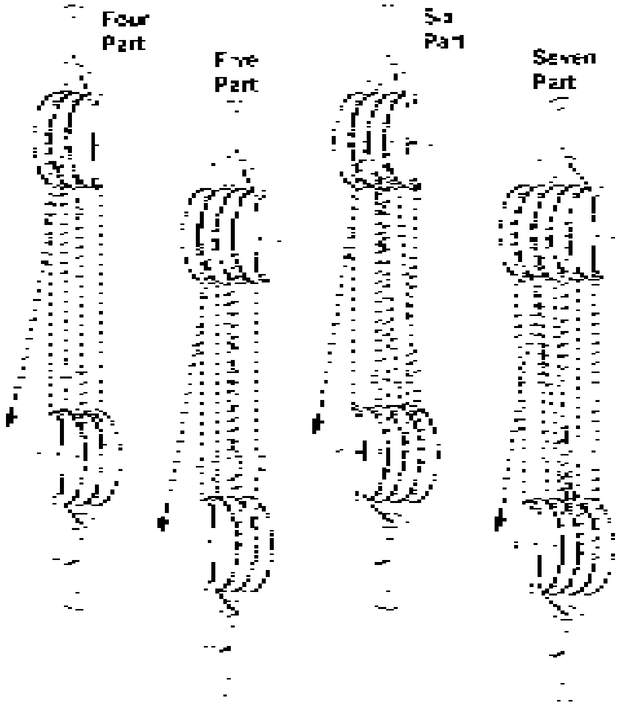


Illustration #155 – Fiber Rope Block Reeving

Block Friction

Do not use more than eight parts of line when using fiber rope blocks. After eight parts, the increased friction becomes greater than the theoretical mechanical advantage gained by adding more parts of line. Additional line loading due to friction is indicated in the following example.

Fiber Rope Block Friction

A 10% friction factor must be used every time a fiber rope passes over a sheave.

Example: Five part set of falls with a load of 2,500 lbs (1 134 kg).

The static (non-moving) load on each line is 2,500 pounds (1 134 kg) divided by 5, or 500 lbs (226.8 kg) per line.

Friction progressively increases the line pull an extra 10% at each sheave or an extra 305 lbs to a total lead line pull of:

500 + 305 = 805 lbs (365.1 kg).

Calculations of Dynamic Loading

Becket	500 lbs	226.8 kg
Line 1	x1.10	x1.10
	550.0 lbs	249.4 kg
Line 2	550.0 lbs	249.4 kg
	x1.10	x1.10
	605.0 lbs	274.3 kg
Line 3	605.0 lbs	274.3
	x1.10	x1.10
	665.5 lbs	301.7 kg
Line 4	665.5 lbs	301.7 kg
	x1.10	x1.10
	732.0 lbs	331.9 kg
Line 5	732.0 lbs	331.9 kg
	x1.10	x1.10
	805.2 lbs	365.1 kg
Lead Line Pull	805.2 lbs	365.1 kg

SECTION ONE QUESTIONS

Rigging

1. Determine if this statement is true or false. The two types of wire rope center core designs are fiber core and independent wire rope core.
   - ❐ true ❐ false

2. What is the percentage gain in strength using an IWRC versus a fiber core wire rope?
   - ❐ 3.5
   - ❐ 5.5
   - ❐ 7.5
   - ❐ 9.5

3. What characteristic increases in a wire rope by using a rope with more strands and more wires in the strands?
   - ❐ rigidity
   - ❐ breaking strength
   - ❐ lubrication
   - ❐ flexibility

4. Determine if this statement is true or false. Grade 110/120 improved plow steel has the highest tensile strength of any type of wire rope.
   - ❐ true ❐ false

5. A regular lay wire rope has strands and wires in the strands that:
   - ❐ are all laid in the right hand direction
   - ❐ are all laid in the left hand direction
   - ❐ are laid in opposite directions
   - ❐ are all laid in the same direction

6. Due to its tendency to unwind, which wire rope should **NOT** be used on single part hoisting lines?
   - ❐ regular lay
   - ❐ lang lay
   - ❐ alternate lay
   - ❐ none of above

7. Determine if this statement is true or false. A 6 x 19 wire rope classification could have as many as 15 to 26 wires per strand.
   - ❐ true ❐ false

8. Which wire rope classification is listed as non-rotating?
- ❑ 3 strand
- ❑ 6 strand
- ❑ 19 strand
- ❑ 35 strand

9. When a non-rotating rope is used in a wedge socket, care must be taken to prevent
- ❑ core slippage
- ❑ rope from unraveling
- ❑ wire slippage
- ❑ strand slippage

10. A rotation resistant wire rope may have a smaller Working Load Limit (WLL) than an equal size 6x19 IWRC because
- ❑ IWRC has a higher ultimate load breaking strength
- ❑ rotation resistant requires higher working load limit
- ❑ both of the above

11. When hoisting personnel on a crane equipped with rotation resistant wire rope, what is the Design Safety Factor required by most safety standards?
- ❑ 3.5:1
- ❑ 5:1
- ❑ 7:1
- ❑ 10:1

12. Newer designs of wire rope with shaped wires and triangular strands are an attempt to prevent rope damage from
- ❑ multiple drum layers
- ❑ cross winding
- ❑ improper tensioning
- ❑ all of the above

13. Referring to the number of outer wires as used in a wire rope, the "Rule of Thumb" for determining rope size is
- ❑ 2:6
- ❑ 3:6
- ❑ 4:8
- ❑ 2:12

14. Wire rope should be replaced if the wear of the outer strand wires exceeds:
- ❑ 1/16 of original diameter
- ❑ 1/8 of original diameter
- ❑ 1/3 of original diameter
- ❑ 1/4 of original diameter

15. Determine if the following statement is true or false. When inspecting wire rope, interior broken wires and corrosion can be checked by magnetic particle testing.
- ❑ true
- ❑ false

16. Corrosion of wire rope is usually caused from:
- ❑ metal fatigue
- ❑ broken wires
- ❑ high speed operation
- ❑ lack of lubrication

17. Which product below is considered a suitable lubricant to use on a wire rope?
- ❑ light mineral oil
- ❑ vegetable oil
- ❑ grease
- ❑ used crankcase oil

18. To avoid kinking wire rope when spooling it onto a drum from the shipping reel, the operator should always:
- ❑ allow the reel to rotate freely
- ❑ keep the reel stationary
- ❑ always suspend the reel in a vertical position
- ❑ always suspend the reel in a horizontal position

19. What is the Rule of Thumb formula to find the Ultimate Load (breaking strength) of an IWRC wire rope?
- ❑ $D^2 \times 42$
- ❑ $D^2 \times 45$
- ❑ $D^2 \times 5$
- ❑ $D^2 \times 10$

20. When the Ultimate Load (breaking strength) of a wire rope is divided by a safety (design) factor, the result is called the:
- ❑ ultimate tensile load
- ❑ nominal strength of rope
- ❑ yield strength of rope
- ❑ working load limit (SWL)

21. What happens when a wire rope is bent around a sheave [illegible]?
- ☐ nominal strength does not change
- ☐ nominal strength is reduced
- ☐ outside strands are in compression
- ☐ inside strands are in tension

22. A [illegible] approximately how efficient?
- ☐ 100%
- ☐ 75%
- ☐ 50%
- ☐ 25%

23. Referring to slings, the terms "Rated Capacity" or "Working Load Limit" replace the old terminology of:
- ☐ safety factor
- ☐ breaking strength
- ☐ rule of thumb
- ☐ safe working load

24. What is the minimum Design (safety) Factor for general [illegible]?
- ☐ 3 to 1
- ☐ 5 to 1
- ☐ 7 to 1
- ☐ 10 to 1

25. Determine if this statement is true or false: [illegible]
- ☐ true
- ☐ false

26. What is the minimum [illegible] Design Factor [illegible]?
- ☐ 25 to 1
- ☐ 20 to 1
- ☐ 15 to 1
- ☐ 10 to 1

27. Determine if this statement is true or false: A sling [illegible]
- ☐ true
- ☐ false

28. When slinging a bundle of pipe or tubing, which of the following would provide the best contact between sling and load?

- ❒ double basket
- ❒ bridle hitch
- ❒ two double wrap chokers
- ❒ single leg choker

29. Determine if this statement is true or false: Because all web slings are manufactured identically, the ID tag does not indicate the rated load.

❒ true ❒ false

30. Determine if this statement is true or false: Synthetic slings can be safely used under any environmental circumstances.

❒ true ❒ false

31. Referring to the standard format of sling load charts, the angle between the top of the load and the sling leg is called the:

- ❒ double angle
- ❒ working angle
- ❒ vertical angle
- ❒ horizontal angle

32. Using two slings to lift a load, at what degree angle to the horizontal is the load on each sling considered to be equal to the weight of the load?

- ❒ 15
- ❒ 30
- ❒ 45
- ❒ 60

33. Calculate using the recommended safe lifting angle, the distance between the lift points connecting the load using two 12 foot slings.

- ❒ 6 feet
- ❒ 8 feet
- ❒ 10 feet
- ❒ 12 feet

34. Using the basic "Riggers Rule of Thumb", calculate the load in pounds on each sling leg using two 12 foot slings with a vertical distance to hook point of 6 feet and a load of 8,000 pounds.

- ❒ 12,000
- ❒ 8,000
- ❒ 6,000
- ❒ 4,000

35. Is the following statement true or false? The standard Riggers Rule of thumb formula can be applied to [illegible] uniform shaped load [illegible] rigging [illegible]

☐ true ☐ false

36. What happens to the rigging hardware when sudden movements or shock loading occurs?

☐ increased load stress
☐ decreased load stress
☐ no load stress if load is below the WLL
☐ load weight will decrease

37. Is the following statement true or false? Using a rigging [illegible] to [illegible] load [illegible] does not require consultation with a structural engineer?

☐ true ☐ false

38. When answering [illegible] all rigging hardware [illegible] stamped with [illegible]? Pick the best answer.

☐ date of manufacture
☐ diameter of pin
☐ traceable code number
☐ ultimate breaking strength

39. Safety regulations [illegible] the use of [illegible] to make rigging sling eyes.

☐ true ☐ false

40. Correctly installed U-bolt type wire rope clips are installed with the U-bolt on the [illegible] of the

☐ dead or short end
☐ on the live or long end
☐ installed either way
☐ alternating up and down

41. When compared to the size of the body, the shackle pin diameter is always?

☐ same size
☐ larger than body
☐ smaller than body
☐ depends on manufacturer

42. Shackles are only rated for their maximum capacity when used in what type of pull?

☐ straight line pull
☐ 90 degree pull
☐ 45 degree pull
☐ designed for any angle pull

43. With two shackles or sling eyes in a hook, what is the suggested maximum included lifting angle?
- ❐ 0 degrees
- ❐ 45 degrees
- ❐ 90 degrees
- ❐ 180 degrees

44. A wedge socket must be attached with the load line coming in a straight line from the:
- ❐ wedge
- ❐ shank
- ❐ point
- ❐ pin

45. Determine if this statement is true or false. Referring to wedge sockets, it is permitted to clip the wire rope dead end to the load line.
- ❐ true
- ❐ false

46. Which type of eye-bolt should be used if there is any possibility of an angular load?
- ❐ shoulder type
- ❐ shoulderless type

47. Determine if this statement is true or false. It is acceptable practice to lift a load at an angle less than 45 degrees to the horizontal with an eye-bolt.
- ❐ true
- ❐ false

48. Custom fabricated lifting beams or any homemade lifting device must be:
- ❐ designed by an engineer
- ❐ have the rated capacity clearly stamped
- ❐ be tested at 125% of rated capacity
- ❐ all of the above

49. What safety requirement must be performed with a basket used to hoist personnel?
- ❐ proof-test lift at 125% of capacity at each new site
- ❐ trial lift with anticipated weight before using
- ❐ trial lift each time crane is relocated
- ❐ all of above

50. The "Rule of Thumb" minimum for wire rope to sheave ratio is:
- ❐ 20 to 1
- ❐ 30 to 1
- ❐ 40 to 1
- ❐ 50 to 1

51 What is the mechanical advantage ratio created on the [illegible] of a two block hoisting system?

- ❐ none
- ❐ 2 to 1
- ❐ 4 to 1
- ❐ depends on number of sheaves

52 When determining the number of parts of line needed in [illegible] the system, what [illegible] makes the use of [illegible] necessary?

- ❐ block weight
- ❐ friction
- ❐ length of wire rope
- ❐ diameter of drum

53 The main disadvantage of [illegible] reeving is

- ❐ line speed is constant
- ❐ the blocks tilt toward each other
- ❐ blocks cannot be brought close together
- ❐ there are reverse bends

54 The main advantage of a [illegible] sheave is to [illegible]

- ❐ change direction of load
- ❐ change direction of wire rope
- ❐ swivel hook
- ❐ ease of reeving wire rope

55 If the load suspended in a single [illegible] hoisting assembly has a [illegible] of 200 pounds [illegible] lines [illegible] what is the load on the [illegible]?

- ❐ 800 pounds
- ❐ 400 pounds
- ❐ 200 pounds
- ❐ 100 pounds

56 When [illegible] the rope from [illegible] to the bottom of a [illegible] the wire rope must come off which [illegible] of the reel?

- ❐ top
- ❐ bottom

57 A [illegible] drum [illegible] right lay wire rope [illegible] Where is the rope [illegible] of the drum?

- ❐ left side
- ❐ right side
- ❐ could be either side
- ❐ depends on the rope size

58 [illegible] wire rope [illegible] drum [illegible] sheave, how must the sheave be positioned?

- ❐ aligned with the center [illegible]
- ❐ aligned with the left drum flange
- ❐ aligned with the right drum flange
- ❐ depends on the rope lay

59. As more wraps of wire rope are spooled onto a drum hoist (tugger), the available pull on the rope will:
- ❒ increase
- ❒ decrease
- ❒ remain the same

60. Determine if this statement is true or false. Before using an air operated tugger, the air line should be blown out to remove excess moisture.
- ❒ true ❒ false

61. Determine if this statement is true or false. One advantage of a chain sling is that it can be safely shock loaded due to its elasticity.
- ❒ true ❒ false

62. Determine if this statement is true or false. Load binding chain is the type used for chain hoisting slings.
- ❒ true ❒ false

63. A matched set of chain slings with one leg longer than the others is likely an indication of:
- ❒ cracked links
- ❒ twisted links
- ❒ hardened links
- ❒ stretched links

64. Determine if this statement is true or false. To safely increase the capacity of a Come-A-Long, a 2 inch 'bar long' pipe can be used.
- ❒ true ❒ false

65. Which of the following is **NOT** a typical type of jack for on-the-floor rigging?
- ❒ ratchet
- ❒ electric
- ❒ screw
- ❒ hydraulic

66. Which of the following could be used to move a heavy load from an outside pad into a building?
- ❒ roller skid
- ❒ steel dolly
- ❒ air caster
- ❒ all of the above

67. The most commonly used grade of natural fiber rope is:
- ❒ number one grade manila
- ❒ number one grade hemp
- ❒ number one grade nylon
- ❒ number one grade sisal

68 Knots and hitches reduce the strength by approximately

- ❑ 10%
- ❑ 25%
- ❑ 30%
- ❑ 50%

69 Which splice is used when forming an eye in fiber rope?

- ❑ side splice
- ❑ short splice
- ❑ long splice
- ❑ bowline splice

70 Which of the following knots can be used as a lasso/emergency rescue sling?

- ❑ bowline on a bight
- ❑ self-centering bowline
- ❑ spanish bowline
- ❑ running bowline

71 This knot is known as a killing knot because it is often used improperly.

- ❑ bowline on the bight
- ❑ spanish bowline
- ❑ reef knot
- ❑ basket hitch

SECTION TWO

CRANE AND HOISTING TRAINING AND CERTIFICATION

Certification Necessity

Statistics from OSHA and OH&S will verify the fact that a high percentage of industrial accidents occur during material handling and load hoisting.

To help lower these accident numbers, more emphasis is being placed on workforce training by contractors, unions, company owners and various government departments and regulatory bodies.

This includes all types of industries ranging from a boom truck moving relatively light loads in a service capacity, a mobile or crawler crane lifting heavier loads for heavy industry or construction, a tower crane on building construction, or an EOT crane in a manufacturing environment.

For load movement by different types of cranes, this emphasis on the training and certification of the workforce is directed at five areas, which are:

1. Load lift planning
2. Load hook-up
3. Load movement signaling
4. Hoisting equipment
5. Crane operators

Load planning – One of the first steps in reducing load movement accidents is proper pre-lift planning. While lift planning to some degree is necessary for any lift, it is an absolute necessity for any lift classified as a critical lift (see Section Three).

Depending on the type of load, the location of the lift and who is responsible, the planning process can be quite complex.

The process starts by determining the load weight, where it is being moved from, and the steps involved in moving the load to a new location. This means that all those involved in planning (engineers, rigging supervisors, riggers and crane operators) may be required to have some type of certification.

This may include operator certificates, rigger training certificates or documented training, and very likely some type of certification, documented training or testing for the signalperson as well. They will have to sign off on the lift plan and its personnel checklist.

Load hook-up (rigging) – After the lift planning is completed, the next step is the crane set-up and actual load hook-up in preparation for lifting. Until recently it has not been mandatory, in most areas, for the rigger to have a certificate or show proof of qualification. However, that situation is changing, as hook-up work performed in some jurisdictions requires the rigger to either be certified, have some type of documented training, be tested, or be working under the direct instruction of someone who is certified and responsible.

There are recent changes to the ANSI B30 standard regarding training parameters for slings and rigging hardware.

These include selection, inspection, cautions to personnel, effects of environment, and rigging practices that will require training and documentation. In general terms, to satisfy the ANSI standards in place and pending for slings and hardware, the training will or may include:

1. Training as deemed necessary by the employer for any employee with assigned rigging duties.
2. Training provided by a qualified person designated by the employer.
3. Training covering the items as specified in the applicable standards chapter.
4. Training time frame varying as required by the individual job description.
5. Training being documented.

Load movement signaling - The person or persons who direct the movement of the load, either by hand signal or by voice communication, are responsible for its safe movement, and the safety of all personnel and bystanders in the area.

Up to this point, it was often not necessary for this person to be any more qualified than having some vague idea about hoisting signals, crane movements, and knowing where the load was going. Many persons performing the signals had a very limited knowledge about crane movements and limitations such as reduced capacity with increased radius, crane deflection, or maintaining a constant load height while moving the load. But that situation is quickly changing, as owners, contractors, unions, and regulatory bodies are deeming it necessary that the signal person knows exactly what they are doing and to understand what is going on.

Within the next several years it is likely that some type of signaling training and or testing will be required in all aspects of industry.

The revised ANSI B30.5 standard, effective in 2004, requires the signal person to be tested prior to crane signaling. Merely attending a training session will not suffice as testing will be required and the person must demonstrate:

1. A basic understanding of crane operation, movements, and limitations.
2. Understanding of standard hand signals (when used).
3. Understanding of standard voice signals (when used).

The new voice requirements will have three elements:

1. Function and direction (example – load up or down, boom in or out, or swing left or right)

2. Distance and speed (distance to final position with appropriate movement speed).
3. Function and stop (example - swing, slowly, 1 foot, stop)

Hoisting Equipment – This includes load movement with indoor hoists such as pole and wall mounted jibs, monorails, and A-frame floor gantries. Generally, on a smaller scale, the person(s) using this equipment combines the above three items (planning, rigging, and signaling) so the training and certification requirements will be similar.

Crane operators – To operate a crane safely and effectively, the operator must understand all aspects of the machine, including: location of controls and their function and the resulting movements; crane movements; capacities, load charts, and related data; operation speeds; and visual and audible signals. In addition, the operator must have a basic knowledge of crane inspection to be aware of any obvious problems in the crane structure, hoisting assembly, or the drive train.

Crane operator certification varies widely, depending on the equipment and the regulatory body within the jurisdiction of a particular location.

In Canada, there are few regulators for EOT crane operators, however most provinces have some type of certification process for tower, mobile and crawler cranes, as well as boom truck operators.

Crane operator certification in the USA is basically regulated by OSHA and ANSI, however various states and municipalities also have regulations. The armed forces and individual companies may also have specific requirements for crane operators. In general terms, anybody operating a crane must have a certificate. It may be necessary in some jurisdictions for crane operators to follow a re-certification process.

Training Program Purpose

The general purpose of any training program is as follows:

1. Define the objectives and duties of the training facility, and or the trainer.
2. Define the administrative policies relating to initial and subsequent certification.
3. Define the responsibilities of personnel to ensure a safe lift process.
4. Ensure the person requiring the training receives the proper technical and safety instruction.

Crane Operator Selection

The four primary ingredients in becoming a fully qualified crane operator are as follows:

- Physical condition
- Hands-on and classroom training
- Certification examination
- Practical experience

When a company or organization requires new trainees for a crane operator program, the prospective trainees will go through some type of selection process established by that company or organization. Common requirements include passing a physical examination and the ability to communicate. Communication means the ability to read and comprehend the crane manuals, instructions, load charts, crane reports, and all warning signs. It also means the operator or trainee must understand the applicable language when instructions or operating signals are verbal.

Note: It is an absolute necessity for trainees and operators to be drug and alcohol free and not be substance abusers. Periodic proof of this avoidance may be required.

Physical Condition: It is suggested (and required by some companies) that operators have a regular physical examination. ANSI stipulates that operators shall be in good physical condition. The primary health concerns are:

a. Vision of at least 20/30 Snellen in one eye and 20/50 in the other, with or without corrective lenses.

b. Ability to distinguish colors, regardless of position.

c. Adequate hearing, with or without hearing aid, for the specific operation.

d. Sufficient strength, endurance, agility, coordination and speed of reaction to meet operation demand.

e. Evidence of physical problems or emotional instability that could create a hazard, in the opinion of the examiner, may be sufficient cause for disqualification. In such a case, specialized clinical or medical tests may be required.

f. Evidence that an operator is subject to seizure or loss of physical control shall be reason for disqualification. Specialized medical tests may be required.

g. Operator must have normal depth perception, field of vision, reaction time, manual dexterity, coordination, and no tendency of dizziness.

h. Physical re-examination may be periodically required (physical re-examination required every three years in the USA).

Training – Classroom: Classroom training will include:

a. Crane nomenclature.

b. Material and load handling requirements.

c. Crane controller and crane movements.

d. Determining crane capacities using the load charts and related data.

e. Basic rigging hardware and its use.

f. Basic crane inspection and maintenance.
g. Pertinent and related safety regulations.

Training – Hands-On: Hands-on training provides an opportunity for the trainee to use the crane during simulated and actual load conditions while under the direct guidance of an experienced and certified operator.

Training Period Duration: The duration of the training period will vary depending on the type of crane and/or the jurisdictional body regulating the certification process.

Whatever the stipulated time frame, any trainee will have to complete the necessary period and/or be able to demonstrate ability through a certification examination that could be written, practical, or a combination of both. A crane operator's certification card will then be issued. A sample is shown in Illustration #166.

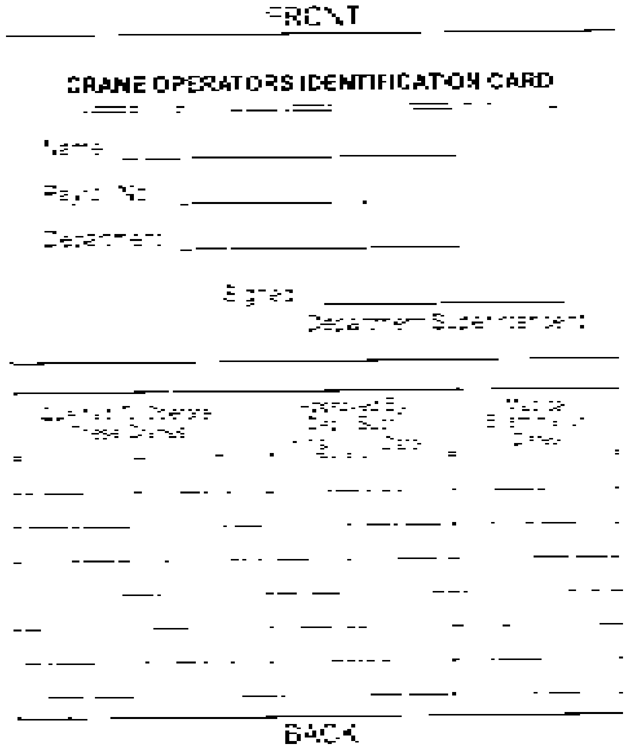


Illustration #166 – Sample Operators Certificate

Practical Experience: Unless the crane operator training period is very specific, and also very in-depth, the newly certified trainee will invariably be a marginal operator. Becoming a good operator requires a great deal of practical experience using a variety of cranes under different configurations and load conditions. Experience plus theory training will make the ideal operator.

Note: Operation Warning – Never operate a crane in any State, Province, or other jurisdiction stipulating compulsory operator certification, unless holding a certification card issued by the applicable authority; or unless you are in a training program and are under the supervision of an instructor or an experienced and certified crane operator.

Operator Conduct

a. The operator shall not engage in any activity that will divert attention from operating the crane.

b. The operator shall not operate a crane when physically or mentally unfit.

c. The operator shall only respond to the designated signal person, however anyone can give a stop signal.

d. The operator is responsible for operations under his control. When in doubt, consult a supervisor before hoisting.

e. Before leaving the crane unattended, the operator shall: land the load, disengage the master clutch, set all brakes and locking devices, put controls in off or neutral position, secure the crane against accidental travel, stop the engine.

SECTION THREE

PRE-LIFT PLANNING

Lift Plan Requirement

Prior to any crane lift, a lift plan of some type is necessary, including lifts that are classed as non-critical. An ill-prepared one ton lift of a sign on a building can be more hazardous than a 400 ton lift of a pressure vessel in an operating refinery, if something is left unaccounted for and a mishap occurs. The plan can be as simple as the supervisor, the crane operator, and the rigger(s) discussing the lift prior to it being made. Or it can be extremely complex, involving detailed site and lift drawings, and a team composed of experienced riggers, crane operators, and engineers with a rigging background.

The lift plan identifies the requirements needed for the primary areas of every lift, including:

- Identifies the size, shape, and weight of the load that is to be lifted, where it will be lifted from, where it will be placed, and where the lifting crane(s) will be located.
- The lift plan will describe the systematic assessment of important load and site factors. These factors are used to determine the size of crane needed, where it will be located and what site preparations will be required.
- The size, type and set-up, of the crane(s) (or other type of lifting device) as well as an up-to-date inspection record.
- The load lifting points, attachment methods, and rigging hardware to be used.
- The step by step movements of the crane(s) required to ensure a safe lift and work-site.
- The plan will include any environmental lifting conditions.
- A documented plan will include the name of those preparing the plan.
- A documented plan will designate the lift supervisor, crane operator(s), rigger(s), and state their qualifications.
- A copy of the plan should go to any designated authority.

Designation of a Critical Lift

There are few set rules to define whether a lift is considered critical and thereby requires a lift study or lift plan. The guidelines will vary from one jurisdiction to another, depending on what is being lifted and where the lift is taking place.

Crane companies and plant owners will often set specific criteria that determines whether a lift study is necessary during new plant construction, or when equipment is being removed or installed in an existing plant.

Some of the factors used to determine whether a lift should be designated as critical are:

- When a load is lifted over or near operating equipment or electrical power lines.
- When two or more pieces of lifting equipment are required to work in unison.
- When special lifting equipment, such as non-standard crane configurations will be used.
- The weight of the load exceeds set limits.
- The load weight is close to the crane's lifting capacity, as specified by the crane manufacturer's rating chart.
- When lifting personnel in a basket.

Lift Criteria: Criteria other than those listed may be specified to define a critical lift, as one company may have a much lower load weight limit than another. For instance, one company might specify that a lift plan is necessary for any lift over 20 tons in weight, or when a lift is to be made in or around any existing above ground structure.

Crane Capacity: Any load that is heavier than 75% of the rated capacity of a crane is a critical lift, and warrants special attention. Do not permit inexperienced or untrained personnel to prepare a critical lift plan.

Many inexperienced people assume that a crane can lift its rated capacity under almost any circumstances.

However, a crane can only lift its maximum capacity when it has a short boom that is positioned at its highest angle. For example, the assumption that a 60-ton crane can always lift 60 tons is incorrect. With a long boom configuration and a low boom working angle, that 60 ton crane may only have a capacity of 2,000 - 3,000 pounds.

Under these conditions it would take very little to tip the crane, and this would undoubtedly be classed as a critical lift.

Critical Lift Preparation

1. *Rigging Print:* It is often necessary to prepare a blueprint or drawing of the rigging job (see examples in this Section). This would include the load and the crane. For the load it would show the exact size, shape, and weight, and how it will be hooked up. It will specify the rigging hardware and indicate whether the load is turned, rotated, or inverted at some point during the lift.

Crane data includes the number, type, and size of crane(s), initial and final crane and load positions, site preparation, and the blocking or pads. Also necessary is the crane configuration (radius, boom length, boom angle, amount of swing) for all steps and positions during the lift. Any buildings or obstructions must be considered. A print is not always needed, but one advantage of drawing one is that it does make it necessary to know all of the details. These include load weight and measurements, crane capacities and measurements, as well as the hardware sizes, sling lengths, etc. This eliminates pacing off or guessing of distances, or guessing weights instead of measuring and calculating.

2. *Firm, Level Ground:* The ground under the crane must be compacted, or proven to be stable. A soil analysis might be needed. The crane must be on outriggers with pads or blocking under the outriggers when necessary (or a crawler crane on bearing mats).

The crane must be perfectly level for full capacity rating and to avoid boom sideloading. For further information refer to pages 234 to 242 for ground conditions and pages 265 to 274 on levelling and stability.

3. Radius, Boom Length, Boom Angle: The boom length must be known, and the load radius and boom angle must be determined exactly and known through the entire lifting process. An in-cab load indicator will show these three pieces of information, but only after the hook is directly over the load, and the operator must know, rather than assume, that the computer readings are correct. These three details must be known during the planning process, not while hooking up to do the lift.

4. Load and Rigging: The exact load weight must be known, including all of the crane and rigging components which are added to find the total weight. The capacity chart readings for gross weight must match before any lift is made.

The rigging hardware must have a suitable safety factor for the lift. Do not, under any circumstances, use the crane on-board load indicator computer to test lift a load to determine an unknown weight. This is an unsafe practice that violates the crane manufacturers operating guidelines and also ANSI B30.5-3.2.1.1 (a)(b)(c).

5. Environmental Conditions: The plan should consider the expected weather conditions for visibility and load safety. Conditions that might force a postponement such as wind, rain, thunderstorms, snow, or fog, tides, and currents around water are concerns. Plan for adequate lighting for any night operation.

6. Operator and Signalperson: Ensure that an experienced operator is at the controls during a critical lift. All movements must be smooth and slow. The signalperson must know the signals.

The operator and signal person must know the sequence of the crane and load movements through the lift process. They must be able to communicate with either hand signals or radio. Radio is a must if the distance is too great to see the hand signals clearly.

Lift Plan Checklist Examples

Several types of planning checklist examples follow.

They include:

- Plans Content Checklist - Table #46
- Planning Checklist - Table #47
- Crane Set-up Lift Analysis - Table #48
- Crane Capacity Lift Analysis - Table #49
- Hardware Lift Analysis Report - Table #50
- Critical Lift Plan Personnel Checklist - Table #51
- Lift Calculation Form - Illustration #167
- Crane Hookup - Illustration #168
- Tailing Crane Hookup - Illustration #169
- Rigging Sketch Sheet - Illustration #170
- Rigging Data Sheet - Illustration #171
- Crane Set-up Summary - Illustration #172

OPERATIONS CRITICAL LIFT PLAN
Plan Contents Checklist #1

Description of Component	Y	n/a
Critical Lift Planning Checklist		
Lift Analysis Report		
Process Contingency Plan		
Copy of Crane's Load Chart		
Copy of Vendor's Charts Showing Capacity of Slings & Shackles		
Copy of Inspection Records for Manufactured Lifting Equipment		
Elevation View Drawings		
Engineering Calculations for Engineered Lifting Components		
Rigging Sketch of Equipment Traveling Height		
Other (list)		

Y = yes, n/a = not applicable

Table #46 - Plans Content Checklist Example

OPERATIONS CRITICAL LIFT PLAN

Planning Checklist #2

Y = yes, n/a = not applicable

Description of Component	Y	n/a
How has the weight been determined? Was a margin added to calculate the weight?		
Have all attachments been considered in the weight calculations?		
Has all the rigging hardware been included in the weight calculations?		
What is the minimum actual clearance between the load and the boom during the lift?		
Who has determined the center of gravity? How was it determined? Is it marked on the load?		
If the radius was calculated, has it been double-checked by measuring in the field?		
Who is in charge of the lift? What are their qualifications? Who will signal the operator?		
Are radios required? Who will provide? What channel? Are they intrinsically safe?		
Is there anything inside the load that could shift during the lift?		
Is the load fragile enough to require lifting from a "strong back" or from multiple attachment points? Has the strong back been designed by a competent engineer and load tested?		

Description of Component	Y	n/a
Will the crane load change as the lift progresses?		
Has the anchor bolt pattern been checked to confirm the load can be landed properly?		
Is the surface area large enough to create unusual control problems in the wind?		
Have all rigging components such as shackles, hooks, and slings been inspected for signs of damage or deterioration before use?		
Has all rigging hardware been selected to work within the manufacturer's specs?		
Have sling angles lower than 45 degrees been avoided and the slings or chains been chosen to allow for increase loads due to sling angles?		
Is the rigging arranged to have the crane hook directly over the load's center of gravity with the load hanging level?		
Have softeners been utilized to protect the rigging where sharp corners could cause damage?		
Does the rigging provide positive control of the of the load to prevent it spinning or shifting?		

Table #47A - Planning Checklist Example #1 (part 1 of 3)

OPERATIONS CRITICAL LIFT PLAN

Planning Checklist #2 (cont.) Y = yes. n/a = not applicable

Description of Component	Y	n/a	Description of Component	Y	n/a
[illegible]			[illegible]		
[illegible]			[illegible]		
[illegible]			[illegible]		
[illegible]			[illegible]		
[illegible]			[illegible]		
[illegible]			[illegible]		
[illegible]			[illegible]		
[illegible]			[illegible]		

Table #57B - Planning Checklist (part 2 of 3)

OPERATIONS CRITICAL LIFT PLAN

Planning Checklist #2 (cont.)

Y = yes. n/a = not applicable

Description of Component	Y	n/a
Has a soil investigation program been performed? What is the assumed load distribution through the timber mats if they are used?		
Where will the crane be assembled? What route will the crane take from the assembly site to the lift site?		
Can the outriggers be fully deployed?		
How will the lifting slings be safely disconnected once the load is landed and anchored?		
Is adequate lighting equipment available for use if the lifting operation should extend beyond normal daylight hours?		
Can rigging personnel safely control and manipulate the load throughout the lifting path?		
Have emergency procedures been determined and communicated to all personnel involved in the lifting operation?		

Description of Component	Y	n/a
Have emergency plans been developed or communicated and understood by operating personnel?		
Are the operating personnel clear regarding isolation of lines containing toxic or flammable material? How are the valves identified?		
Has the lift plan been reviewed with crane operators, riggers, and others involved in the lifting operations? Has the plan been reviewed with supervisors and workers in adjacent areas?		
Does the lift plan reflect the philosophy that safety is the top priority?		

The above checklist has been reviewed and all items listed above have been addressed in the Critical Lift Plan.

Lift Plan Developer ____________________

Rigging Supervisor ____________________

Table #17C – Planning Checklist (part 3 of 3)

OPERATIONS CRITICAL LIFT PLAN - Crane Set-Up Lift Analysis

Location: Description of Item:

Load Length: Load Width: Load Height: Load Weight:

Is weight estimated? Yes / No By whom?

Is weight documented? Yes / No By whom?

LIFT CRANE Make & Capacity		TAIL CRANE Make & Capacity	
Boom Length		Boom Length	
Jib Length		Jib Length	
Boom Extension Length		Boom Extension Length	
TOTAL LENGTH		TOTAL LENGTH	
Over Front		Over Front	
Over Side		Over Side	
Over Rear		Over Rear	
360 degree Rotation		360 degree Rotation	
Radius (verified by Measurement in Field)		Radius (verified by Measurement in Field)	
Chart Capacity		Chart Capacity	
Boom Angle at Pick		Boom Angle at Pick	
Boom Angle at Set		Boom Angle at Set	
Jib Offset Degrees		Jib Offset Degrees	
Parts of Line to be Used		Parts of Line to be Used	
Capacity Per Part		Capacity Per Part	
LIFT CRANE GROSS CAPACITY AT ABOVE CONFIGURATION		TAIL CRANE GROSS CAPACITY AT ABOVE CONFIGURATION	

INCLUDE EXPLANATION OF HOW CALCULATION WILL BE DONE

Table #48 - Crane Set-Up Lift Analysis Example

OPERATIONS CRITICAL LIFT PLAN - Crane Capacity Lift Analysis

WEIGHT DEDUCTIONS:

	LIFT CRANE (est.)	TAIL CRANE (est.)
Main Boom	______	______
Auxiliary Ball	______	______
Jib Stowed	______	______
Jib Erected	______	______
Rigging	______	______
Auxiliary Boom Point	______	______
Loadline (Wt/ft)	______	______
Other (list)	______	______
Total Weight Deductions	______	______

FINAL CALCULATIONS:

	LIFT CRANE	TAIL CRANE
Crane Gross Capacity	______	______
Minus Deductions	______	______
Equals Net Capacity	______	______
Weight of Load	______	______
Divided by Net Capacity	______	______
Equals % of Load Chart used during Lift	______	______

Maximum Wind Speed Allowed for Lift to Proceed: ______

Type and Capacity of Weakest Part of Rigging: ______

Lifting Over Pipe Rack? Yes / No Approval ______

Lifting Over Process Equipment? Yes / No Approval ______

Lifting Over Electrical Lines? Yes / No Approval ______

Table #59 - Crane Capacity Lift Analysis Example

OPERATIONS CRITICAL LIFT PLAN - Hardware Lift Analysis Report

LIFT CRANE - Rigging to be Used

TYPE	QTY	SIZE	LGTH	lbs/ton	WGT.
Wire Rope					
Slings					
Nylon Slings					
Belly Bands					
Shackles					
Eye Bolts					
Spreader Bar					

Hitch Arrangement

TYPE	TOT. CAP.	lbs/ton	° of Angle
Straight Pull			
Choker Hitch			
Legs Vertical			
Basket Hitch			
Bridles			

TAIL CRANE - Rigging to be Used

TYPE	QTY	SIZE	LGTH	lbs/ton	WGT.
Wire Rope					
Slings					
Nylon Slings					
Belly Bands					
Shackles					
Eye Bolts					
Spreader Bar					

Hitch Arrangement

TYPE	TOT. CAP.	lbs/ton	° of Angle
Straight Pull			
Choker Hitch			
Legs Vertical			
Basket Hitch			
Bridles			

Include: Diagram for each Rigging System, Calculations for Sling Angles and Stress Per Leg

Table #50 - Hardware Lift Analysis Report Example

CRITICAL LIFT PLAN - Personnel Checklist

General Information on Lift

Description of Lift:

Area - Unit of Lift: ____________________

Planned Lift Date: ____________________

Plan Developed By: ____________________

Date: ____________________

Project Number: ____________________

Contractor's Review and Approval [illegible]

Rigging Supervisor: ____________________

Superintendent: ____________________

Safety Department: ____________________

Project Manager: ____________________

Engineering Departments: ____________________ (as needed due to complexity of lift)

Review and Concurrence [illegible]

Client Rigging Specialist: ____________________

Client Representative: ____________________
(Project Manager)

Client Safety Representative: ____________________ (as needed due to complexity of lift)

Pre-Lift Safety Meeting [illegible]

Contractor Supervisor: ____________________

Crane Operator #1: ____________________

Crane Operator #2: ____________________

Work Crew Members: ____________________ (attach extra personnel list if necessary)

Table #51 - Critical Lift Plan Personnel Checklist Example

EXAMPLE LIFT CALCULATION FORM FOR CRAWLER CRANES AND TRUCK CRANES

Weight and Description of Slings

Weight and Description of Sheaves

Other Considerations:

Illustration #[illegible] - Lift Calculation Form Example

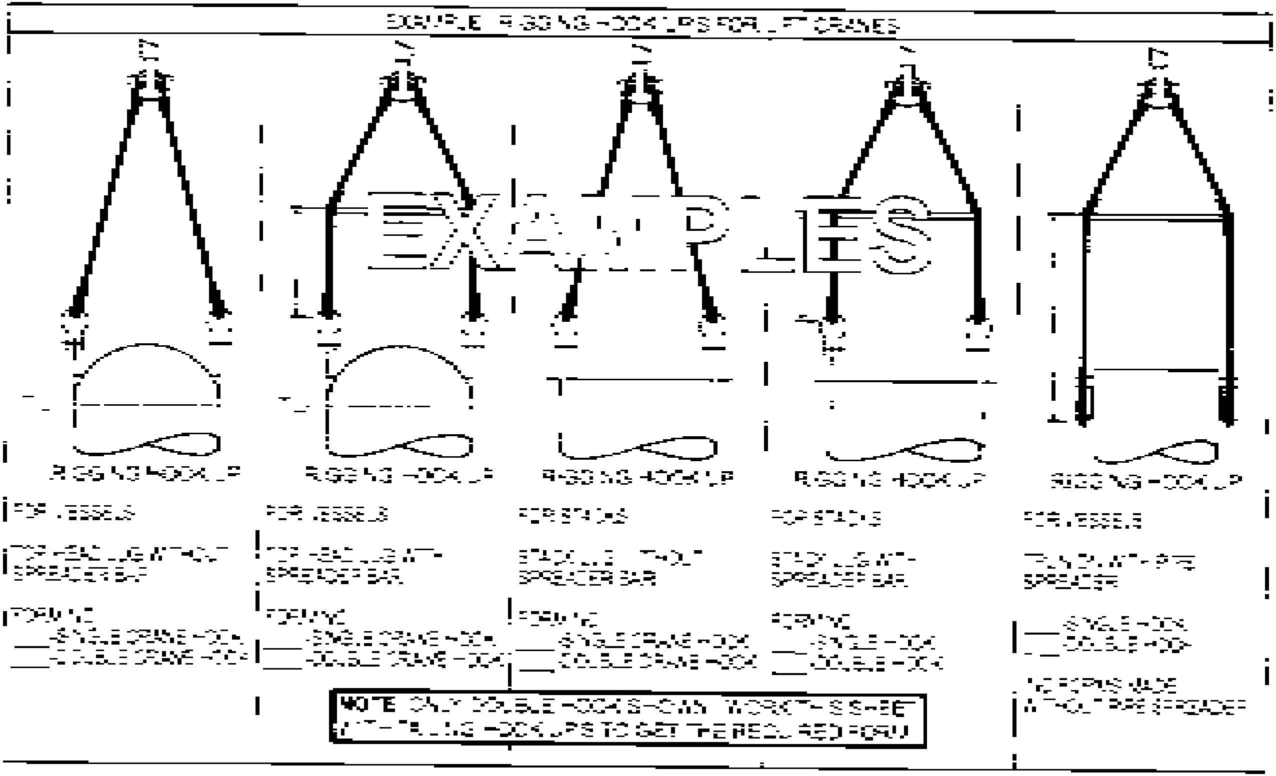


Illustration #166 - Crane Hookup Example

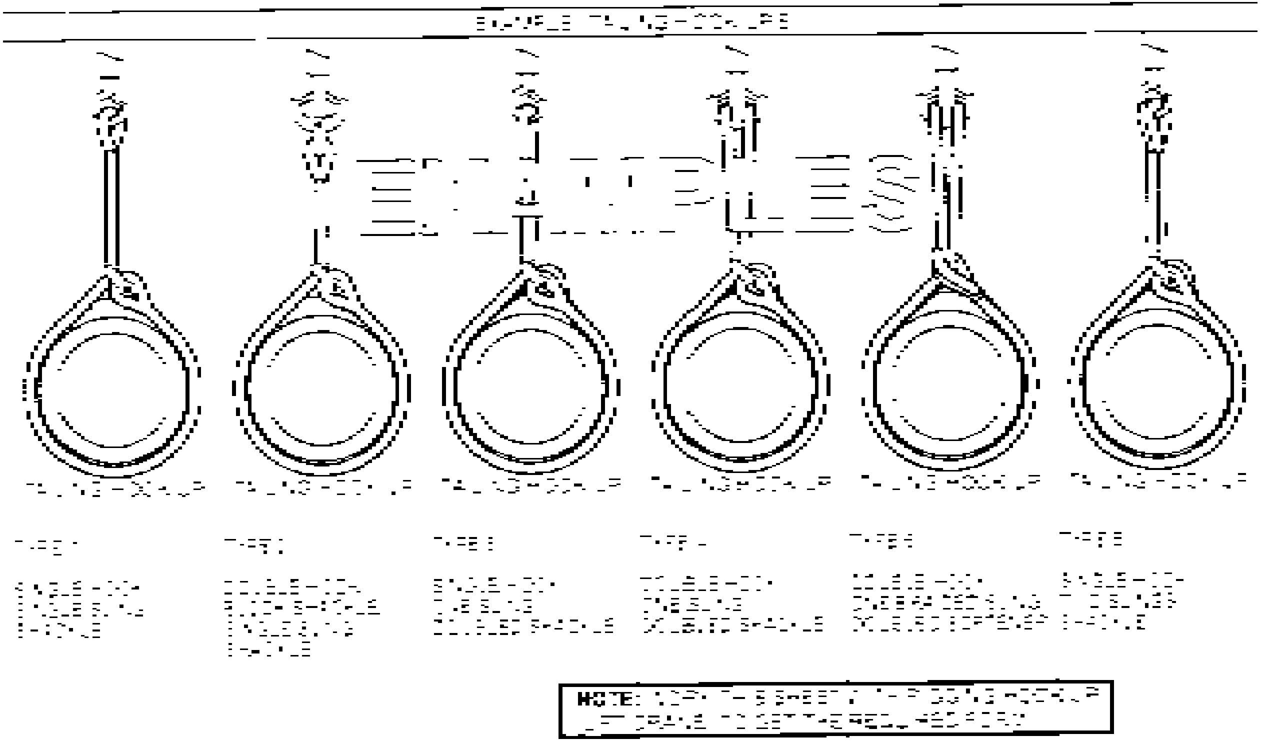


Illustration #188 - Tailing Crane Hookup Example

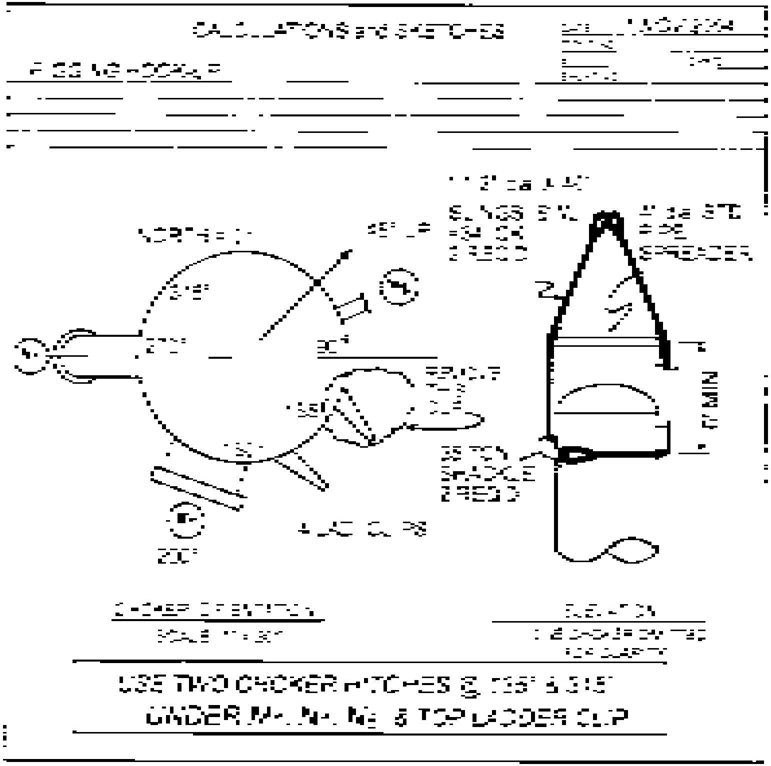


Illustration # 72 - Rigging Sketch Sheet Example

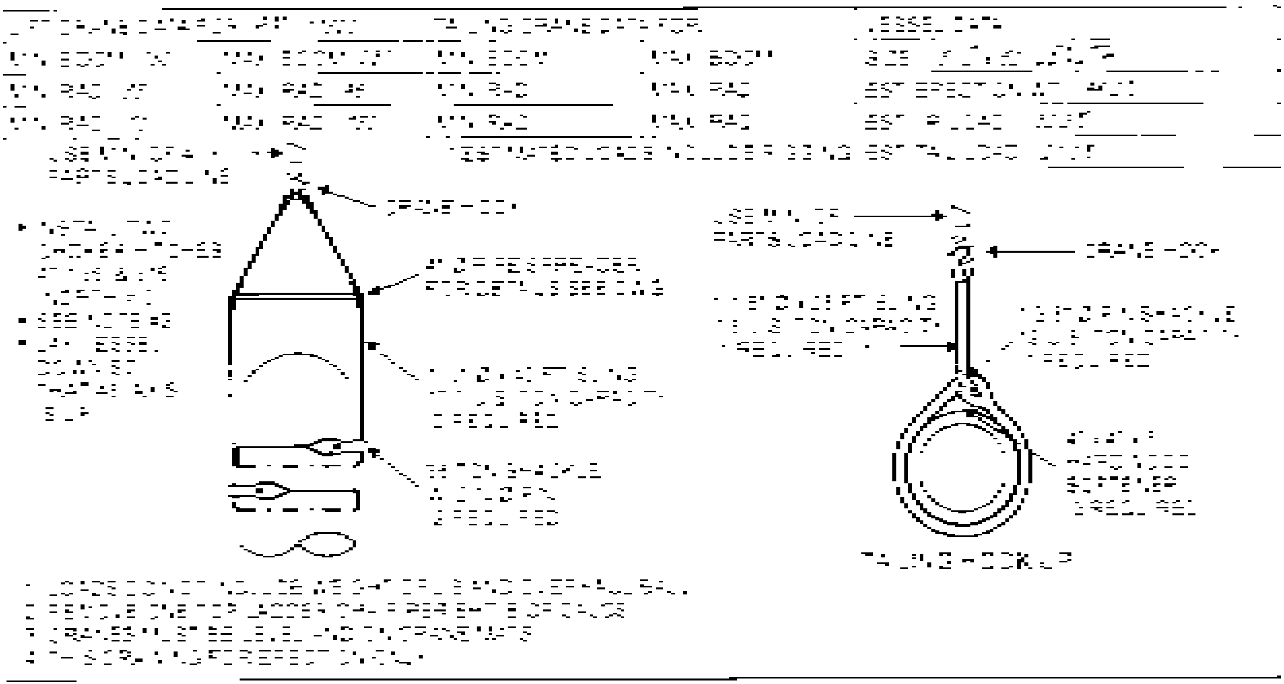


Illustration #[illegible] - Rigging Data Sheet Example

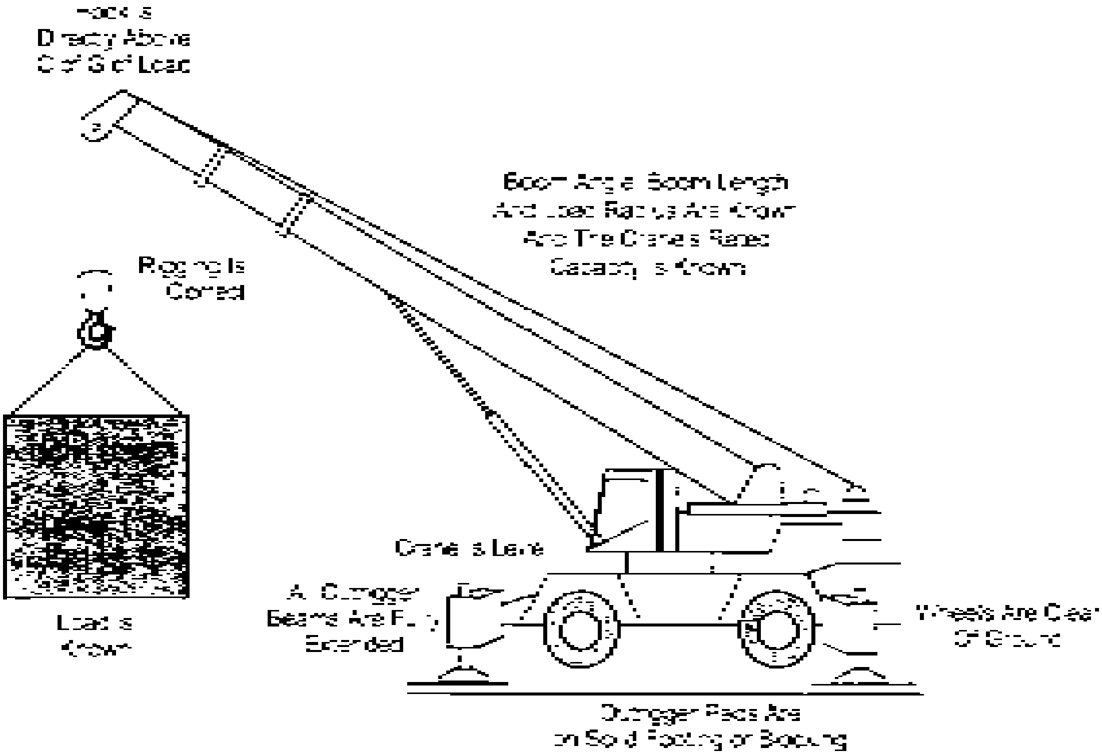


Illustration #172 - Crane Set-Up Summary Example

Lift Plan Drawing Examples

Lift plan drawings for four different hoisting projects are shown on the following pages.

For each crane lift the drawings show:

- a perspective (isometric) view of the lift site
- an elevation (side) view
- a plan (top) view showing the crane and load positioning details
- rigging hook-up details
- specification details for the crane and hardware requirements of each lift.

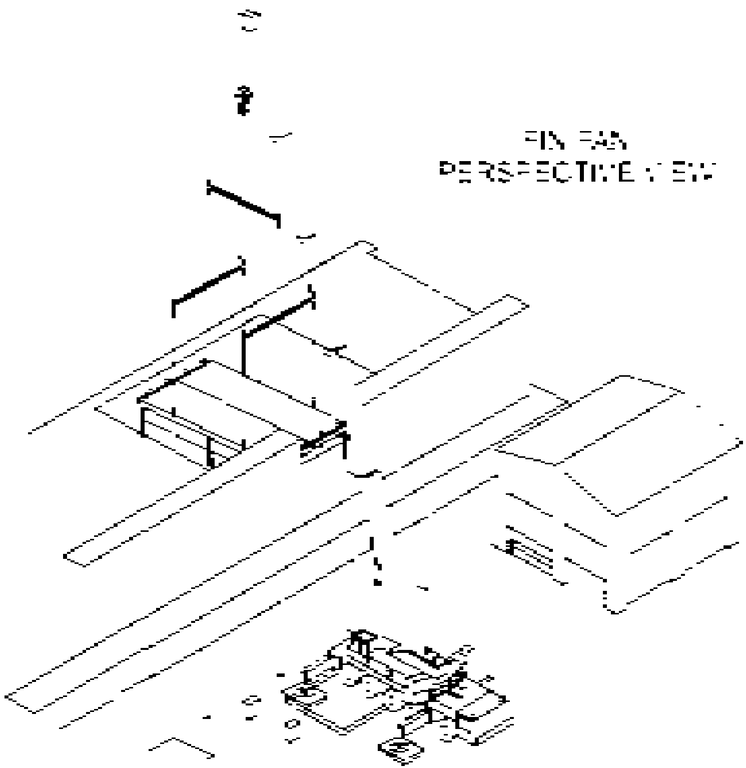


Illustration #171 - Fin Fan Perspective View (part 1 of 6)

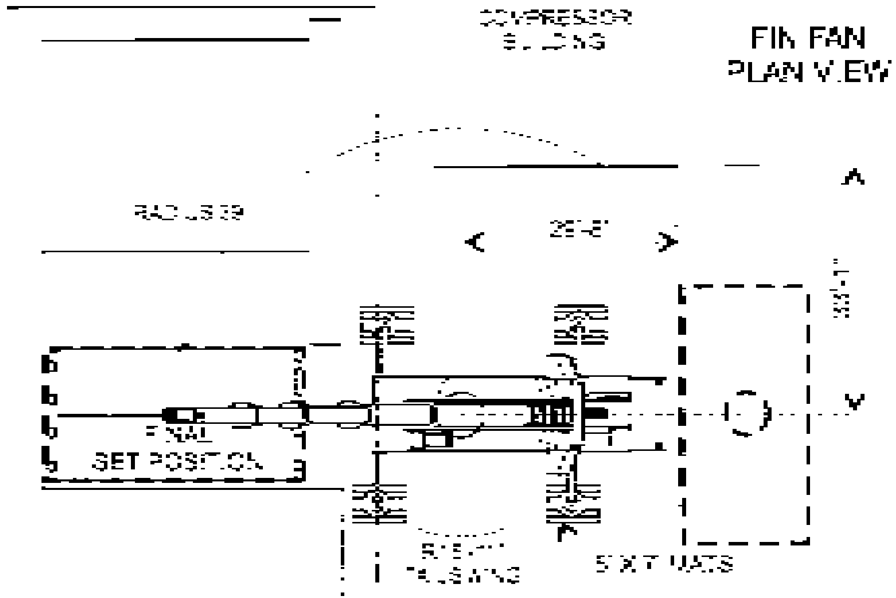


Illustration #173 - Fin Fan Plan View (part 2 of 6)

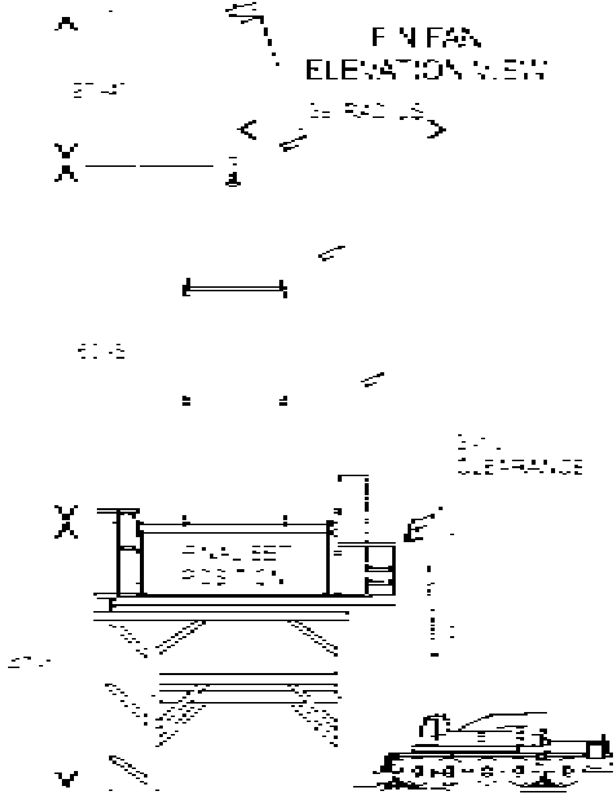


Illustration #175 - Fin Fan Elevation View (part 3 of 6)

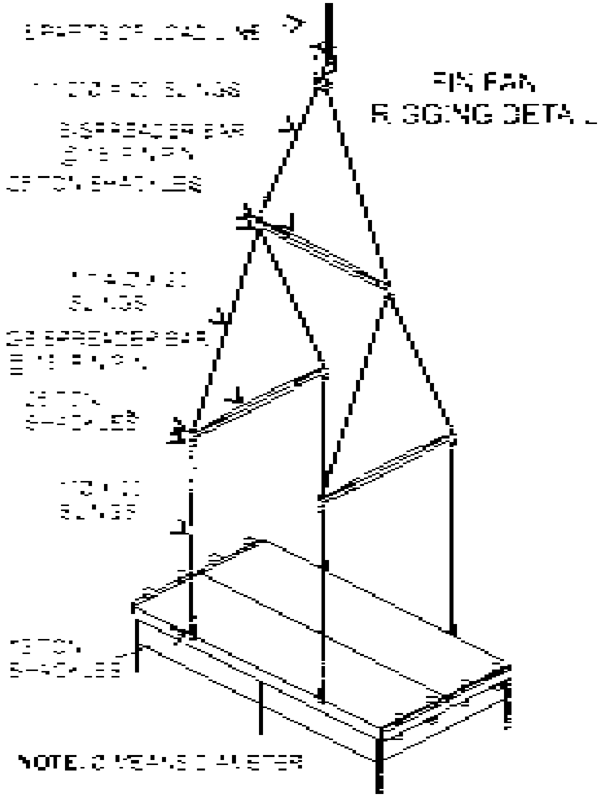


Illustration #175 - Fin Fan Rigging Detail (part 4 of 6)

FIN FAN
CRANE/LOAD/LIFT INFORMATION

NOTE: EQUIPMENT SIZE

EQUIPMENT TYPE - FIN FAN COOLER

CRANE INFO.	
CRANE TYPE	DEMAG AC435
COUNTERWEIGHT	97,000 lbs.
BOOM LENGTH	133.5 ft.
MAST LENGTH	-
LIFT RADIUS	39 ft.
CRANE CAPACITY	66,500 lbs.
LOAD INFO	FULL LOAD
EQUIP. WEIGHT	51,630 lbs.
RIGGING WEIGHT	3,150 lbs.
LOAD BLOCK	2,320 lbs
HEADACHE BALL	-
AUX. HEAD	-
JIB AND BOOM EXT STOWED	-
LIFT INFO	
TOTAL LIFT WEIGHT	57,100 lbs
% OF CHART CAPACITY	86%

Illustration #173 - Fin Fan Crane / Load / Lift Information (part 5 of 6)

FIN FAN RIGGING LIST

ITEM	QTY	DESCRIPTION
1	2	SLING 1 1/2" DIA X 20 FT
2	4	SLING 1 1/4" DIA X 20 FT
3	4	SLING 1" DIA X 20 FT
4	8	SHACKLE 25 TON
5	4	SHACKLE 12 TON
6	1	SPREADER BAR 16' TYPE [illegible] PIN [illegible]
7	2	SPREADER BAR [illegible] TYPE [illegible] PIN [illegible]

PROCEDURE:

1. POSITION CRANE AS SHOWN IN PLAN VIEW
2. ATTACH RIGGING TO COOLER
3. HOIST COOLER TO CLEAR OBSTRUCTIONS
4. SWING COUNTERCLOCKWISE UNTIL OVER FINAL SET POSITION
5. LOWER COOLER INTO FINAL SET POSITION AND SECURE
6. DISCONNECT RIGGING

GENERAL NOTES:

1. ENSURE FIRM AND LEVEL FOUNDATION FOR CRANE
2. MAXIMUM WIND SPEED NOT TO EXCEED 20 MPH DURING LIFT
3. TAG LINES MAY BE USED DURING THE LIFT TO CONTROL THE LOAD
4. ALL WIRE ROPE SLINGS TO BE IPS IWRC

Illustration #172 - Fin Fan Rigging List & Notes (part 6 of 8)

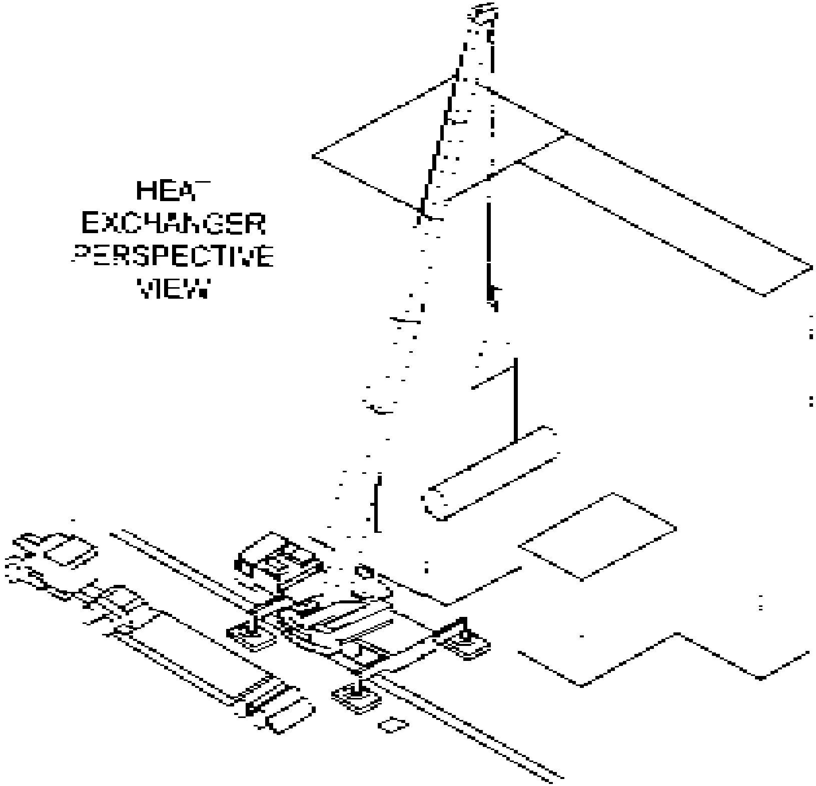


Illustration #174 - Heat Exchanger Perspective View (part 1 of 6)

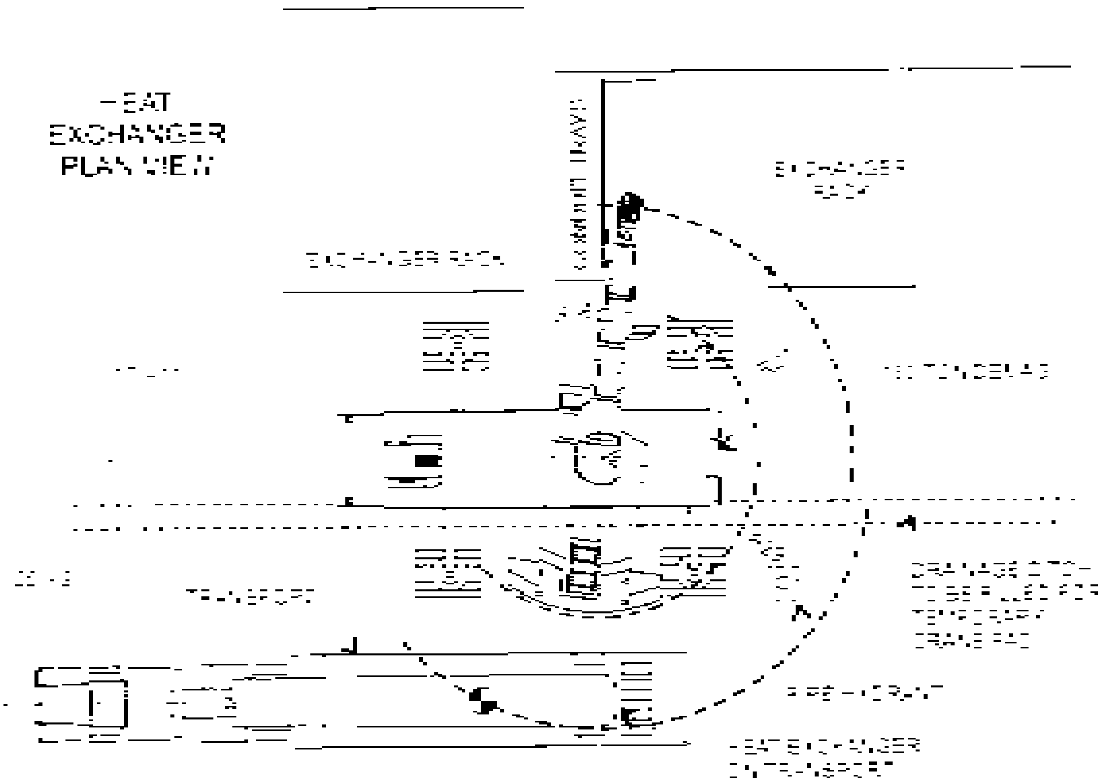


Illustration #174 - Heat Exchanger Plan View (part 2 of 6)

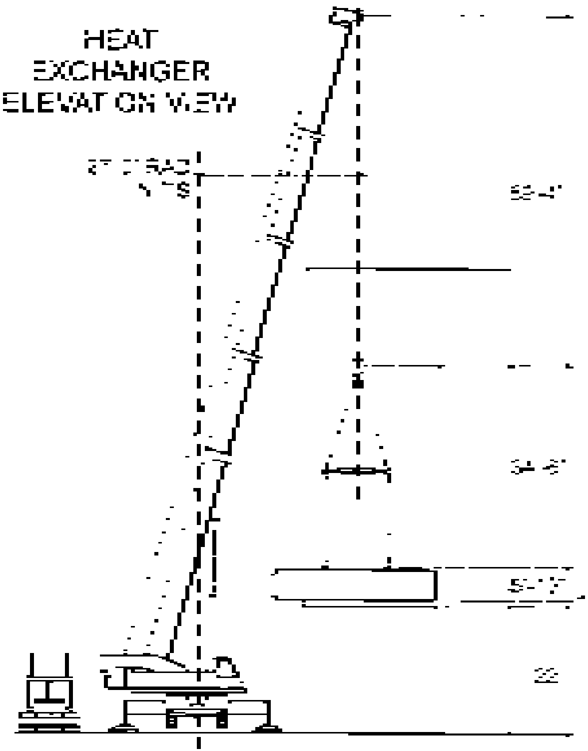


Illustration #174 - Heat Exchanger Elevation View (3 of 6)

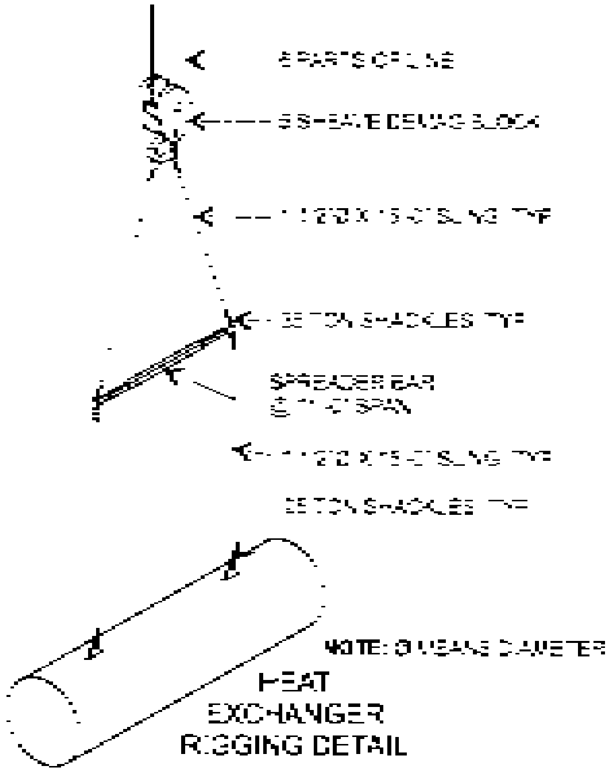


Illustration #174 - Heat Exchanger Rigging Detail (5 of 6)

HEAT EXCHANGER CRANE/LOAD/LIFT INFORMATION

NOTE: EQUIPMENT SIZE 27' - 10 3/4" X 5' - 4" DIA.

CRANE INFO.	
CRANE TYPE	180 TON DEMAG
COUNTERWEIGHT	24,200 lbs.
BOOM LENGTH	115 ft 3 in
MAST LENGTH	N/A
LIFT RADIUS	29 ft 0 in
CRANE CAPACITY	133,500 lbs.
LOAD INFO.	
EQUIP. WEIGHT	63,580 lbs.
RIGGING WEIGHT	1,500 lbs.
LOAD BLOCK	2,680 lbs.
HEADACHE BALL	N/A
AUX. HEAD	N/A
JIB AND BOOM EXT. STOWED	N/A
LIFT INFO.	
TOTAL LIFT WEIGHT	67,760 lbs.
% OF CHART CAPACITY	51%

Illustration #174 - Heat Exchanger Crane • Load • Lift Information (part 5 of 5)

HEAT EXCHANGER RIGGING LIST

ITEM	QTY	DESCRIPTION
1	4	SLING, 1 1/2 in. DIA x 15 ft.
2		
3		
4	4	SHACKLE, 36 TON
5	2	SHACKLE, 25 TON
6		
7	1	SPREADER BAR, "HAT" TYPE 11 ft. 0 in.
8		

PROCEDURE:

1. POSITION CRANE AS SHOWN IN PLAN VIEW
2. ATTACH CRANE RIGGING TO EXCHANGER
3. HOIST EXCHANGER CLEAR OF TRANSPORT
4. SWING COUNTER-CLOCKWISE ENSURING IT CLEARS THE EXISTING EXCHANGER RACK
5. POSITION EXCHANGER ABOVE FINAL SET POSITION AND LOWER
6. SECURE EXCHANGER AND REMOVE RIGGING

GENERAL NOTES:

1. ENSURE FIRM AND LEVEL FOUNDATION FOR CRANE
2. MAXIMUM WIND SPEED NOT TO EXCEED 20 MPH (32 km/hr) DURING LIFT
3. TAG LINES MAY BE USED DURING THE LIFT TO CONTROL THE LOAD
4. ALL WIRE ROPE SLINGS TO BE IPS, IWRC

Illustration #174 - Heat Exchanger Rigging List (part 6 of 6)

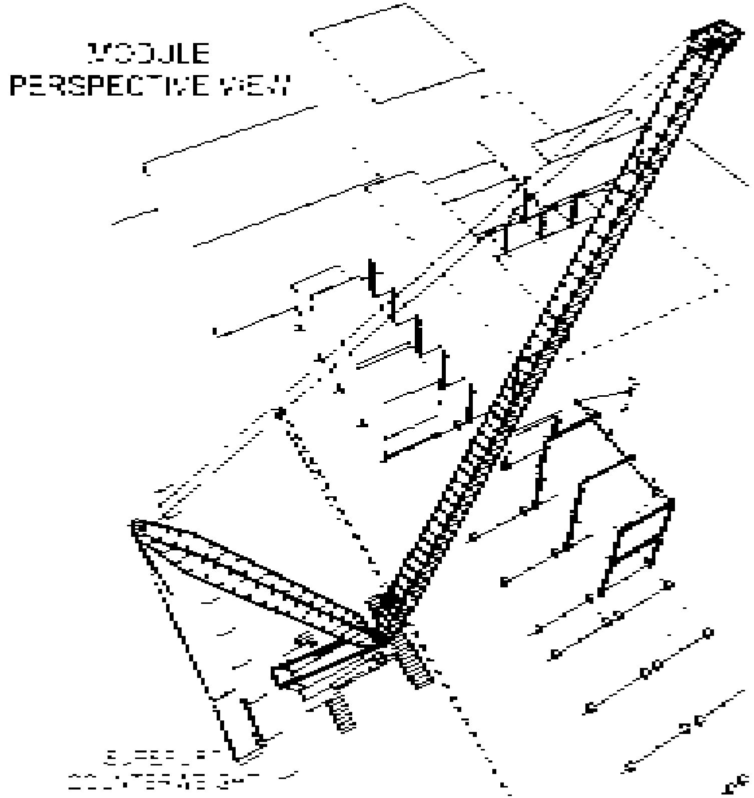


Illustration #175 - Module Perspective View (part 1 of 7)

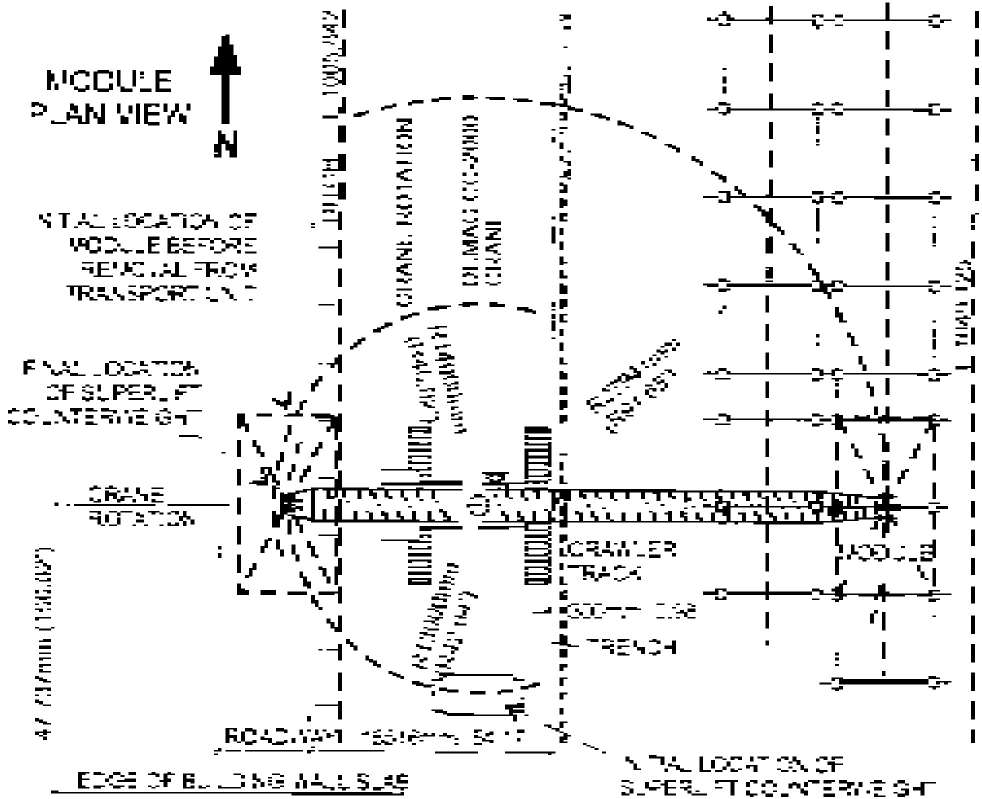


Illustration #175- Module Plan View (part 2 of 7)

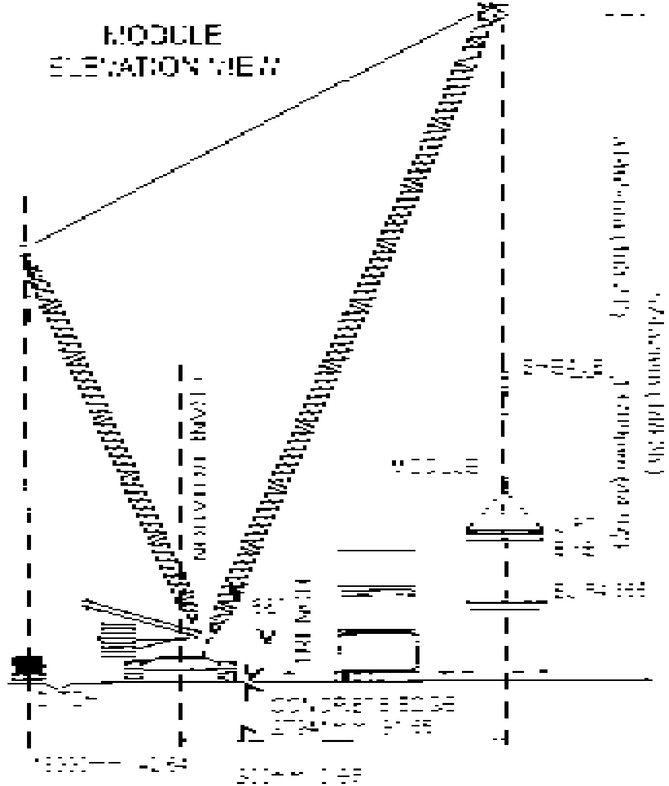


Illustration #175 - Module Elevation View (part 1 of 2)

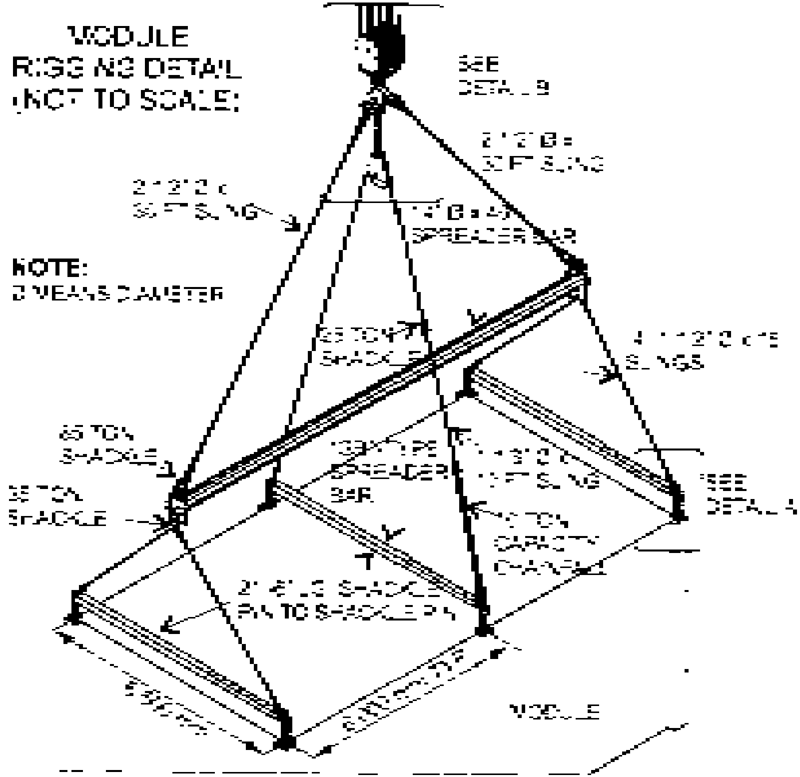
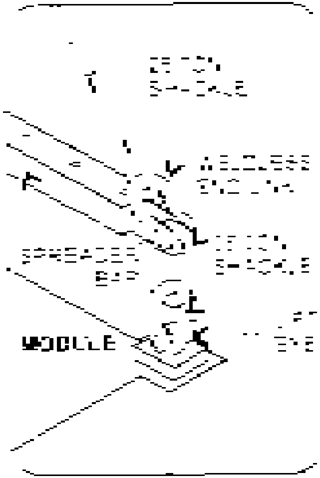


Illustration #175 - Module Rigging Detail (part 4 of 7)

DETAILS NOT TO SCALE



DETAIL A
TYPICAL LIFT EYE

DETAIL B

RIGGING LIST

ITEM	QTY	DESCRIPTION
[illegible]	[illegible]	SLING [illegible]
[illegible]	[illegible]	SLING [illegible]
[illegible]	[illegible]	SLING [illegible]
[illegible]	[illegible]	SLING [illegible]
[illegible]	[illegible]	SLING [illegible]
[illegible]	[illegible]	SHACKLE [illegible]
[illegible]	[illegible]	SHACKLE [illegible]
[illegible]	[illegible]	SHACKLE [illegible]
[illegible]	[illegible]	SHACKLE [illegible]
[illegible]	[illegible]	SPREADER BAR [illegible]
		[illegible]
[illegible]	[illegible]	SPREADER BAR [illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

RIGGING NOTE

ADDITIONAL SHACKLES MAY BE ADDED AS REQUIRED TO LEVEL BALANCE THE LOAD PROVIDING SHACKLE CAPACITY MEETS OR EXCEEDS THE CAPACITY OF THE ADJACENT RIGGING

Illustration #175 - Module Shackle Details and Rigging List (part 5 of 7)

MODULE CRANE/LOAD/LIFT INFORMATION

NOTE: MODULE 68-B WEIGHT 48 637 kg (107,245 lbs.)
MODULE 68-B APPROXIMATE DIMENSIONS: 12 000 mm x 5 500 mm x 5 445 mm
MODULE 68-B APPROXIMATE DIMENSIONS: 40 ft x 21 ft x 18 ft TALL

CRANE INFO.	MODULE 68-B NO SUPERLIFT	MODULE 68-B WITH SUPERLIFT
CRANE TYPE	DEMAG CC 2000 CRAWLER	DEMAG CC 2000 CRAWLER
COUNTERWEIGHT	120 TONNE STD. + 0 TONNE SL	120 TONNE STD. + 40 TONNE SL
BOOM LENGTH	60 m (197 ft)	60 m (197 ft)
MAST LENGTH	36 m (118 ft)	36 m (118 ft)
LIFT RADIUS	14 000 mm (45.92 ft)	27 941 mm (91.65 ft)
CRANE CAPACITY	114 000 kg (251,370 lbs.)	66 207 kg (145,955 lbs.)
LOAD INFO.	ENTIRE MODULE 68-B WEIGHT	ENTIRE MODULE 68-B WEIGHT
EQUIP. WEIGHT	48 637 kg (107,245 lbs.)	48 637 kg (107,245 lbs.)
RIGGING WEIGHT	4 243 kg (9,356 lbs.)	4 243 kg (9,356 lbs.)
LOAD BLOCK	2 721 kg (6,000 lbs.)	2 721 kg (6,000 lbs.)
HEADACHE BALL	N/A	
AUX. HEAD	N/A	
JIB AND BOOM EXT. STOWED	N/A	
LIFT INFO.		
TOTAL LIFT WEIGHT	55 601 kg (122,601 lbs.)	55 601 kg (122,601 lbs.)
% OF CHART CAPACITY	49%	84%

Illustration #175 - Module Crane/Load/Lift Information (part 6 of 7)

PROCEDURE:

1. POSITION CRANE AS SHOWN IN PLAN VIEW
2. POSITION SUPERLIFT COUNTERWEIGHT SOUTH OF CRANE
3. POSITION TRANSPORT SO MODULE CENTER OF GRAVITY IS DIRECTLY WEST OF CRANE
4. SWING DEMAG CC2000 CRANE BOOM OVER MODULE ON TRANSPORT UNIT
5. ATTACH RIGGING TO MODULE AS SHOWN ON RIGGING DETAIL
6. HOIST MODULE FROM TRANSPORT AND SWING BOOM TO DIRECTLY NORTH OF CRANE
7. ATTACH SUPERLIFT COUNTERWEIGHT TO CRANE
8. BOOM DOWN UNTIL SUPERLIFT COUNTERWEIGHT IS CLEAR OF THE GROUND
9. CONTINUE TO SWING MODULE EAST TOWARDS FINAL SET LOCATION
10. HOIST MODULE AS REQUIRED TO CLEAR OBSTRUCTIONS
11. POSITION MODULE 88-E OVER FINAL SET LOCATION
12. LOWER MODULE TO BENTS
13. ATTACH MODULE TO BENTS -- BY OTHERS
14. REMOVE RIGGING FROM MODULE

GENERAL NOTES:

1. ENSURE FIRM AND LEVEL FOUNDATION FOR CRANE
2. MAXIMUM WIND SPEED NOT TO EXCEED 20 MPH DURING LIFT
3. TAG LINES MAY BE USED DURING THE LIFT TO CONTROL THE LOAD
4. ALL WIRE ROPE SLINGS TO BE IPS, IWRC

Illustration #75 - Module Procedure & Notes (part 7 of 7)

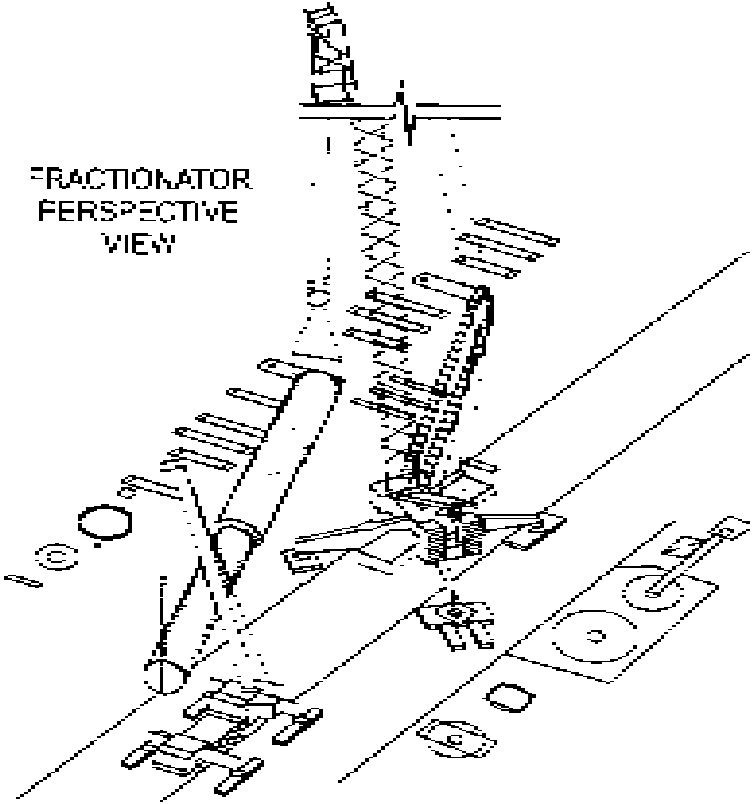


Illustration #176 - Fractionator Perspective View (part 1 of 6)

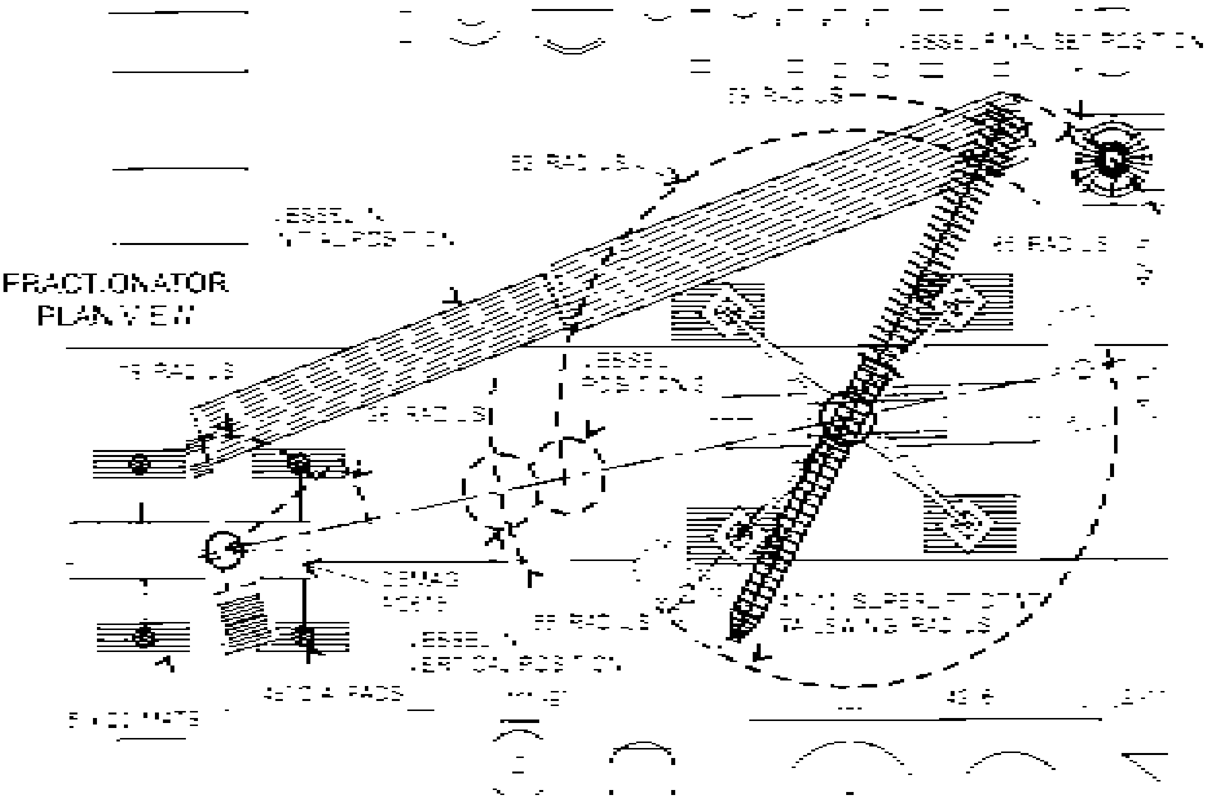
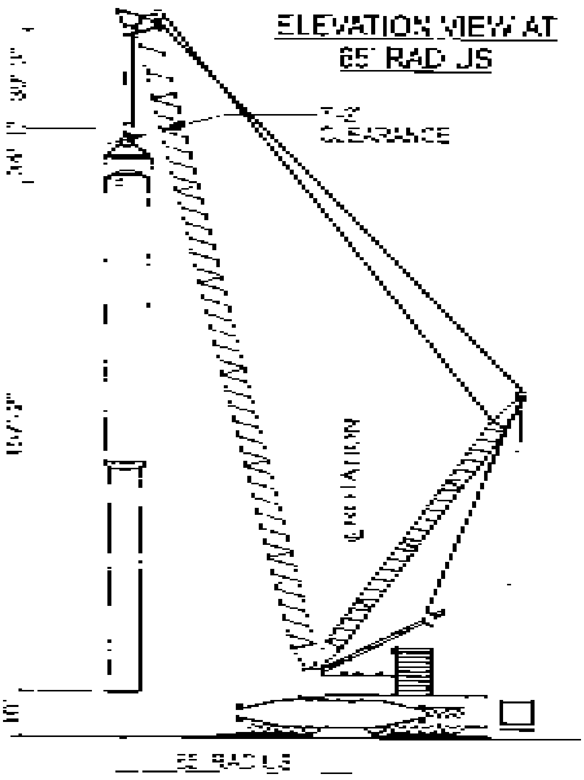


Illustration #175 - Fractionator Plan View (part 2 of 6)



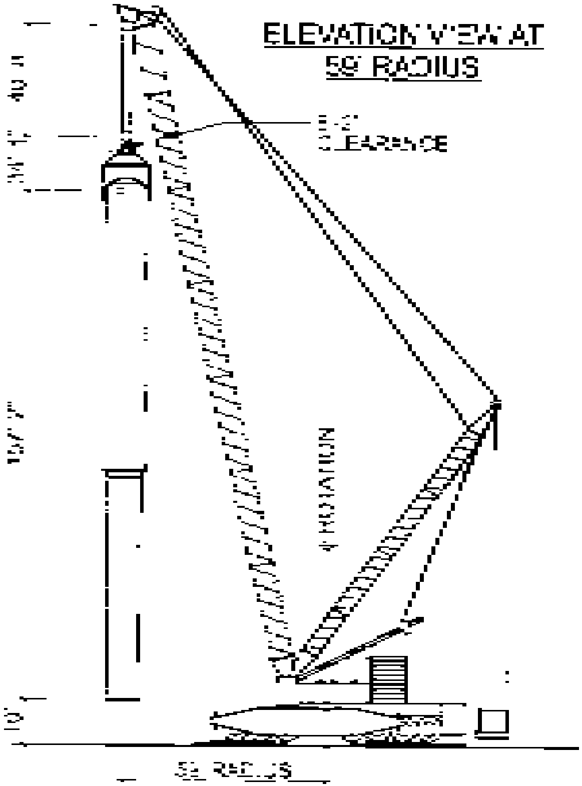


Illustration #176- Fractionator Elevation Views (part 3 of 5)

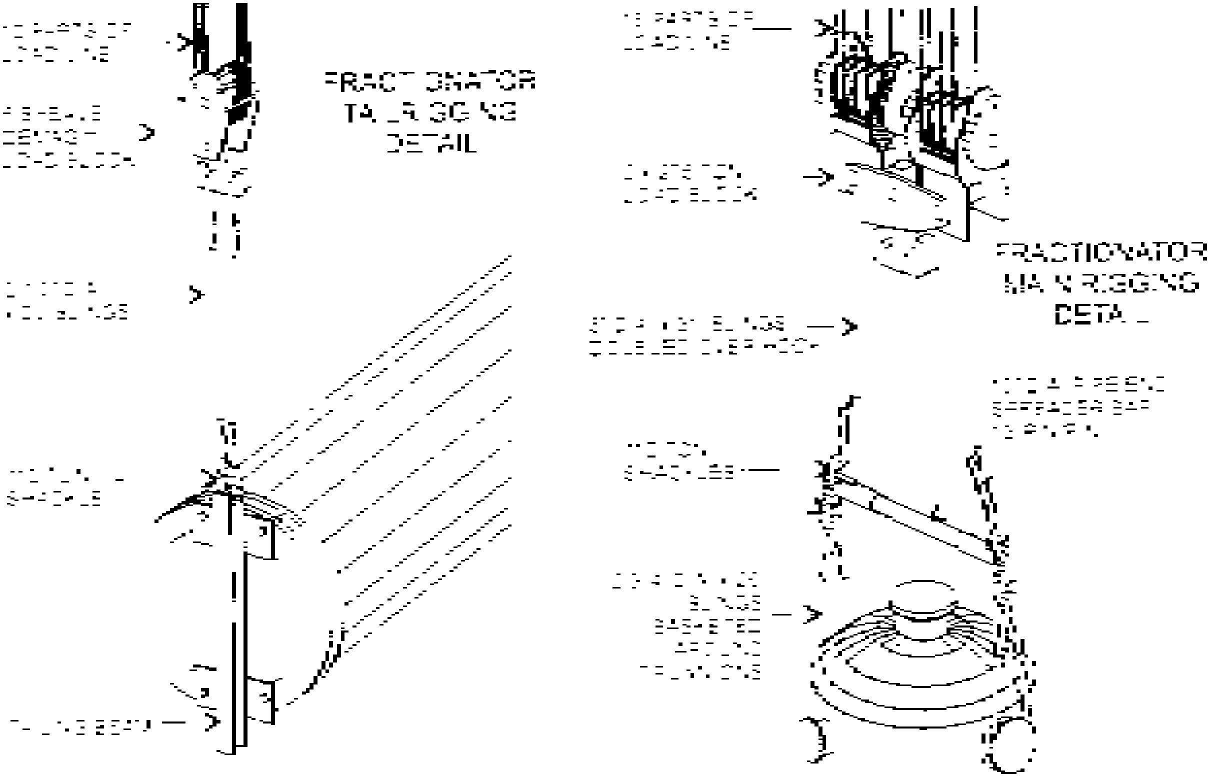


Illustration #175 - Fractionator Rigging Details (part 4 of 5)

CRANE · LOAD · LIFT INFORMATION			
NOTE: EQUIPMENT SIZE - NEW FRACTIONATOR [illegible] TAN/TAN [illegible] OVERALL HEIGHT			
CRANE NO.	MAIN CRANE	MAIN CRANE	TAIL CRANE
TYPE	DEMAG TC[illegible]	DEMAG TC[illegible]	DEMAG AC[illegible]
CTWT	[illegible] T + [illegible] T SL	[illegible] T + [illegible] SL	[illegible] LBS
BOOM LENGTH	236'	236'	[illegible]
MAST LENGTH	85'	85'	—
WORK RADIUS	55'	55'	25'
CAPACITY	454,000 LBS	250,200 LBS	134,500 LBS
LOAD NO.	FULL LOAD	MAIN LOAD	TAIL LOAD
EQUIPMENT	37[illegible],336 LBS	232,[illegible] LBS	[illegible] LBS
RIGGING	5,350 LBS	3,330 LBS	4,430 LBS
LOAD BLOCK	22,700 LBS	22,660 LBS	3,345 LBS
HEADACHE BALL	—	—	—
AUX HEAD	—	—	—
JIB & BOOM EXT.	—	—	—
LIFT NO.			
TOTAL LIFT WT	415,066 LBS	247,596 LBS	116,225 LBS
% OF CHART CAP.	91%	99%	86%

RIGGING LIST		
ITEM	QTY	DESCRIPTION
1	2	SLING 3" DIA x [illegible]
2	2	SLING 2 3/4" DIA x [illegible]
3	2	SLING 2 1/2" DIA x [illegible]
4	[illegible]	SHACKLE, [illegible] TON
5	1	SPREADER BAR [illegible] DIA PIPE
		ENDS & [illegible] SCH 40 PIPE INSERT
6	1	TAIL BEAM

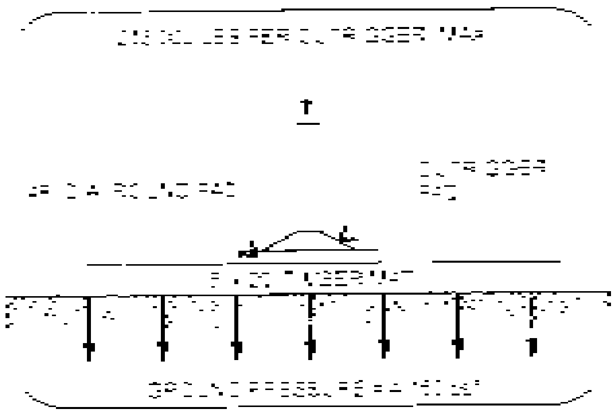
GENERAL NOTES:

1. ENSURE FIRM AND LEVEL FOUNDATION FOR CRANE
2. MAXIMUM WIND SPEED NOT TO EXCEED 20 MPH DURING LIFT
3. TAG LINES MAY BE USED DURING THE LIFT TO CONTROL THE LOAD
4. ALL WIRE ROPE SLINGS TO BE IPS IWRC.

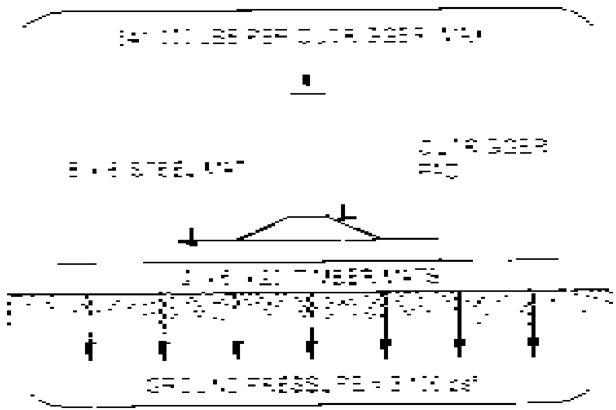
Illustration #176 - Fractionator Crane / Load / Lift Information (part 5 of 6)

PROCEDURE

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]



GROUND PRESSURE DETAIL
FOR DEMAG [illegible]



GROUND PRESSURE DETAIL
FOR DEMAG [illegible]

Illustration #176 - Fractionator - Ground Pressure Details (part 5 of 6)

ANSI and OSHA Standards Applicable to Cranes and Lifting Devices

A92.2	Vehicle Mounted Elevating & Rotating Aerial Devices
A92.3	Manually Propelled Elevating Work Platforms
A92.5	Boom Supported Elevating Work Platforms
A92.6	Self-Propelled Elevating Work Platforms
B30.1	Jacks
B30.2	Overhead and Gantry Cranes (top running bridge, single or multiple girder, top running trolley hoist)
B30.3	Construction Tower Cranes
B30.4	Portal, Tower, Pedestal Cranes
B30.5	Mobile and Locomotive Cranes
B30.6	Derricks
B30.7	Base Mounted Drum Hoists
B30.8	Floating Cranes and Floating Derricks
B30.9	Slings
B30.10	Hooks
B30.11	Monorails and Underhung Cranes
B30.12	Handling Loads Suspended from Rotorcraft
B30.13	Storage/Retrieval (S/R) Machines and Associated Equipment
B30.14	Side Boom Tractors
B30.15	Mobile Hydraulic Cranes (has been withdrawn now included in B30.5)
B30.16	Overhead Hoists (underhung)
B30.17	Overhead and Gantry Cranes (top running bridge, single girder, underhung hoist)
B30.18	Stacker Cranes (top or under running bridge, multiple girder with top or under running trolley hoist)
B30.19	Cableways
B30.20	Below-the-Hook Lifting Devices
B30.21	Manually Lever Operated Hoists
B30.22	Articulating Boom Cranes
B30.23	Personnel Lifting Systems
B30.24	Container Cranes (Under Development)
B30.25	Scrap and Material Handlers
B30.26	Rigging Hardware (Under Development)
B30.27	Material Placement Systems (Under Development)
B30.28	Balance Lifting Units (Under Development)
B56.1	Safety Standards for High and Low Lift Trucks
B56.6	Safety Standards for Rough Terrain Forklift Trucks
B56.7	Safety Standards for Industrial Crane Trucks

HST Performance Standards

HST-1	Electric Chain Hoists
HST-2	Manually Operated Chain Hoists
HST-3	Manually Operated Lever Hoists
HST-4	Overhead Electric Wire Rope Hoists
HST-5	Air Chain Hoists
HST-6	Air Wire Rope Hoists

Table #52A - ANSI and OSHA Standards

ANSI and OSHA Standards Applicable to Cranes and Lifting Devices

D14.1-85 ANSI AWS Std for Industrial and Mill Cranes and Hoists Welding Repair

D14.3 ANSI AWS Std for Earthmoving and Construction Equipment Welding Repair

OSHA 29 CFR - Part 1926 Construction Industry Standards

Sub Part H - Material Handling and Storage
- 1926.251 Rigging Equipment

Sub Part L - Scaffolds
- 1926.453 Aerial Lifts
- 1926.454 Training Requirements

Sub Part N - Cranes, Derricks and Hoists
- 1926.550 1926.552
- 1926.553 1926.554

Sub Part O - Motor Vehicles, Mechanized Equipment and Marine Operations
- 1926.600 1926.601 1926.602
- 1926.603 1926.604 1926.605

OSHA 29 CFR - Part 1910 General Industry Standards

Sub Part F - Vehicle Mounted Work Platforms
- 1910.67

Sub Part N - Materials Handling and Storage
- 1910.176 1910.177 1910.178
- 1910.179 1910.180 1910.181
- 1910.184

OSHA 46 CFR - Parts 1-199 Shipping, U.S. Coastguard and D.O.T. 173.303 - 179.125

OSHA 29 CFR - Part 1917 Marine Terminal Standards

OSHA 29 CFR - Part 1918 Longshoring Standards

ISO-[illegible] Lifting Equipment and Cranes
ISO-[illegible] Lifting Chains/Hooks
ISO-[illegible] Wire Rope
ISO-[illegible] Material Handling
ISO-[illegible] Industrial Trucks

Note: EM 385-1-1 U.S. Army Corps of Engineers General Safety Requirements

Table #328 - ANSI and OSHA Standards

SECTION THREE QUESTIONS

Pre-Lift Planning

1. Determine if this statement is true or false. All lift plans are complex and require an engineering staff and a site drawing.
   ❑ true ❑ false

2. Determine if this statement is true or false. A documented pre-lift plan will state the names of the engineers and supervisors who have worked to prepare the plan.
   ❑ true ❑ false

3. Determine if this statement is true or false. A documented pre-lift plan will state the names of the operators and the riggers who will rig the load and perform the lift.
   ❑ true ❑ false

4. Determine if this statement is true or false. There are standardized industry rules to specify what is classified as a critical lift.
   ❑ true ❑ false

5. Which of the following would be classed as a critical lift?
   ❑ operating over or near power lines
   ❑ two cranes working in tandem
   ❑ the load is close to the crane's capacities
   ❑ all of the above

6. Determine if this statement is true or false. Any load heavier than 75% of the rated capacity of a crane is a critical lift.
   ❑ true ❑ false

7. Determine if this statement is true or false. A print or drawing of a lift never includes actual measurements or distances as they are usually too hard to calculate until the crane is hooked to the load.
   ❑ true ❑ false

8. Determine if this statement is true or false. A detailed print or drawing of a lift eliminates guesswork.
   ❑ true ❑ false

9. Determine if this statement is true or false. If a crane can sit firmly without the base or outriggers sinking into the ground prior to lifting the load, a soil analysis is never needed.
   ❑ true ❑ false

10. [illegible]

- ❐ true
- ❐ false

11. [illegible]

- ❐ true
- ❐ false

12. Which of the following is the most satisfactory method of signaling in a multi-crane lift?

- ❐ one person using hand signals for both cranes
- ❐ one person using hand signals for each crane
- ❐ one person using radio communication

13. As the pre-lift items that must be investigated [illegible] planning [illegible] completed, the results are entered and filed in [illegible]

- ❐ crane log books
- ❐ crane maintenance manuals
- ❐ [illegible] memos
- ❐ check lists

14. [illegible]

- ❐ 33 ft.
- ❐ 30 ft. 1 in.
- ❐ 28 ft. 5 in.
- ❐ 16 ft. 11 in.

15. [illegible]

- ❐ 45 degrees
- ❐ 90 degrees
- ❐ 180 degrees
- ❐ 270 degrees

16. [illegible]

- ❐ true
- ❐ false

17. [illegible]

- ❐ true
- ❐ false

18. [illegible]

- ❐ swing clockwise and boom down
- ❐ swing clockwise and boom up
- ❐ swing counterclockwise and boom down
- ❐ swing counterclockwise and boom up

19. Determine if this statement is true or false. In Illustration #174, the crane boom is reeved using all of the sheaves.

- ❒ true
- ❒ false

20. Determine if this statement is true or false. In Illustration #174, all four slings and shackles will have an equal load stress.

- ❒ true
- ❒ false

21. Determine if this statement is true or false. In Illustration #175, the counterweight is attached prior to lifting the module.

- ❒ true
- ❒ false

22. In Illustration #175, how many shackles are attached to the main load block?

- ❒ one
- ❒ two
- ❒ three
- ❒ fourteen

23. In Illustration #175, what size shackle supports the snatch block?

- ❒ 25 ton
- ❒ 35 ton
- ❒ 65 ton
- ❒ 110 ton

24. Determine if this statement is true or false. In Illustration #175, two cranes are used to lift the load off the ground.

- ❒ true
- ❒ false

25. In Illustration #175, how many 110 ton shackles are used on the main crane lift?

- ❒ one
- ❒ two
- ❒ four
- ❒ five

26. In Illustration #175, after the main crane booms up to 82 degrees, how many times does the load radius change?

- ❒ none
- ❒ one
- ❒ two
- ❒ three

SECTION FOUR

MOBILE CRANES

Crane Signals

Company owners, contractors, unions, and regulatory bodies are deeming it necessary that the person performing hand signals or voice communication understands exactly what he/she is doing during all aspects of a lift. Within the next several years, it is very likely that some type of signal training and/or testing will be required in every type of industry. The revised ANSI B30.5 standard, effective in 2005, requires the signal person to be tested prior to crane signaling. Merely attending a training session will not suffice, as testing will be required. The person must demonstrate a basic understanding of crane operation, movements and limitations, and an understanding of the standard hand signals and/or the standard voice signals with their elements (see Section Two).

- The person performing the signals must be positioned where the load can be plainly seen, and is in clear sight of the crane operator.
- Some organizations require audio communication anytime the load is out of sight of the operator, or the signal person is over 100 feet from the operator.
- The crane operator must only respond to the signals from the designated person other than a stop signal from any crew member.
- The operator and the person performing the signals must agree prior to the lift on any necessary signals that are not included among the standard hand signals (shown in Illustrations #177 & #178).

CONTROL OF PLATFORMS OR SKIPS	
One bell or light	to STOP
Two bells or lights	to RAISE
Three bells or lights	to LOWER
Four bells or lights	ALL CLEAR

HORN SIGNALS FOR TRAVELING AND MOBILE CRANES and as a warning for travel direction for Crawler Machines	
One blast	STOP
Two blasts	FORWARD
Three blasts	REVERSE

Illustration #177 – Bell, Light and Horn Signals

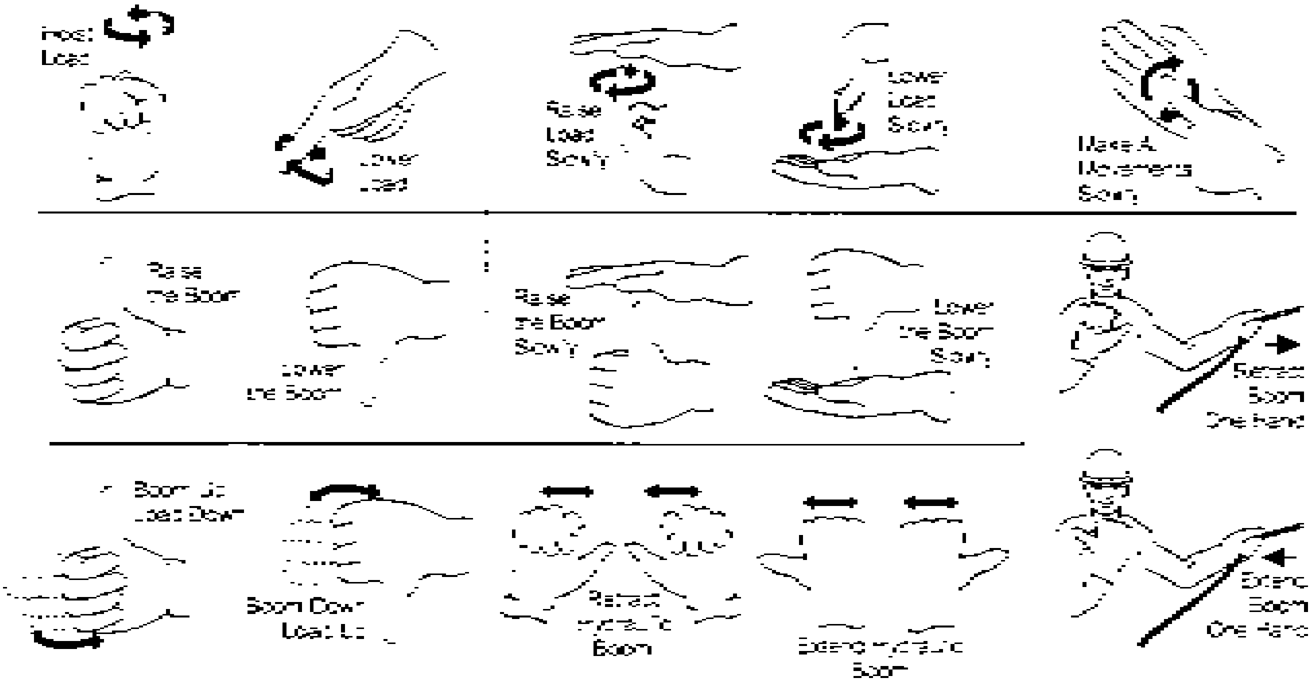
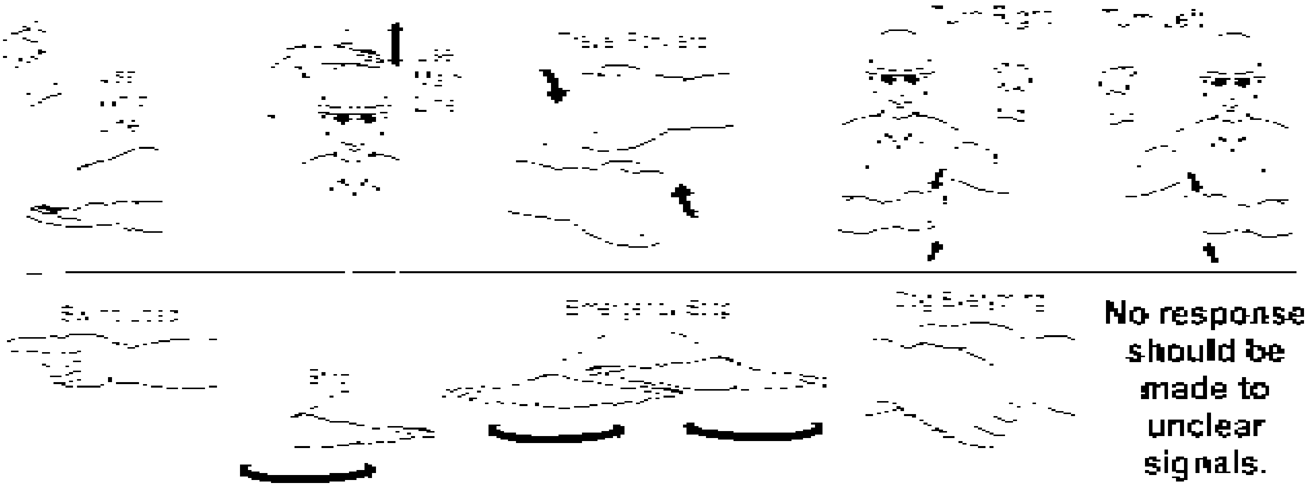
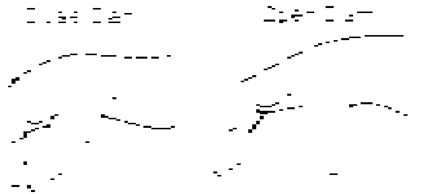


Illustration #176A – Typical Hand Signals

Crane Signals





INSTRUCTIONS TO SIGNALPERSONS

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]

Illustration #[illegible] —Typical Hand Signals

Crane Operational Aids

ANSI standard B30.5 was revised in 2002 to recognize the new category of "operational aid" for mobile crane equipment. An operational aid is a crane accessory that is not essential for the normal movements of booming, swinging, and the lifting operation. However an operational aid will provide information to the operator concerning the operation process. Depending on the device, it may take control of a particular function of the operation when it senses the crane has reached a certain preset limit and may not safely go beyond that limit.

Operational aids include: boom angle indicator, boom hoist shut-off, anti-two block system, load indicator, rated capacity indicator (load moment indicator), and rated capacity limiter. An indicator is a passive device that monitors the specific crane movements and warns the operator about an overload or unsafe condition.

A limiter is a device that also monitors the movements, will warn the operator about an approaching unsafe condition, but will also prevent the crane from any movement that will overload it.

The B30.5 standard requires any crane with a rated capacity of 3 tons or more to have a "load indicator, rated capacity indicator, or rated capacity (load) limiter. An older crane does not require installation of the new operational aid until the crane undergoes modification or repair, at which time the operation aids should be installed.

The standard requires the manufacturer of the device to include information regarding the operational parameters (does it only double-check the operators judgement and warn of an approaching unsafe condition, or does the device set its own limits). The standard also requires the manufacturer to provide information to the user about what to do if the device is not working properly.

Note: See pages 381 and 382 for an example.

Note: Operational Aids must be checked daily for proper functioning, and must be regularly inspected and tested in accordance with the manufacturers requirements.

Note: In the event that the device readings do not match the machine chart ratings, the chart verified weight ratings and measured radii shall take precedence over the indicator readings.

Note: It is a conflict with the manufacturers guidelines and a violation of the ANSI B30.5 standard to use a load indicator as a method to weigh a load.

Crane Introduction

In general, a crane is described as a piece of equipment that is designed to lift, move, and land a load. There is a very wide selection in the types of lifting equipment.

Some of the considerations before selecting the crane capacity for a specific job include:

- The dimensions and weight of the load.
- The maximum lift radius and lift height of the load.
- The number and type of lifts.

Other considerations for the carrier will include:

- How mobile the crane must be.
- Site ground conditions.
- Road conditions.

Crane Identification

All cranes should have identification plates on all removable components. The plate will give the pertinent information concerning that particular crane.

For safety purposes, all components attached to a crane (boom, jib, counterweight, etc.) must be from that particular crane or the identical model.

Crane Types

There are numerous types of cranes that range from smaller capacity mobile units for light industry, up through higher capacity mobile and crawler cranes. Cranes are grouped into several general categories. For each category there are a number of manufacturers with varying types, lift capacities, and boom attachments. Different types of hydraulic gantry lifting devices are also becoming common.

The general crane categories are:

- Telescoping boom rough terrain cranes with a fixed or swing cab
- Telescoping boom carrydeck cranes with a fixed or rotating boom
- Telescoping fixed boom pick and carry crane
- Telescoping boom all terrain crane
- Telescoping boom carrier mounted
- Telescoping boom crawler mounted
- Telescoping boom truck mounted
- Lattice boom carrier mounted
- Lattice boom crawler mounted
- Lattice boom truck mounted tower attachment
- Lattice boom carrier, tower attachment
- Lattice boom carrier mounted with long reach attachment
- Lattice boom crawler mounted with heavy lift attachment

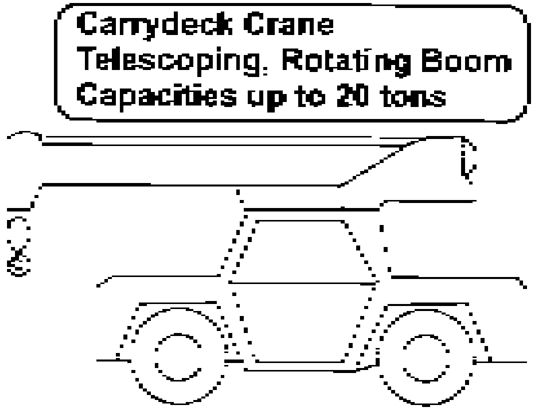
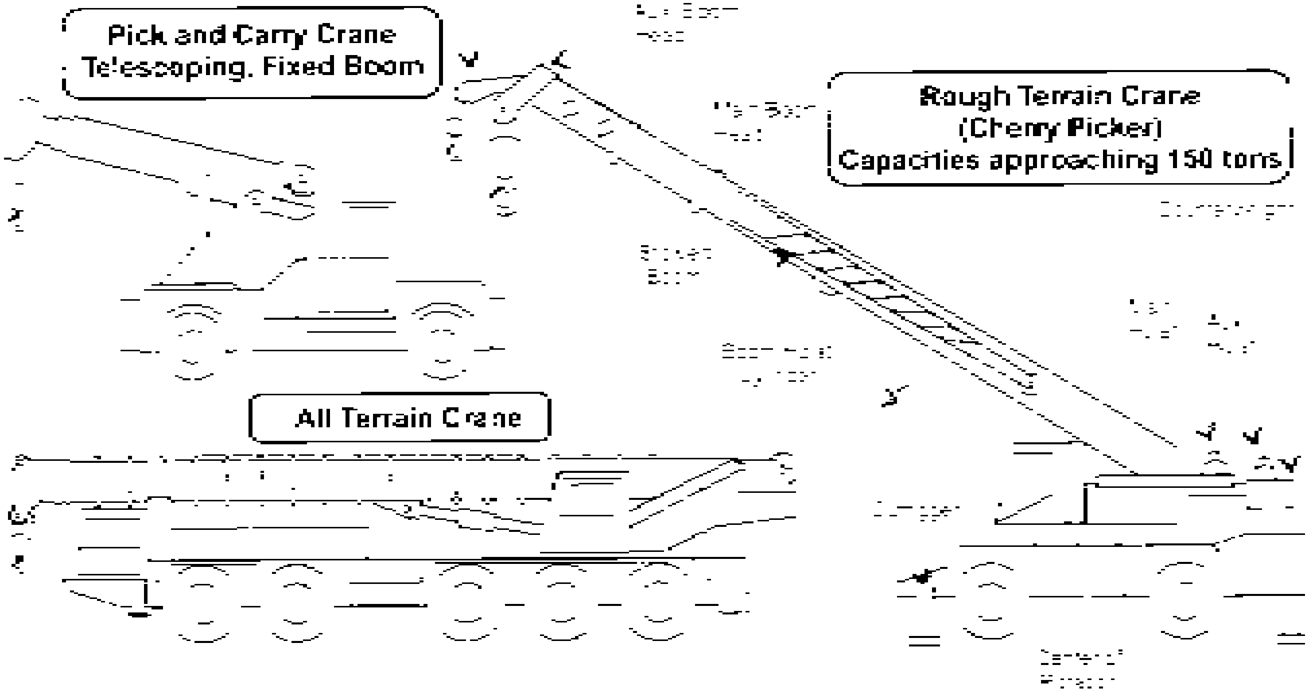
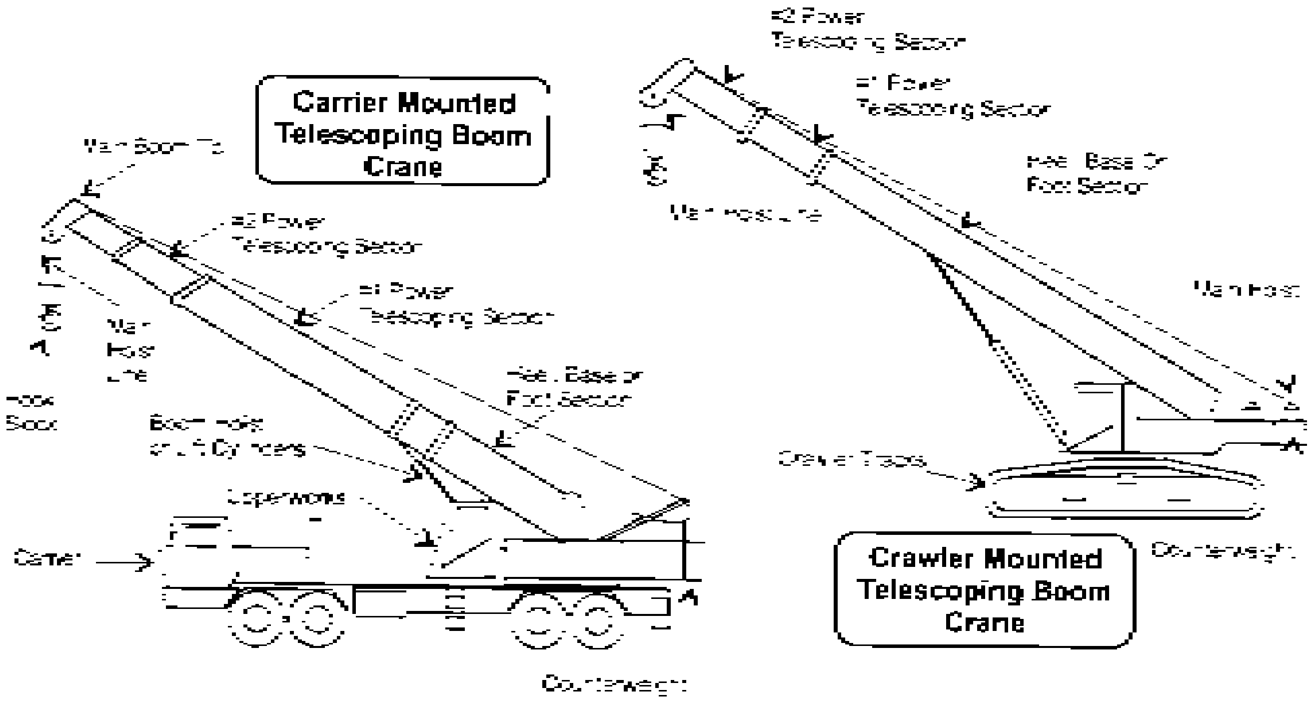


Illustration #175 - Crane Types

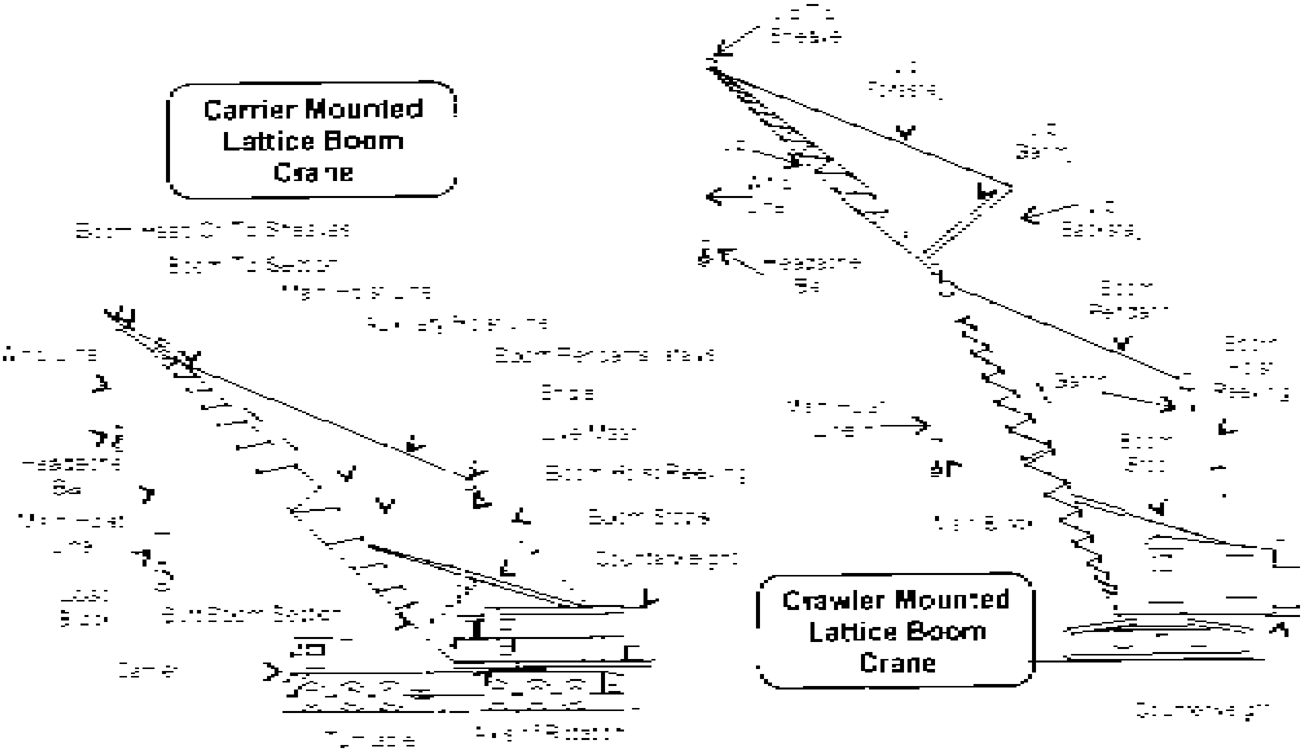


Illustrations #160, 161, 162 - Crane Types

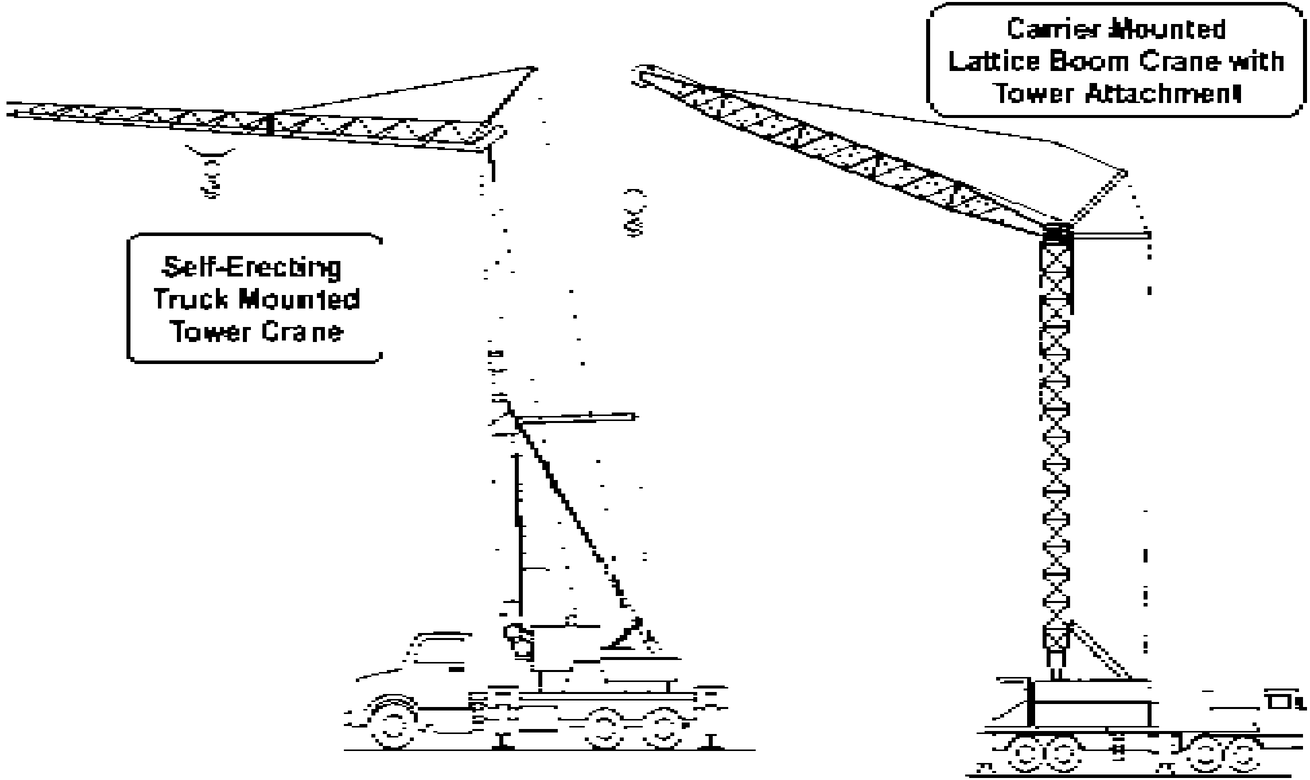


Illustrations #183, 184 – Crane Types

Crane Types

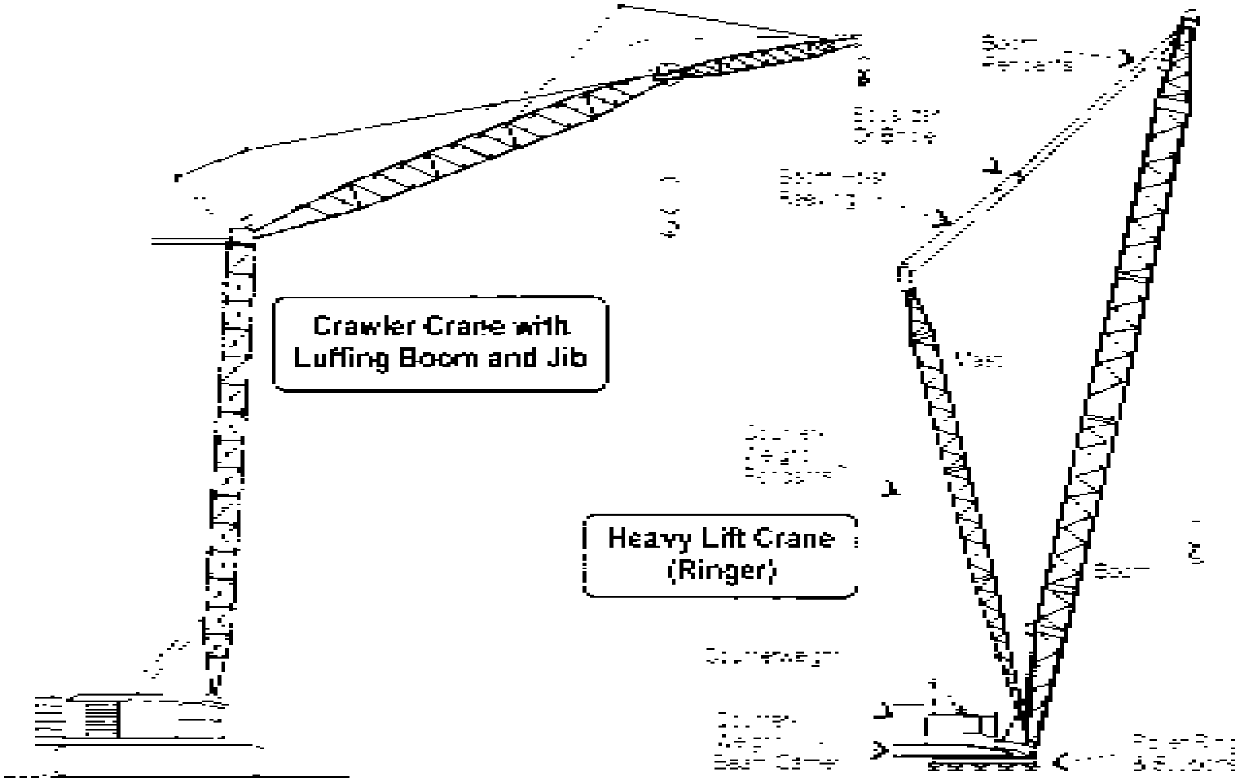


Illustrations #[illegible] – Crane Types

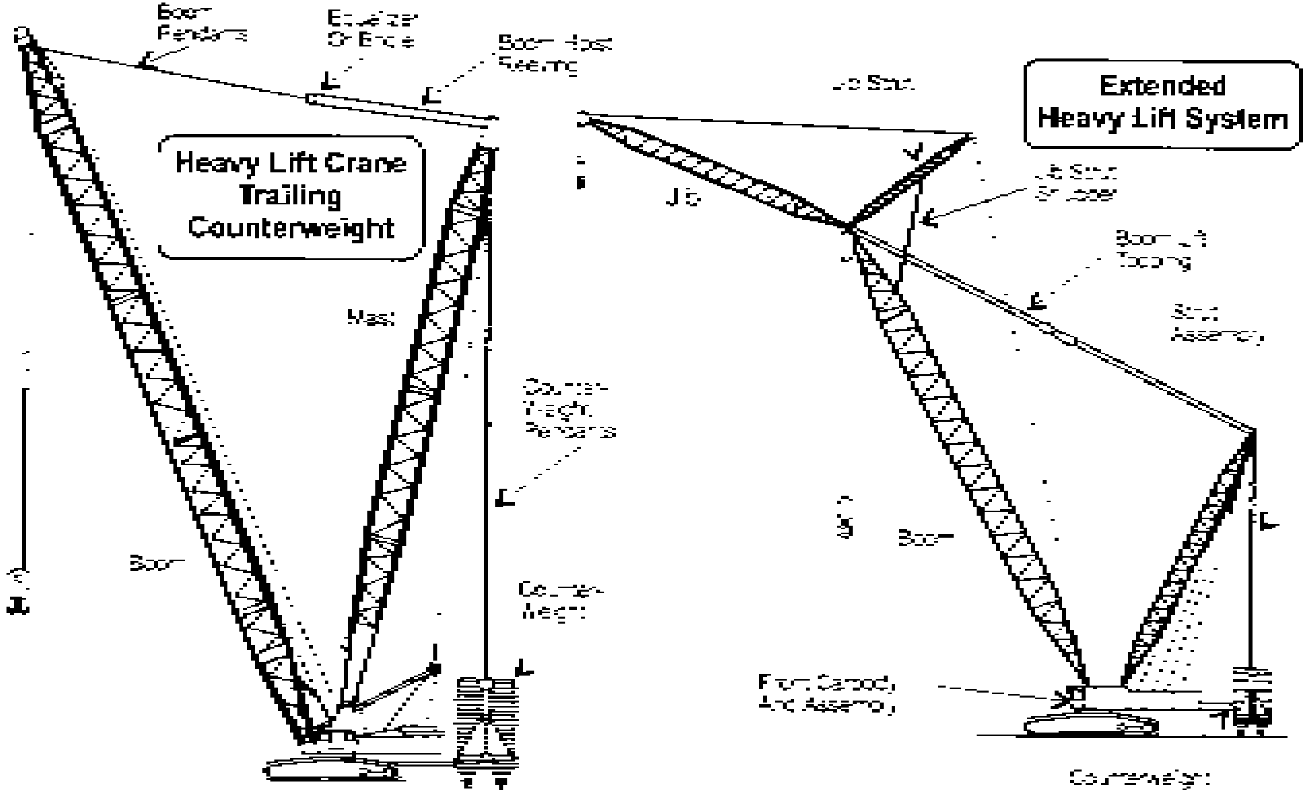


Illustrations #187, 188 – Crane Types

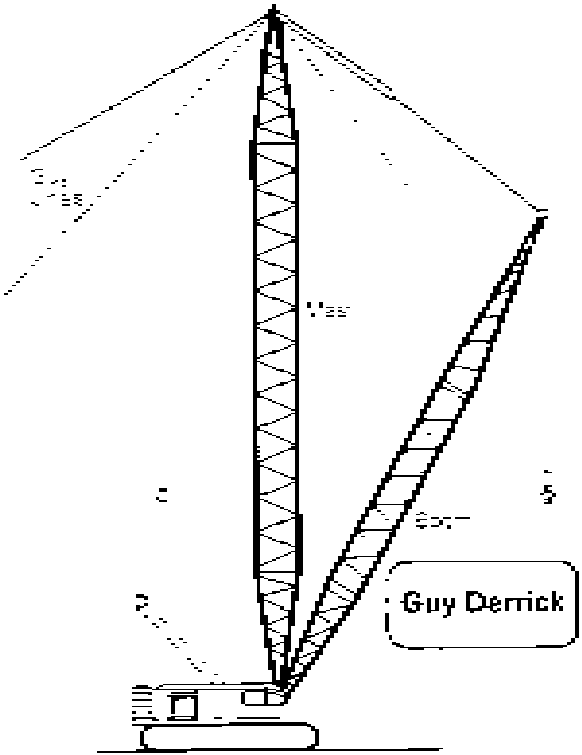
Crane Types



Illustrations #189, 190 – Crane Types



Illustrations #151, 152 – Crane Types



Illustrations #194- Guy Derrick

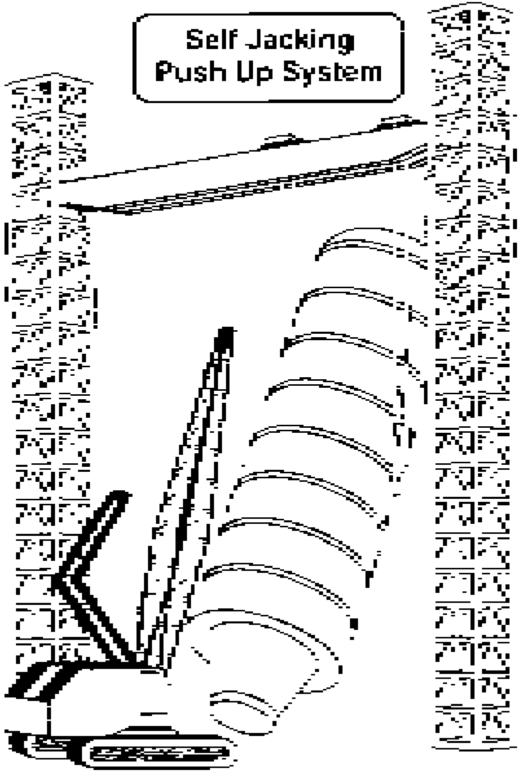
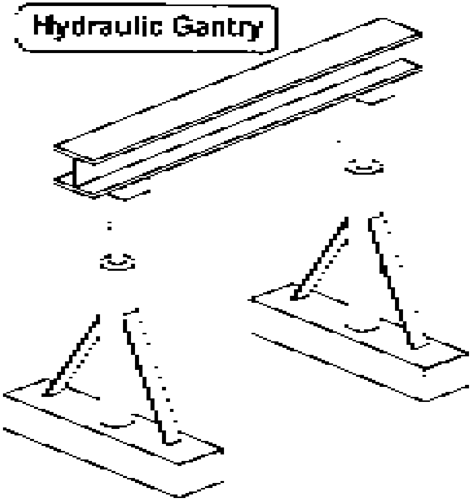


Illustration #195 - Jacking Hoist System



Note: This method under ANSI/ASME B30.1 Jacks.

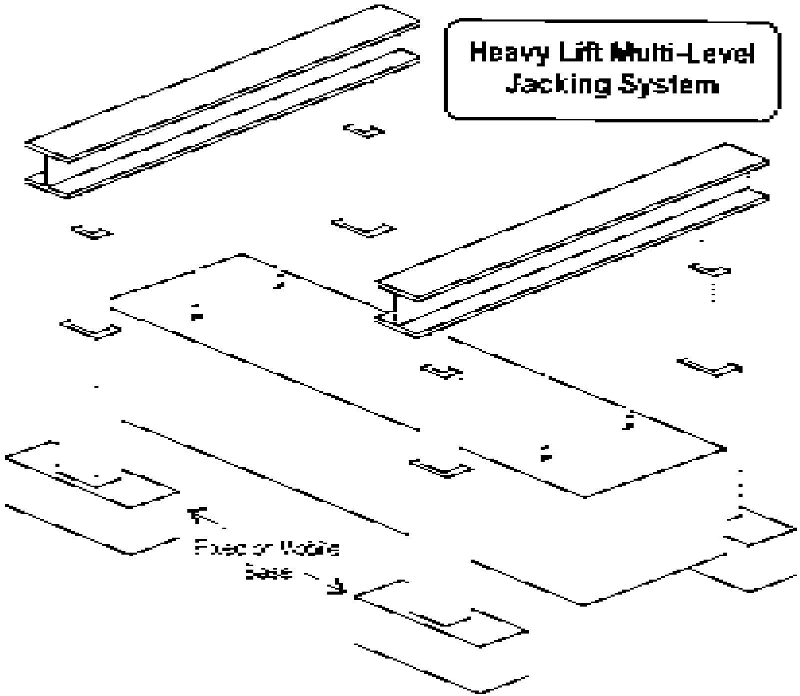


Illustration #195 - Hydraulic Gantry Jacking System

Site Preparation

Prior to any crane set-up or crane hoisting, the site location where the crane will be set-up and/or operating must be properly prepared. The project engineer, rigging superintendent or foreman (or in some cases the operator) will arrange the preparation of a new site or ensure that an existing site is satisfactory.

Site preparation items include:

1. Satisfactory access roads.
2. If necessary, sufficient room to erect the crane and boom.
3. Level and compacted ground for set-up, especially the crane hoisting area (a soil analysis might be needed).
4. Operating location must be well clear of any trenches, shoring, buried utility lines, etc. to avoid ground collapse from excessive machine and load weight.
5. Block off public access, and erect barricades around the set-up and lift area.
6. Set-up and lift area must have a minimum 2 feet of 360 degree swing clearance between the crane counterweight and any obstacle.
7. Keep at least the minimum required distance from any powerline, or ensure the line is shut down during operation.
8. Provide blocking to support boom while being assembled (or dismantled).
9. Provide outrigger blocking (or mats or cribbing) for soft ground conditions.
10. If the crane is to operate on a structure, the person responsible must ensure the structure is adequate to support the crane and the load.

Ground Conditions

The ground conditions must be suitable to operate a crane safely. The surface must have enough stability and bearing capacity to support all loads transferred to it by the crane. This includes the dead weight of the machine, the load, the rigging, plus any shock or impact loads and dynamic conditions such as swinging, hoisting, lowering and traveling.

Use extreme caution when hoisting beside buildings (particularly newly constructed) with uncompacted backfill, along trenches which could collapse, or in areas where water mains, sewer pipes, or steam lines may possibly undermine the soil. See illustration #196.

Note: Compacted soil is not as solid as undisturbed soil.

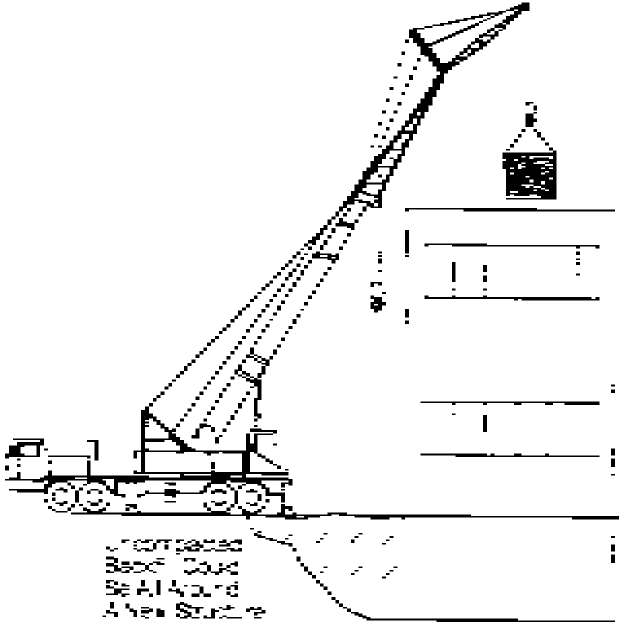


Illustration #196 - Uncompacted Soil

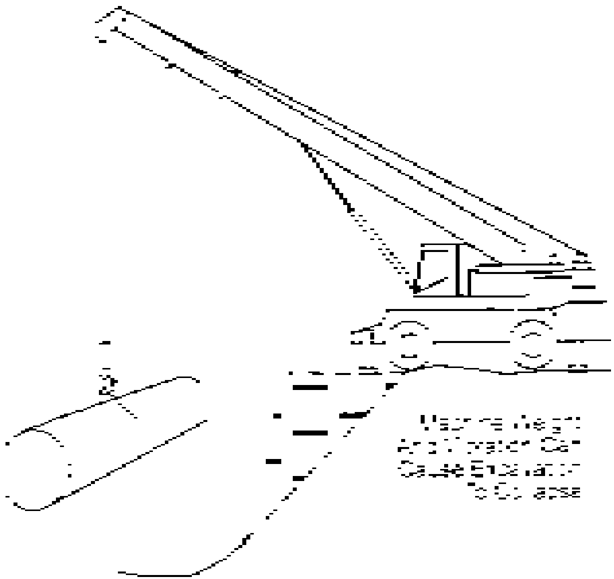


Illustration #197 - Stay Away From Trenches

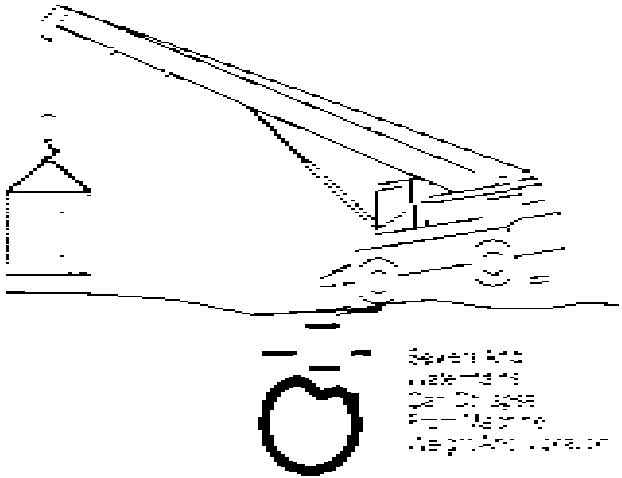


Illustration #198 - Try To Avoid Sewers and Watermains

Bearing Surface

When a crane sits on its bearing surface it exerts varying pressures depending on the operating conditions and area of operation (quadrant).

The lowest pressure on the ground is simply the total weight of the machine distributed over the entire area of both tracks or all outrigger pads.

Illustration #199 indicates the distribution of ground pressure when a crawler crane is used in different quadrants. The greater the density of dots, the greater the pressure. Illustration #200 shows a mobile crane and the weight distribution under its outriggers.

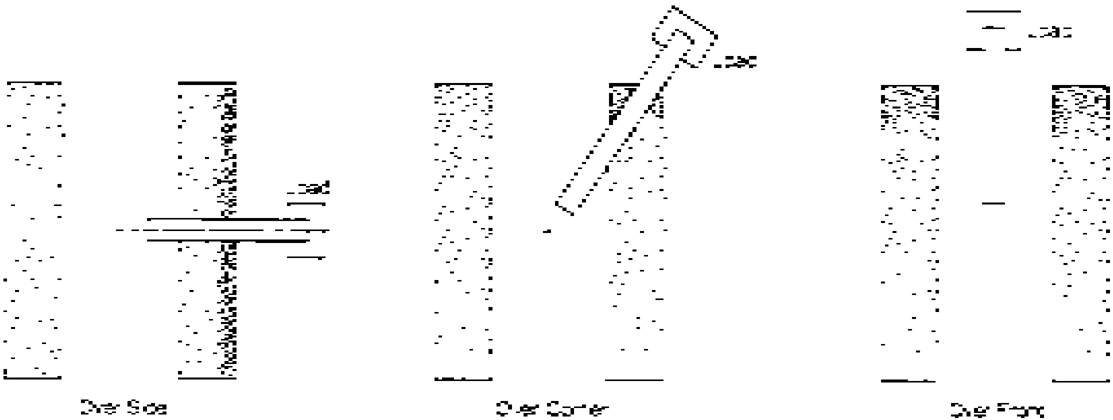


Illustration #199 - Crane to Ground Pressure Points (Crawlers)

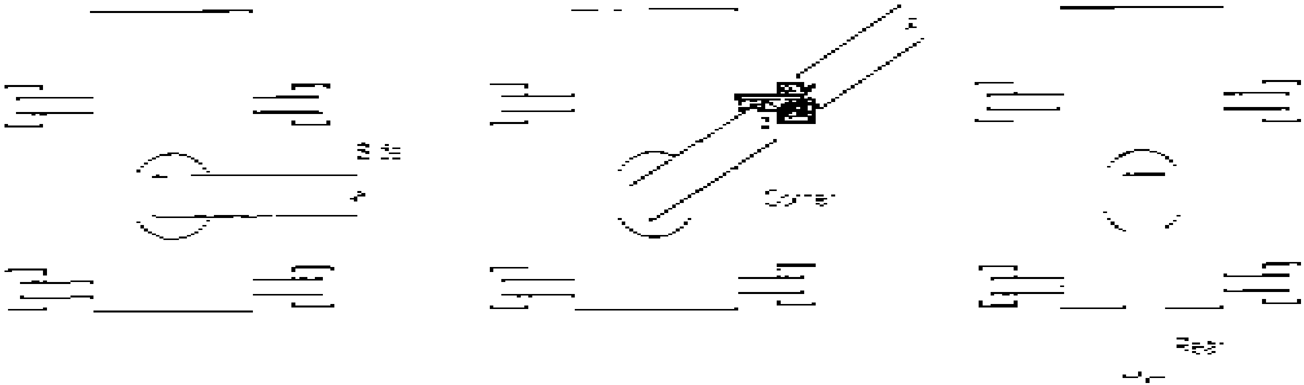


Illustration #238 - Crane to Ground Pressure Points (Outriggers)

Lifting a load over the corner produces the maximum ground bearing pressure. This is the most dangerous position to make a lift. Take into account any dynamic or impact loads. Rapid swinging of the machine or suddenly stopping the load will greatly increase the ground pressure.

The ground pressure on a truck crane can be higher than a crawler crane due to the smaller total bearing surface area of the pads. For this reason always make sure the ground under the outrigger is firm enough to support the machine in a fully loaded condition.

Outrigger Blocking

Any blocking under the outrigger float should be at least three times larger in area than the float. It should be rigid and completely support the total area. See illustration #201.

See illustrations #201 and #202 for examples of incorrect blocking.

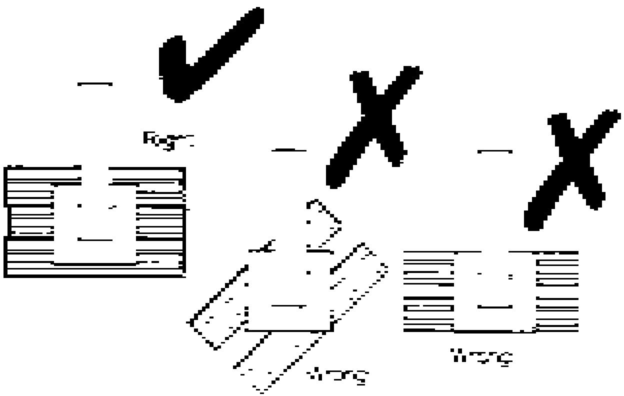


Illustration #201 - Right and Wrong Outrigger Blocking

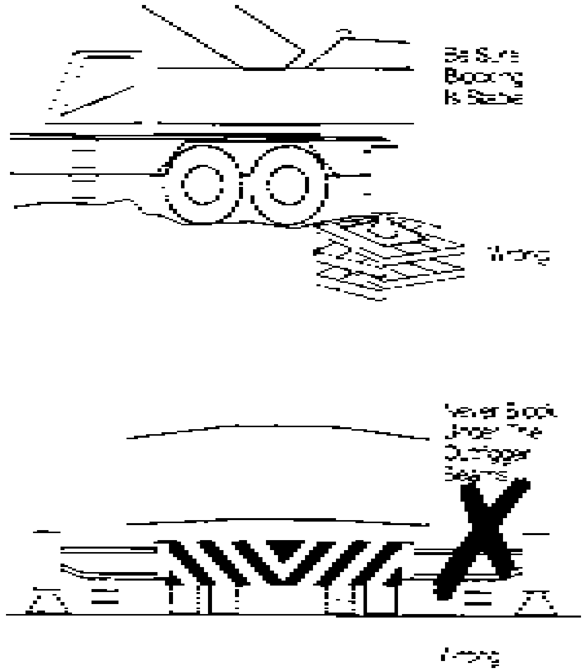


Illustration #202 - Incorrect Blocking

Bearing Mats

The mats can be made of steel or wood, although steel mats offer more rigidity.

Wooden mats should be constructed of Douglas fir or construction grade timber of equal quality.

Wooden mats can be constructed of eight, ten or twelve inch timbers. These are bolted at uniform intervals to any desired width and length. The bolts must go completely through the mat to ensure that the timbers work as a unit. Generally the mats would be five feet wide and sixteen, twenty-four or thirty-two feet long.

The bolts should be counter sunk in the outside timbers to eliminate protruding ends, see illustration #203.

Shackle access openings should be provided near the ends of the mats for ease in handling, see illustration #203.

Illustration #204 indicates the position of the crane on the bearing mats. The timber blocking at the side and ends of the tracks must be secured to the mats.

Note: If there is any doubt about the stability of the ground on your jobsite, consult a soil professional.

Bearing Mat Construction

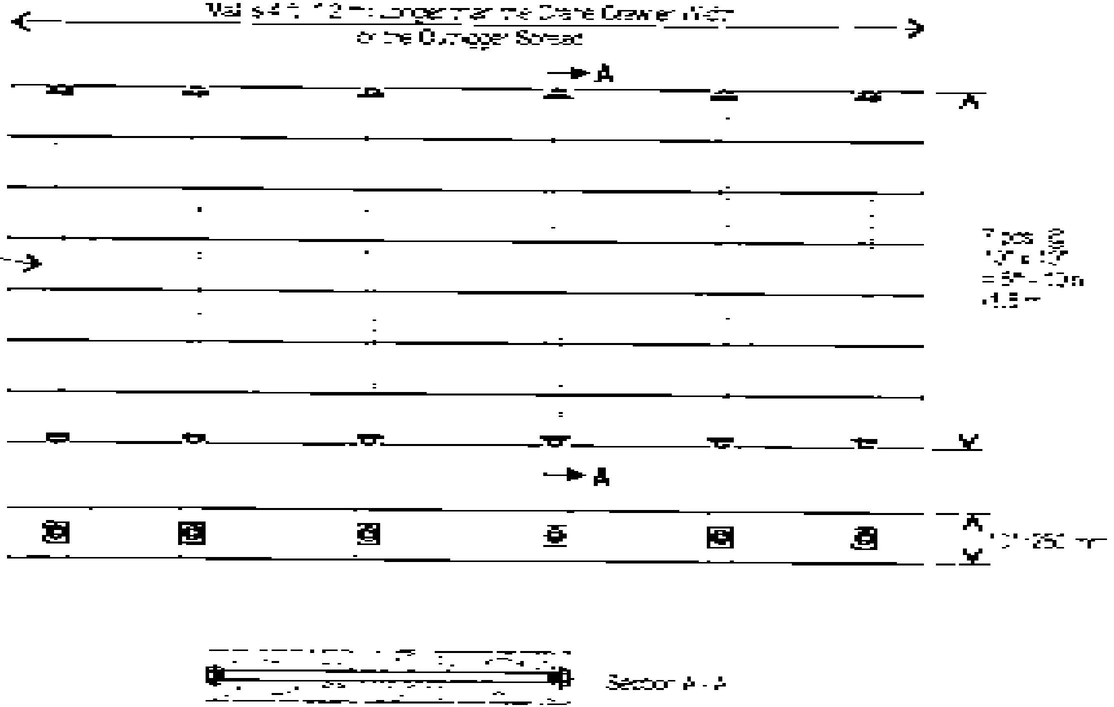


Illustration #203 - Construction of Bearing Mats

Bearing Mats

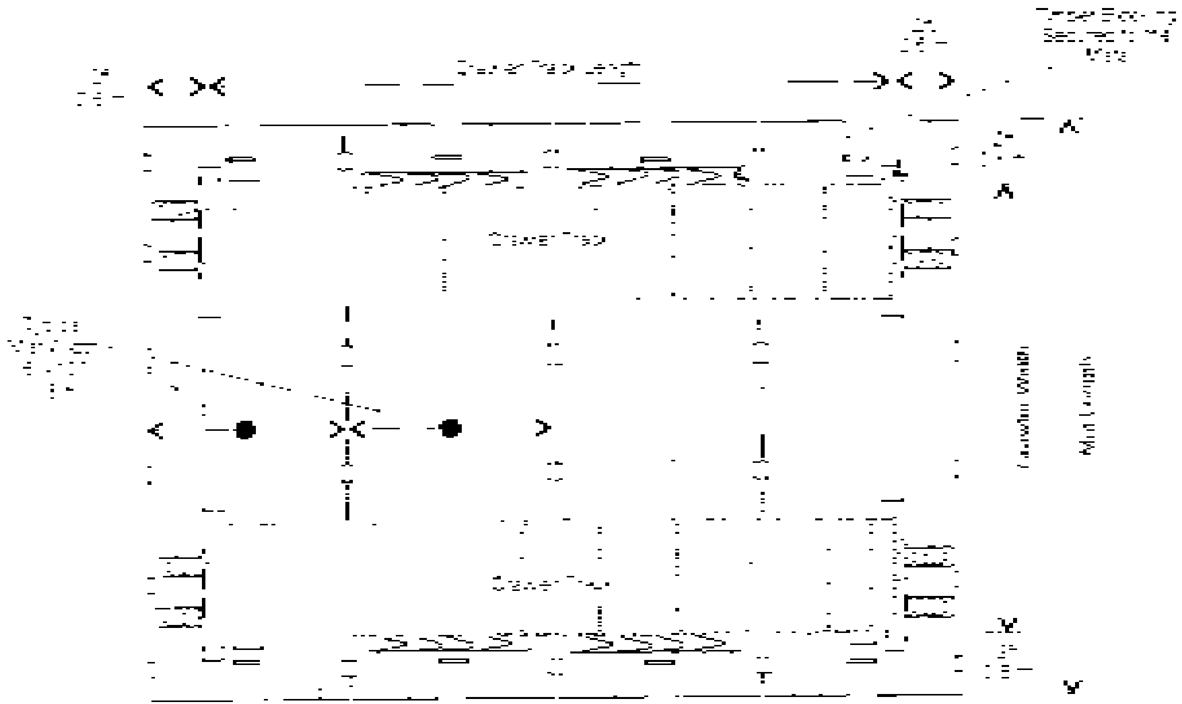


Illustration #204 - Crane Position on a Bearing Mat

Crane Set-up and Assembly

When setting up a crane for use, several steps must be followed:

1. The Operator Manual and the Service Manual for that particular crane must be available for reference.
2. The manufacturers assembly procedure sequence must be followed.
3. All crane components must be in an undamaged condition.
4. The crane logbook for inspection, tests, repairs, etc. must be available.
5. The crane must be inspected prior to use.

Rigging up a Crane

The following instructions for crane assembly apply, in general, to many types of crawler cranes, although there will be some differences with various manufacturers and models.

A second crane must be used to lift the crane house onto the carriage when the crane arrives on site completely broken down.

1. A tri-legged sling assembly made for each crane type is normally used for this lift.
2. Position the house on the carriage and attach as per manufacturer's specifications.
3. Off-load the counterweight, boom sections and load block.
4. Install the outrigger boxes on the carrier mounted cranes before mounting either the boom sections or the counterweight, see illustration #205.

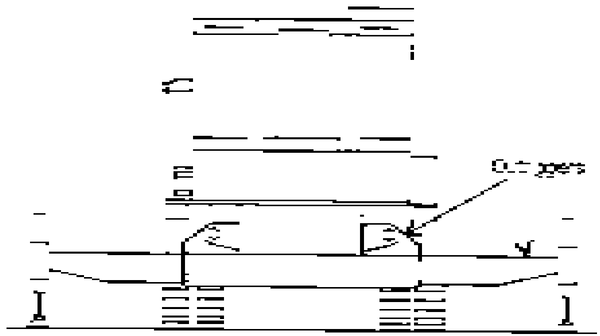


Illustration #205 - Always Use Crane Outriggers

Boom Installation

The same boom installation procedure should be used for both crawler and truck cranes, with the exception that truck cranes must erect booms with all outriggers extended and set.

Lifting Boom Sections

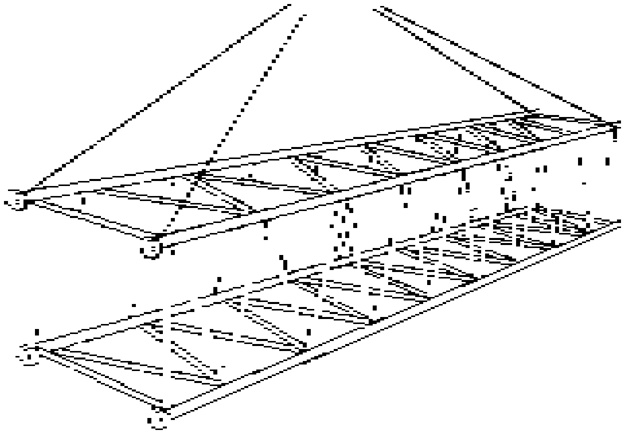


Illustration #206 - Lifting a Boom Section

To avoid boom damage, do not use chain hooks or choked wire rope slings to lift boom sections. Check the manufacturer's manual for the proper rigging procedure. If possible use synthetic slings.

Basic Boom Installation

Pin the boom tail section to the machine. Reeve the bridle between the inner and outer bails and pin the bail to the tail section ears (see illustration #207).

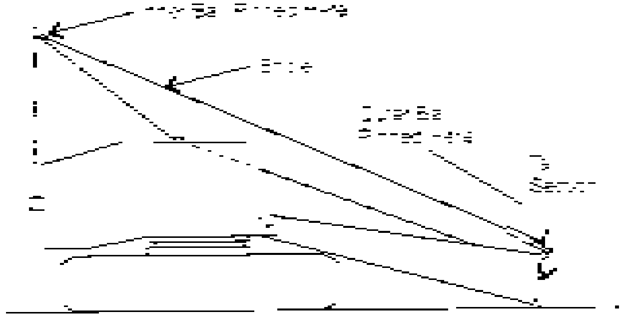


Illustration #207 - Boom Tail Installation

If the counterweight is not on the crane prior to boom installation, connect the boom tip section to the tail section to complete the basic boom. Follow the boom assembly procedure to connect the tip section.

Counterweight Installation

The counterweight is attached to the crane to offset or balance the weight of the boom and the load being lifted.

Note: It should be connected prior to the installation of the complete boom.

A counterweight may be off-loaded from, or loaded onto a railroad car or flatbed truck by its own crane. Cranes can lift their own counterweight (following manufacturers recommendations) if the following requirements are met:

- Firm level ground.
- Gantry must be fully extended.
- Four parts of load line must be reeved on a basic boom.

Set the counterweight on hardwood blocking, as in illustration #208.

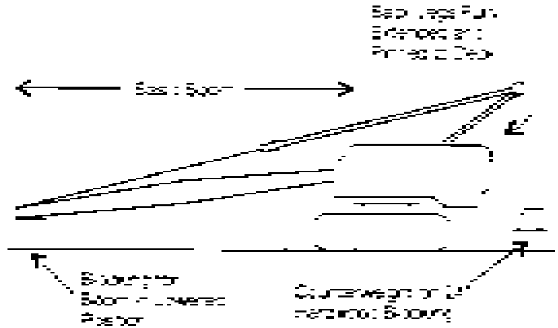


Illustration #208 - Counterweight Blocking

Take the slack out of the boom suspension and backhinges. Slowly lower the boom gantry, (boom down) until the back legs are in position to attach to the counterweight, then pin, see illustration #209.

Illustration #209 - Counterweight Connecting

Boom up until the boom is at approximately 30°, then hook onto the minimum required weight, as indicated in the manufacturer's instructions. #210.

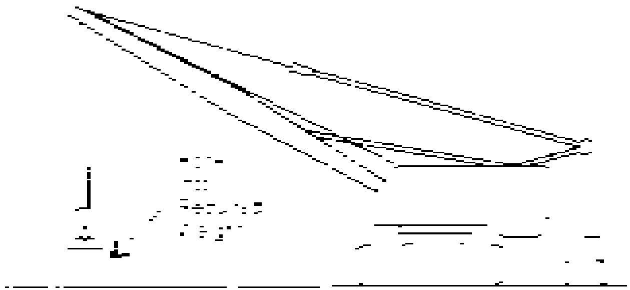


Illustration #210 - Counterweight Lifting

Slowly boom up until the counterweight is in position to be connected to the crane, see illustration #211

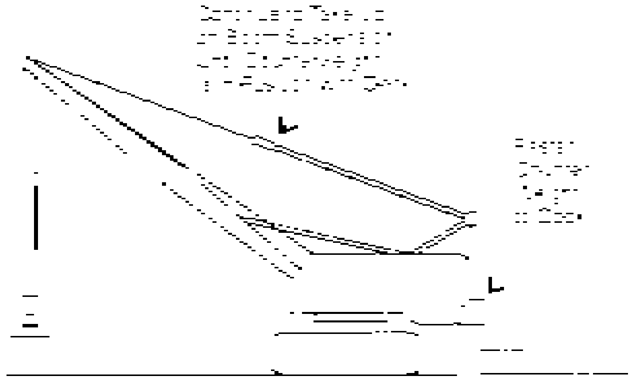


Illustration #211 - Counterweight Connected to Deck

Counterweight Removal

To remove the counterweight, the installation procedure should be followed in reverse order.

Complete Boom Assembly

The remainder of the boom sections can be added after the counterweight installation.

Assemble the boom with the short heavy sections close to the tail.

Keep the pendant lines behind the boom sections being connected.

Assemble the rest of the boom on the ground. Be sure to block up the boom tip to protect the sheave guards.

Lay out the boom sections on blocking, in the order specified by the crane manual, as indicated in Illustration #212.

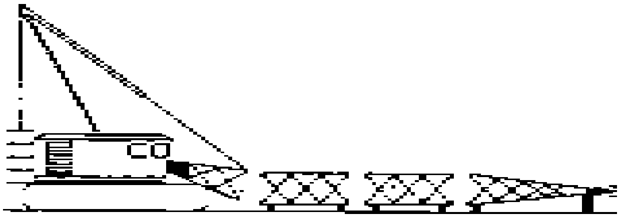


Illustration #212 - Boom Layout

Pull the sections together and line up the upper pin holes. Insert the top pins, using cotter pins as retainers, as in illustration #213.

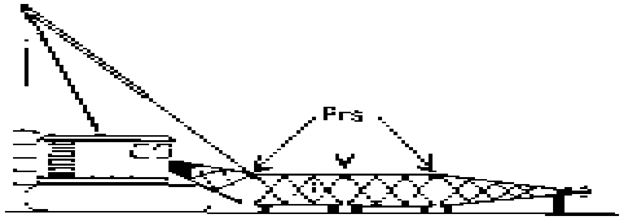


Illustration #213 - Boom Top Pins

Boom up slightly and install the bottom pins when the connection points line up, as indicated in illustration #214.

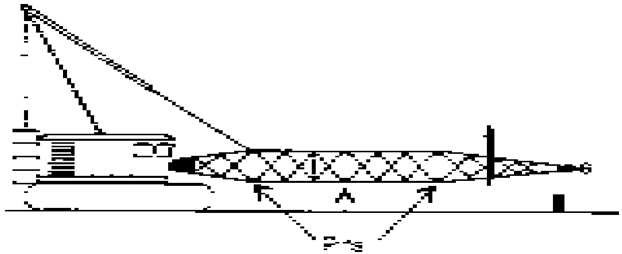


Illustration #214 - Boom Bottom Pins

Boom down onto blocking until the pendants are slack, as indicated in illustration #215.

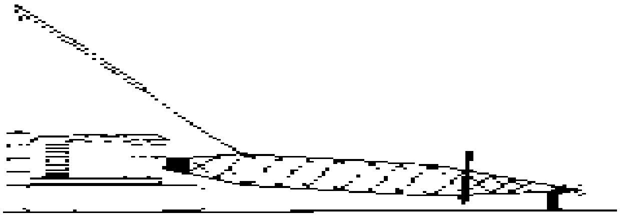


Illustration #215 - Move Pendant Lines

Move the pendants out to the end of the boom, see illustration #216.

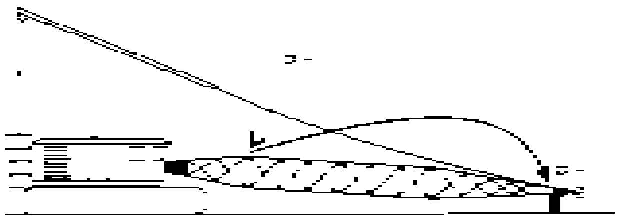


Illustration #216 - Pendant Lines Repositioned

Connect the pendants to the boom tip

***Note:** Pin the pendants from the gantry to the boom section pendants together. The boom pendants must be a matched set to prevent boom twisting, and they should be lashed to the boom sections when dismantling.*

Reeve the load blocks after booming up slightly, see illustration #217.

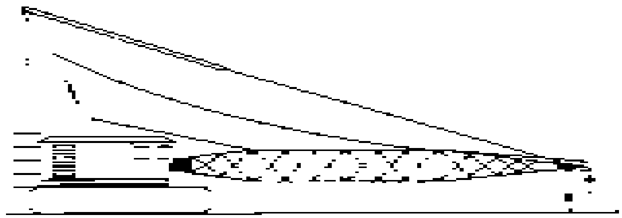


Illustration #217 - Block Reeving

Slowly raise the boom smoothly in one continuous lift. To decrease the weight on the boom, run out the hoist line keeping the block on the ground, as indicated in illustration #218. A second crane is often needed to lift the boom up off the ground.

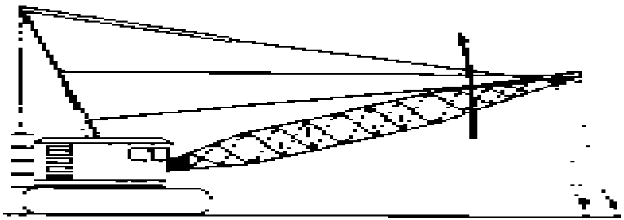


Illustration #218 - Raising the Boom

Boom Pins

All pins should be positioned with the cotter pins on the outside of the boom. The boom sections should go together reasonably easily.

The pins should be installed so they can be removed from the outside. The rigger should never have to climb under the boom to remove any pins, see illustration #219.

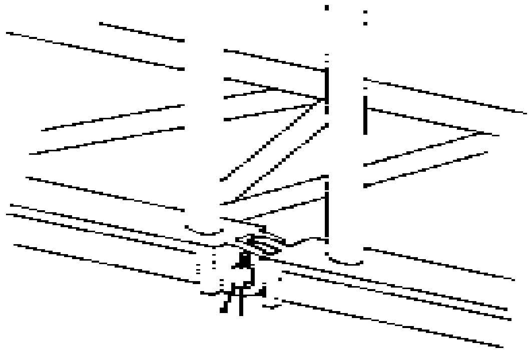


Illustration #219 - Boom Pins on Outside

Note: Some boom types are designed so that the pins are installed from the outside. Avoid pendant line snag. Use extreme caution when dismantling this type of boom.

Dismantling Boom Sections

Lower the boom until it is horizontal with the ground, unreeve and remove the load blocks, see illustration #220.

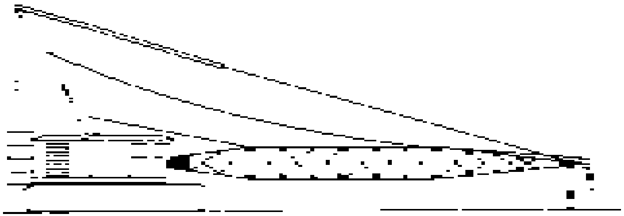


Illustration #220 - Removing the Blocks

Note: An important point to remember in dismantling crane boom sections is to remove the bottom pins first after relocating the pendant lines.

Rest the boom tip on blocking until the pendants are slack. Then move the pendants back no farther than the cantilever length allowed in the crane manual, see illustration #221.

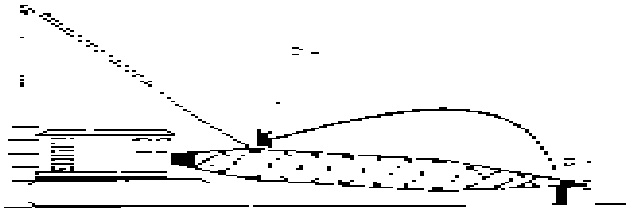


Illustration #221 - Reconnecting Pendant Lines

Boom up slightly and remove all lower pins on the sections ahead of the pendants, see illustration #222

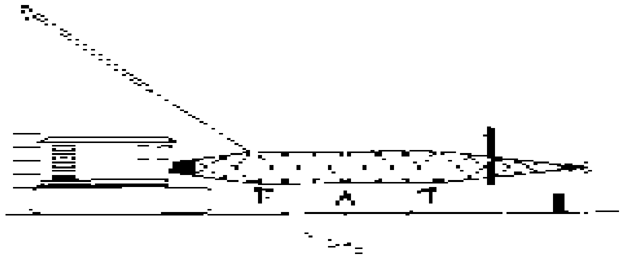


Illustration #222 - Remove Lower Pins

Make sure that every section is supported, then lower onto blocking. Remove the upper pins on the sections ahead of the pendants, as in Illustration #223.

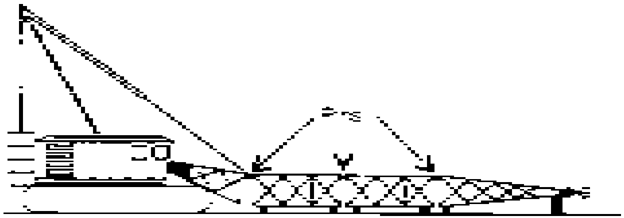


Illustration #223 - Upper Pin Removal

Caution: Do not climb under the boom to remove pins. Use a long bar to knock the pins out if installed with the cotter pins on the inside.

The sections can then be removed and loaded for transport, see illustration #224.

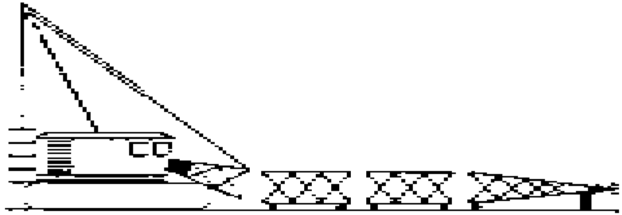


Illustration #224 - Section Separation

***Note:** If crane booms are transported on a trailer, use extreme caution when tying down. Do not pull a tight chain across the boom cords as the tension and movement will dent the chords. Secure the boom to the trailer by using the boom pin attachment points.*

Boom Inspection/Damage

Booms should be thoroughly inspected on a regular basis. See illustration #225 for typical inspection points.

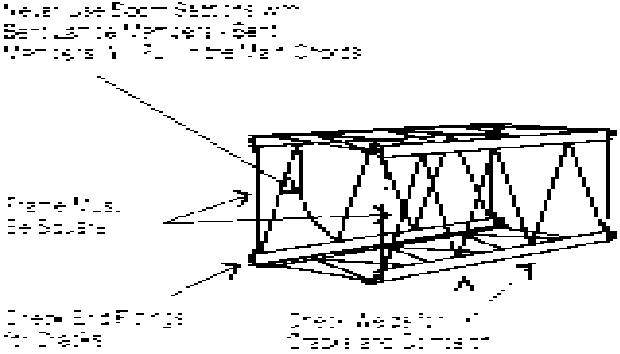


Illustration #225 - Boom Inspection Points

Boom damage can take the form of bent and or dented chords and lacings, or cracks from overloads and metal fatigue. See Illustrations #226, #227.

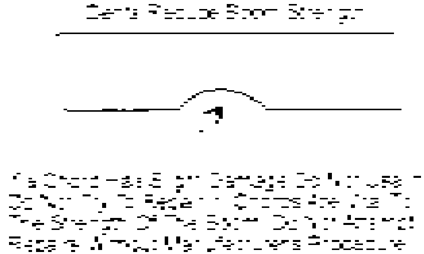


Illustration #226 - Dented Boom

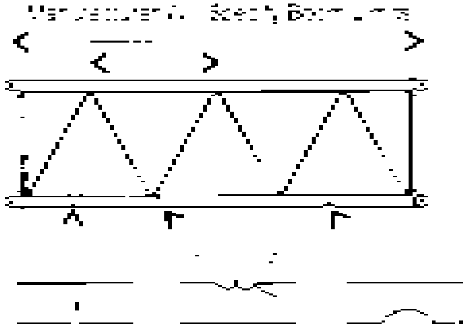


Illustration #227 - Boom Damages

Boom Repair

Use extreme caution when attempting boom repair. Contact the crane manufacturer and follow their procedure.

When removing damaged lacings, cut in a manner which will prevent heat transfer to the chords. See illustration #226.

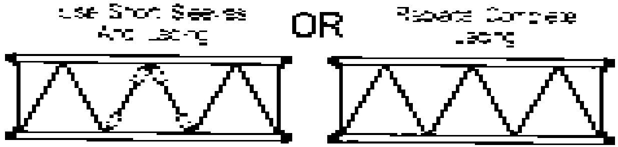


Illustration #229 - Replacing Lacings

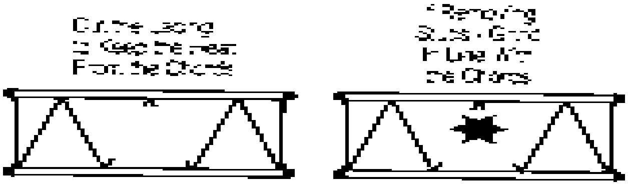


Illustration #228 - Cut Lacings With Care

When welding in a replacement section, follow the manufacturers recommendations on replacement parts, welding rods, heat treatment, and use a welder certified to the proper procedure.

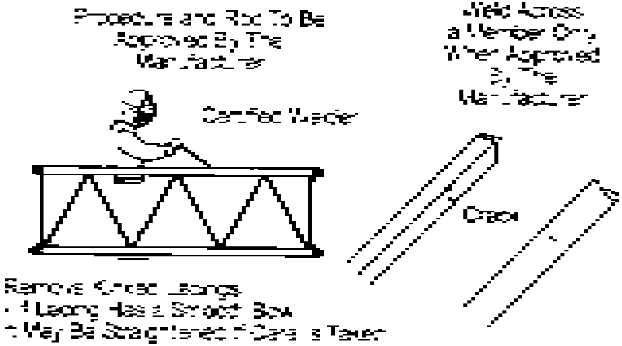


Illustration #230 - Welding Repair

Gantry

The stress is lower on hoisting equipment when the gantry is used in its highest position. This gives longer life and added safety factors for equipment. When the crane is lifting a load the gantry must always be in the highest position, see illustration #231.

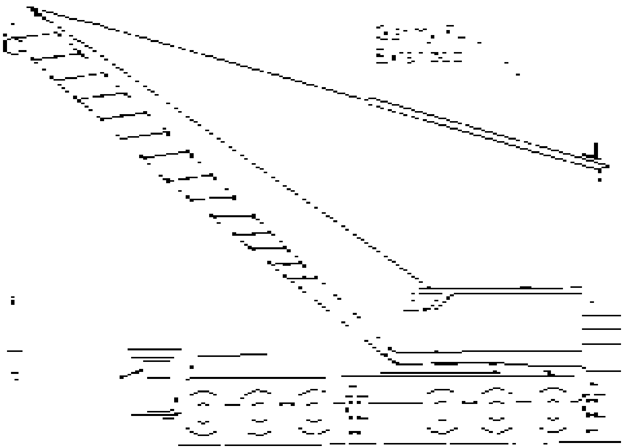


Illustration #231 - Crane Gantry

Jibs

A jib is an auxiliary boom. It may vary in length according to the capacity of the crane and the intended use. The jib can be used as a straight extension to the main boom, or at an angle (offset) to the main boom. A table of maximum safe working loads for the jib at the appropriate offset is always supplied with the crane.

The jib produces a greater clearance between the forward edge of the boom and the jib hook. This is useful in construction for placing loads beyond the outer perimeter of building structures.

The jib or whip line is usually a single line of wire rope, with a maximum capacity up to the cranes rating for a single line.

Jibs/Assembly

If necessary, bolt the jib adaptor to the boom before connecting the jib. An adaptor is usually used only on a hammerhead crane.

Assemble and pin the jib sections together before connecting any part of the jib to the boom. see illustration #232.

Assemble a wrap-around pendant by running it through the jib block sheave and connecting it on each side of the jib pendant adapter. Pin the jib to the boom tip. Attach the backstay lines to the jib mast and raise the mast. The backstay lines may be attached to various positions on the boom.

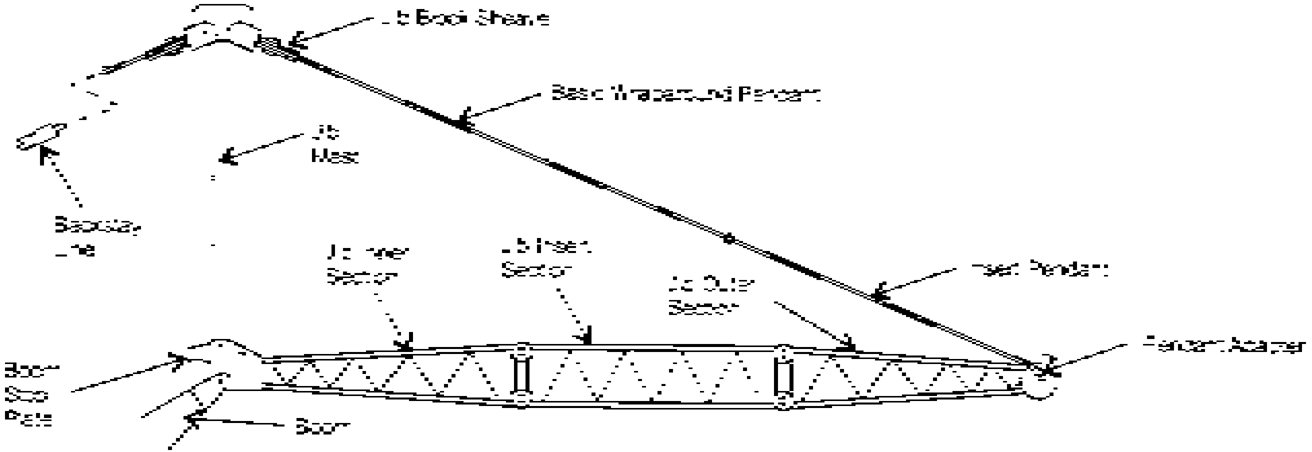


Illustration #232 - Jib Assembly

The distance to the jib backstay line connector from the boom point must be equal to or greater than the length of the jib.

Set the jib offset as allowed by the crane rating sheet. Coil the extra rope and lash it to the boom.

Jib offset is usually allowable to 25° from the centerline of the boom (see illustration #233). Run the load line up the boom through the jib mast sheave and jib tip sheave.

For optimum jib pendant loads, the jib backstay pendants and the jib forestay pendants should be of equal lengths, or the jib backstay pendants should be longer.

When a jib is attached on the boom but is not in use, the working load for the boom must be reduced in accordance with the crane manufacturer's instructions to allow for the weight of the jib and hook.

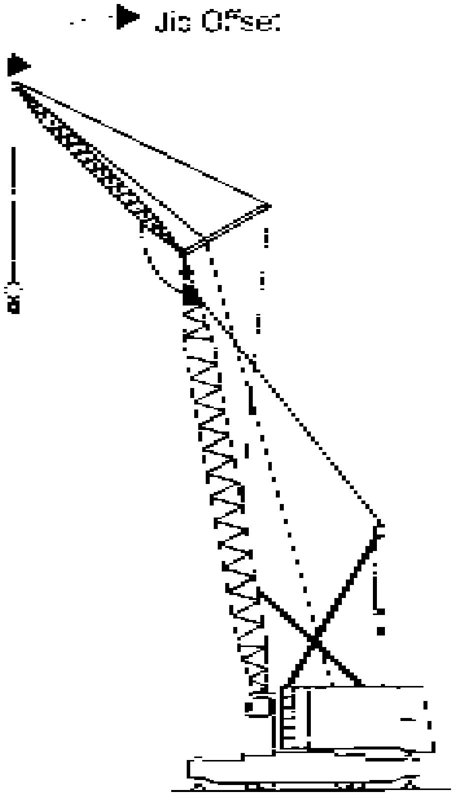


Illustration #233 - Jib Offset

Jibs (stowed and stored)

Jibs that are not being used may be pinned to the base section of the crane boom (stowed). See illustration #234. Another option is to carry the jib on the crane deck (stored).

The weight of a stowed jib will normally have to be considered for calculating crane lifting capacity.

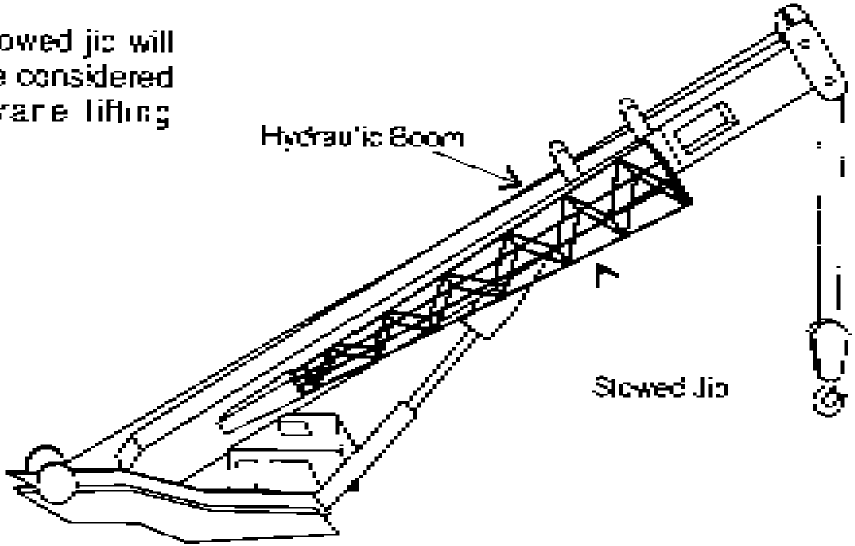


Illustration #234 - Stowed Jib Assembly

Jib Capacity

Do not operate using the boom hoist and jib simultaneously unless the crane has been designed for this movement.

Jib capacity decreases as the horizontal angle lowers. This can be due to a changing boom angle (Illustration #235), or a changing jib offset angle (Illustration #236).

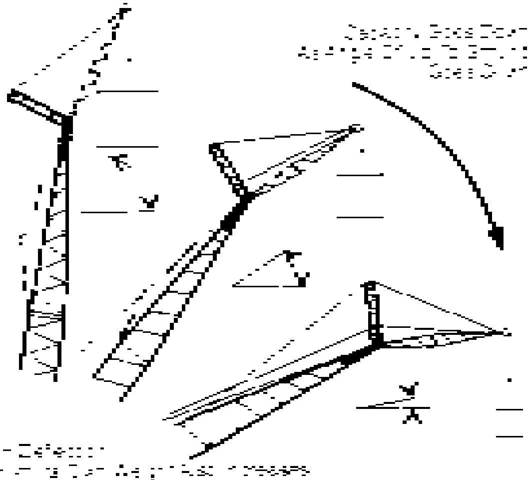


Illustration #235 - Capacity Reduction (Lower Boom Angle)

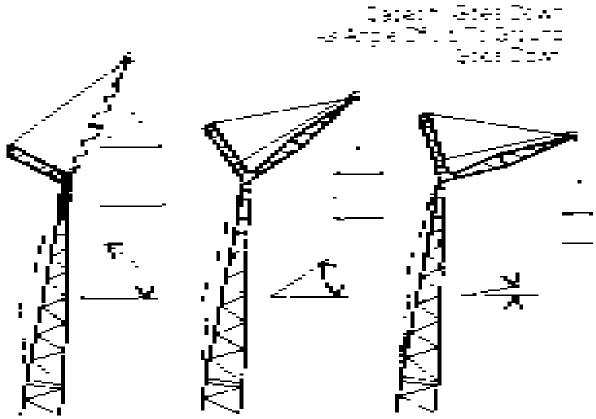


Illustration #236 - Capacity Reduction (Lower Jib Angle)

Note: All jibs shall have positive stops to prevent their movement if more than 5° above the straight line of the jib and boom on conventional type booms. Use of wire rope type belly slings does not constitute compliance with this rule.

Jib as Boom Extension

The jib must not be used as a normal boom extension. The capacity of a boom and jib combination will be considerably less than that of a boom of equal length.

If the jib is used as shown in illustration #238 the capacity chart must be read using the applicable boom length plus the attached jib. The term "boom length" in the load chart does not include the jib.

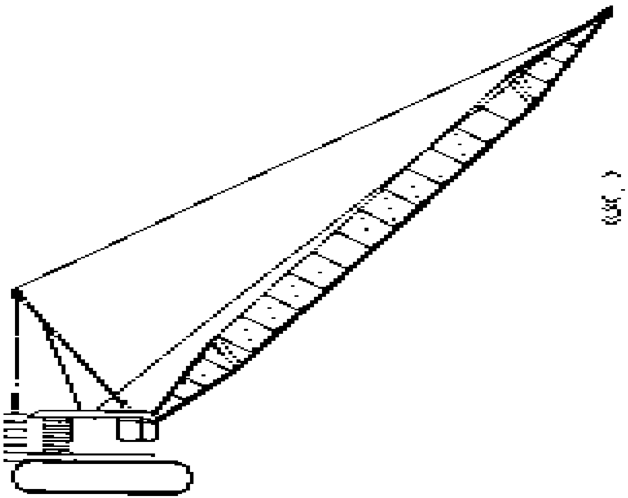


Illustration #237 - Boom Without Jib

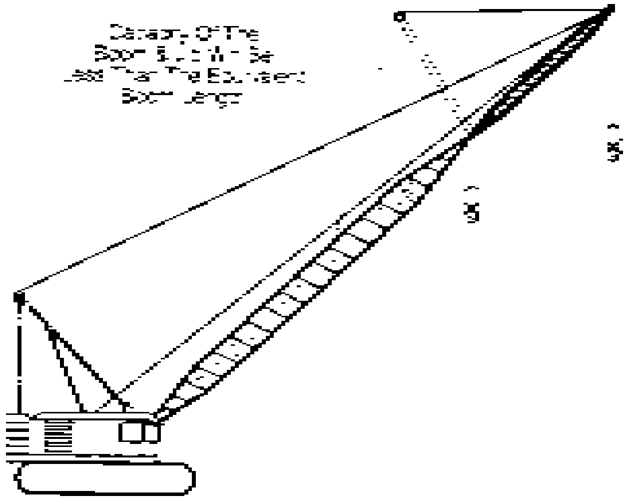


Illustration #238 - Boom and Jib

Crane Wire Rope Safety Factors

The minimum wire rope working load limits (safety factors) for cranes are specified by ANSI B30.5, OSHA 1926.550B2, SAE J959, and CSA Z150. See illustration #239.

Cranes may be designed with higher safety factors by customer request.

***Note:* Slings and other rigging attachments have a 5 to 1 (or higher) working load limit to compensate for general rough usage (see Section One).**

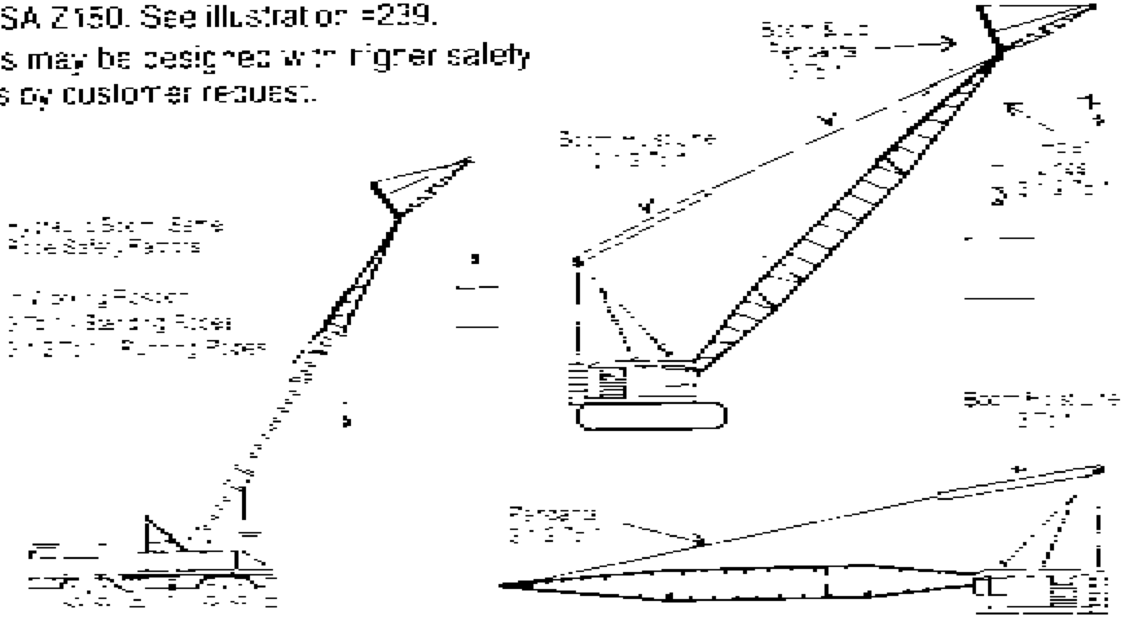


Illustration #239 - Minimum Wire Rope Safety Factors

Reeving Load Blocks

The boom tip sheaves should be symmetrically reeved to avoid torsional loading. This occurs wherever the main hoist line is reeved to one side of the boom tip.

Eccentric Reeving

Examples of eccentric reeving causing boom twisting are shown in illustrations #241 and #242.

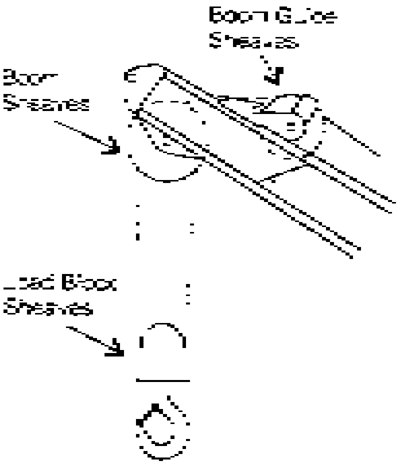


Illustration #240 - Boom Tip Reeving

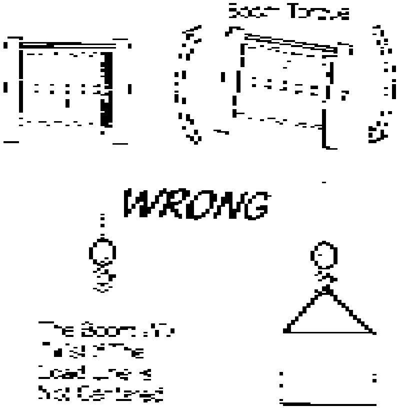


Illustration #241 - Boom Twist

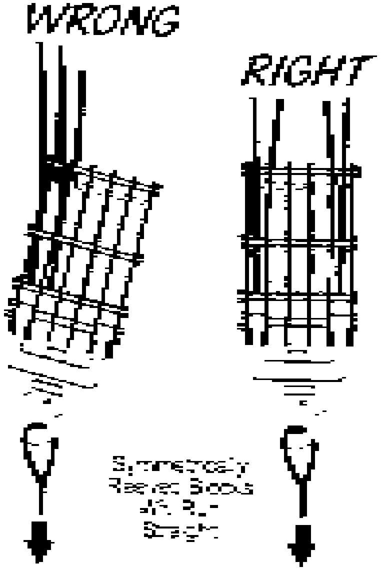


Illustration #242 - Balanced and Unbalanced Block Comparison

Symmetrical Reeving

On single line reeving, the hoist line must run on one of the center sheaves. On a multi-part block the rope must be distributed on each side to share the load. See illustration #243.

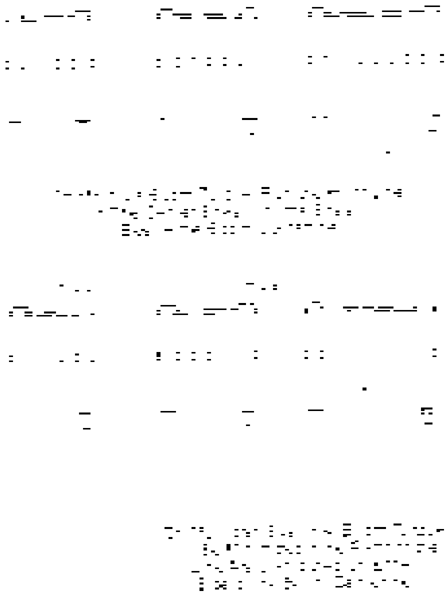


Illustration #243 - Symmetrical Reeving

Reeving Examples

Illustrations #244 - #250 show examples of typical crane block reeving.

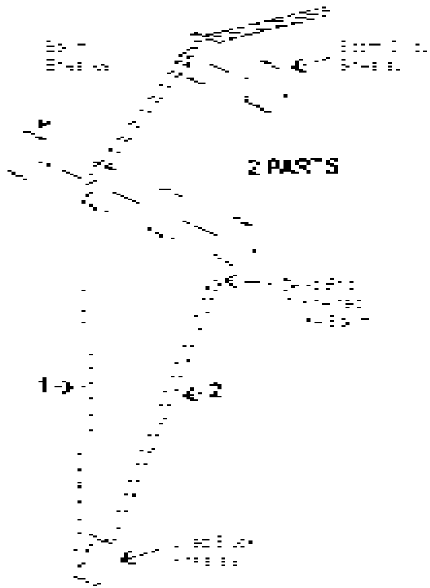


Illustration #244 - Two Part Reeving

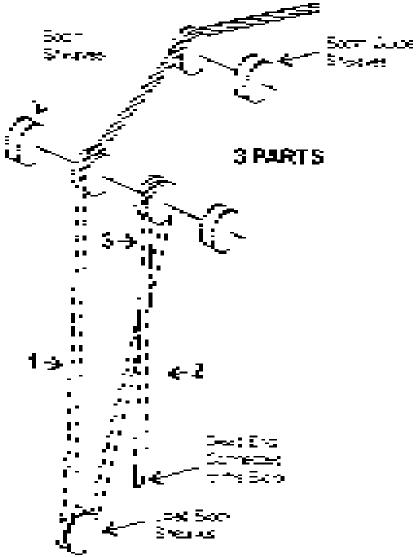


Illustration #245 - Three Part Reeving

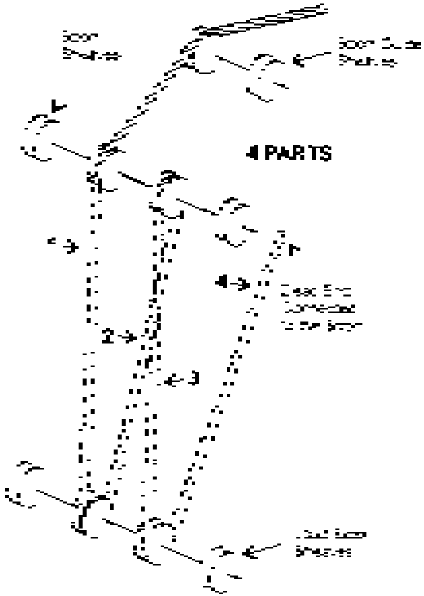


Illustration #246 - Four Part Reeving

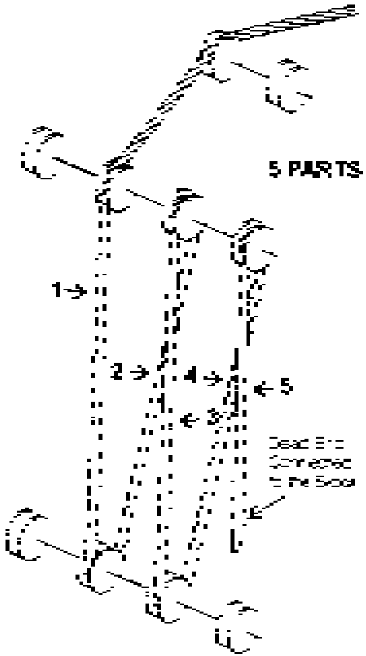


Illustration #247 - Five Part Reeving

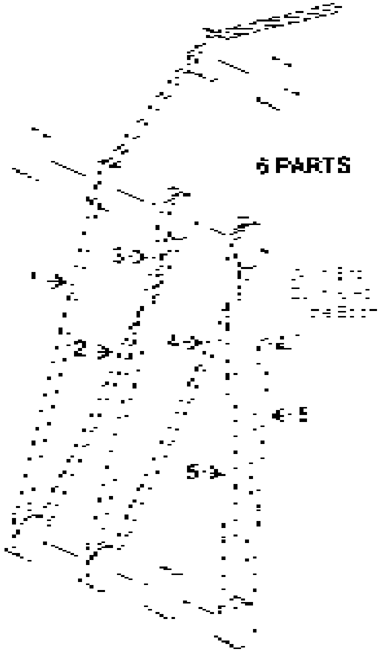


Illustration #248 - Six Part Reeving

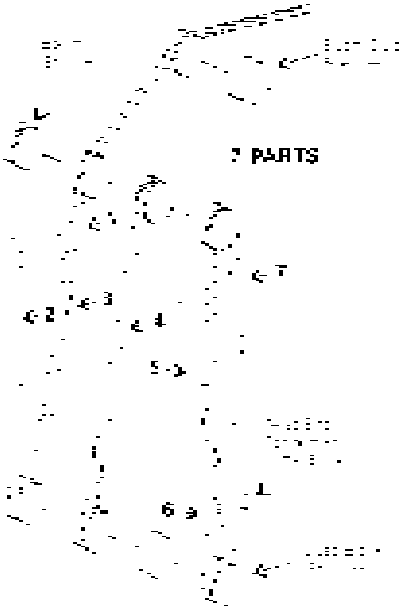


Illustration #249 - Seven Part Reeving

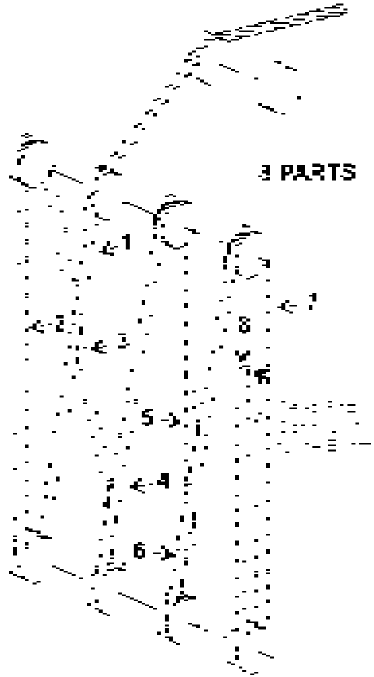


Illustration #250 - Eight Part Reeving

Out-of-Level Cranes

Every crane must be set-up as perfectly level as possible before any hoisting operation begins. Operating a crane off-level can create operating problems, or cause structural damage, either of which can result in an accident.

Most safety standards and regulations indicate a maximum 1% of grade for a crane to operate out-of-level. However every crane manufacturer designs and rates each crane to the company criteria, and some types of cranes must operate within ½% of level to meet the load chart numbers.

Or in other words, a crane must be within 1% of level, unless stated otherwise by the particular crane manufacturer.

ANSI/ASME states the degree of level as a percentage of grade. This means that in a horizontal length of 100 feet (1200 inches), a drop of 1 foot (12 inches) is equal to 1% (see illustration #251).

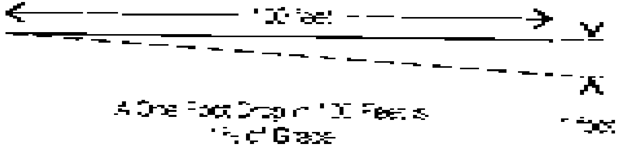


Illustration #251 – 1% of Grade

On a 48 inch crane rotation ring, 1% is equal to .48 inches (less than 1/2 inch), and ½% would be .24 inches (less than ¼ inch) off-level.

A crane that is operating 1% off-level will side-load the boom. The extent of side-loading will depend on the boom length, boom angle and the operating radius. See table #53.

Note: Do not confuse percentage of grade (or slope measurement) with degree measurement. They are not the same. When measuring in degrees, 1% off level on a 48 inch ring would be .573 degrees (slightly over ½ degree).

Boom Length and Radius	Capacity Lost When Crane Out of Level By		
	1°	2°	3°
Short Boom, Minimum Radius	10%	20%	30%
Short Boom, Maximum Radius	8%	15%	20%
Long Boom, Minimum Radius	30%	41%	50%
Long Boom Maximum Radius	5%	10%	15%

Table #50 - Off-Level Lost Capacity

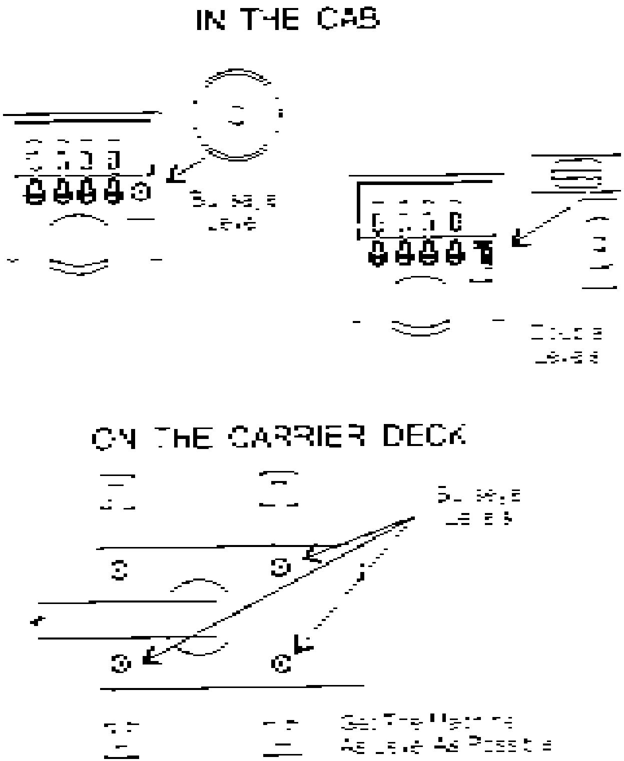


Illustration #252 – Crane Leveling Positions

Crane Leveling

It is impossible to accurately level a crane by eye. Always use a level, preferably a longer carpenters level, or the birds-eye level(s) mounted in the cab or on the deck. See illustration #252 and #253.

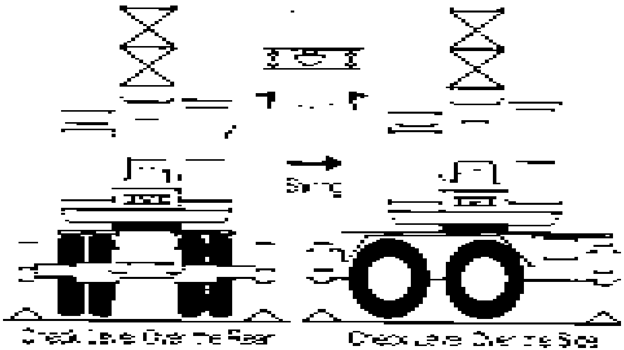


Illustration #253 – Crane Leveling with a Level

When leveling, check the level front-to-back and side-to-side, then rotate the boom 90 degrees and check again. If making a series of lifts, recheck the level of the crane periodically.

After leveling the crane, raise the boom to its highest angle and lower the whip line. With a small compact load in all quadrants (front, side, and corners), the line should lie in the dead center of the boom. With a crane 1% off level, and the boom tip 100 feet high, the whip line would be about 12 inches off-center. See illustration #254.

Do not use this method if it is windy.

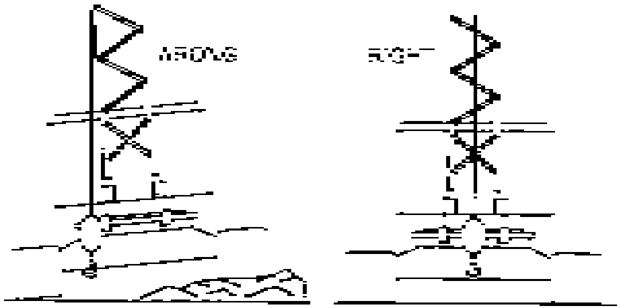


Illustration #254 – Leveling with the Whip Line

Crane Stability

A crane uses the power of its hoisting apparatus to lift a load. This includes the motor, drum, wire rope, and block sheaves.

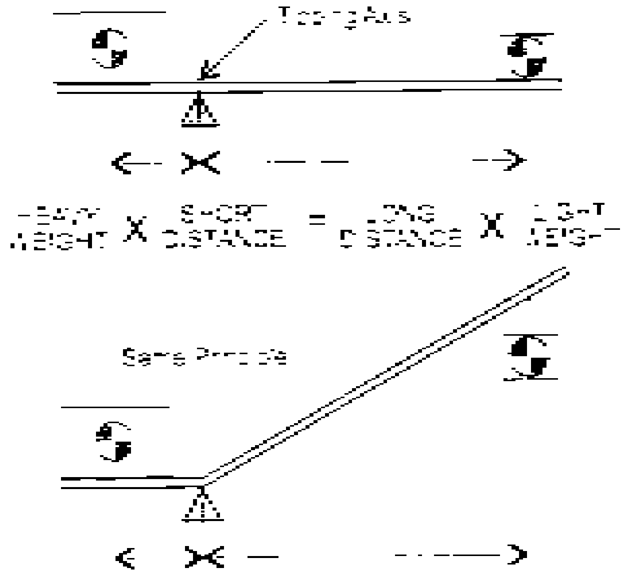


Illustration #255 - Crane Leverage

The actual stability (tipping resistance) of a crane is based on the lever principle. See Illustration #255, #256.

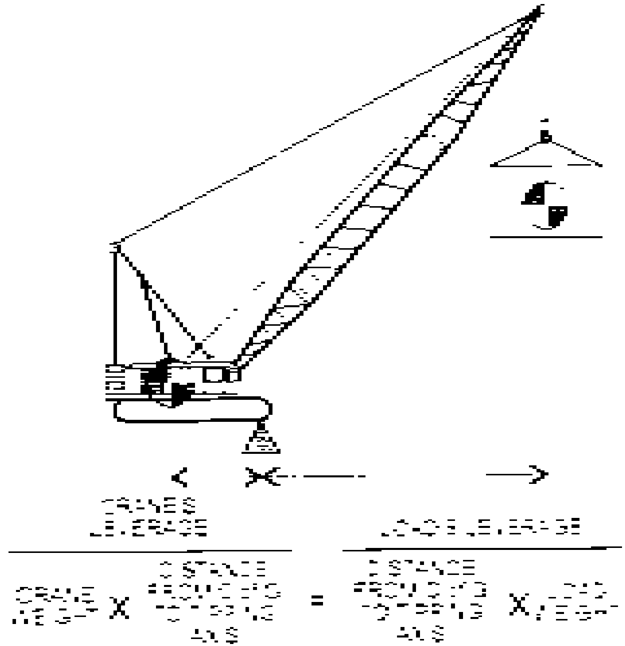


Illustration #256 - Crane vs Load Leverage

Crane Stability (Crawler)

Due to the configuration of a crawler crane with its center of gravity (C of G) almost at the center pin, the C of G changes very little as the crane rotates.

The tipping axis of a crawler crane is at the center of its track on a side lift (illustration #257). The leverage can be increased on some cranes by extending the tracks. The tipping axis is through the diameter of the drive or idler sprocket when lifting over the front or rear (illustration #258).

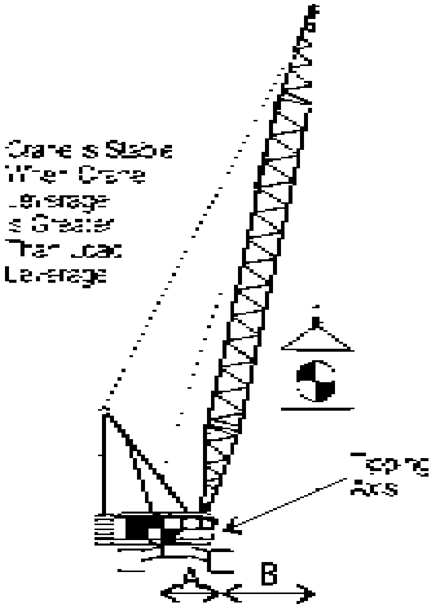


Illustration #257 - Tipping Axis Over the Side

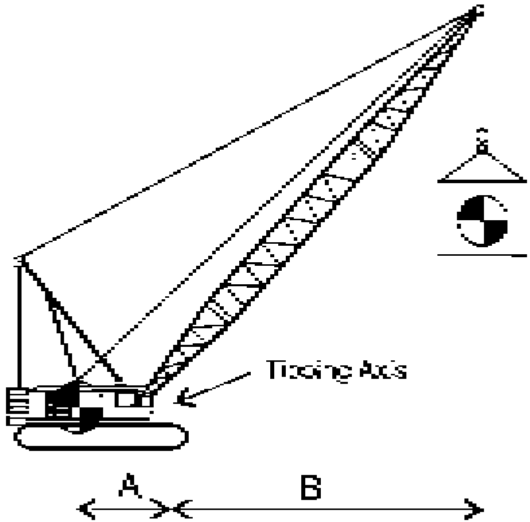


Illustration #258 - Tipping Axis over the Front

Crane Stability (Mobile)

On most rubber tired mobile cranes, the C of G of the unit changes dramatically as the boom swings from the rear, to the side, to over the front.

On a lift over the rear the combined C of G is well back of the tipping axis, see illustration #259.

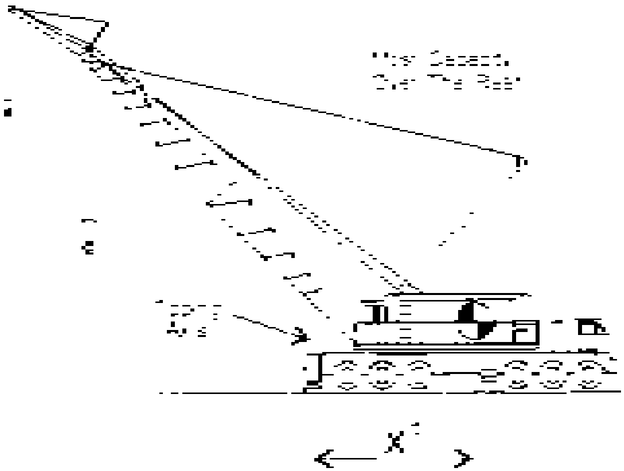


Illustration #259 - Tipping Axis Over the Rear

When the boom swings over the side the C of G shifts closer to the tipping axis, see illustration #260.

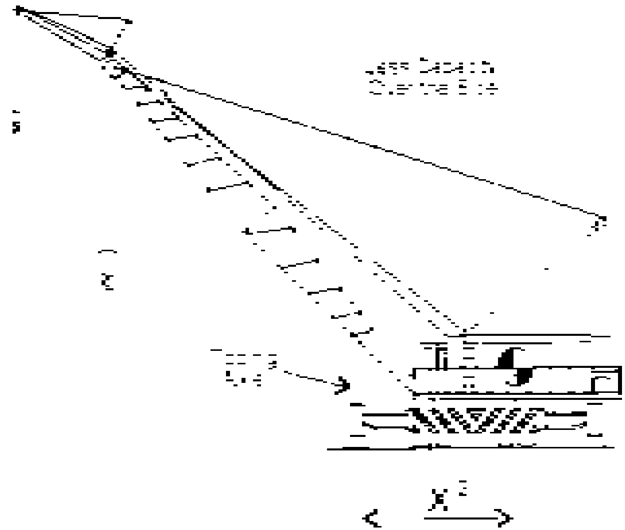


Illustration #260 - Tipping Axis Over the Side

Swinging the boom over the front shifts the C of G dangerously close to the tipping axis, see illustration #261.

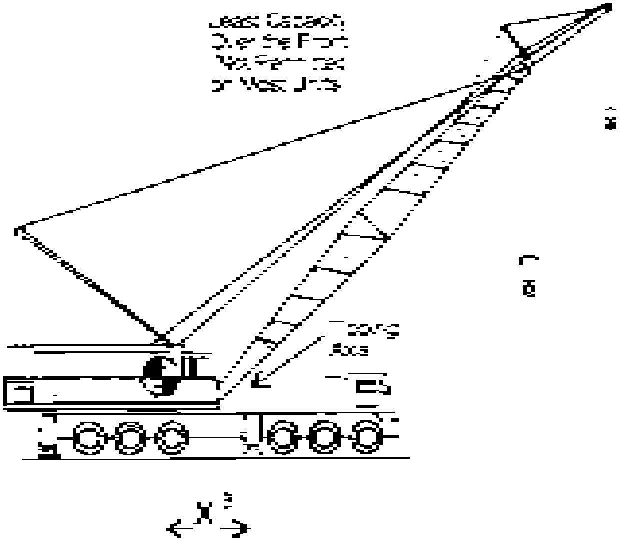


Illustration #261 - Tipping Axis Over the Front

***Note:** When lifting over the front, the cab and truck front drivetrain are hanging over the front outriggers thereby adding leverage to that caused by the load.*

As crane stability is based on the leverage principle, the rule that would apply for crane-load balance is equal leverage; however if the crane is to lift the load without tipping and with a suitable safety margin, the crane leverage must be greater than the load leverage.

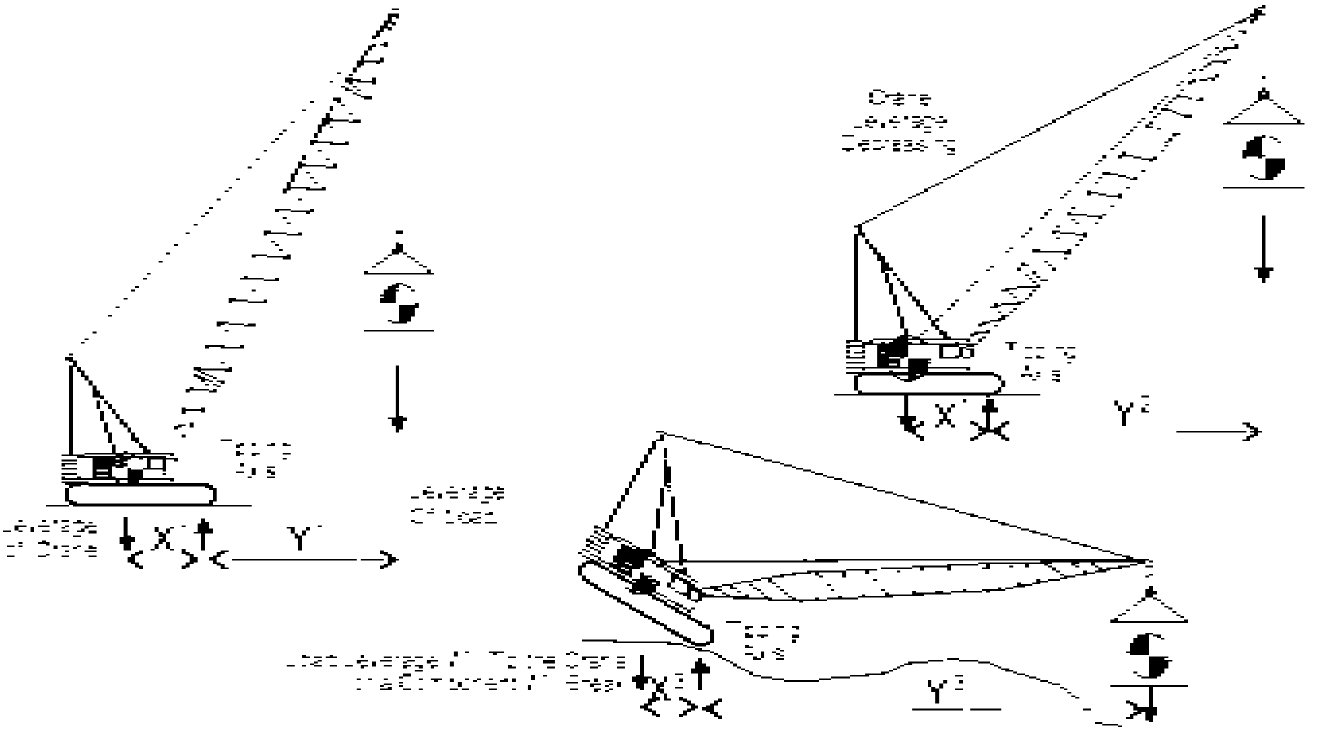


Illustration #252: Lower Boom and Lose Stability

Crane Stability Factor

Cranes operate on a safety factor to avoid tipping. The maximum rated capacity of a crane is a percentage of the load that would tip the crane.

Table #54 and illustration #263 show the rating percentages required by ANSI B30.5.

CAPACITY CHART RATING BASED ON PERCENTAGE OF TIPPING	
TYPE OF CRANE	**PERCENTAGE**
LOCOMOTIVE	85%
CRAWLERS	75%
MOBILES ON ROUGH TERRAIN	
on outriggers	85%
on tires	75%
COMMERCIAL BOOM TRUCKS	
on stabilizers	85%

Check your crane - above percentages not used by all manufacturers

ANSI B 30.5 & CSA Z150

Table #54 – Tipping Percentages

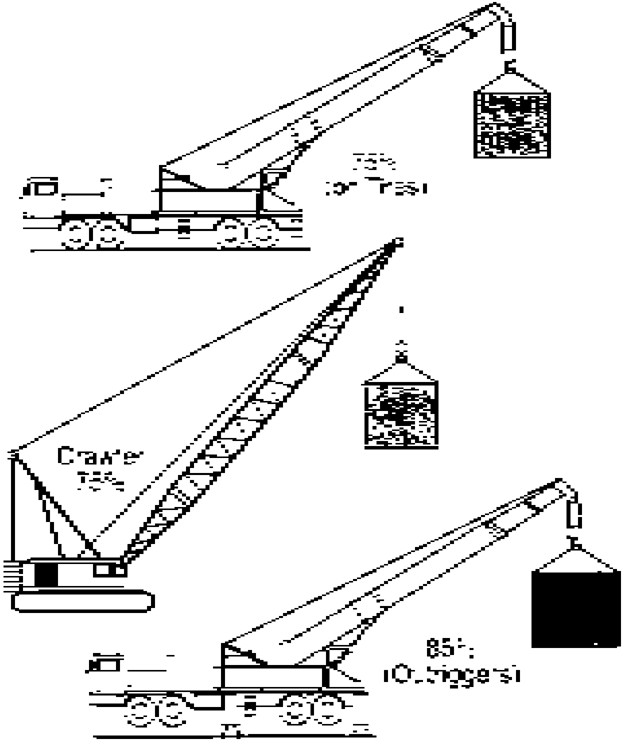


Illustration #263 – Crane Stability Factors

Intermediate Position Outriggers

Up until the introduction of cranes designed to work with outriggers in the intermediate position, it was a violation of safety standards to use a crane in the intermediate position. The two allowable positions were at 100% and 0% extension. Any crane operated with the outriggers partially extended was still rated at the 0% extension.

Modern cranes so designed can now use 0%, 50%, and 100% extensions. Most cranes with this design are pinned at the 50% extension to guarantee that it actually is 50%. Also, it is normally specified that all outriggers be extended the same.

The majority of cranes are rated 85% of tipping with fully extended outriggers. However, the rating varies with different manufacturers for the 50% and 0% position.

Tipping Rating Formula

A formula established by the ISO (International Standards Organization) can be used to determine the tipping rating at 50% and 0%. The formula is now included in many crane load charts. It is:

Tipping Load = 0.1 x load factor + 1.25

To get the load factor, the formula takes the boom weight and the load into consideration. The resulting formula tipping rating will be less than 85% or 75%, as the crane will tip considerably quicker with the outriggers not fully extended.

Computerized Load Indicators

Note: A Load Indicator, Rated Capacity Indicator, or Rated Capacity Limiter must be installed on any crane with a maximum rated capacity of 3 tons or more to warn the operator both visually and audibly when the crane is lifting beyond a preset capacity. The system senses an overload and can lock out the hoist control.

Note: These devices are an aid only. Verified load chart weight ratings and measured radii take precedence over the indicator readings.

A variety of different types of indicators are available as an after market item for older model cranes, and they are usually a standard feature on new cranes. In general terms the device can perform the following functions:

- Display boom angle
- Display boom length
- Display load radius
- Display boom tip height
- Display maximum permissible load
- Display actual lifted weight
- Display approaching two-block condition

Note: Load Indicator Safety Hazard

The proper use of these devices is a major step forward in job lifting safety. However their use has also created an unexpected safety problem. That problem is the use of a load indicator as a method of test weighing a load. This use of the computerized system is in direct conflict with the crane manufacturers' instructions. Indicators must only be used to check the weight of a previously calculated load weight. The electronic equipment is intended strictly as an operator aid, and is not meant to replace crane load charts and operating instructions. The use of these devices to test weigh unknown loads is a violation of ANSI B30.5-3.2.1.1 (a)(b)(c).

Load Shape Factors

Actual crane capacities are based on three basic factors:

1. Weight of the machine
2. Stability
3. Strength of components

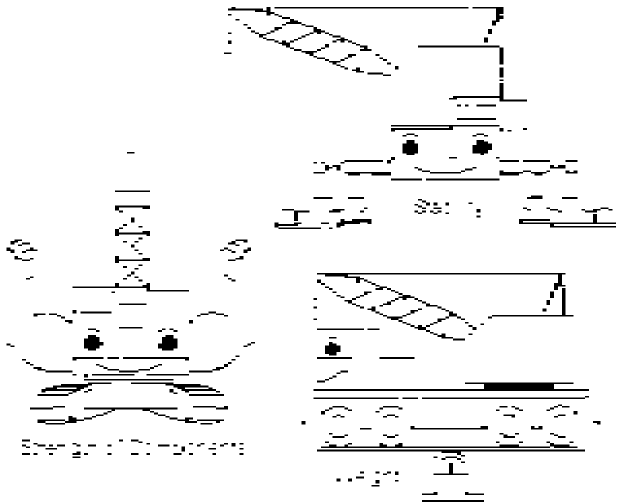


Illustration #264 – Crane Capacity Factors

Additional factors enter the picture to affect the lifting and positioning of a load. The primary one is the actual load weight which includes the rigging equipment, the crane block and its wire rope. Three other major considerations are the shape and dimensions of the load, the height to which it must be raised, and the distance out from the crane (radius).

The capacity limitations of the boom must be determined. Know the length and capacity at different operating angles and radii. For example, illustration #265 shows a large dimension load and its limited lift height due to a rather high boom angle.

To lift the load higher, the boom angle must be lowered, which increases the operating load radius. The longer radius results in less crane capacity, and an increased load stress on its components.

Load Shape

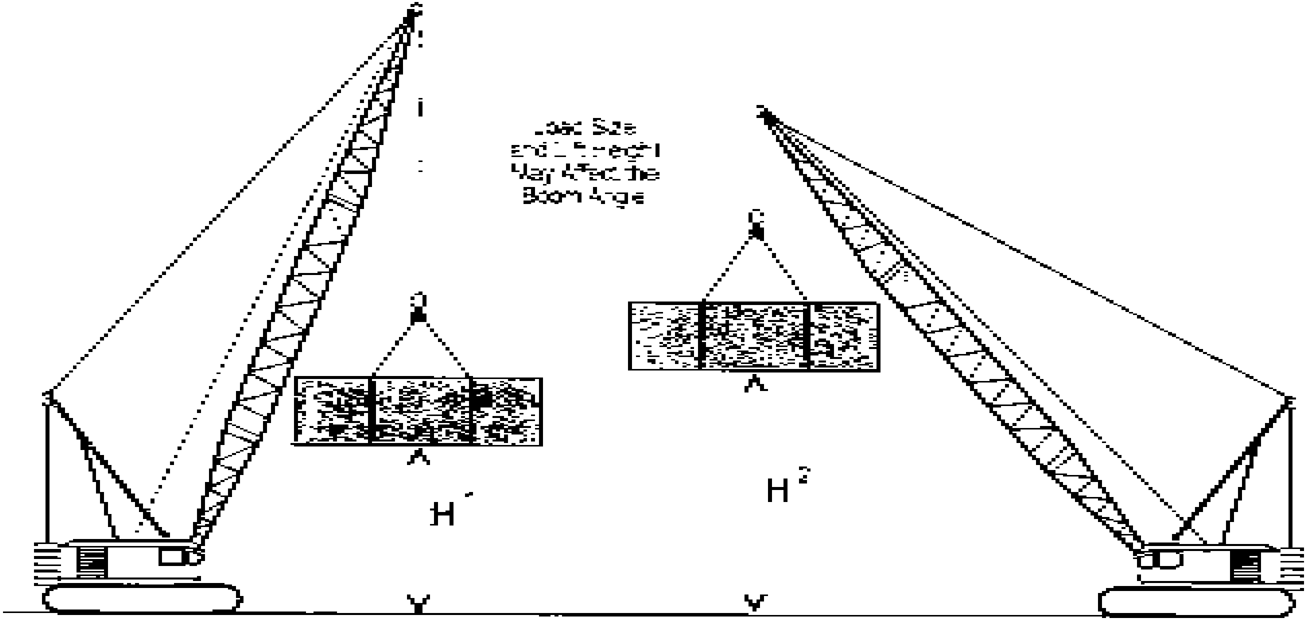


Illustration #265 - Lower Boom Angle Required to Lift Bulky Load

Load Shape & Lift Radius

The load radius is the horizontal distance measured from the rotation center of the crane (mounting pin) to the load hook while the boom is under load.

The load radius will increase when the load is lifted off the ground due to pendant line stretch and/or deflection of the boom and machine. See illustration #256.

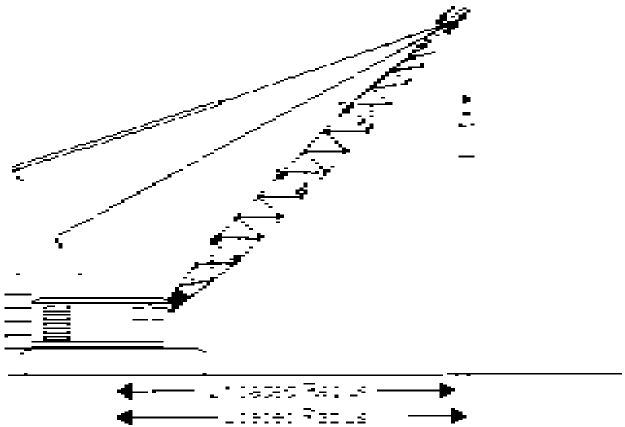


Illustration #256 – Load Radius Deflection

Boom movement is more extreme on a machine sitting on its tires, due to deflection of the rubber.

On critical lifts, the radius should be re-measured after the load clears the ground. Recheck the crane load chart as the increased radius might put the crane into an unsafe lift condition.

Strength vs Stability

It is important to know the difference between the rated capacity of cranes in regards to strength and stability. Strength means that a structural component of the crane will probably break when overloaded (rather than tip). Stability means the crane will tip when overloaded.

Structural Failure

A structural failure does not necessarily mean an immediate fracture.

Cranes that have been overloaded on previous lifts have had catastrophic structural failure on normal, safe lifts. Some of the more common failure points are shown in illustration #267.

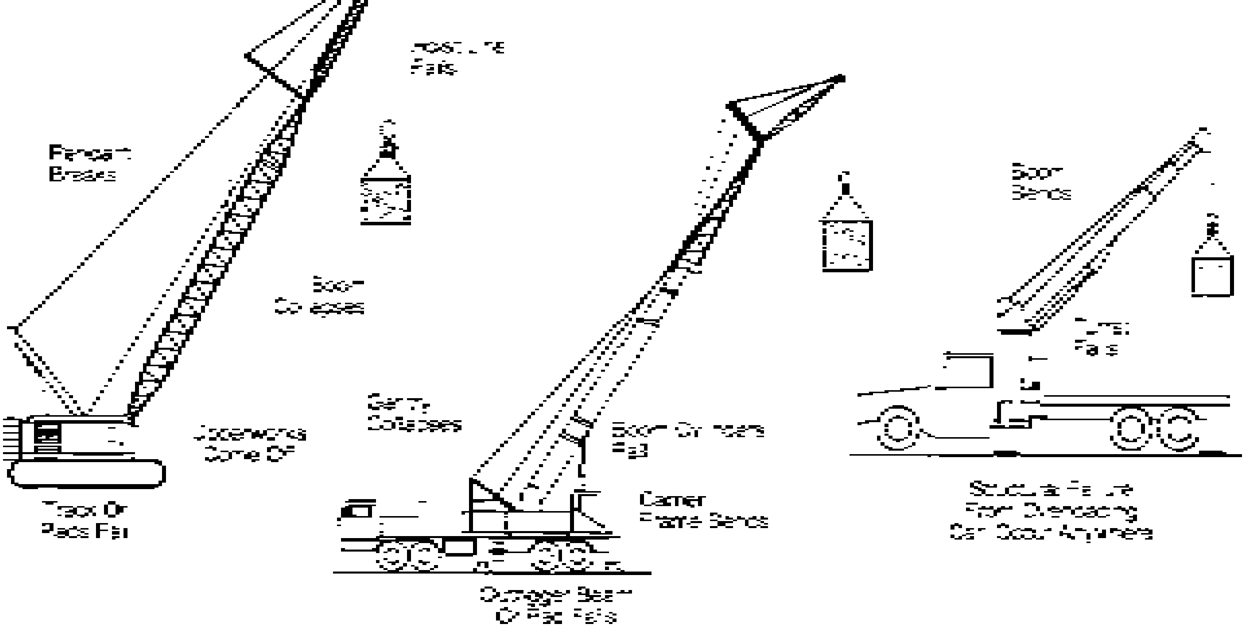


Illustration #267 - Common Failure Points

Boom Strength and Weakness

A crane boom is at its strongest position in a near vertical lift. The compression on the boom does not cause it to bend until it is at a lower angle. See illustration #268.

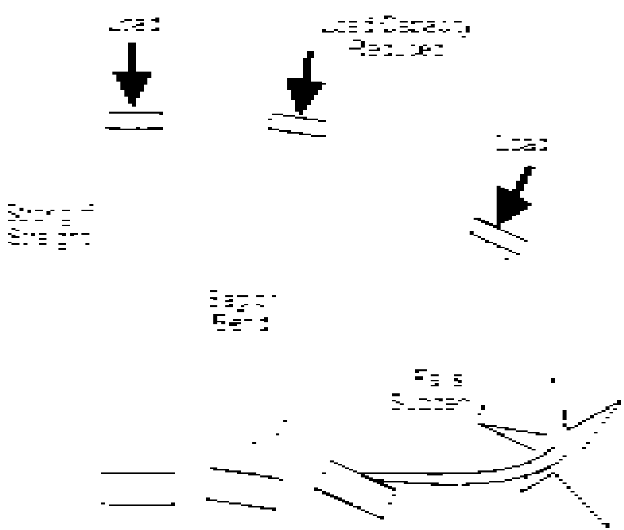


Illustration #268 - Compression Causing Failure

When a conventional lattice boom (or jib) is lowered it has increased sag with more pull on the supporting pendant lines. The capacity is also lowered considerably, see illustration #269.

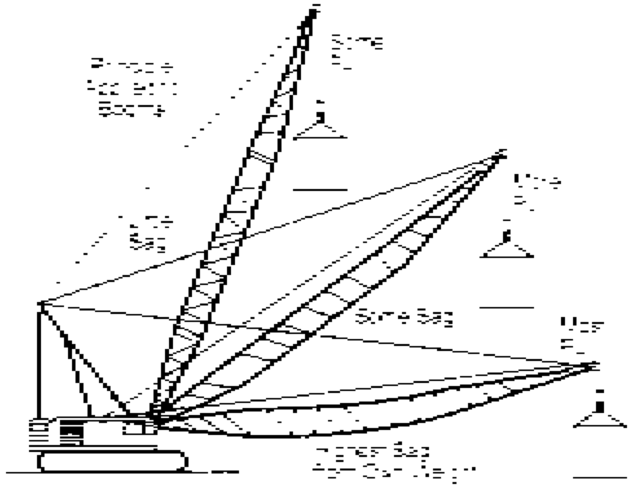


Illustration #269 - Boom Sag From Pendant Line Pull

Boom Strength and Weakness

Lattice Boom

Boom compression is a major cause of failure. As the boom sags the line of compression is between the boom tip and the foot pin. The boom fails when it cannot take the compression factor. See illustration #270.

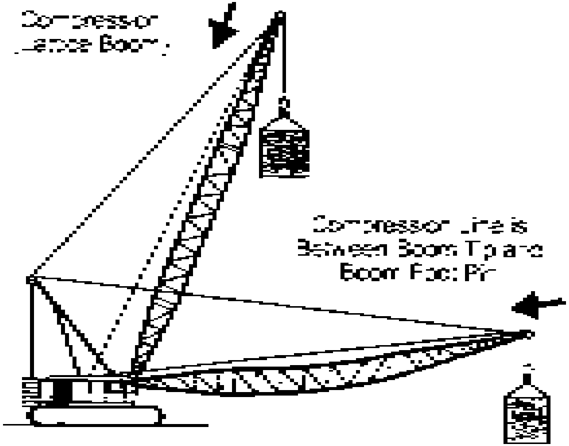


Illustration #270 - Boom Compression and Bending

Many cranes with extremely long booms often need assistance by another crane to lift the boom off the ground. the pendant line pull is too great, and when combined with boom sag can result in boom failure.

Hydraulic Booms

When a hydraulic crane boom is lowered to a dangerous point, the boom tip will bend due to the load leverage. This problem is not as common at a higher lifting angle as much of the boom load is supported by the hydraulic boom cylinders. See illustration #271.

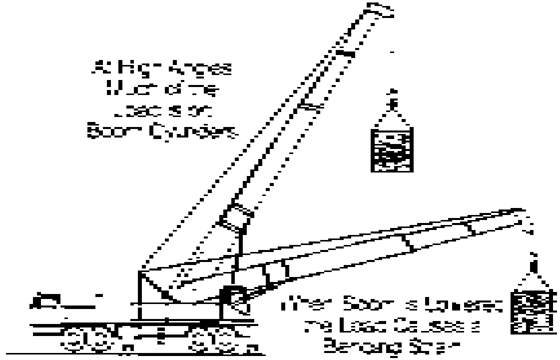


Illustration #271 - Hydraulic Boom Tip Bending

Quadrants of Operation

Every crane has a Quadrant of Operation (or Area of Operation) diagram included with the load rating chart for that particular crane. The diagram shows the safe approved working areas of the crane.

Maximum lifting capacity is approved only in the areas shown in the diagram and listed in the load chart. Depending on the crane model, lifting outside the approved quadrant is either not permitted or there is a reduced capacity. Every different crane model will have a quadrant of operation suitable for that crane only. The quadrant of operation is based on the manufacturer, and on the ANSI B30.5 standard.

- The quadrants are over the rear, over the front, and over the sides. However the scope or shape of these quadrants varies.
- Check each crane for the permitted working quadrant, as there will be variations with every type, make, and model. For example some cranes may have a full 360 degree operation, while others may safely lift more over the rear than over the front or sides.
- Do not lift over the front unless so stated in the chart. Some carrier models may have a front mounted stabilizer or jack.
- Capacity ratings may change when swinging from one quadrant to another (for example, rear to side). If so, use the lower rating.
- Always extend the outriggers fully. The only exception is when the crane has an intermediate outrigger position rating specified in the rating chart.

Several, but not all the quadrant areas are shown in illustrations #272 to #279.

Carrier mounted hydraulic boom

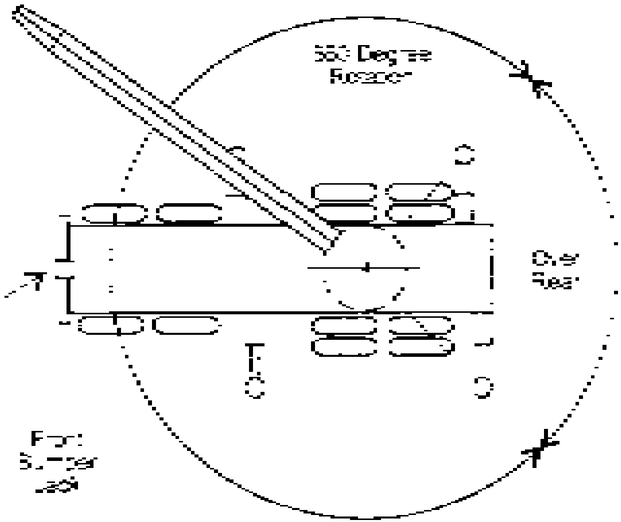


Illustration #272 - Mobile Crane Quadrants

Quadrants of Operation

Carrier mounted lattice boom

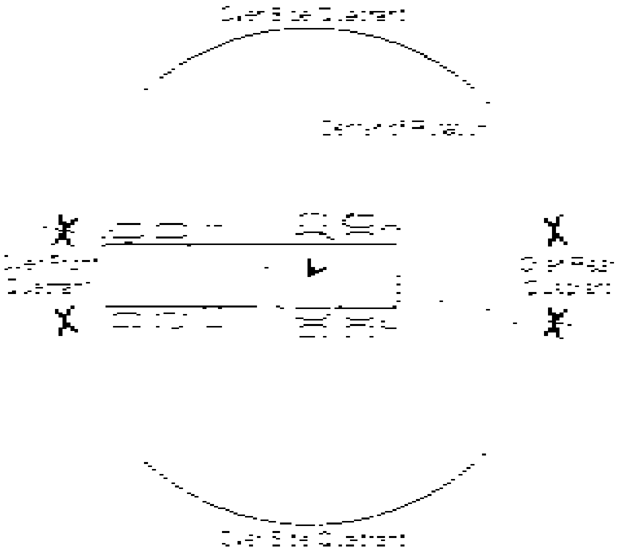


Illustration #271- Free Over Side and Free Over Rear (Outrigger not extended)

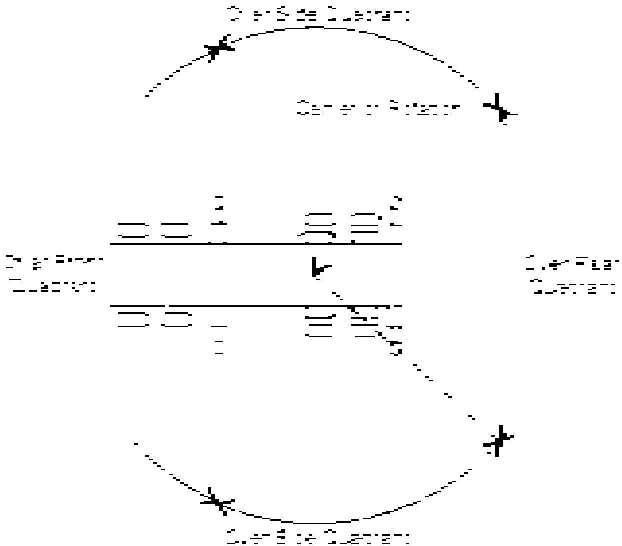


Illustration #272 - Outrigger Extended and Set Over Side or Rear

Rough Terrain Cranes

Rough terrain crane capacities are greatly reduced on rubber.

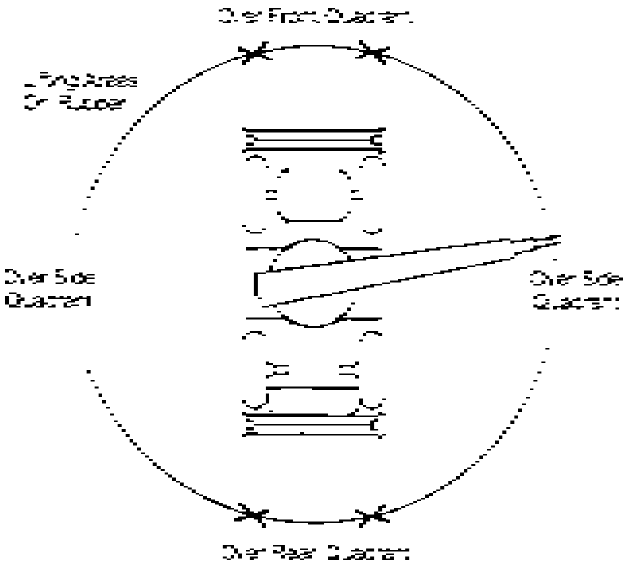


Illustration #275 - Rough Terrain Free Over Side and Rear - Outriggers Not Extended

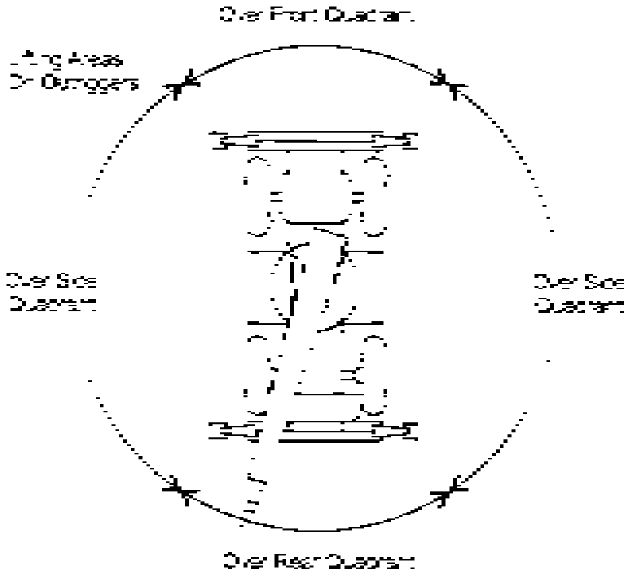


Illustration #275 - Rough Terrain Outriggers Extended

Crawler Cranes

Crawlers Over the Side

Two methods are used to indicate the quadrants of a crawler crane.

Check the specific load chart data for the crane being used. (See illustrations #277, #278 and #279.)

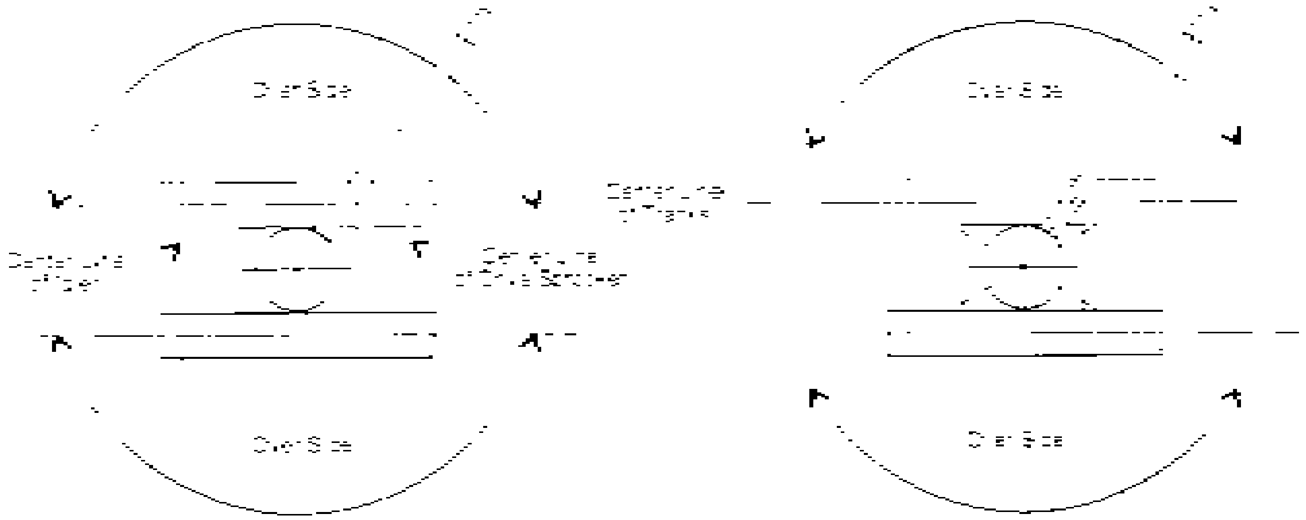


Illustration #277 - Crawler Crane Quadrants

Crawler Cranes

Crawlers Over the End

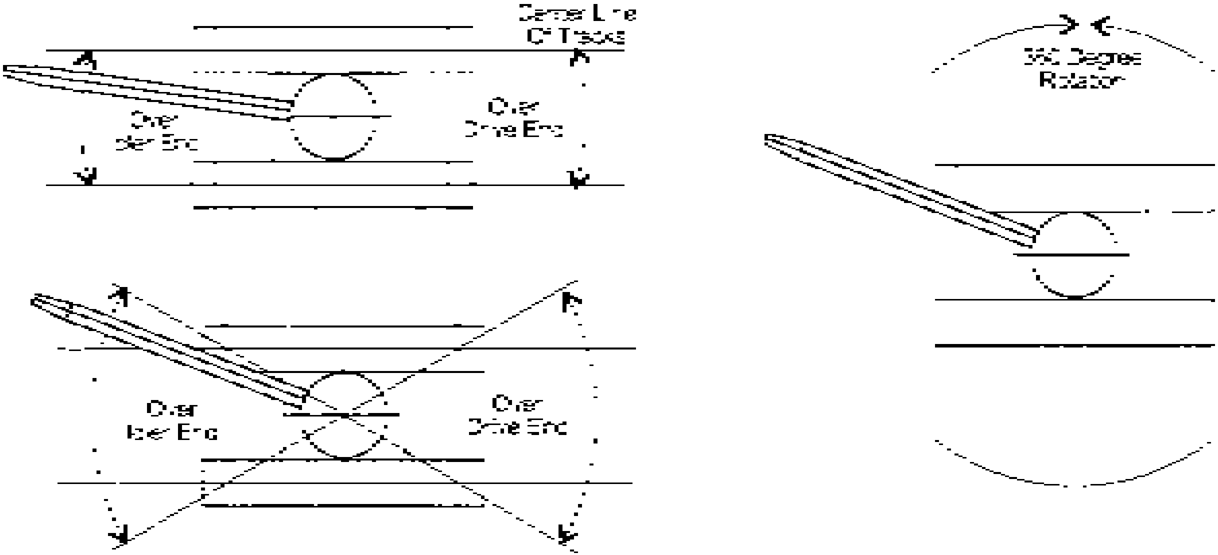


Illustration #276 - Crawler Crane Quadrants

Swing Area Protection

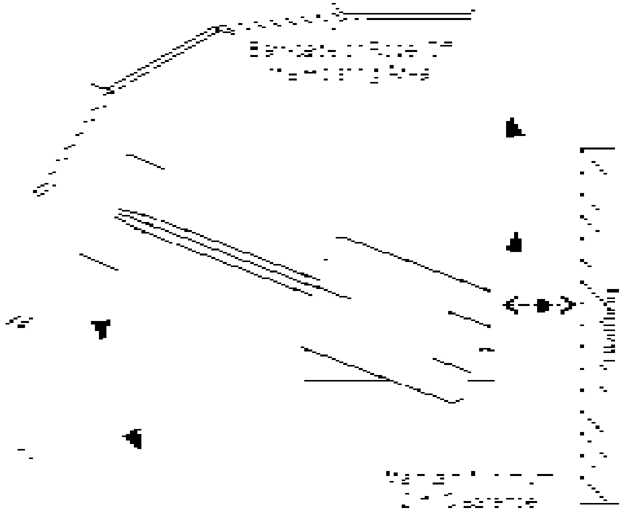


Illustration #273 - Swing Area Protection

The area around the hoisting operation must be blocked off to maintain safety for pedestrians or other nearby workers. See illustration #273.

Either rope the area off or use barricades to prevent access to the swing area of the crane counterweight and/or the load depending upon the amount of swing the crane has to make during the lifting and lowering procedure.

A clear minimum distance of 2 feet must be maintained between any building or structure and the closest point of the crane counterweight during the swing.

Actual vs Effective Load Weight

Under normal conditions anything hanging below the boom tip is considered load. When the main load block is being used for hoisting, and the jib is erected, the effective weight of the jib may be calculated higher than its actual weight.

This can apply to either lattice or hydraulic booms (see illustration #280). Crane manufacturers use different methods of calculating the jib weight.

When the main block is being used and the jib is stowed on the boom its effective weight may be less than its actual weight.

Check the load chart data carefully.

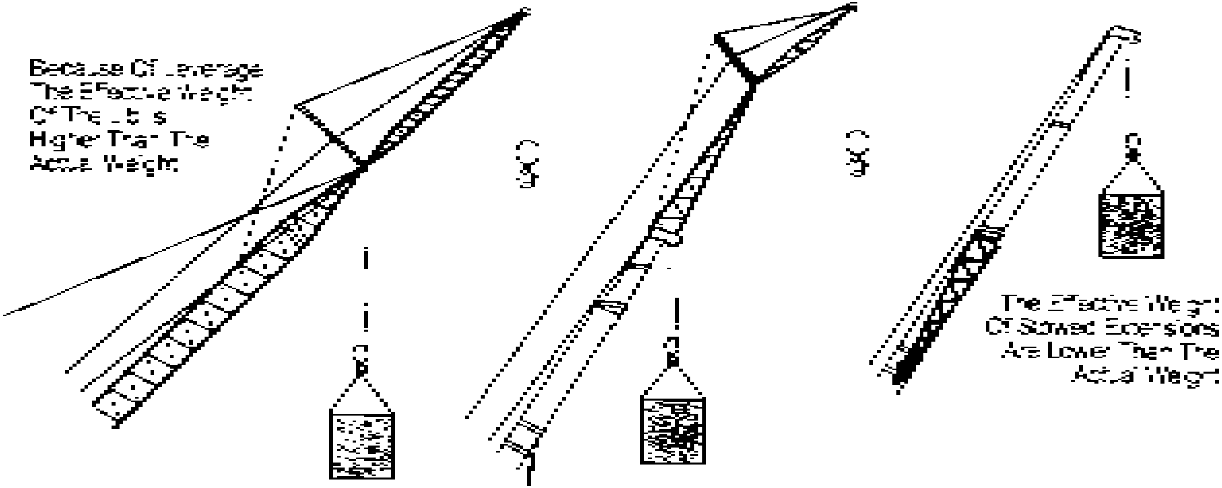


Illustration #280 - Effective vs Actual Jib Weights

Load on Boom

Every crane has specific rules for its boom and jib makeup, however it can be safely assumed that everything under the boom tip is load.

This will include the object being lifted, slings and any rigging components, the hook and hoist block, and the hoist wire rope below the boom tip (on most cranes).

If the jib is erected, it is considered part of the load, as well as the jib gantry and jib pendants. The headache ball and hook are also included, as well as the jib line (on most cranes). See Illustration #281. The crane manual and load charts must be followed closely as some types of cranes will double the jib weight as part of the load. For example a 2200 lb. (1000 kg) jib could be a 4400 lb. (2000 kg) deduction.

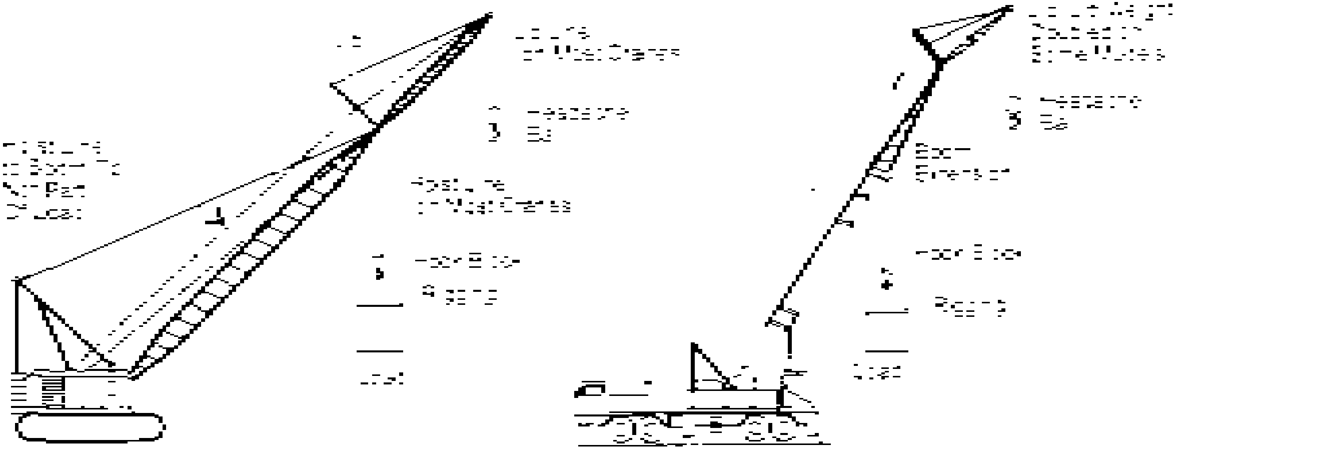


Illustration #281 - Load on Boom With Jib

Load On Jib

The load on the jib will be the weight hanging below the jib tip. This will be the actual load, the slings and rigging components, the headache ball and hook, plus the jib lines (on most cranes).

The main load block and hook as well as the main load line is included as load on most jib calculations.

It must be emphasized that the crane manufacturers manual and load chart data must be studied to obtain the specific load details.

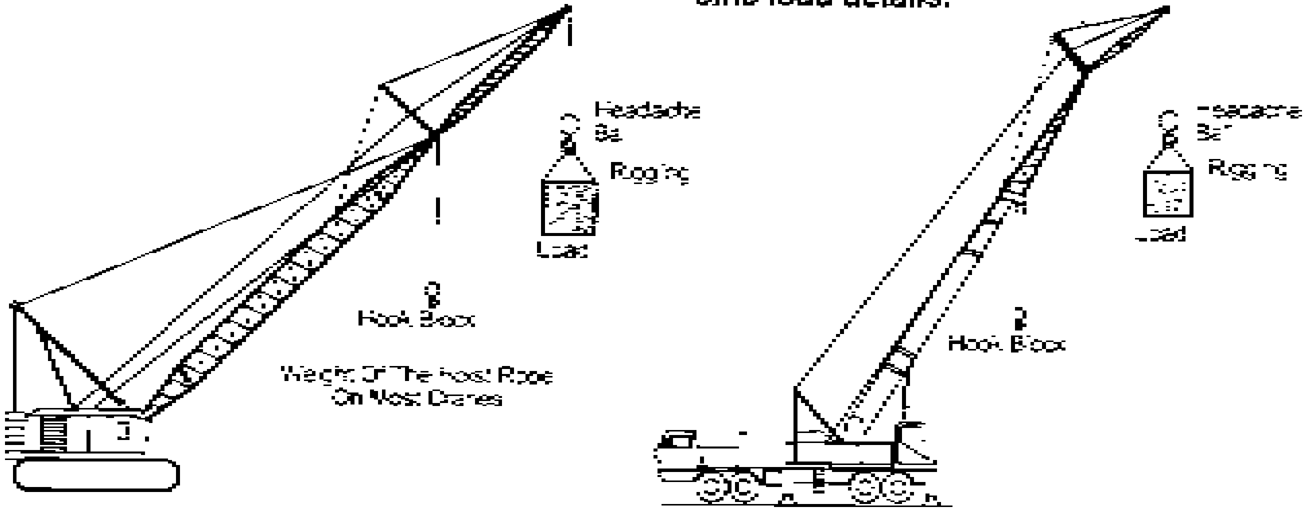


Illustration #262 - Load on Jib

Net and Gross Load

Two terms are used concerning the load being lifted by a crane. Net load is the weight of the object being lifted. Gross load is the net load plus all rigging components, hooks, blocks, wire rope, etc. Gross load is the number used when checking the load charts. See illustration #263.

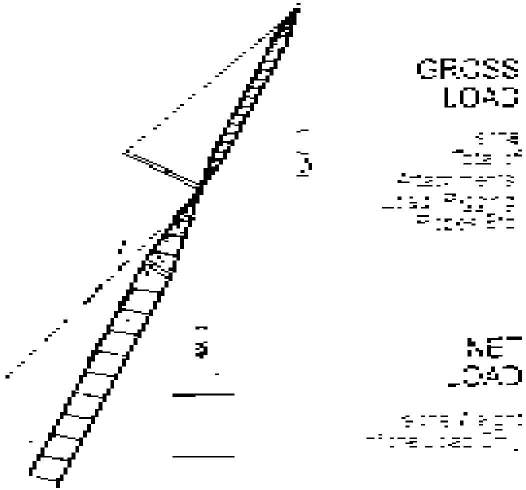


Illustration #263 - Gross and Net Load

Net and Gross Capacity

Two terms are also used concerning crane capacity. Gross capacity is the net capacity plus all attachments, rigging components, blocks, hooks, etc.

Net capacity is the load weight the crane can lift safely. Gross capacity is the number shown on the crane load chart. See illustration #264.

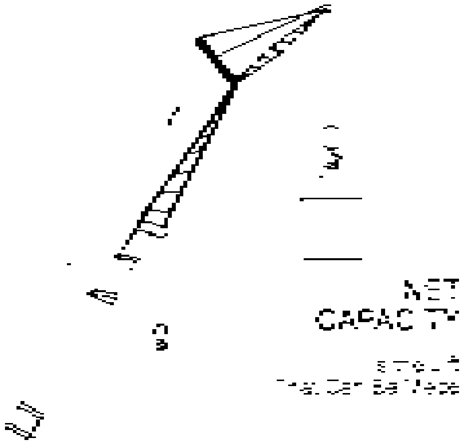


Illustration #264 - Gross and Net Capacity

Static and Dynamic Load

When the load on a crane is suspended in a non-moving situation it is called the static load.

When the load begins to move, extra stress is imposed on the crane. This could be caused by hoisting, lowering and stopping, or rapid swing causing the load radius to increase. A sudden lift or stop is called impact loading and should be avoided, as it can easily increase the load by up to 30% or more. Extreme impact loading can amount to 100% or more.

See illustration #265 for an example of a static and dynamic load.

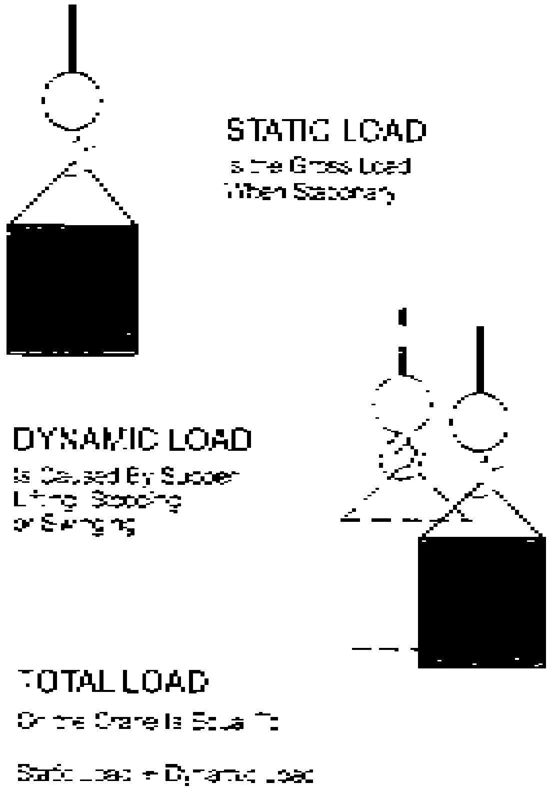


Illustration #265 - Static and Dynamic Load

Necessity of Load Charts

The load chart shows the maximum capacity of that specific crane under every permissible configuration. The ability to interpret this chart correctly is critical for those planning a lift, and to the safe operation of the crane.

Crane manufacturers place the capacity charts in readily accessible locations in the crane cab. They should be attached and not removed.

Load Charts vs Load Indicators

Modern technology, specifically Load Moment Indicators and Capacity Limiters have taken away some of the old 'feel' and error practices. However, accidents happen, almost always for reasons that should have been avoided. Any operator relying on guesswork and a sign of the crane going light (beginning to tip slightly) to warn of overload is playing a dangerous game.

Many modern cranes will be overloaded before there is any indication of tipping. The electronic operator aids must be tested every day to ensure their accuracy. If there is any doubt, the crane manufacturer's load chart information will prevail.

Note: It is a conflict with the manufacturers guidelines and a violation of the ANSI standards to use a load indicator as a method to weigh a load.

- Do not use signs of tipping to indicate capacity limits.
- Some cranes are overloaded before any sign of tipping.
- Cranes at maximum lift configuration will probably fail structurally before there is any sign of tipping.
- An operator may not notice the point when a crane goes from stable to unstable.

- When a crane begins to tip it may be too late to recover, even by a quick release of the load.
- A crane is rated at its maximum capacity load ONLY with its shortest boom section, and lifting at the minimum radius.

Load Chart Information

All crane manufacturers have different capacity charts for each of their cranes, but they all include similar information:

- Type of crane base.
- Type of crane configuration.
- Quadrant of operation.
- Length of boom.
- Angle of boom.
- Load radius.

Subtract from gross capacity for additional equipment (lb. rigging, etc.).

Two sample load charts are shown in tables #55 and #56.

Boom Length Feet	Rad in Feet	Boom Ang Deg	FREE Over Side	FREE Over Rear	Outriggers Set Over Side	Outriggers Set Over Rear
160 ft	27	83	77,590*	68,350	215,960*	215,360
	30	82	69,820*	[illegible]	172,540*	*
	35	80	59,030*	63,510	150,290	172,330
	40	78	50,520*	53,450	122,360	*
	50	75	38,220*	39,790	80,140	135,560
	60	71	30,220	30,540	67,010	*
	70	67	23,550	24,540	54,250	158,210
	80	63	19,150	19,360	44,000	*
	90	59	15,550	16,240	37,550	124,100
	100	56	12,570	13,350	31,790	*
	110	50	10,340	11,390	27,550	83,290*
	120	45	8,470	9,050	23,820	58,710*
	130	40	6,780	7,570	20,550	57,920*
	140	34	5,550	5,960	18,510	45,030
	150	27	4,130	4,660	16,090	43,090
	160	17	3,040	3,570	14,150	38,550
						33,340
						28,250
						25,100
						22,370
						19,390

Ratings with a * are based on strength, not stability.

Table #55 - Carrier Mounted Lattice Boom Example

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Ratings with a [illegible] are based on strength, not stability.

Table [illegible]56 - Crawler Mounted Lattice Boom Example

Typical capacity chart nomenclature includes the following:

Boom length: The measurement from center of boom hinge pin to center of sheave pin.

Operating radius: The horizontal distance from rotation axis to center of load block with the load suspended.

Boom angle: The angle between horizontal and centerline of the boom when the load has been lifted off the ground and the boom has gone through deflection. This indicates operating radius. Operating radius governs capacity.

Maximum capacity: Free over side and rear (outriggers not extended).

Maximum capacity: Outriggers extended and set over side and rear.

Boom point elevation: The distance from ground to center of boom point shaft.

Chart Configurations

The three basic crane chart configurations are:

1. Boom extension and/or jib not installed.
2. Lifting from main load line but with boom extension and/or jib installed.
3. Load lifted from boom extension or jib.

Some cranes can have different styles of boom tops, such as open throat, hammerhead, or light tapered top. Each style of top has its own capacity chart. Some crane models use different numbered booms. The boom number listed on the capacity chart must correspond to the boom number on the crane. The amount of counterweight on the crane must match the specifications in the load chart.

Load Chart Strength vs Stability

The load numbers in the lower section of most capacity charts (indicating the lesser lifting capacities), are based on crane stability or tipping. The load numbers in the upper section of the chart indicate capacities based on structural strength. To indicate the difference, the upper numbers may be shaded, divided by a dark line, or shown with asterisks. These upper chart numbers mean a crane component will break before there is any sign of the crane tipping. See illustration #285 for examples.

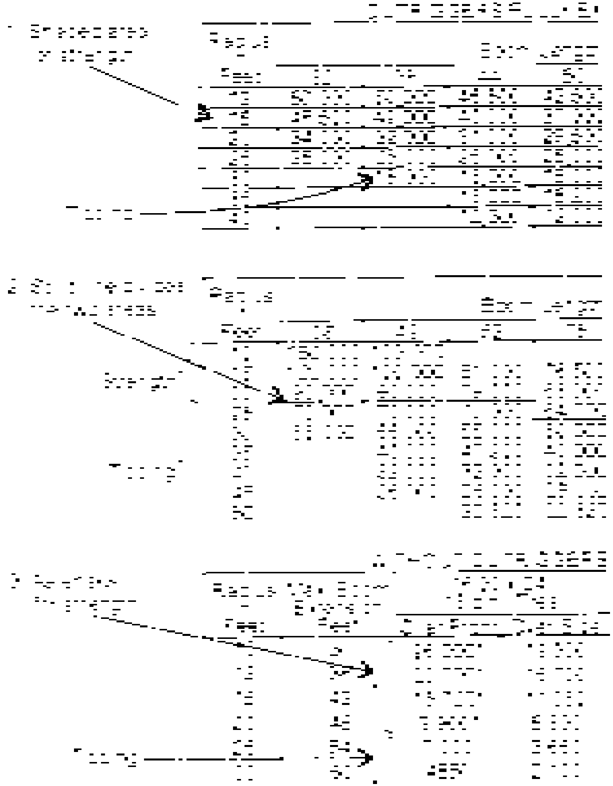


Illustration #286 – Strength vs Stability on Chart

Interpreting the Load Chart

Load radius, boom length and boom angle are three critical load chart factors. When calculating capacity from the chart and any of these three do not match the actual crane set up, then the capacity numbers for a longer radius, a longer boom length, or a lower boom angle on the load chart must be used. It is not permitted to guess or mathematically calculate in-between (interpolated) chart values. The following text and Illustration #287 on radius, #288 on boom length, and #289 on boom angle explains this more clearly.

Radius Between Chart Values

Frequently the measured load radius will fall between two numbers shown on the load chart. When this occurs, the chart radius number used must be the higher number (longer radius-less capacity). In illustration #287, the crane has an 80 foot boom, and is lifting at an off-the-ground radius of 38 feet. The chart (page 301) indicates a load rating of 67,000 pounds at a 35 foot radius, and a load rating of 54,300 at a 40 foot radius. With a measured distance of 38 feet, the 40 foot rating of 54,300 must be used.

Boom Length Between Values

Due to the extension of hydraulic booms, the boom length will often not match the numbers shown in the boom length chart. When this occurs, the next highest boom length number (longer boom-less capacity) must be used. In illustration #288, the crane is lifting with an 85 foot boom.

The chart indicates that an 80 foot boom, at a 50 foot radius, has a rating of 38,900 pounds. A 90 foot boom at a 50 foot radius is rated at 38,600. The 90 foot rating of 38,600 must be used.

Boom Angle Between Values

If the boom angle indicator shows an angle not matching the load chart, the angle value used (lower angle-less capacity) must be the next lowest number. In illustration #289, the crane has an 80 foot boom and the angle indicator shows 59 degrees.

The chart (illustration #289) shows a rating of 38,900 pounds at 55 degrees, and 54,300 at 63 degrees. The lower angle of 55 degrees with the 38,900 rating must be used.

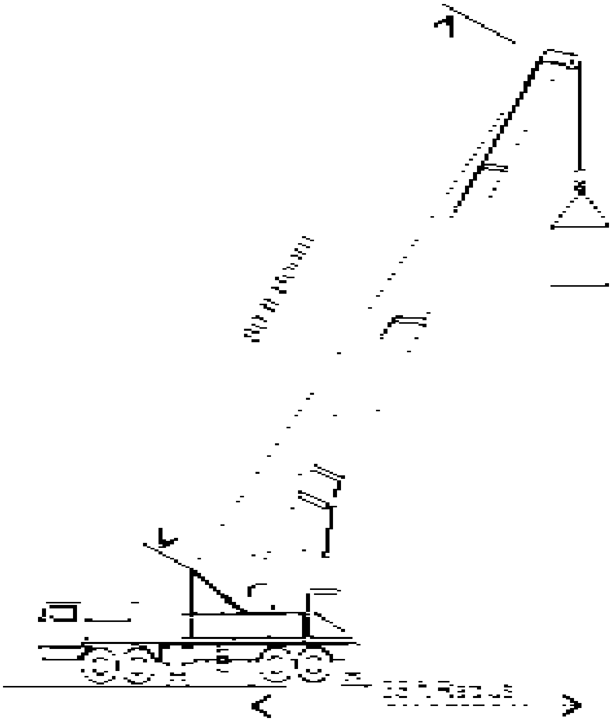


Illustration #267 – Radius Between Chart Values

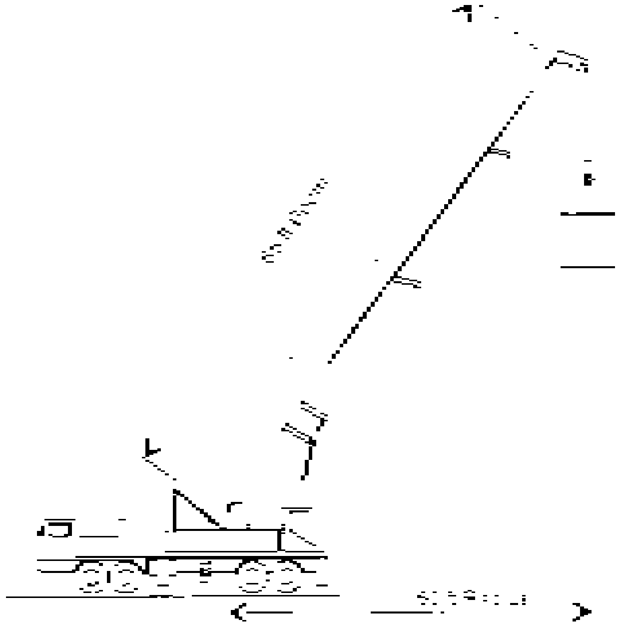


Illustration #268 – Boom Length Between Chart Values

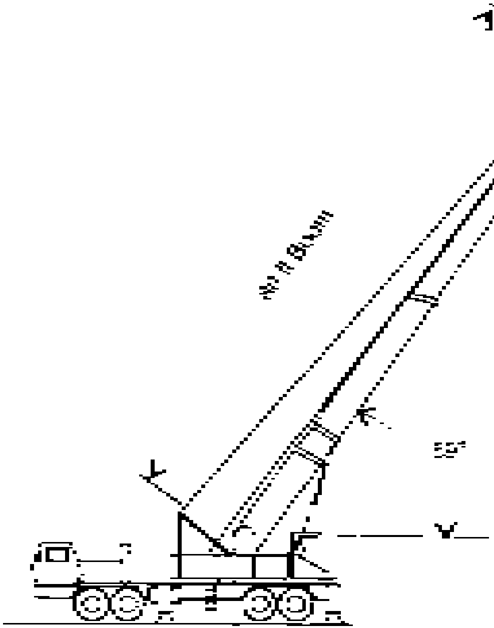


Illustration #289 – Boom Angle Between Chart Values

MAXIMUM ALLOWABLE LOADS IN POUNDS

Boom Length in Feet	Radius in Feet	Boom Angle in Degrees	Boom Point Pin Height	Outriggers Set Over Side or Rear	Without Outriggers Over Side	Without Outriggers Over Rear
40	12	78	46.5'	120,000	102,400	132,700
	15	74	45.9'	1?8,000	74,400	97,400
	20	66	44.0'	145,000	48,700	54,600
	25	58	41.0'	115,000	38,600	47,900
	30	49	37.5'	96,000	28,600	37,500
	35	38	32.5'	67,000	23,300	31,100
50	15	78	56.3'	150,000	54,000	67,000
	20	74	63.0'	117,000	47,500	63,900
	25	68	62.5'	118,500	35,000	47,200
	30	64	61.0'	98,200	27,500	37,100
	35	55	56.5'	87,400	23,400	30,500
	40	50	49.0'	54,700	18,300	25,500
	50	40	45.8'	33,400	13,400	15,100
80	20	78	96.3'	145,000	48,700	63,500
	25	75	94.8'	115,200	34,400	45,500
	30	71	93.0'	55,300	25,300	36,300
	35	67	81.0'	57,000	21,500	25,700
	40	63	78.5'	54,300	18,300	24,300
	50	55	72.5'	38,500	13,300	15,500
	60	45	64.0'	28,300	11,100	14,500
	70	34	52.0'	24,000	9,400	11,500
90	20	80	88.0'	140,000	45,400	63,100
	25	78	94.5'	117,200	34,100	45,500
	30	73	93.8'	85,750	28,500	36,200
	40	66	89.9'	54,100	17,300	24,500
	50	58	84.5'	39,500	13,000	18,200
	60	51	[illegible]	29,500	9,300	14,100
	70	43	56.3'	23,500	7,700	11,200
	80	32	55.5'	19,500	5,100	8,150

Do not make up in-between values.

Range Diagram

The range diagram included on all mobile cranes is a side view of the crane with its full range of configurations. It shows the crane placement, boom length, boom angle, load radius, jib and jib offset, and load heights needed to lift and place the load.

Each chart is marked off with horizontal lines indicating boom tip height, vertical lines indicating load radius, lines, radial boom angle lines and boom tip arcs that trace the position of the boom for each boom length as the radius and boom angle change.

If different jibs are used they would also be indicated on the diagram. See illustration #290 for an example of a range diagram.

Note: Boom angle and boom length determine load radius. Refer to load chart for lifting capacity at required boom length and radius.

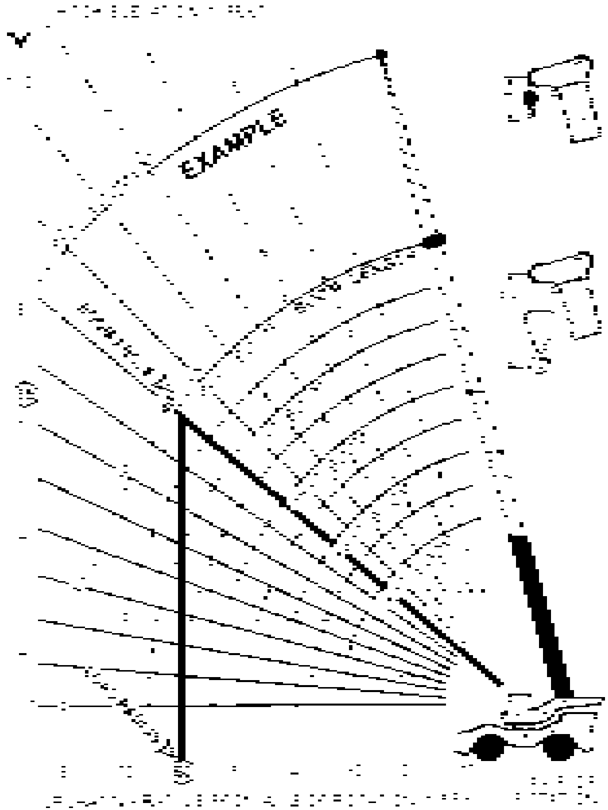


Illustration #290 - Range Diagram Example

Number of Hoist Lines

A crane will often have to be equipped with more than a single hoist line. If the load lifted weighs more than the safe working load of the wire rope the crane will have to be reeved with more line parts.

The load will be the lift plus the hook block, slings, and all components.

Example: The load weighs 60,000 pounds and the block and rigging weighs 1125 pounds. The crane wire rope has a WLL (SWL) of 18,000 pounds.

Line parts = 61,125 / 18,000 = 3.39

The crane will need 4 parts of hoist line. See Illustration #291.

Note: Some load charts may include the weight of the minimum parts of line required to lift a load. Excessive parts of line or an extra fall must be calculated.

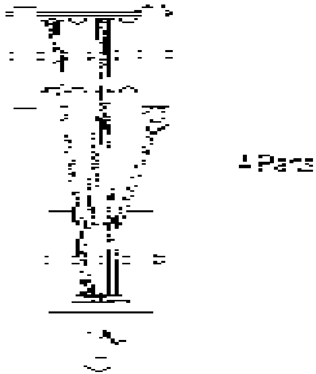


Illustration #291 - Parts of Line

Study the manufacturers chart closely to determine the line parts needed and / or the requirements of determining these line parts.

Boom Capacity (No Attachments)

The following basic requirements are used to calculate boom capacity with no jib or extension attachments:

- Use the load capacity chart and find the gross allowed capacity for the applicable boom length, boom angle, load radius and operation quadrant.
- Use the load chart notes to determine the parts of hoist line reeved and which hook block to use.
- Use the load chart notes to determine specific load deductions, but generally it will be anything beneath the boom tip. This will be the block and hook or headache ball, wire rope, slings and rigging hardware. The load chart notes will indicate if a jib stowed on the boom must be deducted.
- The actual load weight will be the gross capacity minus the deductions.

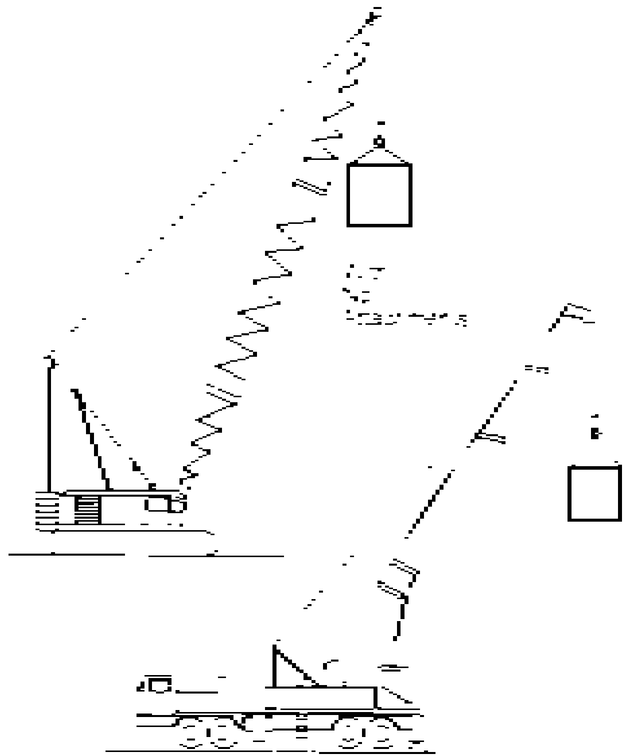


Illustration #292- Boom Capacity Without Attachments

Boom Capacity (With Attachments)

The following basic requirements are used to calculate boom hoisting capacity with a jib or boom extension attached:

- Use the load capacity chart and find the gross allowed capacity for the applicable boom length, boom angle, load radius, and operation quadrant.
- Use the load chart notes to determine the parts of hoist line needed and which hook block to use.
- Use the load chart notes to determine the effective weight of the jib or extension and the attachments. These will be deducted from the boom capacity.
- Use the load chart notes to determine specific load deductions, but generally it will be anything beneath the boom tip. This will be the block and hook or headache ball, wire rope, slings, rigging hardware, and/or the boom effective weight, either erected or stowed on the boom.

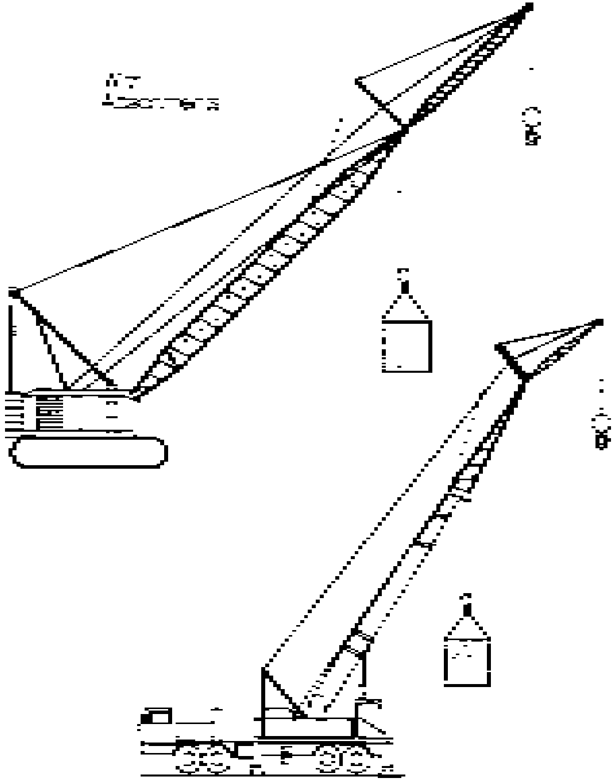


Illustration #256 - Boom Capacity With Attachments

Calculating Jib Capacity

Jib capacity can be checked by a chart from either the tipping factor in the boom chart, or the strength factor in the jib rating chart.

The following basic requirements are used to calculate jib capacity for either lattice or hydraulic boom cranes.

- Use the jib chart, the boom chart, and the chart notes to find the proper jib offset, boom angle, or jib to ground angle.
- Use the jib chart and/or the boom chart to determine the capacity.
- Use the chart to determine which headache ball and hook to use.
- Use the chart notes and tables to determine the load deductions. Generally these will be anything below the jib tip, including the jib hoist wire rope, the ball and hook, the rigging components, and the load. In addition, the wire rope, and the block and hook hanging from the main boom tip will be deducted, plus any boom extension stowed on the boom.

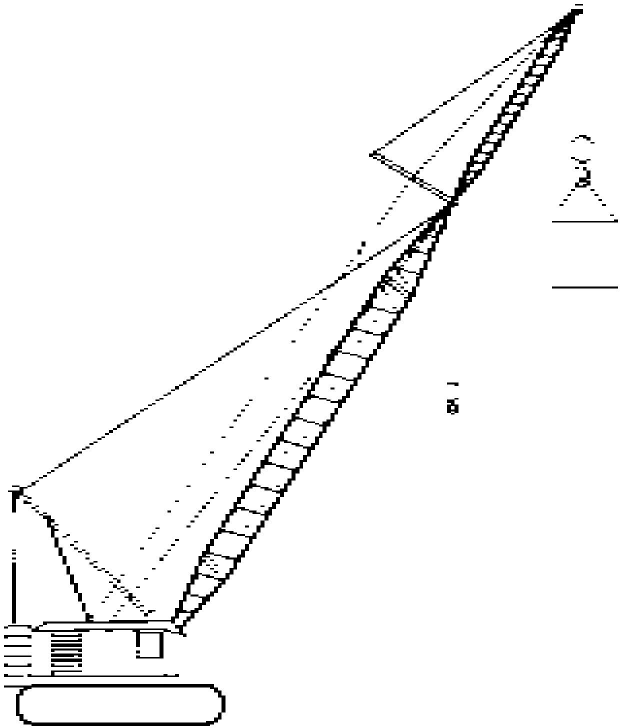


Illustration #294 – Jib Capacity

Jib Lifting Capacity

There are many jib combinations that can be used with each boom. As with the boom capacity charts, the conditions that the chart applies to are stated in the heading, and supplements the applicable capacity chart. All the requirements stated on both capacity chart and jib chart must be met before the jib chart can be used.

See table #57 for an example of a jib capacity chart.

30 ft jib

Jib Point Rad Feet	Capacities – Pounds Boom Length – Feet 150	1[illegible]	180	190	Jib Point Rad Feet
70	45 000	43 900	42 000	41 000	70
75	42 000	41 900	41 300	41 000	75
80	38 400	38 300	38 700	36 300	80
85	36 200	35 900	35 500	34 300	85
90	32 300	32 900	32 300	31 200	90
100	28 300	27 900	27 300	26 300	100
110	24 300	23 900	23 300	22 300	110
120	21 000	20 500	20 000	19 500	120
130	18 200	17 900	17 300	16 300	130
140	15 800	15 500	15 000	14 500	140
150	13 900	13 500	13 000	12 300	150
160	12 200	11 800	11 200	10 700	160
170	10 700	10 300	9 700	9 200	170
180		9 000	8 400	7 900	180

Table #57 - Jib Chart Example

Capacity Chart Points

The example used is a Manitowoc Crane:

Operating Radius: operating radius is the horizontal distance from the axis of rotation to the center of vertical hoist line or load block with the load freely suspended. Add 14 inches to boom point radius for radius of sheave when using single part hoist line, see illustration #295.

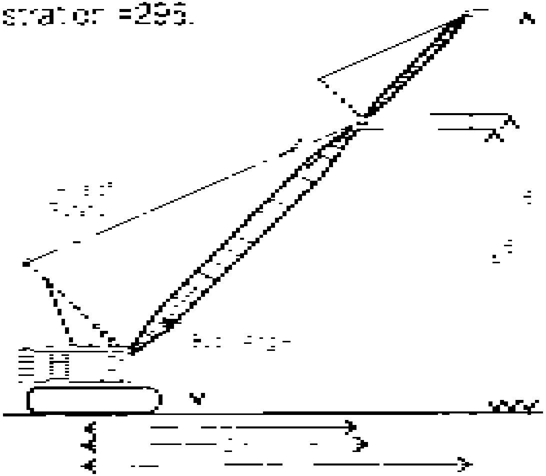


Illustration #295 - Operating Radius and Boom Extension

1. Operating radius - main load line - lower boom point.
2. Operating radius - whip line - upper boom point.
3. Operating radius - jib line - jib point.

The boom point elevation, in feet, is the vertical distance from ground level to centerline of boom point shaft.

4. Boom point elevation - main load - lower boom point.
5. Boom point elevation - whip line - upper boom point.
6. Jib point elevation - jib line - jib point.

The boom angle is the angle between horizontal and boom butt centerline and it is an indication of operating radius. In all cases, operating radius shall govern capacity.

Load Calculation (Example One)

The following is a step method of calculating the crane limit when lifting with the main load line. The two charts used are samples only. With this example, all hoist lines below the boom and jib must be included for weight.

Step 1. The load block weighs 4,550 lbs. and the rigging weighs 760 lbs.

Step 2. Determine the parts of line for the main load block:

1. Load Block = 4,550 lbs.
2. Slings = 760 lbs.
3. Weight of Load = 49,600 lbs.
4. Total = 54,910 lbs.

Hoist reeving for main load block must have equal or greater capacity than the weight to be lifted. From table #58, use 65,000 lbs., which corresponds to a two part line.

Step 3. Determine the total weight of the jib, headache ball, hook and line (table #5, page 28), which is included in the overall weight. Assume 20 feet of line hanging from jib.

1. Jib Weight = 3,500 lbs.
2. Jib Line (20 ft of 1 1/8" @ 2.34) = 47 lbs.
3. Headache Ball and Hook = 950 lbs.
4. Total Jib Components = 4497 lbs.

Step 4. Determine the approximate weight to be lifted:

1. Weight of load = 49,600 lbs.
2. Rigging attachments = 760 lbs.
3. Jib components = 4497 lbs.
4. Load Block = 4,550 lbs.
5. Load block line weight (approximate) = (boom is 240 ft.) x (2 parts line) x (2.34 lbs. per ft.) = 1123 lbs.
6. Total Approx. Lifted Weight = 60,530 lbs.

Table #58 - Hoist Reeving Example for Main Load Block

No. Parts of Line	1	2	3	4	5	6	7	8	9	10	11	12
Max Load - Lbs	32,500	65,000	97,500	130,000	162,500	195,000	227,500	260,000	292,500	325,000	357,500	400,000

Step 5. The approximate weight is 60,530 lbs. From the load chart table #58, with crawlers extended, the crane capacity is 64,800 at a 55 foot radius and with a boom point elevation of 241.5 feet.

As the boom tip elevation is 241.5 feet, the actual line weight will be: 241.5 x 2 x 2.34 lbs = 1130.2 lbs. The actual total lifted weight will be 60,537 lbs.

Note: Some load charts do not show the actual boom height to get this exact line length. Ensure the load chart being used belongs to the right crane.

Crawlers Extended: The total lifted weight is 60,497. With crawlers extended and operating at a 55 foot radius, the load is within the safe range of the crane capacity of 64,800.

Crawlers Retracted: If the crawlers were retracted, the crane capacity is reduced to 56,100 at a 55 foot radius.

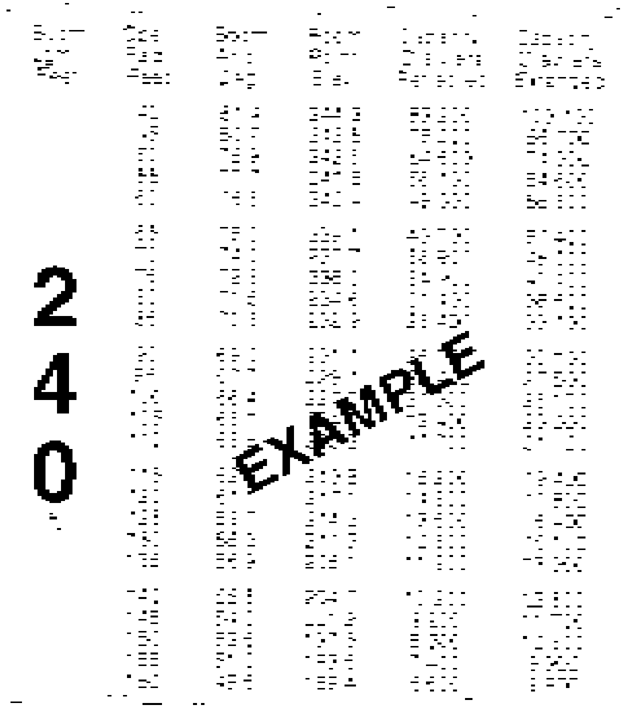


Table #58 - Capacity Chart Example

Maximum Radius Allowable With Lifting (no load): The weight of the jib components, plus the load block, wire rope (block lowered), and slings would be approximately 10,897 lbs. The next highest chart rating is 11,700, which means this boom cannot be lowered under 54 degrees at a 145 foot radius with no load other than the attachments.

Note: When going below grade level, all hoist lines must be considered.

Note: Due to variations, check the crane load chart to find exactly when, and how much, of the load line and jib line wire rope is added to the load weight total.

Load Calculation (Example Two)

Typical load and information charts are used for this example, however, remember that every manufacturers chart will be different. Always use the chart that belongs to that particular crane.

JIB CAPACITIES IN POUNDS
24 ft. JIB and 32 ft. EXT. Combination

Main Boom Angle	Min. 5 Offset	17 Offset	Max. 30 Offset
[illegible]	6,000	5,200	4,500
[illegible]	4,300	3,540	3,550
65	3,430	3,200	[illegible]
60	2,750	2,500	[illegible]
55	2,220	[illegible]	[illegible]

Table #50 - Jib Capacity Example Two

WEIGHT REDUCTION FOR LOAD HANDLING DEVICES

32 ft BOOM EXTENSION	
* STOWED	- [illegible] lbs
# ERECTED	- [illegible] lbs
24 ft JIB & 32 ft EXT COMB	
* ERECTED	- [illegible] lbs
# ERECTED	- [illegible] lbs
* Reduction of main boom capacities.	
# Reduction of 32 ft Ext capacities.	

Table #51 - Weight Reduction Example Two

HOOK BLOCK	
50 Ton 4 Sheave	[illegible] lbs
Auxiliary Boom Head	[illegible] lbs
5 Ton Headache Ball	[illegible] lbs
7 1/2 Ton Headache Ball	[illegible] lbs

Table #52 - Block Weight - Example Two

ON OUTRIGGERS FULLY EXTENDED									
Radius Feet	Boom Length – Feet								[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
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[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
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[illegible]						[illegible]	[illegible]	[illegible]	
[illegible]							[illegible]	[illegible]	
[illegible]							[illegible]	[illegible]	

EXAMPLE

Table #63 - Capacity Chart - Example Two

Example Two Information

1. 50 ton carrier hydraulic boom crane
2. 50 ton, 4 - sheave block, hanging 15 feet below boom tip, with 3/4 inch wire rope @ 1.04 lbs. per foot.
3. 32 foot boom extension, 24 foot jib @ 17 degrees offset.
4. 7 1/2 ton headache ball, with 3/4 inch wire rope @ 1.04 lbs. per foot.
5. Rigging components = 75 lbs.

In example two, the wire rope is considered only when more than the minimum required hoist reeving is in place on the unused block.

Example Two Questions

Question 1. – What is the net jib capacity when the boom is fully extended and is set at an angle of 59 degrees?

Answer 1. – The jib capacity is based on the main boom angle jib chart – Table #60). There is no rating for 59 degrees.

The next lower rating is 55 degrees, and with a 17 degree offset the capacity is 2,110 lbs.

Deduct: 50 ton block = 700 lbs.

Rigging = 75 lbs.

7 1/2 ton headache ball = 300 lbs.

4 parts of rope x 15 ft x 1.04 lbs./ft = 62.4 lbs.

TOTAL = 1,137 lbs.

The net jib capacity for question one would be 973 lbs. (2110 – 1137).

Question 2. – What is the maximum operating radius for a 2,700 lb load? The crane is set up similar to question one.

Answer 2. – The total load will be:

Actual load = 2,700 lbs.

Deductions = 1,137 lbs.

TOTAL = 3,837 lbs.

The closest rating in the jib chart with 17 degrees offset is 3,940 lbs. at 70 degrees.

Use the range diagram (illustration #296) to get the operating radius.

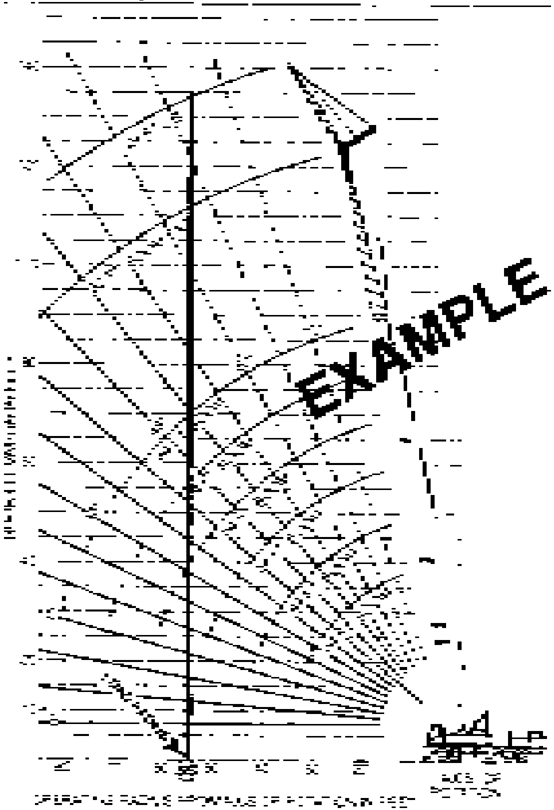


Illustration #296 – Range Diagram - Example Only

At a 70 degree boom angle with maximum length, the operating radius would be 55 feet.

Question 3. – Fully extended, what is the maximum capacity of the main boom with the boom extension and jib attached, and with the same equipment set up as in questions one and two? What will the load radius be?

Answer 3. – Add the deductions:

50 ton block = 700 lbs.

Rigging = 75 lbs.

7 1/2 ton headache ball = 300 lbs.

10 feet of single jib line @ 1.04 per foot

Effective weight of erected extension and jib = 5,825 lbs.

TOTAL = 6,910 lbs.

From the capacity chart, the 84 foot boom has a maximum capacity of 31,000 lbs. (boom angle = 76.5 degrees).

Deduct 6,910 lbs.

The net load would be 24,090 lbs. at a load radius of 20 feet (load chart).

Question 4. – The jib and boom extension have been removed and the extension is stowed. The same load block and rigging is used. Can a 10 ton load be positioned at a 35 foot radius with the boom fully extended?

Answer 4. – The actual load weight is:

Load = 20,000 lbs.

50 ton block = 700 lbs.

Rigging = 75 lbs.

Stowed boom extension = 290 lbs.

Total Load = 21,065 lbs.

From the capacity chart, follow across on the 35 foot radius. The capacity for the 84 foot boom is 20,280 lbs. The 10 ton load could not be safely positioned at 35 feet. The safest radius is at 30 feet with a capacity of 23,300 lbs.

Note: With a shorter radius, the boom tip will be higher, resulting in more wire rope and a slightly heavier gross load.

Tandem Crane Lifts

Any lift involving multiple cranes is a critical lift. Tandem crane lifts are complex and dangerous as crane capacities are based on freely suspended and balanced loads. The use of two, and often more cranes, may introduce side loading of the boom not normally encountered with one crane. The load must be divided as planned and the rigging so arranged.

A lift plan, as outlined earlier, including a rigging print outlining the entire operation must be prepared. This job plan would include: load calculation, crane selection, ground preparation, crane hook up, crane movements, and initial and final positions.

This plan must be prepared by qualified and experienced personnel. The preferable team to prepare this plan would be an experienced construction engineer, a rigging superintendent, and a crane operator. All, or at least one of these people should have previous experience on tandem lifts.

An example of a tandem lift is shown in Illustration #297.

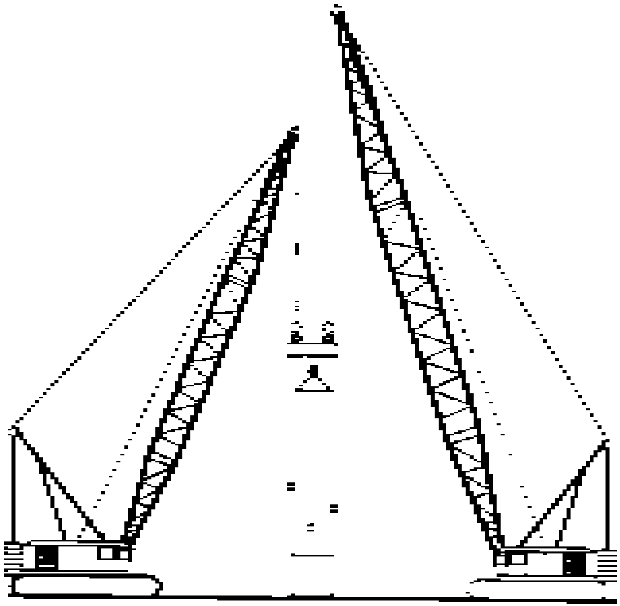


Illustration #297 - Tandem Lift Example

Tandem Lift Job Plan

Extreme care must be taken to include every detail in a job plan. Most of the usual requirements of a tandem or multiple lift are listed below:

1. Ground conditions must support the crane and the load. The ground must be levelled and compacted, (especially so if one or more cranes must travel with the load), and if necessary, blocking and floats provided for hydraulic machines and mats for crawlers. The cranes must be level.
2. The load and crane positions during the lift must be determined. With these positions determined, the load radius, boom length, and boom angle can be calculated for the entire lift operation. Special attention must be paid to the longest load radius.
3. The net load weight must be calculated. After the crane types have been selected, the gross weight of the load can be worked out, including the crane hook blocks and rigging components.
4. The order of #2 and #3 may be reversed. Sometimes it is possible to obtain cranes to match the site and the load; or if specific cranes must be used, the plan may have to be designed to suit the cranes.
5. All cranes must have their capacity calculated for the lift. None of the cranes should have more than a 75% load.
6. If different crane models are used, the operators will have to match line, boom, and swing speed. Unequal hoisting speeds will place extra load on one crane, and unequal swing rates will cause boom sideloading. All swing and boom motors, and crane travel must be kept to a minimum. An equalizer beam may help to share a load if hoist line speeds are difficult to match.

7. Operators, riggers and signalpersons must know exactly what the entire operation is, step by step. At least one dry run should be made. To avoid confusion and time delay, all communication should be made by radio. There must be one person coordinating the lift. This person must be in constant radio contact with all parties.
8. The operators must use extreme caution to maintain jerk-free movements. Hoisting, booming, or swinging requires smooth starts and stops. This will eliminate impact loading on the cranes. The operators, riggers, and signalpersons must constantly watch that the hoist lines are vertical. Off-vertical hoist lines means sideloading.
9. All cranes on a multi-crane lift must lift the load off the ground (or lower onto the ground) simultaneously. If not, one of the cranes will be overloaded.

Tailing Cranes

A tailing crane is often used when erecting a pressure vessel or structural component from a horizontal to a vertical position.

There are two basic tailing crane methods:

Illustration #298 shows the tail crane positioned behind the vessel. As crane #1 lifts the vessel, the tail crane #2 will walk in slowly, keeping the vessel bottom just clear of the ground. As the vessel comes up to the vertical position crane #1 will absorb more and finally, all of the weight.

Illustration #299 shows a tail crane positioned beside the pressure vessel. As crane #1 lifts the vessel, crane #2 will swing the bottom in. This move is a bit more complicated as crane #2 must swing, and also boom up and then down to maintain the same side distance as the vessel moves in to position.

Avoid using a choker type sling on a vessel unless necessary and properly rigged.

The sling could slip as the vessel changes position from horizontal to vertical.

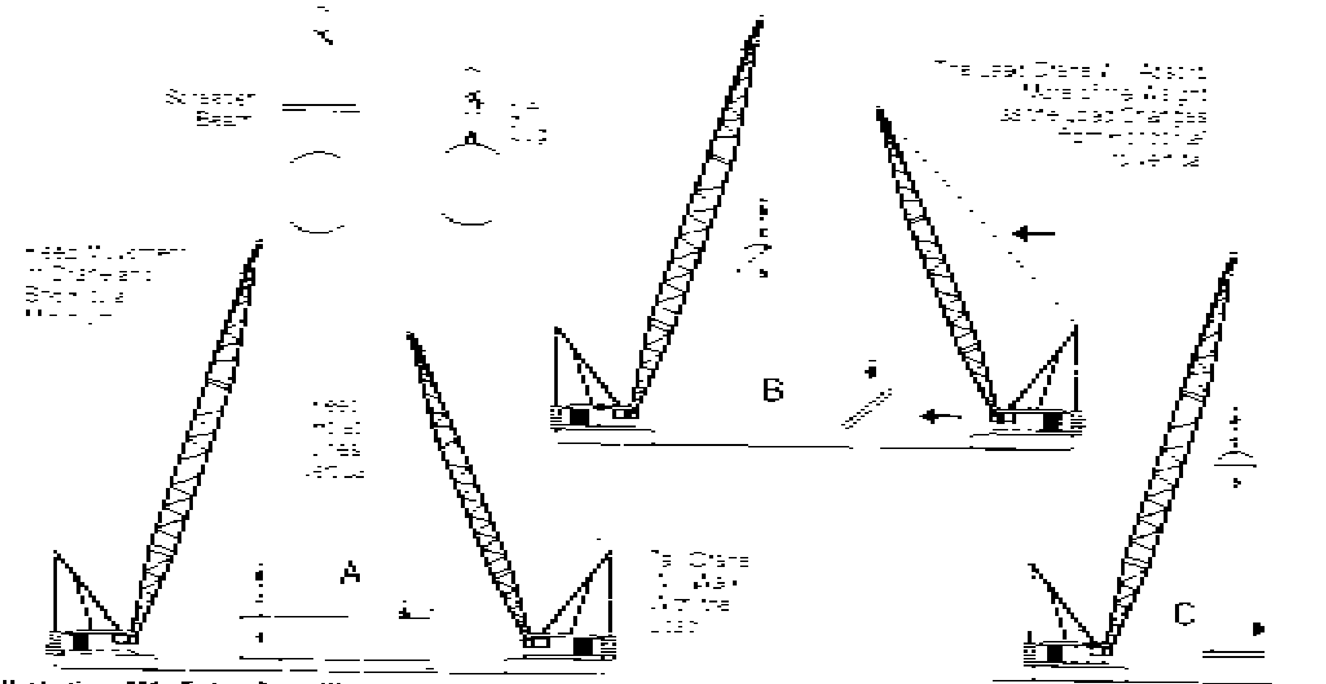


Illustration #298 - Tailing Crane Walking In With Load

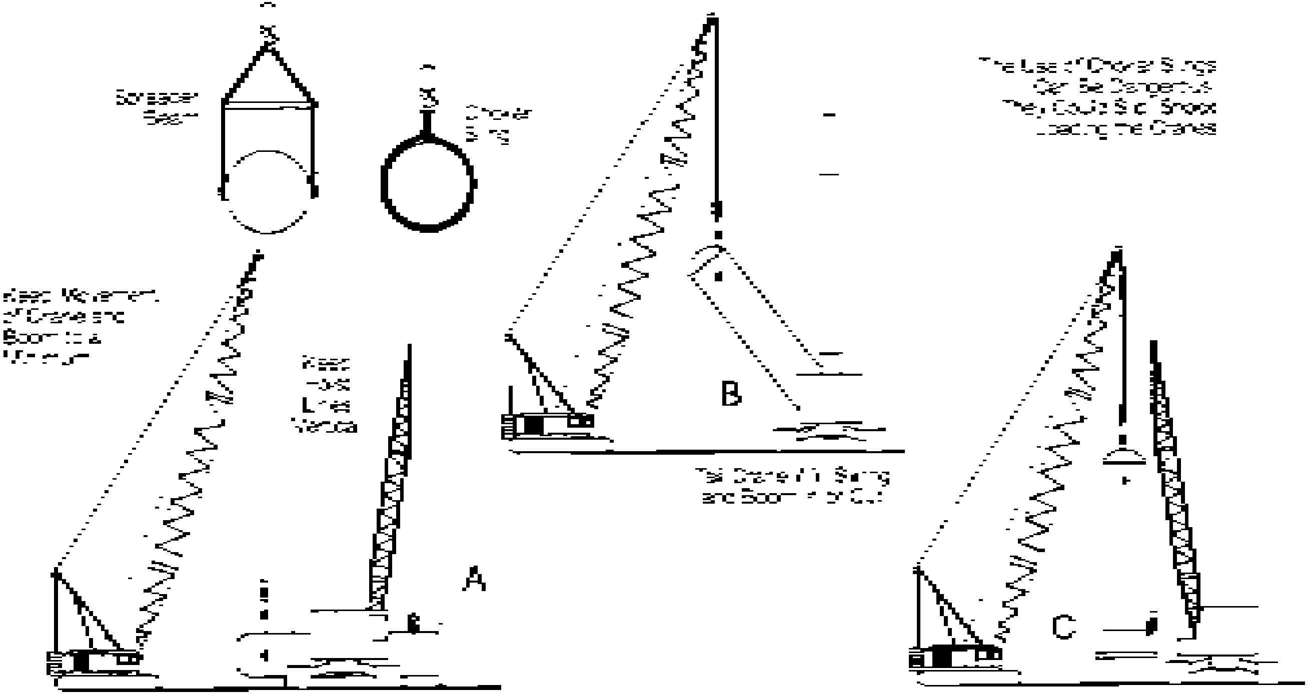


Illustration #299 - Tailing Crane Swinging With Load

Tandem Lift (Unequal Loading)

When two cranes lift a load a determination must be made on the location of the lift points for each crane. This must be calculated to properly distribute the load according to the capacities of each crane.

If a load is non-symmetrical as in illustration #300, the center of gravity will be closer to one end. Therefore it is likely that one crane will be positioned to lift over half of the load weight.

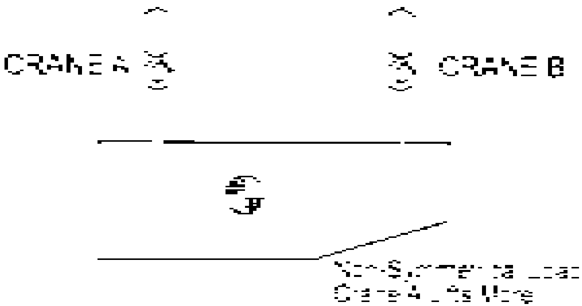


Illustration #300 - Tandem Lift - Non Symmetrical

If the load is symmetrical as in illustration #301, but one crane has less capacity than the other, the higher capacity crane could be positioned closer to the center to lift over half the load weight.

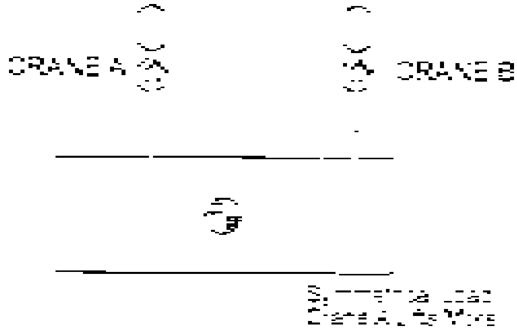


Illustration #301 - Different Capacity Cranes

Determine Lift Point Positions

1. In a tandem lift it is necessary that neither crane be loaded in excess of 75% of its rated capacity.
2. The capacity of each crane must be worked out by considering the load radius, boom angle, boom length, operation quadrants, rigging components and other deductions.
3. The calculated 75% capacities of the two cranes must combine to be greater than the load weight.
4. After the load center of gravity has been established, the two lift points are calculated by the following formula:

   (Net capacity CRANE A) x X =
   (Net capacity CRANE B) x Y
5. Estimate the position of CRANE A at the heavy end of the load. Measure this distance (X) to the center of gravity. See illustration #302.

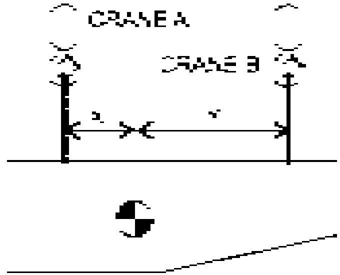


Illustration #302 - Determine Lift Points

$$\text{Distance Y} = \frac{\textit{Net capacity CRANE A}}{\textit{Net capacity CRANE B}} \times X$$

After calculating distance Y, measure it on the load to establish the position of CRANE B. If distance Y is not suitable, change distance X and recalculate distance Y.

Determine Load of Each Crane

The load carried by each crane can be calculated with the formula

$$\text{Load on CRANE A} = \frac{Y}{X + Y} \times \text{load weight}$$

$$\text{Load on CRANE B} = \frac{X}{X + Y} \times \text{load weight}$$

Tandem Lift Example (Illustration #303)

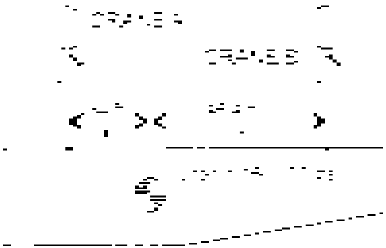


Illustration #303- Tandem Load Example

Net capacity CRANE A = 128,800 pounds

Net capacity CRANE B = 94,300 pounds

Total combined capacity = 223,100 pounds

Load weight = 160,000 pounds

Dimension X = 34 feet

$$\text{Dimension Y} = \frac{\text{Net capacity CRANE A}}{\text{Net capacity CRANE B}} \times X$$

$$Y = \frac{128{,}800}{94{,}300} \times 34 = 46.4 \text{ feet}$$

Determine Load on Each Crane (eg. one)

$$\text{Load CRANE A} = \frac{Y}{X + Y} \times \text{load weight}$$

$$= \frac{46.4}{34 + 46.4} \times 160{,}000 = 92{,}338 \text{ lbs}$$

CRANE A cap. = 128,800 x .75 = 96,600 lbs

CRANE A has a safe lift.

$$\text{Load CRANE B} = \frac{X}{X + Y} \times \text{load weight}$$

$$\frac{34}{34 + 46.4} \times 160{,}000 = 67{,}662 \text{ lbs}$$

CRANE B cap. = 94,300 x .75 = 70,725 lbs

CRANE B has a safe lift.

Tandem Lift Load Change

If the load sharing distribution of two cranes is to remain constant, both cranes must lift and lower in unison. If one end is lifted off the ground before the other, or if one end is lowered onto the ground first, the weight distribution is changed. This could easily place one crane in an overload situation.

Load Change Example (Illustration #304)

On a consistent lift the load on both cranes will remain at 90,000 pounds each (illustration #304A).

CRANE A = 90,000 pounds

CRANE B = 90,000 pounds

When CRANE B lowered its end (illustration #304B), crane A has a significant load increase.

CRANE B = no load

$$\text{CRANE A} = \frac{34}{50} \times 180{,}000 = 122{,}400$$

CRANE A increase = 32,400 pounds

When applying the 75% tandem lift factor, this increase could bring CRANE A close to or over its capacity limit.

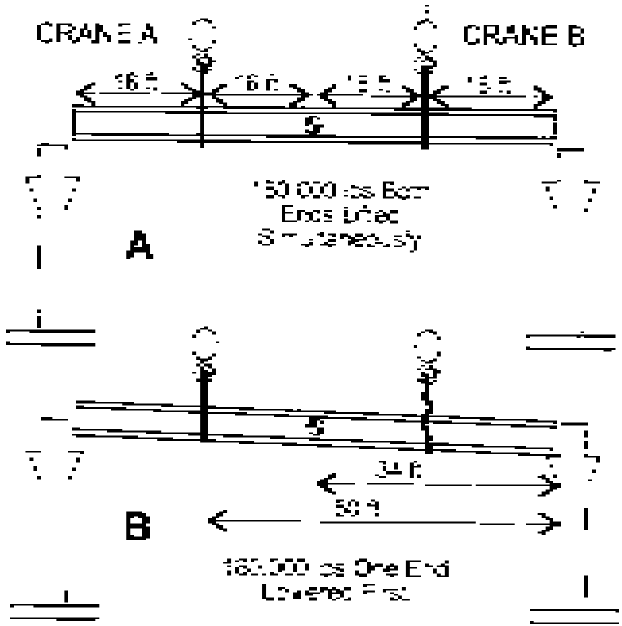


Illustration #304 - Determine Load Change

Tandem Lift With Equalizer

1. A tandem lift with an equalizer beam is similar to other multi-crane lifts in that none of the cranes should be loaded in excess of 75% of the rated capacity. The advantage of an equalizer is that if necessary, the load can be repositioned on the beam to suit the lift capacities of the two cranes.
2. The capacity of each crane must be calculated by determining the load radius, boom angle, boom length, operation quadrants, plus all crane deductions. The load radius is at the lift point, not the center of gravity of the load.
3. The distance between the lift points (Z in illustration #306) must be measured.
4. The lift points of each crane can be worked out with the formula (Z = X + Y):

$$X = \frac{\text{Capacity CRANE B}}{\text{Total Capacity CRANES A + B}} \times Z$$

$$Y = \frac{\text{Capacity CRANE A}}{\text{Total Capacity CRANES A + B}} \times Z$$

5. The load on each is determined by the formula:

$$\text{CRANE A load} = \frac{Y}{Z} \times \text{load weight}$$

$$\text{CRANE B load} = \frac{X}{Z} \times \text{load weight}$$

The actual load weight will include the beam and beam to load rigging.

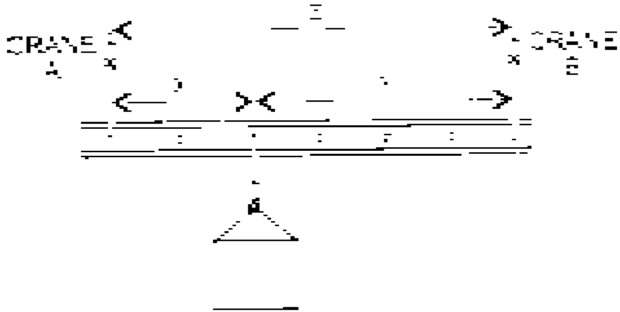


Illustration #306 Tandem Lift With Equalizer

Note: All custom made spreader and equalizer beams must be engineered, and must be load tested at 125% of their rated capacity and have the capacity clearly stamped.

Equalizer Lift Example (Illustration #306)

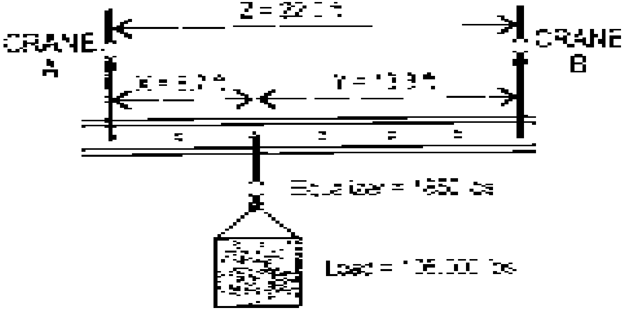


Illustration #306 - Tandem Lift With Equalizer Example

Net capacity CRANE A = 96,400 pounds

Net capacity CRANE B = 62,900 pounds

Load weight = 106,000 pounds

Equalizer weight = 1850 pounds

Distance Z = 22 feet

CRANES A + B = 159,300 pounds

159,300 x 0.75 = 119,475 pounds

(This will allow a safe lift).

Determine Beam Lift Points

$$\text{Distance } X = \frac{\text{CRANE B}}{\text{CRANE A + B}} \times Z$$

$$= \frac{62{,}900}{62{,}900 + 96{,}400} \times 22 = 8.7 \text{ ft}$$

$$\text{Distance } Y = \frac{\text{CRANE A}}{\text{CRANE A + B}} \times Z$$

$$= \frac{96{,}400}{62{,}900 + 96{,}400} \times 22 = 13.3 \text{ ft}$$

Determine Loads on Each Crane

CRANE A load = $\frac{Y}{Z}$ x load + beam

$$= \frac{13.3}{22} \times 107,650 \text{ lbs} = 65,230 \text{ lbs}$$

CRANE A capacity = 96,400 x .75 = 72,300

This is a safe lift for CRANE A.

CRANE B load = $\frac{X}{Z}$ x load + beam

$$= \frac{8.7}{22} \times 107,650 \text{ lbs} = 42,650 \text{ lbs}$$

CRANE A capacity = 62,900 x .75 = 47,175

This is a safe lift for CRANE B.

Equalizer Load Changes

Load distribution changes when the beam lift angle changes. This distribution can be minor or very major.

In illustration #307, the load X - X', Y - Y' ratio stays the same. With the weight hooked just below the beam the load change will be minor.

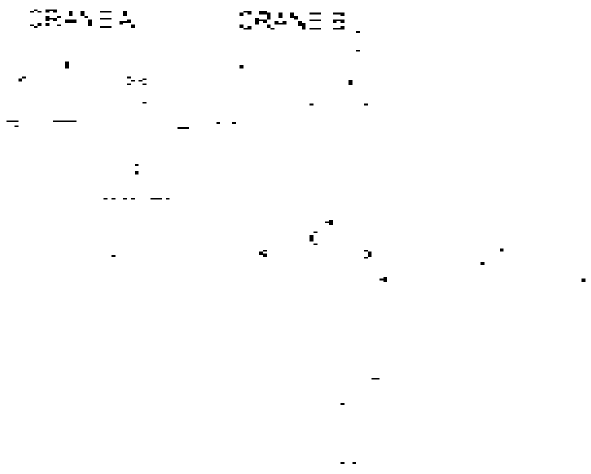


Illustration #307- Equalizer Load Change

In illustration #308 the load and its center of gravity is a solid, non-flexible, irregular shaped object.

When one end is lifted higher (crane A in this example), there will be a major load redistribution to CRANE A as the center of gravity moves left.

All of the careful crane load calculations mean very little if the load is not lifted and lowered evenly.

Note: This applies when the C of G is below the lift points.

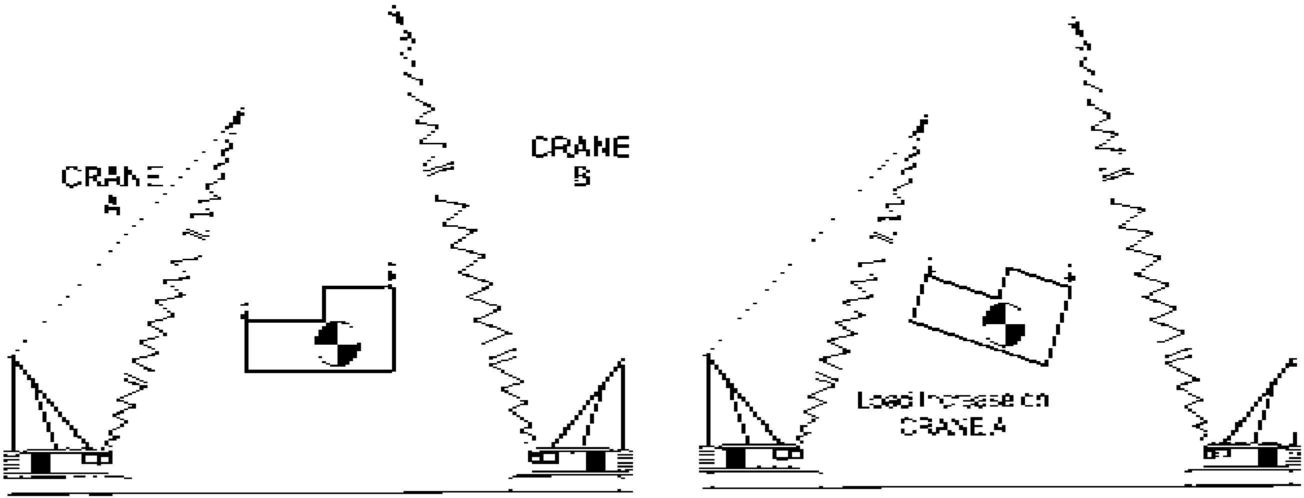


Illustration #308 - Equalizer Load Change

Conditions Affecting Capacity

There are several conditions that could affect the stability/strength of a crane. These could be caused by a lack of awareness by the operator or lift supervisor, or they could be caused by external forces.

The more common situations are listed below:

1. Improper outrigger use or setup. This includes not using all of the outriggers, or not being fully extended, which changes the operating quadrants; or not getting all of the wheels off the ground, which may not allow the full capacity on the load chart.
2. Ground condition. Soft ground should dictate the use of floats under the outriggers. Leaking water mains and steam lines, etc. could cause washouts below the surface. Do not assume that a crane on asphalt or concrete is stable as the ground below may be uncompacted.
3. Using the wrong counterweight will change either forward or backward stability of a crane.
4. Out of level conditions will dramatically alter the lifting capacity. Load chart capacities are based on a level crane.
5. Equipment in poor condition will change the strength or stability of a crane. Some of these include: lattice boom, hydraulic boom, structural welds, hydraulic pumps and hoses, rubber tire condition, equipment bearings, wire rope, outriggers, etc.

Other conditions which will be mentioned in the next several pages include:

- Wind
- Changing radius (swing out, machine deflection)
- Side loading
- Impact loading

Capacity Loss - Off-Level

Load capacity charts require the machine to be level in all directions no matter what the configurations.

Off-level conditions cause boom side-loading resulting in loss of capacity. See illustration #309.

When the crane is off-level, the load radius will change when the boom swings from the high to low side. This situation will also create extra stress on the turntable and other crane components. See illustration #310.

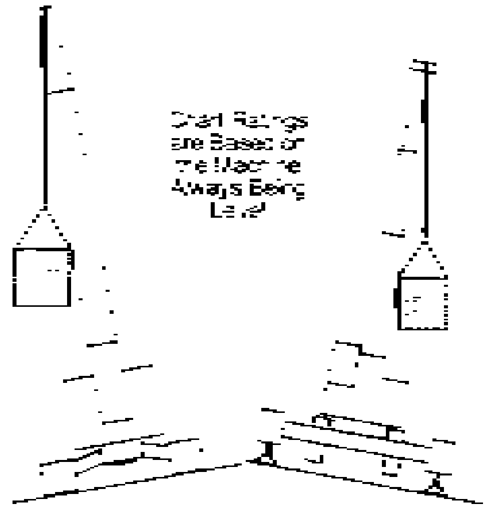


Illustration #309 - Off Level Boom (Capacity Loss)

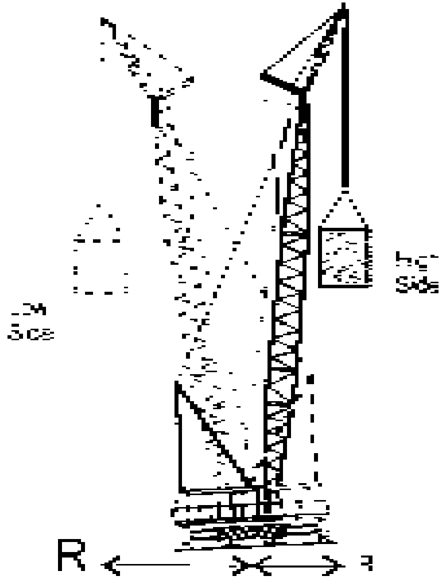


Illustration #310 - Off Level Boom (Radius Increase)

Capacity Loss - Side-loading

Boom side-loading occurs when the load is positioned to one side of the boom.

Hydraulic booms and their rams, and lattice booms are affected. Side-loading can cause rapid structural failure. See Illustration #311

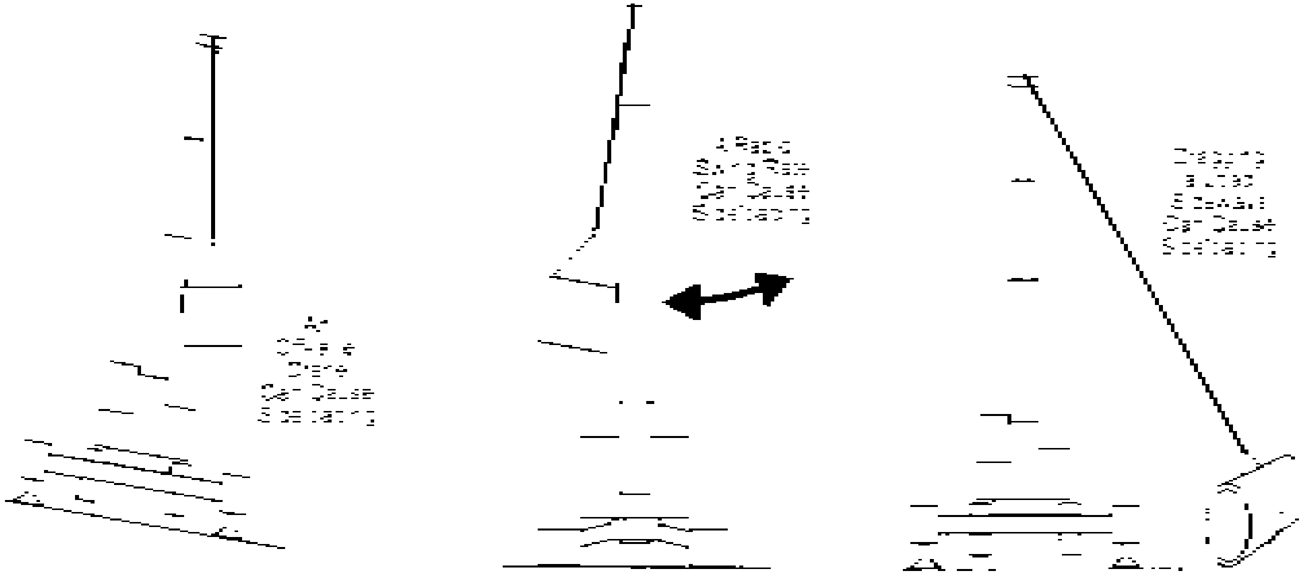


Illustration #311 - Boom Side-loading

Capacity Loss - Rapid Swing

If a boom is moved rapidly the load will not be able to catch up due to inertia and the flexibility in the load line. This positions the load behind the boom causing side-loading. See illustration #312.

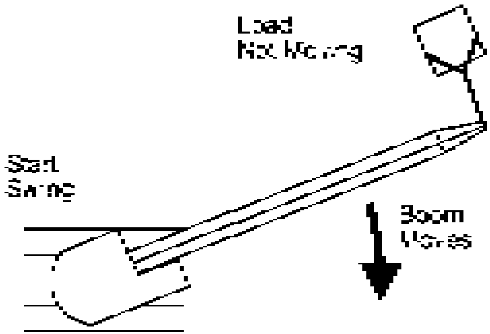


Illustration #312 - Load Cannot Catch Up to Rapid Swing

Rapid swing also causes the load to swing out, thereby increasing the radius, resulting in reduced capacity and boom side-loading. See illustration #313.

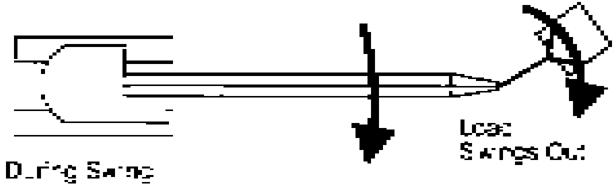


Illustration #313 - Rapid Swing Causes Load Rad. Increase

If the boom is moved rapidly and stopped, the load will continue to swing out past the boom tip causing side-loading. See illustration #314.

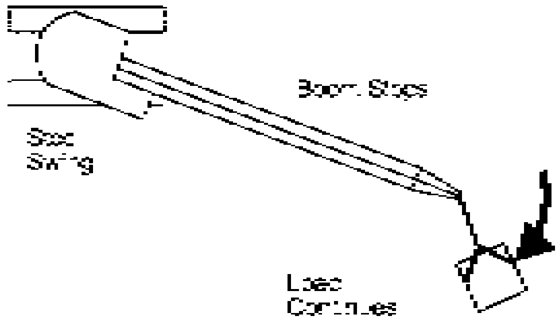


Illustration #314 - Boom Stops - Load Continues to Swing

***Note:** Use caution when swinging long boom cranes. The weight of the boom causes centrifugal force problems in starting and stopping which could result in collapse.*

Capacity Loss - Radius Increase

The load hoist line must remain vertical to maintain the load radius and the load chart rating. Several conditions can cause the load line to swing out thereby increasing the load radius and resulting in lost capacity.

In illustration #315 the load is initially hooked up beyond the boom tip resulting in the wrong radius and a swinging load.

Illustration #316 shows a crane hooked up with the load inside the boom tip. When the load is lifted it will swing out beyond the boom tip causing extra radius.

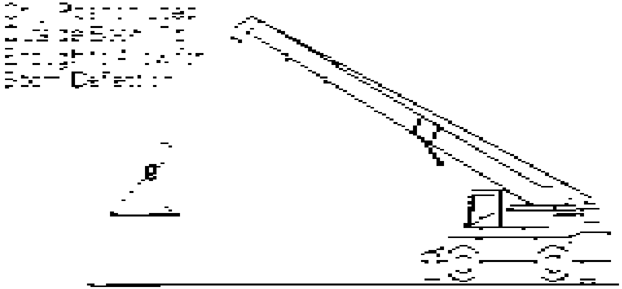


Illustration #315 - Lifting Beyond Boom Tip

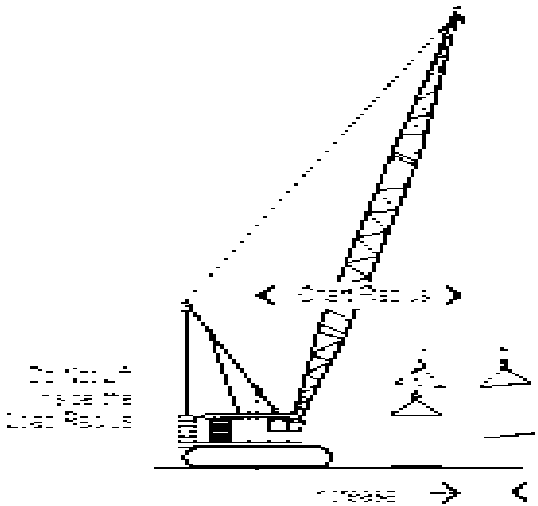
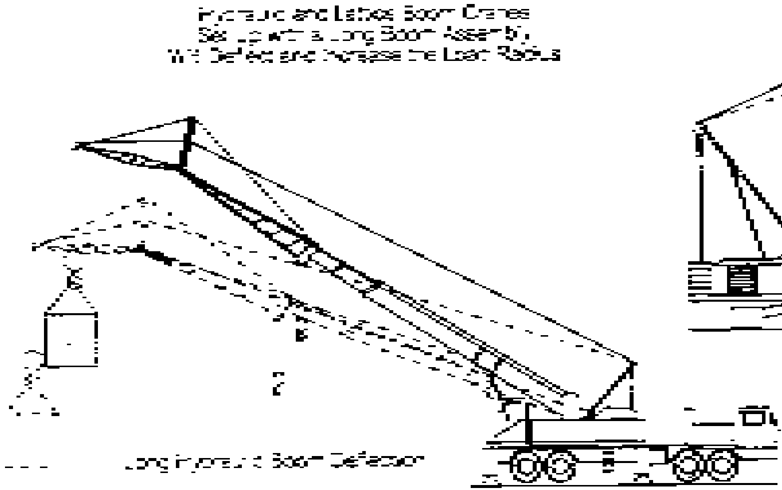


Illustration #316 - Lifting Inside Boom Tip

Illustrations #317 and #318 show cranes increasing the load radius due to deflection. As the load resists moving, the machine components will stretch, bend, give, and tighten up slightly, causing the boom tip to move down and out. This deflection is magnified on a machine on rubber tires.

Deflection also occurs due to decreased tipping radius when the boom is swung from over the rear to over the side.



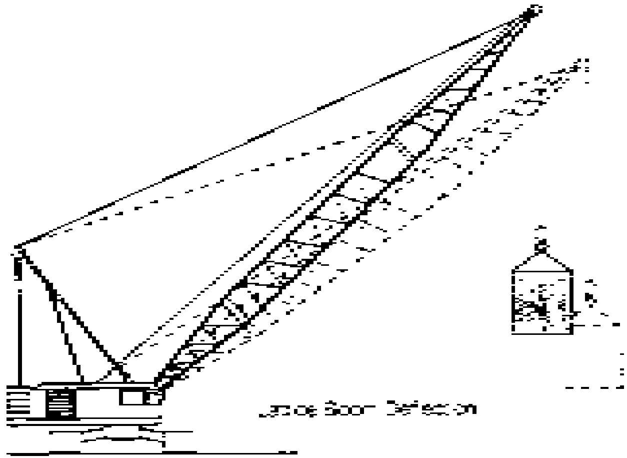


Illustration #317 - Long Hydraulic Boom Deflection

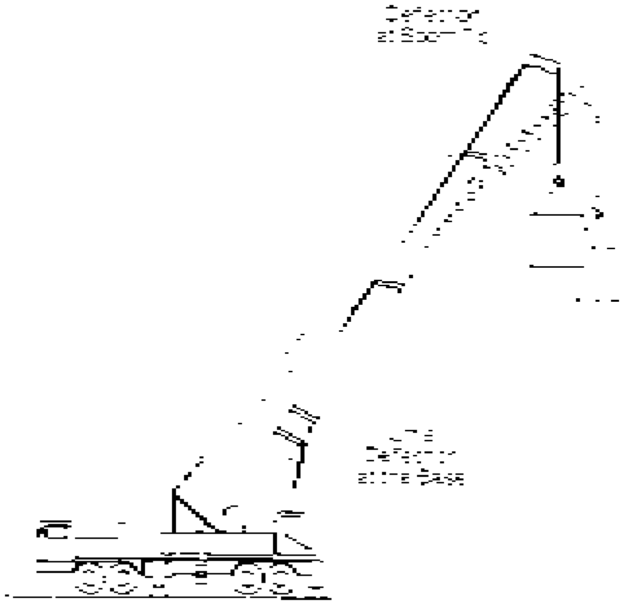


Illustration #318 - Bending Boom Causing Radius Increase

Capacity Loss - Wind Effect

The effect of wind on a crane can be devastating. This is especially true when a crane is rigged in a long boom configuration. Over the years there have been many cases of cranes and loads lost due to wind. See illustration #319.

The wind can push a boom and/or the load sideways causing side-loading.

Wind blowing from behind a crane exerts force on the boom, and helps push the load out past the calculated load radius.

Another result often not considered is that cranes can be (and have been) blown over backward. A long boom crane standing at its highest angle will be susceptible to this problem.

Hoisting activities should be restricted or stopped completely in windy conditions.

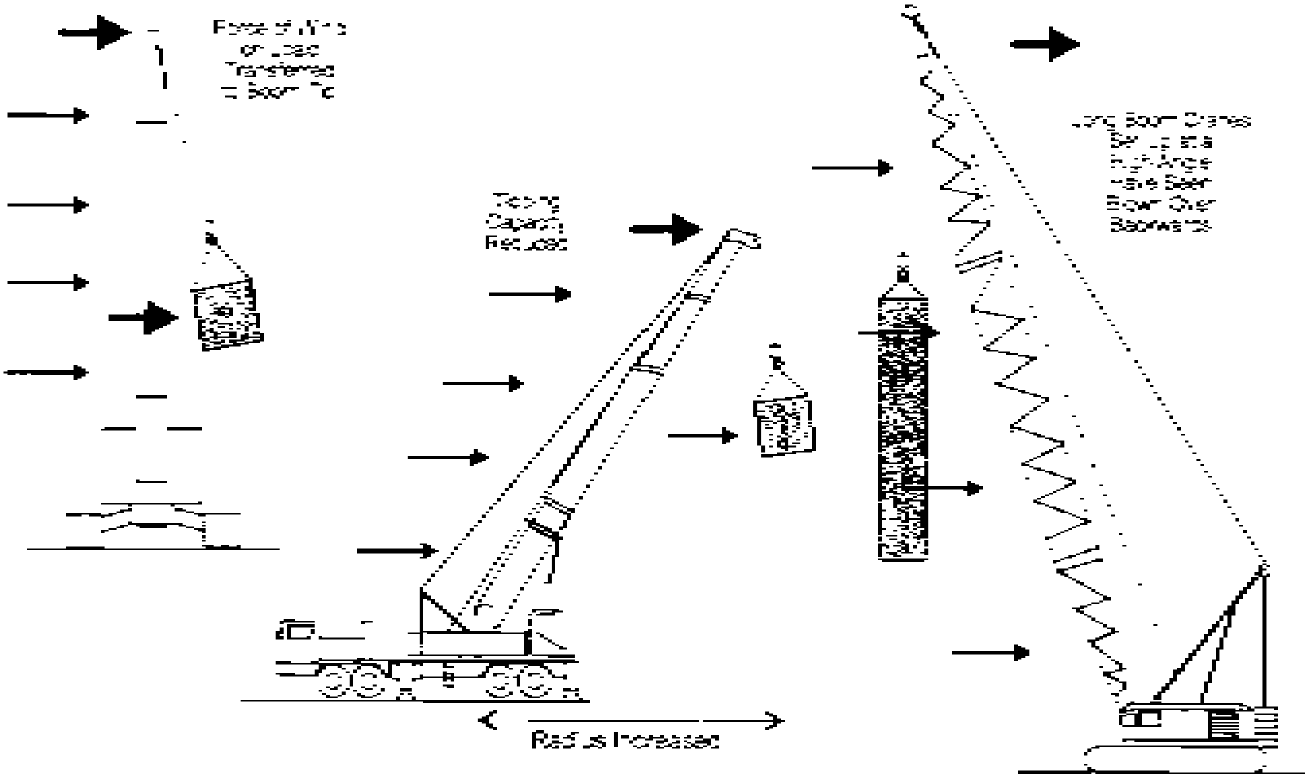


Illustration #319 - Wind Effects on Crane Booms

Capacity Loss - Impact (shock) Loading

Impact loads causing boom and crane problems can result from:

- Rapid acceleration (Ill. #320A).
- Sudden stopping (Ill. #320B, table #64)
- Sudden load release (Ill. #321A).
- Sudden load snatching (Ill. #321B)
- A rigging component vibrating from tension in the system
- Pick and carry operations

INCREASE IN HOOK LOADS WITH VARIOUS LINE SPEEDS

LINE SPEED FT/MIN.	STOPPING DISTANCE (FT) 10	6	2
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Table #64 - Hook Travel Load Increase

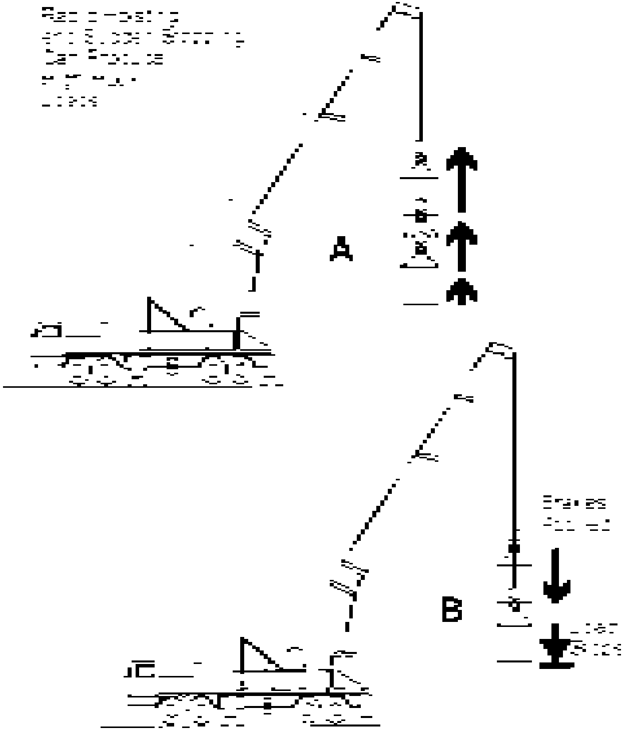


Illustration #320 - Impact Loading

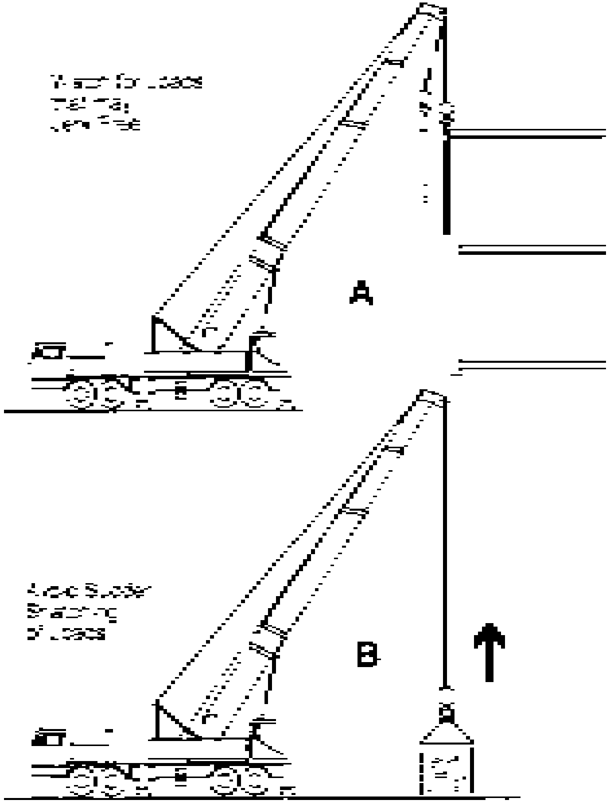


Illustration #321 - Impact Loading

Capacity Loss - Duty Cycle

Cranes that operate in a continuous high speed production operation may not have the full load chart rating. These types of cranes would be in draglines, steel erection, concrete placing, magnet work, etc.

It is quite possible that these cranes will have a separate lower capacity load chart, or will be down-rated by approximately 20%.

The reduction in capacity is due to the extra stresses imposed by the continuous or high speed operation, which causes impact loading, high speed load swingout, and boom side-loading. They also cause extra wear and strain on the mechanical parts.

Traveling with a Load

All capacity ratings are based on the crane being used in a stationary position. This also applies to models designed for pick and carry operations. Traveling with suspended loads entails many variables, including:

- Type of terrain
- Boom length
- Stopping and starting momentum

It is impossible to establish a single standard rating procedure with any assurance of safety. Therefore, when traveling with a load, the prevailing conditions must be evaluated to determine the applicable safety precautions.

Precautions to be followed during pick and carry operations:

- Keep the load as close to the carrier as possible.
- Keep the boom as short as possible.
- Keep the boom as low as possible.
- Load and boom to be carried in line with the direction of travel and in line with the axis of the crane.
- Rough terrain crane - boom and load must be over the front.
- Carrier mounted crane - (engine at rear) boom and load over the rear.
- Crawler - boom and load over the idler end.
- Loads - should be carried close to the ground and tied back to the carrier or controlled with tag lines.

Use extreme caution if the load is behind the direction of travel (illustration #322). If the load is not snubbed to the crane, the load could swing out when the crane starts, thus allowing the crane to walk out from the load and tip over.

Never make any sudden starts or stops. In illustration #323, a sudden start could push the boom over backwards.

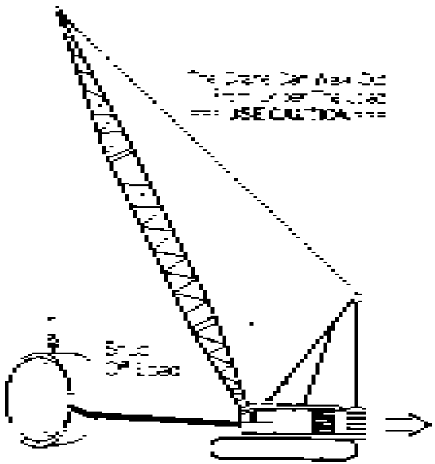


Illustration #322 - Snub Load to Crane

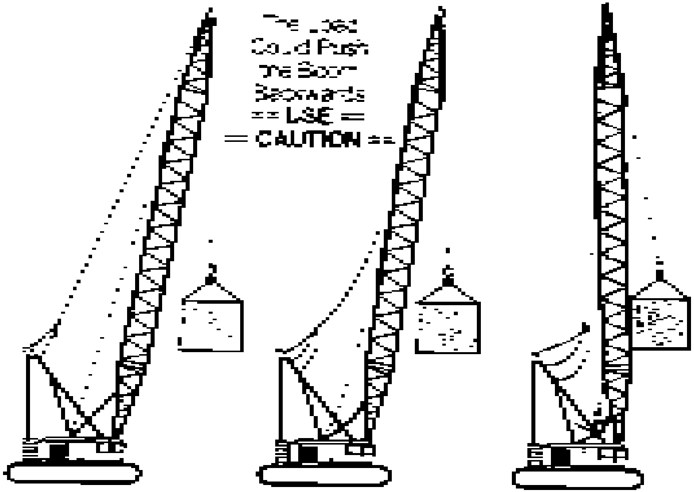


Illustration #323- Effect of Traveling With High Load

Note: Snub the load to the crane to avoid swingout.

Telescoping Booms

Most telescoping boom cranes have a sequencing valve that extends the sections of a hydraulic boom equally. Booms on machines with several boom extension levers will have to be equally extended by the operator.

The load chart is based on the boom sections being equally extended. If the boom sections are not equally extended, the chart readings are not accurate and the longer extended section may be overloaded.

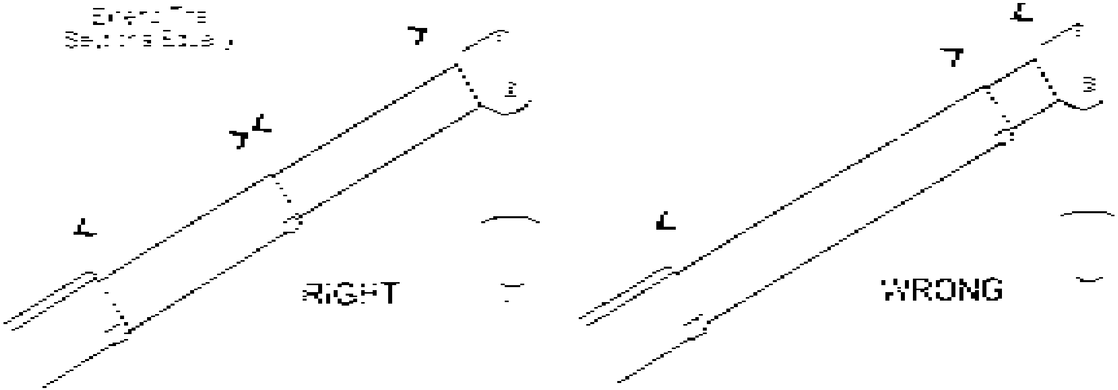


Illustration #324- Right and Wrong Boom Telescoping

Boom Contact Hazard

Keep the load clear of the boom (illustration #325). A load must never be permitted to swing and hit the boom. The boom must not bump any object while swinging or lowering.

If the boom is lowered onto an object, the boom load changes from compression to bending. Any bending force or dented member could allow the boom to collapse.

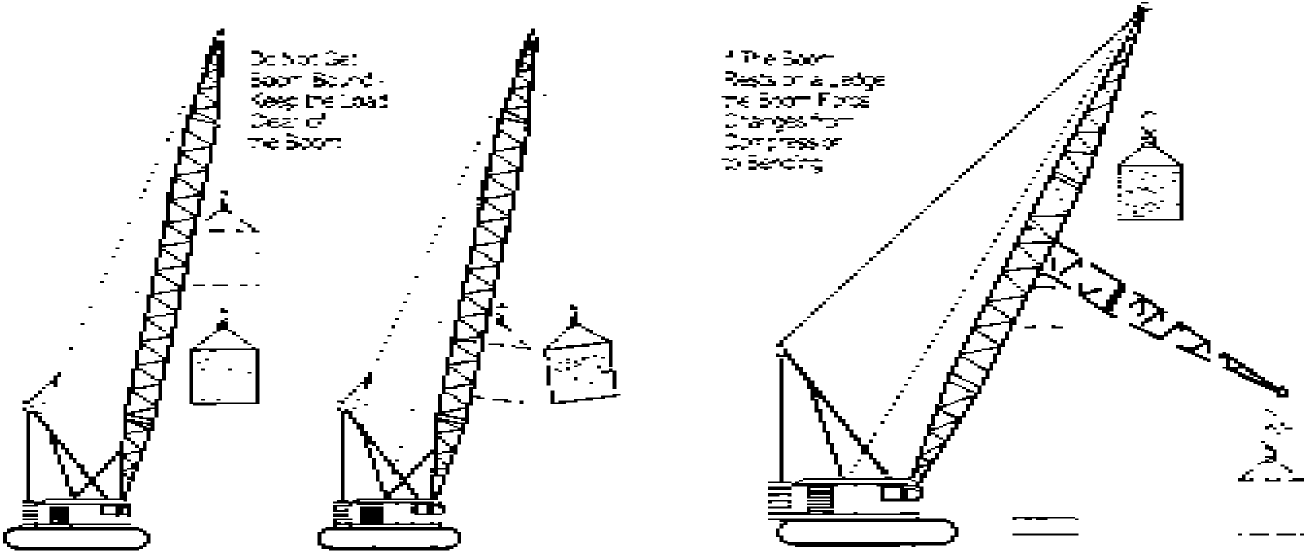


Illustration #325 - Avoid Boom Contact

Anti Two-Block Device

Two-blocking occurs when the hook block is pulled up into the boom tip sheaves. The wire rope can be cut, damaged, or overloaded.

This can happen for several reasons, including simply pulling the block up into the sheaves, or lowering the boom when the block is too close to the boom tip (Illustration #326).

On hydraulic booms it can occur when the boom is extended and the load line is not played out to suit the extra length (Illustration #327).

Illustration #326 – Boom Lowering Two-Blocking

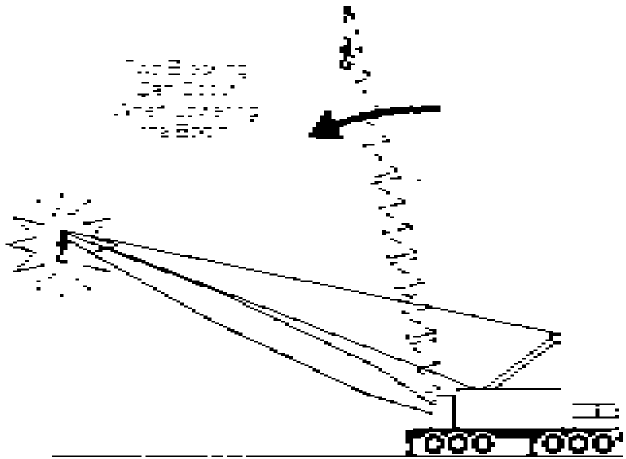


Illustration #327 – Boom Extension Two-Blocking

All cranes should be equipped with an anti-two-block device. This device should be included with most computerized operational aid warning systems. If the anti-two-block system or warning device is not working, ANSI requires someone to watch the boom tip to prevent two-blocking. Do not hoist personnel if the anti-two-block device is not working properly.

A typical system has a weight hanging off the upper sheave casing. If the block comes up and hits the casing, a limit switch solenoid is tripped. See illustration #328.

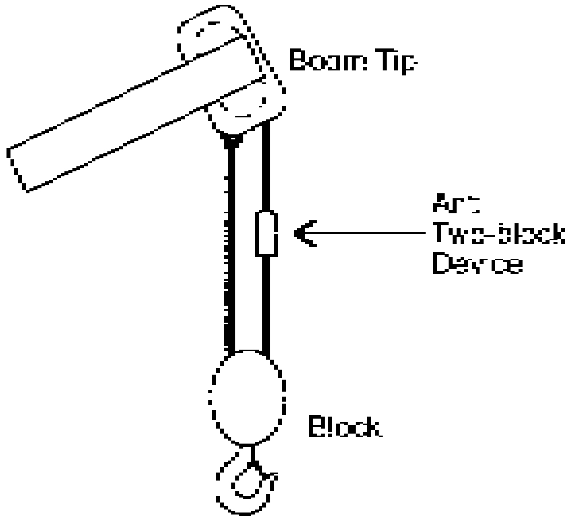


Illustration #328 – Anti-Two-Block Device

Note: ANSI/OSHA regulations require a working anti-two-block device on any crane hoisting a personnel basket.

Electrical Clearances

Accidental electrocutions are among the most frequently repeated crane accidents. Most of these are caused when the boom contacts or approaches too close to overhead power lines. The fatality rate is high, particularly among riggers guiding the load. Inexperienced boom truck operators are another cause of high fatalities.

While the danger is greater from high voltage transmission lines, where flashover can occur without actual contact, fatal accidents have resulted from contact with 440 volts and 220 volt service lines and shunt lighting systems.

The safest procedure is to request the local electrical authority to cut off the power.

If, for any reason this is not possible or practicable, and it is necessary for cranes to be under or near hot power lines, see table #65 for guidelines.

Electrical Hazards Clearance Guide

OPERATING NEAR HIGH VOLTAGE POWER LINES

Normal Voltage (Phase to Phase)	Minimum Required Clearance
to 50 kV	10 ft. (3.05 m)
Over 50 to 200 kV	15 ft. (4.60 m)
Over 200 to 350 kV	20 ft. (6.10 m)
Over 350 to 500 kV	25 ft. (7.62 m)
Over 500 to 750 kV	35 ft. (10.67 m)
Over 750 to 1000 kV	45 ft. (13.72 m)

IN TRANSIT WITH NO LOAD AND BOOM LOWERED

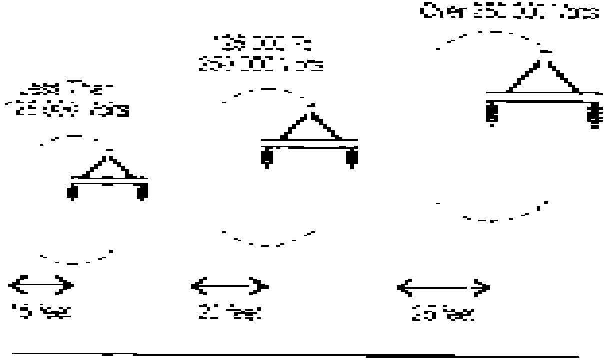
Normal Voltage (Phase to Phase)	Minimum Required Clearance
to 0.75 kV	4 ft. (1.22 m)
Over 0.75 to 50 kV	6 ft. (1.83 m)
Over 50 to 345 kV	10 ft. (3.05 m)
Over 345 to 750 kV	16 ft. (4.87 m)
Over 750 to 1000 kV	20 ft. (6.10 m)

Table #65 - Operating Near Powerlines

Absolute Limit of Approach

Every live powerline has an area around it called the limit of approach. A crane boom, load line, or load cannot operate in this area without the power being cut off. This is an absolute, no exception rule.

The absolute limit of approach will vary somewhat with provincial, state, federal or other regulating bodies; however the guidelines shown in table #65 and illustration #329 are close to those guidelines.



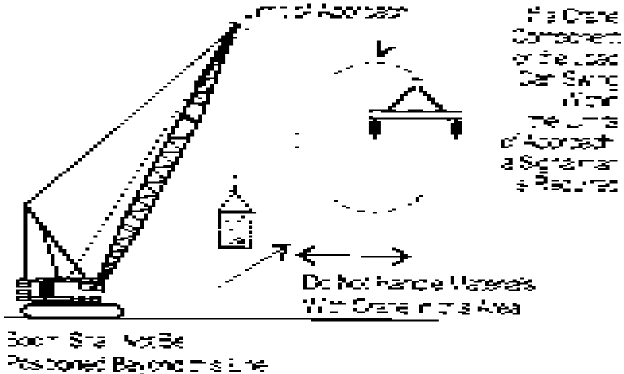


Illustration #329- Powerline Limit of Approach

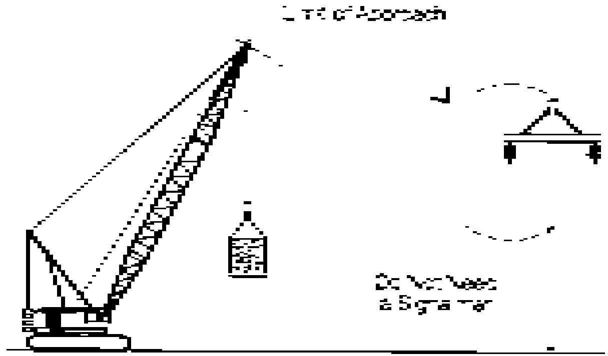


Illustration #330 - Use of Signalman Near Powerline

Powerline Approach Guidelines

1. Maintain a safe operating distance and always observe the absolute limit of approach.
2. A signal person must be used when the crane boom or the load can swing within the limit of approach (see illustration #330). The signal person must be positioned to estimate the minimum distance (see table #65) and warn the operator as the boom approaches the minimum distance. The person giving the signals must not have any other duties.
3. All powerlines must be considered as live. Do not change this assumption until proven otherwise by the line owner.
4. Always notify the utility company when operating near a powerline.
5. All personnel (except the operator) must stay away from the crane when it is near the limit of approach. Do not touch the crane or the load.
6. Only use taglines to control the load or keep it from spinning. All ropes conduct electricity, although dry polypropylene is better than the other types.
7. The operator should slow the crane operation near a powerline.
8. Warning devices and various types of insulators are not fail-safe. They all have limitations.
9. The absolute limit of approach should be increased when operating near long span powerlines as these lines will sway with the wind.
10. Use extreme caution when traveling with a crane under a powerline. Rough ground can cause a boom to undulate.
11. Use synthetic web slings.

Note: ANSI/ASME B30.5 code conditions apply to cranes working near powerlines. It may be necessary for a pre-lift meeting between the crane company and the utility company. Check the B30.5 code, then contact the utility company.

Powerline Contact

The operator should remain in the cab after powerline contact until the power has been disconnected. If this is not practical, the operator must not step from the crane. He must jump clear with both feet together, being careful not to touch the crane. See illustration #331.

After jumping clear, the operator must hop or shuffle to a safe area. The area around the crane will be energized, and a normal step may cause the operator to be the conductor between a high and low voltage area. See illustration #332.

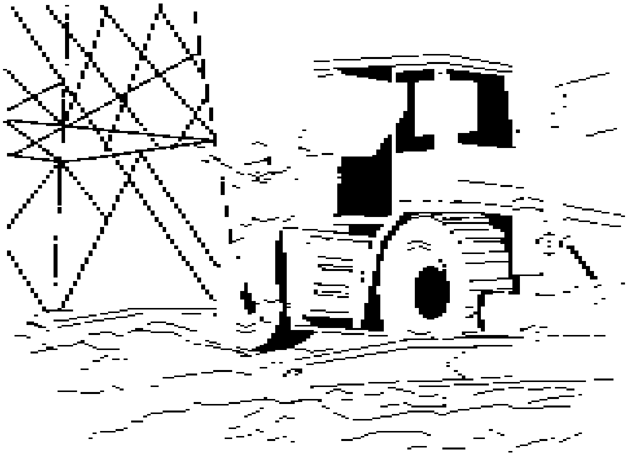


Illustration #331 - Jumping Clear of Crane after Contact

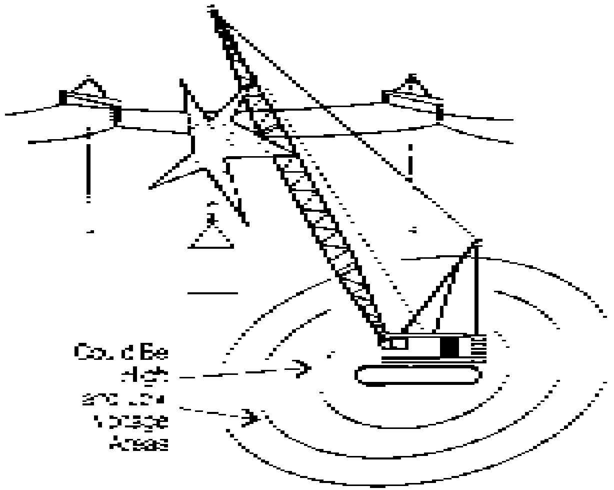


Illustration #332- Energized Zone Around Crane

After Contact

1. After contact the operator must not panic and make hasty moves. If he is not injured, he must assess the situation and warn others to stay away.

2. If the machine is still running, gently try to swing the crane away from the contact zone. If it breaks contact easily, move the boom well clear. If the crane boom or load line is welded to the powerline, do not try to break the contact.

3. Remain in the cab until the utility company de-energizes the line. If waiting is not possible, jump clear as per illustration #331.

4. The machine must be thoroughly inspected before reuse. If any of the crane wire ropes have been arced they must be replaced.

5. All powerline contact must be reported to the utility company as the line will have to be inspected and/or repaired to avoid breakage at a later date.

Crane Log Books

ANSI/OSHA/OH&S regulations require a separate logbook for every crane, derrick, or hoist. The book stays with that particular crane or hoisting device, and is transferred if it is sold. The book must be readily available to any Safety Inspection Officer.

Every crane or hoist component must be inspected on either a daily, weekly, monthly, periodic, or yearly basis and recorded in the logbook with each entry initialed and signed. The inspection time frame depends on the component, but the key operating components are inspected daily. Any accidents involving the equipment must be recorded. Operators must familiarize themselves with all recent entries prior to commencing operation.

Logbook data includes:

- Date and time of any work or repairs.
- Inspections, examinations, checks and tests including those specified in the manufacturer's instructions.
- Defects or deficiencies.
- Sizes and types of wire rope used, including any rigging information.
- Hours of service.
- Any matter or incident that may affect the safe operation of the crane or hoist.
- A record of certification complying with the appropriate requirements of the latest applicable edition of the standards for the country, state, province, or region.
- Any other operational information specifically identified by the manufacturer.
- For tower cranes, whether the weight-testing device was used before the lifting of materials commenced for the day.

Table 68A,B,C show a sample inspection timeframe for one type of carrier mounted hydraulic crane.

Check the specific crane logbook, as there will be variations in requirements from one manufacturer or crane model to another.

Daily = D, Weekly = W, Monthly = M, Periodically = P

Operators Cab General Items	
Overall Cleanliness	D
Window Glass	D
Signal Horn	D
Fire Extinguisher	D
Safety and Instruction Decals	D
Windshield Wipers	D
Heater Defroster	D
Air Conditioner	D
Flood Lights	D
Cab Lights	D
Fuel Gage	D
Engine Oil Pressure Gage	D
Water Pressure Gage	D
Ammeter	D
Drum Rotation Device	D
Computerized Operator Aids	D
Crane Level Indicator	D
Boom Angle Indicator	D
Boom Angle Limit Switch	D
Load Rating Charts	D
Operating Manual	M
Control Mechanisms	
Computerized Operating Aids	D
Swing	D
Swing Brake	D
Swing Lock	D
Boom Hoist Automatic Brake	D
Boom Hoist Overrunning Clutch	D
Boom Hoist Pawl	D
Main Hoist Automatic Brake	D
Main Hoist Overrunning Brake	
Main Hoist Free Fall Brake	D
Main Hoist Free Fall Clutch	D
Aux Hoist Automatic Brake	D
Aux Hoist Overrunning Clutch	D
Aux Hoist Free Fall Brake	D
Aux Hoist Free Fall Clutch	D
3rd Drum Automatic Clutch	D
3rd Drum Overrunning Clutch	D
Boom Telescope Function	D
Boom Synchronization Function	D
Boom Hoist Function	D
Anti Two Block Device	D
Outrigger Controls	D
Engine & Upperworks Components	
Radiator	D
Engine Oil Level	D
Engine Master Clutch Oil Level	D
Engine Master Clutch	D
Fuel Tank Level	D
Fuel Cap	D
Gear Boxes	D
Lubricating System	D

Table #66A Inspection Timeframes (part 1 of 3)

Item	Timeframe
Batteries	M
Engine Transmission Mounting Bolts	M
Air Cleaner	M
Engine Oil & Filter	M
Drive Belts	M
All Hoses	M
Loose Nuts & Bolts	M
Machine Guards	M
Exhaust System	M
Muffler Guards	M
Railings, Walkways	P
Crane Hydraulics	
Hydraulic Tank	D
Hoses & Fittings	D
Hyd. Tank Breather Filter	M
Hose Reel	M
Pumps & Motors	M
Valves	M
Cylinders	M
Magnetic Plugs	M
Swivel Assembly	M
Drums, Hoist Rope, Fittings	
Boom Pendants	D
Jib Pendants	D
Boom Hoist	D
Main Hoist	D
Auxiliary Hoist	D
3rd Drum	D
Sheaves & Guards	W
Hooks & Hook Blocks	W
Drums	M
Revolving Frame, Welded Components	
Boom Foot Lugs	W
A-Frame Anchor Lugs	W
A-Frame Pin Connection	W
A-Frame Sheaves	W
Swing Circle & Bolts	W
Boom	
Boom ID Decals	W
Boom Foot & Pins	W
Boom Chord & Lacings	W
Boom Splice Pins & Lugs	W
Boom Bearing Points	W
Boom Side Plates	W
Boom Sections	W
Rope Guards	W
Boom Point	W
Boom Backstops & Lugs	W
Hydraulic Cylinder Mounting	W
Jib	
Jib ID Decals	W
Jib Foot Pins	W
Jib Chords & Lacings	W
Jib Splice Pins & Lugs	W
Jib Point	W
Jib Backstop & Lugs	W
Jib Mast Foot Lugs & Pins	W
Jib Mast Backstop & Lugs	W
Jib Mast Point	W
Outriggers	
Attachment Lugs & Pins	W
Beam Bearing Points	W
Beam Housing	W
Vertical Cylinder Attachment	W
Floats	W

Table #88 Inspection Timeframes (part 2 of 3)

Counterweight	
Removal Device	[illegible]
Attachment Lugs	[illegible]
Pins & Bolts	[illegible]
Truck Carrier Inside	
Overall Cleanliness	D
Engine Oil Pressure Gage	D
Warning Lights & Buzzers	D
Air Pressure Gage	D
Low Air Warning Device	D
Parking Brake	D
Brakes	D
Horn	D
Windshield Wipers/Washers	D
Heater/Defroster	D
Mirrors	D
Steering Wheel Play	D
All Lights	D
All Glass	D
Fire Extinguisher	D
Warning Flags & Reflectors	D
Operator's Manual	[illegible]
Truck Carrier Outside	
All Lights	D
Windshield Wiper Blades	D
Mirrors	D
Tires, Wheels & Lugs	D
Fuel Tank & Cap	D
Engine Oil Level	D
Radiator	D
Drive Belts	D
Steering Gear	D
Air Compressor	D
Air Governor	D
Air Tanks & Lines	D
Hydraulic System	D
Hydraulic Reservoir & Filter	D
Outrigger Controls	D
Batteries	D
Master Cylinder	W
Air Cleaner	W
Thermostat & Hoses	[illegible]
Muffler & Exhaust	[illegible]
Muffler Guards	[illegible]
Clutch	[illegible]
Transmission	[illegible]
Transfer Case	[illegible]
Drive Shaft & U Joints	[illegible]
Differential	[illegible]
Front Axle	[illegible]
Rear Axle	[illegible]
Axle Cylinders	[illegible]
Shocks & Springs	[illegible]

Table #56C Inspection Timeframes (part 3 of 3)

Typical Crane Inspection Guide

- ***Engine Performance & Gages*** - check for any irregularities or power losses. Gages must be operational and legible.
- ***Oil Pressure and Levels*** - shall be within manufacturer's specifications.
- ***Housekeeping*** - the unit shall be clean of litter, grease and oil accumulations.
- ***Fire Extinguisher*** - an all-purpose fire extinguisher shall be fully charged, properly mounted and suitable for extreme cold weather conditions.
- ***Audible Warning Device*** - the device shall be operational and loud enough to be heard by workers in the vicinity.
- ***Rear View Mirrors and Lights*** - mirrors and lights including headlights, emergency flasher, interior and boom lights shall be clean and operational.
- ***Hydraulic Lines and Fluid*** - lines shall be free of nicks, bulges, abrasions or leaks.
- The level of the fluid shall be maintained and the fluid shall be reasonably clean.
- ***Windshield, Wipers and Door Locks*** - windshields shall be clean, free of cracks, hazing, discolouration and frosting so as not to affect visibility. Wipers are to be operational. Cab doors shall have key lockable devices.
- ***Batteries and Charging Systems*** - battery fluids shall be kept at the proper level and maintained by an operational charging system.
- ***Hand Signal Chart*** - the chart is to be mounted on the unit in a conspicuous place. Additional copies shall be available for reference purposes.
- ***Load and Radius Chart*** - chart is to be mounted where operator can see it while working or where it is immediately available for reference.
- ***Guards*** - all exposed gears, drive belts, pulleys, clutches and brakes shall be adequately guarded.

- ***Clutches*** - all bands and plates shall be properly lined and in good condition. The operation shall be smooth with no grabbing.
- ***Outriggers*** - outriggers shall extend and retract completely with pins and retainers in good operational condition. Check valves shall be protected where required. All levelling devices must be operational and legible.
- ***Brakes*** - all brakes shall be fully operational. When parking brake is applied how many wheels lock up? Check
- ***Boom Hoist Pawl*** - shall be fully operational and in good working condition.
- ***Swing Dog and Brake*** - operation shall be smooth and the brake shall engage properly.
- ***Track, Drive, Lugs and Pins*** - check for excessive wear, missing or broken parts.
- ***All Rollers Including Under Carriage Rollers*** - shall be free of defects and properly adjusted.

Turntables shall be true, free of excessive wear, cracks or gouges and all fasteners shall be tight and in place.

- ***Drive Chains*** - shall be properly lubricated in a safe manner, adjusted and free of excessive wear and damage.
- ***Sheaves and Drums*** - sheaves shall not have excessive wear on shoulders, grooving or gouging in the drums and shall be the correct size. Check sheave bushing and bearings for excessive wear. Drums shall be free of gouges, excessive wear and large enough in size to properly contain the wire rope.
- ***Wire Rope (Boom, Hoist and Pendant)*** - check for excessive wear or damage such as broken strands, reduction in diameter, kinks, corrosion, etc.
- ***Hoist Block and Hooks*** - check for grooving, gouging or excessive shoulder wear of sheaves. Check bushings, bearings and pins for excessive wear.

Check hoist block body for cracks, breaks, excessive wear or missing parts. Check hook for bends, cracks, corrosion and enlarged throat opening, free swivel action and operational safety latch.

- ***All Pins*** - shall be lubricated as needed. Retainer shall be in place and operational. Pins should not be excessively worn.
- ***Outriggers and Tracks*** - ensure that suitable additional support pads shall be provided for soft or unstable conditions.
- ***Boom*** - chords shall be straight, free of kinks, bends or cracks, lacings shall all be in place, free of bends, cracks and broken welds. All joining devices shall be in place and tightened as required.
- ***Boom and Jib Stops*** - shall be installed on the crane, be free of defects and in operational condition.
- ***Boom Angle Indicators*** - shall have legible degree markings and the indicator arms should be in place and fully operational.
- ***Boom Locking Device*** - cranes shall have an up and down power design and the dog brake shall be fully operational.
- ***Transmissions*** - shall be fully operational, clutches and selector operation shall be free with no "grabbing".
- ***Steering*** - shall be properly aligned in accordance with manufacturer's specifications.
- ***Gantry and Jib-Gantry*** - shall be free of cracks, excessive rust and wear etc.
- ***Wheels and Tires*** - shall be in good condition, properly mounted and the tires inflated to manufacturer's specifications.
- ***Carrier Assembly*** - check carrier frame and cross-members for cracks and defects.

- ***Operating Aids*** - must be checked for function and be included in the periodic inspection.
- ***All controls*** - Hoisting, Swing, Travel and Boom shall be checked.
- ***Load Limit and Safety Devices*** - shall be tested.

Note: The above guide will vary according to crane type and model.

Periodic Crane Inspection

Cranes which have not been in use for several months should be given a normal inspection before being used.

If the crane has been out of service for an extended time it should be given a complete inspection before use.

Annual Crane Inspections

The boom and other structural components, as well as the hoist assembly and hook must be inspected annually by a quality control company recognized by OH&S OSHA.

The inspection will be one of the non-destructive testing methods.

The inspection reports should be retained in the file for the applicable crane.

Inspections As Needed

Wherever sudden and unusual shock loads are applied to a crane, an inspection is required immediately due to the possibility of damage in the load bearing components.

This inspection is visual and, if necessary, is also performed by using non-destructive testing methods.

Any damage must be repaired before the crane is returned to service.

The boom, jib, and other load bearing components are the most likely to be damaged by any sudden shock load or whipping by a quick load release; however do not limit the inspection to these areas. A machine which has been shock loaded needs a thorough inspection.

Note: All inspections must be fully recorded in the crane log book, and must be dated and signed by the inspector.

Crane Manual and Records

A manual supplied by the manufacturer with data relating to operation and maintenance for the specific model of crane should be provided with each machine. The manuals will vary with different manufacturers, but the basic information will include:

- The name of the crane manufacturer, and any related design different from the manufacturer.
- The crane model name, designation, or type, plus the model number, the serial number, and the year of manufacture.
- Specific crane data including:

1. Weight of the unit and the ground bearing pressures on tracks, or tires and outriggers.
2. The load chart and all charts, tables and data necessary to calculate capacity in various configuration combinations.
3. Data including size and weight of boom sections.

4. The erection and rigging procedures needed for all designed configurations.
5. The inspection and maintenance procedures on booms and outriggers including materials, welding, and bolt and torque specifications.
6. A log book. This must be routinely used to maintain records on inspections, tests, repairs, maintenance, and hours of service related to the machine. The log book entries should be dated and signed by the operator, repairman and supervisor. If the crane is sold or is a rental unit, the owners should ensure that the log book remains with the machine and is kept up-to-date throughout its working life.
7. Any crane which was modified or altered (also repair of damage) from the original specifications, which could in any way affect the operation should not be used unless there is proof the changes were engineered and certified by a competent authority.

Crane Maintenance Safety

A preventative maintenance program based on the manufacturers' recommendations should be established for all cranes.

The log book must be used to record all details of hours worked, inspections, adjustments, repairs, replacement parts, and testing.

The maintenance and repair personnel must be aware of the hazards involved in working on cranes, must have a working knowledge of the crane and have access to the manufacturer's literature.

Prior to the start of any maintenance or repairs on a crane, other than for minor adjustments, safety precautions including some of the steps below should be followed:

1. The crane should be positioned where it will cause the least interference with other equipment or operations in the area.
2. Rope off the area and post warning signs to keep unnecessary personnel away.
3. The boom should be lowered to the ground or otherwise blocked or secured from dropping.

Note: Always block the boom when assembling or disassembling (see section on assembly - disassembly). Never stand on or climb beneath the boom during this operation. Never reach into holes in hydraulic booms unless the sections are securely anchored together (either with the boom on or off the machine).

4. Lower the load blocks to the ground, or secure them from falling if the boom cannot be lowered.
5. Any crane component which could move or collapse during repair should be blocked or secured.
6. The engine must be shut off during repairs if it is not needed. The ignition key must be removed, and warning signs placed in the cab.
7. Maintenance personnel must never be under any part of the machine if the engine is running, or if anyone is at the crane controls.
8. The controls should be secured so they cannot be accidentally actuated.
9. Keep the crane deck clear and free of oil, grease, rags, scattered tools and miscellaneous parts and pieces. Keep all loose tools and parts in a box. Use nonflammable solutions for cleaning.
10. Never wear loose clothing which may become entangled. Keep hands, feet and clothing away from gears, ropes, drums and sheaves, or any other moving component such as fans, while the engine is running or the component could slip.

11. Ensure that safety equipment (such as fire extinguishers) is available and in good condition. Never tamper with or alter any safety devices.
12. Never use the wire rope to aid in climbing to the top of the cab.
13. Use a bar to guide wire ropes onto drums.
14. Protective guards and panels must be replaced before operating the machine.
15. Before testing a crane or returning it to service, all components which have been affected by the maintenance or repair should be thoroughly inspected. This is followed by an operational check by the operator to ensure that the components are functional.
16. Never restart the engine until all personnel involved know what is going to happen and when it will happen.
17. Do not put the crane into operation until all personnel are well clear of the crane.

Note: Welding repairs to crane components other than the boom must be in accordance with ANSI/AWS D14.3.

Crane Maintenance Safety (Hydraulic)

Hydraulic components present specific hazards to maintenance personnel. The boom, outriggers, and other attachments are maintained in position by a high pressure trapped column of oil.

When this pressure is released, the boom or attachment will or can fall, and the outriggers will or can retract. Pressure may also be maintained in the system with accumulators. Improper release of this pressure can cause oil, and items such as pipe plugs, to discharge at a very high velocity. Anyone in the line of this discharge could be seriously injured. To help avoid injury, the following safety guidelines are used:

1. Lower the boom to its lowest position and lower the machine off its outriggers before doing repair work. If it is necessary to work with the crane on outriggers or the boom in the raised position, each must be securely blocked.
2. Operate all hydraulic control levers through the operating positions before beginning the repair work. Pressure may be retained in some circuits almost indefinitely. If the boom or outriggers are blocked, move the control levers to relieve trapped pressure and ensure the blocking is actually supporting the boom or outriggers without the assistance of trapped oil.
3. When a crane is operating, oil and air in an unvented hydraulic tank becomes heated and expands, thereby raising the pressure inside the unvented tank. If the filler cap is removed rapidly, the pressure in the tank could blow the oil out of the tank. The oil can be extremely hot and cause severe personal injury. To prevent injury, loosen the hydraulic system filler cap part way to allow pressure in the tank to dissipate.
4. Hydraulic relief valve settings should not exceed the manufacturers specified pressure settings. If relief valve settings require readjustment, it must be performed by qualified personnel.
5. Crane components, which have been damaged and extensively repaired, must be completely inspected and tested by a qualified inspection agency, or by a manufacturer's representative, before going back into service.
6. A boom which has failed or which is suspected of having been overstressed must be removed from service until it has been properly repaired and thoroughly inspected and tested by an acceptable authority who will document that the structural integrity has not been impaired.

***Note:* Boom repairs, especially those involving welding, require special methods, skills, and experience. Before attempting any boom repair, contact the manufacturer or the crane distributor.**

The manufacturers procedure must be followed. The welder must be certified to that procedure.

7. All crane parts replaced or repaired must have at least the same safety factor and specification as the original part. Purchasing parts from the original equipment manufacturer will ensure that the machine's original quality is maintained.
8. All crane repairs and adjustments must be made only by qualified and authorized personnel. Under no circumstances should any person attempt any crane repair for which he is not fully qualified.

Crane Cab Control Layout

- Cabs and control stations on all mobile cranes conform to basic standards and guidelines for design and layout.
- Controls used during the normal crane operating process must be located within easy reach of the operator and allow satisfactory room for operation. The control arrangement should be in accordance with SAEJ983.
- On some crane types, the control levers are adjustable to the operator's reach. A thumb screw on top of the lever shaft can be loosened thus allowing the lever length to be pulled out or pushed in.
- Load hoist, boom hoist, and swing clutch controls must hold in neutral without the use of positive latches.
- All controls must be clearly marked to indicate the function. See illustration #334 for a typical hydraulic cab layout, illustration #335 for control lever direction, and illustration #336 for a typical conventional cab layout.

- Controls move in the direction of the resultant load movement or machine movement.
- Control lever functions speed up the operation farther away from the neutral position and slow it down closer to neutral. See illustration #333.
- Cranes must have a clutch for disengaging power to the superstructure machinery.
- Whenever possible, controls should be of the deadman type.
- Controls must be adjusted so the force needed to actuate the hand controls is less than 35 lbs. and that needed to actuate the foot controls is less than 50 lbs. The travel distance on hand levers must not exceed 24 inches on one-way levers and 14 inches on two-way levers (from the neutral to the engaged positions). The travel distance on foot pedals must not exceed 10 inches.

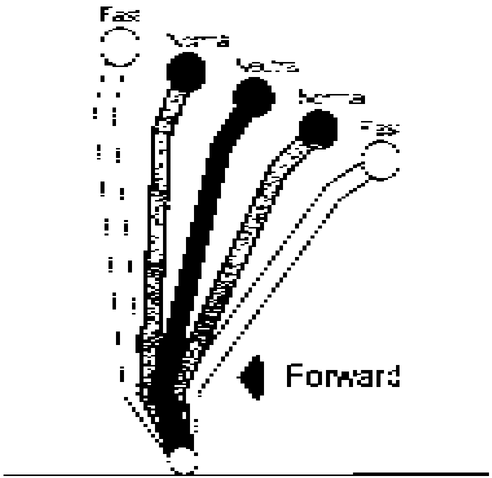
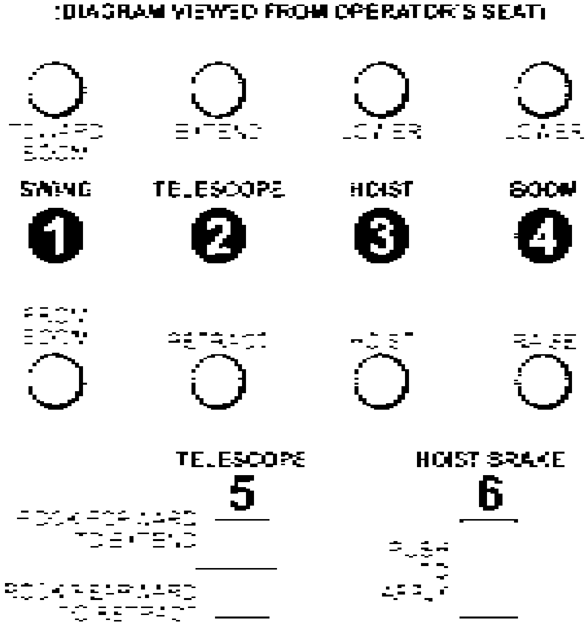


Illustration #333 - Control Lever Functions

Typical Control Layout (Hydraulic)



CONTROL	OPERATION
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Illustration #334 Hydraulic Control Layout

Crane Control Lever Direction

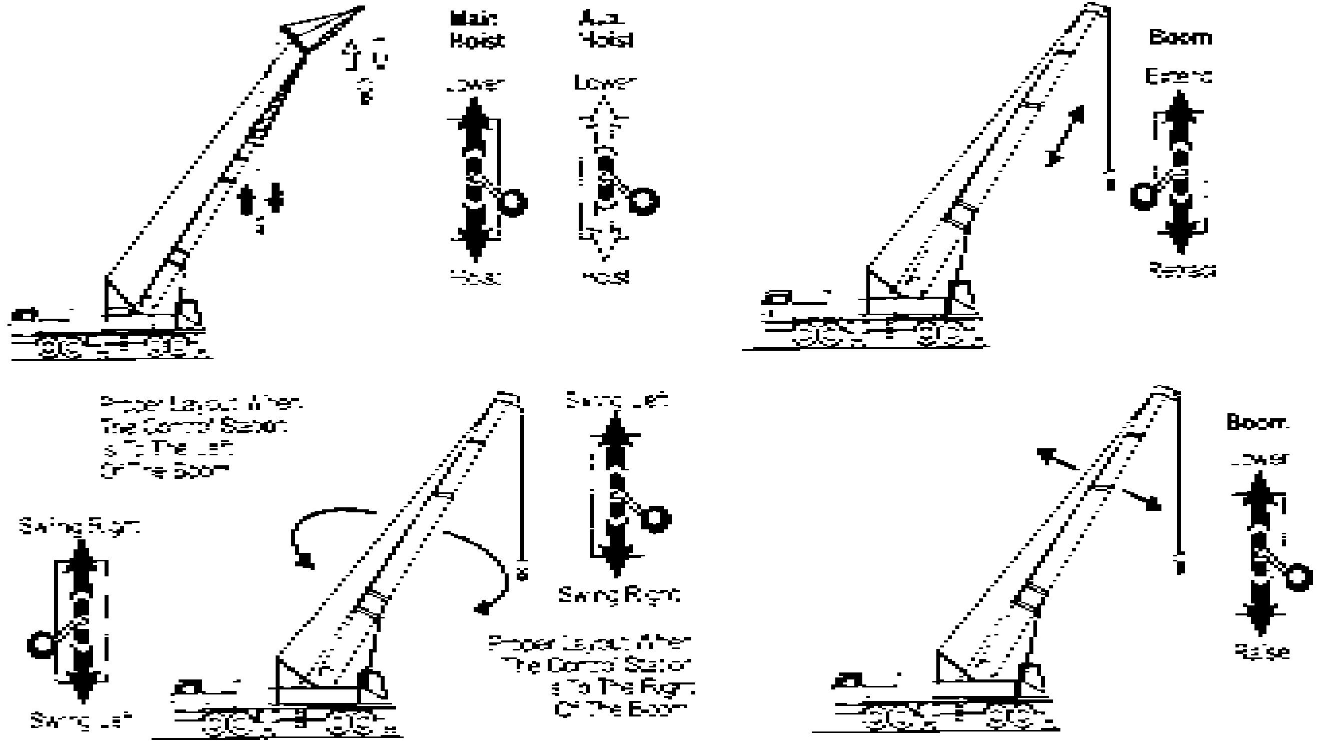
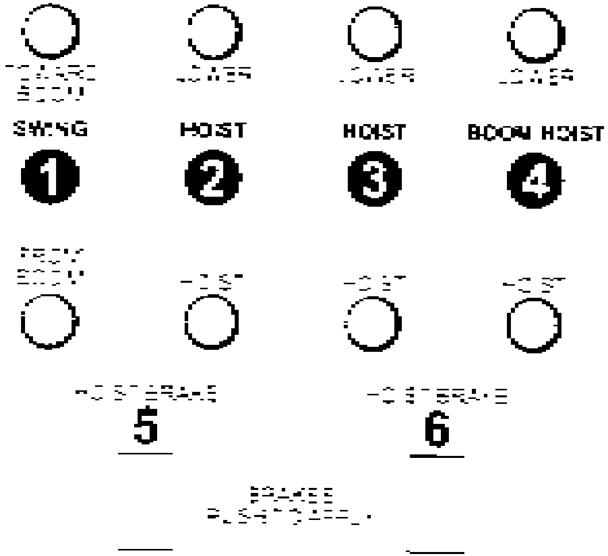


Illustration #355 - Crane Control Lever Direction

Typical Control Layout (Conventional)

(DIAGRAM VIEWED FROM OPERATOR'S SEAT)



CONTROL	OPERATION
1 [illegible]	[illegible]
2 [illegible]	[illegible]
3 [illegible]	[illegible]
4 [illegible]	[illegible]
5 [illegible]	[illegible]
6 [illegible]	[illegible]

Illustration #336 - Conventional Crane Cab Layout

Outrigger Control

Two typical outrigger activation systems are shown in Illustration #337. The system may be activated by a two position switch on the panel or a pedal type control.

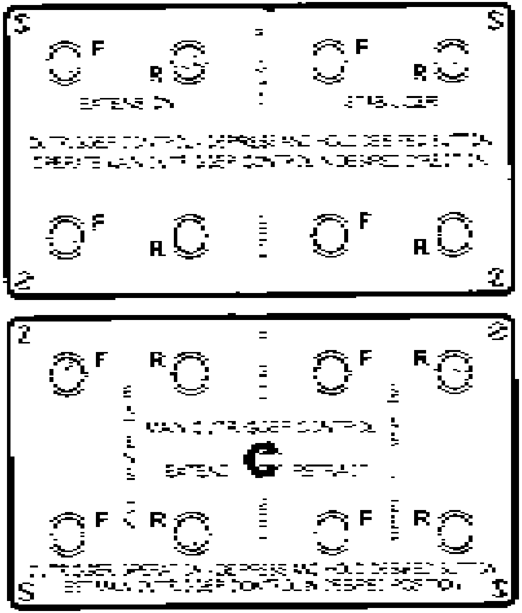


Illustration #337 - Outrigger Controls

Pre-Operation Notes:

- Before starting the engine, ensure the transmission is in neutral, the parking brake is applied, and the swing lock is engaged.
- If the oil pressure and temperature gages do not display the proper reading shut off the engine.
- The engine must be off before engaging the hydraulic pumps.
- Always disengage the hydraulic pumps for extended travel, cold weather starting, or engine checks.
- Operate the engine at or near the governed RPM while using the crane.
- Extend and set the outriggers before attempting any lifting.
- On outriggers controls with toggle switches, depress a button before moving the toggle switch. Failure to do so could cause a hydraulic lock.
- Before swinging the crane make sure the area is clear.

Control Operation

Swinging the boom: Depending on the control and boom position, pushing the lever forward will move the boom either right or left, and pulling it back will reverse the movement (see illustration #335). Swing is stopped by either reverse swing or pedal application, depending on the model. When rotation stops, engage the mechanical swing brake and the positive swing lock.

Note: Never push or pull the swing lever through neutral to stop the swing motion.

Boom raising and lowering: Pull the boom elevation lever back to the UP position to raise the boom. Push the lever forward to DOWN to lower the boom.

Boom foot control: Some cranes may be equipped with a foot control to raise or lower the boom. Push the pedal forward to LOWER the boom. Push the pedal back down to RAISE the boom.

Note: Long booms can create a tipping condition when lowered too far, even with no load. When lowering, let out the load line to prevent two-blocking.

Extending and retracting the boom: Both telescoping levers (some cranes may only have one lever) must be pushed forward to the OUT position to extend the boom. Both levers are pulled back to the IN position to retract the boom.

Note: Power telescoping sections must be extended equally to satisfy the load chart capacity ratings. Check the load chart capacity ratings for boom length, boom angle, load radius, before extending the boom. When extending the boom, let out the load line to prevent two-blocking.

Raising and lowering the load line: To lower either the main load or auxiliary load line, the applicable lever is pushed forward to DOWN. To raise, the lever is pulled back to UP. The hoist speed can be changed to high or low range.

Note: Do not change the hoist speed range with the hoist moving. Do not jerk the control lever to cause shock loading.

Emergency boom operation: On rare occasions the boom lift cylinders hydraulic equalizer line can fail. If this happens, restricting devices allow continued operation until the hydraulic reservoir empties. Immediately try to get the boom to a safe position and the load on the ground.

a. Keep the engine at normal operating RPM.
b. Keep the desired boom angle by pulling back (UP) on the lever as needed.
c. Keep the boom angle and telescope in the boom sections while operating the hoist to get the load on the ground in a safe location.
d. If operating over the side, telescope in as much as possible before lowering the boom. If operating over the rear, immediately lower the boom.

Typical Crane Safety Features

The safety features in mobile cranes will vary somewhat in design and application with the various crane manufacturers and the individual crane models.

The points listed below are commonly used:

- A fire extinguisher in a readily accessible position. Operators and crane support personnel must be familiar with the use and care of the fire extinguishers provided.
- Self-closing fuel filler caps and flame arrestors on fuel tanks.
- Suitable lighting for night operations, with back-up lights for all mobile units.
- Rear view mirrors on both sides of mobile equipment that are large enough to give the operator a satisfactory rear view.
- Wheel chocks on mobile units to stop movement on slopes when the equipment is on rubber, is unattended, or is being repaired.

- Boom angle indicators. The indicator must be clearly visible to the operator from the seat. It must also be readable to within one degree.
- Boom length indicators should be installed on all machines having telescopic booms.
- Boom stops and hoist safety shutoffs. See illustration #338 for examples.

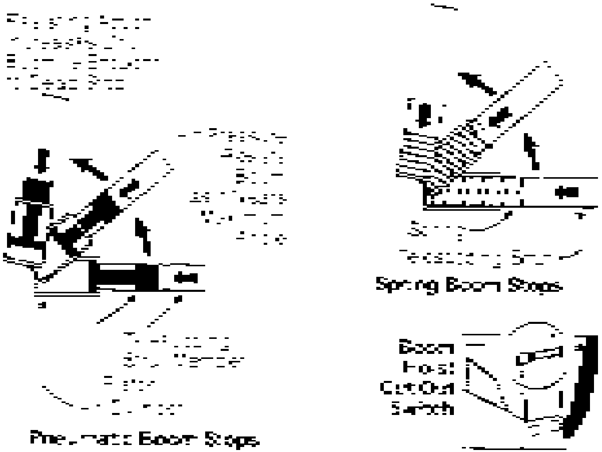


Illustration #338 - Boom Stops

- Devices to automatically stop boom drum motion when the maximum boom angle is reached.
- Drum rotation indicators clearly visible to the operator.
- Outriggers must be marked or painted to clearly indicate the outrigger beam is fully extended.
- A clearly audible outside warning signal. The control for the signaling device must be within easy reach of the operator.
- A spirit level at the outrigger control station for leveling the crane.
- A machined surface on the revolving deck to place a four foot level for final precision leveling.
- A scale by the boom foot pins indicating the distance to the center of rotation. This distance, plus the distance of the boom out to the load center, gives the total load radius (center of rotation to center of load).

Hoist Drum Safety

- Crane drums must have sufficient clutching or power engaging devices that immediately start and stop the drum motor.
- Crane drums must have self-setting fail-safe brakes that are capable of supporting the rated loads with recommended reeving and which operates automatically should the power fail. See illustration #339.
- Crane drum brake and clutch assemblies must have adjustments to compensate for wear and maintain adequate spring force, when used.
- Crane drum boom hoisting mechanisms must have an auxiliary ratchet and pawl or an equivalent positive locking device. See illustration #340.
- Crane hoist drums should be provided with a method to ensure even spooling of the wire rope on the drum.

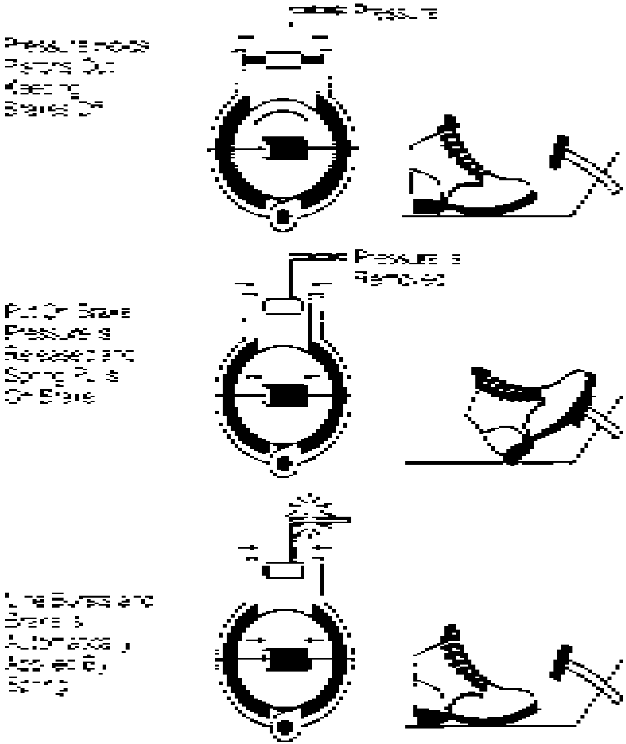


Illustration #339 - Fail-Safe Brake

Hoist Drum Safety

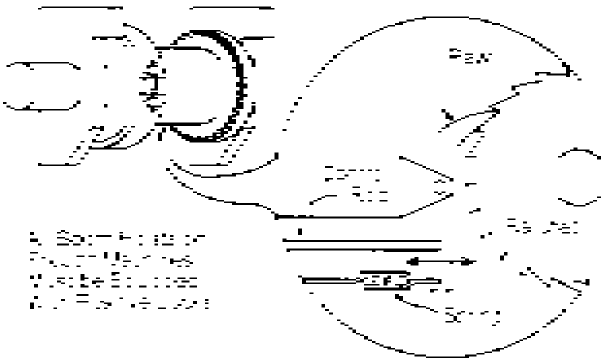


Illustration #340 - Crane Drum Fail-Safe Brake

- Crane drums must have rims and flange guards large enough to prevent a slack wire rope from jumping off the drum.
- Crane drums should have at least three full wraps of rope remaining on the drum in all service conditions. This number is contentious as the requirements in some jurisdictions might require five full wraps and others may require only two wraps. To be sure, check with the local OH&S OSHA department.
- Grooved crane drums must have the correct minimum groove pitch and groove depth for the diameter of the rope.

Brake Safety

- Pneumatic, hydraulic and electrical brakes must be designed so the brakes will apply automatically if there is a loss of power or pressure. The brakes must not release until power has been restored to the machine and the brake is deliberately released.
- Foot brake pedals should have a means of being latched in the applied position.
- Load hoist drums must have fail-safe brakes which are released electrically, hydraulically or pneumatically. There cannot be a belt or chain drive connection between the drum and the brake.
- Hoist brakes must be capable of holding the capacity rated load.
- The brake drum surface must always be in good condition. The brake must have a method of adjusting for lining wear.
- Swing brakes must have a fail-safe method stopping the swing with full load, and hold the boom in 30 mph (50 km/hr) winds. They must hold without operator attention.
- Cranes must have a positive swing lock or house lock to prevent accidental engagement or disengagement. This is used when moving the suspended load, and when traveling the crane.
- Mobile cranes must have brakes which can hold the machine stationary under normal working conditions, as well as holding on the maximum grade for travel recommended by the manufacturer.
- Hydraulic cranes must be equipped with integrally mounted devices to prevent boom lowering or retracting in the event of hydraulic failure.

Operator Hoisting Safety Points

1. If there is reasonable doubt concerning the mechanical or structural status of a crane it should not be used until the questionable components have been repaired or proven satisfactory.
2. A pre-operation inspection must be carried out. This will include:

   Fuel and battery levels; leakage of fuel or lubrication fluids; hydraulic hoses for leaks or damage; tire pressure and stud tightness; lighting, signal and warning lights; brakes, air brake pressure and brake warning devices; clutches, brakes, and control operation; status of warning gages; wire rope, sheaves, blocks, hooks, and other hoist components; boom and boom hoisting apparatus; structural integrity of machine for loose or missing parts, cracked welds.
3. The operator should be familiar with the machine preventive maintenance program to help avoid any problems.
4. No one should operate any crane until they are familiar with the machine, competent at operating all controls, and certified by the applicable area authority.
5. The operator must know the location and use of all emergency shutdown features.
6. The engine should warm up to circulate the oil in the pumps. The hoist winches, boom hoist cylinders, boom extension cylinders, and swing mechanism should all be operated to circulate the oil through the system and warm it up to the manufacturers specifications. Perform this circulation exercise slowly in cold weather to prevent hydraulic shock loading.
7. Do not repair or lubricate the crane while it is running. Lower the boom to its lowest point and then shut off the engine.

8. The crane engine should run close to the maximum governed speed during lifting and normal operation for fuel economy, plus operating efficiency, power, and overall safety.
9. If the crane is to operate in a confined space, such as a building, the engine exhaust fumes must be vented and adequate air circulated for personnel safety and combustion air for the machine.
10. Use extreme caution if it is necessary to operate in poor visibility situations such as darkness, fog, dust, rain or snow.
11. Some weather conditions also warrant special attention. Wind can be very dangerous to hoisting operations. The dangerpoint of wind velocity will vary with the dimensions and weight of the load, and the height of the lift. Extreme cold can also be hazardous to crane components that are shock loaded.
12. If a crane develops any audible or visible evidence of problems during a hoisting operation, the operation should cease until the problem is checked.
13. If a machine has to back up, the operator must have clear vision behind the machine, or use a signalperson. The area behind the crane must be clear of personnel, and the crane warning device should be used.
14. A crane must be secured, including blocking if necessary, from any travel during the hoisting operation.
15. If it is necessary to lift on rubber, the air brakes must be on and the wheels must be blocked. The transmission should be in neutral as movement might damage it during operation.

Operator Hoisting Safety Points

16. It is always a benefit if a practice or dry run of the lift without the load is made first. This will allow a smoother lift and eliminate problems encountered by guesswork when a lift plan is not made, or steps are missed in the plan.

17. The crane should be positioned to allow adequate clearance for tail swing. No part of the crane should come within 2 feet of any obstruction which could pin a worker. A barrier or fence should be used to keep vehicles and unnecessary personnel away.

18. The operator should practice on all the controls to get the feel of the crane if this is not his normal machine. The operator must devote full attention to the load and not be distracted.

19. The operator must not leave his seat when the crane has a suspended load. No one should be permitted to get on or off an operating crane.

20. If the crane is equipped with a boom hoist lever lock, it should be engaged when the boom hoist is not in use.

21. A manually operated boom hoist drum pawl (if so equipped) must be engaged at all times, except when lowering the boom. Automatically engaged boom hoist drum pawls should be regularly checked.

22. When planning a lift or setting up a crane, make every effort to find location of utility lines, pipelines, and sewers.

23. Wherever possible, the crane must be set up to operate in its most stable position and in the area of highest capacity. This usually means lifting over the rear.

24. A crane should always be set up on outriggers, with the beams fully extended and the wheels off the ground, regardless of the load weight. The crane must be level at all times. Level should also be checked during an operation that has several lifts.

25. The crane should be spotted as close as possible to the load to minimize load swing and help reduce boom length.
26. Do not swing or lift over the front of a truck mounted crane, unless it is approved in the manufacturer's manual.
27. Caution must be used in lift planning, and lift implementation, to ensure that working personnel and other non-involved people are not in the swing radius of the crane.
28. The load weight must be known before a safe lift can be planned. Be aware that using a load indicator as a test scale is a violation of the ANSI codes.
29. Read the load charts carefully to get the crane capacity. The total load weight will generally include everything beneath the boom tip, plus the jib weight (if attached), when lifting off the main block. Use extreme care in calculating near-capacity lifts.
30. The lift plan should be carefully worked out for crane and load positioning, and swing clearances. It is much easier and safer to work it out in advance than to lower the load and reposition the crane.
31. Lifts over 75% of the crane capacity are critical, and require special attention and planning for load radius, load lift height, load weight, and crane capacity.
32. For any lift, the crane must be rigged with sufficient parts of line to make the lift (as per the load chart details). The boom tip must be situated directly over the load center of gravity (make sure the load line is always vertical). Ensure that the rope is properly seated on the drum and in the sheaves. Watch for any slack rope condition or improper spooling on the drum.

Operator Hoisting Safety Points

33. The load must be safely rigged (use a minimum 5:1 safety factor) and all loose load objects secured or removed. Use taglines to keep the load from spinning out of control. Make sure the load is not bolted or fastened down before lifting.

34. Do not impact load the crane by sudden lifting or stopping. Lift the hook gradually until the slack is out of the hoist line.

35. Lift a heavy load a short distance off the ground, then hold it to check the hoist brakes.

36. Do not operate by the seat of the pants method to check a load for stability. Many cranes will fail structurally before tipping. If a crane shows signs of tipping it is overloaded.

37. If a load is lifted and it does not balance properly, put it down and rehook until it is balanced.

38. No one must ever ride the load or the hook.

39. The operator must take signals only from one designated signalperson. An emergency stop signal from anyone must be obeyed.

40. The operator must never take his eyes off the load. Do not be distracted. If the load cannot be seen, a signalperson is required.

41. Two separately rigged loads must never be lifted at once, regardless of the weight. Excess slings must never hang loose during a lift.

42. Make sure the load does not catch on any obstructions during the lift.

43. Never swing a load over personnel. Never permit anyone to work under a suspended load.

44. A crane must not drag a load sideways as this creates boom side-loading. Side-loading has been the cause of many collapsed booms.

45. Make sure it is clear before swinging a load. The outriggers must be down and the load must always be under control. Do not make any rapid moves when swinging a load as centrifugal force might pull the load out past the proper radius.
46. The load should always be as close to the crane and the ground as possible; but be careful not to hit the boom or the outriggers.
47. After the boom hoist limiting device has functioned it may sometimes be necessary to boom up a little to release the boom hoist pawl (when the override control is used, the limiting device will be inactive and this may allow the boom to come back against the stops hard enough to cause boom damage).
48. Do not operate the boom at a higher angle than the chart allows, as a sudden load release could result in boom kick back.
49. The drum should always have at least three full wraps of wire rope (this minimum number may vary in some jurisdictions). If all the rope accidentally winds off the drum it must be rewound in the right direction.
50. Be carefull about keeping a safe clearance between the hook block and head sheaves. Two-blocking can be caused in different ways, and it can result in a broken hoist rope.
51. Load charts for hydraulic boom cranes are based on the boom sections being equally extended. If the crane has multiple telescoping levers, the sections will have to be extended equally by the operator. Never make a lift by using one telescopic section. The sections extend equally on a single lever crane.

52. Some cranes have foot pedal brake locks. They are engaged with the operators feet remaining on both pedals; the operator must be ready to react to the safety of personnel. Their purpose is to rest the operator's legs while suspending the load for short periods.

53. Many cranes are equipped with power load lowering devices. They give precise control for lowering loads and allows the hoist brake to be kept in reserve.

54. Torque converters can be used to lower heavy loads. The hoist clutch remains engaged and the engine speed is regulated to either hold the load suspended or allow it to creep down. With this method the engine turns normally and the machinery turns backward. Increasing the engine speed or applying the brake will stop the load. If the load is suspended for more than a few seconds, the hoist brake should be applied and the hoist clutch disengaged.

This method of lowering is recommended for precise spotting of heavy loads only.

Note: When slowly lifting, lowering, or holding a load with the torque converter, do not engage any other clutch as additional load will cause the converter to slip.

55. While hoisting, the operator should keep his foot on the hoist brake at all times to prevent the load from falling if the engine stalls.

56. The drum rotation indicator can be used as a guide when inching a load into position.

57. If the load is suspended for an extended period, the safety pawl must be engaged.

58. In the unlikely event of a power failure during a lift, set the brakes and locking devices. If it is practical and/or possible, a suspended load should be landed under brake control rather than left hanging.

Note: Always keep Murphy's Law in mind while performing a rigging or hoisting operation. "If it can go wrong, it will." To avoid this always double check and be careful.

Operational Aids

ANSI B30.5 requires an Operational Aid on any new crane with a rated capacity of 3 tons or more. This can be a load indicator, rated capacity indicator, or rated capacity (load) indicator. An older crane does not require installation of a new operational aid until the crane undergoes modification or repair.

The manufacturer of the device must include manual information regarding the operational parameters. This information would include whether the device only shows the operating conditions (load weight, radius, boom angle, two-block, etc.) and warns the operator about an approaching unsafe condition or whether the device has its own preset limits and will override the crane operator and actually stop operation.

There are numerous manufacturers of these devices, and although they are somewhat similar, the actual display and programming will vary. The example shown in illustration #341 shows the basic items included in an operational aid. The boom angle and load radius are shown on the right side. The left side display shows the crane capacity and the load being lifted (at the real time boom angle and load radius). The load is also shown as a percentage of capacity.

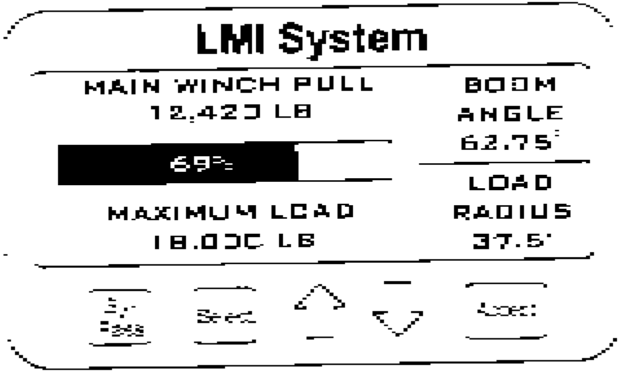


Illustration #341 - Load Indicator

These devices can be as basic as showing the actual lift circumstances, or they can be much more complex with shutdown features for an overload situation, and they may record and store movement history for later review. Careful study of the manual is required to fully understand the programming of the unit, as well as what the display actually means.

Note: Operational Aids must be checked daily for proper functioning, and must be regularly inspected and tested in accordance with the manufacturer's requirements.

Note: In the event that the device readings do not match the machine chart ratings, the verified chart ratings and measured radii shall take precedence over the indicator readings.

Note: It is a conflict with the manufacturers guidelines and a violation of the ANSI standards to use a load indicator as a method to weigh a load.

SECTION FOUR QUESTIONS

Mobile Cranes

1. Determine if this statement is true or false. As crane signaling is only a basic function and the signal person knows where the loads will be positioned, training or testing of the signal person should not be required.

❑ true ❑ false

2. When using hand signals to direct a crane operator, an extended arm with the thumb vertical and the fingers opening and closing into a fist indicates:

❑ lower load
❑ raise boom and lower load
❑ raise the load line
❑ extend boom

3. Two closed fists with both thumbs pointing toward each other is the signal for:

❑ retract hydraulic boom
❑ extend boom
❑ retract middle section of boom only
❑ secure load in position

4. Which of the following is not a permitted use of an operational aid?

❑ warn of approaching two-block condition
❑ indicates changing boom angle
❑ warns of approaching crane overload
❑ used to test weigh a load prior to hoisting

5. Determine if this statement is true or false. Any crane component can be used on any other crane made by the same company.

❑ true ❑ false

6. A rough terrain crane is commonly referred to as:

❑ mobile crane
❑ crawler crane
❑ carrier crane
❑ cherry picker

7. Which of these conditions could be dangerous when operating a crane around a newly constructed building?

❑ height of structure
❑ uncompacted soil
❑ protected accessways
❑ compacted soil

8. When hoisting on outriggers [illegible] 360 degree swing [illegible] most hazardous [illegible] conditions?

- ❒ Over front
- ❒ Over rear
- ❒ Over side
- ❒ Over corner

9. Determine if this statement is true or false: The ground pressure under outriggers [illegible] greater than [illegible] because [illegible] surface.

❒ True ❒ False

10. [illegible]

- ❒ same
- ❒ 1.5 times
- ❒ 2 times
- ❒ 3 times

11. When setting up a mobile crane [illegible] which of the following [illegible]?

- ❒ operator manual and service manual
- ❒ inspected components
- ❒ crane logbook
- ❒ name of the person [illegible] operate the crane

12. When [illegible] boom sections?

- ❒ use the end connections
- ❒ [illegible]
- ❒ [illegible]
- ❒ depends on boom length

13. Determine if this statement is true or false: During crane assembly, [illegible]

❒ True ❒ False

14. When assembling [illegible] boom sections [illegible] should be [illegible]?

- ❒ left side
- ❒ right side
- ❒ both lower
- ❒ both upper

15. When [illegible] the boom [illegible] should be [illegible]:

- ❒ outward from boom center
- ❒ [illegible] boom center

16. When dismantling a lattice boom, which boom pins should be removed first?
- ❑ left side
- ❑ right side
- ❑ both lower
- ❑ both upper

17. Determine if this statement is true or false. It is safe to climb under a boom to knock out the boom pins if the crane has tension on the pendant lines.
- ❑ true
- ❑ false

18. What important step must be followed when welding a damaged crane boom?
- ❑ follow manufacturer's welding procedure
- ❑ have a welder certified to the correct welding procedure
- ❑ use correct welding rods and heat treatment
- ❑ all of above

19. What position should the gantry of a crane be in when lifting a load?
- ❑ highest position
- ❑ third position
- ❑ middle position
- ❑ lowest position

20. Jib forestay and backstay pendant lines should be
- ❑ of equal length, or the forestay pendant lines should be longer
- ❑ of equal length, or the backstay pendant lines should be longer

21. Determine if this statement is true or false. Jib capacity increases as the angle to the ground decreases.
- ❑ true
- ❑ false

22. Determine if this statement is true or false. On most cranes the jib hoist and boom hoist can be safely operated simultaneously.
- ❑ true
- ❑ false

23. Which of the following is an auxiliary boom or an extension of the main boom?
- ❑ gantry
- ❑ mast
- ❑ jib
- ❑ all of above

24. A wire rope on a crane hoist line has a minimum [illegible] design safety factor of:
- ☐ 2.5 to 1
- ☐ 3 to 1
- ☐ 3.5 to 1
- ☐ will vary, depending on the crane and the application

25. [illegible] the boom [illegible] should be reeved:
- ☐ non-symmetrical
- ☐ symmetrical
- ☐ with an even number of line parts
- ☐ with an uneven number of line parts

26. Determine if this statement is true or false. When determining whether a crane is level, percentage of grade and degree measurement is the same.

☐ true ☐ false

27. How much out of level [illegible] does a crane have to be [illegible]?
- ☐ almost 6 inches
- ☐ almost one-half inch
- ☐ almost one-eighth inch
- ☐ too small to measure

28. Determine if this statement is true or false. A crane being 3 degrees off level [illegible] can mean an increase in boom stress [illegible] of 30%, 50%.

☐ true ☐ false

29. The load line is hanging plumb when positioned over the rear. When positioned [illegible] the load line is observed to be [illegible]. This means it is:
- ☐ safe to lift over the rear
- ☐ safe to lift over the corner
- ☐ safe to lift over the side
- ☐ not safe to lift in all positions

30. Crane stability is based on:
- ☐ lever principle
- ☐ ability of crane hoist to lift load
- ☐ load measurements
- ☐ weight of lift

31. The crane operator signals [illegible] for which type of machines?
- ☐ crawler cranes
- ☐ truck cranes
- ☐ cherry pickers
- ☐ same with all types

32. Determine if this statement is true or false. Hoisting with a crane is performed only on rubber or with outriggers fully extended unless it is designed for an intermediate outrigger position and has a matching chart.
- ❒ true ❒ false

33. Determine if this statement is true or false. Computerized Load Moment Indicators warn the operator of an overload condition.
- ❒ true ❒ false

34. Determine if this statement is true or false. Use of Computerized Load Moment Indicators is a quick, easy method of checking a load weight that is approved by crane manufacturers and safety regulations.
- ❒ true ❒ false

35. What determines crane capacity?
- ❒ machine weight
- ❒ stability
- ❒ strength of components
- ❒ all the above

36. Determine if this statement is true or false. Load dimensions could have as much bearing on boom radius as the load weight.
- ❒ true ❒ false

37. Deflection of the boom and pendant stretch will increase:
- ❒ load radius
- ❒ weight of boom
- ❒ load weight
- ❒ crane stability

38. Determine if this statement is true or false. A crane that has been overloaded, resulting in structural failure, will always have the breakage show immediately.
- ❒ true ❒ false

39. When raising a long boom up off the ground, what will avoid excessive pendant pull and boom compression?
- ❒ keep main block on ground while raising the boom
- ❒ use a second crane to raise the boom
- ❒ all the above

40. Determine if this statement is true or false. The approved swing working areas of a crane are referred to as quadrants of operation.
- ❒ true ❒ false

41. The effective weight of a load is:
- ❒ higher than the actual weight
- ❒ lower than the actual weight
- ❒ same as actual weight
- ❒ depends on crane, could be any of the above

42. When using the main load line with the jib attached, the working load from the chart must be reduced by:
- ☐ weight of jib attachments
- ☐ weight of jib extenders
- ☐ weight of jib
- ☐ manufacturer's specifications for jib and hook weight reduction

43. What are the safe load weight numbers given in the load chart based on?
- ☐ net capacity
- ☐ net load minus rigging
- ☐ gross load minus rigging
- ☐ gross load

44. When hoisting a load, sudden starts and stops produce a:
- ☐ static load
- ☐ dynamic load

45. Sources of data used in calculating the weight of crane components used in a safe lift include:
- ☐ operator's manual
- ☐ rigging handbook
- ☐ load chart data
- ☐ all of the above

46. Determine if this statement is true or false: A method of determining if the centre of gravity is directly under the hook is to lift the load slightly off the ground and see if the load is shifting.
- ☐ true ☐ false

47. Determine if this statement is true or false: All crane types, when not level, are rated and can be safely operated from the normal load chart rating.
- ☐ true ☐ false

48. Determine if this statement is true or false: The placement of outriggers is shown on most mobile crane load charts.
- ☐ true ☐ false

49. On load charts with the bold line and the load numbers above the line, what is the limiting factor?
- ☐ tip
- ☐ structural fail
- ☐ cannot lift the load
- ☐ none of the above

50. Determine if this statement is true or false: When using crane load charts, it is acceptable to guess or calculate in-between values.
- ☐ true ☐ false

51. Boom angle is the measured angle between __________ and the centerline of the boom.

- ❐ vertical
- ❐ horizontal

52. If the measured radius between crane rotation point and load center is 57 feet and the load chart only shows values at 55 feet and 60 feet, which value would be used?

- ❐ 55 feet
- ❐ 60 feet
- ❐ must consider boom length
- ❐ depends on load weight

53. Using the range diagram on page 310, determine the approximate load radius under the jib tip at the offset shown and maximum boom extension at a 60° angle.

- ❐ 44 feet
- ❐ 60 feet
- ❐ 77 feet
- ❐ 86 feet

54. From the previous question, what chart radius value would be used to calculate capacity?

- ❐ 45 feet
- ❐ 50 feet
- ❐ 80 feet
- ❐ 85 feet

55. Determine if this statement is true or false. The crane is always set up to specification, therefore the load chart does not have to be used to determine the required number of parts of line in the main load block to lift a load.

- ❐ true
- ❐ false

56. Determine if this statement is true or false. In general terms, everything below the boom tip is considered load.

- ❐ true
- ❐ false

57. What load chart weight term defines the main block, rigging hardware, the actual load and any attachments and jib stock?

- ❐ gross load
- ❐ net load

58. Using load calculation example one, on pages 309 and 310, and a load weight of 53,400 pounds, what is the maximum radius allowed with the outriggers extended?

- ❐ 50 feet
- ❐ 55 feet
- ❐ 60 feet
- ❐ 65 feet

59. Determine if this statement is true or false: [illegible]

- [x] true
- [ ] false

60. Determine if this statement is true or false: [illegible]

- [ ] true
- [ ] false

61. Determine if this statement is true or false: Crane [illegible]

- [ ] true
- [ ] false

62. Page 322 [illegible]

- [ ] CRANE A = ______
- [ ] CRANE B = ______

63. Pages 322 and 323 [illegible]

- [ ] CRANE A = ______
- [ ] CRANE B = ______

64. From question 63 determine [illegible]

Crane A

- [ ] yes
- [ ] no

Crane B

- [ ] yes
- [ ] no

65. [illegible]

- [ ] Improper outrigger setup
- [ ] Changing radius
- [x] Wind
- [ ] All of the above

66. Determine if this statement is true or false. After a load is off the ground and the boom starts to swing, the actual swing rate of speed will never have any bearing on the conditions affecting the crane.

❑ true ❑ false

67. Which of these weather conditions is most likely to restrict or completely stop hoisting activities?

❑ wind gusts
❑ light breeze
❑ light rain
❑ light snow

68. When a crane is traveling with a load, whenever possible the load should be:

❑ tied off, low to ground, and close to carrier
❑ low to ground and far out
❑ as high as possible without hitting boom
❑ always carried over the rear

69. When a hydraulic boom is not extended with equal section lengths, the effect is:

❑ damage the hydraulic system
❑ overload the longest section
❑ equal extension does not matter

70. Determine if this statement is true or false. It is permissible to let the boom of a crane rest on the edge of a building while lowering a load onto the roof.

❑ true ❑ false

71. Determine if this statement is true or false. As long as another person is on watch, it is permissible to hoist personnel in a basket when the anti-two-block device is not working.

❑ true ❑ false

72. Determine if this statement is true or false. Even with high voltage power lines, it is not possible to have an electrical accident unless the crane or load actually hits the line.

❑ true ❑ false

73. Determine if this statement is true or false. A signalperson must be used if a crane can swing within the limit of approach of a power transmission line.

❑ true ❑ false

74. Determine if this statement is true or false. The operator should always jump out of the cab as quickly as possible if the crane makes contact with a power line.

❑ true ❑ false

75. Determine if this statement is true or false: [illegible]

- ☐ true
- ☐ false

76. Who is responsible [illegible]

- ☐ operator
- ☐ signal person
- ☐ mechanic
- ☐ inspector

77. Determine if this statement is true or false: [illegible]

- ☐ true
- ☐ false

78. Determine if this statement is true or false: [illegible]

- ☐ true
- ☐ false

79. Determine if this statement is true or false: [illegible]

- ☐ true
- ☐ false

80. [illegible] the boom will:

- ☐ swing left
- ☐ swing right
- ☐ could be either, depending on boom and control position

81. Which of these items [illegible]

- ☐ transmission was in neutral
- ☐ oil pressure gauge
- ☐ parking brake was applied
- ☐ swing lock is engaged

82. Determine if this statement is true or false: [illegible]

- ☐ true
- ☐ false

83. Determine if this statement is true or false: [illegible]

- ☐ true
- ☐ false

84. Determine if this statement is true or false: [illegible]

- ☐ true
- ☐ false

85. Determine if this statement is true or false. With a suspended load, the operator can leave the seat if the machine is in perfect condition and all brakes are set.

- ☐ True
- ☐ False

86. Determine if this statement is true or false. The operator must take signals from one person only, but must obey a stop signal from anyone.

- ☐ True
- ☐ False

87. Determine if this statement is true or false. After being programmed, an operational aid must ONLY be checked for accuracy by the manufacturer [illegible].

- ☐ True
- ☐ False

88. Determine if this statement is true or false. If the readout of an operational aid does not match the crane load chart ratings, the operational aid numbers will take precedence.

- ☐ True
- ☐ False

SECTION FIVE

BOOM TRUCKS

Boom Trucks

Boom Truck Types

A boom truck is another type of mobile hoisting equipment. What makes this classification different is that the lifting apparatus is mounted on a truck chassis. It is designed to lift a load, place it on the truck, transport it on a highway, and then unload it at the new location.

Due to their popularity and versatility, boom trucks are being manufactured in an ever-increasing number of styles and lifting capacities. Some of these newer units have capacities in excess of 75 tons. The normal extending boom type falls under ANSI standard, B30.5.

Starting in 2008, the standard requires that any machine built with a capacity of 3 tons or more must be equipped with an operational aid of either a load indicator, a rated capacity indicator, or a rated capacity (load) limiter. See Mobile Crane Section for further information on operational aids.

Similar to a mobile crane, a boom truck must have a log book and an inspection chart. Many items must be checked daily, including the digital operational aids.

The two most common types of boom trucks are front or rear mounted turret (illustrations #342 and #343), however the articulating (knuckle) boom type (illustrations #344 and #345) is becoming widely used in North America due to the ability to work in confined spaces. The articulating boom type falls under ANSI B30.22.

A turret mounted boom truck uses a standard "straight" boom similar to a crane, along with a hoisting drum and wire rope. An articulating boom type has a "live" boom with hinged sections, where the hook is on the boom tip and the load is lifted with the actual boom, although some types also have a hook, wire rope, and a drum similar to other cranes.

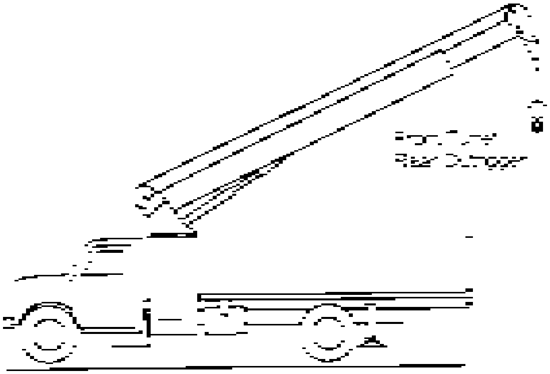


Illustration #342 – Front Mounted Turret

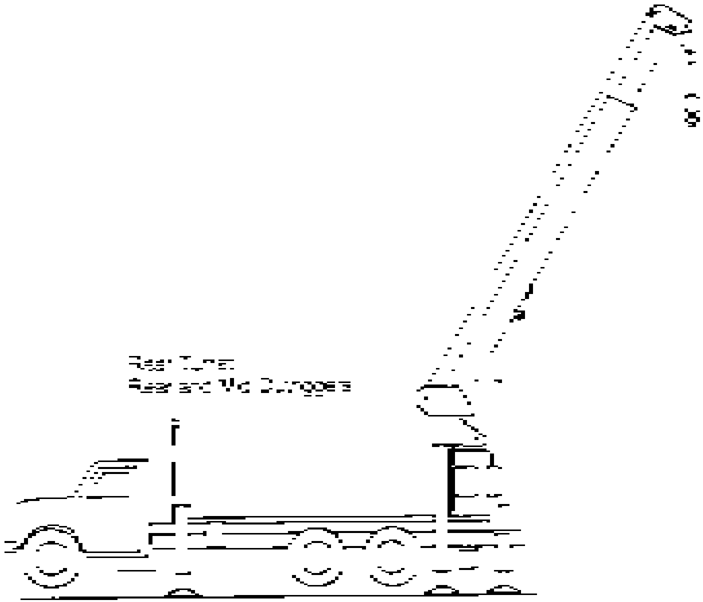


Illustration #343 – Rear Mounted Turret

Most boom truck operating controls require the operator to stand at the side or rear of the boom. However several of the larger capacity units have a sit-down type cab.

Some of the articulating boom types are equipped to be operated by remote control. The basic boom truck components are shown in illustrations #346.

Boom Truck Types

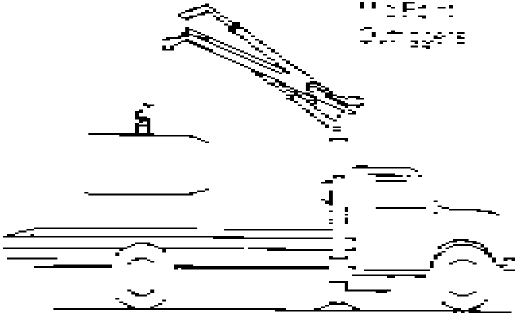


Illustration #344 – Articulating Boom

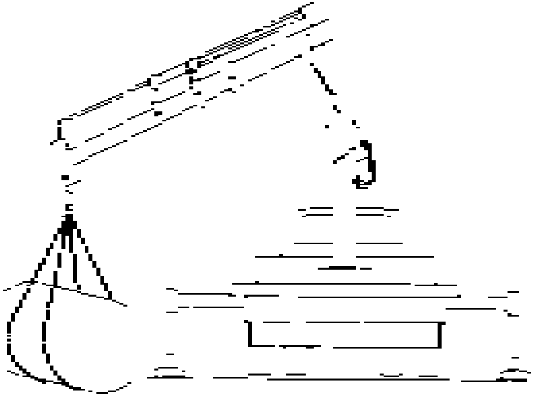


Illustration #345 – Lifting From Boom Tip

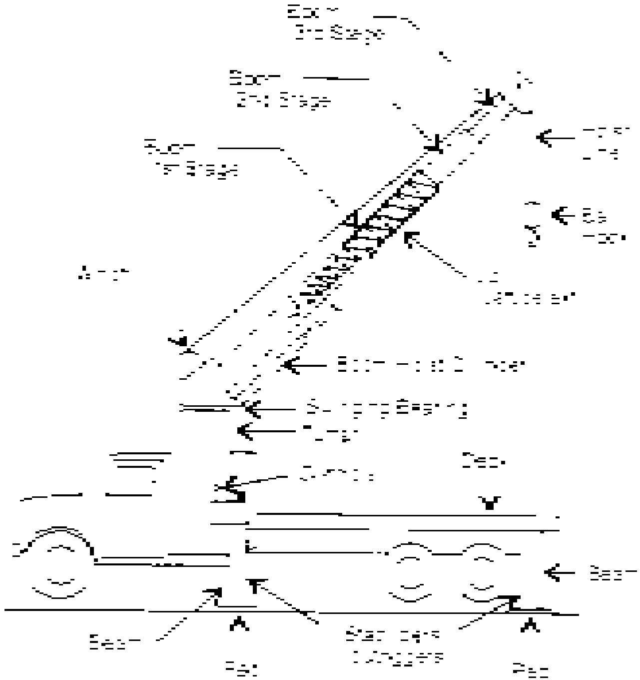


Illustration #346 – Boom Truck Components

Boom Truck Stability

Boom trucks are available with varying types of boom and outrigger configurations.

Several common boom turret locations and outrigger positions are shown in illustration #347. Two basic outrigger designs for boom trucks are shown in illustration #348.

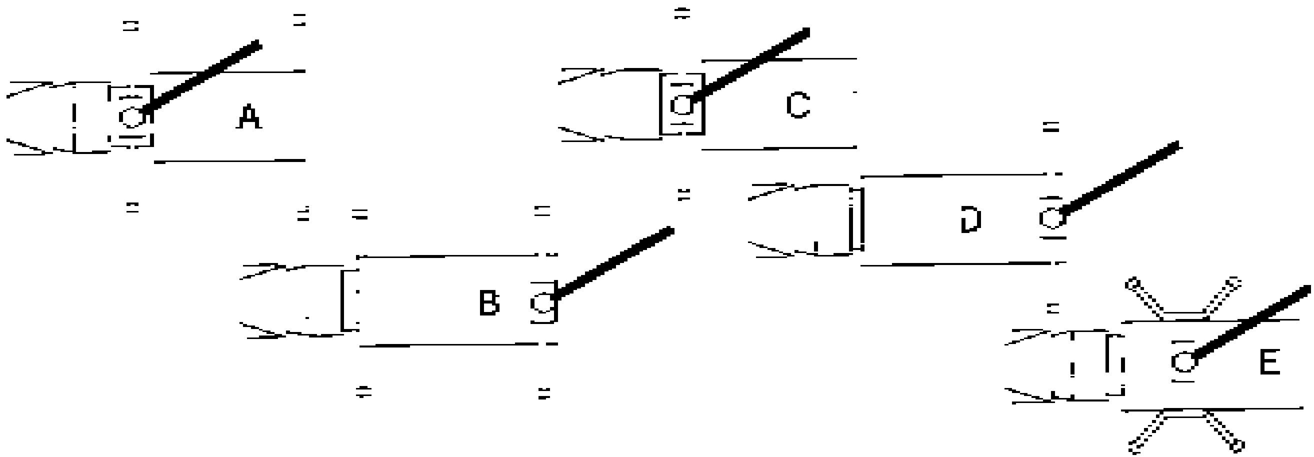


Illustration #347 – Turret and Outrigger Positions

Boom Truck Stability

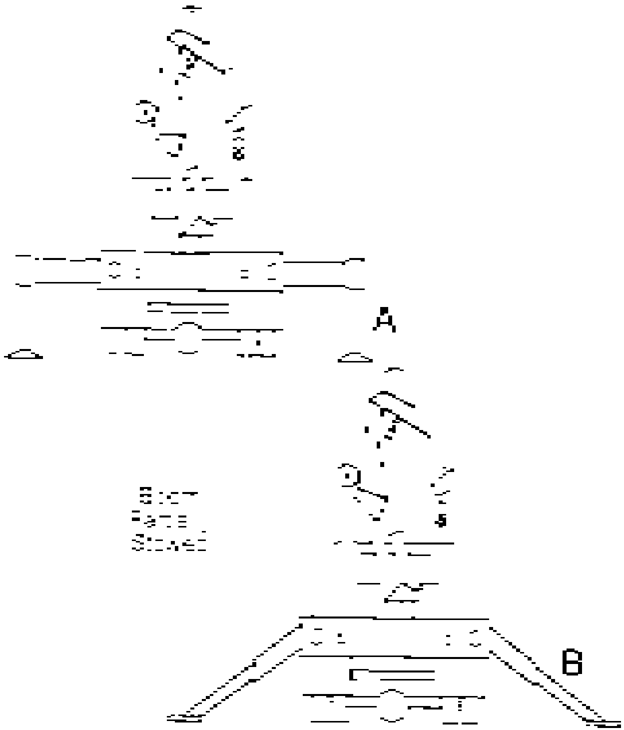


Illustration #348 - Outrigger Designs

Due to the wide variety of boom truck outrigger positions and types, it is necessary to know the operating quadrants specified in the manual provided with each boom truck.

Lifting a load that swings outside the tipping axis, or an area supported only by springs and tires, may cause stability problems or structural failure. The tipping axis will vary with outrigger position, several examples of which are shown in illustrations #349.

Angled outriggers not fully set as shown in illustration #350 will have reduced capacity on the short side.

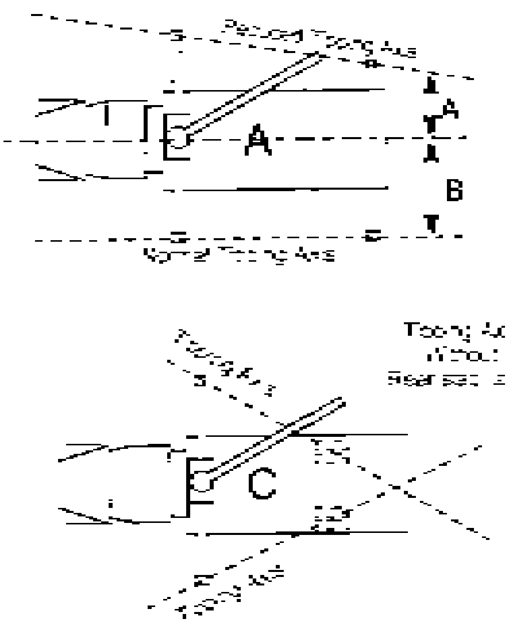


Illustration #349 – Tipping Axis

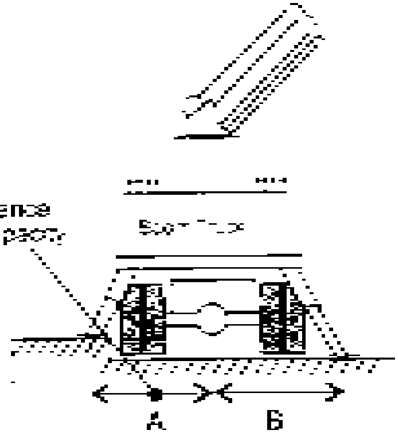


Illustration #350 – Outrigger Spread Variation

Setting Outriggers

Because of the various boom truck outrigger configurations, it is necessary to know the procedure for setting the outriggers. Study the manual and load chart requirements. One fact that is consistent with all boom trucks is that in order to obtain the full load rating, the outriggers must be extended and the unit leveled.

If it has four outriggers, all four must be extended, and the weight taken off the wheels. If it only has mid-point side outriggers, extend them and level the unit side to side. Then extend the rear stabilizer (if so equipped) and level front to back. Also extend the front stabilizer if so equipped. Depending on the unit the wheels may or may not have to be off the ground. Check the operator's manual. Use pads under the outriggers if the ground is soft.

The unit is leveled with either a birds-eye level at the control station, or a carpenters level on the turret. See illustration #351.

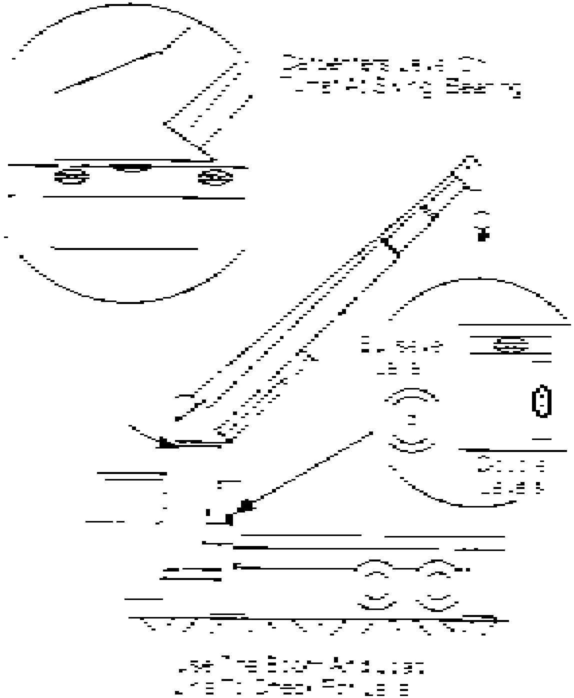


Illustration #351 – Leveling Positions

A method of checking level is to extend the boom and lower the load line, then stand back and look at the load line in relation to the boom. If it hangs off-center the unit is not level. Rotate the boom and check in all four quadrants. The basic points for a safe lift are shown in illustration #352.

Load Radius

A major area of concern for boom truck hoisting is the load radius. Due to many factors, the load may be lifted at a radius that is not safe. This can be caused by swinging into an area outside the tipping axis, by not having the outriggers properly set, by not following the load chart instructions for measuring radius, or by having the load swing out due to deflection of the machine tires, frame, outriggers, and boom. Illustration #353 shows the load radius before and after machine deflection.

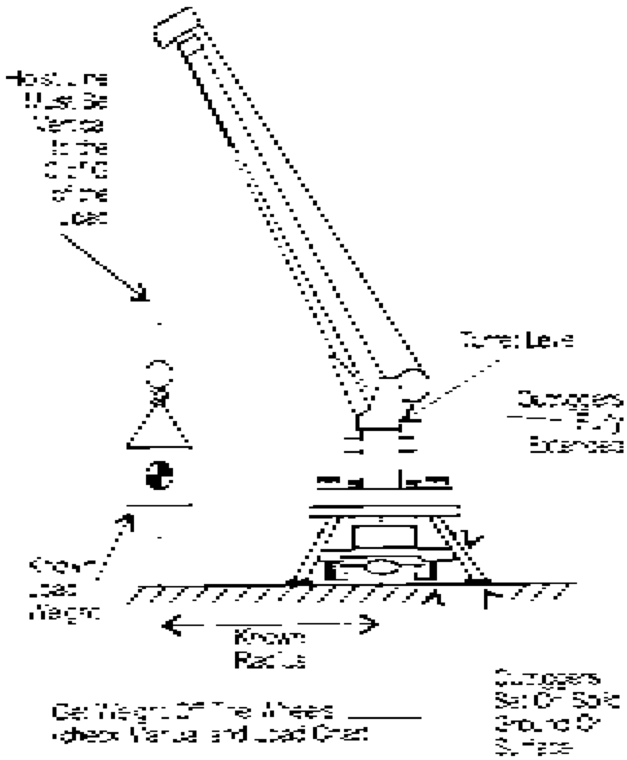


Illustration #352 – Safe Lift Set-up

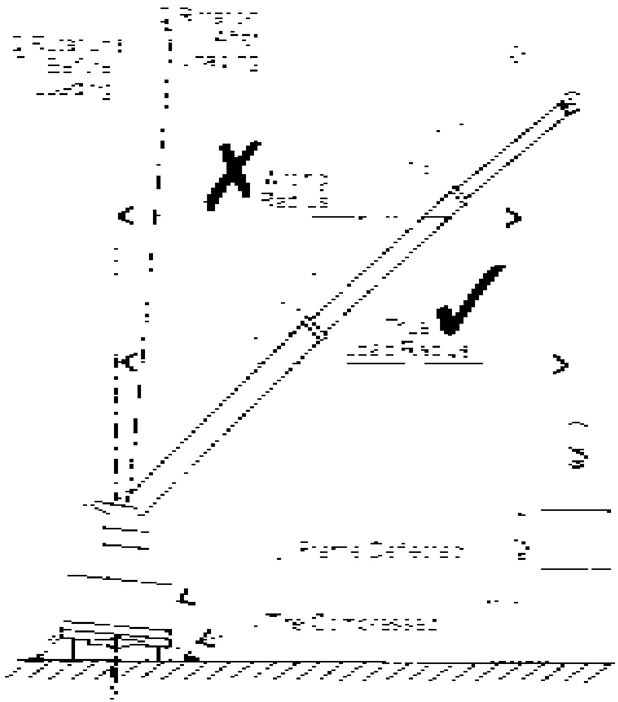


Illustration #353 – Load radius Increase

Pre-Use Inspection

Like any other piece of hoisting equipment, the components of a boom truck must be inspected on a daily, weekly, monthly, periodic, or yearly basis. An inspection log-book must be in the unit and be available for a safety inspector when requested. In general, the pre-use inspection points include:

1. Checking the truck chassis for fluid levels, lights, brakes, and the tires for inflation, cuts, or loose wheel nuts.
2. Checking the hydraulic system for fluid levels, leaks, or bulging hoses.
3. Checking the structural integrity of the unit for bends, twists, and cracks. This includes the frame, the boom and mounting, and the outrigger assembly.
4. Checking the hoisting system including the drum, for damage and proper spooling, wire rope condition, sheaves for rotation and condition, and the hook for cracks or twisting. Computerized operational aids must be checked daily.

5. Checking the rigging hardware condition, including wire rope or synthetic slings, hooks, shackles, etc.

Typical Controls

Although there are many manufacturers of boom trucks with various control panels, the type of control will be basically similar to those listed below and shown in illustration #354. However an operator, going from one type of unit to another, should be aware that control movement and component movement will vary, also the control locations in relation to each other may be different.

- ***Turn:*** Operate the lever to RIGHT to rotate the boom clockwise, and LEFT to rotate the boom counterclockwise. This is looking from the front to the rear of the unit.
- ***Boom:*** Operate the lever to DOWN to lower the boom, and UP to raise it.
- ***Boom Telescope:*** Operate the lever to OUT to extend the boom, and IN to retract the boom.
- ***Winch:*** Operate the lever to DOWN to lower the hoist line, and UP to raise the hoist line.
- ***Outriggers:*** Operate the lever to DOWN to extend, and UP to retract.
- ***Stabilizers:*** Operate the lever to DOWN to lower, and UP to raise.
- ***Foot Throttle:*** Depress the foot throttle to accelerate the truck engine. Increased engine speed increases the operating speed.
- ***Kill Switch:*** Operate the switch to stop the truck engine. The switch must be reset to restart the engine from the cab.
- ***Winch + BOS:*** Operate this (burst of speed) to get an increase in hoisting or lowering speed. Do not use this regularly.

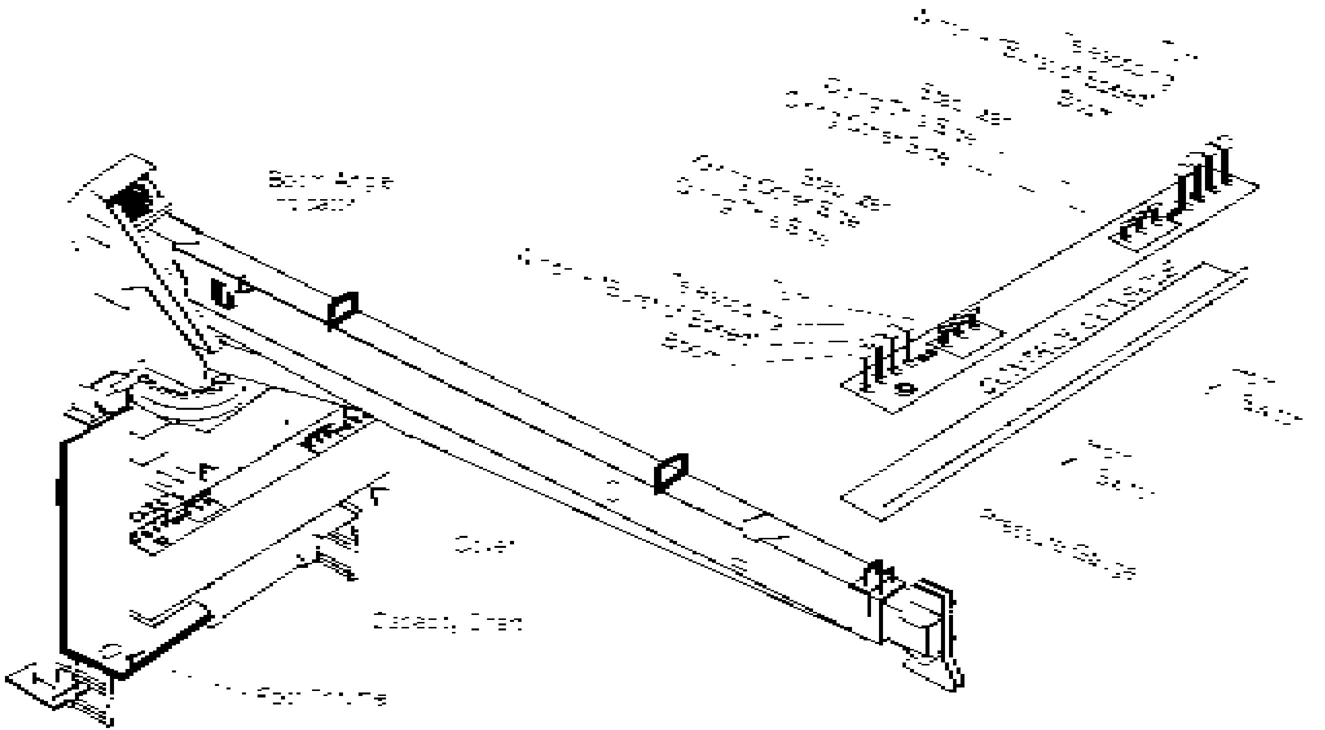


Illustration #354 - Boom Truck Controls

- ***Capacity Chart:*** The chart shows the capacities at different load weights, load radii, boom lengths, boom angles, and operating quadrants.
- ***Boom Angle Indicator.*** Use the angle indicator with the capacity chart to calculate the safe load capacity.
- ***Horn:*** Use the horn to warn personnel of crane movements.

Stowed Jib

A stowed jib is shown in illustration #355A, and is shown in its extended position in illustration #355B. The jib is kept in position (either extended or stowed) by the use of pins with retaining clips.

To move the jib from one position to another, remove the locking pins but be sure not to remove the pin the jib will pivot on.

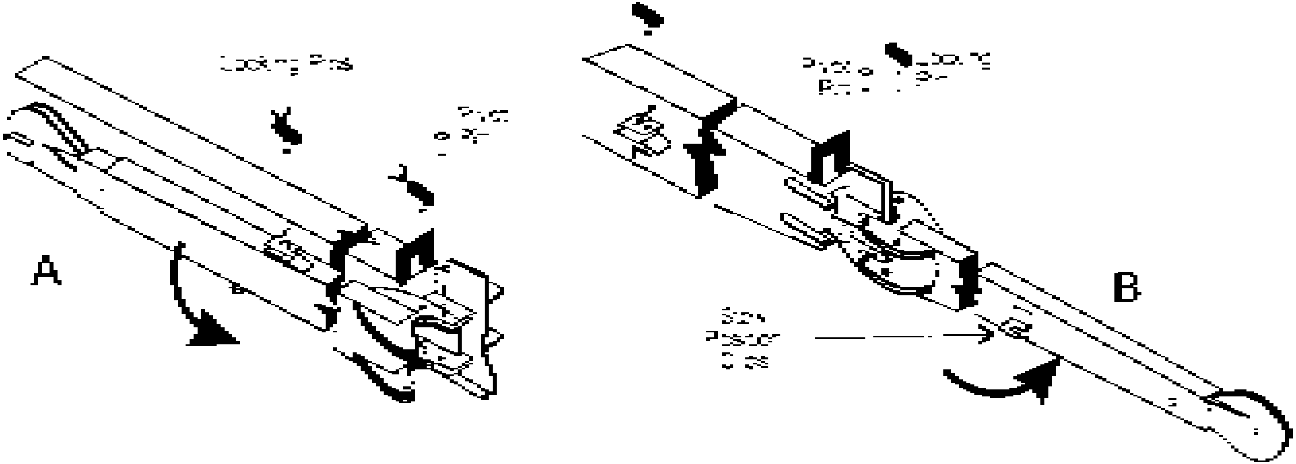


Illustration #355 - Jib Stowed and Extended

Position the jib, either extended or stowed and insert the pins with their safety clips. Ensure the pivot pin does not tie the jib and the boom tip together when the jib is in the stowed position. Do not forget to reattach the anti-two-block switch to the boom or jib tip.

Several types of boom truck jibs are shown in Illustration #355.

Boom Truck Capacity Chart

A typical boom truck or mobile unit is rated on the structural integrity of the unit and on an 85% stability tipping factor.

The following method is typically used to determine the ability of a crane to handle a load:

1. Calculate the load weight plus all slings and rigging components.
2. Measure the radius from the center of rotation to the load center. Then measure the distance from rotation to the final load position.

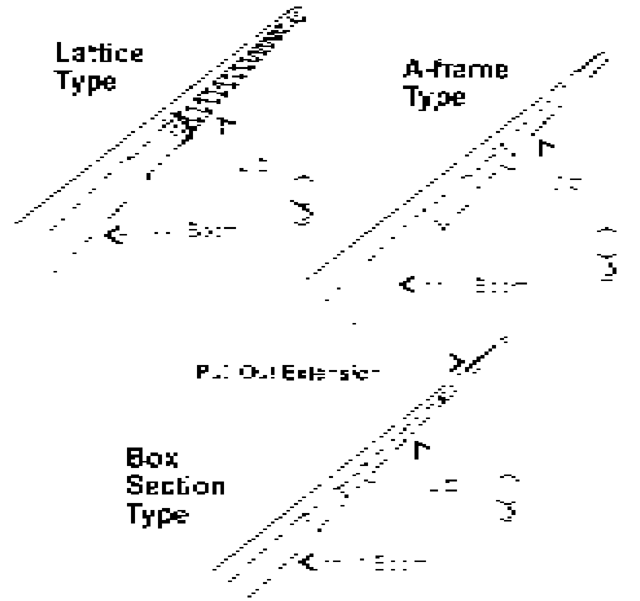


Illustration #355 – Boom Truck Jibs

3. Measure the height of where the load will be positioned. Use this height to find the boom angle and boom length.

4. Use the capacity chart information to find out if the load weight, load radius, boom length, and boom angle will be within safe operating limits.
5. Use the capacity chart notes on winch pull to see what block reeving will be required to lift the load.

It is necessary that the load weight be known. Never attempt to test lift an unknown load to see if the crane can handle it. When the crane begins to "go light" it means the crane is overloaded. At this point it may have already suffered structural damage; or on some units, when it starts to tip it might be too late to stop it from going over even by releasing the load. It is an ANSI violation to use an operational aid to test weigh a load.

Load Charts

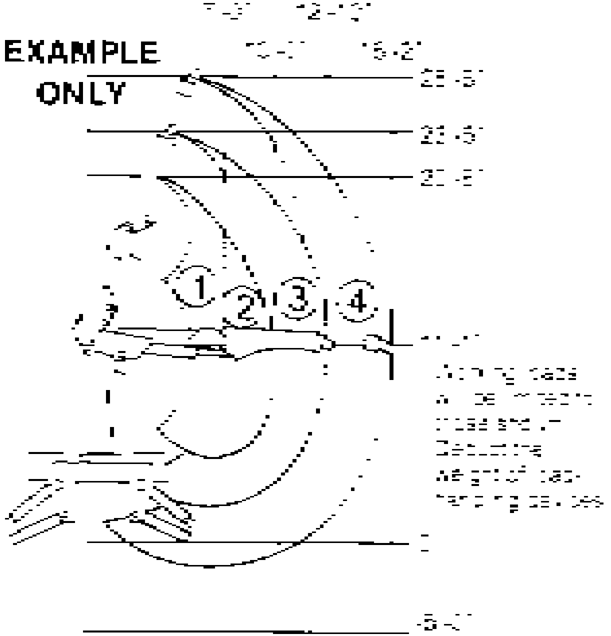
There are various types of load charts for boom trucks, depending upon the manufacturer, the type and capacity.

One type, a combined range capacity chart, for knuckle boom trucks is shown in illustration #357.

The shaded areas in illustration #357 are Range 1, Range 2, Range 3, and Range 4, with capacities as shown:

- In Range 1, the outer hook lifts within a 7 ft radius and 20 ft 8 in. height (capacity 14,000 lb).
- In Range 2, the outer hook has its maximum radius of 10 ft and height of 20 ft 8 in. (capacity 12,000 lb).
- In Range 3, the retracted boom extension has a radius of 12 ft 10 in. and lift height of 23 ft 5 in. (capacity 10,000 lb).
- In Range 4, the fully extended boom extension has a radius of 16 ft 2 in. and lift height of 26 ft 8 in. (capacity 8,000 lb).

A more typical straight hydraulic boom chart along with a load example is shown in illustration #358 and #359.



RANGE	1	2	3	4
REACH	[illegible]	[illegible]	[illegible]	[illegible]
CAPACITY	[illegible]	[illegible]	[illegible]	[illegible]
HEIGHT	[illegible]	[illegible]	[illegible]	[illegible]

Illustration #137 - Knuckle Boom Load Chart Example

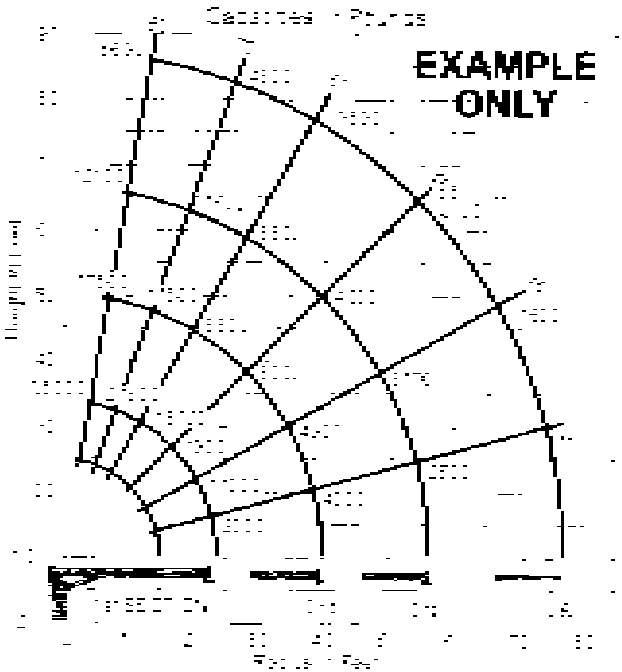
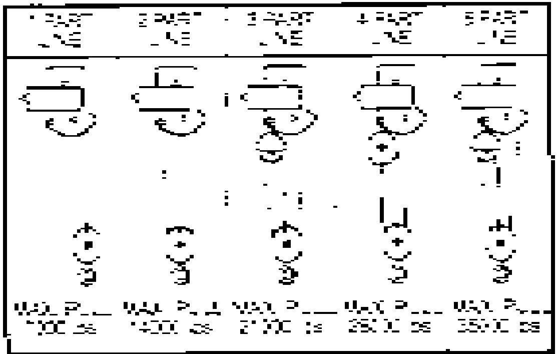


Illustration #138 - Load Chart Example



CAUTION

DO NOT DEADHEAD LINE BLOCK AGAINST THE BOOM TIP WHEN EXTENDING THE BOOM.

KEEP AT LEAST 3 WRAPS OF LOAD LINE ON THE DRUM AT ALL TIMES.

USE ONLY 9/16" dia. CABLE WITH 35000 lbs BREAKING STRENGTH ON THIS MACHINE.

MAX. CAPACITY WITH "BURST OF SPEED" IS 5000 lbs

CAUTION

1. LOAD RATINGS SHOWN ON THIS CHART ARE MAXIMUM ALLOWABLE LOADS WITH THE OUTRIGGERS PROPERLY EXTENDED ON A FIRM LEVEL SURFACE AND THE CRANE LEVELED AND MOUNTED ON A FACTORY RECOMMENDED TRUCK.
2. ALWAYS LEVEL THE CRANE WITH THE LEVEL INDICATOR LOCATED ON THE CRANE FRAME.
3. THE OPERATOR MUST REDUCE LOADS TO ALLOW FOR FACTORS SUCH AS WIND, GROUND CONDITIONS, OPERATING SPEEDS AND THE EFFECT OF FREELY SUSPENDED LOADS.
4. OVERLOADING THE CRANE MAY CAUSE STRUCTURAL COLLAPSE OR INSTABILITY.
5. WEIGHTS OF ANY ACCESSORIES ATTACHED TO THE BOOM OR LOAD LINE MUST BE REDUCED FROM THE LOAD CHART CAPACITIES.
6. DO NOT EXCEED LB CAPACITIES AT ANY REDUCED BOOM LENGTH.

Illustration #359 - Load Chart Example (continued)

Load Chart Capacity Example

The load chart used in this example (illustrations #358 and #359) is only one of many different types. There are many manufacturers of boom trucks and each manufacturer will have at least several different models.

The load chart for each will vary but all will contain similar data including radius, boom length, boom angle and caution notes.

- Load .... 6800 pounds
- 2 Part Block .... 150 pounds
- Rigging Hardware .... 70 pounds
- Stowed Jib .... 250 pounds
- Total Weight .... 7270 pounds

Example 1 - The 6,800 pound load is positioned at a 20 foot radius. Is this a safe lift using the first section?

Answer 1 - The line pull is only 7,000 pounds, therefore the two part block is needed. The maximum capacity of the first section is 8,200 pounds. This is a safe lift.

Example 2 - Can the load be repositioned at an 18 foot radius on top of a 55 foot high structure?

Answer 2 - To lift the load to the 55 foot level means the 3rd section must be used. The load chart indicates the capacity of the boom at a 70° angle is 7,500 pounds. This capacity is at the approximate 18 foot radius line. With a gross load of 7,270 pounds and a capacity of 7,500 this lift would require extreme care. Any lift over 75% of rated capacity is a critical lift.

Example 3 - If the jib is attached, can a 2,300 pound load be positioned at a 55 foot radius and 30 feet high?

Answer 3 - The 2,300 pound net load will have the weight of the rigging hardware plus the block added to it.

The capacity chart reading for a load at a 55 foot radius and 30 feet high means the jib must be used. The capacity is only 2,300 pounds. Do not make this lift.

Example 4 - What two precautions must be considered when attempting to lift the maximum load of 35,000 pounds?

Answer 4 - The maximum load this unit can lift is 35,000 pounds.

a. The line pull is only 7,000 pounds, therefore the 5 part line would have to be used.

b. The 35,000 pound rating is only handled at a very limited load radius of less than 5 feet.

Operation Safety Tips

1. The hoist drum must have a minimum of three wraps of wire rope (check this with the applicable OCHS/OSHA office as the requirement will vary in some areas.
2. Know both the winch pull and the boom capacity. They will be different. The load weight must not exceed the lesser amount.
3. Always know the load weight, boom angle, boom length, and load radius to avoid overload.
4. Add the weight of the rigging slings and hardware to the load weight when calculating capacities.
5. Do not exceed the jib rating when lifting with a jib, even though the boom is retracted.
6. Reeve the crane with the proper parts of wire rope needed to lift the load.
7. Follow the manufacturers method of reeving the hoist blocks.
8. Ensure the boom tip is positioned directly over the center of gravity of the load before hoisting.
9. Ensure the jib is securely stowed before operating the boom.
10. Never use the feel of crane tipping or going light to determine load capacity.

11. Before hoisting, always make sure the load is not bolted or fastened down. Do not try to lift loads frozen to the ground.
12. Never let the load be positioned to one side of the boom while lifting or lowering.
13. Keep the swing movement slow to avoid sideloading the boom or creating excessive load radius.
14. Never use the hoist line to drag a load and never use the boom to drag a load sideways.
15. Never permit anyone to ride the hook or the load.
16. Never swing a load over working personnel or any bystanders.
17. Always keep the load as close as possible to the ground.
18. Make sure any loose objects are secured on the load. Never try to make two lifts at once.
19. If signals are required, only one person must give the signals, and the person must understand what is required.
20. The operator must obey a stop signal from anyone.
21. If taglines are used they must be of a non-conductive material.
22. Do not operate in hazardous weather conditions such as: high winds, electrical storms, poor visibility.
23. Operate the controls slowly and smoothly. This protects the hydraulic system and prevents jerky and erratic load movements.
24. The operator should not be at the controls with greasy hands. The control deck must be free of grease, oil or ice to maintain secure footing.
25. Always have tension on the hoist wire rope to maintain proper spooling.

26. The operator should warn personnel to keep their feet away from the outriggers. The outrigger may lift up from the load weight then suddenly drop.
27. Never allow the load block to pull up into the boom tip sheaves (two-blocking) while hoisting or extending the boom.
28. Never leave the crane unattended with a suspended load.
29. Never disconnect hydraulic components if they are pressurized.
30. Avoid areas of hydraulic leaks as the hot fluid and high pressure can cause injury.
31. A. Danger and Caution decals must be maintained and visible on the crane.
32. A very high percentage of all mobile crane accidents involve power line contact. Always keep the recommended minimum distance between the power line and any part of the crane (boom, jib, load line, load) (see table #78 in Mobile Crane section). Ensure the signal person is aware of the hazards. There should be a pre-lift discussion amongst all parties to plan the load movements.

SECTION FIVE QUESTIONS

Boom Trucks

1. Determine if this statement is true or false. Because boom trucks are not in the same category as a crane, they do not require a log book or an inspection chart.
   - ❑ true ❑ false
2. When referring to the boom, what is one of the primary differences between a turret type and an articulating type?
   - ❑ all turret boom types have higher capacities
   - ❑ all turret types have more boom sections
   - ❑ only articulating type have remote control operator
   - ❑ articulating boom has hinged boom sections
3. Determine if this statement is true or false. All articulating boom types do not have a hoisting wire rope with a drum.
   - ❑ true ❑ false
4. Determine if this statement is true or false. All boom trucks have four outriggers similar to a mobile crane.
   - ❑ true ❑ false
5. Determine if this statement is true or false. If a boom truck only has two outriggers, the turret must be located at the rear.
   - ❑ true ❑ false
6. Which piece of literature or book would the quadrants of operation be found in?
   - ❑ manufacturers manual or load chart
   - ❑ inspection checklist
   - ❑ log book
   - ❑ quadrants not used in boom trucks
7. Determine if this statement is true or false. After setting the outriggers, boom truck stability does not change when swinging a load from an area supported by the outriggers to an area supported by springs and tires.
   - ❑ true ❑ false
8. Which condition occurs as a result of having higher blocking on one side when the truck is equipped with angled type outriggers?
   - ❑ uneven load on boom
   - ❑ boom truck not level
   - ❑ tipping axis distance reduction
   - ❑ has no effect

9. Determine if this statement is true or false: If a boom truck has the outriggers extended, the outriggers [illegible] be level.

- ☐ true
- ☐ false

10. Determine if this statement is true or false: When using all four outriggers on a boom truck, it is not necessary to take the vehicle weight off the tires.

- ☐ true
- ☐ false

11. A crane [illegible] increase the load center from an extended boom would indicate:

- ☐ outriggers not extended
- ☐ boom angle too high
- ☐ unit is not level
- ☐ boom not fully extended

12. Determine if this statement is true or false: When setting up a boom truck, the unit [illegible] side to side [illegible] front to rear.

- ☐ true
- ☐ false

13. Determine if this statement is true or false: The distance from the center line of rotation to the load center can change after the load leaves the ground.

- ☐ true
- ☐ false

14. The actual radius of the load is:

- ☐ the estimated distance from crane rotation point to load center
- ☐ the actual distance from crane rotation point to unhooked load center
- ☐ the actual distance from crane rotation center to hooked load center
- ☐ the distance from crane rotation point to center of outrigger

15. Determine if this statement is true or false: Due to the [illegible] lower lifting capacities than most other cranes, boom trucks do not need the regular [illegible] yearly inspections.

- ☐ true
- ☐ false

16. Which of the following [illegible] when using the controls of a machine the operator is not familiar with?

- ☐ individual control positions may be different
- ☐ individual control movements may be different
- ☐ control and component movement may be different
- ☐ all of the above

17. Determine if this statement is true or false: A [illegible] the most stable position [illegible] use of [illegible] and [illegible].

- ☐ true
- ☐ false

18. Determine if this statement is true or false. Overloading or structural damage is not a factor with boom trucks as their load charts are based on the unit tipping before something breaks.

❑ true ❑ false

19. Determine if this statement is true or false. It is a common and accepted practice to use a computerized load indicator to test weigh a load to get the actual weight.

❑ true ❑ false

20. Changing the wire rope boom reeving from a single line to multiple parts will:

❑ increase the lifting capacity
❑ require the boom to be shortened
❑ require the jib to be attached
❑ all of above

21. Determine if this statement is true or false. It is possible the winch pull capacity could exceed the boom capacity.

❑ true ❑ false

22. Which of the following could cause structural damage to, or overload a boom?

❑ lifting a load positioned beyond the boom tip
❑ rapid swinging of a load
❑ lifting a load positioned off to one side of the boom tip
❑ all of above

23. Determine if this statement is true or false. Boom trucks have smaller booms than mobile cranes, therefore fewer [illegible] accidents. As a result a pre-lift planning meeting is not necessary.

❑ true ❑ false

SECTION SIX

MATERIAL HANDLING LIFTING DEVICES and LOCOMOTIVE RAIL CRANES

Material Handlers

The term "Material Handler" loosely covers a range of machinery designed to move different types of loads. They are widely used in manufacturing and production plants, scrapyards, and construction sites. Some designs are basically rough terrain forklifts. One of the two types mentioned in this section has more capacity and reach with an extendable boom, and the forks can be replaced with other devices, including a hoisting hook, which turns the unit into a crane. The other type of material handler in this section is similar to an articulating (knuckleboom) crane, equipped with either a scrapyard style magnet or grappling hook instead of a conventional hook.

These handlers are covered by various sections of the ANSI standards, depending upon the use, type, and design.

Multi-Purpose Material Handler

ANSI refers to this type of unit as a Variable Reach Boom Type Rough Terrain Forklift. It is similar to a standard forklift except for the extendable boom (Illustration #360).

The boom head is usually designed to remove the forks (Illustration #361).

The forks can be replaced with various attachments including a slinger for lifting cable spools (Illustration #362), or a pipe or lumber grappler (Illustration #363).

Other attachments include a material bucket, scraper blade, barrel or container handler, rail car coupler or a fifth wheel (for moving rail cars or semi-trailers). Some units have a recessed hoisting hook with wire rope and a hoist drum, or a hook can be attached (Illustrations #364 - #365).

Note: Higher capacity units are used at rail yards and ports to move shipping containers.

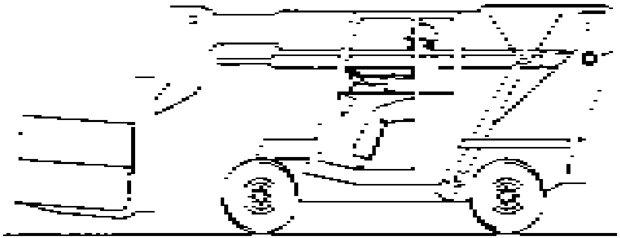


Illustration #360 - Extendable Boom Material Handler

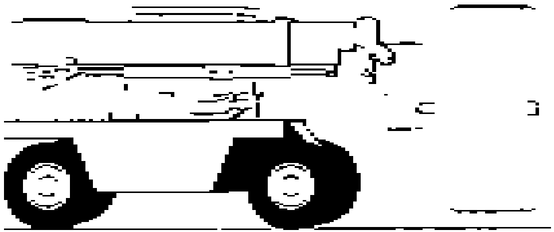


Illustration #362 - Reel or Spool "Stinger" Attachment

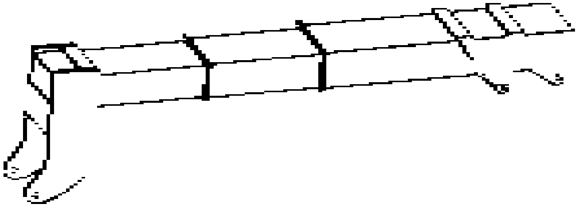


Illustration #361 - Boom Without Attachment

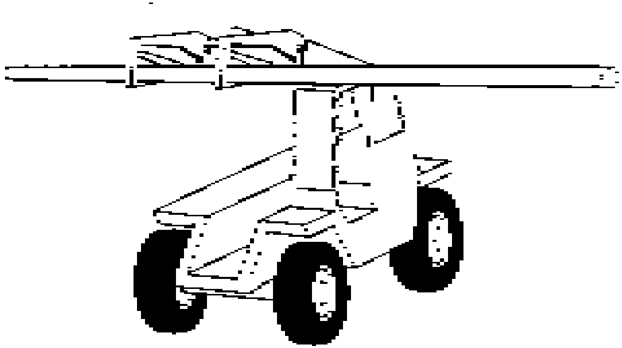


Illustration #363 - Pipe or Lumber Grappler

In the typical fork configuration it falls under the ANSI 56.6 standard; however B30.5 crane standards can also apply when hoisting with the hook.

Illustration #364 - Recessed Hook

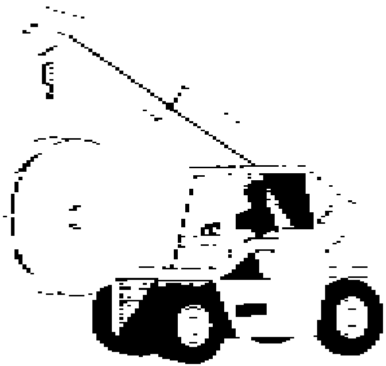


Illustration #365 - Hoisting Hook

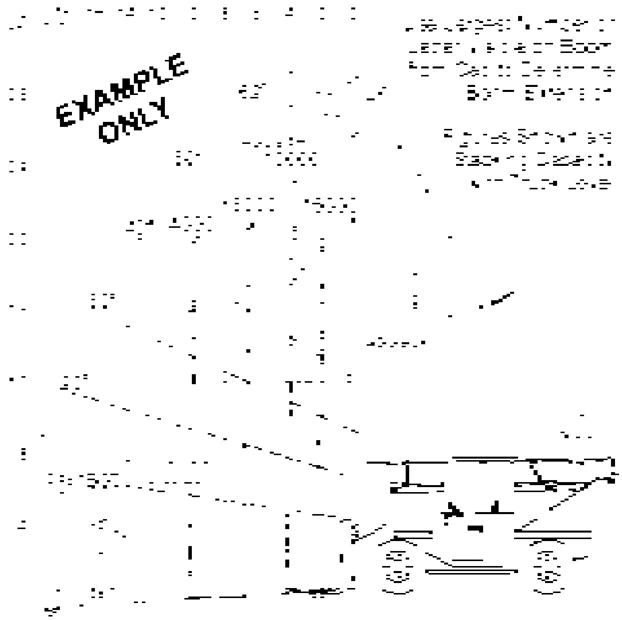


Illustration #366 - Load Chart for Forks or Hook

Capacity Chart

A capacity chart similar to a crane chart is included with the unit showing the weight capacities at different boom lengths, boom angles, load radius, and heights. See illustration #366 for an example.

To determine boom extension, use the largest number of letter on the boom visible from the cab.

Some manufacturers have models that may have the following features:

- A front stabilizer (similar to crane outrigger beams)
- A leveling device to keep the body, forks and load level while the wheels are off-level (illustration #367)
- Right and left swing forks
- Center articulating
- Steering is either front wheel, rear wheel, front with rear wheel circle or rear wheel crab.

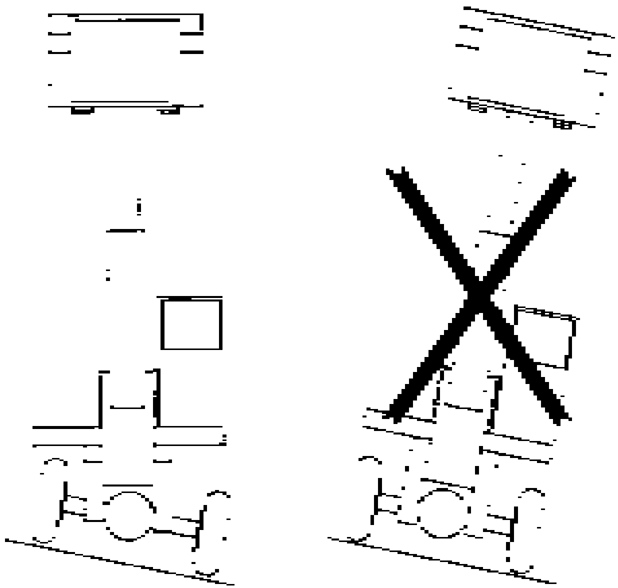


Illustration #367 – Lifting with Leveling Device

Multi-Purpose Operation Requirements

Operation of this type of multi-purpose machine definitely has grey areas and cross-overs. While selection, training, and certification of the operator for safe use of a forklift is required in most jurisdictions, it is mandatory for a crane operator. Most forklift training is not the same as, or include crane operator training, and vice versa. How this type of unit is equipped and its use will determine how and what type of training is required. That will vary somewhat depending on whether it is the United States or Canada, what state or province, or what particular company or organization controls the machine use. To be sure, check the applicable operation regulations.

Safety Tips

Although there are various types of multi-purpose handlers, most have similar safety requirements.

- Any new operator must read and be familiar with the operation and safety manual.
- Inspect the unit every day before use. Check the gages, controls, lights, brakes, and check for leaks or any unusual noise.
- Check the coolant and battery level. Use caution.
- Fill fuel tank in a ventilated area with the engine off.
- Keep clear of fan, pulleys, belts, gears, etc. Keep guards in place.
- Know the working area. Watch for soft or uneven ground.
- Keep the necessary distance from power lines.
- Know the load weight before lifting. Do not exceed capacity.
- Keep the load centered for balance.

- Keep the load against the forks and tipped back slightly.
- Travel with the boom retracted and low to the ground.
- Keep the load uphill when traveling on slopes.
- Do not allow people to ride the load or forks.
- Check the load hoist wire ropes, attachments, and slings.
- Do not drag or side-pull a load with the hoist.

Scrap and Material Handler

ANSI refers to this type of machine as a Material Handler. It falls under ANSI standard B30.25 when equipped with a scrap magnet or a grappling hook (as compared to B30.22 for articulating boom cranes).

Illustration #368 shows a crawler mounted unit with a grappling hook and illustration #369 is a rough terrain mobile unit with a magnet. They can also be pedestal, rail car, or truck mounted. Different manufacturers will have various types of articulating booms.

Material Handler Operation Requirements

As this type of material handler is basically a crane with a magnet or grappling hook instead of a load hook, the operator selection, training, and certification is treated the same as a crane in most jurisdictions. As with the multi-purpose handler, check the applicable operation regulations. The requirement for safe crane operation applying to these include: load weight, operating radius, quadrants of operation, ground conditions, and use of outriggers when applicable.

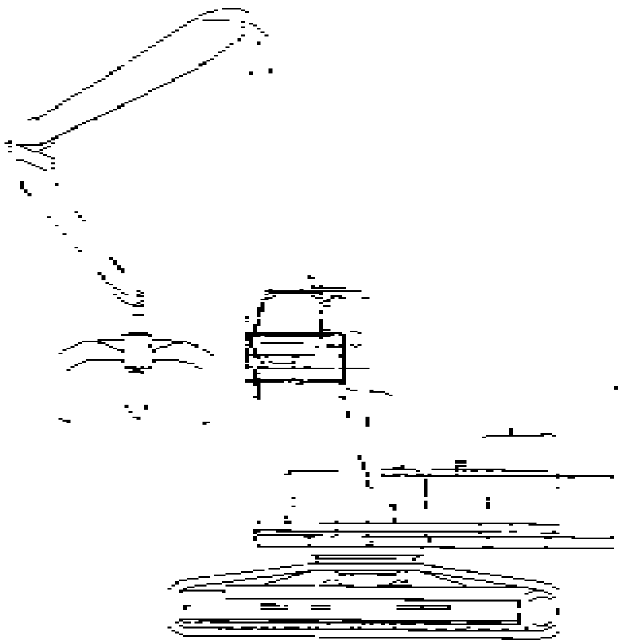


Illustration #368 - Crawler Mounted with Grappling Hook

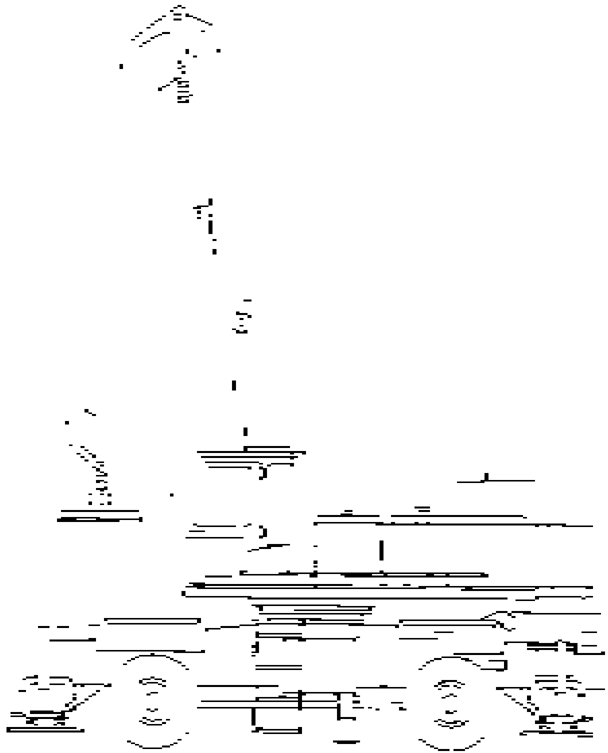


Illustration #365 - Mobile Mounted with Magnet

Locomotive and Rail Car Cranes

Rail Crane Types

There are two basic types of railway cranes. The locomotive type is mounted on rail wheels and can be self-propelled or propelled by an external source. See illustration #370.

The other type of rail crane is usually a tracked or wheeled land crane mounted on a flat car. This type must be moved by an external method. See illustration #371. Both wheeled or track type could have a conventional or a hydraulic boom.

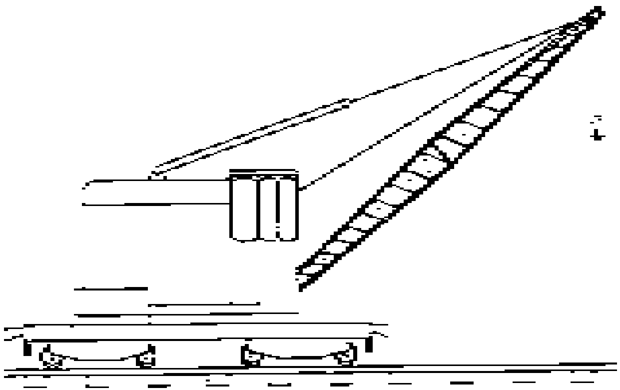


Illustration #370 – Locomotive Crane

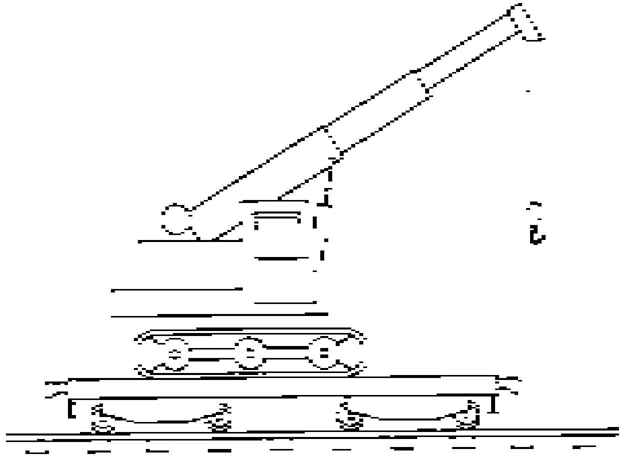


Illustration #371 – Rail Car Crane

Crane Stability Ratings

Locomotive and rail cranes are regulated by ANSI standard B30.5. Due to the fact they are on rails and their use is greatly affected by the movement of freight and passenger trains, they are also regulated by the ARA (American Railroad Association).

Similar to land cranes, there are two load chart ratings - one based on the use of outriggers and one without outriggers. With outriggers, the crane chart is rated at 80% of capacity without outriggers. It is based on 85% of capacity with up to a 60 foot boom. Know the crane capacity.

Counterweights are sometimes used for additional over-the-side hoisting stability. The counterweight can be transported on a following flat car along with tools and blocking. The trailing flat car can also be used to support the crane boom.

Crane Stability

Locomotive style cranes work with a huge stability disadvantage compared to land cranes. This is because of the short rail-to-rail spacing distance. Stability of cranes mounted on flat cars is even worse due to the car movement.

The crane and/or rail car must be securely blocked to prevent movement or tipping. Various railroad lines have used different methods of blocking and/or securing rail cranes for stability. One method of blocking outriggers is listed below and illustrated in #372.

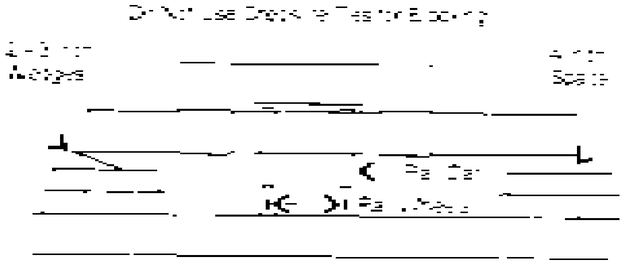


Illustration #372 - Rail Crane Outrigger Blocking

1. The ground under the crane outriggers is leveled. A solid crib is formed using 6 x 8 hardwood timbers to within approximately 4 inches of the outrigger.

2. A layer of 3-inch hardwood is placed on the cribbing.

3. The outrigger is lifted with a jack, then two hardwood wedges are driven in, one from each side.

4. Do not use oiled or creosote timbers (no old railway ties) for cribbing.

5. Do not use a sledgehammer directly on the timber ends as hammering could shatter the timber interior.

Side Boom Hoists

Due to the lack of any method to move a crane sideways and closer to the load, crane hoisting for such problems as derailed cars can create difficult or impossible working circumstances.

Therefore the use of rail type cranes is being reduced by some railroad lines and is limited to car-to-car movement of material or track maintenance. They are being replaced by wheeled cherry picker or rough terrain hydraulic cranes for urban area uses. In the case of derailments and remote track maintenance, side boom hoists are more predominately used. A wheeled side boom is shown in illustration #373, and a tracked side boom with a moveable or adjustable counterweight is shown in illustration #374. Side boom hoists are covered under ANSI B30.14.

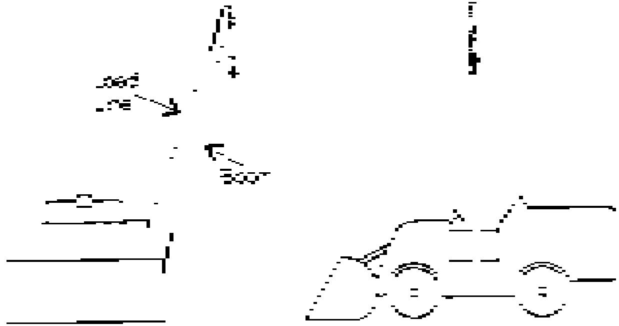


Illustration #373 – Wheeled Side Boom Hoist

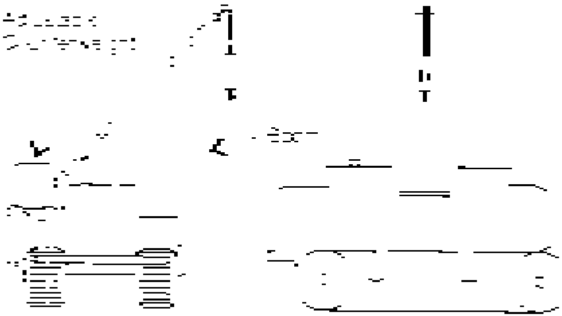


Illustration #374 – Tracked Side Boom Hoist

Rail Signals

Standard crane hand signals may be used for the hoisting operator (see Section Four). However, due to the fact that the crane is in a railway environment, often with multiple tracks, other types of signals and lights come into play concerning the movement of rolling equipment on the track. The standard railroad light (lantern) or flag signals for train movement should be known. See illustration #375.

If flags are used, a red flag is used in daylight and a white flag is used at night. Voice communication can also be used.

Colored Light (Flag) Warnings

A series of colored lights (red, yellow, or blue) should be set up and used as a warning to oncoming trains concerning movement or a possible hazard ahead, or if there are workers immediately ahead.

Red Light or Flag: A train must stop short of a red flag and only proceed when authorized.

Yellow Light or Flag: This denotes caution and slow down. For example, for a 40 mph speed limit, the train must slow to 10 mph.

Blue Light or Flag: This denotes that workers ahead are engaged in inspection, testing, repair or servicing of equipment. They are on, under, or between rolling equipment and the equipment must not be coupled or moved. In addition, rolling equipment must not pass a blue signal on a track protected by that signal.

Note: Additional railroad regulations are required for mainline cross-country situations.

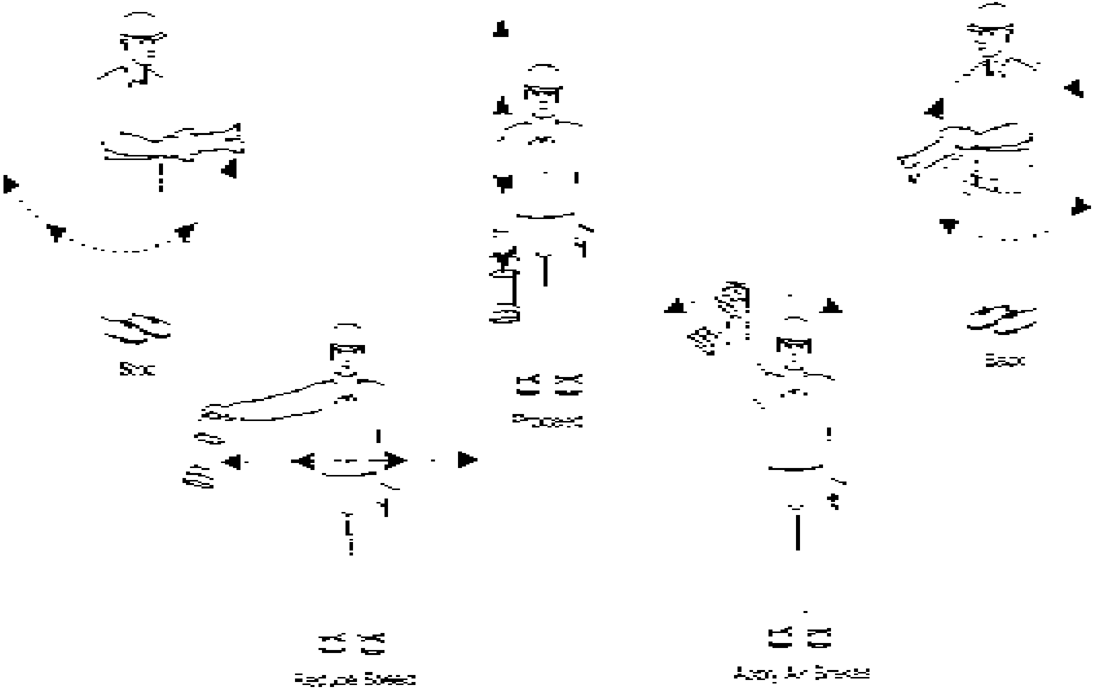


Illustration #375 – Railroad Hand Signals

SECTION SIX QUESTIONS

Material Handling / Rail Cranes

1. Determine if this statement is true or false. If the Variable Reach Boom Type Rough Terrain Forklift material handler is using a hoisting hook to lift a load, the operation is under the ANSI crane standard B30.5.
   - ❏ true
   - ❏ false

2. The above type of material handler can also be equipped with what type of attachment?
   - ❏ stinger for lifting a reel
   - ❏ pipe or lumber grappler
   - ❏ rail car coupler
   - ❏ all of above

3. Determine if this statement is true or false. Most of these handlers have a letter or number on the boom, visible from the cab, which indicates the boom section being used.
   - ❏ true
   - ❏ false

4. Determine if this statement is true or false. These variable reach forklifts have an extendable boom, however they do not require a load chart for different load positions because of the light loads involved.
   - ❏ true
   - ❏ false

5. Determine if this statement is true or false. Training for all variable reach forklifts is standardized.
   - ❏ true
   - ❏ false

6. Determine if this statement is true or false. Training for variable reach forklifts could be either forklift training or crane training.
   - ❏ true
   - ❏ false

7. Determine if this statement is true or false. A scrap and material handler is similar to an articulating boom crane with the exception of a different ANSI standard.
   - ❏ true
   - ❏ false

8. Determine if this statement is true or false. Operator training for a scrap handler with a grappling hook is similar to that of an articulating crane.
   - ❏ true
   - ❏ false

9. Determine if this statement is true or false: [illegible]

☐ True ☐ False

10. Determine if this statement is true or false: Rail cranes are covered under the [illegible] ANSI Standard.

☐ True ☐ False

11. Determine if this statement is true or false: [illegible]

☐ True ☐ False

12. Determine if this statement is true or false: [illegible]

☐ True ☐ False

13. Determine if this statement is true or false: When using a [illegible] crane, [illegible]

☐ True ☐ False

14. [illegible]

☐ Proceed slowly
☐ A person is on or under equipment ahead
☐ Hoist the load
☐ Lower the crane boom

15. [illegible]

☐ Proceed
☐ Stop
☐ Back up
☐ Slow down

SECTION SEVEN

AERIAL WORK PLATFORMS

Types of Aerial Platforms

Aerial work platforms fall under several different categories, and are manufactured in a variety of designs. They are covered by four sections of the ANSI standard.

1. Vehicle mounted elevating platforms (Illustration #376) (A92.2)
2. Manually propelled elevating platform (Illustration #377) (A92.3)
3. Boom-supported elevating platforms (Illustration #378) (A92.5)
4. Self-propelled elevating platform (Illustration #379) (A92.6)
5. Upright elevating lift mast platforms (Illustration #380)

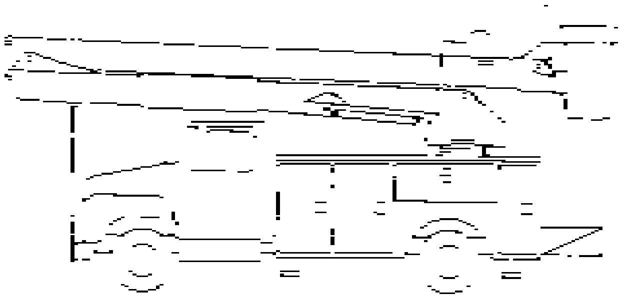


Illustration #376 – Vehicle Mounted Platform

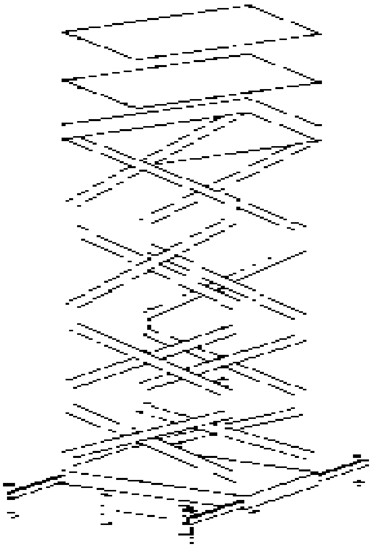


Illustration #377 – Manually Propelled Platform

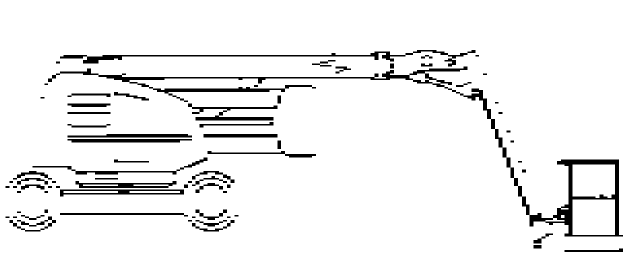


Illustration #378 – Boom-supported Platform

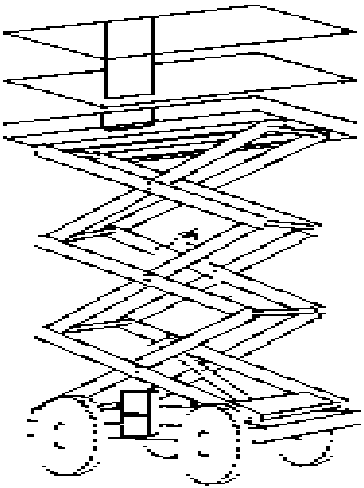


Illustration #379 – Self-propelled Platform

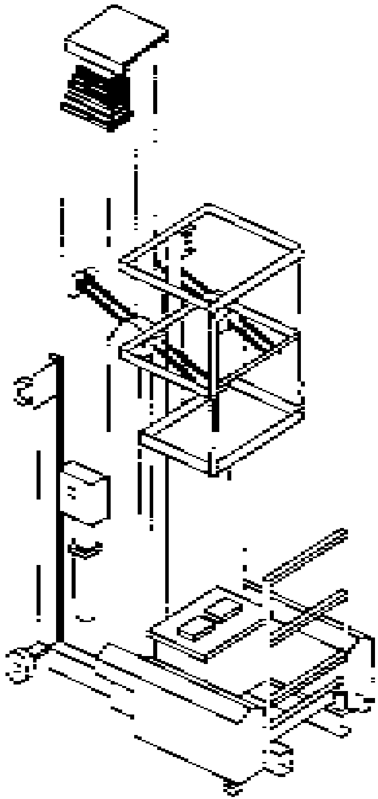


Illustration #380 – Up-right Mast Platform

Aerial Platform Safety

Aerial platforms are set up and operated under the same general rules and guidelines as any other piece of mobile hoisting equipment. However, due to the fact that these platforms are used solely to hoist personnel, safety precautions are a must. Many accidents happen every year due to operator misuse, taking shortcuts, or using the equipment for something it wasn't designed for.

Three major safety items concerning the operation of these platforms must include:

- a thorough operator training program
- thorough inspection and care of the equipment
- understanding and protection against electrical hazards

Aerial Platform Training Program

No one must be permitted to operate an aerial platform without having been thoroughly trained in its use. Training points must include:

- Read, understand, and be familiar with the contents of the operation manual.
- Know what to look for and how to conduct a pre-operation inspection of the unit.
- Know the location and function of all the controls. The operator should be able to go immediately to the required control.
- Know the set-up and operating sequence of the unit, especially the holding valve testing procedure.
- Know the rated load capacity. Overloading can cause instability or structural failure.
- If so equipped, always use the outriggers.
- Have a plan for dealing with system breakdowns while in use.

Note: Do not minimize the importance of operator training.

Note: Don't assume that a person trained on one make, or type of equipment is qualified to operate other devices, as the capacities, controls, and operating characteristics will vary.

Note: Do not overload the basket or use it as a crane for hoisting.

Note: Avoid powerline contact (illustration #381).

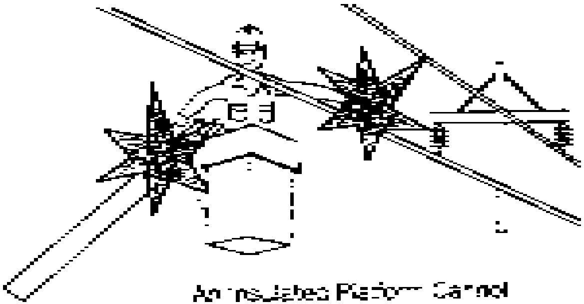


Illustration #381 – Avoid Powerline Contact

Note: Personnel in the basket are always under the control of the ground operator, as the base controls are dominant, and will override platform controls. See illustration #382.

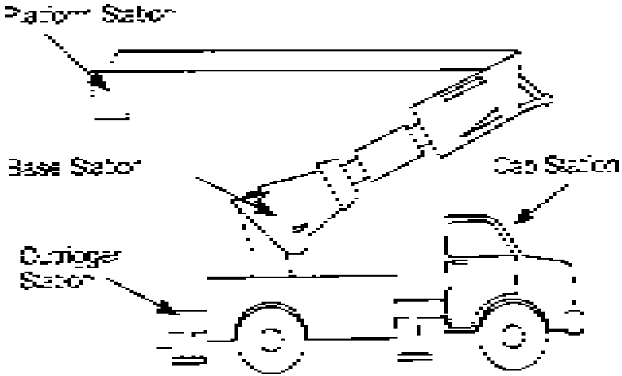


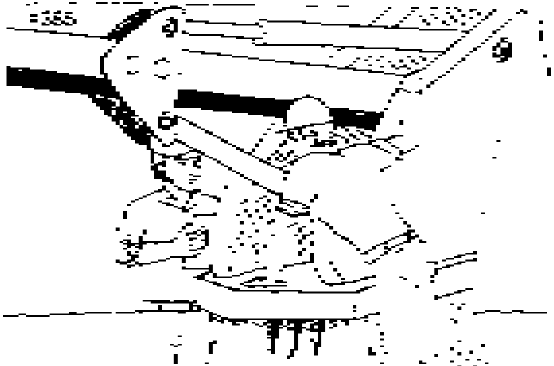
Illustration #382 – Control Locations

Aerial Platform Safety

#363

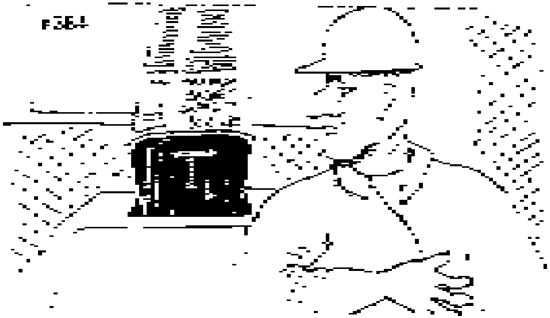
Know the location and function of ALL controls on the unit.

#365



Make a pre-operation inspection. Use a checklist.

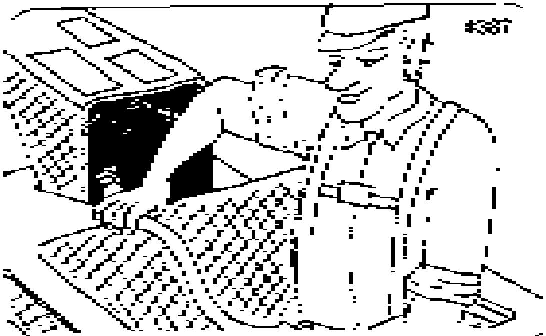
#364



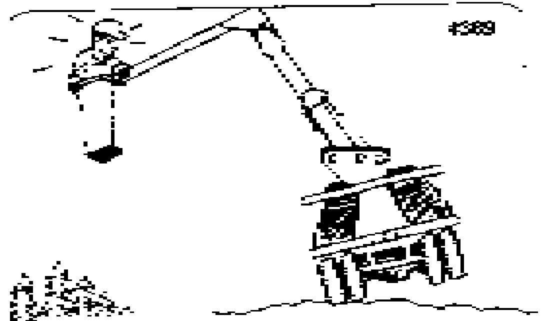
Note the rated load capacity. Exceeding the rated load can result in instability and structural failure.

#366

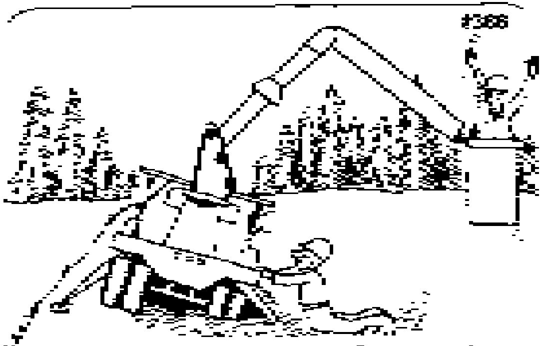
Operators should run a complete cycle of operation with emphasis on the holding valve tests. The controls should be handled SMOOTHLY.



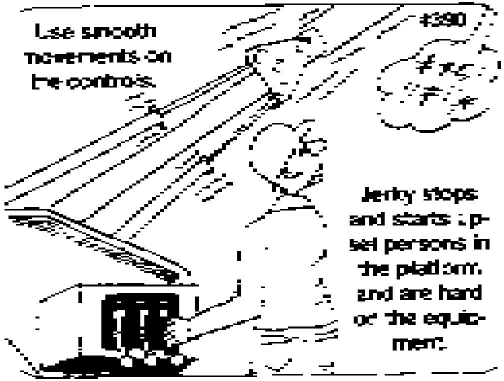
Use a safety harness and lanyard in all aerial equipment. Always buckle up.



Test outrigger and boom holding valves. A defective holding valve can allow an outrigger or boom to creep out of position.



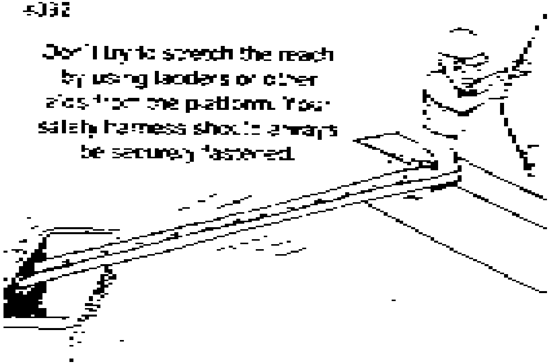
Ensure the outriggers are on firm ground. When in doubt, use a float under the foot.



#391

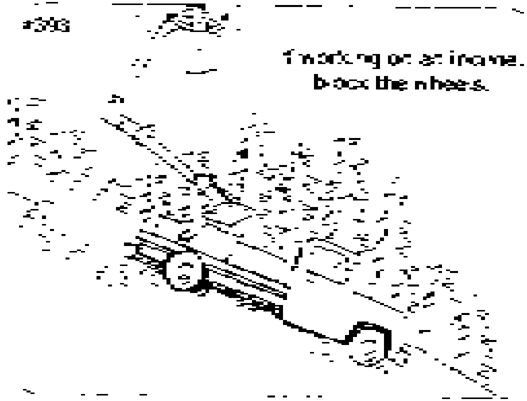
Always check the work area for overhead obstructions. Look before moving.

#392



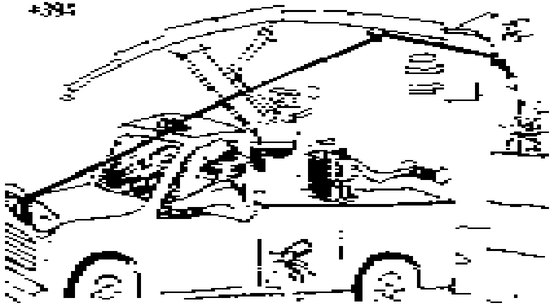
Don't try to stretch the reach by using ladders or other aids from the platform. Your safety harness should always be securely fastened.

#393



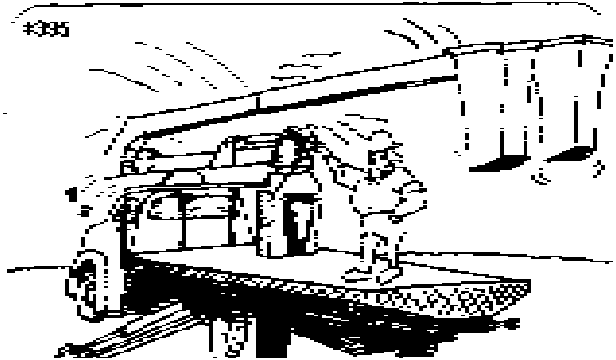
If working on an incline, block the wheels.

#395



Unauthorized alterations of the unit could cause structural failure or personnel injuries. Use the equipment as it was intended.

Aerial Platform Safety Points



#335

When stowing the unit, ease the booms into place. Slamming could cause damage. Don't forget to tie the booms down.

Aerial Platform Inspection

All safety regulators require aerial platforms to be inspected on a daily, weekly, or monthly basis, and at least once a year for a complete inspection. Aerial platforms specially equipped for work on live power lines will normally have insulated booms and fiberglass baskets, requiring a dielectric test for the boom, ultrasound test for the basket, and a magnetic particle test for the structural components.

See illustration #336 and tables #67 and #68 for inspection checkpoints and an equipment checklist.

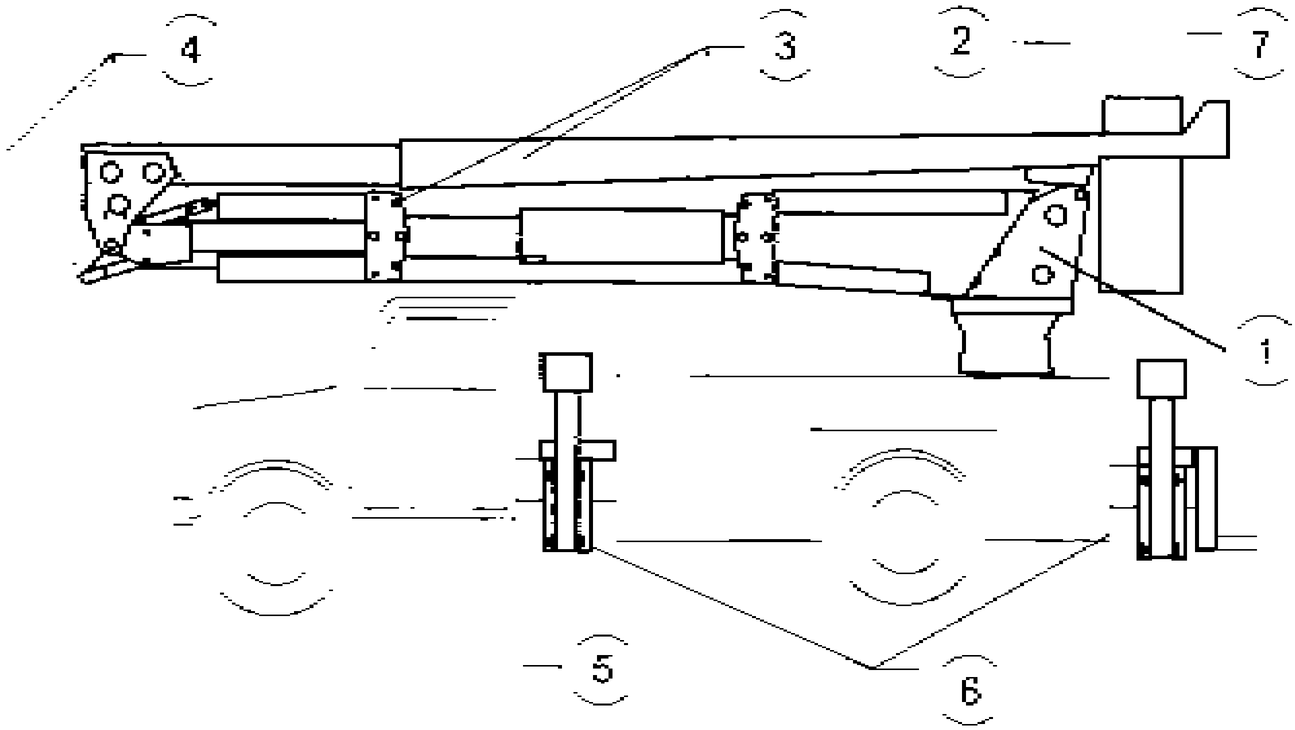


Illustration #396 - Inspection Checkpoints

INSPECTION GUIDE CHECKPOINTS		
SECTION	**ITEM**	**CONDITION**
1 - Turntable	Rotation gearbox	Securely bolted to frame
	Rotation bearing	All bolts tight and in place
	Main boom pivot	Pivot pin secure, no cracking around pivot bearing
	Cylinder pivots	Pivot pins secure, no cracking around pivot points
	Lower controls	All controls free in movement with no binding
	Structure	No visible damage or cracks
2 - Platform	Upper controls	All controls free in movement with no binding
	Leveling drive	Leveling gearbox or cylinder securely fastened
	Fiberglass	Clean, attachment points secure, no cracks or damage
3 - Booms	Fiberglass sections	Clean, no looseness or obvious damage
	Steel sections	No visible damage or cracks
4 - Elbow	Pivot	Pivot pin secure, no cracking around pivot bearing
	Cylinder points	Pivot pins secure, no cracking around pivot points
	Structure	No visible damage or cracks
5 - Vehicle	Safety harness & lanyard	Clean, no looseness or obvious damage
	Equipment	No visible damage or cracks
6 - Stabilizers	Outrigger arm pivots	Pivot pin secure, no cracking around pivot pins
	Cylinder pivots	Pivot pins secure, no cracking at pivot points
	Structure	No visible damage or cracks
7 - Jib Boom	Structure	Boom sound, no visible cracks, securely pinned to mounting
	Winch lines	No fraying, lines reeved over sheave properly

Table #67 – Inspection Locations

EQUIPMENT CHECKLIST

DATE ____________ MODEL ____________ S/N ____________

ITEM	CONDITION	YES	NO
1	Are outrigger arms and pivots sound and free of cracks?		
2	Are control handles at all stations free of binds?		
3	Are booms free of cracks especially near all pivots?		
4	Are fiberglass boom sections sound and securely fastened to booms?		
5	Are rotation bearing bolts in rotation head tight?		
6	Is rotation drive gearbox tight, secured to turntable?		
7	Are all hydraulic lines free of signs of excess seepage or leaks?		
8	Is leveling linkage cable in sound condition?		
9	Is fiberglass platform sound and secure at attachment points?		
10	Are safety harnesses free of cracks and outrigger pads on hand?		

Any "NO" check disqualifies unit from use until corrected. INSPECTOR ____________

Table #68 – Aerial Platform Checklist

SECTION SEVEN QUESTIONS

Aerial Platforms

1. Determine if this statement is true or false: Aerial work platforms are covered by four different ANSI Standards.
   - ❑ true
   - ❑ false

2. Which of the following is the primary safety item regarding aerial platforms?
   - ❑ thorough operator training program
   - ❑ thorough inspection and care of equipment
   - ❑ understanding and protection against electrical contact
   - ❑ all of above

3. Determine if this statement is true or false. Aerial platforms are designed to be used as working platforms for personnel and also as cranes to hoist material.
   - ❑ true
   - ❑ false

4. A person fully trained to operate one type of platform can immediately operate any other type of platform.
   - ❑ true
   - ❑ false

5. Determine if this statement is true or false. Due to the usually small basket size, a boom type aerial platform cannot be overloaded.
   - ❑ true
   - ❑ false

6. Determine if this statement is true or false. As an aerial platform is not classified as a crane, it does not require a yearly inspection.
   - ❑ true
   - ❑ false

7. Determine if this statement is true or false. A safety harness and attached lanyard are not required in an aerial lift platform.
   - ❑ true
   - ❑ false

8. Determine if this statement is true or false. Even when so equipped, outriggers are rarely required for hoisting personnel.
   - ❑ true
   - ❑ false

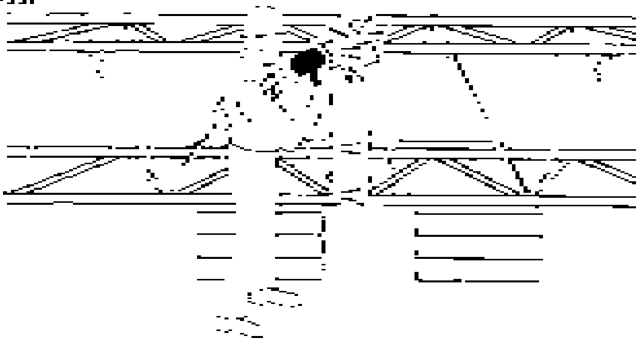
9. What is the regular inspection schedule for the various components of an aerial platform?
   - ☐ daily
   - ☐ weekly
   - ☐ monthly
   - ☐ any of above depending on component

10. Which of the following should be checked before an aerial platform is being used?
   - ☐ cracks in outriggers
   - ☐ fiberglass boom & platform is secure
   - ☐ safety harness & waist strap is attached
   - ☐ all of above

SECTION EIGHT

MOBILE EQUIPMENT SAFETY

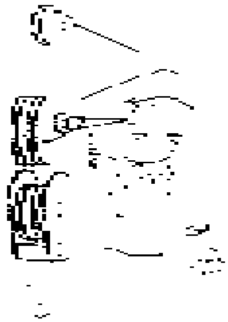
#397



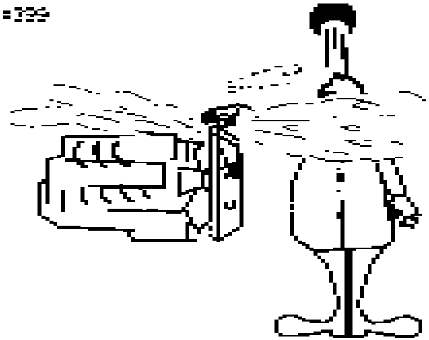
Use Correct Assembly Procedure

#398

Inspect the Equipment Before Use



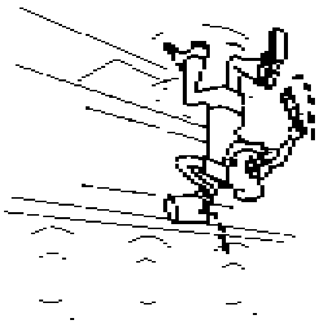
#399

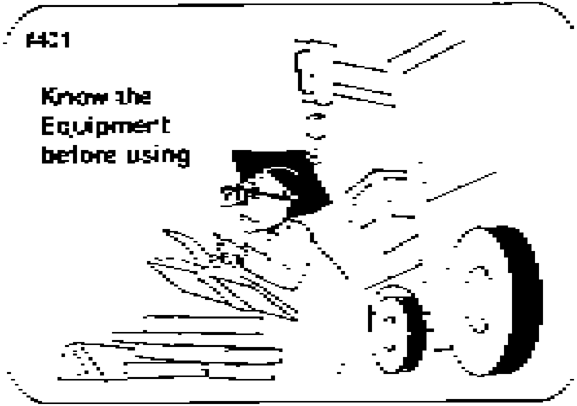


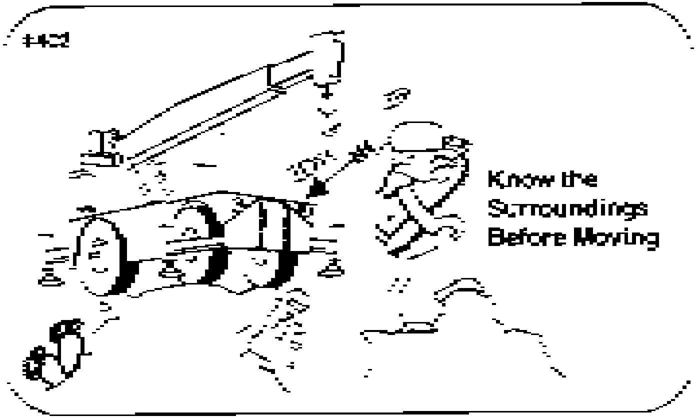
Use Caution While Inspecting the Unit

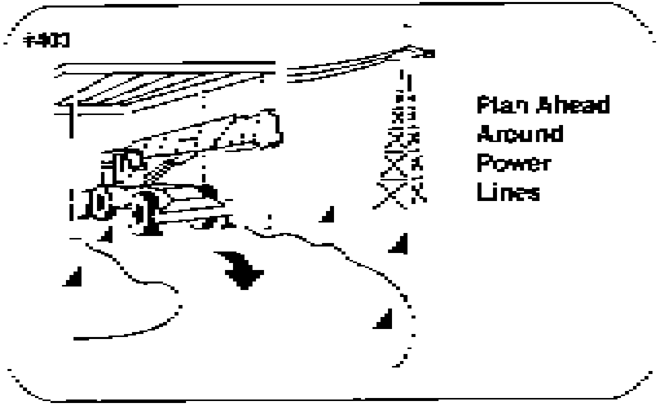
#400

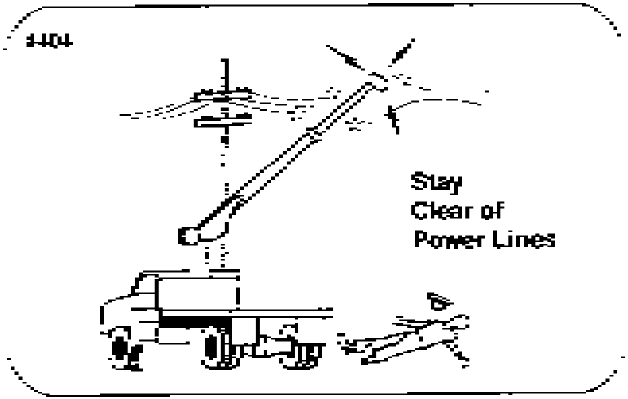
Keep the Unit Free of Grease and Clutter



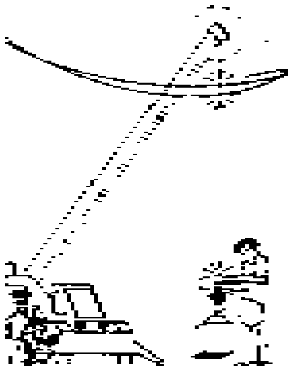

#401
Know the Equipment before using


#402
Know the Surroundings Before Moving


#403
Plan Ahead Around Power Lines

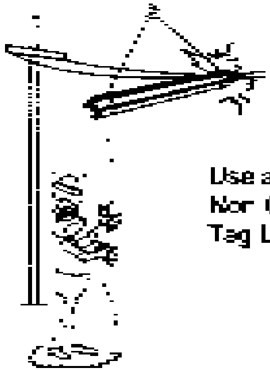

#404
Stay Clear of Power Lines

#405



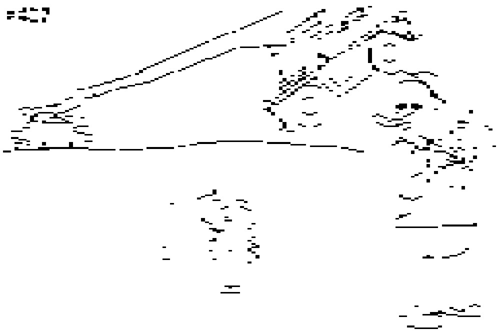
Use Extreme Caution Around Power Lines

#406



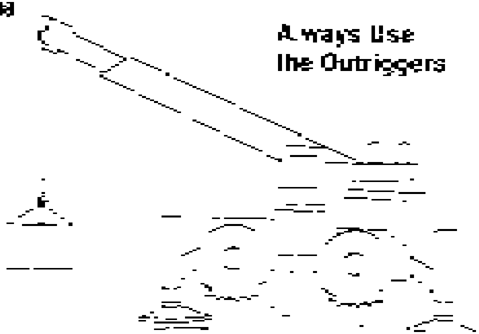
Use a Non Conductive Tag Line

#407



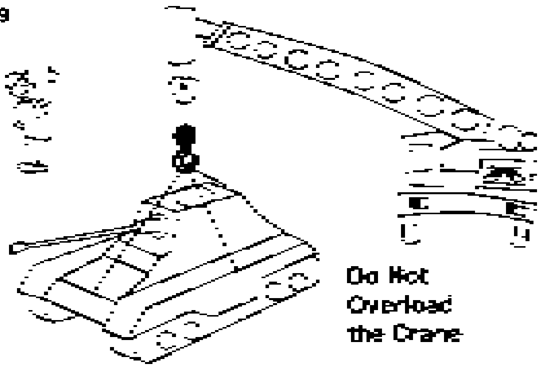
Know the Load and Limitations

#408



Always Use the Outriggers

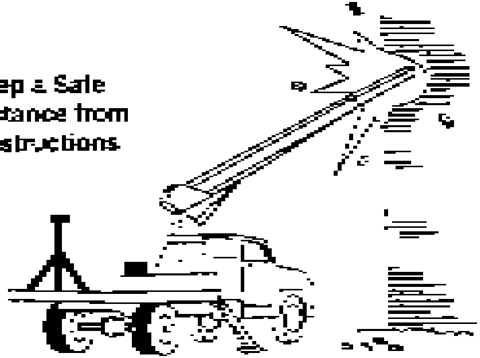
#409



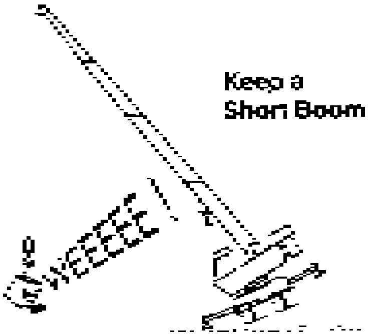
Do Not Overload the Crane

#410

Keep a Safe Distance from Obstructions

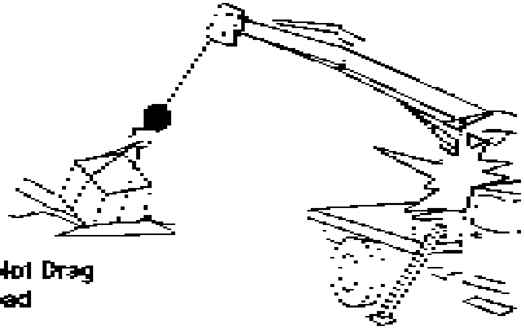


#411

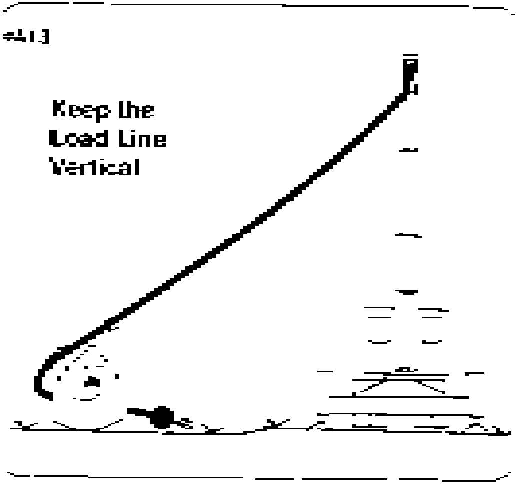


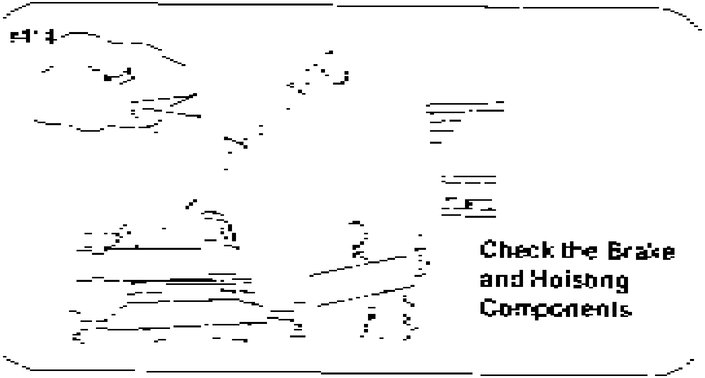
Keep a Short Boom

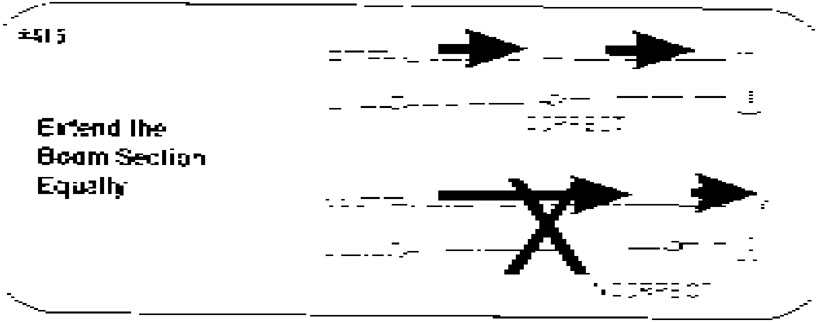
#412

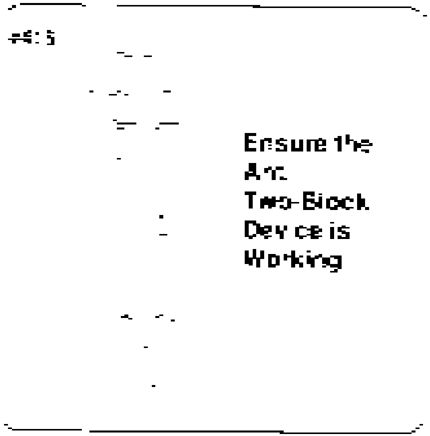


Do Not Drag a Load

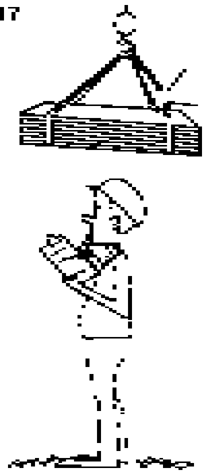

Keep the
Load Line
Vertical


Check the Brake
and Hoisting
Components


Extend the
Boom Section
Equally


Ensure the
Anti
Two-Block
Device is
Working

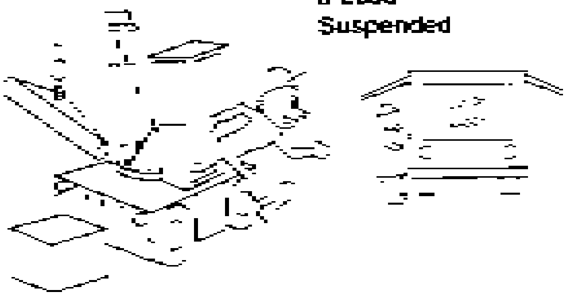
#417



Never Swing a Load Over Anyone

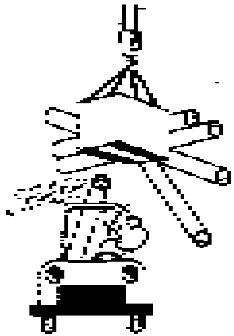
#418

Never Leave a Load Suspended



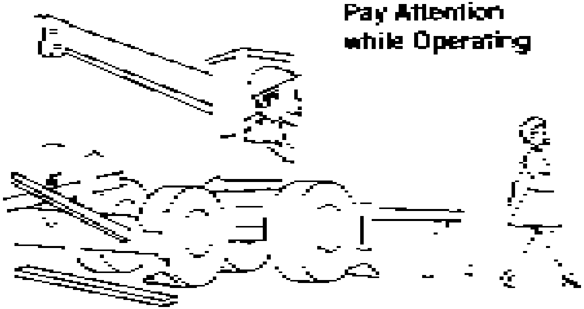
Never Lift Two Loads at One Time

#419



#420

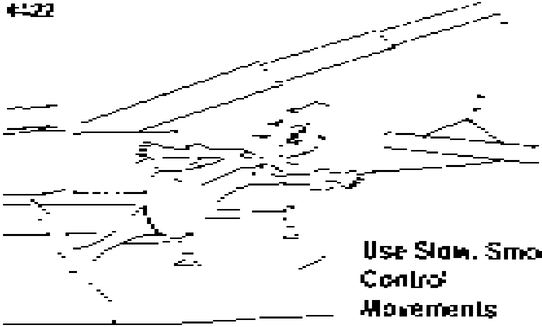
Pay Attention while Operating



#421

Use the Alarm When Backing Up

#422



Use Slow, Smooth Control Movements

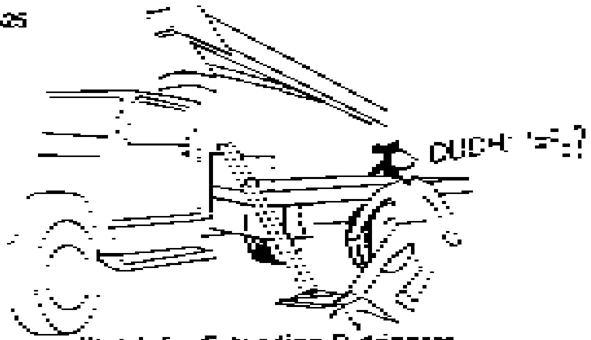
#423

Never Operate in Unsafe Conditions

#424

Avoid Moving Equipment

#425

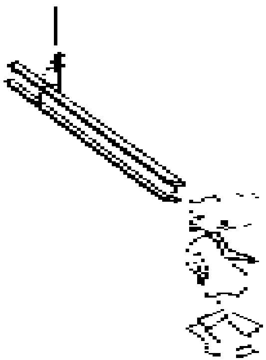


Watch for Extending Outriggers

#426

Avoid equipment Pinch Points

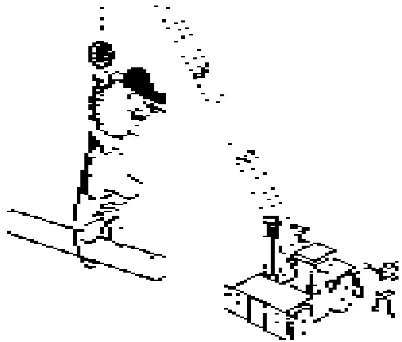
#427

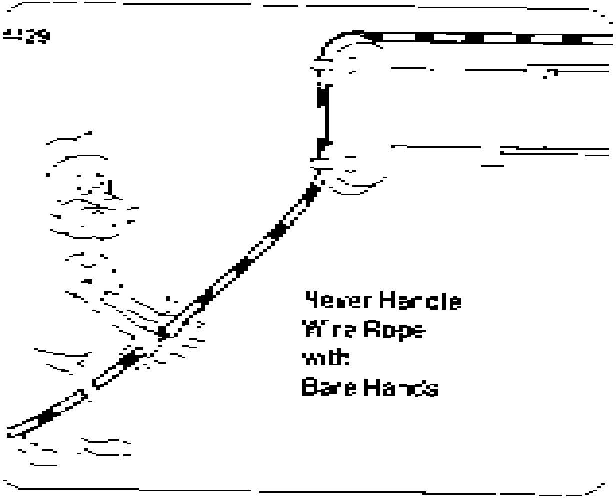


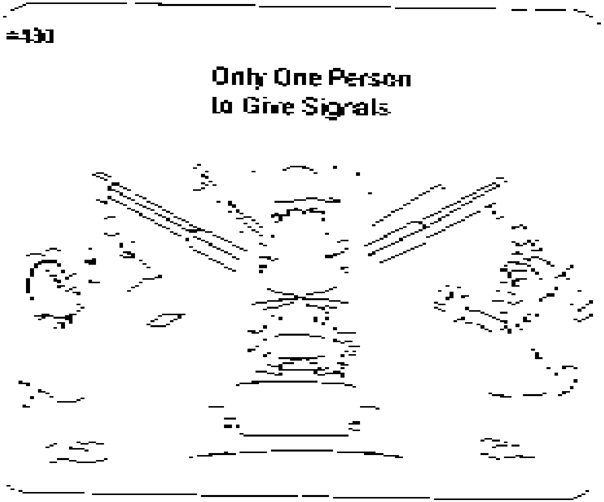
Use the proper Load Rigging

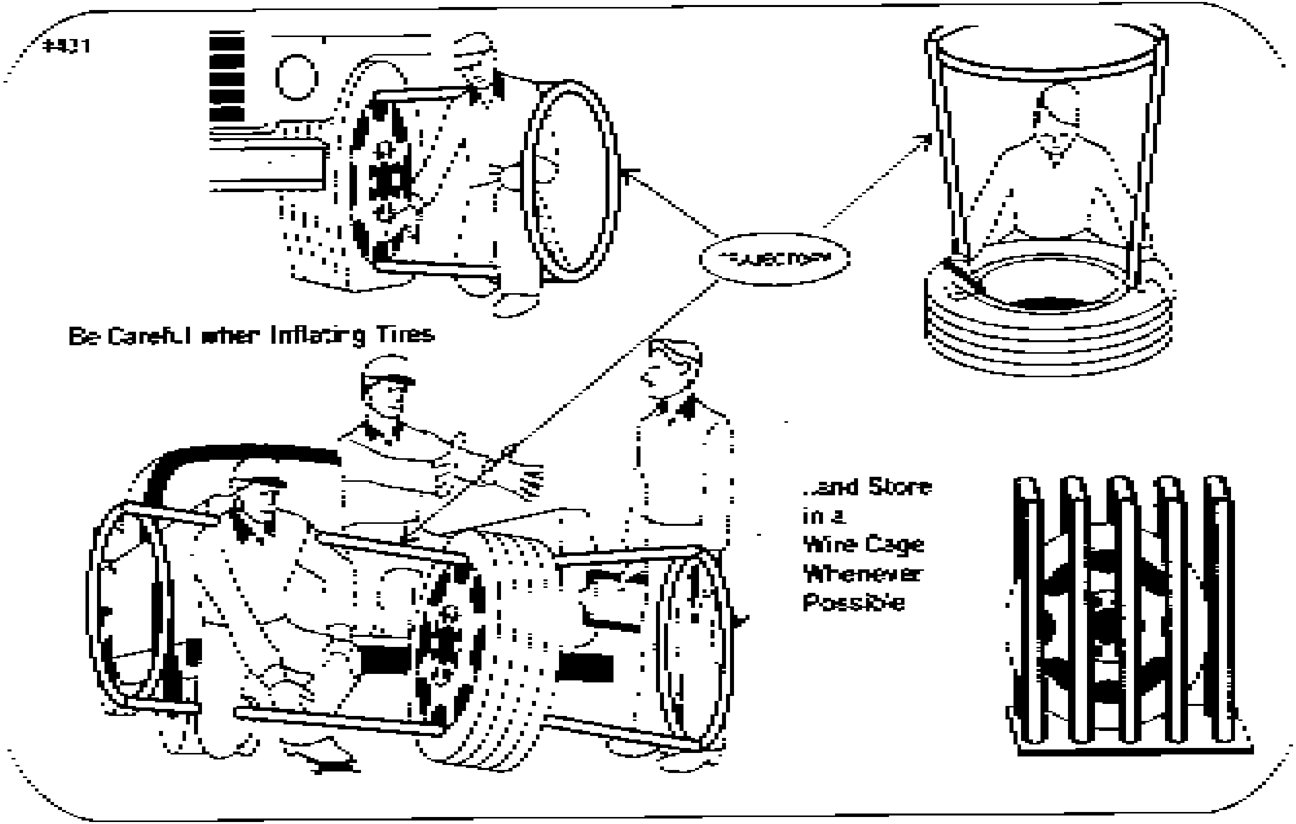
#428

Never Ride the Hook, Slings or Load




#429
Never Handle
Wire Rope
with
Bare Hands


#430
Only One Person
to Give Signals


#431
TRAJECTORY
Be Careful when Inflating Tires
...and Store in a Wire Cage Whenever Possible

SECTION NINE

BARGE, SHIP and OFFSHORE CRANES

Barge Mounted Cranes

Barge mounted cranes are widely used for loading, offloading, and dredging on North American rivers and coastlines. They are far more extensively used in the United States than in Canada. The equipment on floating cranes derricks, crane barges, and shipboard cranes are designed in accordance with the following:

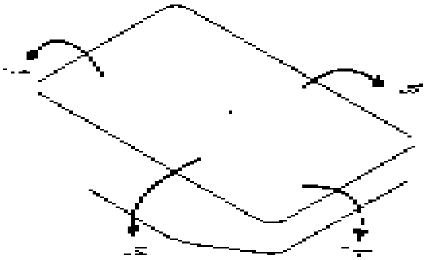
1. ANSI ASME B30.8
2. American Bureau of Shipping (ABS) – Guide for Certification of Cranes
3. ANSI API Specification 2C
4. SAE Report J1366 – Rating Lift Cranes Operating on Platforms in the Ocean Environment

Dynamic Barge Movements

Operating a floating crane can be a radical adjustment for an operator who has only previously worked on land.

Such factors as list and roll, trim, currents, tide, waves, and surge can turn a simple pick and place operation from a routine job into a disaster.

1. Trim is backward or forward barge sloping. (Illustration #432)
2. List is sideways inclination, and is usually barge list but can be machine list or both. (Illustrations #432 and #433)
3. Trim and especially list can be magnified by roll, which is wave action.
4. Trim or list, and roll movement can easily change the load radius or side-load the boom. Working with two barges or ships moving in different directions (one going up while the other goes down) due to wave action requires some operating practice and experience. (Due to all these movements, cranes very seldom operate when level.)
5. Freeboard is the distance between the water line and the deck.



NOTE: Barge can roll front to back (Trim), side to side (List) from wave actions or crane load movement. Barge can also move vertically from wave and tide movement.

Illustration #432 – Barge List and Trim

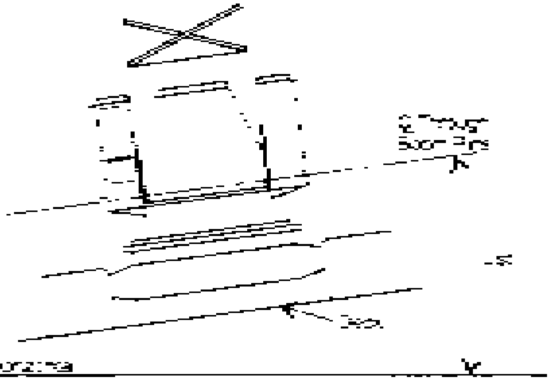


Illustration #433 – Barge or Crane List

ANSI/ASME Trim or List Limits

1. Cranes designed for barge mounting: For cranes up to 25 tons capacity, the maximum allowed list or trim is 5 degrees, and for cranes rated over 25 tons, the maximum allowed list is 7 degrees.
2. Derricks designed for barge mounting: The maximum allowed list or trim for any capacity is 10 degrees.
3. Land cranes or derricks mounted on barges: The maximum allowed list or trim is 5 degrees or the maximum specified by the manufacturer.
4. Barge designed crane and derrick load design conditions: The unit must be stable under the following conditions:

- Rated load, 60 mph (100 km/h) wind, 2 feet (.6 m) freeboard.
- Rated load + 25%, 60 mph (100 km/h) wind, 1 foot (.3 m) freeboard.
- High wind, no load, 60 mph (100 km/h) wind, 2 feet (.6 m) freeboard.

- Backward stability – High boom, no load luff back, est. 90 mph (140 km/h) wind.

5. Land crane and derrick load design conditions:

- The land based rating will be modified due to trim, list, wind and waves. The barge size will also have a bearing on the rating. Each crane/derrick must be rated by the manufacturer to suit the particular barge under the expected weather conditions.
- When unloaded, the barge deck must be above water.
- When loaded, the entire bottom area must be submerged.
- Derricks must be tied-down to transmit loading to the barge or pontoon. Do not weld padeyes directly to a non-reinforced area of the barge hull.
- Cranes must be blocked and secured to prevent shifting.
- Truck or crawler cranes must be attached to the barge with a slack tie down to prevent travel.
- Pick and travel operations are not permitted.

Land Crane on Barge Applications

Illustrations #434 and #435 depict typical mobile crane on barge applications which incorporate a slack tie down system.

Illustration #436 is a square type pedestal mount often referred to as a tub.

Illustration #437 is a typical turret pedestal mount which elevates the crane and enhances deck space and eliminates pinch points.

Illustration #438 is a crawler mounted ringer crane with the ring secured to the barge.

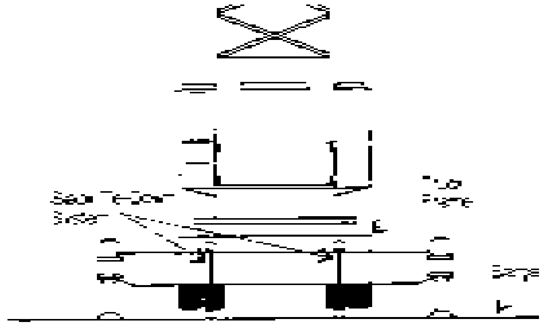


Illustration #434 - Mobile Crane

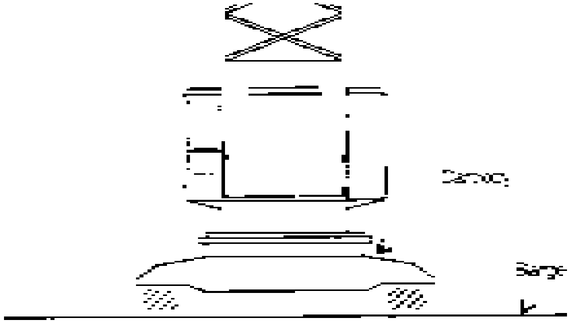


Illustration #436 - Square Type Pedestal

Note: Consult the crane manufacturer about the bolting pattern and the type and number of bolts if the crane carbody or a ringer is bolted to the barge or structure.

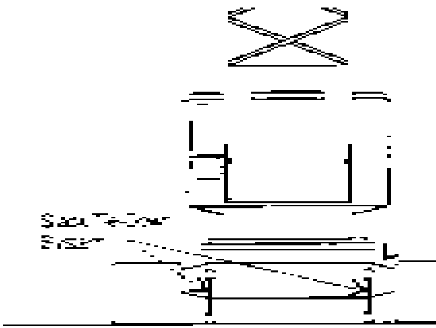


Illustration #435 - Crawler Crane

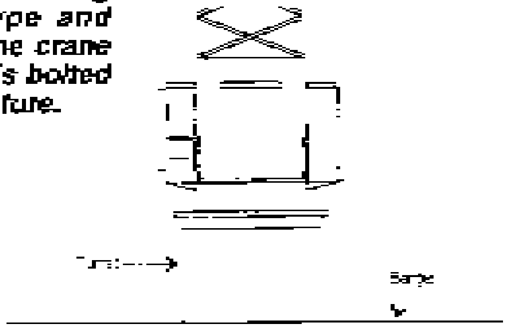


Illustration #437 - Mounted on Pedestal

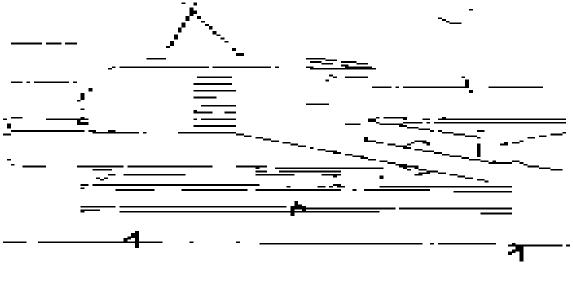


Illustration #438 - Ringer Crane

Barge Crane and Derrick Types

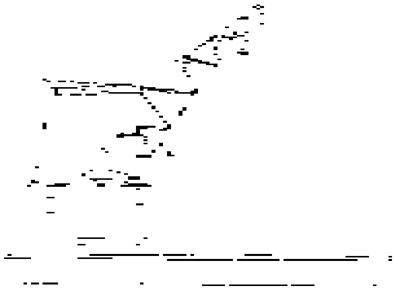


Illustration #439 - Pedestal Crane

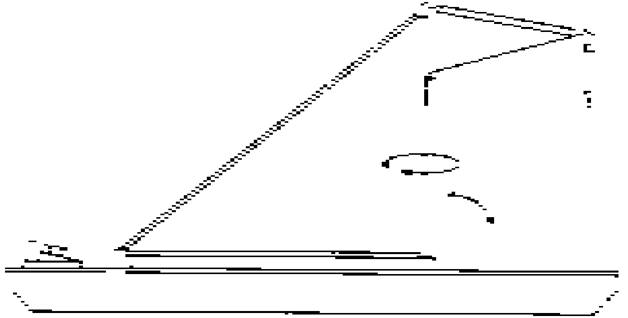


Illustration #440 - Stiffleg Derrick

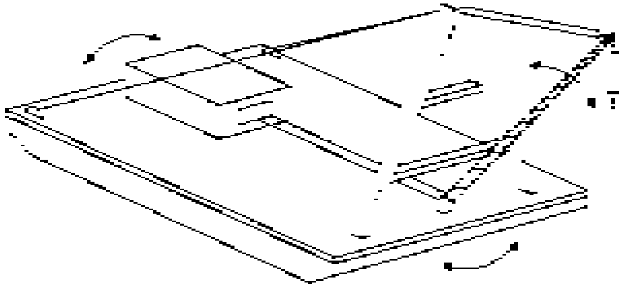


Illustration #441 - Floating A-Frame Derrick

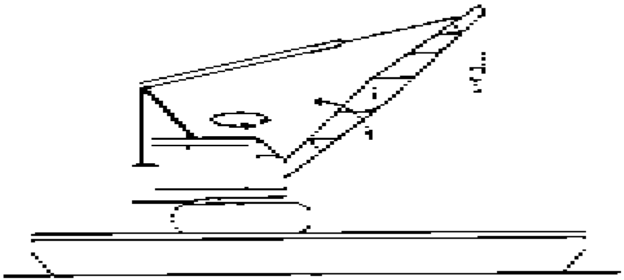


Illustration #442 – Barge Mounted Land Crane

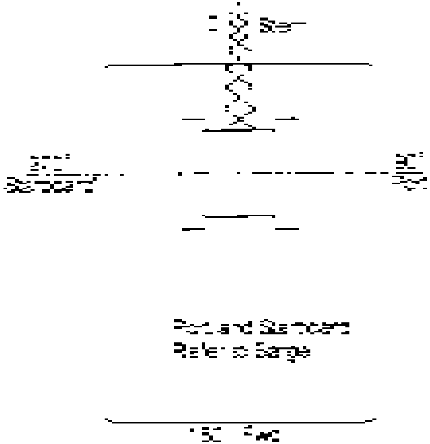


Illustration #443 - Hoisting Over Stern

Crane and Barge Stability

Crane placement on a barge is important. If possible, the crane should be centered side to side for 360 degree rotation.

Cranes are often positioned to hoist over the rear (stern) of the barge for reach. See illustration #443.

If the crane load chart and the pre-lift test lift are based on the crane being positioned in the center, the crane should not be moved (see illustration #444). If the load chart and the pre-lift test lift are based on the forward or stern position (illustration #445), the crane can be moved to the center for more stability, however the load chart capacity remains the same. Equipment on a crane barge is acceptable, but the barge and crane must be closely monitored (see illustration #446). Wheeled equipment on a barge must be securely tied down. Any barge with a deployed crane must be certified (see illustration #447).

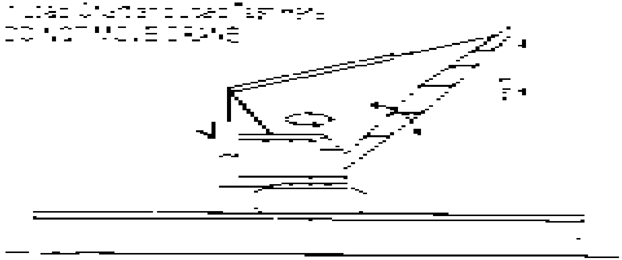


Illustration #444 – Center Position

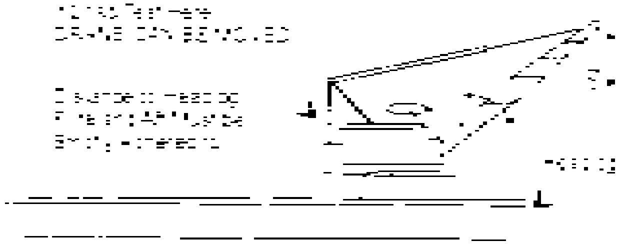


Illustration #445 – Fore or Aft Position

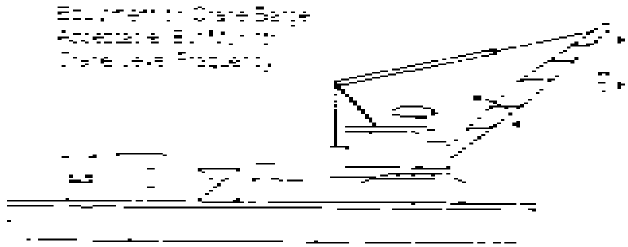


Illustration #446 – Equipment on Barge

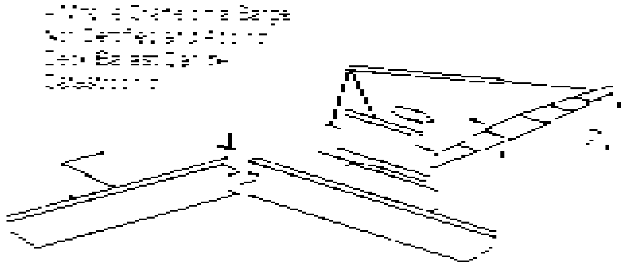


Illustration #447 – Barge Failure

Load Rating

A floating crane load rating is the maximum working load at various radii. This is determined by the manufacturer or other qualified person. This must be determined for each crane barge installation and reflect the design standard, machine list and trim, and the anticipated dynamic and environmental loadings. A Naval Architectural Analysis is required to determine these parameters.

The load rating is based on the structural competence of the crane, the wire rope strength, the hoist capacity, the crane to barge attachment, and the stability and freeboard of the barge.

The rated load of a land crane or derrick must be modified by the manufacturer or other qualified person, and evaluated by a qualified person specific to that crane to barge or ship combination. See pages 453 and 454 for an example of a manufacturer's barge/crane load rating.

If the manufacturers' specifications are not available, the crane limitations must be determined by an engineer competent in this field and the ratings must be documented and recorded.

A barge mounted crane or derrick must have the normal load chart data including operating radii, boom lengths, boom angles, and jib configurations. In addition the operator must have the manufacturers' and/or applicable ANSI requirements on list and trim, plus dynamic and environmental factors including deck loads and weather conditions. Other cranes or derrick requirements include:

1. A method for the operator to visually determine from the seat both list and trim, and machine list and trim.
2. A boom angle indicator readable from the operator's seat.
3. All floating cranes and derricks must be equipped with a load limiting device (LLD) to prevent overloading through the range of all crane operating positions.

4. All floating cranes and derricks must be equipped with a load moment indicator (LMI).
5. If a load approaches the maximum rating of the crane, the person in charge must ascertain that the load weight is within +/- 10% of its stated weight before lifting.
6. Boom stops are required to prevent backward boom movement.
7. Walking surfaces shall be skid-resistant.

Capacity Charts

The load chart must identify the following Naval Architect Notes, and the safety points addressed:

- Draft limits including deck load.
- Barge motion limits
- Barge and machine list and trim limits
- Barge condition including watertight integrity and dry bilges. Bilges must be as dry as possible to avoid the affect of sloshing liquids.
- Never ballast an open hull barge with water.
- A Naval Architect or Marine Engineer must formulate a ballast configuration.
- Deck ballast is usually not recommended due to likely crane center-of-gravity changes while swinging.

Before using a crane on a barge or ship, ensure the correct capacity chart is being used. See illustrations #448 & #449. Crane companies will provide two types of load capacity charts for cranes mounted on a barge or ship. They are based on either tipping capacity or strength capacity.

Tipping Capacity A crane secured only to prevent shifting shall have a chart based on tipping capacity.

Strength Capacity A crane secured for use as a pedestal crane shall have a chart based on the strength of its components.

Note: The tie-down method used to secure a crane from shifting may not be adequate for using the pedestal strength capacity chart.

Remember, mobile cranes incorporate a slack tie-down system.

Note: Because of possible structural damage, it is recommended that the hook roller assembly be inspected every day for any sign of damage or overloading.

Note: Releasing the load during clamshell excavation results in excessive rocking motion thereby adding extra strain on components.

Environmental Conditions

1. All floating cranes must be equipped with a wind speed and direction indicator within view of the operator's seat.
2. The project supervisor must obtain a daily weather forecast before beginning work and as frequently as necessary to monitor unsafe conditions.
3. When a local storm condition exists, follow the manufacturer's recommendation for securing the crane.

Work shall halt when excessive wave action exists.

Example Load Charts

The following three examples of load charts are from one crane with a 130 ft. boom and a 102,400 lb. counterweight mounted on a 53 ft. x 75 ft. barge. Illustration #446 shows this fully revolving assembly used under normal hoisting operations.

Illustration #449 shows the same boom and counterweight assembly with a clamshell. Note the down-rated capacities. This is due to the manufacturers' concerns about the dynamic loads imposed not only on the 130 ft. boom, but also on the house and hook rollers caused by the clamshell loading and unloading.

EXAMPLE LOAD CHART

130' Boom, 102,400 lb CTRWT Mounted on 53' x 75' Barge

Rigging Radius (Feet)	Operating Radius (Feet)	WLL (lbs)	Proof Load (lbs)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Illustration #446 - 130 ft Boom WLL (Fully Revolving Lifts)

EXAMPLE CLAMSHELL LOAD CHART

130' Boom, 102,400 lb CTRWT Mounted on 53' x 75' Barge

3 yd. Bucket Weighs 17,500 lbs

Bucket Full of Material Weighs 26,000 - 27,000 lbs

Operating Radius (Feet)	Boom Angle (degrees)	Capacity (lbs)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Illustration #453 - 130 ft Boom with Clamshell (Fully Revolving Lifts)

EXAMPLE LOAD CHART

Boom Lgth. Feet	Jib Oper. Rad. Feet	Boom Ang. Deg.	Jib Point Elev. Feet	0 Degree List/Trim Capacity Pounds	1 Degree List/Trim Capacity Pounds
130 ft	35	7[illegible]	161.5	20,000	14,000
	40	7[illegible]	160.7	20,000	14,000
	45	75.4	159.5	20,000	14,000
	50	74.3	158.2	20,000	14,000
	55	72.5	156.6	20,000	14,000
	60	70.5	154.9	20,000	14,000
	65	68.7	153.0	20,000	14,000
	70	66.3	150.9	20,000	14,000
	75	64.3	148.5	20,000	14,000
	80	62.3	145.7	20,000	14,000
	90	58.3	140.4	20,000	14,000
	100	54.5	133.3	20,000	14,000
	110	50.1	125.3	20,000	14,000
	120	45.3	116.7	20,000	14,000
	130	40.1	106.3	17,300	14,000
	140	34.2	92.2	15,300	14,000

0 and 1 degree List and Trim

Illustration #450 - 130 ft Boom with Jib

Illustration #450 shows the 130 ft. boom equipped with a jib that loses 30% capacity when 1 degree off-level. Some authorities suggest a jib may not be a suitable choice due to dynamic boom loading with out-of-level conditions.

Note: *The chart examples in illustrations #448, #449, #450 are from one barge/crane combination, with the crane down-rated approximately 45% for clam-shell work by the manufacturer to match the barge. Other barge/crane combinations will be rated to suit the crane, the barge, and the type of work being performed.*

Barge Safety Point Summary

1. When loaded, the barge deck must be above water and the entire bottom must be submerged.
2. The barge must maintain watertight integrity and never ballast an open hull with water.

3. Deck ballast is usually not recommended.
4. Mobile or crawler cranes - land cranes on a barge must be tied down with a slack tie-down system.
5. Land cranes - the manufacturer or other qualified person must rate land cranes mounted on a barge. The load chart must suit that particular crane to barge combination. Land rated load charts must not be used.
6. If the load chart and pre-lift test is based on the crane being positioned in the barge center the crane must not be moved. If the load chart and pre-lift test is based on a stern or forward position, the crane can be moved but the rating remains the same.
7. Operators and crew must be thoroughly trained concerning out-of-level conditions due to list and trim parameters while hoisting and swinging.
8. Critical lift plans and lift communications are an absolute must.
9. Cranes must have enough power to perform swing, boom, and hoist operations when list conditions occur. However higher torque swing motors may operate at a slower speed during cycle work. Consult the manufacturer before using a land crane on a barge.
10. For stability, all cranes must comply with USCG requirements specified in OSHA 46 CFR 173.005 through 173.025.
11. All floating cranes must be equipped with a load limiting device (LLD) in compliance with OSHA 29 CFR 1915.86 (h).
12. List, trim and freeboard limits shown on pages 445 and 446 are those listed by the ANSI ASME standard. For operation working limits, the applicable crane rating chart for that particular crane and barge or ship must be used. Use extreme caution, as depending on wind, wave action, or other conditions, the rated capacity limits may not be attainable.

Ship & Offshore Drilling Cranes

In general terms, ship mounted cranes are covered under the ANSI B30.8 standard, as well as those mentioned on the first page of this section. This covers ship list and trim movements allowed for hoisting.

However, various other regulatory bodies can have codes and standards relating to floating cranes.

A ship with a tandem crane system is shown in illustration #451. Two different types of supply ship cranes are shown in illustrations #452 and #453.

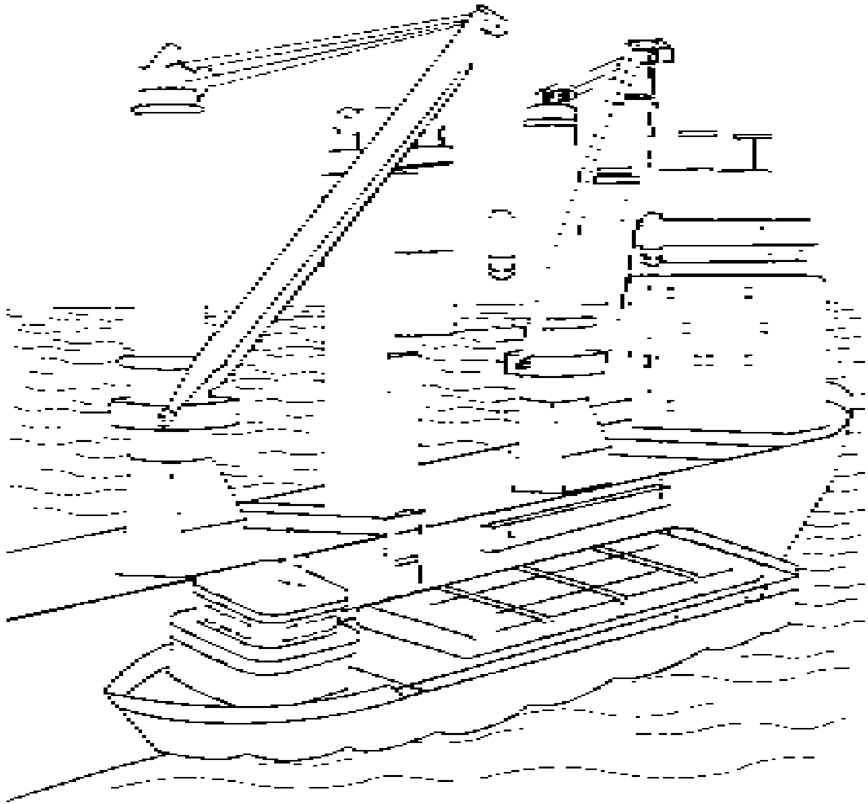


Illustration #451 – Tandem Ship Cranes

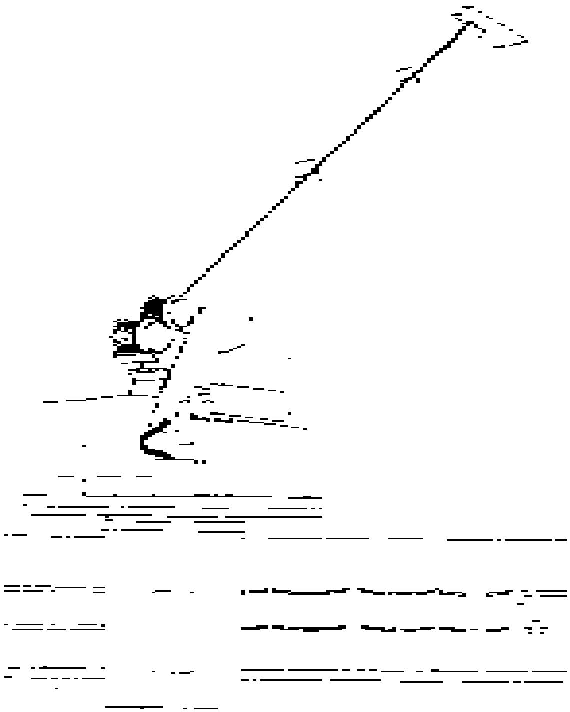


Illustration #452 – Supply Ship Crane

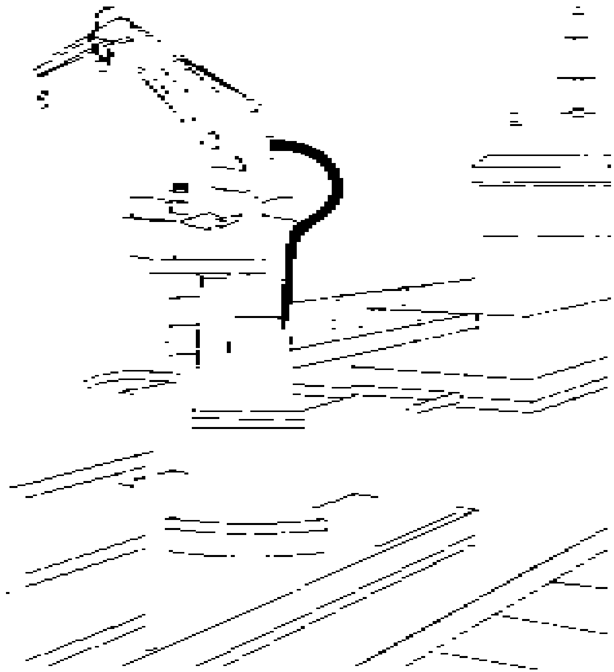


Illustration #453 – Knuckleboom Ship Crane

API (American Petroleum Institute)

The API 2C (effective 2004) regulates the cranes on various types of drilling and off-shore equipment, such as fixed structures, tension leg platforms, semi-submersibles, drill ships, and floating production storage off-loaders (ships that drill and store).

Examples of offshore cranes mounted on pedestals (kingposts) are shown in illustrations #454 and #455. Two other examples of offshore platforms with cranes are shown in illustrations #456 and #457.

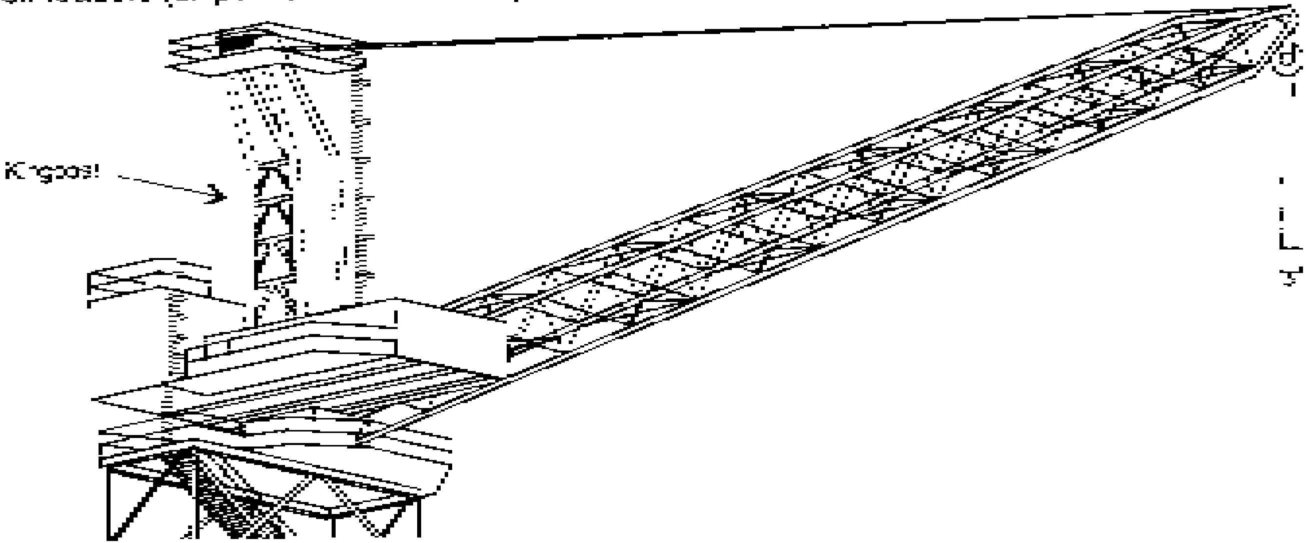


Illustration #454 – Typical Offshore Crane

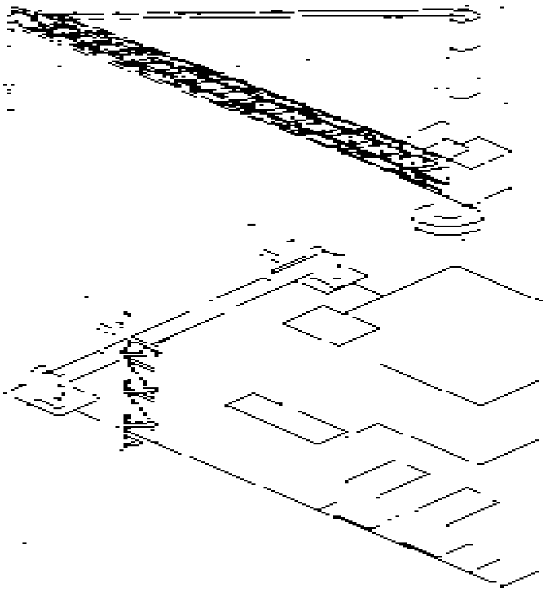


Illustration #455 – Offshore Crane on Platform

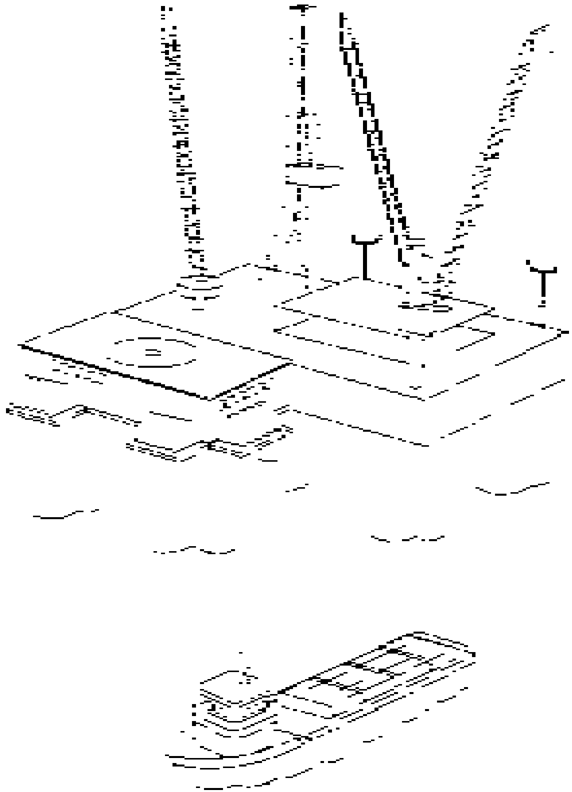


Illustration #456 – Offshore Crane

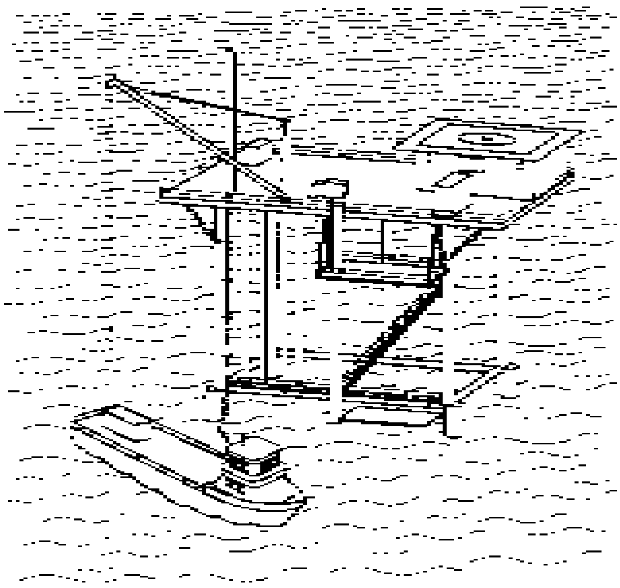


Illustration #457 – Offshore Crane

API 2C Standard

The purpose of the API 2C is to ensure the crane is designed and rated to match the type of installation.

To establish the crane load chart ratings, the user must provide the crane manufacturer with the following data:

- Type of platform
- Wave heights
- Wind speeds
- Crane to sea-level lifting distance

Note: Crane load chart ratings under API 2C are generally down-rated by approximately 25 – 35% as compared to a similar capacity type of crane under the ANSI B30.8 standard.

API 2C Rating for Fixed Platforms: On fixed platforms, the load rating parameters for onboard (static) or offboard (dynamic) lifts were modified similar to those shown in illustration #458 and #459. Note that Cv (dynamic load coefficient) is now 1.4 rather than 1.33. These show the possible movements that must be taken into consideration when establishing a load chart rating.

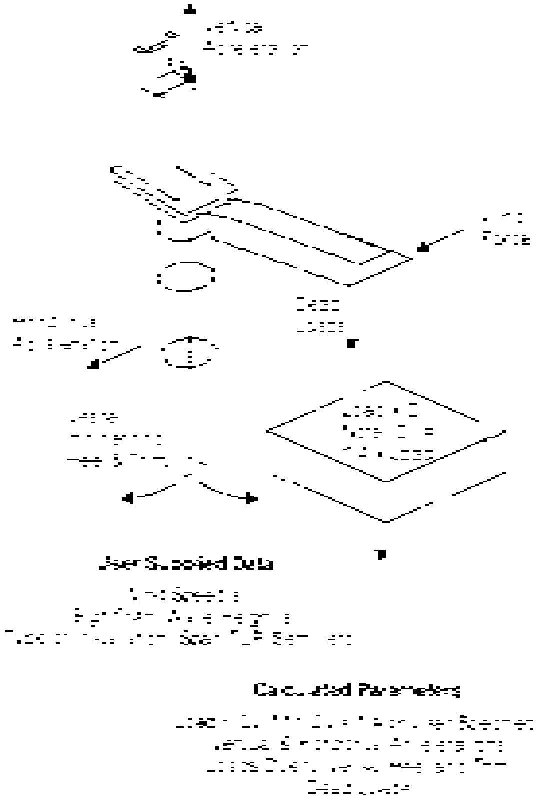


Illustration #458 – Offboard Lift Parameters

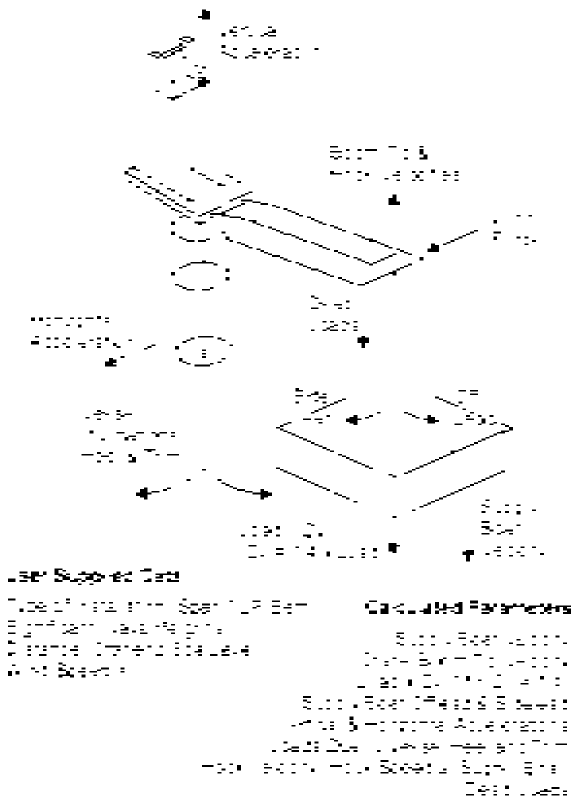


Illustration #459 – Offboard Lift Parameters

API 2C Rating for Supply Boats: For supply boats, a Cv (dynamic coefficient) of load x 2.0 applies in normal mild sea and wind conditions. Unless the ship is extremely large, it would be hoisting under almost constant off-level conditions. The boat must maintain a constant position relative (possibly tethered) to the platform. For rougher sea conditions, the wave action must be taken into consideration. These are addressed in API detailed wave coefficient factor tables.

Dynamic Coefficient

In basic terms, this means that the load weight is multiplied by the applicable coefficient number. This gives the number that is used in the load chart for hoisting capacity. One example is a 5500 lb. weight lifted from a supply ship deck by a fixed platform crane (5500 x 1.4 = 7700). 7700 is the number used in the load chart.

Another example is a 5500 lb weight lifted from a supply ship by the ship crane (5500 x 2.0 = 11,000). In this case, 11,000 is the number used in the load chart.

Wave Action

There are two primary problems that affect offshore hoisting. One is the wind and the other is wave action. With the crane mounted on a fixed platform, which may or may not have movement depending on the platform type and size, the difficulty is hoisting a load from the deck of a supply vessel that moves laterally and vertically. The point is to get the load off the deck and clear of any ship obstructions as quickly as possible before the wind and waves cause the ship to move and interfere with the load.

The other scenario is the hoisting operation with a crane on a supply ship that moves a load to a fixed platform (or to another ship). In this situation, the operator has to deal with almost constant off-level conditions, vertical movement of the ship and crane, and perhaps an unstable load drop area as well.

Load Chart Data

In additional to the standard load capacities at various radii, the following operator information must be included on the load chart.

- Conditions applicable to the chart (wave coefficients, load coefficients, etc.)
- Rating method used to establish capacity.
- Hook speed at supply boat level.
- Block reeving diagrams.
- Warning notes pertaining to equipment limitations.
- All hoist wire rope data.
- Instructions on use of emergency load release devices.

Operator Safety

For operator safety, the API 2C standard states that in the event of a catastrophic failure, the equipment should be designed so that some piece of equipment will fail other than the crane mounting or kingpost. This would prevent the operator's cab from being pulled down or overboard if a situation, such as the hook snagging a supply boat, should occur.

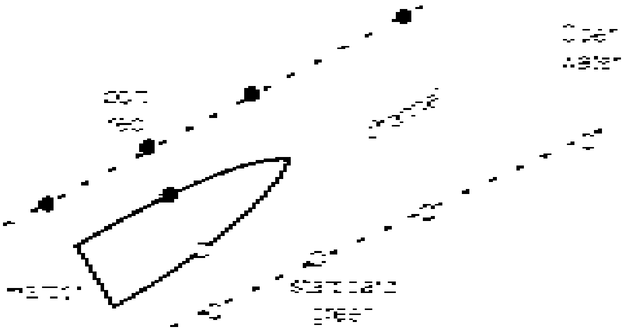
Navigation Lights

Ship, boat, or barge running lights have a standard system of **red on the left (port)**, and **green on the right (starboard)**. Ships must also have one (or more) center mounted white mast light, and a rear (stern) center mounted white light.

Floating buoys or other types of navigation channel markers use a system of:

green (right) and red (left) going outbound or,

red (right) and green (left) going inland.



SECTION NINE QUESTIONS

Barge, Ship & Offshore Cranes

1. Determine if this statement is true or false. Land cranes mounted on a barge fall under the ANSI B30.5 standard.
   - ❑ true ❑ false

2. When determining barge movement, sideways inclination or movement is called:
   - ❑ trim
   - ❑ list
   - ❑ wave dynamics
   - ❑ freeboard

3. When determining barge movement, backward or forward movement is called:
   - ❑ trim
   - ❑ list
   - ❑ wave dynamics
   - ❑ freeboard

4. Determine if this statement is true or false. The distance between the waterline and the deck is called freeboard.
   - ❑ true ❑ false

5. For cranes designed for barge mounting up to 25 tons, the maximum allowed list is:
   - ❑ 5 degrees
   - ❑ 7 degrees
   - ❑ 10 degrees
   - ❑ must be level at all times

6. For cranes designed for barge mounting over 25 tons the maximum allowed list is:
   - ❑ 5 degrees
   - ❑ 7 degrees
   - ❑ 10 degrees
   - ❑ must be level at all times

7. For land cranes mounted on a barge, the maximum allowed list is:
   - ❑ 5 degrees
   - ❑ 7 degrees
   - ❑ 10 degrees
   - ❑ must be level at all times

8. Determine if this statement is true or false. A land crane mounted on a barge will always have the same chart rating on the barge as it did on land.
   - ❑ true ❑ false

9. Determine if this statement is true or false: [illegible] land crane mounted on a barge [illegible] the same [illegible] regardless of the actual barge size.
   - ☐ True
   - ☐ False

10. Determine if this statement is true or false: [illegible] barge deck [illegible] must NEVER be [illegible] area of [illegible]
   - ☐ True
   - ☐ False

11. Determine if this statement is true or false: [illegible] crane [illegible] barge [illegible] it is permissible [illegible] crane [illegible]
   - ☐ True
   - ☐ False

12. Determine if this statement is true or false: [illegible] on a barge deck is NOT permitted when [illegible] crane on the barge.
   - ☐ True
   - ☐ False

13. Determine if this statement is true or false: [illegible] crane [illegible] barge [illegible] it is permissible [illegible] barge [illegible]
   - ☐ True
   - ☐ False

14. When mounting a land crane on a barge, which of the following should NOT determine the crane capacity?
   - ☐ operator
   - ☐ manufacturer
   - ☐ marine engineer
   - ☐ none of above

15. Determine if this statement is true or false: [illegible] cranes and [illegible] are NOT required [illegible]
   - ☐ True
   - ☐ False

16. Which of the following [illegible] required [illegible] crane?
   - ☐ Boom angle indicator
   - ☐ Wind speed indicator
   - ☐ List and trim indicator
   - ☐ all of above

17. Determine if this statement is true or false: [illegible] crane fastened to a barge deck [illegible] system.
   - ☐ True
   - ☐ False

18. Determine if this statement is true or false: [illegible]
   - ☐ True
   - ☐ False

19. Determine if this statement is true or false. Jibs are routinely and safely used on barge mounted cranes.

❑ true ❑ false

20. Determine if this statement is true or false. Partially filling with water is the method commonly used to ballast a barge with an open hull.

❑ true ❑ false

21. Determine if this statement is true or false. Small leaks are permitted provided all pumps are in good working order.

❑ true ❑ false

22. Cranes mounted on offshore drilling platforms and the platform supply boats are normally regulated by what standard?

❑ ANSI
❑ OSHA
❑ API
❑ none of above

23. When hoisting with a crane from a fixed offshore platform, the load weight coefficient is:

❑ 1.00
❑ 1.33
❑ 1.40
❑ 2.00

24. When hoisting with a crane from a supply boat in mild sea conditions, the load weight coefficient is:

❑ 1.00
❑ 1.33
❑ 1.40
❑ 2.00

25. Determine if this statement is true or false. When hoisting a load from a supply boat with a fixed platform crane, the load must be lifted from the deck quickly because of the wave action.

❑ true ❑ false

SECTION TEN

TOWER CRANES

Tower Crane Operator Certification

Changes to ANSI/OSHA and various OCHS standards and regulations are requiring compulsory operator certification in most areas of both the United States and Canada.

Tower Crane Standards

Construction tower cranes are regulated by the ANSI B30.3 standard. Their use is expanding from the usual low-rise (up to 6 stories), mid-rise (7 – 15 stories), and high-rise (over 15 stories) buildings to include structures such as: stadiums, medical and retail centers, industrial plants, and communication towers. New designs with higher capacities, luffing boom models with little rear overhang, and self-erecting types are making these cranes more attractive to use.

Self Erecting Models

Self-erecting tower cranes have been available for a number of years, however they are becoming more popular for several reasons including cost, easy erection and quick erection.

The self-erecting system is either hydraulic or wire rope and drum. Earlier self-erecting models were generally considered small in size and capacity, however the height, reach, and capacity is continually increasing due to technology.

A fixed tower crane requires a concrete pad (for example 30 ft. x 30 ft. x 4 ft. thick with anchor bolts) poured well in advance to allow the concrete to cure. It also requires several truckloads of components and a mobile crane to erect the tower, jib, and counterweight.

New truck mounted units are becoming more common, and are available in different sizes and capacities. They arrive on site, are set up within an hour or two, then self-erect in minutes.

Depending on the manufacturer they are self-contained on one truck, or one trailer, or a truck-trailer combination, complete with the counterweight. Smaller units are operated by remote control. Larger units can be operated by remote control or from a cab.

Self-erecting Site Preparation

Site preparation for these units is extremely important. Due to the relatively small base, long mast and jib, they must be stable and level. The ground must be solid and level. Large pads may be required under the outrigger floats to distribute the ground pressure.

Two types are shown in illustration #460 and #461.

Illustration #460 is a truck unit that has a boom tip capacity of 4,000 lbs. with a boom length approaching 200 feet.

Illustration #461 is a trailer unit with four operating mast heights and a combined boom and jib lifting height of 330 feet.

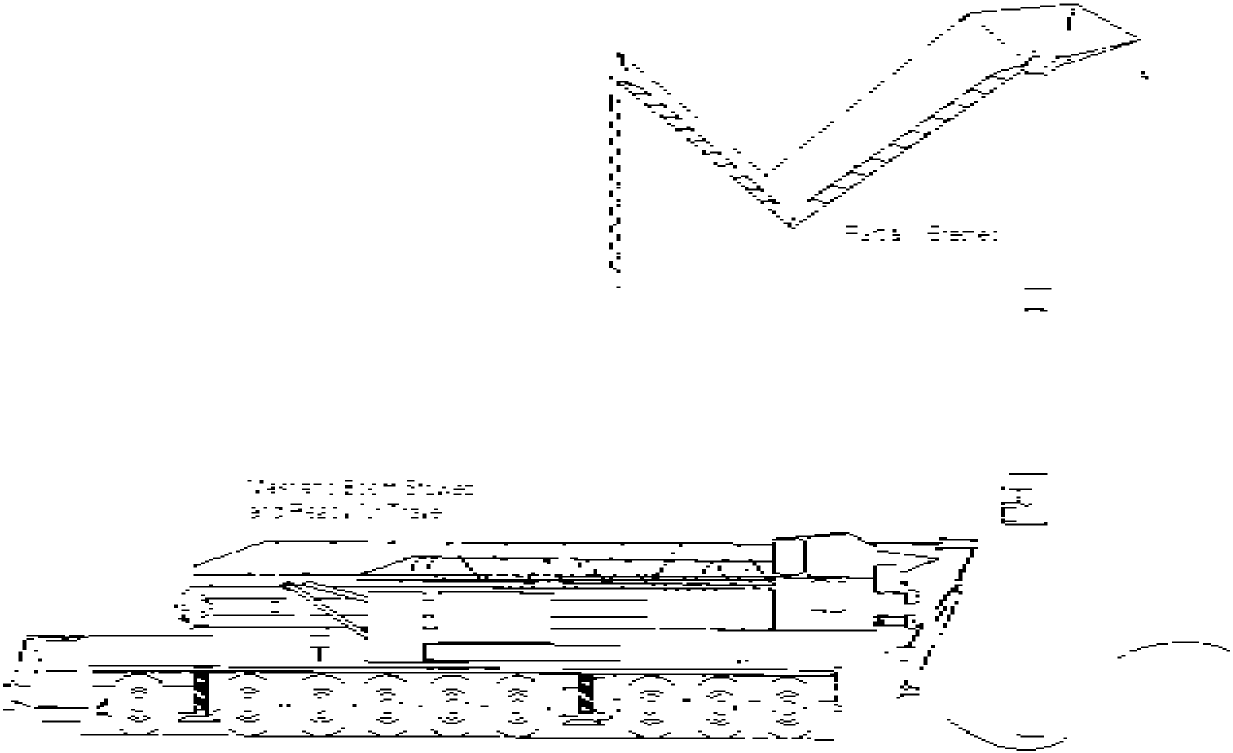


Illustration #450 – Self-erecting Truck Crane

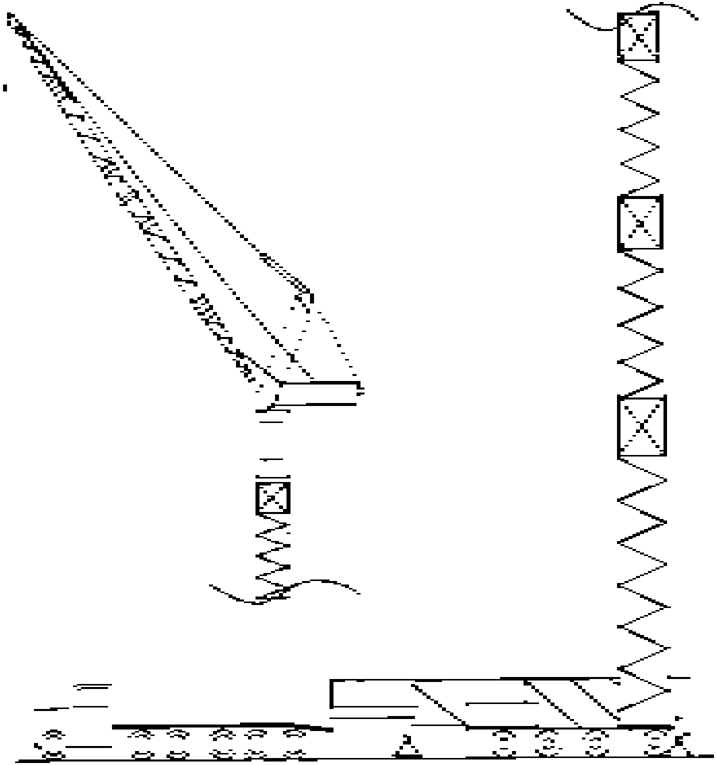


Illustration #451 – Self-erecting Trailer Crane

Tower Crane Types

Tower cranes are of two basic types:

1. ***Fixed Tower*** - The base is non-moving, and a rotating or slewing ring is located beneath the jib. See illustration #482.
2. ***Slewing Tower*** - The slewing ring is located at the base and the entire assembly rotates. See illustration #483.

These two tower types are also available in three basic designs:

a. Telescopic Towers - This type has at least two sections which slide inside each other. This gives a height adjustment without dismantling the crane. See illustration #484.

b. Inner-Outer Towers - The jib is supported by a partial slewing inner tower which rotates inside the fixed outer tower. See illustration #485.

c. Mono Tower - This type is a single tower which can be either fixed or slewing. See illustration #486.

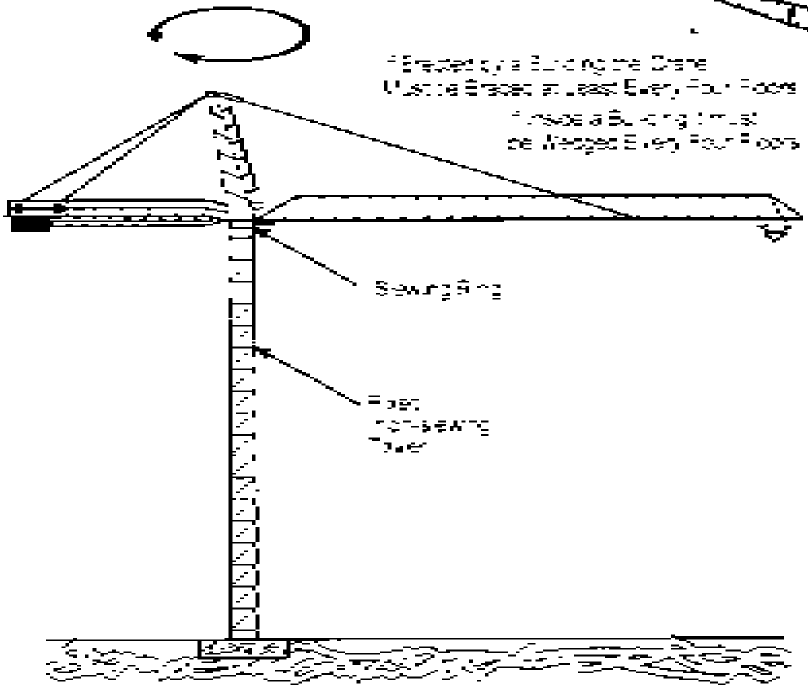


Illustration #462 - Fixed Tower Crane

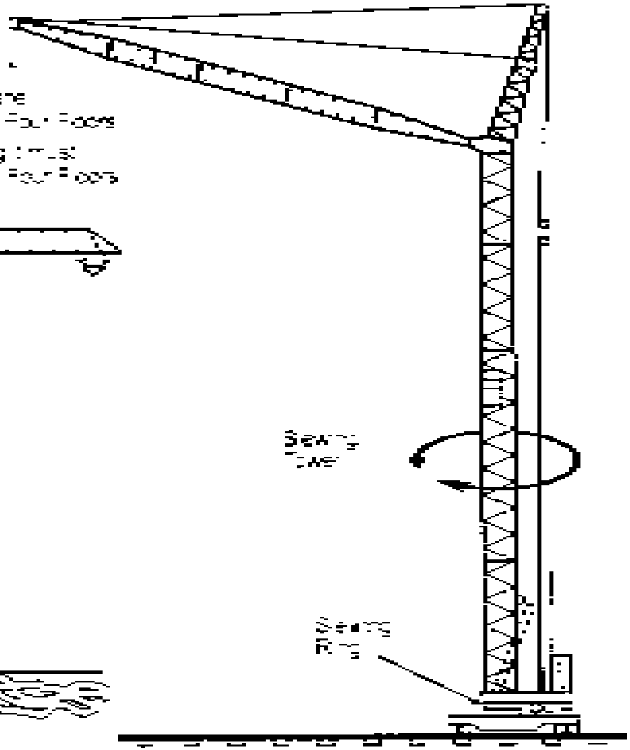


Illustration #463 - Slewing Tower Crane

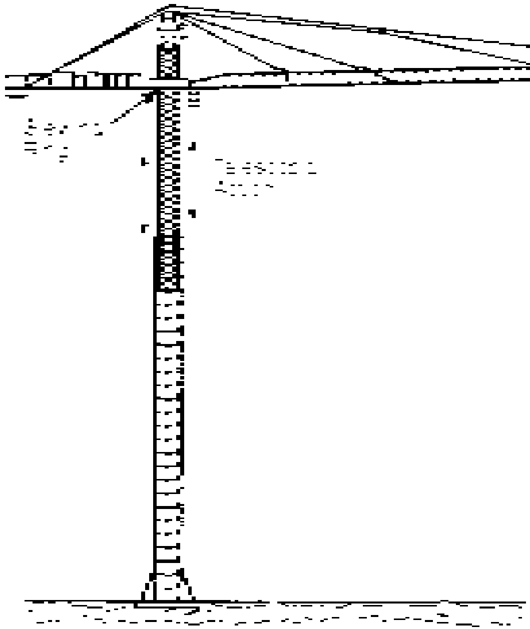


Illustration #454 - Telescoping Tower Crane

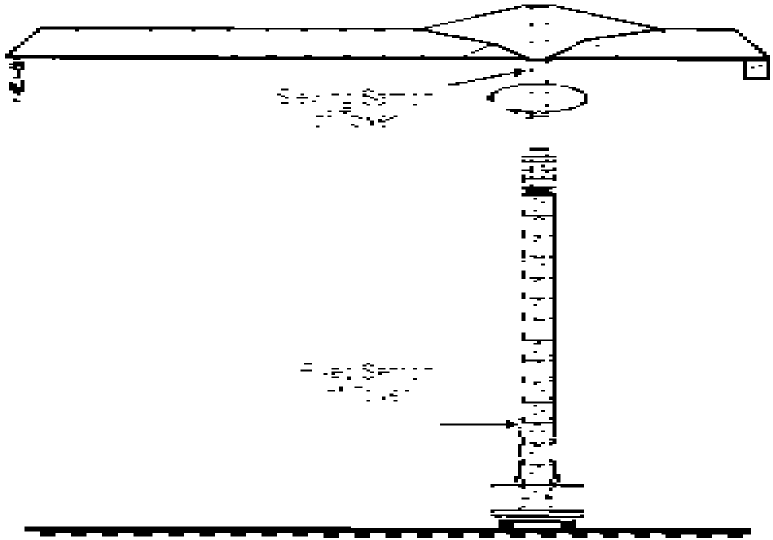


Illustration #455 - Inner-outer Tower

Crane Jib Types

Tower cranes use four basic types of jib assemblies:

1. Saddle Jib - The jib is horizontal or slightly angled and is supported by pendant lines. A movable trolley supports the hoist assembly. It allows a smaller operating radius than a luffing jib. See illustration #467.

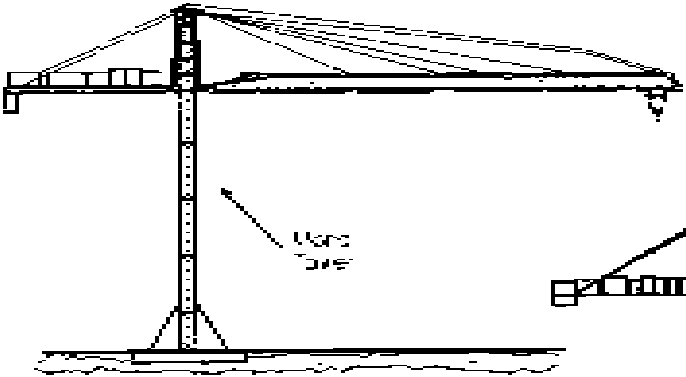


Illustration #466 - Mono Tower Crane

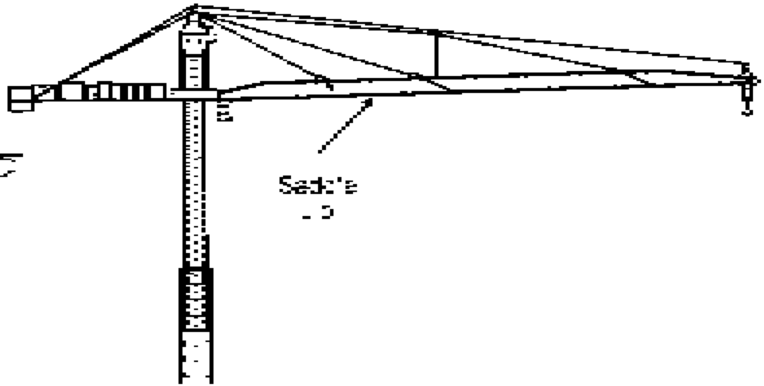


Illustration #467 - Saddle Jib

2. Luffing Jib (Front Pivot) - The luffing jib does not have a movable trolley. The jib raises and lowers to change the load radius similar to a mobile crane. These usually have a top mounted slewing ring. This type has a higher operating height than a saddle type. See Illustration #468.
3. Luffing Jib (Rear Pivot) - This type is similar to the above, except the jib pivots behind the tower. This type has a smaller load radius than a front pivot. See Illustration #469.
4. Fixed Luff Jib - The fixed luff jib has a fixed angle, supported by pendant lines. The hoist assembly is supported from a movable trolley. See Illustration #470.

Note: Remember a tower crane loses capacity with a longer load radius. A jib will deflect when a load is lifted and this deflection will increase the load radius.

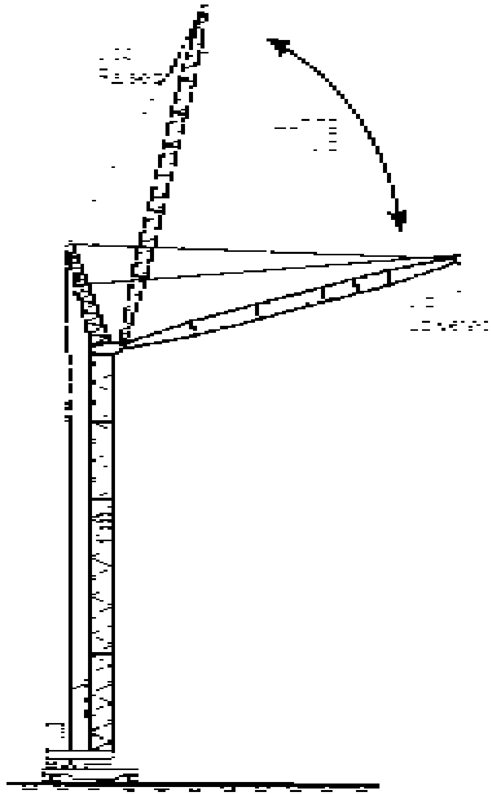


Illustration #468 - Front Pivot Luffing Jib

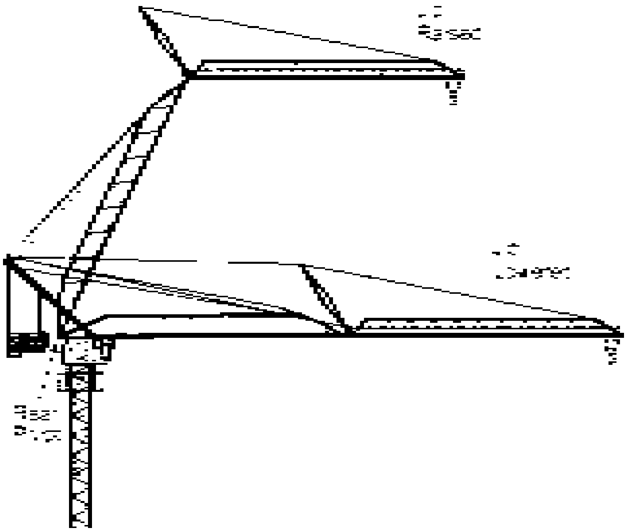


Illustration #469 - Rear Pivot Luffing Jib

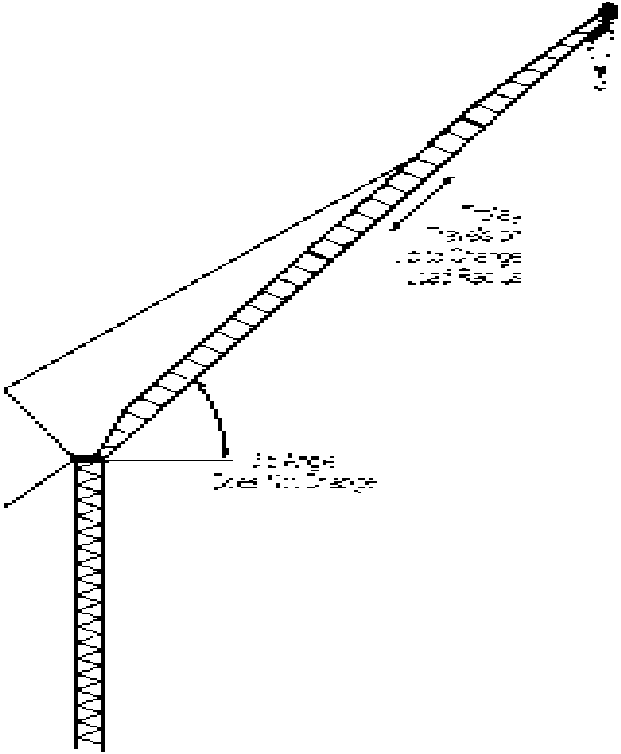
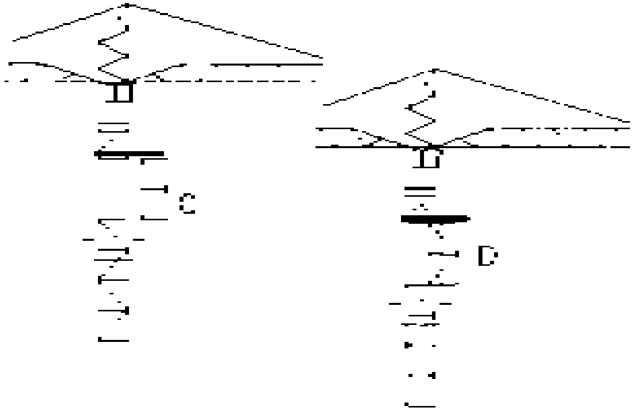


Illustration #470 - Fixed Jib

Crane Mounting

Tower cranes have four basic types of mounting configurations:

- Stationary units are fixed in position. They can be free standing up to the crane limit, and/or can be attached to a building or structure for support. If the crane height has to be extended, it would be simpler if the crane was of a type that could add its own extra sections without dismantling. See Illustration #471A to #471E.



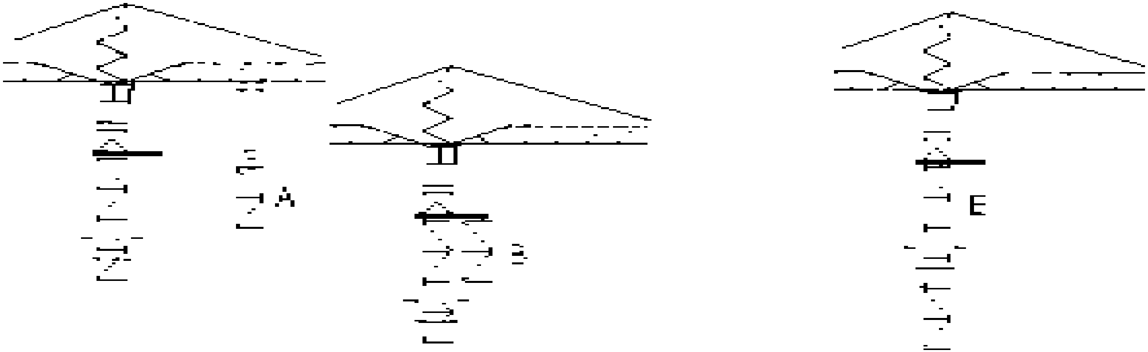


Illustration #471 - Self-installing Sections

- Mobile units can be either truck mounted or on crawlers. The main advantage in the mobile tower unit is a longer reach than a normal lattice or hydraulic crane boom over a building edge. Some types are self contained and self-erecting. The greatest disadvantage is having a limited load capability.
- Rail mounted tower cranes can have any type of tower or jib configuration. They usually handle a load better while travelling than a comparable mobile tower crane.
- Climbing tower cranes are supported by and attached to the building structure being constructed. As the building height increases, the crane height is increased by means of climbing ladders. The tower is attached to the building, or is wedged at least every four floors.

Component Identification

All crane components must have a plate with the crane manufacturers name, serial number, model number, year of manufacture, weight and size of unit (see illustration #472).

These plates must also be attached to the removable components to indicate which crane they belong to. Crane components can not be mixed and matched with anything except the original crane or an identical unit.

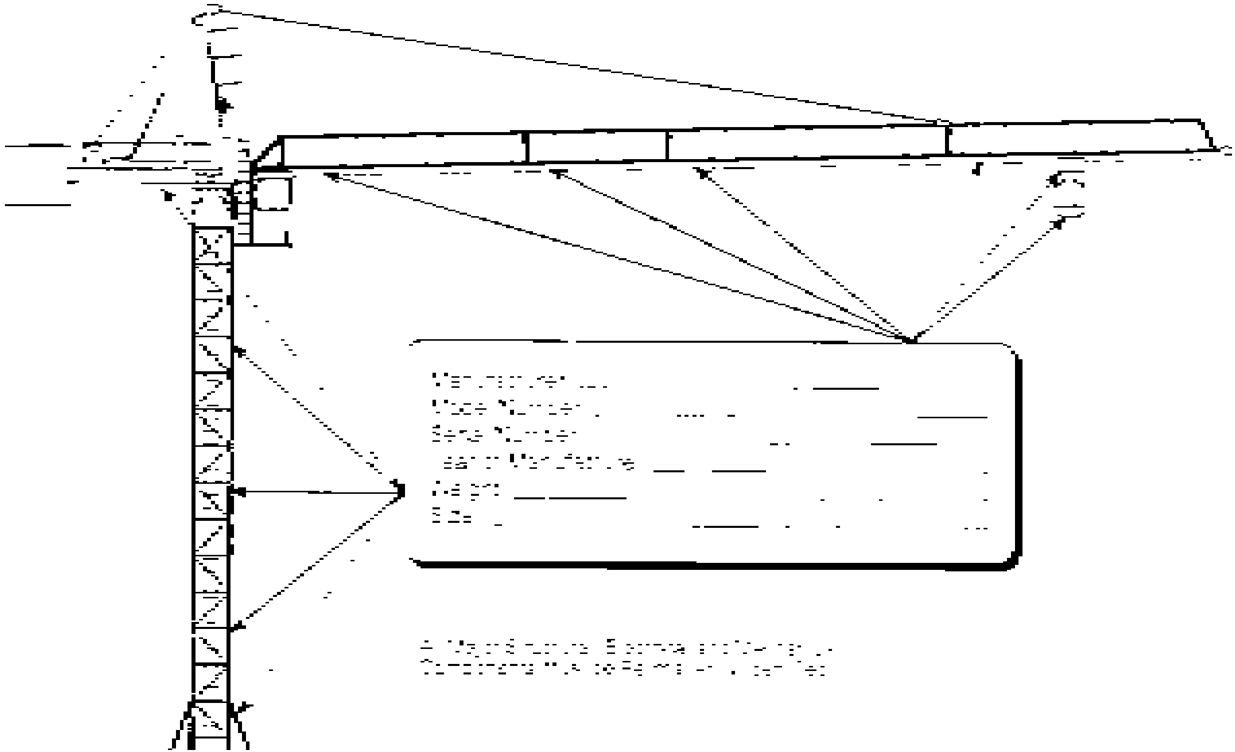


Illustration #472 - Tower Crane Identification

Crane Equipment Records

Every machine must have a manufacturer's manual with specific data concerning the machine, its setup, and with provisions to record inspections and maintenance.

The data included must include specific information concerning:

- crane type
- manufacturer
- model and serial number
- year of manufacture and sale
- weight of boom sections
- weight of unit and ground pressure exerted if mobile
- load charts and all data needed to calculate lifts, rigging and erection procedures, type of material, welding and bolting specifications for load bearing structural components.

Log Book

A log book must be kept in the crane to record all operating hours, inspections and any maintenance. This book must be updated daily and signed by the operator, service mechanics, and a supervisor.

Tower Crane Erection

A site plan must be carefully prepared before a tower crane is set up. This plan must show the location, swing radius in relation to other buildings or objects; the location of underground sewers, waters mains; and it must show any bracing methods. The crane must maintain the applicable clearance from a powerline. A soil testing company should be used to ensure the ground will support the weight.

It is absolutely essential that a tower crane be set up on a firm, level base; whether it be a concrete pad or a base inside a building structure. Numerous accidents have occurred because of poor footing. Ground movement due to frost heaving in colder climates must be considered.

When the tower is set inside a structure the opening must be large enough to permit the climbing frames to work and to fit the hardwood support and levelling wedges as recommended by the manufacturer. The wedges must be inserted at a minimum of every four floors as shown in illustration #473.

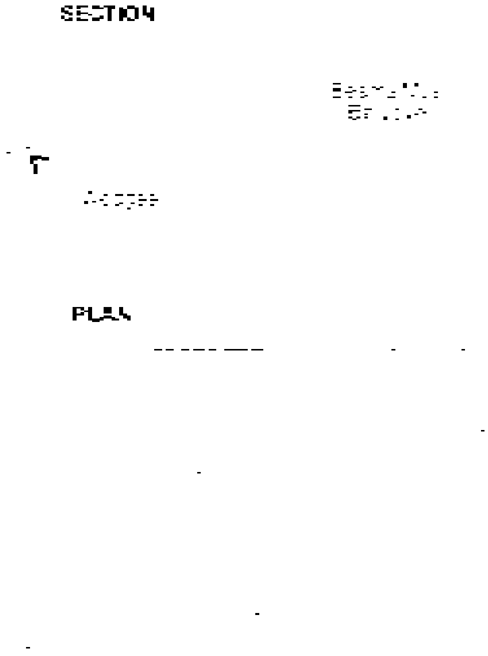


Illustration #473 - Tower Base and Securement

Carefully follow the manufacturer's erection guidelines. These will include:

1. Maximum free standing height.
2. Use and location of bracing and wedges.
3. Use of guylines.
4. Follow the recommendations on wind speed limits.
5. Be very careful with the size of the counterweight. If it is too light the crane will have less capacity, and if it is too heavy the tower could suffer from structural overload.
6. Always use new bolts of the recommended type. During assembly the bolts are usually torqued to 75%, then to 100% after the crane is erected.

Tower Crane Assembly

Crane erection details will vary with different machines, however the basic steps will be as follows:

1. The tower can be assembled on the ground, or the sections erected vertically one by one on the base; a mobile crane will be needed. Either way the sections must be oriented properly. Guylines are often needed to support a free standing tower.

See illustration #474 for good and poor methods of using wire rope on the tower angle iron legs. Crane support guylines must meet the minimum design (safety) factor. See illustration #475. Make sure the tower is plumb and the guyline tensions are equal.

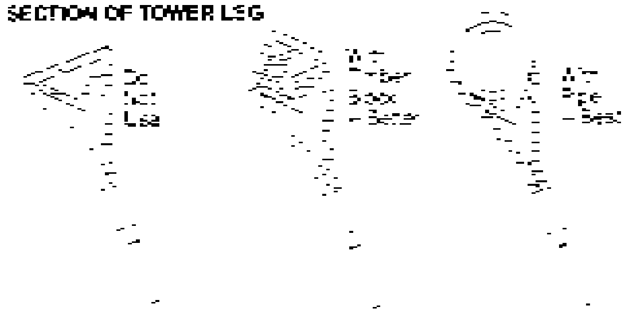


Illustration #474 - Tower Guy Wire Attachment

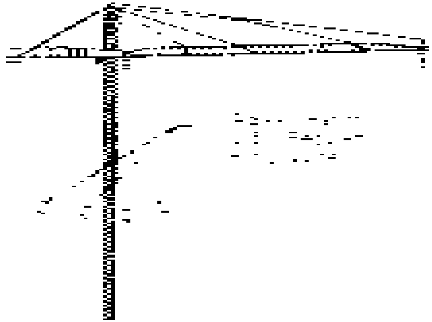


Illustration #475 - Permanent Guylines

2. Install the mast to the turntable on the ground. Torque the bolts to 100Ft. Check and lubricate the gearing. Pin the pendants in place.
3. Use a crane to lift the mast assembly into place. Check the orientation.
4. Block up the main jib and counter jib sections on the ground. The short heavier sections are located next to the mast. Torque the bolts to 100Ft.
5. Install the trolley on the main jib. Make sure it is lubricated and aligned.
6. Use a crane to hoist the counter jib. Lift it level. Insert the jib into the turntable and pin. Lift the end slightly and pin the pendants. Adjust the pendant turnbuckles so the jib hangs at the right angle and is not twisted. See Illustration #476. Use cotter pins, not spring clips on the pins.

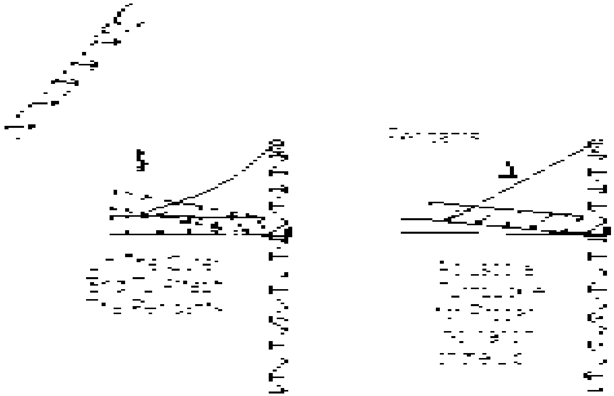


Illustration #476 - Counter Jib Erection

7. The main jib is lifted using a crane. Keep it level while lifting. Pin the jib to the turntable. Lift the end and pin the pendants. Adjust the angle with the pendant turnbuckles. Check across the trolley rails for level. See illustration #477. Use cotter pins.

8. Using the other crane, lift the counterweight into position. Lift one at a time. Make sure the counterweight is securely in place.

9. Reeve the main hoist line as per the manufacturers manual. See illustration #478 for a typical 2 and 4 part reeving system.

Note: If a tower crane is secured to the outside of a building it must be secured a minimum of every four floors. The securement must be approved by an engineer.

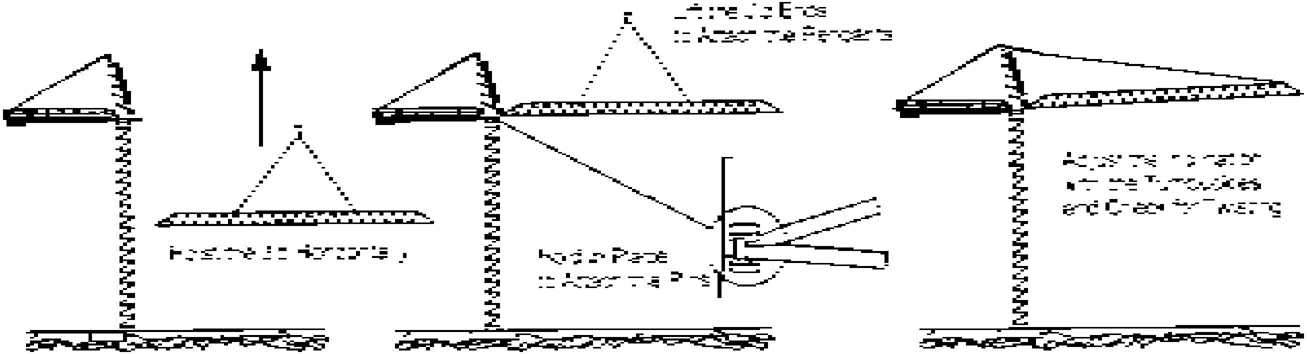


Illustration #477 - Main Jib Erection

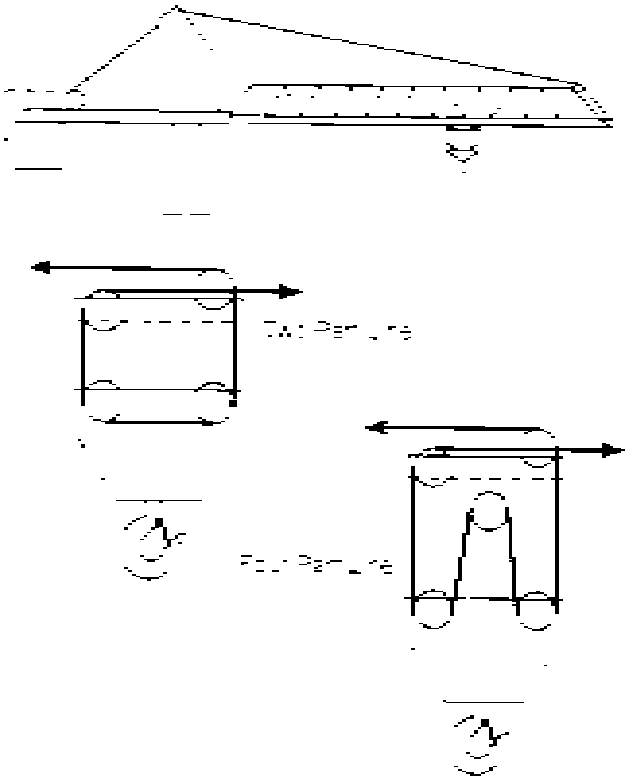


Illustration #176 - Hoist Reeving

10. All electrical connections must be done by a certified electrician in accordance with the applicable local authority.
11. All bolts which were only partially torqued must now be torqued to 100%. The counterweight is rotated to be positioned over the slewing ring bolts being tightened. See the torquing tables in the Appendix of this book.
12. All limit switches must be set and tested.

Tower Crane Safety Features

There are several safety features that all tower cranes should be equipped with:

- An audible warning device for rail or mobile mounted units.
- Lighting for night operation.
- Jib stops of a shock absorbing type, and a jib hoist limit switch on luffing cranes.
- A jib angle indicator visible to the operator is required on all cranes with a luffing type jib.

- A fire extinguisher is required on all cranes.
- All walkways should be anti-skid.
- Guardrails are required on all outside platforms. Also safety lines for the attachment of safety lanyards, or safety platforms should be on all jibs.
- Jibs should be equipped with radius markers. See illustration #479.

Limit Switches

Every tower crane must be equipped with several properly installed and set limit switches to prevent crane overload. The switches can be microprocessors for digital control or mechanical for older types of cranes. Examples of the position of these switches are shown in illustrations #480 to #484.

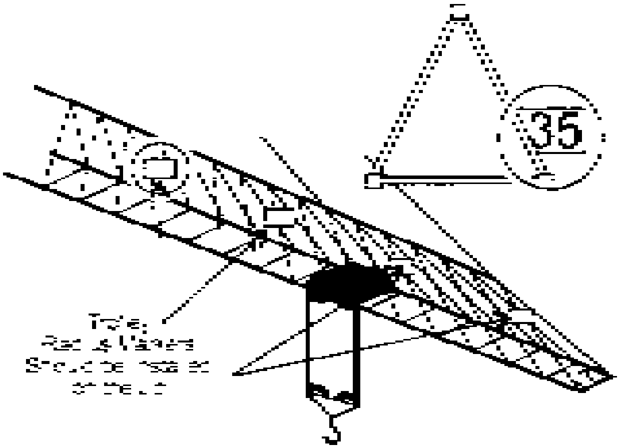


Illustration #479 - Jib Radius Markers

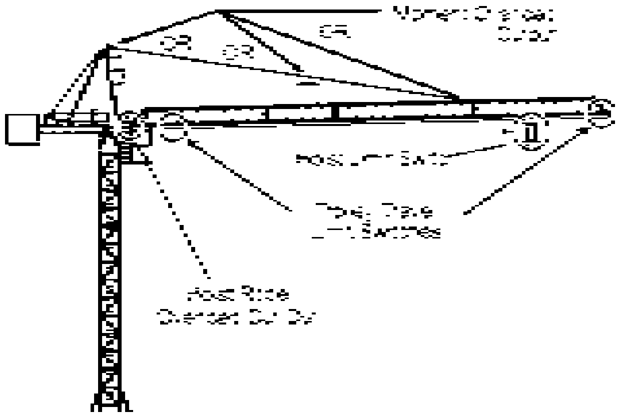


Illustration #480 - Load Switch Positions

Safety Features/Limit Switches

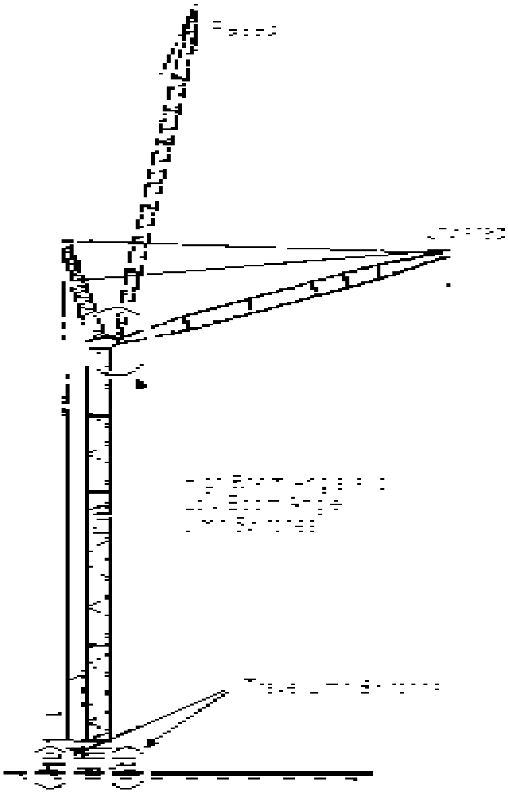


Illustration #481 - Limit Switch Positions

1. ***Trolley Limit Switch*** - This switch cuts trolley power when it reaches a predetermined position.
2. ***Hook Height Limit Switch*** - This stops the block from hoisting at a predetermined distance from the jib sheaves. See Illustration #482.

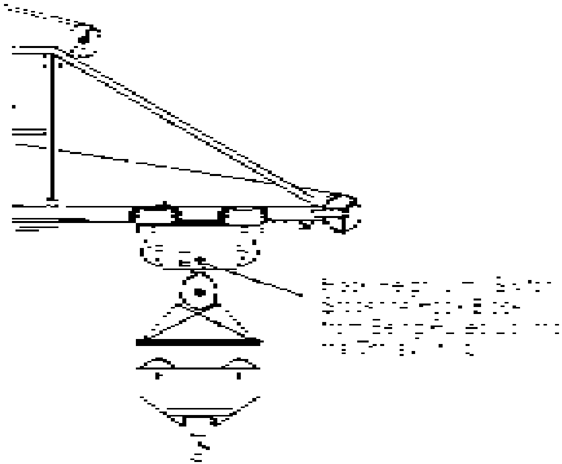


Illustration #482 - Hook Height Limit Switch

3. ***Rail Travel Limit Switch*** - The travel brakes are applied when the crane approaches the rail end.
4. ***Luffing Jib Limit Switch*** - The jib hoist drum is stopped when the jib angle gets too high or too low. The luffing jib must also have a physical stop to keep it from flipping over if the jib is whipped.
5. ***Hoist Drum Stop Limit Switches*** - There are several of these that stop the hoist drum when an overload is reached.
6. ***Hoist Line Overload Switch*** - This switch cuts hoisting power at a 5% overload on the hoist line, regardless of the jib or trolley position. See Illustrations #483 and #484.
7. ***Jib Pendant Tension Overload Switch*** -This switch cuts hoisting power at a 5% overload when the load weight deflects the jib and increases the tension on the jib pendant lines. This switch also stops trolley travel.

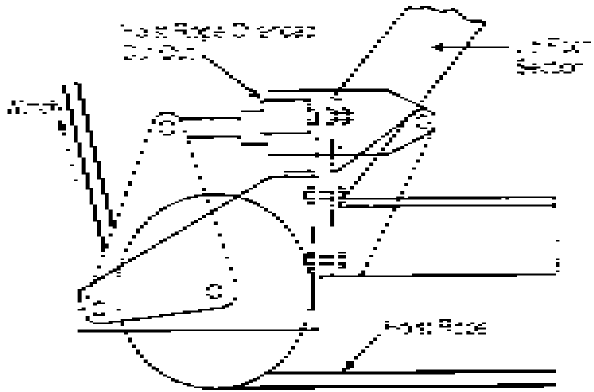


Illustration #483 - Hoist Line Overload Switch

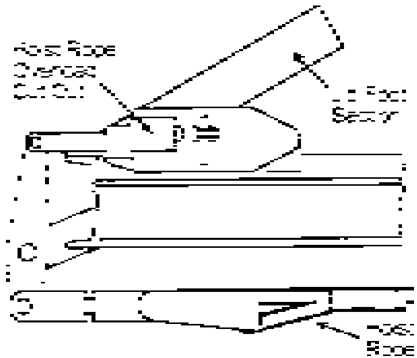


Illustration #484 - Hoist Line Overload Switch

Tower Crane Brakes

All tower crane brakes must be of the fail safe type that automatically apply when there is a loss of power. These brakes must not be released until power is restored, and then they are mechanically released. See illustration #455 for an example of a fail safe brake.

The slewing drive brake will hold the crane from moving under designed wind velocity; however the brake will slip with winds over that design velocity and the crane will weathervane.

Note: Never allow a load to be lowered only by brake control unless the hoist has a speed limiting device. Uncontrolled lowering is extremely dangerous.

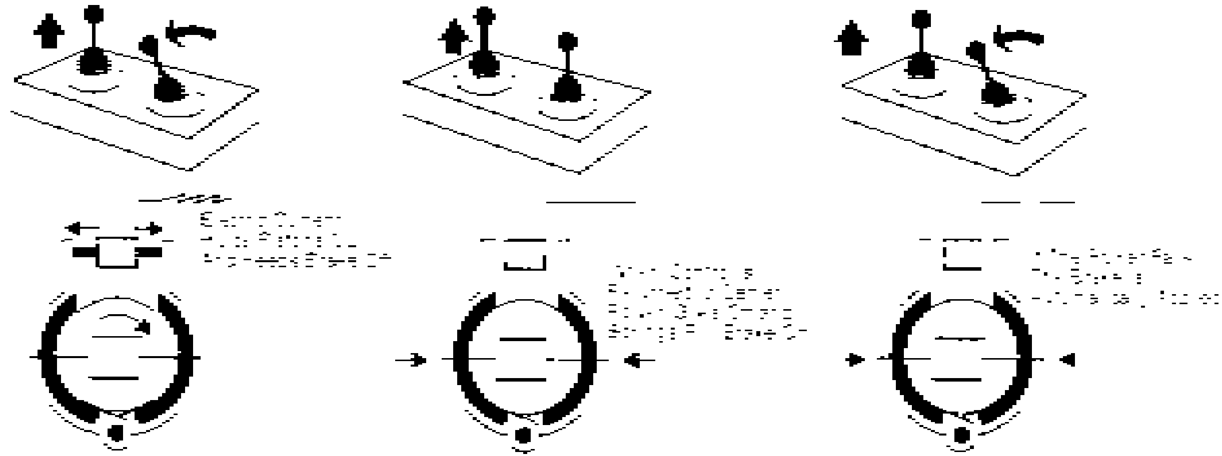


Illustration #455 - Fail Safe Brakes

Testing

1. Set the hoist height limit switch. Run the block in slowly, then lower and run in again at full speed. Check the drift and re-set the limit switch with a suitable safety distance.
2. Set the trolley in and out limit switches. Ensure there is a safe distance from the stops at the ends.
3. Set the jib hoist limit switches on luffing jibs. Boom up and down slowly allowing the jib to contact the stops. Set the switches to stop the jib before contacting the stops.
4. Set the jib deflection overload switch. The switch should cut out at 5% over the rated capacity.
5. Set the hoist overload switch. Lift the rated load off the ground and hold. Fasten a second weight to the first. The limit switch should stop the hoist at a 5% overload. Check this overload at both minimum and maximum lift radii.

   Note: Many crane types are tested at 125% of rated capacity. Do not test load a tower crane at more than 5% overload!!
6. After testing the limit switches do a 100% load test to check the overall crane operation.

Tower Crane Operator Controls

The use of microprocessor controls is becoming widely used in new or modified tower cranes. They allow accurate readings for the operator and also remote control operation. However these types of controls must be checked every day for the proper function.

The following outlines the use of the older style controls.

- Controls should be of the dead man type. They will return to neutral when pressure is released. See Illustration #486
- Controls must be clearly marked to show their function. See Illustration #487

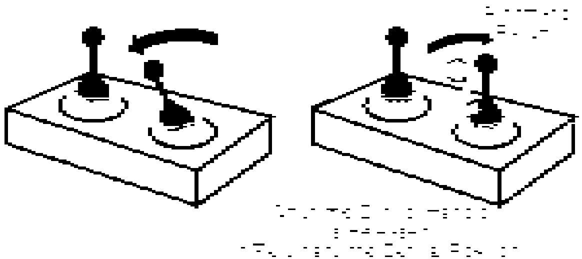


Illustration #486 - Dead Man Type Controls

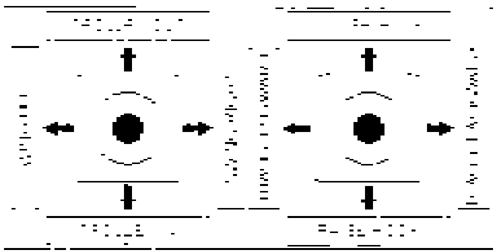


Illustration #487 - Control Markings

- Controls must be installed and marked to move the crane in the direction indicated. See Illustration #488 to #491.

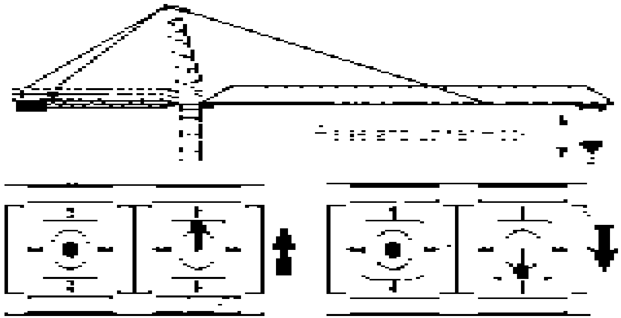


Illustration #488 - Hoist Raise & Lower

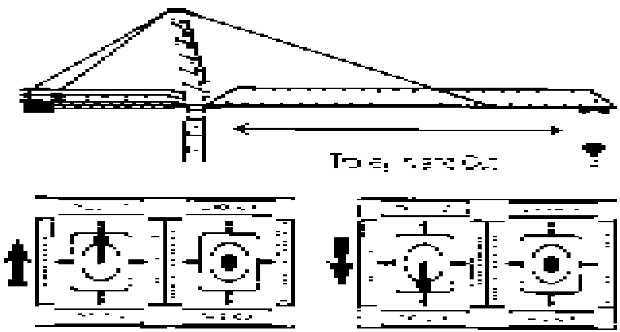


Illustration #489 - Trolley In And Out

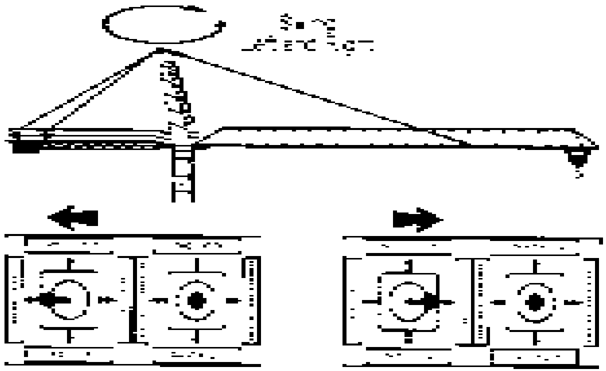


Illustration #491 - Swing Left and Right

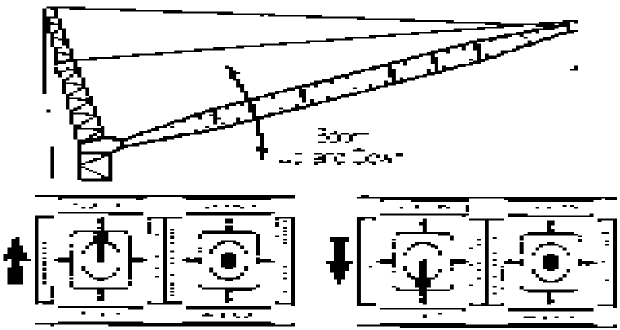


Illustration #490 - Boom Up And Down

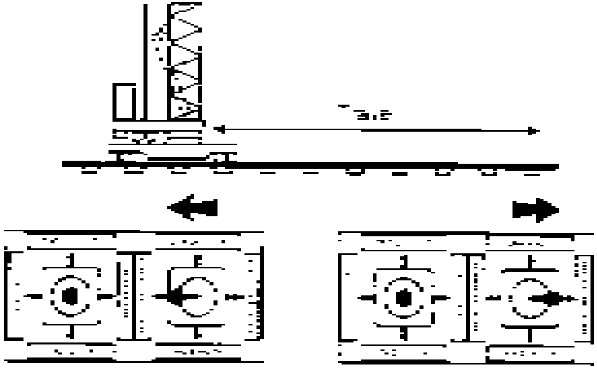


Illustration #492 - Tower Travel

Tower Crane Load Rating Charts

There must be a load chart in every tower crane cab giving specific data about the crane hoisting limits under different conditions and capacities. If the tower crane is a remote control unit, the control console must have a load chart attached to it (illustration #493).

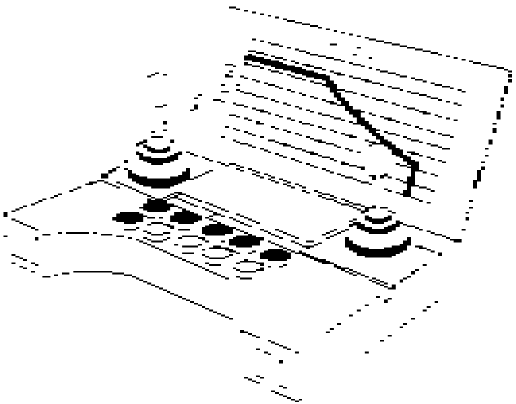


Illustration #493 - Remote Control With Chart

The load chart will include the following basic information:

- Specific data including the crane serial number, model number, and year of manufacture.
- Load ratings for all crane operating configurations including tower height, jib length, operating radius, installed counterweight.
- Load ratings when manufacturer approved optional equipment is used such as bracing, guy wires, or extra counterweights.
- Wire rope type, size, and reeving; plus line pull, line speed, and drum capacity.
- Operating limits in windy or cold weather conditions.

Two different types of load chart are shown in illustrations #494 and #495.

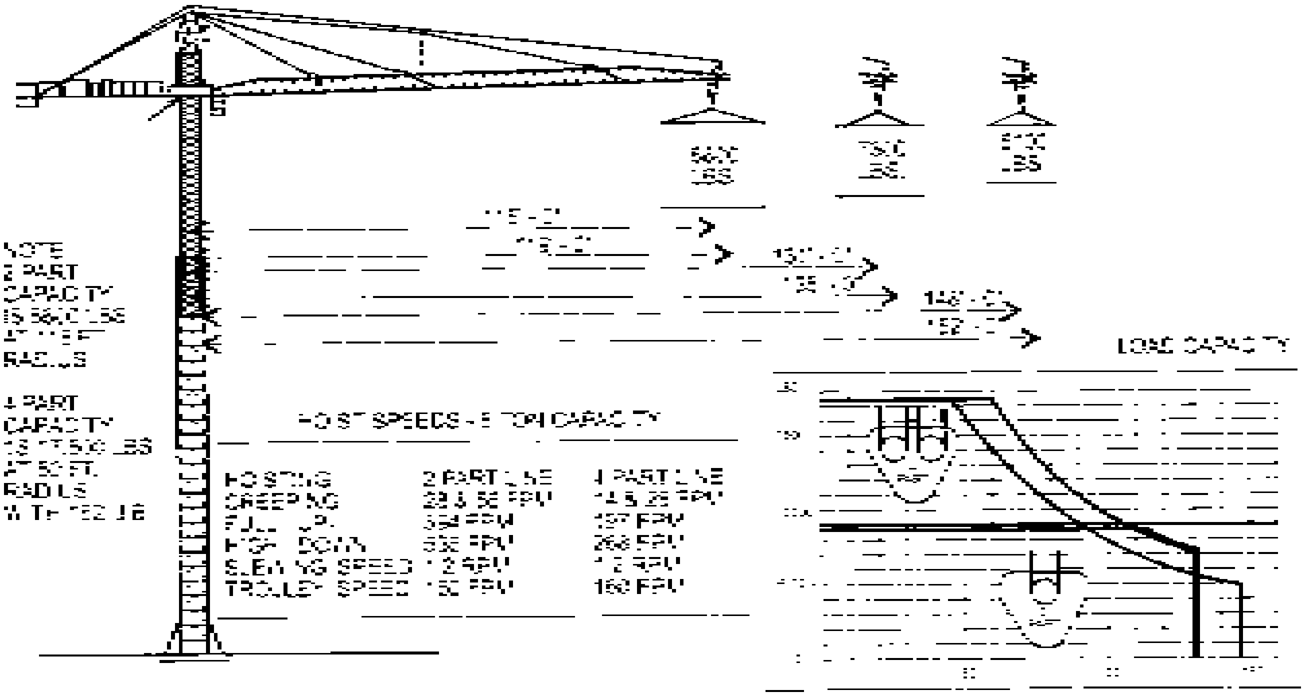


Illustration #494 - Capacity Chart Example

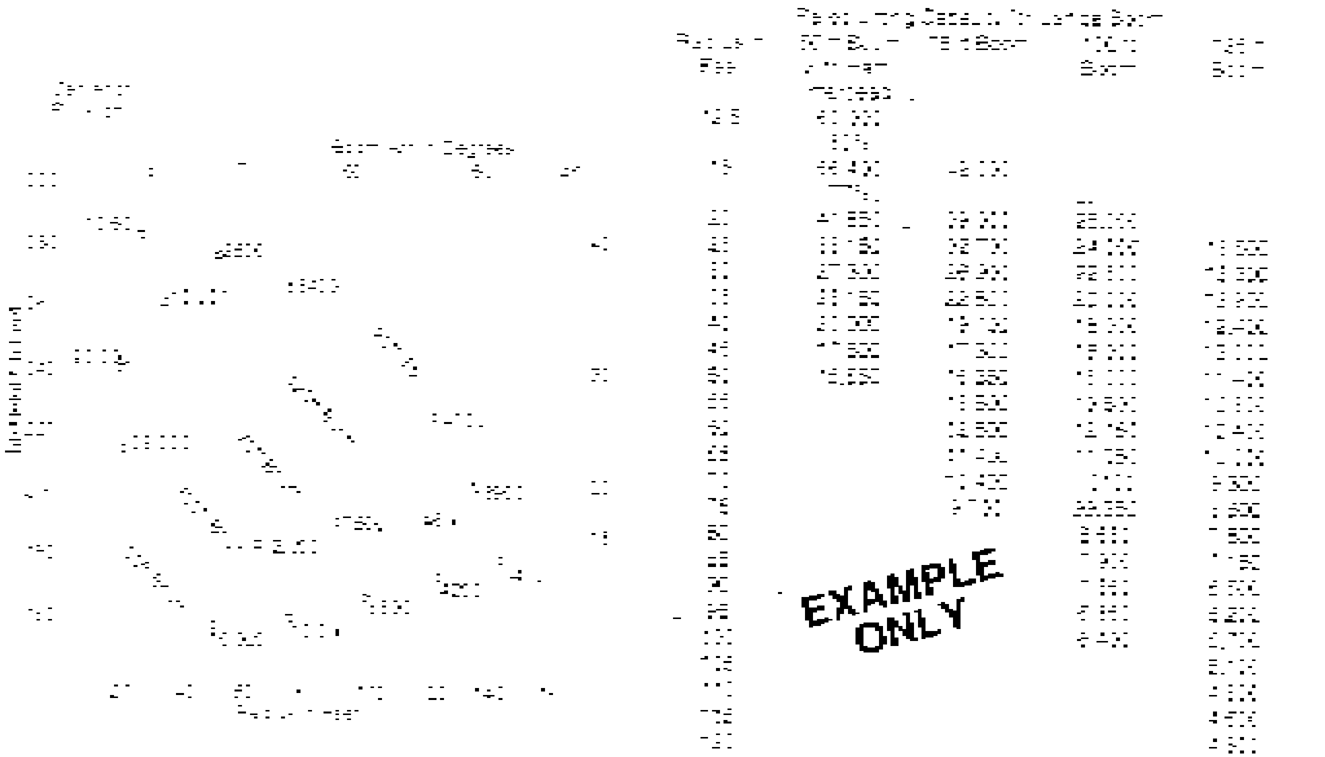


Illustration #496 - Self-erecting Chart Example

Tower Crane Operator Precautions

1. Determine exactly the weight of any load. The actual load plus the rigging slings and hardware make up the total load. This load weight and the final position is then compared to the load chart to see if the crane can safely lift it. Do not forget that rapid swing increasing the load radius, or impact loading can immediately eliminate all previous calculations.
2. Mobile and rail mounted cranes must not be moved until the operator is sure everything is clear. A warning device should be sounded, and a signalperson must be used when vision is not clear.
3. All personnel must stay off the tower or the jib when the crane is operating.
4. The operator and the signalperson must be certain the crane is not hoisting over working personnel or pedestrians.
5. Never attempt to repair or lubricate a crane which is in operation.
6. Wind is always a major factor on any crane, but especially so with a tower crane. Winds tunneling between high buildings, or vortexing off the top of a building can double the actual wind speed. Load dimensions and weight are major factors in how a load will be moved about by wind. Wind speeds of 20 to 30 mph (30 - 50 km/h) should be the operating limit (depending on applicable safety regulations).
7. Cold weather operation is hazardous to crane operation. The flexing of tower cranes in cold weather increases metal fatigue. Shock loading in cold weather can cause fracture of components. A temperature of 0° F (- 17 °C) is considered an operating limit.
8. Make sure the block is not lowered to the ground. The hoist line must not be allowed to go slack. Always watch the drum spooling.

9. Always ensure the load center of gravity is directly under the hoist line sheave. Do not side load the jib under any circumstances and do not allow the load to swing out from the jib tip.
10. Never use the limit switches or the computerized control system as a scale to judge or check the load weight. Limit switches and/or digital operator aids must be tested, but they are not to be used as a weight scale.
11. A tower crane operator often can not see the load being rigged, and therefore does not know or can not even estimate the load weight unless told by voice communication. Someone must be in charge of calculating all load weights. This person and the operator must determine whether or not the load can be safely lifted and transported.
12. Load charts on tower cranes are based on lifting capacities at various radii. The load radius must be known at all times. Extra load radius can be caused by radio swing, by lifting behind or beyond the jib tip and allowing the load to swing out. Load radius increase due to jib or pendant line deflection must be considered when preparing a load for hoisting.
13. Always avoid shock loading the hoist wire rope. Lifts and stops must be done gradually. Lifting and traveling speeds must be attained gradually. Never do anything which could result in the backward whipping of a luffing jib.
14. If a load does not lift and hang level, lower the load and rehook.

15. Riggers and the signalperson must always ensure the load can not catch on any projections. If the load catches or is hung, use extreme caution to ensure the load does not whip, drop, or sideload the jib.
16. Always have at least three wraps of wire rope on the drum (check this with the local OCHS/OSHA department as the requirement may vary in some areas.
17. Watch the electrical cables. Do not allow them to become wound around the tower with more than two or three tower swings.
18. Never under any circumstances should the operator leave his seat while the crane is moving or a load is suspended.
19. The load must not be allowed to swing out over traffic or pedestrians. If the jib overlaps the street below, barricades must be used to detour traffic.

Tower Crane Signals

The importance of a good signalperson cannot be overemphasized with tower crane operation. A signalperson must be present when the operator is near a powerline, is moving a crane on rails, or is hoisting loads not clearly visible (which is often the case with tower cranes).

The signalperson must be aware of the hoisting operation and have enough experience to spot potential hazards. The signalperson must be positioned to clearly see the load at all times, although it is often necessary to have more than one signalperson on a large structure. If two or more signalpeople are using hand signals, one of them must always be in sight of the load, and they should be in sight of each other.

A 2 way radio communication system is a preferred signaling method for tower cranes if a hard wire system is preferred. Hand signals over long distances are difficult to identify. Signal confusion can easily lead to an accident.

When hand signals are used day-glo orange gloves or a vest should be worn to help the operator see the signalperson.

If the 2 way radio link is lost, or the operator loses sight of the signalperson using hand signals, the operation must stop until the operator is signaled to resume.

Note: See Section Two concerning training and testing requirements for signalpersons.

Adjacent Cranes

Two cranes operating within reach of each other always have the potential for colliding or interfering. The two towers must be set at different heights to allow one to swing under the other without contact.

The two operators should be in constant radio contact. A preferred method is to have one person organize the loads and the hoisting operation to ensure there are no collisions or fouled loads.

Unattended Tower Crane

The operator must never leave the controls with a suspended load. The unexpected could happen and allow an unattended load to drop or lower.

If the operator leaves the cab he must:

a. Lower the load, bring the hoist up to the jib and in close to the tower.

b. Raise the hoist on a luffing jib and position the jib at 15 degrees. See illustration #498.

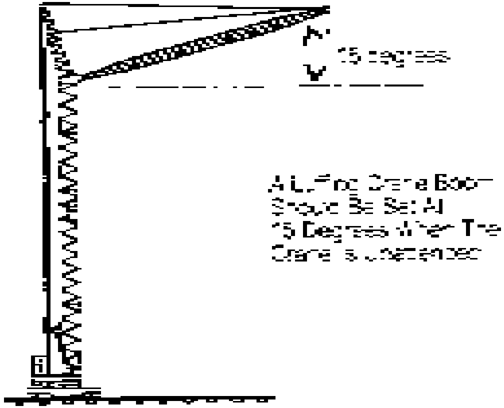


Illustration #498 - Luffing Overnight Position

c. Allow the crane to weathervane.

d. Shut off the main power and lock the switch box, the control console and the cab door.

e. Clamp the wheels to the rail (if applicable).

f. If the in service height is higher than that allowed for out of service, the crane will have to be anchored off.

Weathervaning

A tower crane must weathervane if left unattended. That is, the jib is allowed to rotate with the wind with the main jib drifting downwind as shown in illustration #497. If an advertising sign is on the counter jib, the operator should allow the crane to weathervane and see if it will rotate properly. If it won't, the sign will have to be removed. If it still will not weathervane, a sign or plywood sheet may have to go at the jib tip.

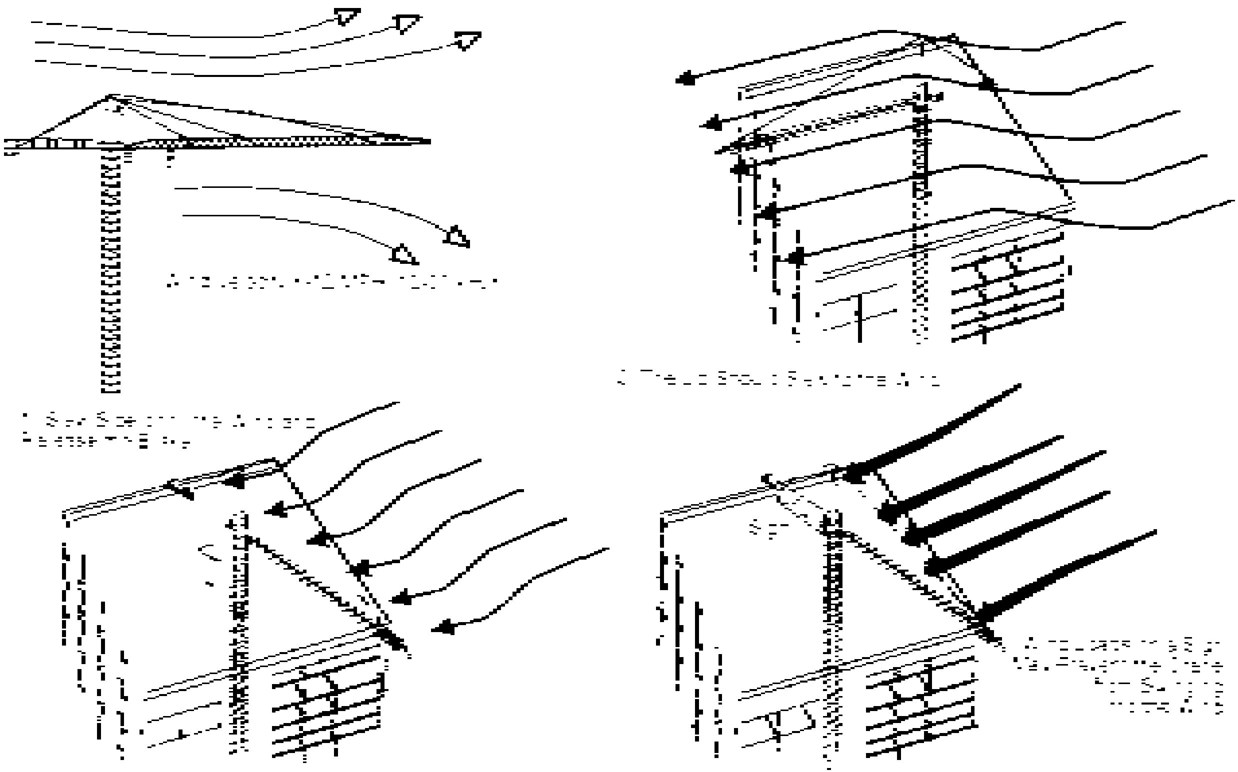


Illustration #497 - Jib Weathervaning

Tower Crane Inspection

All cranes must be inspected on a regular basis to ensure the safety of the machine. A safe policy is a daily inspection before operation on obvious wear points. A more thorough inspection should be done at least on a weekly or monthly basis, and tower crane structural components prone to metal fatigue must have a yearly non-destructive inspection by a registered inspection company.

1. All wire ropes, sheaves, hooks, drums, attachments, and hoisting components must be thoroughly checked for wear, cracks, bends or twists and proper rotation.
2. Any tower support must be thoroughly checked daily. This includes tower support beams, shoring or bracing; tension of guywires; tightness of hardwood wedges (while the crane is operating).
3. Check the counterweight.
4. Check the condition of all hydraulic hoses and connections for leaks or signs of wear.
5. Check the level of all lubricating oil reservoirs. Check filter condition. Watch for sign of leaks around connections and gear boxes.
6. Check condition of slewing ring gear.
7. Check gears for backlash and any drive belts for proper tension.
8. Check all electrical connectors and wiring. Ensure the power is off.
9. Check all clutches and brakes for condition and operation. Test load the brake by suspending a load a short distance off the ground.
10. Check all limit switches. Test weights should be used to ensure the settings are correct.

11. Thoroughly check the structural integrity of the jib and the tower. Watch for bent or damaged lattices or chords. Look for cracks, especially in welded joints; flaking paint may indicate metal fatigue.

Note: Tower cranes are susceptible to metal fatigue. All components are continually flexing, but the tower in particular is always being pulled by either the load or the counterweight. Check the slewing ring, gears, support brackets for wear and cracks. This area of a tower crane is also very susceptible to fatigue cracking.

All structural components must be inspected regularly, and a non-destructive inspection by a registered inspection company must be performed on the entire structure at least yearly or before being erected on a new job. Tower or jib repairs must follow the manufacturers procedure. A welder must be qualified to that procedure.

12. Frequently check the torque of the support bolts, including slewing ring, tower, and jib. Bolts should not be retightened more than once. Bolts that come loose a second time should be checked or replaced as they may be stretched.

Torquing of Bolts

When the tower base bolts are retorqued, the jib is rotated so the counterweight is positioned over the bolts being tightened. See illustration #498.

The jib slewing ring bolts should be retorqued with approximately a 75% load on the jib tip. Rotate the jib to position it over the the bolts being tightened. See illustration #499.

Torquing of Tower and Slewing Ring Bolts

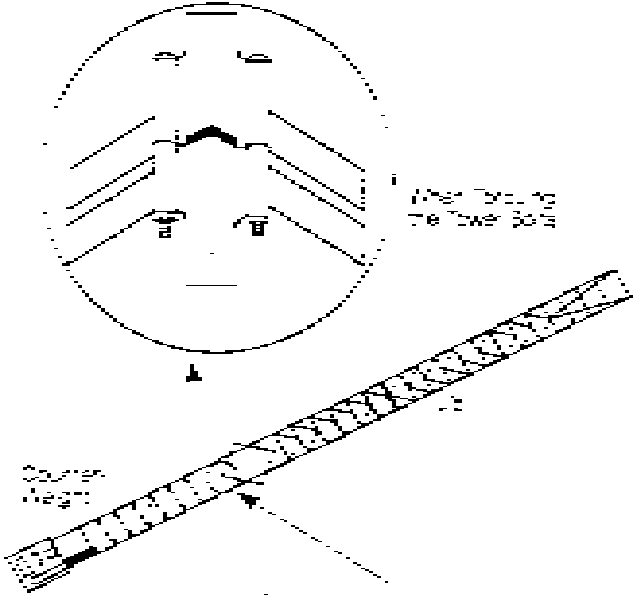


Illustration #498 - Torquing Tower Bolts

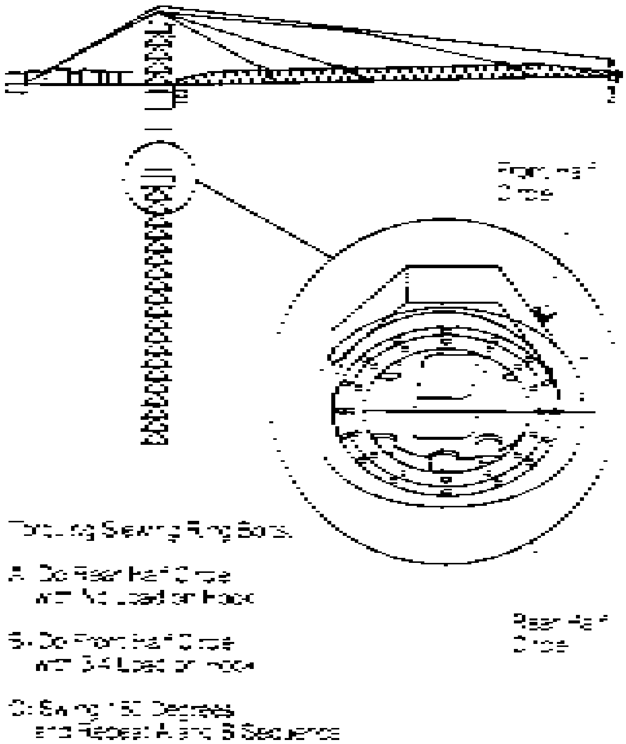


Illustration #499 - Torquing Slewing Ring Bolts

SECTION TEN QUESTIONS

Tower Cranes

1. Determine if this statement is true or false. Very few areas in either the United States or Canada require certification to operate a tower crane.
   - ❑ true ❑ false

2. Determine if this statement is true or false. Self-erecting tower cranes are easier to erect than a conventional tower crane, but erection time takes longer.
   - ❑ true ❑ false

3. How does the crane rotate with a fixed tower base?
   - ❑ slewing ring at the base
   - ❑ slewing ring beneath the jib
   - ❑ depends on the manufacturer
   - ❑ does not rotate

4. Determine if this statement is true or false. A mono-tower type of tower can be either fixed or slewing.
   - ❑ true ❑ false

5. What best describes a tower crane saddle jib?
   - ❑ rolling trolley and supported by fixed pendant lines
   - ❑ stationary trolley and jib pivots at front of tower
   - ❑ stationary trolley and jib pivots at rear of tower
   - ❑ none of above

6. What best describes a tower crane luffing jib?
   - ❑ rolling trolley and supported by fixed pendant lines
   - ❑ stationary trolley and jib pivots at front of tower
   - ❑ stationary trolley and jib pivots at rear of tower
   - ❑ none of above

7. Determine if this statement is true or false. In general, tower cranes are designed to have the same lifting capacity regardless of the jib length and load radius.
   - ❑ true ❑ false

8. Determine if this statement is true or false. A tower crane only requires one identification plate. All components are included on that one ID plate.
   - ❑ true ❑ false

9. Determine if this statement is true or false. All tower cranes manufactured by a company will have a common manufacturer's manual that is generic to all cranes made by that company.
   - ❑ true ❑ false

10. Of the following, who must sign a tower crane log book?
- ❑ operator
- ❑ service mechanic
- ❑ supervisor
- ❑ all of the above

11. What is the first step taken before erecting a tower crane?
- ❑ decide on type of erection bracing
- ❑ check for underground water mains
- ❑ prepare a site plan
- ❑ measure height of nearby buildings

12. Determine if this statement is true or false: Because of the potential high operating heights, tower crane operators should [illegible] and [illegible] from [illegible] regulations.
- ❑ true ❑ false

13. What items are often used to level and secure the tower structure during erection [illegible]?
- ❑ hardwood wedges
- ❑ steel wedges
- ❑ turnbuckles
- ❑ hydraulic jacks

14. When erecting tower cranes, how many times [illegible] be used?
- ❑ only once
- ❑ two times
- ❑ three times
- ❑ as long as [illegible] in good condition

15. Determine if this statement is true or false: [illegible] never used to secure a freestanding tower while it is being assembled.
- ❑ true ❑ false

16. Determine if this statement is true or false: When assembling the [illegible] are used to secure the [illegible] because of the ease and safety.
- ❑ true ❑ false

17. What is used to adjust the [illegible] and [illegible]?
- ❑ turnbuckles
- ❑ bolts
- ❑ pendants
- ❑ wedges

18. A tower crane fastened to the outside of a building should be secured a minimum of:

- ☐ every floor
- ☐ every two floors
- ☐ every three floors
- ☐ four floors

19. What is the purpose of a jib radius marker?

- ☐ indicate length of jib
- ☐ indicate height of jib
- ☐ indicate overlap of jibs of two adjacent cranes
- ☐ indicate position of trolley on jib

20. Determine if this statement is true or false. A limit switch is a safety device that restricts movements of the crane and prevents overloading or damage.

☐ true ☐ false

21. Determine if this statement is true or false. Each crane requires only one limit switch. That switch will be on the trolley hoist.

☐ true ☐ false

22. Determine if this statement is true or false. All limit switches are of a mechanical type, including those on digital control cranes.

☐ true ☐ false

23. Tower crane brakes must apply when there is a power loss. These are called:

- ☐ fail safe brakes
- ☐ automatic lowering brakes
- ☐ hydraulic brakes
- ☐ mechanical brakes

24. Determine if this statement is true or false. Tower and mobile cranes are both load tested at 125% overload.

☐ true ☐ false

25. Tower crane operator controls should automatically return to what position when pressure is released?

- ☐ forward
- ☐ reverse
- ☐ neutral
- ☐ automatic lowering

26. Every tower crane cab MUST be equipped with a:

- ☐ serial number
- ☐ wire rope capacity chart
- ☐ drum capacity chart
- ☐ load rating chart

27. Determine if this statement is true or false. Because of the light weight, it is not necessary to include slings and rigging hardware in the pre-lift load weight calculations.

☐ true ☐ false

28. Determine if this statement is true or false: A tower crane can be safely operated in wind speeds exceeding 20-30 mph (32-48 km/h) [illegible] crane capacity.

☐ true ☐ false

29. Determine if this statement is true or false: [illegible] system can be used as a [illegible].

☐ true ☐ false

30. Determine if this statement is true or false: The person giving signals must always be in a position to see the load clearly at all times.

☐ true ☐ false

31. The preferred method of contact between a signal person and operator is:

☐ wireless voice communication
☐ hard wire voice communication
☐ hand signals
☐ flags

32. When using multiple tower cranes [illegible] cranes can overlap, which of the following conditions should be met?

☐ jibs set at different heights
☐ operators have close contact
☐ one person organizing hoisting operations
☐ all of above

33. Determine if this statement is true or false: The [illegible] tower crane is [illegible] and never [illegible] with the wind.

☐ true ☐ false

34. Determine if this statement is true or false: A tower crane used regularly and in good working condition only requires inspection every 6 months.

☐ true ☐ false

35. After [illegible] the [illegible] be positioned [illegible]?

☐ counterweight [illegible] boom
☐ counterweight at 90 degrees to the boom
☐ counterweight at 180 degrees to the boom
☐ tower cranes never require [illegible]

SECTION ELEVEN

OVERHEAD CRANES

Overhead Crane Introduction

In the past and, even to some extent, in this era of safety awareness, an overhead crane is a lifting device taken for granted far too often. It was all too easy to point at someone, anyone, and say "run the crane". To a great extent, those days have ended. This is partially due to larger capacity and more complex cranes requiring operator knowledge combined with a much greater awareness by almost all companies on employee and equipment safety. In addition, there are new safety regulations and standards concerning hoisting operation which, in most jurisdictions, requires some type of operator certificate of proficiency for any or all types of hoisting equipment or machinery.

ANSI Standards & Classifications

The ANSI standards for overhead cranes, gantries, and monorails are as follows:

- ANSI B30.2 – Overhead and Gantry Cranes with Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist
- ANSI B30.18 – Stacker Cranes with Top or Under Running Bridge and Top or Under Running Trolley
- ANSI B30.17 – Overhead and Gantry Cranes with Top Running Bridge, Single Girder, Underhung Hoist
- ANSI B30.16 – Underhung Overhead Hoists (air, electric or chain powered)
- ANSI B30.11 – Monorails with Underhung Hoists

There are three ANSI service classifications:

- Normal Service: Operating at less than 85% rated load and, with rare exception, no more than 10 lifts per hour.
- Heavy Service: Operating at 85% - 100% of rated load, or over 10 lifts per hour.
- Severe Service: Normal or heavy service under abnormal operating conditions.

CMAA Classifications

There are seven service classifications of overhead cranes established by the Crane Manufacturers Association of America (CMAA). They are: A1, A2, B, C, D, E, and F.

- Class A1 (Standby Service): Used for exact positioning of machinery. It is slow operating and often sits idle. Used in a powerhouse or nuclear reactor turbine room.
- Class A2 (Infrequent Use): Used in pump rooms and laboratories, etc.. Usually light loads, slow speeds, and low accuracy required. Lift frequency would be several per day.
- Class B (Light Service): Used in warehouses, light fabrication or repair facilities. Slow speed and lift frequency is 2 – 5 per hour at 50% capacity.
- Class C (Moderate Service): Used in typical machine shop. Lift frequency is 5 – 10 per hour, with no more than 50% at capacity.
- Class D (Heavy Duty): Used in steel fabrication shops, foundries, or with bucket or magnet operations. High speed crane used 15 – 20 times per hour with loads at 50% capacity. Not over 65% of loads are capacity.
- Class E (Severe Service): Used in scrap yards, fertilizer and cement plants. Operates continually at high speed with capacity loads. Frequency is 20 or more per hour.
- Class F (Steel Mill AISE): Used for steel mills. Falls under Association of Iron and Steel Engineers' Standard 6-1969 for EOT cranes.

Indoor Crane & Hoist Types

Industry has created two vague definitions of indoor and outdoor hoists and cranes. The indoor type generally refers to smaller hoists.

They can range from a hand powered come-a-long or chain fall, to a compressed air or electric powered hoist on a monorail, jib, or hand or powered gantry. However bridge style EOT (electric overhead traveling) cranes are also included in this category, and they can have capacities up to several hundred tons. Also included are various types of stacker cranes used in warehouses.

For powered hoists, the crane operator may be seated in a cab above the load, standing on the floor with a pendant control, or use radio remote control. Examples of indoor cranes are shown with the following illustrations:

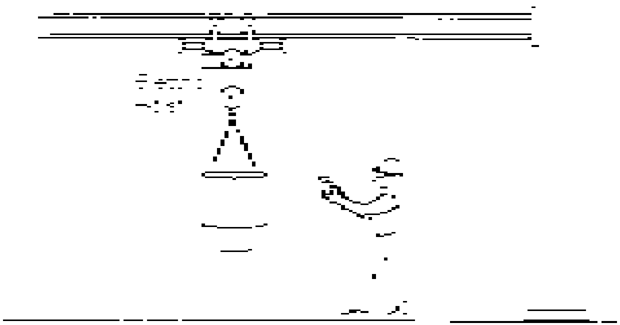


Illustration #500 - Electric Hoist Monorail

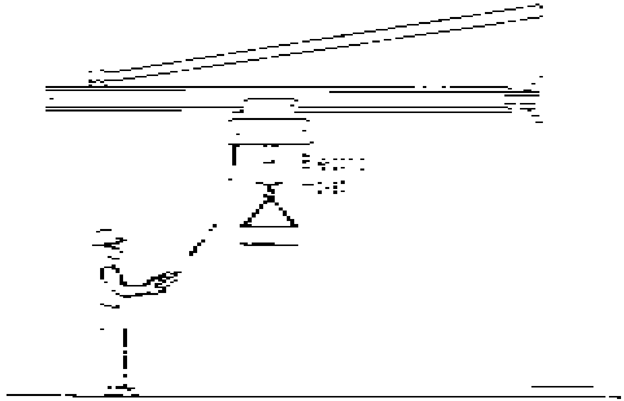


Illustration #501 - Electric Hoist Jib

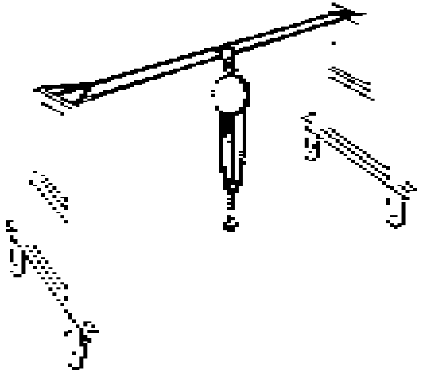


Illustration #502 - Over-The-Floor Gantry with a Chain-Fall

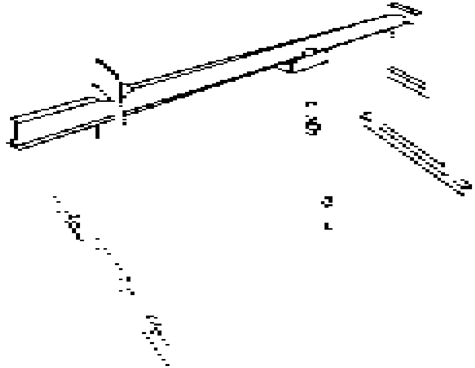


Illustration #504 - Cantilever Type Gantry

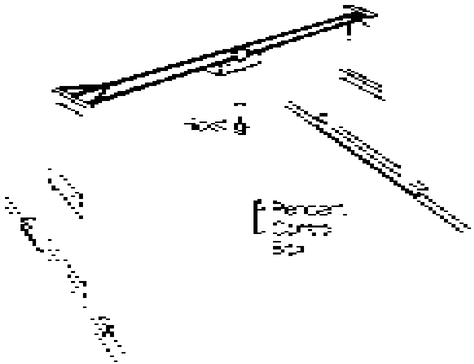


Illustration #503 - Rail Gantry With Electric Hoist

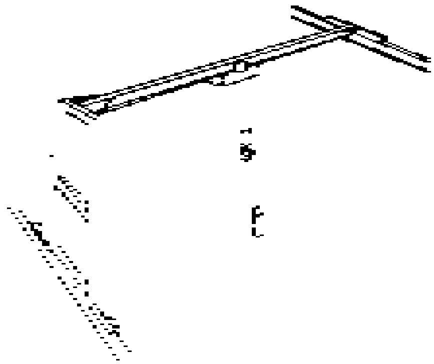


Illustration #505 - Semi-Gantry

Illustration #506 - Under-Hung Bridge Crane

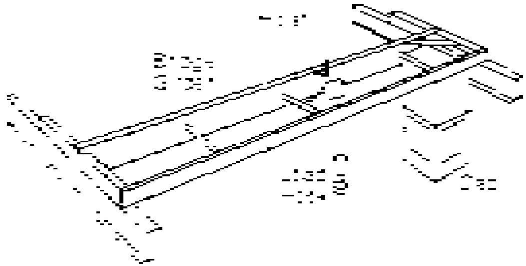


Illustration #508 - Top Running, Under-hung, Cab Operated

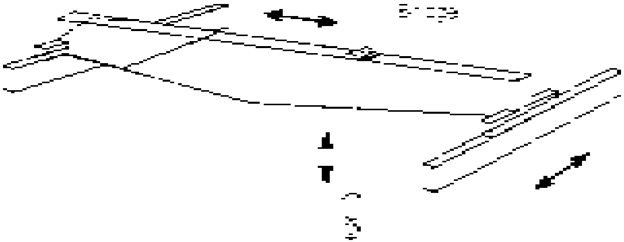


Illustration #507 - Top Running, Top Hoist Bridge Crane

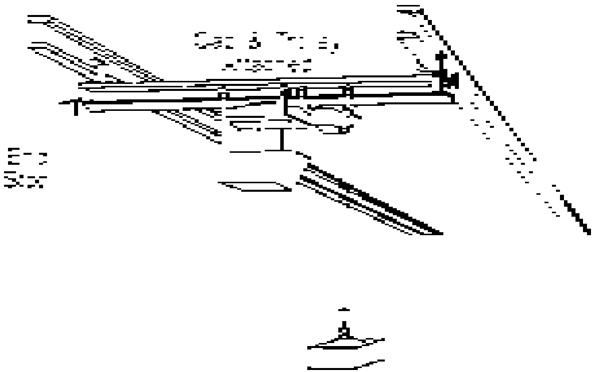


Illustration #509 - Cab-Operated Under-Hung

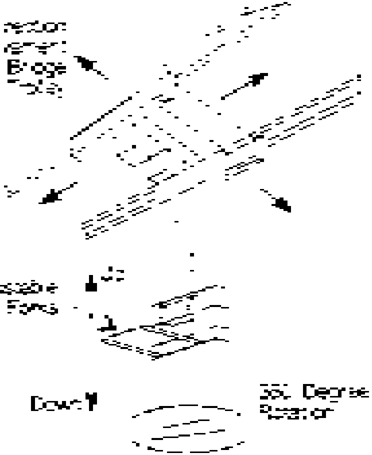


Illustration #510 - Under-Hung Stacker

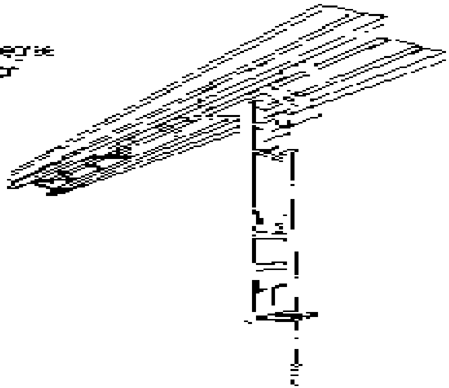


Illustration #511 - Floor Operated Stacker

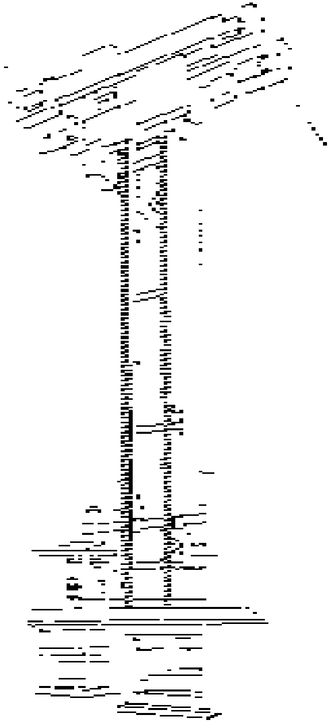


Illustration #512 - Cab-Operated Stacker

Indoor Crane Safety

There are two aspects to hoisting safety. The first is rigging of the load. The second is the actual hoisting operation.

Rigging the Load: Rigging safety involves knowing the load weight, how the slings or lifting devices will be attached, and what type and size of slings and hardware are required to provide a suitable factor for a safe lift.

Depending upon the jurisdiction, the person doing the load hook-up may have to be trained or show proof of having been trained.

Hoisting the Load: Due to the wide range of indoor hoisting apparatus, from a chain-fall on a monorail to a cab type overhead crane, safety regulation requirements also vary widely for hoisting. Generally, if the same person who hooked up the load is going to use a chain fall, come-a-long, a pendant control or remote control electric hoist, then the applicable training program should cover both aspects, safe rigging and safe use of the hoisting equipment.

However, if the crane, such as a cab mounted unit, is operated by a specific person, then the training requirements should be specific to that particular type of equipment. Most safety regulations are rapidly changing to make it a necessity for all crane operators to have some type of certification.

Outdoor Cranes

Outdoor cranes are bridge or rail mounted gantries of various designs. They are similar to the indoor types, except they are usually much larger in size and with capacities up to many hundreds of tons. A gantry crane is similar to an EOT in that both types have a bridge structure that supports the hoist trolley. The EOT has dolley wheels and travels on a type of runway structure. The gantry usually travels on tracks. The crane hoist apparatus for both types travels either on top-running rails or is under-slung, where the hoist rides on the bottom flanges of the runway beams.

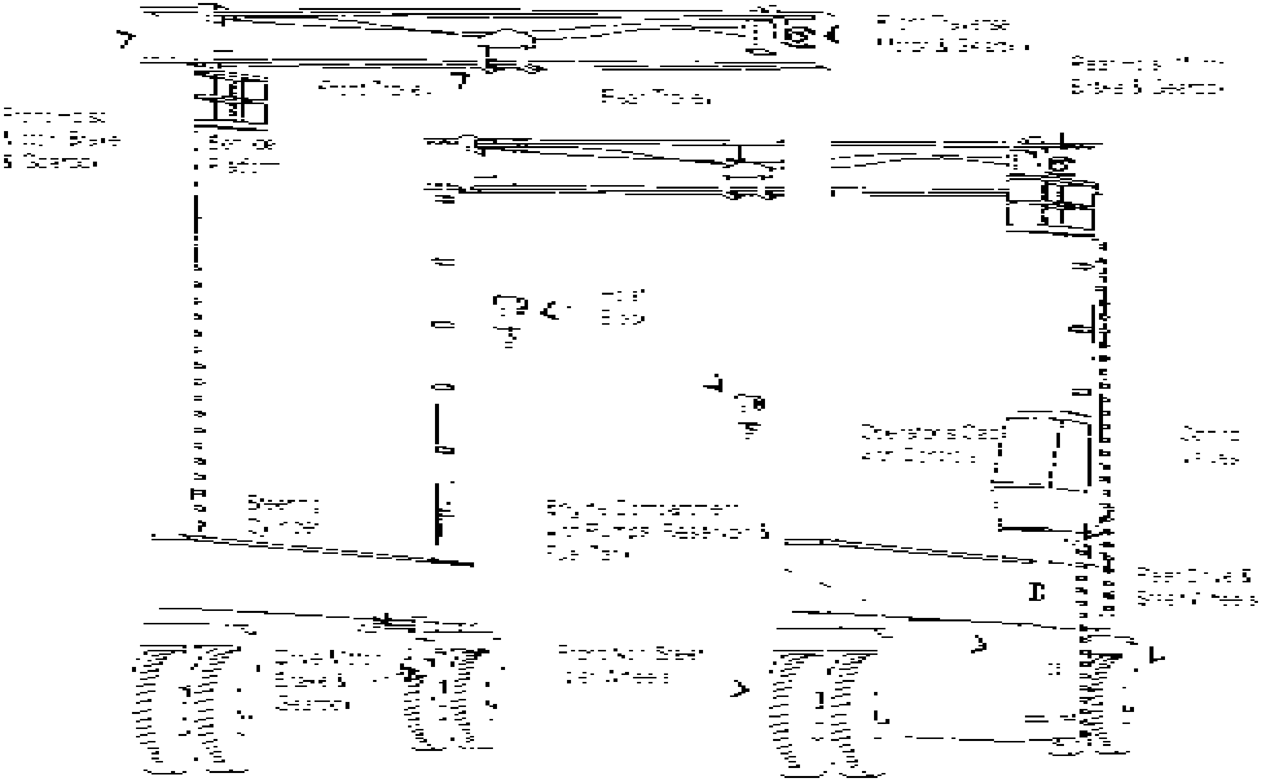


Illustration #513 – Straddle Lift Components

Mobile Straddle Lift Gantry

Another outdoor crane type is the mobile straddle mount gantry, which is used primarily in rail and shipping yards for moving containers.

These cranes have capacities up to 100 tons. A straddle lift is similar to a gantry except it has both a front and rear trolley hoist, and it runs on rubber tires. With most types, the two front wheels are non-powered, non-steering, while the rear wheels are powered and steer the crane. It has a selector for forward or reverse, and four controls for the two hoists to move left or right and up or down. It has a vehicle type steering wheel, and can pivot on one front wheel in a 90 degree turn. The capacity will vary with different models, but will be clearly indicated on a chart in the cab.

These units are usually powered by hydraulics. This means the throttle runs the engine at a constant speed while a volume control pedal controls all applications. The volume control pedal controls the forward or reverse speed, as well as the trolley and hoist speed (drive, traverse, hoist).

None of the lever functions work until the applicable lever is pushed or pulled and the volume control pedal is pushed in. Releasing pressure on the volume control pedal slows or stops the operation.

The basic components of a straddle lift crane are shown in illustration #513. Illustration #514 shows the wheel positions while making a 90 degree, or less than 90 degree turn.

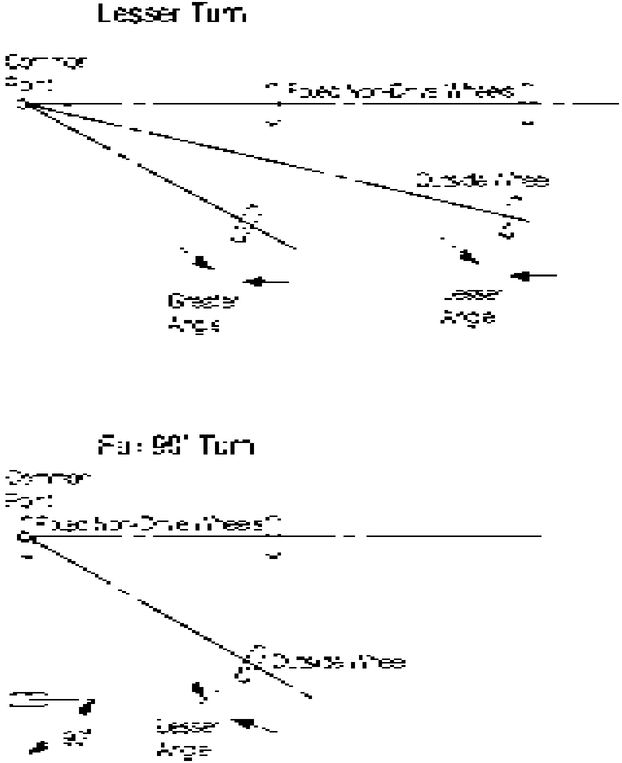


Illustration #514 – Wheel Turning Positions

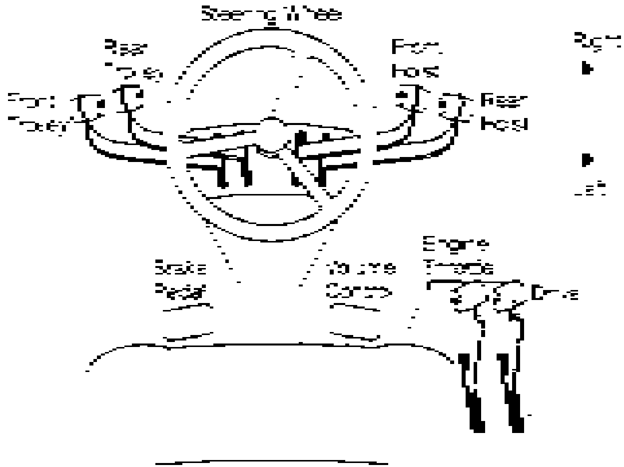


Illustration #515 – Example Cab Layout

EOT Cranes

This section will cover the components, movements, types of controls, and safe operation tips for EOT (electric overhead traveling) cranes. Illustration #516 shows the bridge, trolley, and hoist of a typical overhead crane, along with the three crane movements. These are in-out for the trolley, left-right for the bridge, and up-down for the hoist. Some cranes may have two or more hoists designed for a specific use, such as light duty and heavy duty, high and low speed, or several hoists to handle long loads. The various components making up a typical overhead crane are shown in illustration #517.

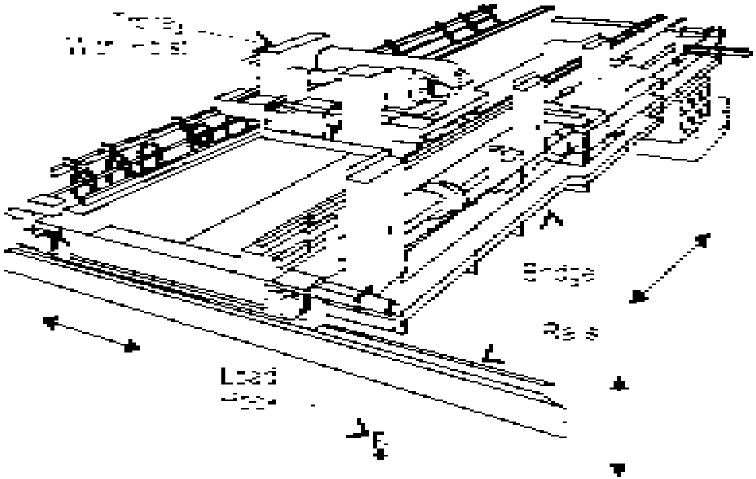


Illustration #516 - Typical EOT Movements

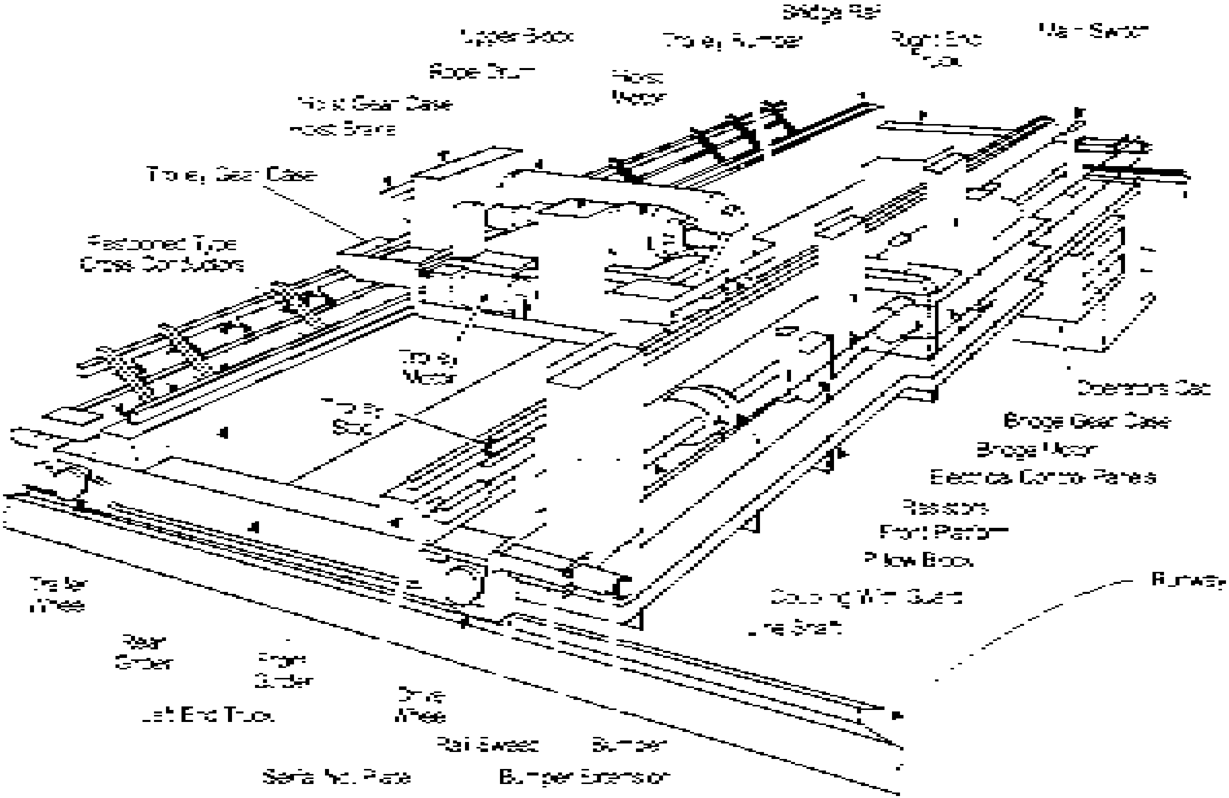


Illustration #517 – Typical EOT Components

Crane Terminology

Bridge - The bridge is made up of girders that are connected on each end to wheel trucks. There is also a walkway, conductors powering the motors, a cab, controllers, and controls.

Bridge Travel - This is movement of the crane from one end of a building runway to the other.

Bumpers - Bumpers are located on both sides of the bridge and trolley to prevent over-travel.

Cab - The cab is usually hung under the bridge and contains the crane controls.

Centering - Loading and unloading is accomplished in three motions:

- Center bridge over loading area.
- Center the trolley over loading area.
- Lowering and raising of hoist over load.

Controls - Controllers in the cab give motion to the bridge, trolley, and hoist. Control cabinets are located on the walkway of the bridge. Controls can also be pendant or remote.

Crane Braking (Mechanical) - Mechanical brakes are applied by foot pressure on a brake pedal.

Crane Braking (Electrical) - Electric power holds the brakes off. The brake is applied mechanically when the power is shut off.

Crane Braking (Dynamic) - Eddy current braking occurs when the hoist is being lowered with a load.

Drift - This is movement of a crane after the power is shut off. It can be bridge or trolley motor while traveling, or hoist movement while lifting or lowering.

Drive Motors - The bridge motor drives the bridge and a trolley motor drives the trolley. The hoist motor powers the load block.

Festoon - Power cables are hung in draped curves on the crane.

Hoist: The hoist mechanism raises and lowers the load. It is a drum mounted on the trolley, which is spooled with wire rope and is driven by a motor and a gearing system.

Hoist (Auxiliary) - This hoist is similar to the main hoist, but has less lifting capacity and is faster.

Hoist Block - The hoist block consists of sheaves, sheave pins, bearings, swivel and a hook suspended by the hoist wire rope.

Hoist Movements - The load block is raised and lowered by the operator controls.

Hook - The hook is connected to the hoist block and is used for lifting loads. A hook safety latch prevents the slings or chains from slipping off the hook.

Inching - Inching is the term used to indicate very short movements. This is accomplished by applying motor power for a fraction of a second, then quickly removing the power to stop the bridge, trolley, or load movement after it has moved a slight distance.

Idler - An idler is an end truck or bogie wheel that does not drive.

Load Swing - Load swing is movement of the block and load caused by acceleration or deceleration of the crane.

Main Line Shaft - The main line shaft is the motor powered shaft driving the bridge.

Mechanical Load-Brake - This is a drag brake which is engaged only while lowering. When hoisting, the brake releases, thereby eliminating the drag on the motor.

Monorail - This is a single rail with a hoist.

Overhauling Load - This load is heavy enough to overcome the friction of the hoisting mechanism (gears, wire rope, drum, etc.). The motor must be aided in holding back the load by a mechanical load brake or by a dynamic lowering control.

Pendant Control - This is the operator's crane controller box hanging from the bridge or trolley by a cable. The pendant box must be supported so as to eliminate any strain on the electrical connections.

Plugging - Plugging is the use of reverse motor power to stop a forward-moving load. The controller handle is moved to supply power in the direction opposite to the direction of travel. When the load stops, the controller handle must be centered at the off position, otherwise the load will accelerate in the reverse direction.

Radio Control - Radio signals can be transmitted from an operator on the floor with a control box to a receiver on the crane.

Rail Runways - Runways are floor tracks or tracks supported by beams on the side of a building, on which the crane can travel over the work area.

Reeving - This is the system of wire rope connecting the upper and lower sheaves on the hoisting blocks.

Skewing - Skewing is when the crane girders are not perpendicular to the runway rails and one end of the crane is ahead of the other. This condition should be immediately corrected.

Slack Out - This occurs when the initial lifting tension is applied to the hoist wire rope and the load chains or slings.

Torque - The ability of a motor to exert rotary force is called torque. Sufficient power is applied by controllers to the motor to move the load.

Trolley - This is a frame which consists of end trucks, a drive motor, a hoist motor, a drum with wire rope and a hoist block. It is operated through controllers and it travels on rails across the bridge structure, while supporting the load.

Walkway - This is an aisleway across the span of the bridge girders. It allows access to the trolley and to the bridge drive mechanism.

Power to the Crane

EOT cranes can receive their power by various methods. Several examples are shown in illustration #518.

Rail Runways: These are the supports for the crane in the work area. The conductors for the electric power to the crane are on one side. The conductors are attached below the rail on the girders by insulators. These insulate the conductors from going to ground. They run the full length of the runway. A master switch is located at ground level and connected to the conductors. Each end of the rail runways should have wheel stops to limit travel of the crane.

Power To Bridge: Power to the bridge is through collectors that ride the conductors. The power is to the main line switch located on the bridge. Power from the master switch is connected to conductors that run the length of the bridge span and also to controls in the cab, as well as the control cabinets.

Power to Trolleys: The motors that operate the trolley racking and the motors for the hoist are powered through the conductors that run the length of the bridge. The crane operator controls the trolley and hoist from the cab, with either a floor pendant control box or a radio control unit.

Crane Controls

EOT cranes can be controlled by several methods, including

- Keypad style adjustable frequency controls
- Remote radio adjustable frequency control
- Pendant style control hanging from hoist
- Operator in a cab with controls

Illustration #519 – Electrification Methods

Keypad Adjustable Frequency Controls

The technology in this method of overhead crane control is advancing rapidly, year by year, with the use of transistors and microprocessors. In addition to being a controller, it can also indicate a number of warning conditions and store information for later readout concerning maintenance problems. The operator uses a keypad type control box, and can be used for cab-mounted, pendant controllers and radio or infrared remote controls. An example is shown in Illustration #519.

Due to computerized torque control of the motors, this type of control allows precise mastery of all loads with exact positioning and speeds.

- By programming it will be certain that lifting torque is less than lowering torque, thereby ensuring a load can be safely lowered. And by programming torque, it will prevent attempting to lift an overload.
- When the lift button is pressed, an adequate torque to lift a suspended load is generated before the brake is released. This prevents the load from any downward movement before going up.
- The system can prevent any free-fall in the event of brake failure by a slow speed automatic lowering of the load.

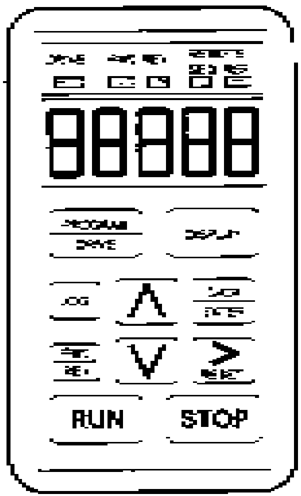


Illustration #519 – Digital Keypad Control Example

Digital Operator Benefits

- Allows precise positioning and creep speeds
- Reduces possible operator error when lifting or lowering
- Can program various lifting speeds, depending on the load
- Electronic reverse plugging makes for a smoother operation

Digital Equipment Benefits

- Reduces mechanical shock with built-in soft starts and stops
- Less brake wear with electronic dynamic braking
- Reduced component wear with programmed torque limits
- Magnetic contactors and their built-in mechanical problems are eliminated by using electronic selectors

Remote Radio Control

Portable Radio Remote Control (PRRC's) technology for overhead cranes operation has advanced considerably in the past few years. Electromechanical actuators are being replaced with more advanced electrohydraulic systems. The older style with their sometimes dangerous lower operating frequencies are being replaced with higher frequency hopping technology using digital codes. They can be watertight and dust-proof for either indoor or outdoor applications.

The working range is usually up to 160 feet, however that depends on the unit and the requirements. Having the crane too far away from the operator's visibility can create safety problems. The controls must be designed so the crane will stop if the signal becomes dislocated, and the crane must not respond to any other source.

The basic components consist of an antenna and receiver on the bridge, and a portable operator-worn transmitter. An example of a transmitter box is shown in illustration #520. Strict safety rules must be followed with these remote control cranes due to the possibility of personnel being on or around the crane without the operator's knowledge.

Radio Control Advantages

- Better operator visibility for spotting loads
- Operator can be a safe distance from hazardous loads or environment
- Operator does not have to walk with the crane or be confined to the cab
- Fewer missed signals between floor workers and cab positioned operator

TRANSMITTER CONTROL ARRANGEMENT

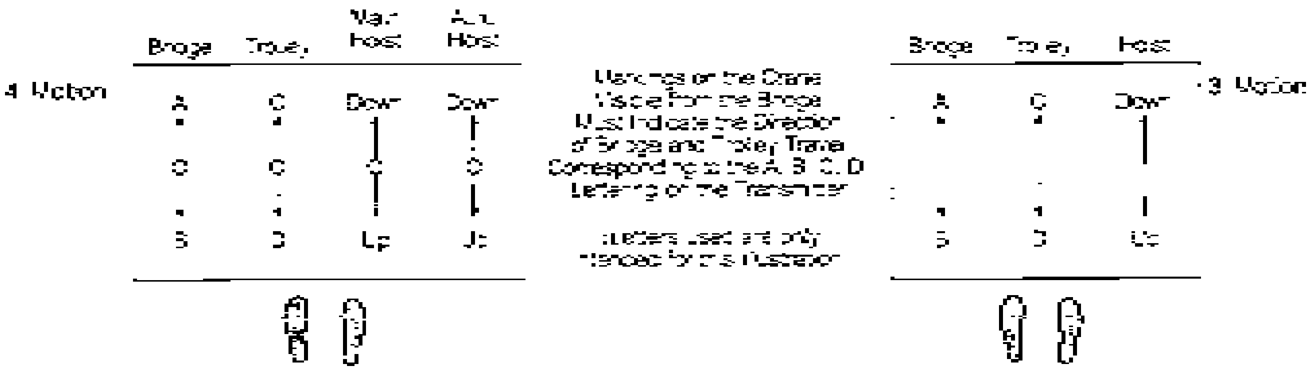


Illustration #525 – Radio Control Example

Radio Control Rules

Note: The following rules on the next several pages cover crane operation when they are on radio control. If a radio crane is operated on cab control, special care must be taken to secure the Radio Control Box (transmitter). The supervisor in charge of crane operations must ensure that this is done.

Radio Controlled Crane Operators

- Only designated employees shall be permitted to operate radio controlled cranes and only after proper training.
- Cranes shall not be operated by any persons who cannot read and understand the applicable signs, notices and operating instructions.
- Cranes shall not be operated by a person with seriously defective eyesight or hearing, or who may be suffering from any problem causing physical or mental impairment.

Check List For Radio Controlled Crane Operators

- ✓ Knowledge of hazards inherent to crane operator.
- ✓ Familiar with safety rules for radio controlled cranes.
- ✓ Ability to judge distance to stationary objects.
- ✓ Knowledge of the safe use of the radio control box (transmitter).
- ✓ Know the limit switch test procedure.
- ✓ Knowledge of plugging for crane motions.
- ✓ Familiar with signal devices (i.e. siren, horn).
- ✓ Observance of signal lights on crane.
- ✓ Operation care in avoiding any equipment or obstructions in building.
- ✓ Maintain proper clearance of load or hook before moving bridge or trolley.
- ✓ Replacing radio control box in proper storage box when not in use.

✓ Proper procedure for transferring the control box to another person.

✓ Reporting unsafe or unusual operating and/or equipment conditions.

✓ Exercise caution in approaching bridge or trolley bumpers.

✓ Awareness of the capacity of the equipment.

✓ Knowledge of safety problems when making lifts below floor level.

✓ Knowledge of hazard in making side pulls. Maintaining a safe distance for operator and/or co-workers from load.

✓ Use of proper signals when a second person directs the crane operator.

✓ Inspection of wire rope, hooks, and other crane components.

✓ Knowledge of procedure for testing hoist, trolley and bridge brakes.

Operating Area For Radio Controlled Cranes

- Unobstructed aisleways must be maintained for the radio controlled crane operator's movement. These aisleways should be a minimum of 3 feet (900 mm) wide.
- The radio controlled crane operator shall always be in position for the best view of the crane.
- Never operate the crane blindly. Always keep the crane and the load in sight, and stay as close as possible to the load.

Radio Control Box (Transmitter)

If the control box has switches, they will be of the dead man type (spring return to off). The antenna handle should act as a guard for these switches to prevent accidental movement of the switches. These switches must never be mechanically blocked in an on position.

The master change on the radio control box must always be turned off when the box is not in use.

A prescribed storage space shall be provided for the radio control box. It shall always be placed there when not in use. This precaution will prevent unauthorized people from operating the crane.

The master change must be turned off when the operator is putting on the control box and belt assembly or taking it off (fastening or unfastening the carry support straps).

Radio Controlled Crane Operation

1. The crane limit switches shall be checked at the beginning of each shift or when a new operator takes control of the crane. To avoid injury or equipment damage in the event of an accident while checking the limit switches, the hoist should be centered over an area free of personnel and equipment.
2. The limit switches must never be used as a stopping device. They are designed to be protective devices only.
3. If so equipped, the bridge and trolley brakes must be tested at the beginning of each shift or when a new operator takes control of the crane. They are tested with the bridge and trolley at low speed.
4. When lifting maximum, or near maximum loads, the operator shall test the hoist brakes by raising the load a few inches from the floor. If the brakes do not hold, the load shall be immediately lowered to the floor and the problem reported immediately.
5. Operators should never make lifts in excess of the rated capacity of the overhead crane, or the rigging equipment.
6. When making lifts, the trolley should be centered directly over the load. This will prevent swinging when the load is raised.

7. When raising or lowering a load, proceed slowly and ensure the load is under control. Tag lines must be used to control long or awkward loads. Raise by taking the slack out of the chains or slings gradually. Make sure all personnel are clear before making a lift.
8. Side pulls should be avoided. If such a lift is necessary, it must only be with the permission of supervision. The operator shall not be positioned in the line or path of travel of the load, but shall operate the crane from a position either to the side or behind the line of travel.
9. The crane operator shall keep all body parts away from the load and shall never be positioned under it.
10. Never make a lift or move the crane if anyone is in a position to be injured.
11. The operator of a crane transporting a load must ensure the load is not carried over floor personnel.
12. When the crane is traveling with a hanging load, the operator shall sound the warning device frequently.
13. If the radio crane operator is being assisted, the operator shall not move the crane until an all clear signal has been received from the assistant.
14. If personnel are in the path of travel, the operator must stop and clear the area before proceeding.
15. Bumping into runway stops or other cranes on the same runway is prohibited.
16. The crane must not travel with slings, chains, etc. dragging on the floor.
17. When moving the crane, the operator must ensure that the hook block and any attachments or slings will not snag floor equipment. Wire rope and other slings will slingshot when broken by overtension.

18. All loose material or parts must be removed from the load, or secured, before starting the lift. Loose material can shake free and fall, striking personnel below.
19. The radio operator shall maintain a safe distance when another stationary crane on the same runway has a hanging load.
20. If the radio controlled crane operator is asked to do something that is believed to be unsafe, the operator shall refuse to perform the task, and call supervision for advice.
21. The crane operator must never permit anyone to ride on the load or the hook.
22. Plugging shall not be used as a regular means of stopping the radio crane. It is intended for emergency stops only, except when authorized by qualified supervision. Caution must be used when plugging with the radio control box. When plugging, the operator must pause on 1st point in the direction opposite to travel. If the crane is traveling in the forward direction, the operator must pause for a second or two on 1st point reverse when plugging.
23. The load must always be raised high enough to clear everything below.
24. Where gloves are not required for safety reasons they shall not be worn when operating the radio control box (the guard over the switches make the wearing of gloves very difficult).
25. If there is a power failure, all switches must be positioned in the off position.
26. If the crane fails to respond correctly, the operator shall stop operation and turn off the master channel on the radio control box. The condition must be reported immediately.

27. Outside cranes subjected to movement by weather conditions must be securely anchored when left unattended. If the crane is equipped with bridge brakes, the parking brake should be set.

Radio Controlled Crane Boarding

The radio controlled crane shall not be boarded without a supervisor's permission.

The person boarding the crane must turn off the master channel on the control box and carry the box onto the crane.

When several people board the radio controlled crane, one person shall be responsible to see that all personnel are off the crane before the control box is returned to operation.

Radio Controlled Crane Repair

1. When the repair crew consists of several people, one person shall be designated as the leader.
2. The crew leader shall turn off the master channel on the radio control box and carry the box onto the crane. The leader shall board the crane first, open and lock out the main switch, and then signal the other members of the crew that it is safe for them to board the crane.
3. Warning signs shall be placed on the floor beneath the crane, or suspended from the crane.
4. Safety belts shall be worn by the crew if the work is to be done in areas of the crane other than those protected by standard handrails.
5. All tools and equipment must be moved onto the crane by the use of handlines. The tools and equipment should be adequately secured.
6. If it is necessary to energize the control circuits on the crane, the crew leader will open all power circuits to the motion switches before closing the main switch.

7. If during the course of repairs, it becomes necessary to move the crane, it shall be the responsibility of the leader of the repair crew to see that everyone, plus all tools and equipment are in safe positions before the crane is moved.
8. Headroom is at a minimum in certain crane cabs and crane walkways. Caution should be exercised by people boarding such cranes, and hard hats should be worn.
9. If any other cranes are operating on the same or adjacent runways, all operators must be notified prior to the start of repairs. This notification should include the nature of the repair, safety features provided, as well as the limitations of other crane movements.
10. Cranes which must be positioned for repairs and cannot be moved must be protected against bumping by other cranes.

Bumpers suitable for crane protection should be installed on the exposed side of the crane under repair at a minimum distance of 20 feet (6.1 m). The bumpers shall be indicated by red lights placed to be clearly visible to other persons operating cranes traveling on the same runway. When it is impossible to use bumpers for protection, red lights must be placed in clear view of other persons operating cranes on the runway to indicate the repair or restricted travel zone. It is desirable that such red lights be located a minimum of 20 feet (6.1 m) from the crane under repair. All operators of cranes on the same runway must be thoroughly informed on the repair work, and the safe operating procedures for other cranes.

11. When a runway is positioned adjacent to that of the crane being repaired, and if any hazard exists involving repair personnel, the adjacent runway should be blocked off in accordance with the preceding paragraph. When it is necessary to continue operation of the cranes on adjacent runways, warning lights must be installed clearly visible to persons operating such cranes on the adjacent runways and identifying the restricted area. Cranes on the adjacent runways should come to a full stop prior to entering the restricted area and only proceed through this area upon receiving permission from a signal man posted for this purpose.
12. Upon completion of repairs, it shall be the responsibility of the crew leader to ensure that all personnel are off the crane and in a safe position before removing the main switch lock and putting the crane back into operation.

Radio Controlled Crane as a Work Platform

When the radio controlled crane is to be used as a stationary platform for work on the building or structure, the lockout rules outlined previously will apply.

When using the crane for this purpose and the crane has to be moved, the operator must position himself on the crane with the radio control box. The operator must ensure that all persons working on the crane are in a safe position before moving the crane to the next working station. It must also be the operator's duty to ensure that the main switch is open and locked before work is resumed after each movement.

Radio Control System

Most radio controlled cranes will have a security start system somewhat similar to the following points. This particular system cannot be activated until eight conditions have been met.

1. All signals must be within the pass band of the master receiver.
2. The Safety Channel must be present.
3. A second channel (usually alarm) must be present.
4. A third channel (usually a motor second speed) must be present.
5. All signal amplitudes must be above the minimum level.
6. All signal amplitudes must be below the maximum level.
7. All signals must be present simultaneously.
8. All signals must be maintained for approximately three seconds.

Note: The above eight steps illustrate how the system is fail-safe and specifies why it is unlikely the eight conditions could be matched by any outside interference.

Not only do the eight conditions have to be achieved but also three different frequencies are needed to start the system.

Radio Control Box (Transmitter)

- If the control box is equipped with switches they should be of the dead man type. The handle acts as a guard for the switches to prevent accidental movement of the switches. The switches should never be blocked in an opened position. The handle swivels for easier use when operating the controls. The handle protects the controls if the box is dropped.
- If the box has control knobs, they should have different shapes to help the operator identify by feel the motor control that is being activated. The box is usually light, weighing between 8 and 10 pounds (4 kg) and is either worn on the chest or the hip of the operator.

- The box features a key lock which must be turned off when the crane is not in use. The key must be turned to the off position when the operator is putting the box on or taking it off.
- The radio control box must always be placed in the prescribed storage place when not in use.
- The operator should use one hand when engaging the controls. Using the controls with both hands should only be performed when necessary and after considerable practice by the operator.

Radio Control Box Starting Procedure

1. Insert key and turn it in a clockwise direction. Turn the red toggle switch to the on position.
2. Depress start button and hold for 2 to 3 seconds. The siren will sound and the green light on the backside of the cab will come on indicating the system is ready for operation.

Special Considerations For Operation

- The radio control box is not a toy and must be handled with a sense of responsibility.
- Only authorized, trained personnel should operate a radio controlled crane.
- The operator with the radio control box is responsible for its use. The operator must not tamper with the transmitter box. **Do not open the box.** The transmitter box must be kept in a secure area. The box and key should be stored separately.

Pendant Controls

A gantry hoist or overhead crane operated with a hanging pendant has the same three movements as any other type of control; however, with smaller gantries or monorails the pendant may only control the hoist up-down. The pendant is either remote control or hard wired into the hoist apparatus. If hard wired, the pendant must be supported to avoid strain on the electrical connections.

A push button type pendant is shown in illustration #521.

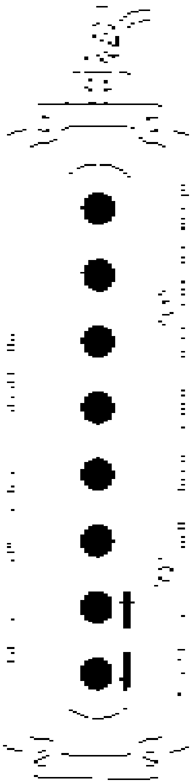


Illustration #521 - Push Button Pendant

Pendant Control Safety

Knowledge of the crane movements while using a pendant control is extremely important. The operator must be aware of the three movements, bridge, trolley, and hoist, and the load position at all times. Don't try to do things too quickly.

The button or control positions must be memorized, as the operator may be in a critical hoisting operation and should not take his or her eyes off the load.

The pendant control does not have a foot brake to stop the bridge motion. Therefore unless the bridge has a brake controlled by the pendant stop button, or a brake operated when the bridge button is released is shown, the bridge must be stopped by either coasting or plugging. Plugging is not recommended with some types of pendant cranes.

Safety regulations require the pendant controls to be kept clean, free of anything that might cause the buttons to stick, and the button labels must be legible.

Pendant Control of Movements

The pendant controller box with a push-button panel is suspended from the crane by a cable and control wires, unless it is a wireless remote.

The push buttons are of the dead man type, which means they will pop back to the off position when finger pressure is released.

The operator, by pushing the proper buttons, controls the movement of the bridge, trolley or hoist. A point that inexperienced operators may not realize is that increasing pressure on the button will increase the speed. Wearing gloves may compound the operators problems.

By releasing the button, the motion is stopped. Careful control of these motions is in the hands of the operator. When starting to move the crane, the operator should signal to persons in the area that the crane is moving. A light, bell, or horn are some of the usual warning devices.

Note: EOT pendant cranes should be tested for limit switches, load brakes and travel at the beginning of each shift, similar to a cab mounted crane.

Bridge Travel

The pendant control has push buttons that determine the bridge travel. Depressing the direction button controls the movement of the bridge, and pressing harder on the button controls the speed of the bridge. Releasing the button cuts the power, and the bridge comes to a stop. Careful control of the bridge speed and stopping can only be performed by the careful judgement of the operator. After an operator gets the feel of the control, the bridge can be moved or stopped with accuracy.

Trolley Travel

Operation of the trolley by the pendant control buttons is similar to the bridge except the trolley runs back and forth on the bridge rails. The trolley supports the hoist motor drums, gears of the hoist and hoist block and hook.

Depressing the button for direction of trolley travel controls the speed and stopping of the trolley.

It is possible to move both the trolley and the bridge simultaneously, although this takes some operator skill and practice.

Hoist Movement

Operation of the hoist by pendant control is accomplished by depressing the buttons for raising or lowering.

In lowering, a heavy load may have a tendency to overcome the lowering speed and a different motor action has to take place to slow the hoist motion.

Pendant Control Summary

Operations Safety Awareness

a. Check main switch to hot rails

b. Check pendant control

c. Test hoist limits

d. Check bridge movements and drift

e. Check trolley movements and drift

f. Test crane brakes

Spotting Movements

a. Move bridge over load pick up area

b. Move trolley over load pick up area

c. Lower hoist down to pick up

Control of Swinging Movements

a. Control swing with bridge

b. Control swing with trolley

c. Control swing with bridge and trolley

Movement of Bridge and Trolley with Hoist Lowered

a. Around floor objects

b. Be aware of surrounding workers

Material Handling

a. Proper use of slings

b. Test hoist brakes

c. Plan movement of materials

d. Use hand signals

e. Use of tag lines

f. Remove slings when finished

Crane Parking

a. Move crane to safe parking area

b. Shut off and lock out power

Cab Crane Controls

Cab Controls and Layout

There are two basic overhead crane cab designs. The cab is either attached to the trolley and moves in and out across the bay opening, or it is attached to the bridge and moves up and down the length of the bay.

The cab may be positioned with a right or left facing position, or center facing. (See illustration #522.)

The primary advantage of the cab is that the operator is up over the load and usually has a good overall view of the load and the surrounding area.

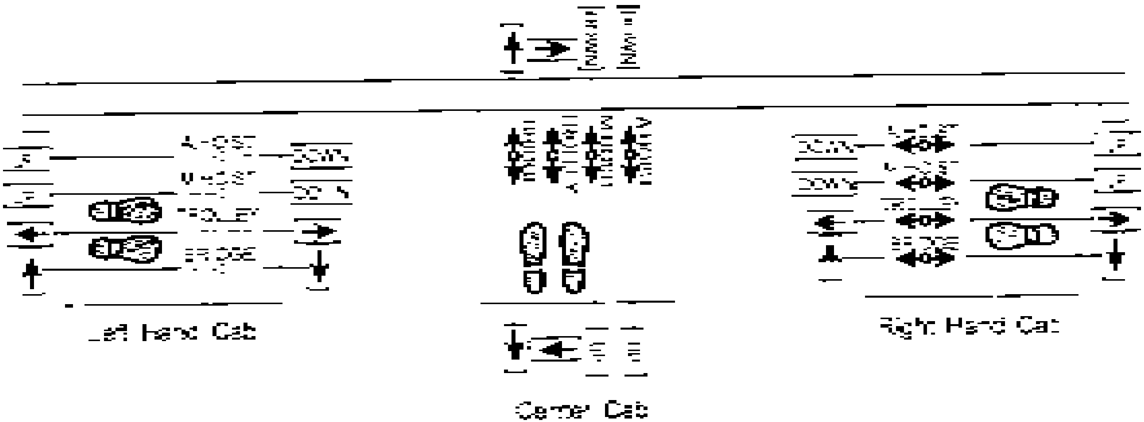


Illustration #522 – Operator Positions

The two main disadvantages are depth perception difficulties while looking down and possible view obstructions from larger loads. Until the beginning of the computer era, the operating of larger types of overhead cranes was done exclusively by an operator sitting at electro-mechanically designed controls that required constant maintenance.

Many older cranes still function quite well with this type of controls. However, many new cranes, as well as older retrofitted cranes, are equipped with microprocessor type controls similar to those mentioned earlier in the Digital Keypad portion.

This section will cover the basic operating procedures using the older controls for the bridge, the trolley, and the hoist.

Overhead Crane Bridge

The bridge travels on a rail structure attached to structural steel. There are wheels or tandem wheels on each corner. Smaller cranes have two wheels connected by a common driveshaft driven by a motor. Larger cranes are driven by two or more motors wired to a common controller.

Bridge Movement

The control is often mounted at right angles to the hoist and trolley controllers. The handles, when moved to the right or left, automatically indicate the direction of travel of the crane along the runway. See illustration #523.

If mounted with handles operating parallel to the hoist and trolley controllers, it is always advisable to check the direction of travel by a small movement of the controller as control arrangements and control direction movement will vary from crane to crane.

The bridge motor may be free-running and not be equipped with limit switches at each end of the runway to cut off power and stop the crane. Bumpers are usually attached on the outside corners of the crane, see illustration #524.

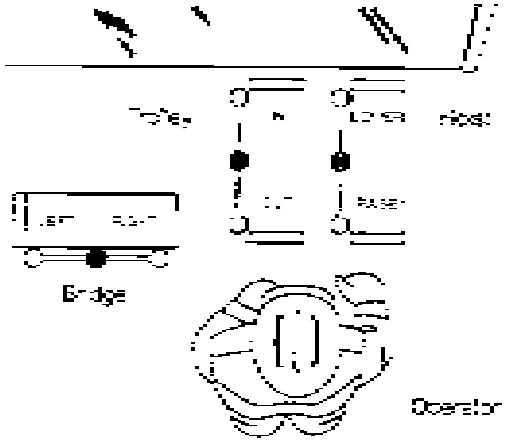


Illustration #523 – Bridge Control Position

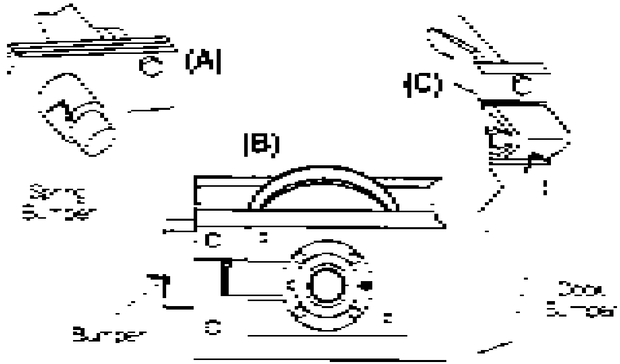


Illustration #525 – Bridge Bumpers

These bumpers should not be depended upon to stop the crane. They are a safety measure only to protect the end of the building or another crane on the same runway.

When approaching the extreme end of the runway, bring the crane to a stop. Then restart and move slowly until the bumper touches.

Bridge Controllers

If the crane is equipped with manual controllers, accelerate the bridge gradually by moving the control handle, point by point, in the desired direction. Correct acceleration will eliminate spinning the bridge wheels and allow the load hanging down from the hook to gather momentum at the same rate as the crane to prevent swinging.

It will also prevent the motor and crane from undergoing unnecessary stress.

If a magnetic control is used, the master switch may be moved at once to the full on position, as proper acceleration is automatically supplied by the accelerating relays.

When an operator changes from a crane with a manual control, it must be remembered that acceleration with a magnetic control is provided automatically in proportion to the ability of the motor to gather speed and move the load. Speed cannot be forced. See Illustration #525.

Do not operate the bridge over long distances up and down the runway with the controller handle part way between the off and full on positions. This heats the controller excessively. If the bridge is traveling too fast, return the controller to off and coast. Re-apply power as needed.

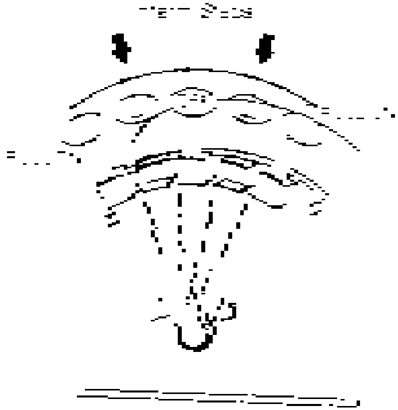


Illustration #525 – Manual Controller

The bridge controller is designed for slow starting on the first point with a gradual increase in speed and motor torque as the handle is notched along to the full on position.

As shown in illustration #526, the bridge structure is long and narrow, not compact like the trolley which carries the hoisting mechanism.

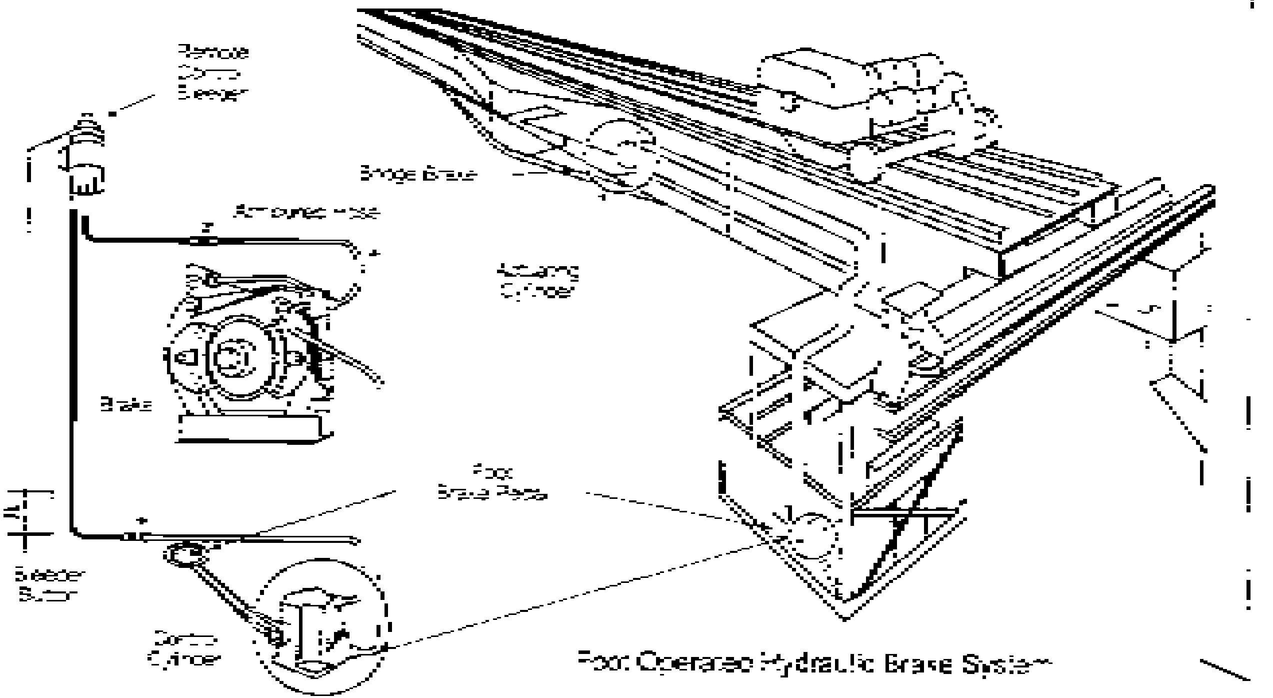


Illustration #526 - Hydraulic Brake System

The bridge is heavier than the trolley and also has to carry the weight of the trolley plus the load. It must be started and stopped slowly to avoid misalignment or skewing of the bridge. Care in operating the bridge will not only keep maintenance down, but will also result in easier operation for the crane operator and those working on the floor through reduced load swing and overall smoother handling.

Bridge Braking System

Note: ANSI/OH&S/OCHS safety regulations require a brake for the bridge motion of all overhead and gantry cranes, except those which have a non-coasting mechanical drive. A bridge brake for cab operated cranes is usually hydraulic. Other types of cranes will have an automatic electric-released, spring-applied brake. See illustration #526 for a typical hydraulic brake system.

The proper method for stopping the bridge motion will vary in different plants and crane types. The variations are due to:

- Length of the crane span.
- Type of bridge construction.
- Gearing between the motor and bridge wheels.
- Speed at which the bridge will travel with control on the last point.
- Type of control (manual or magnetic) by which the bridge motor is operated.
- Size and weight of any load.

Because of the variations listed above there is no standard rule for stopping the bridge drive. For an operator unfamiliar with a crane, questions should be asked about the proper stopping procedure before starting to operate. Even if the operator changes cranes in the same plant, it is advisable to ask which method should be used on the new crane.

Generally, the preferred method of stopping cab operated cranes is by using the foot brake.

After the bridge is moving under power, the controller should be brought to the off position as the stopping point is approached. Allow some distance to coast without power to reduce speed then apply the foot brake gradually.

Note: Avoid the practice of pressing the foot brake so hard that the wheels skid. This will cause flat spots on the wheels, making the crane hard riding and also results in more difficulty in positioning the crane over a load.

Bridge Plugging

Where the bridge is operated by magnetic holding brakes with drift point, the bridge may be stopped by the use of reverse power (or plugging).

Before this stopping method is permitted, the plugging relay and resistor drift point must be properly adjusted to take care of the plugging operations. See illustration #527 for a typical reverse plugging and control system.

When properly adjusted, this automatic feature of the control can be advantageous in stopping the crane. Similar to a manual bridge controller, some distance should be allowed to coast with the power off before using the plugging feature.

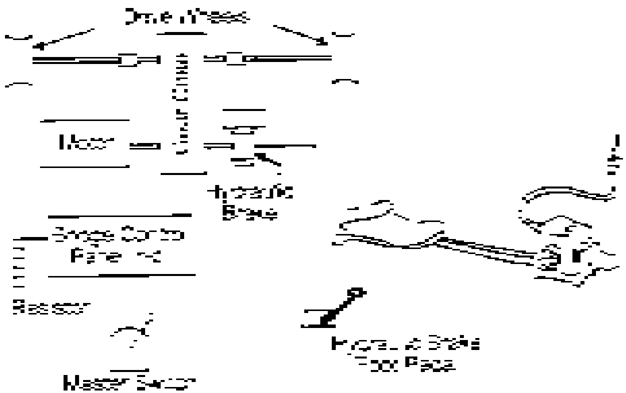


Illustration #527 – Reverse Plugging System

The operator's foot should be within easy reach of the brake foot pedal so the brake can be applied immediately in case power should fail at the moment plugging starts. Failure to apply a foot brake in time can result in a serious accident. The foot brake should be used frequently even though plugging is permitted. The brake must be checked regularly. The operator should report immediately any improper adjustment or response that is detected on the brake during normal operation. Bridge controller or master switches for the bridge motion are usually mounted in the cab, adjacent to the trolley controller.

Overhead Crane Trolley

The trolley is a wheeled structure containing the hoist assembly that runs back and forth on rails on top of, or underslung from, the crane girders. See Illustration #528. The trolley motor is usually geared to one of the axles with a wheel at each end.

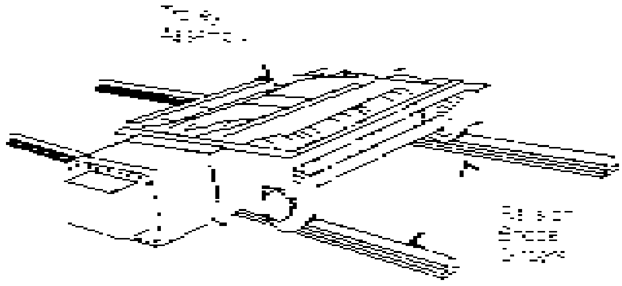


Illustration #528 - Crane Trolley

The trolley may be free-running and, due to momentum, might continue to coast after power is cut off from the motor.

On equipment where roller bearings have been mounted to reduce friction, the coasting ability of the trolley has increased considerably.

Electric brakes, keyed to the trolley-motor shaft, are installed on some crane trolleys.

The electric brake operates automatically similar to the hoist-motor brake. Power through the motor releases it. When power is cut off from the motor, the brake is automatically applied by a spring to stop the trolley. When the power is off, the brake is set and keeps the trolley stationary.

Note: A trolley brake is mandatory on cab operated cranes when the cab is attached to the trolley either as a trailer type or overhanging type. On other types the trolley brake is optional.

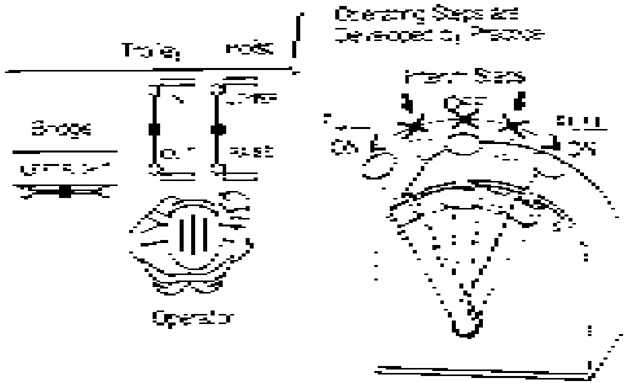


Illustration #529 – Trolley Controller Movement

Trolley Controller

The trolley controller is generally mounted adjacent to the hoist controller. It is usually a straight lever which is pulled toward the operator to bring the trolley in, or toward the cab end of the crane. The controller is pushed away from the operator to move the trolley away from the cab toward the opposite end of the crane. See illustration #529.

Controllers are designed to allow slow starting on the first point in either direction. Advancing the controller toward the "full-on" position, either forward or backward, increases the speed at which the trolley moves on the crane rails.

Centering the Trolley

The trolley is spotted approximately over the load and the operator's hand stays on the trolley control handle to make any re-adjustment necessary to position the trolley exactly over the load. Exact positioning of the crane for a vertical lift is the duty of a signalperson. After hook up, the hoist ropes must be perpendicular to the floor and the load lifted in a vertical line.

Controller Plugging

Reverse power is applied to the trolley motor to stop a moving trolley which is not equipped with a brake. This is done by moving the trolley control handle in the direction opposite to which the trolley is traveling.

When the trolley stops, the control handle should be centered at the off position.

Under normal conditions, it is recommended that the first point of the controller is used to plug the motor to rest with reverse power.

Using the second, third, or succeeding points on the controller will stop the trolley more quickly, but may cause the trolley wheels to slide, resulting in higher loads on the motor and the trolley mechanism. See Illustration #530.

A manual controller carries main power circuits directly to the motor. The position of the control handle determines the amount of current or power to the motor. When the magnetic-contactor control is used, a small master switch allows the operator to choose the forward or reverse direction desired. The main power circuits to the motor are made by the magnetic contactors on the control panel. The closing of these connectors is controlled by automatic relays which govern acceleration or plugging operations to the motor. See Illustration #531.

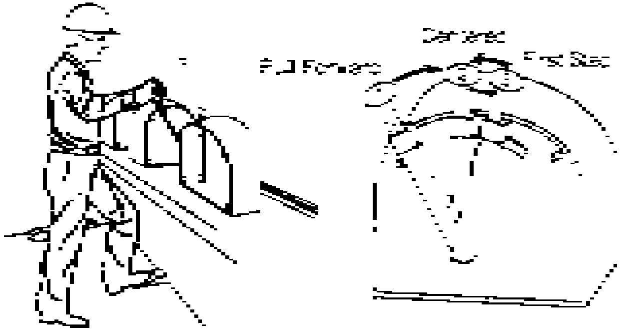


Illustration #530 – Controller Full On

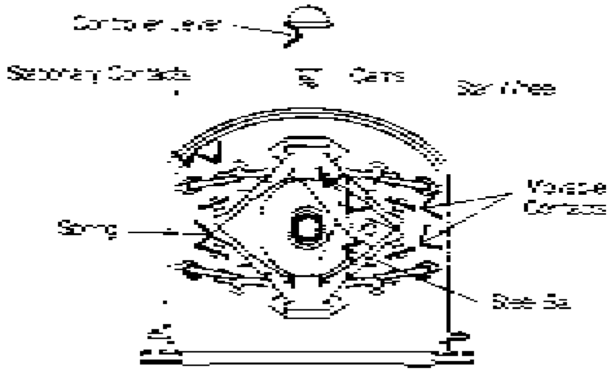


Illustration #531 – Controller Contacts

By this automatic method, the motor cannot be given too much plugging current when bringing the trolley to rest by reverse power regardless of whether the master handle is on first, last, or intermediate points. When the trolley stops, the master switch handle must be returned to the off position or the trolley will start to accelerate in the opposite direction.

Trolley Stopping

On most cranes, there are no limit switches at the end of the crane to cut off power and stop the trolley motor. A stop or bumper is usually welded to the girder to keep the trolley from rolling too far. See illustration #532A. A seldom used trolley wheel stop is shown in illustration #532B.

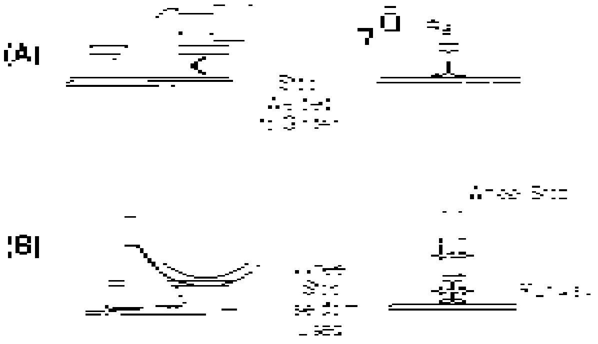


Illustration #532 – Trolley Stops

When stops are used, extreme care should be used to avoid striking these at high speed or the trolley may be derailed.

If it is necessary to run the trolley against the rail stop in order to make a lift at the extreme end of the crane, it is recommended that the trolley be brought completely to rest a suitable distance from the end.

Then, slowly approach the stop by moving the control handle on and off. Do not forget the coasting ability of the trolley. When the trolley touches the rail stops, the controller should be centered in the off position.

Note: Do not operate the trolley over long distances of travel with the control handle on intermediate points as this heats up the motors. Some trolleys equipped with roller-bearings travel very easily. If the trolley runs too fast with the controller on the last point, do not move the control handle to an intermediate point. Bring it all the way back to the off position. Let the trolley coast, and then stop at the desired point by reverse-power plugging.

Overhead Crane Hoist

The hoist assembly consists of the electric motor, speed reducer, hoist brake, drum, wire rope, hoist block, and hook. The motor and the drum mounting frame are attached to the trolley. Larger cranes may have two or more hoists. See Illustrations #533 - #535.

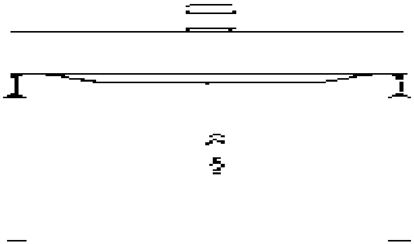


Illustration #533 - Single Trolley - Single Hoist

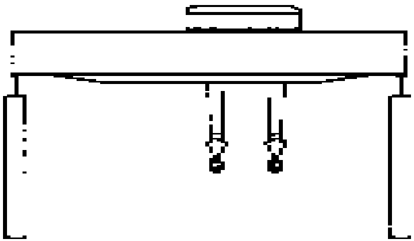


Illustration #534 - Single Trolley - Double Hoist

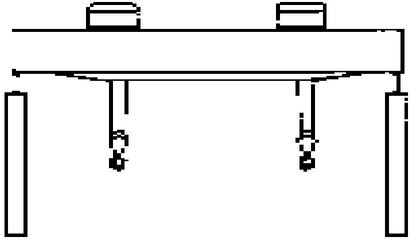


Illustration #535 - Double Trolley - Single Hoist (Each)

Hoist Controllers (Lifting)

Hoist controllers are usually equipped with vertical handles and arranged for lever operation, moving toward and away from the operator. Pulling the handle forward raises the hook and pushing the handle away causes the hook to lower.

In the up direction, illustration #536, the hoist motor has to lift the load against gravity. This means that it will require more power to start a heavy load than a light one; also a heavy load will hoist more slowly than a light one.

1. Handle position 1 (first point) is slow speed, low torque (or power) is supplied to start the empty hook up smoothly.
2. Handle position 2 (second point) gives an increase in speed for the empty hook being hoisted, or more torque for smooth starting of a medium size load which was too heavy to start on first point.
3. Handle position 3 (third point) gives a further increase in speed for the empty hook and pick-up in speed for the medium load, or still more power for smooth starting up of a heavy load which, due to its weight, would not start on the first or second controller point.
4. Fourth and remaining handle positions give further increases in speeds until the full on position is reached which gives the maximum speed at which the motor will hoist the load.

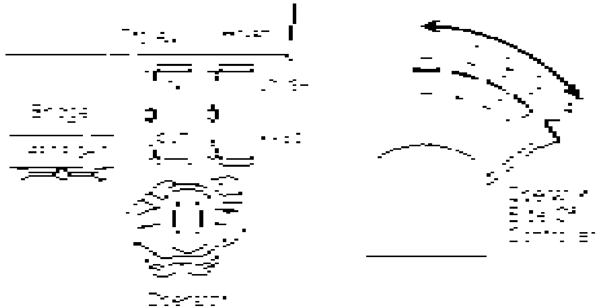


Illustration #536 - Point by Point Lifting

Illustration #537 - Point by Point Lowering

Hoist Controllers (Lowering)

1. On first point lowering, all loads will start slowly. Use this point to inch the load down. If the controller is allowed to stay on this point, the heavy load will reach a higher maximum speed than the empty hook or a light load.
2. On second point lowering, an increase in speed of all loads will be obtained.
3. Third and remaining points will give further increase in speed, until the motor is running at the highest speed, with the controller in the full on position.
4. When lowering very heavy loads, it is recommended that intermediate speed points be used. This slower speed reduces strain on the hoisting mechanism and wear on the brake when the load is finally stopped. It helps to ensure more accurate control by being able to stop the heavy load more quickly when necessary.

Dynamic Lowering

To prevent heavy loads from lowering too quickly, two systems are used. Both are automatic.

One method is a mechanical load brake which is built into the drum mechanism to limit the maximum lowering speed of the motor under any condition.

The other dynamic lowering method is electrical. It is an automatic feature of the controller which drives the empty hook or light non-overhauling load down and holds back a heavy, overhauling load.

When the operator is lowering, and any overspeeding is detected on any lowering point (with any type of load and with either system), the fault should be reported at once to the supervisor. The load brake may need adjustment, the resistor-tap connections may have been damaged or tampered with. The hoist may be unsafe and should be repaired immediately.

Dynamic lowering is a modern feature and is in use on the majority of cranes in service. The following comments apply specifically to cranes equipped with dynamic lowering controllers. The same comments, however, apply to cranes equipped with a load brake and operated by reversing controllers.

Raising Heavy Load

When raising a heavy load, use the first point of the controller to take the slack out of the wire rope. This will avoid whipping and impact loading. When the wire rope is taut, advance the controller slowly until the load starts to rise. Then move the controller point by point until the full on point is reached.

Note: Ensure the hoist brake will hold a heavy load. Test it after the load has been lifted a short distance. If the brake will not hold, lower the load to the floor at once and call the supervisor or repairman to adjust or repair the hoist brake.

Inching a Load

When a heavy load is suspended from the crane hook, the first two hoisting points of the controller give reduced motor power for smooth starting of light loads or an empty hook. If the load is to be raised above its suspended position, remember which control point was required to make the motor start when the load was first raised off the ground and go to that point quickly; otherwise the hook may lower due to the weight of the load. For this reason, it is desirable to inch a heavy load down rather than up.

When possible, hoist above the landing point and lower into position.

When lowering a load, reduce speed as the landing point is approached by returning the controller toward the off position. To set a load down carefully, it is advisable to stop the motor when the load is a few inches from the ground.

Then restart the motor and use the first point of the controller (or first point and off, repeated as needed) to lower the remaining distance.

When making fractional movements to position a load, move the controller to first point lower, and pause only an instant before returning the controller to the off position. Avoid excessively rapid movements of the controller between these two points. Operating too fast will not allow time for the magnetism in the electric holding brake to build up to the releasing point; operating too slow may allow the load to lower too far.

A few practice movements will enable a perfection of this positioning operation. Definite, short movements will please the ground crew and eliminate unnecessary wear on the crane controller.

Summary of Crane Movements

Power:

- Check the controls to see if they are in the off position.
- Close the main bridge switch.
- Push the on button; power is now on.
- Proceed with crane operation.

Hoist:

- Test hoist limit switch.
- Check the hoist brake by raising the hoist up rapidly, then shut off the power well below the limit block to see how far the hoist will drift and make sure the brake holds.
- Slowly hoist the block to the limit switch just below the drum.

1. Raise slowly to see where the hoist block stops.
2. If the limit switch stops the hoist block at the right position, lower and then raise the block rapidly to check limit switch shut off and drift of hoist.

3. If the limit switch stops the hoist block while below the drum, lower the block to a safe position.

Bridge:

- Operate bridge control to move bridge over the center of the load.
- Test bridge brake.
- Check the bridge drift after shutting off the bridge control.

Note: Motor and resistors will overheat in a few seconds if the crane bridge or trolley is operated at intermediate speed. Always go to the full on position.

Trolley:

- Operate trolley back to center of load position.
- When trolley is centered directly over the load, operate either the main hoist or the auxiliary hoist, depending on the capacity of the load to be lifted.

Coordination of Three Movements

It is sometimes necessary to operate both the hoist and trolley controllers while lowering down to hook onto a load. One hand is kept on the hoist control handle to always be in position to stop the hook and the other hand is on the trolley controller to adjust the trolley movement so that it will be centered directly over the load.

At times, while still positioning the trolley and lowering the hoist, it will be necessary to bridge slightly to the left or right to get the hook in proper position.

To make this extra move, it is recommended that the hand be transferred from the trolley controller to the bridge controller. Always keep the one hand on the hoist controller to stop the hook or load instantly when necessary.

Obviously these three positioning movements can be done individually, however as operators become experienced they are able to operate the crane controllers with all three motions simultaneously. After the load has been raised to a sufficient height to pass safely over all floor obstacles, the trolley is started in or out, being careful not to pass over workers below. At the same time, the bridge motion is starting to move the crane up or down the runway.

Note: The trolley or bridge motions must not be started until the load is off the ground and will safely pass by, or over, floor equipment or obstacles.

Swinging Load

Stopping a load from swinging quickly after having traveled some distance and approaching the point where the load is to be landed, requires an experienced operator. See illustration #538.

Swing is the result of the flexible connection between crane and load.

Applying power to the bridge motor starts the crane immediately, but the load lags slightly behind with the hoist wire rope at an angle to the perpendicular. When the crane is slowed down, or decelerated by the footbrake, momentum of the load does not slow it down immediately. The result is a load that swings ahead in the leading position and exerts a pulling force on the crane.

An experienced crane operator takes advantage of this leading pull by the load to prevent the hook from swinging back and forth when the crane is completely stopped.

Instead of permitting the load to go past the landing point and then swing back and forth several times until it comes to rest in a perpendicular position between the crane girders, the operator stops the crane a short distance before the final stopping point is reached.

At the instant the load is directly above the discharge point, the crane is accelerated quickly with forward power so that it catches up with the load. Then both load and crane can be stopped simultaneously directly over the place where the load is to be spotted.

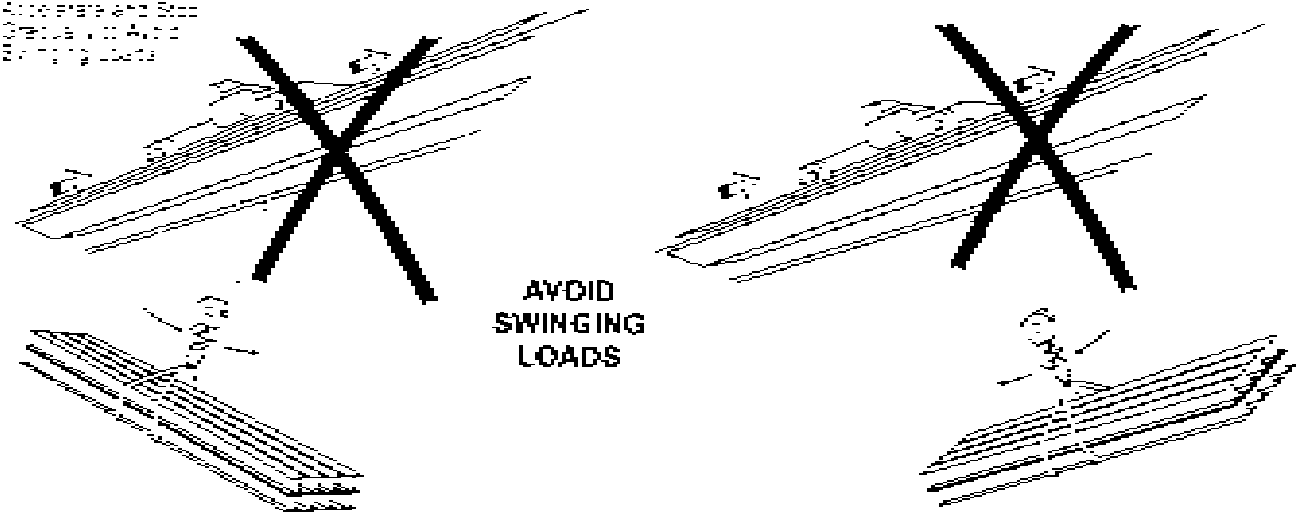


Illustration #536 - Swinging Loads

Note: Coordinated operation speeds up production, but it is recommended that this not be done until the operator has become very familiar with the crane and knows the time required to safely allow any of the motors to run before it is necessary to shut off power or stop motion.

When practicing coordinated movements of the three motions, new or inexperienced operators should only do so when traveling without a load and when there are no other cranes close by on the same runway.

The movements may also be practiced without power on the motors; the various control handles being operated exactly as though the crane were in motion.

Standard Hand Signals

Note: Crane operators must observe signals only from persons duly authorized for crane service, and under no circumstance is a load to be moved until the signal is received from the proper person.

The standard hand signals are shown in illustration #539.

Overhead Crane Signals

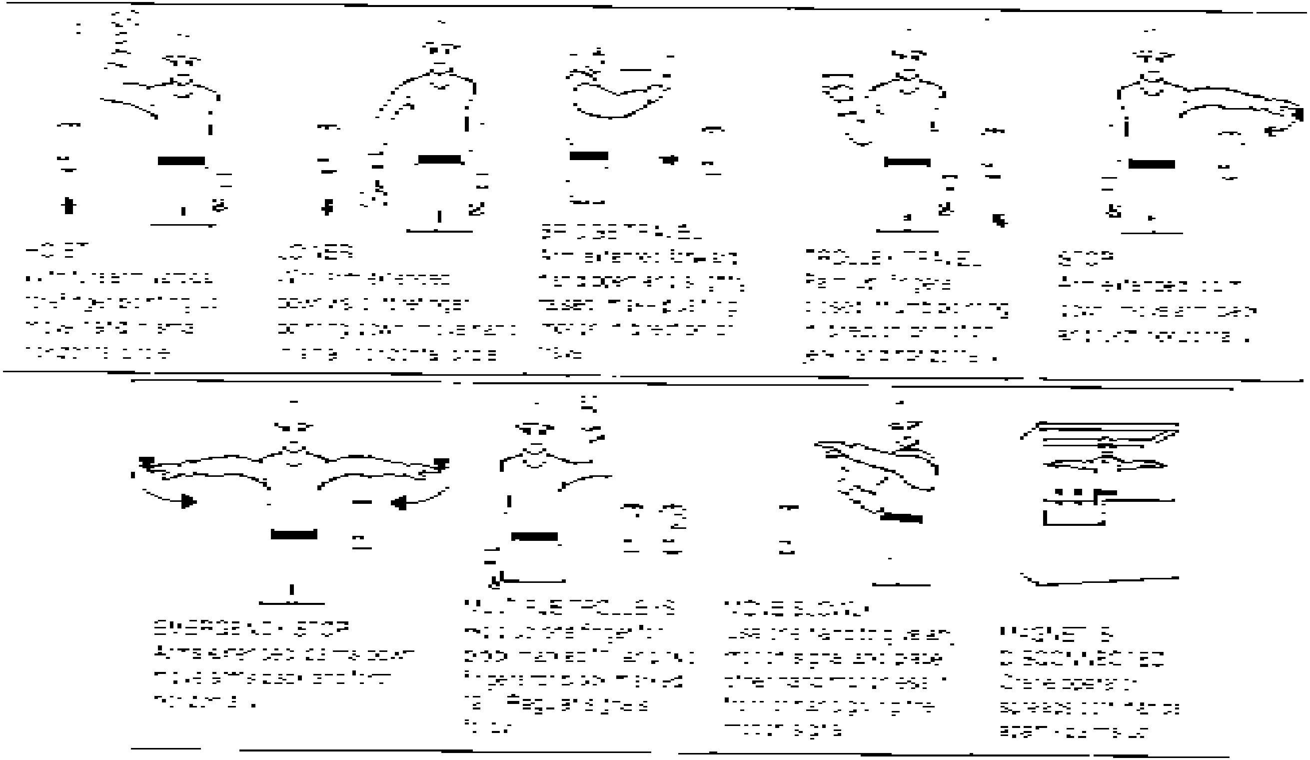


Illustration #539 – Hand Signals

Hoisting With A Magnet

- Never use the magnet as a hammer or a battering ram to break up packed material. A hard blow can break a magnet.
- Keep the magnet as dry as possible. Do not cool it off with water. Store it under cover and off the ground.
- Keep the terminal box closed. Do not allow it to get wet.
- Keep the chain links greased. This prevents friction and wear.
- Watch the temperature when handling hot material. Switch to a spare magnet if one overheats. Extreme heat will damage a magnet.
- Lower the magnet to the ground or on the load carefully. Broken magnets are difficult and costly to repair.
- Check the magnet bolts for tightness. Loose bolts allow moisture to get in, reducing safety and efficiency.
- ***Never use magnets to transport oxygen or other high pressure cylinders.***
- Never sling another load to the hook with the magnet attached.
- Never transport anything on top of the magnet.
- Prevent unnecessary swinging of the magnet when traveling with a load.
- The operator must acknowledge that the power has been disconnected before hooking or unhooking magnet plugs.
- Lift, move, and lower the load as soon as possible (and as safely as possible). The longer the power is on, the hotter the magnet will get.
- When loading a rail car, the signal person must be positioned in front of the crane but at the far end of the car.
- ***Protect the electrical components. Notify supervision if the controls do not respond correctly. Defective parts may cause the load to drop unexpectedly.***

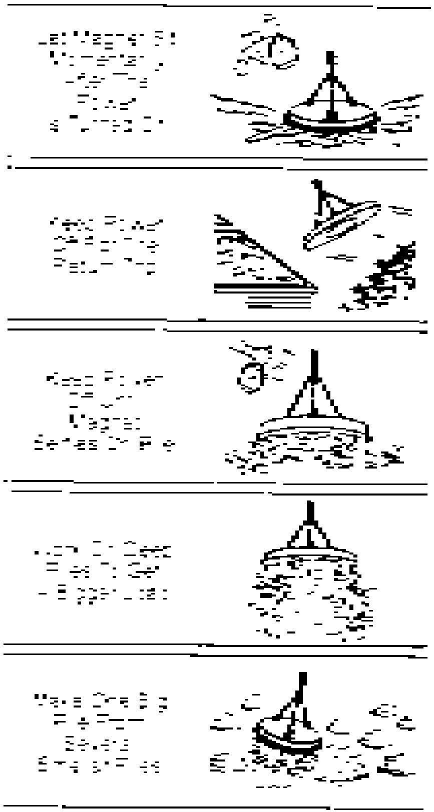


Illustration #542 – Magnet Use

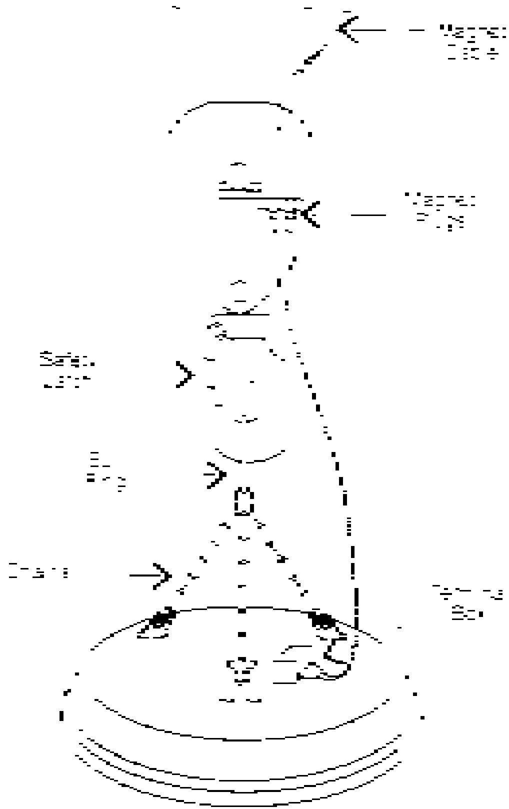


Illustration #541 – Magnet Parts

Hoist Assembly

The hoisting assembly is made up of an electric motor, drum, wire rope, the load block and hook. The wire hoist rope is securely attached to the drum (Illustration #542). The applicable safety regulations will specify how many wraps of wire rope must be left on the drum with the block at its lowest position. The wire rope usually rides in the grooves in the drum (Illustration #543), and is then reeved through a set of blocks. Depending on the crane capacity, there may only be two parts of line, or two dozen or more (Illustration #544). The hook, with a 360 degree swivel, is attached to the lower block. Depending upon the crane capacity, some types of block can be very large (Illustration #545). The hook also has a latch guard to prevent slings from slipping out. When using a sister hook (Illustration #546), the load must be balanced on each side.

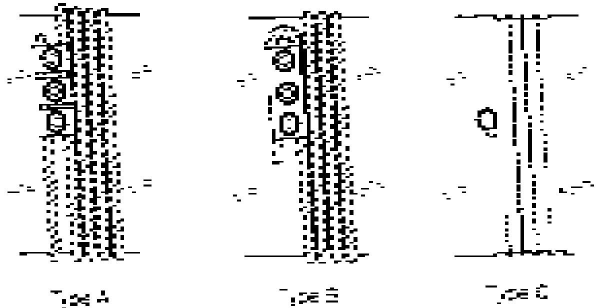


Illustration #542 – Wire Rope to Drum Attachments

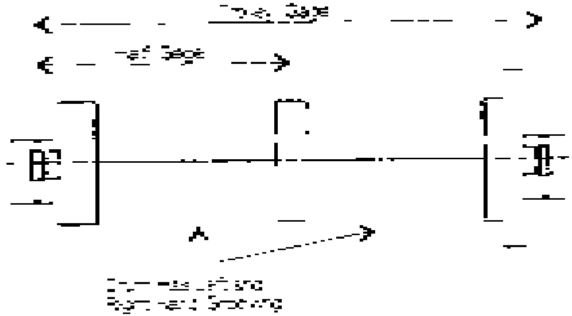


Illustration #543 – Left and Right Drum Grooving

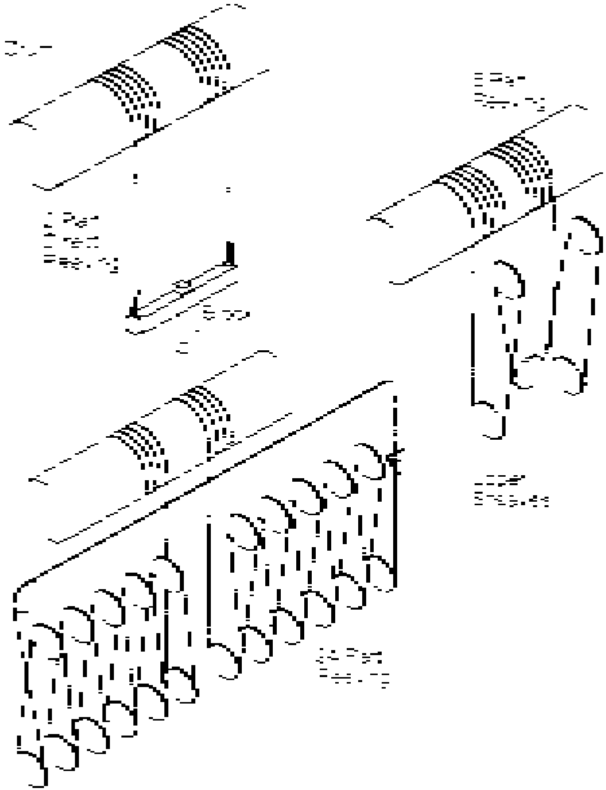


Illustration #544 – Reeving Examples

Illustration #545 – Short and Long Blocks

Illustration #546 – Sister Hook

WEIGHT AND NOMINAL BREAKING STRENGTHS IN TONS FOR VARIOUS GRADES OF 6 x 37 WIRE ROPE

Rope Dia. (inches)	Weight per Foot (lbs)		Improved Plow Steel (tons)		Extra IPS (tons)	Super Tensile	Extra Super T
	Fiber Core	Wire Core	Fiber Core	Wire Core	Wire Core	Wire Core	Wire Core
1/4	0.105	0.116	2.74	2.94	3.40	—	—
5/16	0.164	0.180	4.26	4.58	5.27	—	—
3/8	0.236	0.260	6.10	6.56	7.55	—	—
7/16	0.32	0.35	8.27	8.89	10.2	—	—
1/2	0.42	0.46	10.7	11.5	13.3	14.6	—
9/16	0.53	0.59	13.5	14.5	16.8	16.5	—
5/8	0.66	0.72	16.7	17.9	20.6	22.7	24.3
3/4	0.95	1.04	23.8	25.6	29.4	32.3	34.6
7/8	1.29	1.42	32.2	34.6	39.8	43.8	46.6
1	1.68	1.85	41.8	44.9	51.7	57.5	63.0
1 1/8	2.13	2.34	52.6	56.5	65.0	71.5	80.0
1 1/4	2.63	2.89	64.6	69.4	79.9	87.9	97.5
1 3/8	3.16	3.50	77.7	83.5	96.0	106.0	117.0
1 1/2	3.78	4.16	92.0	98.9	114.0	125.0	139.0
1 5/8	4.44	4.88	107.0	115.0	132.0	145.0	—
1 3/4	5.15	5.67	124.0	133.0	153.0	168.0	—
1 7/8	5.91	6.50	141.0	152.0	174.0	191.0	—
2	6.72	7.39	160.0	172.0	198.0	218.0	—

Table #69 – 6 x 37 Wire rope

Hoist Wire Rope

Due to its flexibility the hoist wire rope is usually the 6 x 37 classification. The wire core type is preferred over fiber core as it is stronger, does not crush as easily on the drum and is better for high heat applications. See table #69 for the nominal strength of 6 x 37 wire rope. The B30 ANSI standards specify the maximum load on the wire to be:

The load weight plus the hook block weight divided by the number of parts of reeving shall not exceed 20% of the wire rope nominal strength. This is a 5 to 1 design (safety) factor.

Note: If the block weight is not known, the total weight of the load and the block is sometimes calculated at 1.02 times the load weight.

Hoist Limit Switch

To prevent pulling the load block up into the drum, all overhead cranes should be equipped with a type of limit switch. Older cranes may have some type of mechanical switch, such as a paddle or lever type, a weight on the wire that trips a counterweight, or a rotating gear type attached to a shaft in the hoist. Some newer or reconditioned cranes may have a limit switch controlled by microprocessors.

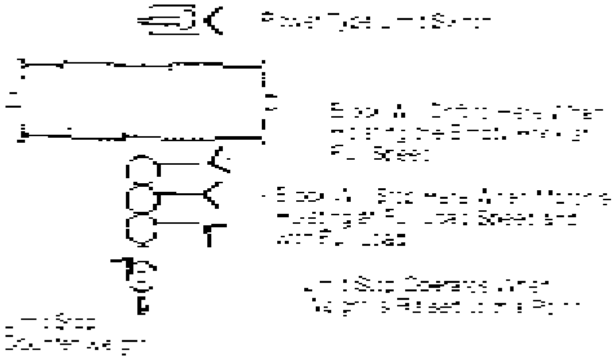


Illustration #547 – Limit Switch Drift

Limit switches disconnect power from the motor and automatically set the electric holding brake.

When the limit switch has tripped, reverse the controller to lower, using an inching movement until the limit switch is reset.

Some types of limit switches not only disconnect the motor from the line, but bring it to a quick stop by an electrical braking connection.

This avoids excessive drift and permits the limit switch to be adjusted for close clearance between the hook block and the drum, making high headroom available and eliminating frequent limit switch operation when high lifts are numerous.

Downward Limit Switch

When a lower limit switch is required, it will usually be the rotating type which will stop the lowering movement after a set number of revolutions.

All EOT cranes should have limit switches to prevent excessive upward travel, however, it is possible that a downward switch was not installed. If the motor is allowed to run after the hook touches the floor, the wire rope will run off the hoisting drum and then wind up in the opposite direction. If this occurs, stop immediately. Reverse winding of the wire rope on the drum may damage the rope and could also make the upper limit switch inoperative.

If the rope is allowed to continue to wind up in the reverse direction, the hook will run against the drum, break the rope, and drop the load which will damage the crane and injure personnel below. Special attention should be given to the possibility of this problem when working in areas which are below floor level.

Note: The crane hoist should be set up to have at least the minimum number of wraps remaining on the drum, required by the applicable safety regulations, when the hook is at its lowest position.

Limit Switch Guidelines

The following or similar guidelines regarding limit switch testing are followed by many companies. They have been prepared to provide the operator with a definite procedure to follow. The knowledge that the limit switch is in good working order should be helpful throughout the operators shift as the danger of an overhoisting accident will be considerably reduced.

At the beginning of each shift, it is recommended that the operator regularly check the working condition of the limit switch by running the hoist block up carefully. The limit switch is a safety device and should never be used to stop the hoist motor. A cautious operator will avoid this practice by stopping the hoisting motor with the controller, allowing the limit switch to act only in an emergency.

Proceed as follows to test the hoist limit switch...

- Move the crane to a clear space where the hook block will not injure anyone or damage equipment below, if the block falls.
- Raise the block up to a point just below where the limit switch normally operates and bring the hoist controller to the off position.
- Proceed carefully into the limit switch, using the first point hoisting. If the limit switch is operating properly the hoist will stop and the controller should be centered at the off position.
- The operator must closely watch the hook block during this test. If it does not stop within the proper clearance between hook block and hoisting drum, the hoist motor must be stopped by the controller instantly. The faulty switch must be examined and repaired or reset by a qualified person.

- If the limit switch operates satisfactorily under the conditions described above, the hook block should be lowered about half-way to the floor.
- The hoist controller should then be moved to the last hoisting point and the hook block allowed to go into the limit switch at full speed.
- Should any inaccuracy by the limit switch to stop the hoist be detected, the condition must be reported at once. Excessive hoist drift may be caused by the hoist brake being out of adjustment, or due to improper operation of the limit switch. The weights on weight-operated-type switches must always hang in their proper position.
- There may be occasions when it is necessary to purposely lift to the highest possible height. If this happens, proceed as follows...

The hoist motor should be brought to a complete stop a suitable distance before entering the limit switch. Proceed to hoist until stopped by the limit switch, using the first controller point or the slowest speed point which will raise the load.

Do not use the hoist limit switch as a means of stopping the hoist motion.

It is a safety device for the protection of the operator, fellow workers, the crane and surrounding equipment, and should be reserved for emergency use only.

Note: Never change the height of the tripping weight or make special high lifts unless this change is made under qualified supervision.

Geared Limit Switch

The adjustable geared limit switch opens the hoist circuit when the bottom block reaches a preset upper limit, and opens the lower circuit when the bottom block reaches a preset lower limit. The limit switch is driven by the hoist drum, and is actuated after a predetermined number of drum revolutions.

Both the hoist and lower circuits are connected through sets of normally closed contacts in the limit switch. Both the upper and lower limits of bottom block travel are preset at the factory.

Hoist Brakes

To hold a load stationary when the hoist controller handle is in the "off" position, a brake is keyed to the shaft of the hoist motor that is located on the trolley. The brake is automatic, and is applied by a spring when the power is off. See Illustration #548.

Note: OCHS/OH&S safety regulations requires each independent crane hoist to have at least one holding brake and one control braking means.

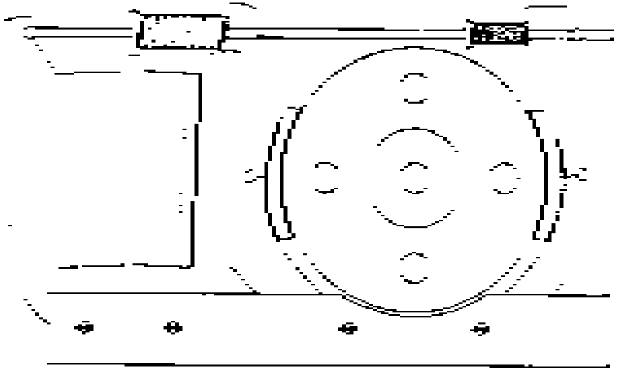


Illustration #548 - De-Energized Brake

The brake is released electrically by the current through the motor when the controller handle is moved to raise or lower the load.

For safety reasons some cranes, particularly those of large capacity, have an additional brake keyed on the drum or to the gearing between motor and drum. In these cases, both of the brakes work simultaneously and automatically by the motor current. See illustration #549.

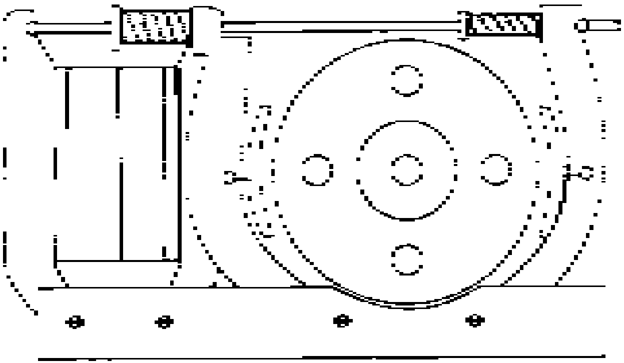


Illustration #549 - Energized Brake

Hoisting Overload Protection

Safety regulations prohibit the loading of a crane beyond its rated capacity. Many people assume that a dropped load is the result of equipment failure. While this is true in some cases, most loads are dropped for reasons that could have been avoided. The reasons are often from damaged wire rope due to rope abuse, such as bad spooling. Other reasons are sudden overloads caused by two-blocking and load snatching, as well as lifting over-capacity loads. Rope damage from the drum can be reduced by frequent inspections and ensuring the equipment is working the way it is supposed to, and also avoiding side pulls or lifting swinging loads. A sudden overload is an operating problem caused by an inexperienced or careless operator. Overloads are avoided by knowing the weight or by having the crane equipped with an overload device.

Overload Detection

There are a variety of devices manufactured by a number of companies that can show the weight of a load. These can range from a basic scale or dynamometer between two shackles in the load line just above the load hook (Illustration #550) giving a digital readout to the person who hooked up the load.

A more advanced type has a remote readout for the operator in the cab.

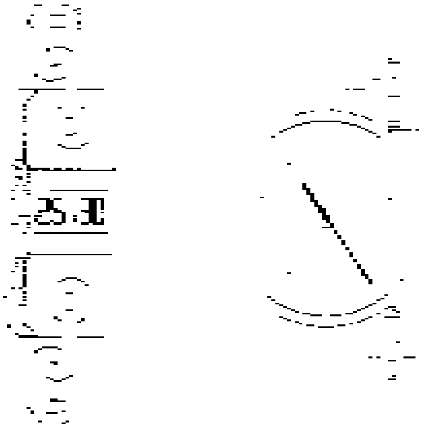


Illustration #550 – Dynamometer Examples

An overload device that can shut down the hoist or activate an alarm when an overload occurs can be set or programmed to a set limit. These devices can be attached with shackles in the load line or can be clamped onto the load line. The modern types are equipped with microprocessors for exact settings. See Illustration #551 for two examples.

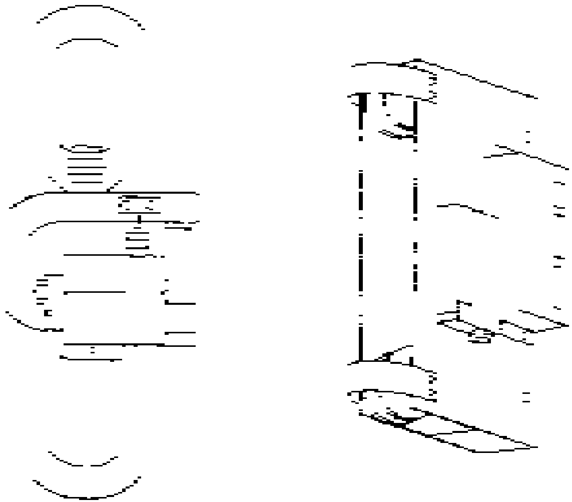


Illustration #551 – Overload Protection Switch Examples

The older types are mounted on the hoist assembly, and generally are not totally accurate. See illustration #552 for equalizer arm and spring mounted examples.

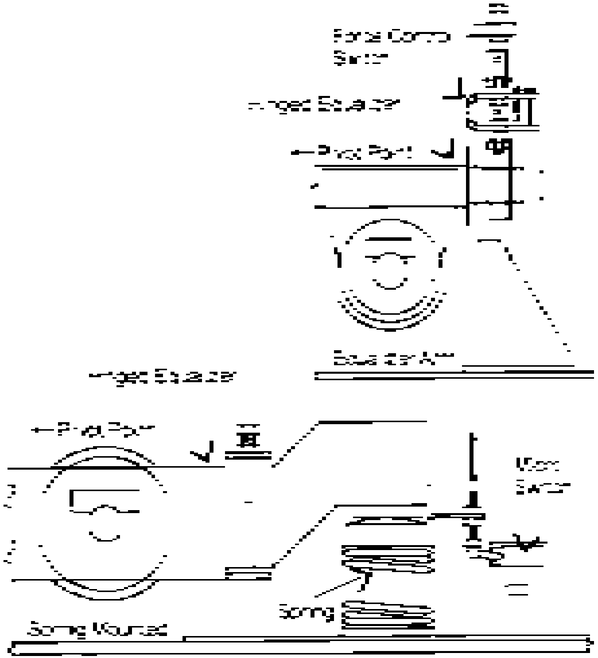


Illustration #552 – Equalizer Arm & Spring Detection

Pre-operation Inspection

The operator should visually inspect the crane on each shift indicating conditions that are satisfactory or unsatisfactory. The operator should lock out the main switch on the crane, and place his lock and tag on it. The crane conditions should be checked off on a list designed for this purpose. Any unsatisfactory condition that needs attention should be immediately reported to the supervisor in charge.

Checklist items would include:

- ✓ ***Walkway, hand rails on bridge: Check for loose floor plates, debris, bolts, welding rods, oil grease.***
- ✓ ***Controls located at walkway: Open cabinet, check for heating of wires, coils or burnt contacts.***
- ✓ ***Resistance grids: Check for broken, cracked, loose connections; check and remove if welding rods or any metal objects are laying on grids.***

- ✓ *Check bridge conductors.*
- ✓ *Check drive motor and line shaft, also check wheel grease.*
- ✓ *Ensure collectors are in place.*
- ✓ *Trolley rails: Check for wear or flat spots.*
- ✓ *Trolley motors: Check both main hoist and auxiliary brushes on commutator, and/or slip rings for burning or pitting.*
- ✓ *Check motor bearing for grease.*
- ✓ *Check gear boxes for lubrication.*
- ✓ *Brakes: Check both bridge and trolley.*
- ✓ *Trolley conductors and collectors: Check for wear or loose or dislodged collectors.*
- ✓ *Drum rope: Check for wear, kinks or other faults.*
- ✓ *Hoist block sheaves: Check for wear, pitting, misalignment.*
- ✓ *Load Hook: Check for cracks or bends, also check safety latch.*
- ✓ *Fire extinguisher: Check seals to see if they are broken. If so replace with full extinguisher.*
- ✓ *Before removing the lock and tag from the main switch, check the controllers in cab.*
- ✓ *Try the controls for movement to positions.*
- ✓ *Check function of digital controls.*
- ✓ *Bridge brake: Depress foot pedal.*
- ✓ *Remove lock and tag, then close the switch.*
- ✓ *Check bell, gong, sirens, lights, or any alarm systems.*
- ✓ *When check list is completed, turn it in to the supervisor.*

Table F70 shows a pre-operational checklist.

PRE-OPERATION INSPECTION CHECKLIST

EQUIPMENT TYPE ______________________ NUMBER __________

DEPARTMENT ______________________ SHIFT __________ DATE __________

SIGNATURE OF INSPECTOR ______________________ CLOCK # __________

Place an (X) on the item or items that require service.

- A - Crane signal lights and sounding device
- B - Loose parts and materials removed from walkways and platforms
- C - All guards, gear in place
- D - Limit switch cables
- E - Main hoist cables, spool and sheaves
- F - Auxiliary hoist cables, spool and sheaves
- G - Bridge brake
- H - Trolley brake
- I - Main hoist limit switch
- J - Auxiliary hoist limit switch
- K - Hook latch
- L - Controls stocking (cab, pendant & radio operated)
- M - Battery test on radio transmitter control box (radio control crane only)
- N - Fire extinguisher for cab operated cranes
- O - Check rigging equipment (pendant and radio crane operators)
- P - Lubrication
- Q - Fluid levels: gear boxes and hydraulics
- R - Proper spooling on drums
- S - Wheels, shafts and couplings visual inspection
- T - Electrical system visual inspection
- U -
- V -
- W -

REMARKS: ____

____

Use alphabet letters when remarking on the above items.

Table #7[illegible] – Pre-operation Inspection Checklist

Operator Awareness Rules

1. Do not move the load or the crane unless the floor signals are clearly understood.
2. Signals to be given only by one person.
3. Start and stop slowly.
4. Be careful that the load does not swing to injure anyone on the floor.
5. Never pick up a load greater than the capacity of the crane. Double check the load weight and the crane capacity if unsure of either.
6. Never operate when in doubt of the load condition, or in doubt of the crane condition.
7. When raising, lowering, or moving the load, ensure that it will safely clear nearby equipment.
8. Make all moves slowly to prevent swinging loads.
9. Personnel are not permitted to "ride" on the hook or the load.
10. Ensure there is no loose object on the load.
11. Signal the alarm when approaching workers below.
12. Never stop suddenly by using either the brake or the plugging motion, except in an emergency.
13. Stop on emergency signal at all times, no matter who gives it.
14. Never bump or move another crane when it is under repair.
15. Avoid side pulls (illustration #553).
    a. Under no circumstances are side pulls permitted.
    b. Center the crane over the load before hoisting to avoid swinging the load as it comes off the floor.
    c. Loads should not be swung by the crane to reach areas not under the crane.
    d. Crane hoisting ropes must be kept vertical.

16. Cooperate with those hooking on the load. The operator and those on the floor are a team handling a valuable piece of equipment. Never let it become a hazard.
17. ***Never do anything that is not safe.***

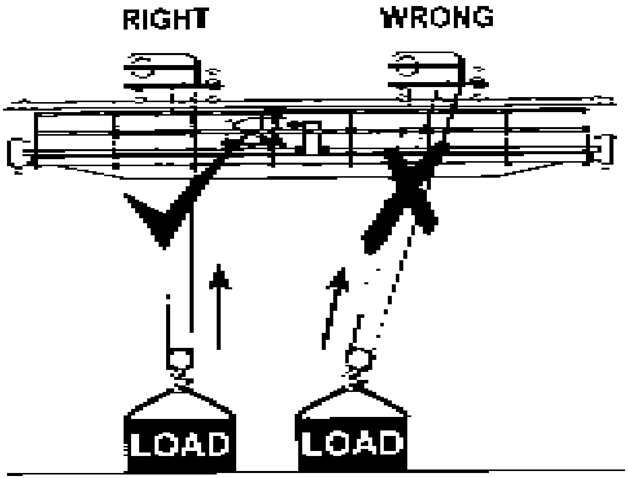


Illustration #553 - Avoid side-pulls

Crane Safety Summary

1. A crane's operation from initial start to running speed to stop is regulated by the controller one step at a time.
2. When the drift of crane motions are known, less braking and/or plugging is needed.
3. Full speed should always be the rate of travel, unless jogging is necessary for some movements. Less than full speed operation must be used with extreme care as the motors and resistors will heat.
4. Warning devices shall be activated when the crane is in motion to alert personnel of crane movement.
5. The crane shall never be overloaded, except for test purposes.
6. All load hoisting shall be made with the hoist ropes in the vertical position. Never pick up loads that may swing out of control.

7. Side pulls should never be attempted. If necessary, use a snatch block to drift the load.
8. All lifts shall be made slowly to remove all slack from hoist ropes.
9. Loads that are unsafe should never be moved. Long extended loads should have a hand line (tag line) attached to keep the movements under control.
10. Signals for crane movement are only given by one person.
11. When an emergency stop signal is given by anyone, it must be obeyed. The crane is not moved until a signal is given.
12. Under normal operating conditions, only the authorized operator shall be on the crane. The exceptions are for maintenance and repair or operator trainee instruction.
13. Do not lower the block below a point where less than the minimum wraps of rope remain on the drum.
14. If the block is lowered too far and the rope begins to rewind in the opposite direction, stop immediately and ensure that the rope is properly rewound.
15. Never move magnetic held loads over personnel or equipment. A power loss will drop the load.
16. Hot metal should never be carried over or near personnel.
17. Bumpers should not be used to stop crane travel. Do not bump another crane on the runway.
18. When carrying a load with the weight shared by the main hook and the auxiliary hook, the load must be balanced before traveling.
19. Outside cranes must be secured when unattended due to the possibility of wind damages.
20. All cranes must have a fire extinguisher readily accessible.

21. Hand signals must be in accordance with prescribed standards, unless radio, telephone, or other communications are supplied. If other signals are to be used, they must be agreeable to the signalperson and the crane operator.
22. Cranes and their trolleys and hoists must be marked as to rated load.
23. Maximum loads shall not be moved until the hoist brakes are tested by raising and holding the load a short distance above floor level. If the brakes do not hold, do not lift and travel with the load. Notify supervision immediately.
24. When lifting magnet leads that are to be disconnected for repairs or for other reasons, the magnet main switch must be opened by the operator and notice given that the switch is open before disconnecting the leads.
25. All danger and warning signs are for personnel safety and protection. They are to be obeyed at all times.
26. All main switches must be opened and tagged by the people who will work on the crane. This is for their protection and for the protection of others who may come in contact with the equipment.

Housekeeping & Fire Hazards

- Crane operators are responsible for keeping their crane cab clean.
- Sweep the cab on every shift.
- Operators should refrain from littering the cab.
- Cab windows must be kept clean at all times. Dirty windows minimize visibility and increase the possibility of an accident. Report any broken windows as soon as found.

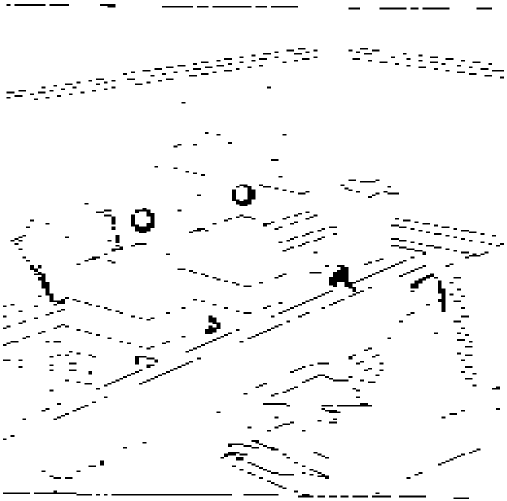


Illustration #554 - Keep Cab Clean

- Debris of any kind must not be allowed to accumulate on cranes. This includes pop bottles or cans, bolts, nuts, welding rod stubs, etc.

Be on the alert for grease or oil spots on crane runways, walkways or stairs. These are hazardous and must be cleaned up.

If, after cleaning, such conditions occur again, operators should notify the proper supervisor so that arrangements can be made to repair the cause of such leakage.

Fire on cranes is hazardous to personnel and usually results in extensive operating delays by damage to complicated electrical equipment.

Standard safety practices are:

- Keep the crane bridge and the trolley free of oil, grease, litter, and dirt accumulation.
- Keep the crane cab free of rags, waste, wood, oil, or other combustibles. Clothing should not be kept in the cab.
- Maintain the required stock of fire extinguishers, stored neatly and ready for use. It will be the responsibility of the operator to report to supervisors when fire fighting equipment has been used.
- Inspect the electrical system regularly for hot connections, overheated wires or resistors and insufficient insulation.

If it is necessary to carry lubricating supplies on the crane, a suitable container must be provided and located a safe distance from the cage and other vital areas of the crane.

Overhead Crane Lockout

A lock-out procedure must be established and strictly followed prior to any inspection of EOT cranes. All applicable plant personnel should be notified of this inspection and they should be notified of the results.

If other cranes are operating on the same runway, bumpers are placed 20 feet (6.1 m) from the crane on either side. Danger flags and/or lights, or a flagperson must be posted to warn approaching cranes. The floor area below the crane must be roped off with pennant warning lights.

If this is the only crane on the runway, pull the main switch to kill power to the runway conductors. This switch must be locked out and tagged by the supervisor in charge. The power switch must also be opened, locked and tagged by personnel inspecting the crane. The tags and locks are only removed when the inspection is finished.

If another crane is being operated adjacent to the crane being inspected, lights and pennants must be used to warn all inspection and operation personnel. Travel from the inspection area into the working crane area should be avoided.

If a crane requires moving as part of the inspection process, a crane operator must be in the cab, and all persons alerted to this movement.

Table #71 shows the suggested frequency of inspection.

Table #72 shows a sample mechanical checklist.

Table #73 shows a sample electrical checklist.

SUGGESTED FREQUENCY OF INSPECTION

Components	Crane Use: Continuous	Crane Use: Intermittent and Standby
Hoist System Motor Shaft & Couplings Hoist Gearing Drum, Drum Shafts & Bearings Sheaves & Pins Block	Inspect monthly	Inspect before each return to service, then monthly during period when crane is in service
Hoist Motor Brake(s) Rope Damage - such as wear, cut, crushed, kinked, unstranded, corroded, loss of lubricant, birdcaged, heat damage, welding, etc.	Inspect monthly	Inspect weekly during period when crane is in service
Hook - cracked, bent, spread Limit Switches per ANSI B30.2.0 Reverse phasing, check hoist direction.	Inspect at start of each operating shift	Inspect before each return to service, then at start of each operating shift
All other crane components	See ANSI B30.2.0	

Table #71 - Inspection Frequency

CHECKLIST: MECHANICAL PARTS

[illegible]

Bridge	
Alignment	
Girders camber	
Rails	
Rails, stoppers, railings	
Truck to girder connection	
Trucks	
Wheels, driver	★
Wheels, idler	★
Wheel bearings	★
Axles ★ & couplings	
Squaring shaft	
Squaring shaft bearings	★
Squaring shaft couplings	
Motor coupling	★
Motor pinion	
Motor gear	
Axle pinion	
Axle gear	
Gear case bearings	
Hydraulic brake	★
Brake linings	★

CHECK COLUMN

Trolley	
Wheels, driver	★
Wheels, idler	★
Wheel bearings	★
Axles & couplings	
Motor coupling	★
Motor pinion	
Motor gear	
Axle pinion	
Axle gear	
Gear case bearings	

★ requires additional daily inspection

■ requires monthly inspection & lubrication

Items not marked to be inspected and lubricated every six months

Table #724 - Mechanical Checklist

CHECKLIST: MECHANICAL PARTS

Hoist	
[illegible]	■
[illegible]	
[illegible]	☆
[illegible]	☆
[illegible]	☆
[illegible]	■ ☆
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	☆
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	

CHECK COLUMN

[illegible]	☆
[illegible]	☆
[illegible]	☆
[illegible]	
[illegible]	
[illegible]	☆
[illegible]	☆
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	☆
[illegible]	

☆ [illegible]

■ [illegible]

[illegible]

Table #72B - Mechanical Checklist (continued)

CHECKLIST: ELECTRICAL PARTS

CHECKLIST: ELECTRICAL PARTS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bridge motor bearings								
Bridge motor brushes	★							
Bridge motor rings								
Trolley motor bearings								
Trolley motor brushes	★							
Trolley motor rings								
M.H. motor bearings								
M.H. motor brushes	★							
M.H. motor rings	★							
A.H. motor bearings								
A.H. motor brushes	★							
A.H. motor rings								
M.H. brake shoes								
M.H. brake lining	★							
M.H. brake linkage								
M.H. brake coil								
A.H. brake shoes								
A.H. brake lining	★							
A.H. brake linkage								
A.H. brake coil								
Trolley brake shoes								
Trolley brake lining	★							

CHECK COLUMN

CHECK COLUMN		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trolley brake linkage								
Trolley brake coil								
Bridge brake shoes								
Bridge brake lining	★							
Bridge brake linkage								
Bridge brake coil								
Hydraulic brake bleeder	★							
M.H. limit safety contacts								
A.H. limit safety contacts								
Trolley collectors	★							
Runway collectors	★							
Sanders								
Magnet cable & connectors								

★ requires additional daily inspection

Items not marked to be inspected and serviced every six months.

Table #73A - Electrical Checklist

CHECKLIST: ELECTRICAL PARTS

Item	Check column
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	★
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
For Manual Drum Control:	
[illegible]	★
[illegible]	★
[illegible]	★
[illegible]	★
[illegible]	★
[illegible]	★
[illegible]	★

CHECK COLUMN	
[illegible]	
For Magnetic Control	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	
[illegible]	

★ [illegible]

[illegible]

Table #73B - Electrical Checklist (continued)

Overhead Crane Testing

A crane must never be loaded beyond its rated capacity during normal operation. This limitation is an ANSI/OH&S/OCHS regulation. Using a crane above its rated capacity for other than test purposes may void the warranty, invalidate the user's insurance, and present a severe safety hazard.

The normal 125% test load shall be handled for bona fide test purposes only.

Preliminary Test (without reeving):

The preliminary test is done before the hoist block is reeved. Test the various motions as follows:

- Close the runway disconnect switch.
- Close the main crane disconnect switch.
- Close the individual motor and accessory switches (if used) in that order.

Hoist Test:

1. Place the master switch in 1st point hoist position.
2. Observe the contactor for proper sequence and direction of hoist drum rotation. Increase the speed gradually if operating correctly.
3. If the hoist contactor and rotation is not correct, shut-off the power, reverse the two leads on the main line collectors or on the hoist motor (whichever is incorrect), to obtain the correct phasing. Restore the power and repeat steps 1 and 2.
4. After checking the hoisting motion, return the master switch to neutral position and observe the braking action. Readjust if needed.
5. Place the master switch in lower 1st point and observe if correct motion and contactor sequence occurs.
6. Reset hoist limiters if necessary.

7. Speed points are for accelerating only and should not be used for running full speed over a long distance. The maximum time for acceleration is 15 seconds unless special equipment is provided. If held on full speed for a longer time there may be resistor damage.
8. If the crane is equipped with an auxiliary hoist the check is the same as the main hoist.

Trolley Motion Test:

1. Place the master switch in 1st point trolley travel position.
2. Observe contactor sequence and direction of travel through full range of master switch. Reverse the phasing if necessary.
3. Allow trolley to move the entire length of bridge span, watching alignment of trolley collector pole and bridge conductors, and also for any interference with the building or equipment. Do not run the trolley into end stops.
4. Adjust end limit switch trip (if used).
5. Reverse the master switch and repeat steps 1 through 4.
6. Reset the trolley timers if needed.

Bridge Motion Test:

1. Place the master switch in 1st point bridge travel position.
2. Observe contactor sequence and direction of travel through the full range of master switch. Reverse the phasing if necessary.
3. Allow the bridge to move the entire length of the runway, watching the alignment of main collector pole and runway conductors, and also for any interference with the building or equipment. Do not run bridge into end stops.
4. Adjust end limit switch trip (if used).
5. Reverse master switch and repeat steps 1 through 4.
6. Reset bridge timers if needed.

Crane Testing (Limit Switch)

No-Load Test - Upper Limit Switch:

1. After reeving the hoist test the operation of the hoist limit switches.
2. Raise empty block to within approximately 2 feet (600 mm) of its upper position.
3. Raise empty block at the lowest speed until the limit switch trips and stops the hoisting motion. Watch for proper alignment between load block and limit switch trip (if used).
4. Ensure the block stops at the correct height as shown on drawings. Adjust limit switch if necessary.
5. Lower the block approx. 5 feet (1.5 m).
6. Raise block at about half speed.
7. Check for adequate clearance between block and trolley frame (or upper sheaves).
8. Repeat points 5.6.7 with the block being raised at full speed.

No-Load Test - Lower Limit Switch

If the crane is equipped with a lower limit switch, proceed as follows:

1. Lower the empty block until a minimum two wraps of rope remains on each end of the drum.
2. Set lower limit switch to trip at this point, or any position which is higher.
3. Never lower the block beyond the point when the minimum wraps remain at each end of the drum.

Crane Testing (Load Test)

Load Test - With Load

After completing the no-load running test, the crane should be tested with loads in the following manner:

1. Raise a load equal to about 50% of the rated capacity no higher than necessary to clear the floor (or load's support) and do the following steps:
   a. Adjust brakes if necessary.

b. Raise the load approximately 3 feet (900 mm).

c. Lower the load about 12 inches (300 mm) and stop.

d. Check the load drift while stopping. If load drifts, brakes are not properly adjusted.

e. Repeat the test until the brakes are properly adjusted.

f. Lower the load carefully back to the floor or its supports.

2. The crane will now be tested with a maximum 125% test load.

a. Hoist the load high enough to clear obstructions but not higher than necessary.

b. Move the trolley across the entire span of the bridge.

c. Transport the test load with the bridge for the full length of the runway in one direction with the trolley at one end of the crane.

d. Transport the load in the other direction with the trolley at the other end of the crane.

e. Reduce the amount of bridge and/or motor travel when it is not reasonable or prudent due to personnel or equipment on the floor.

f. Lower the load carefully onto its supports. Never raise or lower a load more than two feet (600 mm) at reduced speeds, except with creep-speed control, as the resistors and/or hoist motor may overheat.

g. If the crane is equipped with a creep speed control, it should be tested for approximately two feet (600 mm). The creep-speed drive is designed for continuous operation and prevents overheating problems which can occur with other types of controls when operated at less than full speed.

Note: In accordance with regulations

a. *A test load shall not be less than 100% of the rated load of the crane, or more than 125% of the rated load unless otherwise recommended by the manufacturer*

b. *The final load rating should not be more than 80% of the maximum load sustained during the test*

Note: The testing process listed above is a guideline which will suit most EOT cranes, however check with the specific crane manufacturer's manual if it is available.

Crane Cab Boarding

Note: An operator approaching a crane to begin work should not attempt to board the crane unless the crane is at its authorized platform and the operator coming off duty is exiting the crane at the boarding point, or is at ground level.

Note: Inspect the crane at the beginning of each shift.

Do not operate the crane if:

1. The limit switch fails.
2. The wire rope is damaged or out of the drum groove.
3. The status lights do not work.
4. The brakes fail to work.

Overhead Crane Securing

Bridge: Park the crane only at its authorized boarding platform.

Trolley: Secure the trolley next to the cab.

Hoist. Raise the hoist block to a position just below the limit switch.

Controls: Position all controls to off.

Main Switch: Open the main switch. Lights. Turn on red light. Turn off heater or air conditioners. Place bridge brake in park position.

Disembark: Ensure the crane will not be bumped by another crane. Step off the crane. Secure the crane entrance with a chain or gate to prevent others from stepping off platform. Turn in the checklist.

Outdoor Storage Bridge Cranes

Outdoor Storage gantry types of cranes fall under the guidelines of ANSI B30.2.

They may be equipped with:

a. Remote operated rail clamps or an equivalent device. A parking brake is considered as minimal compliance with the ANSI regulation.

b. A wind indicator, giving visible and audible warning to the operator when wind reaches a predetermined velocity (usually 45 mph (70 km/h)) must be provided.

c. The rail clamps must only be applied when the crane is not in motion.

d. When rails are used for anchorage, they must be secured to withstand the resultant forces applied by the rail clamp. If the clamp acts on the rails, any projection or obstruction in the clamping area must be avoided.

SECTION ELEVEN QUESTIONS

Overhead Cranes

1. Determine if this statement is true or false. Because they are easy to operate, overhead crane operators seldom requires operator certification.

   ❐ true ❐ false

2. A crane operating continuously at high speeds with capacity loads would most likely be of what class?

   ❐ A2
   ❐ B
   ❐ D
   ❐ E

3. Determine if this statement is true or false. Monorail and jib cranes usually have more lifting capacity than a typical overhead crane.

   ❐ true ❐ false

4. A mobile straddle lift gantry crane runs on:

   ❐ a jib
   ❐ rails
   ❐ rubber tires
   ❐ none of above

5. A mobile straddle lift gantry crane is usually used for what purpose?

   ❐ in a steel foundry
   ❐ in a manufacturing plant
   ❐ in a ship repair yard
   ❐ for moving shipping containers

6. Determine if this statement is true or false. The Bridge, Trolley, and Hoist are the three basic components of an overhead crane.

   ❐ true ❐ false

7. Keypad Adjustable Frequency Controls are used with what control method?

   ❐ cab mounted controls
   ❐ hanging pendant controls
   ❐ walkabout remote controls
   ❐ all of above

8. Determine if this statement is true or false. A disadvantage of a Keypad Adjustable Frequency control is that it cannot be programmed for what is known as a soft start or stop.

   ❐ true ❐ false

9. Other types of remote control units can be dangerous for what reason?
   - ❑ range too short
   - ❑ range too long
   - ❑ combining low operating frequencies
   - ❑ combining high operating frequencies

10. When operating a radio control led crane the operator must never operate the crane:
   - ❑ at night
   - ❑ blindly
   - ❑ without a load
   - ❑ without a signal person

11. What must happen to the transmitter box to prevent [illegible] of a remote control crane that is not in use?
   - ❑ antenna and [illegible] removed [illegible]
   - ❑ box placed in a secure location
   - ❑ operator must carry box at all times
   - ❑ none of above

12. Determine if this statement is true or false: If a radio control crane fails to operate properly, all movements must stop immediately and the transmitter [illegible].
   - ❑ true ❑ false

13. When a crew is operating a radio control crane, who is responsible for the crane's control?
   - ❑ designated radio crew member
   - ❑ any radio crew member
   - ❑ a designated person not on the crane
   - ❑ the shift supervisor

14. When operating in a critical load situation with a pendant control crane and the pushbuttons are not clearly labeled the operator should [illegible] the load?
   - ❑ have a second person advise which button to push
   - ❑ memorize the button positions
   - ❑ stop and start with each separate movement
   - ❑ all of above

15. Determine if this statement is true or false: The primary advantage of a pendant control crane is a good view of the load.
   - ❑ true ❑ false

16. Determine if this statement is true or false: The two disadvantages of a pendant control crane are [illegible]
   - ❑ true ❑ false

17. A condition caused by possible rough operation whereby the crane girders are not perpendicular to the runway resulting in one end being ahead of the other is called:
- ❑ inching
- ❑ [illegible]
- ❑ plugging
- ❑ skewing

18. Determine if this statement is true or false. All cab operated cranes should be stopped by using the same basic operation method.
- ❑ true
- ❑ false

19. When slowing or stopping a cab-controlled crane bridge primarily with reverse power (when the crane controls are designed for this purpose), the movement is called:
- ❑ inching
- ❑ [illegible]
- ❑ plugging
- ❑ skewing

20. Determine if this statement is true or false. The plugging operation is best achieved on controller points 3 and 4.
- ❑ true
- ❑ false

21. Positioning the bridge and trolley over the load for hoisting is called:
- ❑ centering
- ❑ aligning
- ❑ rocking
- ❑ [illegible]

22. Determine if this statement is true or false. For overall efficiency, a load should be moved with the controller on a continuous intermediate point.
- ❑ true
- ❑ false

23. When hoisting, which position of the hoist controller will result in the slowest speed?
- ❑ first position
- ❑ second position
- ❑ third position
- ❑ fourth position

24. Determine if this statement is true or false. On 3rd point hoisting, the load will increase in speed for light loads and start to move with heavy loads.
- ❑ true
- ❑ false

25. Determine if the statement is true or false: On cranes [illegible] [illegible] [illegible].

❑ True ❑ False

26. Determine if the statement is true or false: The [illegible] [illegible] [illegible].

❑ True ❑ False

27. Which term is used to describe very short, slow movements during hoisting operations?

❑ Inching
❑ Jogging
❑ Plugging
❑ Sneaking

28. As the operator in a cab-operated crane, if you must use two control handles at the same time, one hand should always be on the ...

❑ Bridge controller
❑ Trolley controller
❑ Hoist controller

29. Determine if the statement is true or false: A [illegible] [illegible] [illegible].

❑ True ❑ False

30. Which of the following is a hazardous practice when using a magnet for hoisting?

❑ Contact with water
❑ Allowing it to get excessively hot
❑ Hoisting of high pressure gas cylinders
❑ All of the above

31. Determine if the statement is true or false: Overhead crane [illegible] require a safety [illegible].

❑ True ❑ False

32. Determine if the statement is true or false: [illegible].

❑ True ❑ False

33. Determine if the statement is true or false: The [illegible] [illegible] OSHA [illegible].

❑ True ❑ False

34. Determine if this statement is true or false. A 6 x 37 wire rope classification has good flexibility and is generally suitable for use on overhead cranes.

❑ true ❑ false

35. The hoist wire rope on an overhead crane will typically have a working load limit safety factor of:

❑ 3 to 1
❑ 4 to 1
❑ 5 to 1
❑ 10 to 1

36. Referring to the chart on page 175, what is the nominal breaking strength in tons for a 1 inch diameter Improved Plow Steel wire core rope?

❑ 41.8
❑ 44.9
❑ 51.7
❑ 57.5

37. What is the purpose of a hoist limit switch?

❑ prevent overloading
❑ prevent pulling load block into drum
❑ prevent excessive bridge travel
❑ prevent excessive trolley travel

38. The hoist limit switch operation should be checked:

❑ each shift
❑ daily
❑ weekly
❑ monthly

39. Determine if this statement is true or false. Two possible methods of overload detection for overhead cranes are a dynamometer attached to the crane hook or an in-cab computerized digital readout.

❑ true ❑ false

40. A overhead crane [illegible] visual inspection [illegible]?
- ☐ every shift
- ☐ every week
- ☐ every month
- ☐ every year

41. What process must be followed [illegible] working on an overhead crane?
- ☐ lift hook to highest level
- ☐ notify supervisor
- ☐ turn off power
- ☐ use a lockout procedure

42. Under what circumstances [illegible] overhead crane [illegible]?
- ☐ [illegible] possible
- ☐ after approval by the superintendent
- ☐ only after approval by the OCHS OS+A department

43. Determine if this statement is true or false: [illegible]
- ☐ true
- ☐ false

SECTION TWELVE

APPENDIX

Weights Of Materials (Based on Volume)

Material	lbs. per cu. ft
METALS	
Aluminum	165
Brass	535
Bronze	[illegible]
Copper	560
Iron	480
Lead	710
Steel	490
Tin	[illegible]
MASONRY	
Ashlar masonry	140-160
Brick masonry, soft	110
Brick masonry, common (about 3 tons per thousand)	125
Brick masonry, pressed	140
Clay tile masonry, average	60
Rubble masonry	130-155
Concrete, cinder, haydite	100-110
Concrete, slag	130
Concrete, stone	144
Concrete, stone, reinforced (4050 lbs per cu. yd.)	150
ICE AND SNOW	
Ice	56
Snow, dry, fresh fallen	8
Snow, dry, packed	12-25
Snow, wet	27-40
MISCELLANEOUS	
Asphalt	80
Tar	75
Glass	160
Paper	60
Oils	58
TIMBER, AIR-DRY	
Cedar	22
Fir, Douglas, seasoned	34
Fir, Douglas, unseasoned	40
Fir, Douglas, wet	50
Fir, Douglas, glue laminated	34
Hemlock	30
Pine	30
Poplar	30
Spruce	28

Table #74 - Weights of Miscellaneous Materials

Weights Of Materials (Based on Volume) Material	lbs. per cu. ft.
LIQUIDS	
Alcohol, pure	49
Gasoline	42
Oils	58
Water	62
EARTH	
Earth, wet	100
Earth, dry (about 2050 lbs. per cu. yd.)	76
Sand and gravel, wet	120
Sand and gravel, dry	105
River sand (about 3240 lbs. per cu. yd.)	120

Weights Of Materials (Based on Volume) Material	lbs. per cu. ft.
BUILDING MATERIALS	
Portland Cement	94
Concrete-Stone	144
Concrete Reinforced	150
Earth-Dry, Loose	76
Earth-Packed, Wet	96
Gravel-Loose, Dry	110
Gravel-Packed, Wet	113
Granite	167
Limestone	165

Conversions

lbs x 27 = weight per cubic yard

lbs x 35.31 = weight per cubic metre

lbs ÷ 2.2 = weight in kg

Table #74 (cont'd.) - Weights of Miscellaneous Materials

Concrete Bucket Sizes and Weights

Bucket Size cu. yd.	Outside Diameter inches	Loading Height Inches	Weight in pounds LW*	GP*	HW*
[illegible]	36	34	240	330	-
[illegible]	42	40	260	440	-
[illegible]	50	45	320	577	-
[illegible]	57-61	46-56	400	643	1910
[illegible]	60-64	54-61	450	778	2075
2	61-71	57-75	642	1123	2343
3	71	87	-	-	4250
4	77	100	-		5150
6	96	118	-	-	7250
8	96	123	-	-	9000

1 cu. yd. = 0.76 m³, 1 in = 25.4 mm, 1 pound = 0.45 kg
LW - Light Weight Buckets used with small cranes.
GP - General Purpose concrete buckets
HW - Heavyweight Bucket used for concrete with large aggregates of 1.5 inch
Reinforced concrete - 150 lb/cu.ft = 4050 lb/cu.yd = 2400 kg/m³

Table #75 - Concrete Bucket Weights

Weight of Imperial and Metric Reinforcing Bars

Imperial Weight

Bar Size	lb/ft	kg/m
#3	0.376	0.56
#4	0.668	0.994
#5	1.043	1.552
#6	1.502	2.235
#7	2.044	3.042
#8	2.67	3.973
#9	3.4	5.06
#10	4.303	6.404
#11	5.313	7.907
#14	7.65	11.384
#18	13.6	20.239

Metric Mass

Bar Designation	kg/m	lb/ft
10M	0.785	0.527
15M	1.57	1.055
20M	2.355	1.582
25M	3.925	2.637
30M	5.495	3.692
35M	7.85	5.275
45M	11.775	7.912
55M	19.625	13.188

Table #76 - Weights of Rebar

Weights of Seamless and Welded Pipe (in pounds)

Nominal Pipe Size	STD	X.S.	X.X.S.	10	20	30	40	50	60	100	120	140	160
							Schedule Number						
2	3.65	5.02	9.03				3.65		5.02				7.46
2 1/2	5.79	7.66	13.70				5.79		7.66				10.01
3	7.58	10.25	18.58				7.58		10.25				14.31
3 1/2	9.11	12.51					9.11		12.51				
4	10.79	14.98	27.54				10.79		14.98		[illegible]		22.52
5	14.62	20.78	38.55				14.62		20.78		27.04		32.96
6	18.97	28.57	53.16				18.97		28.57		36.39		45.34
8	28.55	43.39	72.42		22.36	24.70	28.55	35.64	43.39	50.95	60.71	67.76	74.69
10	40.48	54.74	104.13		28.04	34.24	40.48	54.74	64.43	77.03	89.29	104.13	115.64
12	49.56	65.42	125.49		33.38	43.77	53.52	73.22	88.57	107.29	125.49	139.58	160.33
14	54.57	72.09		36.71	45.68	54.57	63.37	85.01	106.13	130.79	150.76	170.22	189.15
16	62.58	82.77		42.05	52.36	62.58	82.77	107.54	136.58	164.86	192.40	223.57	245.22
18	70.59	93.45		47.39	59.03	82.06	104.76	138.17	170.84	208.00	244.14	274.30	308.55
20	78.60	104.13		52.73	78.60	104.13	123.06	166.50	208.92	256.15	296.37	341.10	379.14
22	86.61	114.81		58.07	86.61	114.81		197.42	250.82	302.88	353.61	403.01	451.07
24	94.62	125.49		63.41	94.62	140.80	171.17	238.35	296.58	367.45	429.39	483.24	542.13
26	102.63	136.17		85.73	136.17								
28	110.64	146.85		98.41	146.85	182.73							
30	118.65	157.53		98.93	157.53	196.08							
32	126.66	168.21		105.76	168.21	209.43	229.92						
34	134.67	178.89		112.43	178.89	222.78	244.51						
36	142.68	189.57		119.11	189.57	236.13	282.35						
42	166.71	221.61			221.61	276.77	330.41						

Pipe weights shown above are given in pounds per lineal foot of plain end pipe. To convert lbs/ft to metric 1 lb/ft = 1.49 kg/m

Table #?? - Weight of Pipes

Useful Formulas

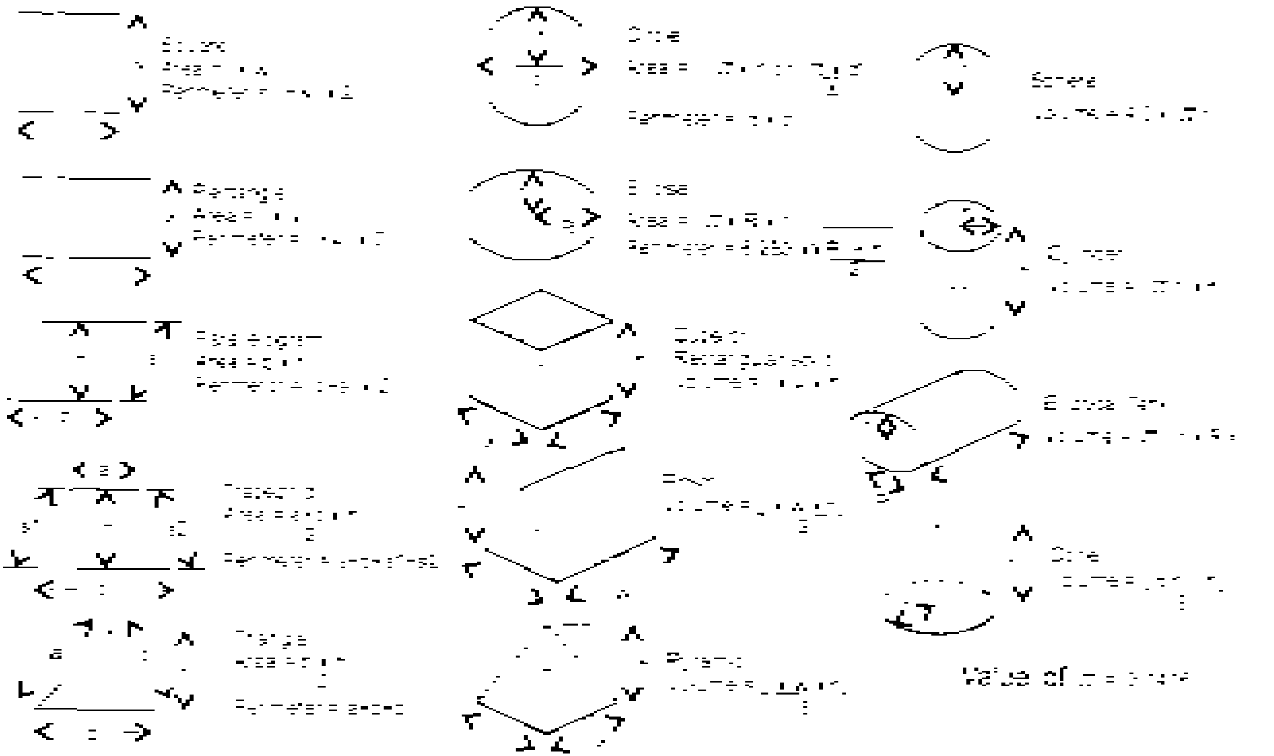


Table #7[illegible] - Useful Mathematical Formulas

Weight of Steel Plate

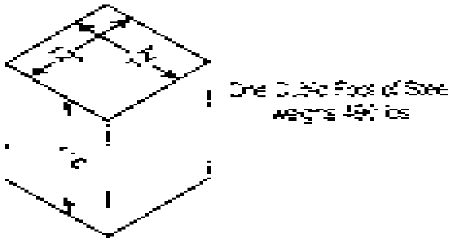


Illustration #555 - Cubic Foot of Steel

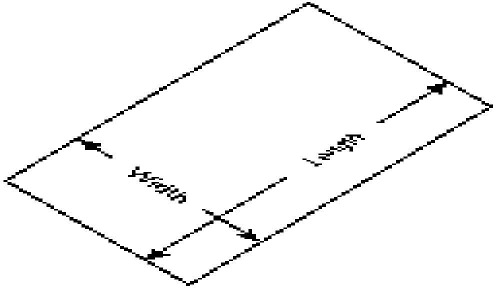


Illustration #556 - Area of Steel Plate

One cubic foot of steel plate = 490 pounds.

490 / 12 = 40.8 lbs/sq.ft. per inch thickness

This 40.8 lbs/sq.ft. per inch of thickness is rounded off to 40 for convenience.

Therefore every 1/8 inch of plate one foot square = 5 lbs.

- 1/8" = 5 lbs. 1/4" = 10 lbs.
- 3/8" = 15 lbs. 1/2" = 20 lbs.
- 5/8" = 25 lbs. 3/4" = 30 lbs.
- 7/8" = 35 lbs. 1" = 40 lbs.

Area = Length x Width A = L x W

Weight = Area (in sq. ft.) x Weight/sq. ft.

Example:

4 ft. x 12 ft. x 7/8" steel plate.

A = L x W

A = 4 x 12 = 48 sq. ft.

Weight = Area x Wt. sq. ft.

Weight = 48 sq. ft. x 35 lbs./sq. ft.

= 1680 pounds.

Rectangular Container

Weight = Area of All Sides (in sq. ft.)
x Weight/sq. ft.

Volume = Area of Base x Height

Weight of Contents = Cu. ft. x Weight/cu. ft.

Weight of Cylindrical Objects

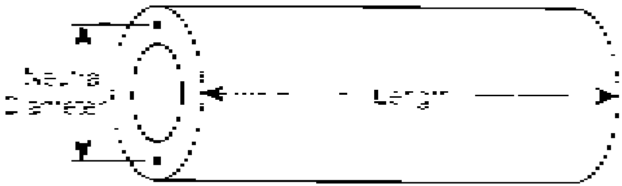


Illustration #557 - Neutral diameter of a Pipe

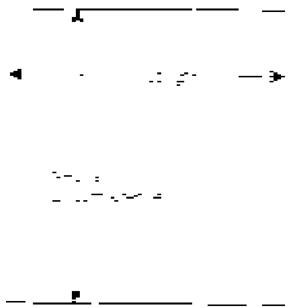


Illustration #558 - Surface Area of a Pipe

1. Measure thickness to get wt. sq.ft.
2. Measure neutral diameter
3. Circumference = neutral diameter x 3.14.
4. Convert circumference to feet
5. Area = Circumference (ft.) x Length (ft.)
6. Weight = Area in sq.ft. x Wt. sq.ft.

Weight Example

18 inch pipe, [illegible] wall, 20' - 9" long

1. Wt. sq.ft. ([illegible]) = 15 pounds
2. Neutral diameter = 17 [illegible] - 5 [illegible]
   1.4688 ft.
3. Circumference = Diameter x 3.14
   1.4688 x 3.14 = 4.61 ft.
4. Length = 20'-9" = 20.75 ft.
5. Area = Circumference x Length
   = 4.61 ft. x 20.75 ft.
   = 95.66 sq.ft.
6. Weight = Area x Wt. sq.ft.
   = 95.66 sq.ft. x 15 lbs. sq.ft.
   = 1435 pounds

Weights of Structural Shapes

Calculate the weight of each part and add them together, or refer to a steel data book for weight per lineal foot of various structural shapes.

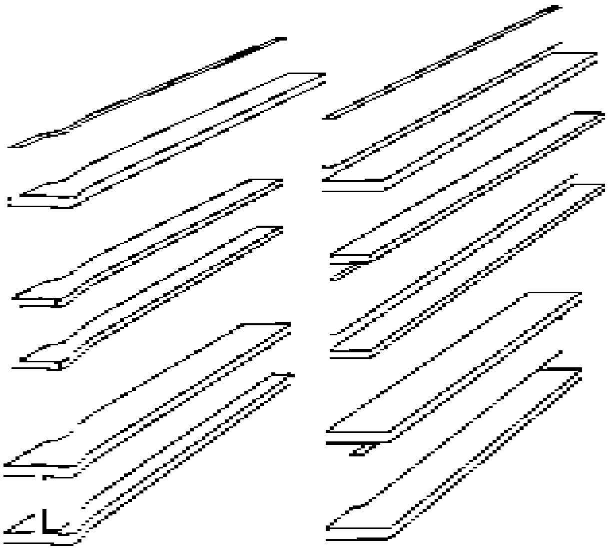


Illustration #559 - Weight of Structural Shapes

Use of Equivalent Tables

For tables #6 to #9, units in the left hand column are equivalent to the number under each unit across the top.

For example in the length table, one m (metre) in the first column of the length table is equivalent to 39.37 inches under the inches column.

In the tables, "scientific notation" is used to express large numbers with several zeros. To interpret these numbers, move the decimal to the left or right as dictated by the exponent.

For example, $9.53 \times 10^4 = 95300$ (4 decimal places to right).

A negative moves the decimal left.

Therefore $9.53 \times 10^{-4} = 0.000953$ (4 decimal places to the left).

	mm	cm	dm	m	Inches	Feet	Yards	Miles
mm	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
dm	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Inches	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]
Feet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Yards	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Miles	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table #79 - Imperial-Metric Equivalents (Length)

	mm^2	cm^2	dm^2	m^2	Square Inches	Square Feet
mm^2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
cm^2	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
dm^2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
m^2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Square Inches	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
Square Feet	[illegible]	[illegible]	[illegible]	[illegible]	144	[illegible]

Table #80 - Imperial-Metric Equivalents (Area)

	Cubic cm	litres	Cubic m	Cubic Inches	Cubic Feet	US Gallon	Can. Gallon	US Barrels
Cubic cm		1×10^{-3}	1×10^{-6}	61.024×10^{-3}	0.0353×10^{-3}	0.2642×10^{-3}	0.21997×10^{-3}	0.00629×10^{-3}
litres	1000		1×10^{-3}	61.024	0.0353	0.2642	0.22	0.00629
Cubic m	1×10^{6}	1000		61023.744	35.3147	264.2	219.9694	6.29
Cubic Inches	1.6387	0.0164	1.638706×10^{-5}		5.787×10^{-4}	4.329×10^{-3}	3.606×10^{-3}	1.03×10^{-4}
Cubic Feet	2.8317×10^{4}	28.3170	2.8317×10^{-2}	1728		7.48055	6.22883	0.1781
US Gallon	3.785×10^{3}	3.78541	3.785×10^{-3}	231	0.1337		0.833	2.38×10^{-2}
Can. Gallon	4.546×10^{3}	4.54609	4.546×10^{-3}	277.4193	0.1605	1.20095		2.877×10^{-2}
US Barrels	158.98×10^{3}	158.98	0.15898	9701.856	5.6145	42	34.973	

Table #[illegible] - Imperial-Metric Equivalents [Volume]

	Ounce	Pound	milligram	gram	kilogram	Short Ton	Long Ton	Metric Tonne
Ounce		0.0625	28344.57	28.3447	0.02835	3.125×10^{-5}	2.79×10^{-5}	2.835×10^{-5}
Pound	16		453287.5	453.2875	0.4535	0.0005	4.464×10^{-4}	4.536×10^{-4}
milligram	35.28×10^{-6}	2.205×10^{-6}		0.001	1.001×10^{-6}	1.102×10^{-9}	9.842×10^{-10}	1×10^{-9}
gram	35.28×10^{-3}	2.205×10^{-3}	1000		0.001	1.102×10^{-6}	9.842×10^{-7}	1×10^{-6}
kilogram	35.28	2.205	1×10^{6}	1000		1.102×10^{-3}	9.842×10^{-4}	0.001
Short Ton	32000	2000	907.2×10^{6}	907.2×10^{3}	907.2		0.8929	0.907
Long Ton	35840	2240	1016×10^{6}	1016×10^{3}	1016	1.12		1.016
Metric Tonne	35280	2205	1×10^{9}	1×10^{6}	1000	1.102	0.9842	

Table #[illegible] - Imperial-Metric Equivalents [Mass]

Decimal Equivalents	
Fraction	Decimal
1/64	0.015625
1/32	0.03125
3/64	0.046875
1/16	0.0625
5/64	0.078125
3/32	0.09375
7/64	0.109375
1/8	0.125
9/64	0.140625
5/32	0.15625
11/64	0.171875
3/16	0.1875
13/64	0.203125
7/32	0.21875
15/64	0.234375
1/4	0.25
17/64	0.265625
9/32	0.28125
19/64	0.296875
5/16	0.3125
21/64	0.328125
11/32	0.34375

Decimal Equivalents	
Fraction	Decimal
23/64	0.359375
3/8	0.375
25/64	0.390625
13/32	0.40625
27/64	0.421875
7/16	0.4375
29/64	0.453125
15/32	0.46875
31/64	0.48438
1/2	0.5
33/64	0.515625
17/32	0.53125
35/64	0.546875
9/16	0.5625
37/64	0.578125
19/32	0.59375
39/64	0.609375
5/8	0.625
41/64	0.640625
21/32	0.65625
43/64	0.671875
11/16	0.6875

Decimal Equivalents	
Fraction	Decimal
45/64	0.703125
23/32	0.71875
47/64	0.734375
3/4	0.75
49/64	0.765625
25/32	0.78125
51/64	0.796875
13/16	0.8125
53/64	0.828125
27/32	0.84375
55/64	0.859375
7/8	0.875
57/64	0.890625
29/32	0.90625
59/64	0.921875
15/16	0.9375
61/64	0.953125
31/32	0.96875
63/64	0.984375
1	1.000

Table #83 - Decimal Equivalents

Threaded Fasteners - Descriptions and Standards

ASTM and SAE Grade Markings for Steel Bolts and Screws

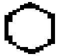
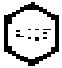
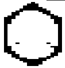
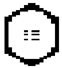
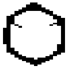
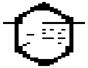
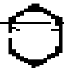
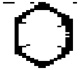
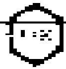
Grade Marking	Specification	Material	Grade Marking	Specification	Material
	SAE-Grade 1 ASTM-A 307 SAE-Grade 2	Low or Medium Carbon Steel Low Carbon Steel Low or Medium Carbon Steel		ASTM-A 325 Type 3	Atmospheric Corrosion (Weathering) Steel, Quenched and Tempered
	SAE-Grade 5 ASTM-A 449	Medium Carbon Steel, Quenched and Tempered		ASTM-A 354 Grade BB	Low Alloy Steel, Quenched and Tempered
	SAE-Grade 5.2	Low Carbon Martensite Steel, Quenched and Tempered		ASTM-A 354 Grade BC	Low Alloy Steel, Quenched and Tempered
	ASTM-A 325 Type 1	Medium Carbon Steel, Quenched and Tempered		SAE-Grade 7	Medium Carbon Alloy Steel, Quenched and Tempered, Roll Threaded After Heat Treatment
	ASTM-A 325 Type 2	Low Carbon Martensite Steel, Quenched and Tempered		SAE-Grade 8 ASTM-A 354 Grade BD	Medium Carbon Alloy Steel, Quenched and Tempered Alloy Steel, Quenched and Tempered
		Note: Ensure both nut and washer match the applicable bolt and stud		ASTM-A 490	Alloy Steel, Quenched and Tempered

Table 484 - Bolt Head Markings

Tightening Torque Guide

SAE Grade 5 - Coarse Thread

Size	Clamp Load	Plain	Plated
1/4-20 (.250)	2,025	8 ft lbs	6 ft lbs
5/16-18 (.3125)	3,338	17 ft lbs	13 ft lbs
3/8-16 (.375)	4,950	31 ft lbs	23 ft lbs
7/16-14 (.4375)	6,788	50 ft lbs	37 ft lbs
1/2-13 (.500)	9,075	76 ft lbs	57 ft lbs
9/16-12 (.5625)	11,625	109 ft lbs	82 ft lbs
5/8-11 (.625)	14,400	150 ft lbs	112 ft lbs
3/4-10 (.750)	21,300	266 ft lbs	200 ft lbs
7/8-9 (.875)	29,475	430 ft lbs	322 ft lbs
1-8 (1.000)	38,625	644 ft lbs	483 ft lbs
1 1/8-7 (1.125)	42,375	794 ft lbs	596 ft lbs
1 1/4-7 (1.250)	53,775	1120 ft lbs	840 ft lbs
1 3/8-6 (1.375)	64,125	1469 ft lbs	1102 ft lbs
1 1/2-6 (1.500)	78,000	1950 ft lbs	1462 ft lbs

Table #85 - SAE Grade 5 - Coarse

Tightening Torque Guide

SAE Grade 5 - Fine Thread

Size	Clamp Load	Plain	Plated
1/4-28 (.250)	2,325	10 ft lbs	7 ft lbs
5/16-24 (.3125)	3,675	19 ft lbs	14 ft lbs
3/8-24 (.375)	5,588	35 ft lbs	26 ft lbs
7/16-20 (.4375)	7,575	55 ft lbs	41 ft lbs
1/2-20 (.500)	10,200	85 ft lbs	64 ft lbs
9/16-18 (.5625)	12,975	122 ft lbs	91 ft lbs
5/8-18 (.625)	16,350	170 ft lbs	128 ft lbs
3/4-16 (.750)	23,775	297 ft lbs	223 ft lbs
7/8-14 (.875)	32,475	474 ft lbs	355 ft lbs
1-12 (1.000)	42,300	705 ft lbs	529 ft lbs
1-14 (1.000)	43,275	721 ft lbs	541 ft lbs
1 1/8-12 (1.125)	47,475	890 ft lbs	668 ft lbs
1 1/4-12 (1.250)	59,550	1241 ft lbs	930 ft lbs
1 3/8-12 (1.375)	72,975	1672 ft lbs	1254 ft lbs
1 1/2-12 (1.500)	87,750	2194 ft lbs	1645 ft lbs

Table #86 - SAE Grade 5 - Fine

Tightening Torque Guide

SAE Grade 8 - Coarse Thread

Size	Clamp Load	Plain	Plated
1/4-20 (.250)	2,850	12 ft. lbs	9 ft. lbs.
5/16-18 (.3125)	4,725	25 ft. lbs	18 ft. lbs
3/8-16 (.375)	6,975	44 ft. lbs	33 ft. lbs
7/16-14 (.4375)	9,600	70 ft. lbs	52 ft. lbs.
1/2-13 (.500)	12,750	106 ft. lbs.	80 ft. lbs.
9/16-12 (.5625)	16,350	153 ft. lbs.	115 ft. lbs
5/8-11 (.625)	20,325	212 ft. lbs.	159 ft. lbs.
3/4-10 (.750)	30,075	376 ft. lbs.	282 ft. lbs.
7/8-9 (.875)	41,550	606 ft. lbs.	454 ft. lbs.
1-8 (1.000)	54,525	909 ft. lbs.	682 ft. lbs.
1 1/8-7 (1.125)	68,700	1288 ft. lbs.	965 ft. lbs.
1 1/4-7 (1.250)	87,225	1817 ft. lbs.	1363 ft. lbs.
1 3/8-6 (1.375)	105,950	2382 ft. lbs.	1787 ft. lbs.
1 1/2-6 (1.500)	126,450	3161 ft. lbs.	2371 ft. lbs.

Table #87 - SAE Grade 8 - Coarse

Tightening Torque Guide

SAE Grade 8 - Fine Thread

Size	Clamp Load	Plain	Plated
1/4-28 (.250)	3,250	14 ft. lbs	10 ft. lbs.
5/16-24 (.3125)	5,113	27 ft. lbs	20 ft. lbs.
3/8-24 (.375)	7,875	49 ft. lbs	37 ft. lbs
7/16-20 (.4375)	10,650	78 ft. lbs	58 ft. lbs.
1/2-20 (.500)	14,400	120 ft. lbs.	90 ft. lbs.
9/16-18 (.5625)	18,300	172 ft. lbs.	129 ft. lbs.
5/8-18 (.625)	23,025	240 ft. lbs.	180 ft. lbs.
3/4-16 (.750)	33,600	420 ft. lbs	315 ft. lbs.
7/8-14 (.875)	45,825	668 ft. lbs.	501 ft. lbs.
1-12 (1.000)	59,700	995 ft. lbs.	746 ft. lbs.
1-14 (1.000)	61,125	1019 ft. lbs.	754 ft. lbs.
1 1/8-12 (1.125)	77,025	1444 ft. lbs.	1083 ft. lbs.
1 1/4-12 (1.250)	96,600	2012 ft. lbs.	1509 ft. lbs.
1 3/8-12 (1.375)	118,350	2712 ft. lbs.	2034 ft. lbs.
1 1/2-12 (1.500)	142,275	3557 ft. lbs	2668 ft. lbs.

Table #88 - SAE Grade 8 - Fine

Rated Loads for Single Ply, Class 5, Synthetic Web Slings (in pounds)

Hitch Type	Types I, II, III and IV Single Leg			Two-Leg or Single Basket Horizontal Angle				Type V Endless Vertical
Width (inches)	Vertical	Choker	Basket	Vertical	60 deg	45 deg	30 deg	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Notes:

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]

Table [illegible] - Single Ply, Class 5, Synthetic Web Slings

Rated Loads for Heavy Duty Metal Mesh Slings (in pounds) Design Factor = 5					
Width (inches)	Vertical Choker	Basket	60 deg	45 deg	30 deg
2	1,600	3,200	2,770	2,260	1,600
3	3,000	6,000	5,200	4,240	3,000
4	4,400	8,800	7,620	6,220	4,400
6	6,600	13,200	11,430	9,330	6,600
8	8,800	17,600	15,240	12,440	8,800
10	11,000	22,000	19,050	15,550	11,000
12	13,200	26,400	22,860	18,660	13,200
14	15,400	30,800	26,670	21,770	15,400
16	17,600	35,200	30,480	24,880	17,600
18	19,800	39,600	34,290	28,000	19,800
20	22,000	44,000	38,100	31,100	22,000

Widely used where loads are abrasive, hot or other applications that tend to cut other types of slings.
Slings feature: A smooth bearing surface, flexibility to conform, to abrasion and cutting resistance to temperatures up to 550 degrees.

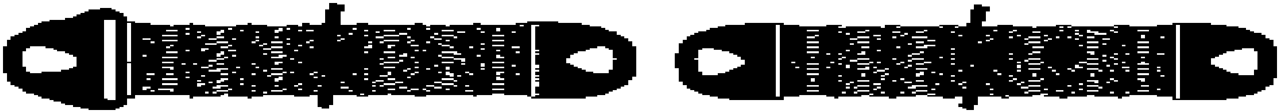
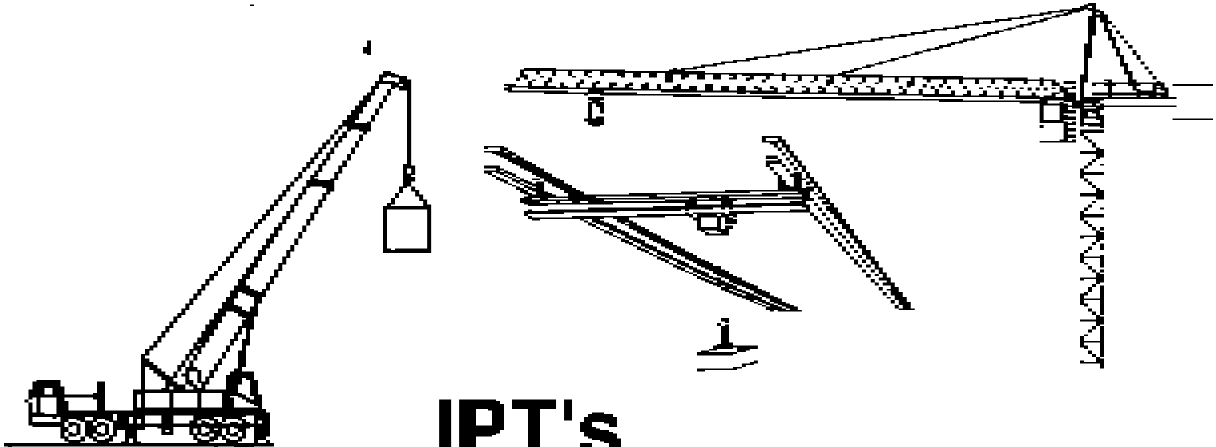


Table [illegible] - Rated Load for Metal Mesh Slings



IPT's
CRANE and RIGGING
ANSWER BOOK

RONALD G. GARBY

SECTION ONE ANSWERS

Rigging

Instructions: All answers are shown with the question. Correct answers (✓) are in bold. **(Reference Page #)**

1. Determine if this statement is true or false. The two types of wire rope center core designs are fiber core and independent wire rope core.
   ✓ **true** ❑ false **Page 2**

2. What is the percentage gain in strength using an IWRC versus a fiber core wire rope?
   ❑ 3.5
   ❑ 5.5
   ✓ **7.5** **Page 3**
   ❑ 9.5

3. What characteristic increases in a wire rope by using a rope with more strands and more wires in the strands?
   ❑ rigidity
   ❑ breaking strength
   ❑ lubrication
   ✓ **flexibility** **Page 3**

4. Determine if this statement is true or false. Grade 110/120 Improved Plow Steel has the highest tensile strength of any type of wire rope.
   ❑ true ✓ **false** **Page 4**

5. A regular lay wire rope has strands and wires in the strands that:
   ❑ are all laid in the right hand direction
   ❑ are all laid in the left hand direction
   ✓ **are laid in opposite directions** **Page 5**
   ❑ are all laid in the same direction

6. Due to its tendency to unwind, which wire rope should **NOT** be used on single part hoisting lines?
   ❑ regular lay
   ✓ **lang lay** **Page 6**
   ❑ alternate lay
   ❑ none of the above

7. Determine if this statement is true or false. A 6 x 19 wire rope classification could have as many as 16 to 26 wires per strand.
   ✓ **true** ❑ false **Page 7**

8. When wire rope classification is listed as non-rotating?
- ❑ 3 strand
- ❑ 6 strand
- ❑ 19 strand
- ✓ **35 strand** **Page 9**

9. When a non-rotating rope is used in a wedge socket, care must be taken to prevent:
- ✓ **core slippage** **Page 10**
- ❑ rope from unraveling
- ❑ wire slippage
- ❑ strand slippage

10. A rotation resistant wire rope may have a smaller Working Load Limit (WLL) than an equal size 6 x 37 IWRC because:
- ❑ IWRC has a higher ultimate load (breaking strength)
- ❑ rotating resistant requires higher working load limit
- ✓ **both of the above** **Page 11**

11. When hoisting personnel on a crane equipped with rotating resistant wire rope, what is the Design (safety) Factor required by most safety standards?
- ❑ 3.5:1
- ❑ 5:1
- ❑ 7:1
- ✓ **10:1** **Page 11**

12. Newer designs of wire rope with shaped wires and triangular strands are an attempt to prevent rope damage from:
- ❑ multiple drum layers
- ❑ cross winding
- ❑ improper tensioning
- ✓ **all of the above** **Pages 12, 13**

13. Referring to the number of broken wires allowed in a wire rope, the "Rule of Thumb" for determining replacement is:
- ❑ 2/6
- ✓ **3/6** **Page 18**
- ❑ 4/6
- ❑ 2/12

14. Wire rope should be replaced if the wear in the outer strand wires exceeds:

- ☐ 1/16 of original diameter
- ☐ 1/8 of original diameter
- ✓ **1/3 of original diameter** ***Page 18***
- ☐ 1/4 of original diameter

15. Determine if the following statement is true or false. When inspecting wire rope, internal broken wires and corrosion can be detected by magnetic particle testing.

- ✓ **true** ☐ false ***Page 19***

16. Corrosion of wire rope is usually caused from:

- ☐ metal fatigue
- ☐ broken wires
- ☐ high speed operation
- ✓ **lack of lubrication** ***Page 19***

17. Which product below is considered a suitable lubricant for use on a wire rope?

- ✓ **light mineral oil** ***Page 23***
- ☐ vegetable oil
- ☐ grease
- ☐ used crankcase oil

18. To avoid kinking wire rope when spooling it onto a drum from the shipping reel, the operator should always:

- ✓ **allow the reel to rotate freely** ***Page 26***
- ☐ keep the reel stationary
- ☐ always suspend the reel in a vertical position
- ☐ always suspend the reel in a horizontal position

19. What is the Rule of Thumb formula to find the ultimate load (breaking strength) of an IWRC wire rope?

- ☐ $D^2 \times 42$
- ✓ **$D^2 \times 45$** ***Page 27***
- ☐ $D^2 \times 5$
- ☐ $D^2 \times 10$

20. When the ultimate load (breaking strength) of a wire rope is divided by a safety (design) factor, the result is called the:

- ☐ ultimate tensile load
- ☐ nominal strength of rope
- ☐ yield strength of rope
- ✓ **working load limit (SWL)** ***Page 29***

21. What happens when a wire rope is bent around a sheave or a hook?
- ❐ nominal strength does not change
- ✓ **nominal strength is reduced** ***Page 31,32***
- ❐ outside strands are in compression
- ❐ inside strands are in tension

22. A 1 inch wire rope eye sling [illegible] lifting a load with a 1 inch shackle will be approximately how efficient?
- ❐ 100%
- ❐ 75%
- ✓ **50%** ***Page 32***
- ❐ 25%

23. Referring to slings, the terms "Rated Capacity" or "Working Load Limit" replaces the old terminology of:
- ❐ safety factor
- ❐ breaking strength
- ❐ rule of thumb
- ✓ **safe working load** ***Page 33***

24. What is the minimum Design (Safety) Factor for general sling use?
- ❐ 3 to 1
- ✓ **5 to 1** ***Page 33***
- ❐ 7 to 1
- ❐ 10 to 1

25. Determine if this statement is true or false. A 4-leg bridle sling will always carry the load weight equally on all 4 legs.
- ❐ true ✓ **false** ***Page 36***

26. With an improved plow wire rope sling, the preferred D/d basket hitch ratio is:
- ✓ **25 to 1** ***Page 38***
- ❐ 20 to 1
- ❐ 15 to 1
- ❐ 10 to 1

27. Determine if this statement is true or false. A sling wrapped around a rectangular load in a basket is rated at the full basket hitch Working Load Limit.
- ❐ true ✓ **false** ***Page 40***

28. When slinging a bundle of pipe or tubing, which of the following would provide the best contact between sling and load?

- ☐ double basket
- ☐ bridle hitch
- ✓ **two double wrap chokers** — **Page 43**
- ☐ single leg choker

29. Determine if this statement is true or false. Because all wire slings are manufactured identically, the [illegible] leg does not [illegible] the rated load.

- ☐ true
- ✓ **false** — **Page 46**

30. Determine if this statement is true or false. Synthetic slings can be safely used under any environmental circumstances.

- ☐ true
- ✓ **false** — **Page 45**

31. Referring to the standard format of a sling load chart, the angle between the top of the load and the sling leg is called the:

- ☐ double angle
- ☐ working angle
- ☐ vertical angle
- ✓ **horizontal angle** — **Page 50**

32. Using two slings on the load, at what degree angle to the horizontal is the load on each sling considered to be equal to the weight of the load?

- ☐ 15
- ✓ **30** — **Page 52**
- ☐ 45
- ☐ 60

33. Calculate, using the recommended safe lifting angle, the distance between the [illegible] connecting the [illegible] using two 12 foot slings.

- ☐ 6 feet
- ☐ 8 feet
- ☐ 10 feet
- ✓ **12 feet** — **Page 53**

34. Using the basic "Riggers Rule" [illegible], calculate the load in pounds on each sling leg using two 12 foot slings with a vertical distance to hook point of 6 feet and a load of 6,000 pounds.

- ☐ 12,000
- ☐ 8,000
- ✓ **6,000** — **Page 55**
- ☐ 4,000

35. Is the following statement true or false? The standard Riggers Rule sling load formula can be applied to a non-symmetrical shaped load lifted with 2 sling legs.
   - ❑ true
   - ✓ **false** ***Page 56, 62***

36. What happens to the rigging hardware when sudden movements or shock loading occurs?
   - ✓ **increased load stress** ***Page 64***
   - ❑ decreased load stress
   - ❑ no load stress if load is below the WLL
   - ❑ load weight will decrease

37. Is the following statement true or false? Using a high line to lift a load inside a building does not require consultation with a structural engineer.
   - ❑ true
   - ✓ **false** ***Page 65***

38. Which answer below is always embossed on good quality forged rigging hardware? Pick the best answer.
   - ❑ date of manufacture
   - ❑ diameter of pin
   - ✓ **traceable code number** ***Page 70***
   - ❑ ultimate breaking strength

39. Safety regulations prohibit the use of [illegible] made hoisting [illegible]
   - ✓ **true**
   - ❑ false ***Page 70***

40. Correctly installed U-bolt type wire rope clips are installed with the U portion of the clip on the:
   - ✓ **dead or short end** ***Page 71***
   - ❑ on the live or long end
   - ❑ installed either way
   - ❑ alternating up and down

41. When compared to the rated size of the body, of a shackle, the diameter of the pin is always:
   - ❑ same size
   - ✓ **larger than body** ***Page 75***
   - ❑ smaller than body
   - ❑ depends on manufacturer

42. Shackles are only rated for their maximum capacity when used for what type of pull?
   - ✓ **straight line pull** ***Page 75***
   - ❑ 90 degree pull
   - ❑ 45 degree pull
   - ❑ designed for any angle pull

43. With two shackles or sling eyes in a hook, what is the suggested maximum included lifting angle?
- ❑ 0 degrees
- ❑ 45 degrees
- ✓ **90 degrees** *Page 75*
- ❑ 180 degrees

44. A wedge socket must be attached with the load line pulling in a straight line from the:
- ❑ wedge
- ❑ shank
- ❑ point
- ✓ **pin** *Page 81*

45. Determine if this statement is true or false. Referring to wedge sockets, it is permitted to clip the wire rope dead end to the load line.
- ❑ true
- ✓ **false** *Page 82*

46. Which type of eyebolt should be used if there is any possibility of an angular load?
- ✓ **shoulder type** *Page 83*
- ❑ shoulderless type

47. Determine if this statement is true or false. It is acceptable practice to lift a load at an angle less than 45 degrees to the horizontal with an eyebolt.
- ❑ true
- ✓ **false** *Page 83*

48. Custom fabricated lifting beams or any homemade lifting device must be:
- ❑ designed by an engineer
- ❑ have the rated capacity clearly stamped
- ❑ be test lifted at 125% of rated capacity
- ✓ **all of the above** *Page 91*

49. What safety requirement must be performed with a basket used to hoist personnel?
- ❑ proof test lift at 125% of capacity at each new site
- ❑ trial lift with anticipated weight before using
- ❑ trial lift each time crane is relocated
- ✓ **all of above** *Pages 92.93*

50. The "Rule of Thumb" minimum for wire rope to sheave ratio is:
- ✓ **20 to 1** *Pages 94-95*
- ❑ 30 to 1
- ❑ 40 to 1
- ❑ 50 to 1

51. What is the mechanical advantage ratio created by the top fixed sheave of a two block hoisting system?
- ✓ **none** ***Page 97***
- ❒ 2 to 1
- ❒ 4 to 1
- ❒ depends on number of sheaves

52. When determining the number of parts of line needed for rigging a system, what common factor makes the use of a ratio chart a necessity?
- ❒ block weight
- ✓ **friction** ***Pages 99, 100***
- ❒ length of wire rope
- ❒ diameter of drum

53. The main disadvantage of lace reeving is:
- ❒ line speed is constant
- ✓ **the blocks tilt toward each other** ***Page 104***
- ❒ blocks cannot be brought close together
- ❒ there are reverse bends

54. The main advantage of side opening snatch blocks is: Check the best answer.
- ❒ change direction of load
- ❒ change direction of wire rope
- ❒ swivel hook
- ✓ **ease of installing on wire rope** ***Page 112***

55. With the load suspended, a single block hoisting assembly has a each line pull of 200 pounds. If the lines are parallel, what is the load on the block?
- ❒ 600 pounds
- ✓ **400 pounds** ***Page 113***
- ❒ 200 pounds
- ❒ 100 pounds

56. When spooling wire rope from a reel to the bottom of a drum on a hoist drum, the wire rope must come off which part of the reel?
- ❒ top
- ✓ **bottom** ***Page 115***

57. A hoist drum is an overwind type using right lay wire rope. Where is the rope connected in relation to the hoist operator standing behind the drum?
- ✓ **left side** ***Pages 115, 116***
- ❒ right side
- ❒ could be either side
- ❒ depends on the rope size

58. If the wire rope hoist line coming off the drum is fed into a sheave, how must the sheave be positioned?
- ✓ **aligned with the proper fleet angle** ***Page 117***
- ❒ aligned with the left drum flange
- ❒ aligned with the right drum flange
- ❒ depends on the rope lay

59. As more wraps of wire rope are spooled onto a drum hoist, tugger, the available pull of the rope will

- ❑ increase
- ✓ **decrease** **Page 119**
- ❑ remain the same

60. Determine if this statement is true or false. Before using an air operated tugger, the air line should be blown out to remove excess moisture.

✓ **true** ❑ false **Page 121**

61. Determine if this statement is true or false. One advantage of a chain sling is that it can be safely shock loaded due to its elasticity.

❑ true ✓ **false** **Page 124**

62. Determine if this statement is true or false. Load binding chain is the type used for chain hoisting slings.

❑ true ✓ **false** **Page 125**

63. A matched set of chain slings with one leg longer than the others is likely an indication of

- ❑ cracked links
- ❑ twisted links
- ❑ hardened links
- ✓ **stretched links** **Page 126**

64. Determine if this statement is true or false. To safely increase the capacity of a Come-Along, a few foot long snipe can be used.

❑ true ✓ **false** **Page 134, 136**

65. Which of the following is NOT a typical type of jack for machinery rigging?

- ❑ ratchet
- ✓ **electric** **Page 140**
- ❑ screw
- ❑ hydraulic

66. Which of the following could be used to move a heavy load from an outside pad into a building?

- ❑ roller skid
- ❑ skate dolly
- ❑ air caster
- ✓ **all of above** **Page 144**

67. The most commonly used grade of natural fiber rope is

- ✓ **number one grade manila** **Page 147**
- ❑ number one grade hemp
- ❑ number one grade nylon
- ❑ number one grade sisal

68 Knots tied in fibre rope reduce the strength by approximately

- ❐ 10%
- ❐ 25%
- ❐ 35%
- ✓ **50%** **Page 151**

69 Which splice is used when forming an eye in fibre rope?

- ✓ **side splice** **Page 154**
- ❐ short splice
- ❐ long splice
- ❐ bowline splice

70 Which of the following can be used as a last resort emergency rescue knot?

- ❐ bowline on a bight
- ❐ self-centering bowline
- ✓ **spanish bowline** **Page 156**
- ❐ running bowline

71 This knot is known as a "killer" knot because it is often used improperly.

- ❐ bowline on the bight
- ❐ spanish bowline
- ✓ **reef knot** **Page 160**
- ❐ becket hitch

SECTION THREE ANSWERS

Pre-Lift Planning

Instructions: All answers are shown with the question. Correct answers (✓) are in bold. *(Reference Page #)*

1. Determine if this statement is true or false. All lift plans are complex and require an engineering staff and a site drawing.
   ❑ true ✓ **false** ***Page 176***

2. Determine if this statement is true or false. A documented pre-lift plan will state the names of the engineers and supervisors who have worked to prepare the plan.
   ✓ **true** ❑ false ***Page 176***

3. Determine if this statement is true or false. A documented pre-lift plan will state the names of the operators, and the riggers who will rig the load and perform the lift.
   ✓ **true** ❑ false ***Page 176***

4. Determine if this statement is true or false. There are standardized industry rules to specify what is classified as a critical lift.
   ❑ true ✓ **false** ***Page 177***

5. Which of the following would be classed as a critical lift?
   ❑ operating over or near powerlines
   ❑ two cranes working in tandem
   ❑ the load is close to the cranes' capacities
   ✓ **all of the above** ***Page 177***

6. Determine if this statement is true or false. Any load heavier than 75% of the rated capacity of a crane is a critical lift.
   ✓ **true** ❑ false ***Page 177***

7. Determine if this statement is true or false. A print or drawing of a lift never includes actual measurements or distances as they are usually too hard to calculate until the crane is hooked to the load.
   ❑ true ✓ **false** ***Page 178***

8. Determine if this statement is true or false. A detailed print or drawing of a lift eliminates guesswork.
   ✓ **true** ❑ false ***Page 178***

9. Determine if this statement is true or false. If a crane can sit firmly without the tracks or outriggers sinking into the ground prior to lifting the load, a soil analysis is never needed.
   ❑ true ✓ **false** ***Page 178, 179***

10. Determine if this statement is true or false. On a critical lift, it is necessary that the load radius, boom length, and boom angle are known when rigging to the load.

✓ true ❏ false **Page 179**

11. Determine if this statement is true or false. Using the crane load indicator as a scale to weigh a load is an accepted practice when preparing a lift plan.

❏ true ✓ **false** **Page 179**

12. Which of the following is the most satisfactory method of signaling on a two-crane lift?

❏ one person using hand signals for both cranes
❏ one person using hand signals for each crane
✓ **one person using voice communication**

Page 179,180

13. As the pre-lift items that must be investigated by a planning group are completed, the results are entered and filed in a series of:

❏ crane log books
❏ crane maintenance manuals
❏ inter-office memos
✓ **checklists** **Pages 180-187**

14. In Illustration #173, what is the load radius?

✓ **39 ft.** **Pages 195,196**
❏ 33 ft. 1 in.
❏ 29 ft. 3 in.
❏ 16 ft. 11 in.

15. In Illustration #173, what is the swing circle?

❏ 45 degrees
❏ 90 degrees
✓ **180 degrees** **Page 195**
❏ 270 degrees

16. Determine if this statement is true or false. In Illustration #173, there is only several inches of clearance between the boom and the building structure.

❏ true ✓ **false** **Page 196**

17. Determine if this statement is true or false. In Illustration #173, the crane capacity is 37,000 lbs.

❏ true ✓ **false** **Page 197**

18. In Illustration #174, what does the crane do during the lift process?

❏ swing clockwise and boom down
❏ swing clockwise and boom up
❏ swing counterclockwise, boom down
✓ **swing counterclockwise and boom up**

Pages 200,205

19. Determine if this statement is true or false. In Illustration #174, the crane boom is [illegible] of the [illegible].

- ❑ true
- ✓ false — Page 201

20. Determine if this statement is true or false. In Illustration #174, all [illegible] and shackles [illegible] load areas.

- ❑ true
- ✓ false — Page 201

21. Determine if this statement is true or false. In Illustration #175, the counterweight is attached prior to lifting the module.

- ❑ true
- ✓ false — Page 210

22. In Illustration #175, how many shackles are attached to the main load block?

- ❑ one
- ❑ two
- ✓ three — Page 208
- ❑ fourteen

23. In Illustration #175, what size shackle supports the [illegible] block?

- ❑ 25 ton
- ✓ 35 ton — Page 208
- ❑ 85 ton
- ❑ 110 ton

24. Determine if this statement is true or false. In Illustration #175, two cranes are used to lift the load off the ground.

- ✓ true
- ❑ false — Page 216

25. In Illustration #176, how many 110 ton shackles are used on the main crane [illegible]?

- ❑ one
- ❑ two
- ✓ four — Page 214
- ❑ five

26. In Illustration #17[illegible], after the main crane booms up to [illegible] degrees, how many times does the load radius change?

- ❑ none
- ❑ one
- ❑ two
- ✓ three — Page 216

SECTION FOUR ANSWERS

Mobile Cranes

Instructions: All answers are shown with the question. Correct answers [✓] are in bold. (Reference Page #)

1. Determine if this statement is true or false. As crane signaling is only a basic function and the signal person knows where the loads will be positioned, training or testing of the signal person should not be required.
   - ❑ true
   - ✓ **false** **Page 220**

2. When using hand signals to direct a crane operator, an extended arm with the thumb vertical and the fingers opening and closing into a fist indicates:
   - ❑ lower load
   - ✓ **raise boom and lower load** **Page 221**
   - ❑ raise the load line
   - ❑ extend boom

3. Two closed fists with both thumbs pointing toward each other is the signal for:
   - ✓ **retract hydraulic boom** **Page 221**
   - ❑ extend boom
   - ❑ retract middle section of boom only
   - ❑ secure load in position

4. Which of the following is not a permitted use of an operational aid?
   - ❑ warns of approaching two-block condition
   - ❑ indicates changing boom angle
   - ❑ warns of approaching crane overload
   - ✓ **used to test weigh a load prior to hoisting**

   Page 224

5. Determine if this statement is true or false. Any crane component can be used on any other crane made by the same company.
   - ❑ true
   - ✓ **false** **Page 224**

6. A rough terrain crane is commonly referred to as a:
   - ❑ mobile crane
   - ❑ crawler crane
   - ❑ carrier crane
   - ✓ **cherry picker** **Page 225**

7. Which of these conditions could be dangerous when operating a crane around a newly constructed building?
   - ❑ height of structure
   - ✓ **uncompacted soil** **Page 235**
   - ❑ protected pathways
   - ❑ compacted soil

8. When hoisting on outriggers with a permitted 360 degree swing, which position is the most hazardous in most conditions?
   - ☐ over front
   - ☐ over rear
   - ☐ over side
   - ✓ **over corner** ***Page 238***

9. Determine if this statement is true or false: The ground pressure under outriggers is higher than it is under a crawler track because of its smaller bearing surface.
   - ✓ **true** ☐ false ***Page 236***

10. An outrigger float should be approximately how much larger than the outrigger pad?
    - ☐ same
    - ☐ 1.5 times
    - ☐ 2 times
    - ✓ **3 times** ***Page 239***

11. When setting up a crawler crane for use on a new site, which of the following is not required prior to use?
    - ☐ operator manual and service manual
    - ☐ inspected components
    - ☐ crane logbook
    - ✓ **name of the person who will operate the crane** ***Page 243***

12. Where should the slings be attached when lifting lattice boom sections?
    - ✓ **use the end connections** ***Page 244***
    - ☐ choke at mid-point of the main chords
    - ☐ to the chord lacings
    - ☐ depends on boom length

13. Determine if this statement is true or false: During crane assembly, the counterweight is mounted after the installation of the complete boom.
    - ☐ true ✓ **false** ***Page 245***

14. When assembling lattice boom sections, which set of pins are installed first?
    - ☐ left side
    - ☐ right side
    - ☐ both lower
    - ✓ **both upper** ***Page 247***

15. When installing the boom pins, the pin should be pointing:
    - ✓ **out away from boom center** ***Page 249***
    - ☐ in toward boom center

16. When dismantling a lattice boom, which boom pins should be removed first?

- ❒ left side
- ❒ right side
- ✓ **both lower** **Page 250**
- ❒ both upper

17. Determine if this statement is true or false. It is safe to climb under a boom to knock out the boom pins if the crane has tension on the pendant lines.

❒ true ✓ **false** **Page 251**

18. What important steps must be followed when welding a damaged crane boom?

- ❒ follow manufacturer's welding procedure
- ❒ have a welder certified to the correct welding procedure
- ❒ use correct welding rods and heat treatment
- ✓ **all of above** **Page 253**

19. What position should the gantry of a crane be in when lifting a load?

- ✓ **highest position** **Page 254**
- ❒ initial position
- ❒ mid position
- ❒ lowest position

20. Jib forestay and backstay pendant lines should be:

- ❒ of equal length, or the forestay pendant lines should be longer
- ✓ **of equal length, or the backstay pendant lines should be longer** **Page 256**

21. Determine if this statement is true or false. Lift capacity increases as the angle to the ground decreases.

❒ true ✓ **false** **Page 258**

22. Determine if this statement is true or false. On most cranes the jib hoist and boom hoist can be safely operated simultaneously.

❒ true ✓ **false** **Page 258**

23. Which of the following is an auxiliary boom or an extension of the main boom?

- ❒ gantry
- ❒ mast
- ✓ **jib** **Page 259**
- ❒ all of above

24. All wire rope of a crane (hoist lines, boom hoist lines, pendant lines, etc.) have a standardized design safety factor of:
- ❑ 2.5 to 1
- ❑ 3 to 1
- ❑ 3.5 to 1
- ✓ **will vary depending on the crane and the application.** **Page 260**

25. To avoid torsional loading, the boom tip sheaves should be reeved:
- ❑ non-symmetrical
- ✓ **symmetrical** **Page 261**
- ❑ with an even number of line parts
- ❑ with an uneven number of line parts

26. Determine if this statement is true or false. When determining whether a crane is level, percentage of grade and degree measurement is the same.
- ❑ true ✓ **false** **Page 265**

27. How much out of level, in inches, is a crane with a 48 foot outrigger spread that is 1% off level?
- ❑ almost 5 inches
- ✓ **almost one-half inch** **Page 265**
- ❑ almost one-eighth inch
- ❑ too small to measure

28. Determine if this statement is true or false. A crane sitting 3 degrees off level with a long boom at minimum radius can have an increase in boom stress of approximately 50%.
- ✓ **true** ❑ false **Page 266**

29. The load line is hanging plumb when positioned over the rear. When positioned over the side, the load line is observed to be off center. This means it is:
- ❑ safe to lift over the rear
- ❑ safe to lift over the corner
- ❑ safe to lift over the side
- ✓ **not safe to lift until level in all positions** **Page 267**

30. Crane stability is based on:
- ✓ **lever principle** **Page 268**
- ❑ ability of crane hoist to lift load
- ❑ load measurements
- ❑ height of lift

31. The crane center of gravity will vary the most while swinging from rear to side to front with which type of machine?
- ❑ crawler cranes
- ✓ **truck cranes** **Pages 270,271**
- ❑ cherry pickers
- ❑ same with all types

32. Determine if this statement is true or false. Hoisting with a crane is performed only on rubber or with outriggers fully extended unless it is designed for an intermediate outrigger position and has a matching chart.

✓ true ❒ false **Page 274**

33. Determine if this statement is true or false. Computerized Load Moment Indicators warn the operator of an overload condition.

✓ true ❒ false **Page 274, 275**

34. Determine if this statement is true or false. Use of Computerized Load Moment Indicators is a quick, easy method of checking a load weight that is approved by crane manufacturers and safety regulations.

❒ true ✓ false **Page 275**

35. What determines crane capacity?

❒ machine weight
❒ stability
❒ strength of components
✓ all the above **Page 276**

36. Determine if this statement is true or false. Load dimensions could have as much bearing on boom radius as the load weight.

✓ true ❒ false **Page 277**

37. Deflection of the boom and pendant stretch will increase:

✓ load radius **Page 278**
❒ weight of boom
❒ load weight
❒ crane stability

38. Determine if this statement is true or false. A crane that has been overloaded, resulting in structural failure, will always have the damage show immediately.

❒ true ✓ false **Page 279**

39. When raising a long boom up off the ground, what will avoid excessive pendant pull and boom compression?

❒ keep main block on ground while raising the boom
❒ use a second crane to raise the boom
✓ all the above **Page 281**

40. Determine if this statement is true or false. The combined swing working areas of a crane are referred to as quadrants of operation.

✓ true ❒ false **Page 282**

41. The effective weight of a pile is:

❒ higher than the actual weight
❒ lower than the actual weight
❒ same as actual weight
✓ depends on crane, could be any of the above
Page 289

42. When using the main load line with the jib attached, the working load for the boom must be reduced by:
- ❑ weight of jib attachments
- ❑ weight of jib pendants
- ❑ weight of jib
- ✓ **manufacturer's specifications for jib and hook weight reduction** ***Page 289***

43. What are the safe load weight numbers given in a crane load chart?
- ❑ net capacity
- ❑ net load minus rigging
- ❑ gross load minus rigging
- ✓ **gross load** ***Page 292***

44. When hoisting, a sudden start or stop produces a:
- ❑ static load
- ✓ **dynamic load** ***Page 293***

45. Specific data for calculating the weight of crane components to set up for a safe lift are found in:
- ❑ operators manual
- ❑ rigging handbook
- ✓ **load chart data** ***Page 294,295***
- ❑ all of above

46. Determine if this statement is true or false. A method of determining when a crane is nearing overload is to watch for the outriggers to slightly lift off the floats, the first sign of tipping.

❑ true ✓ **false** ***Page 294,295***

47. Determine if this statement is true or false. A crane that [illegible] overloaded and can be safely [illegible] load charting.

❑ true ✓ **false** ***Page 294,295***

48. Determine if this statement is true or false. The quadrant of operation is shown on most mobile crane load charts.

✓ **true** ❑ false ***Page 295***

49. On load charts with the upper and lower numbers divided, the upper numbers are in the range that mean the crane will do what if it is overloaded?
- ❑ tip
- ✓ **structurally fail** ***Page 297***
- ❑ cannot lift the load
- ❑ none of above

50. Determine if this statement is true or false. When using crane load charts it is not permitted to guess or calculate in-between values.

✓ **true** ❑ false ***Page 298***

51. Boom angle is the measured angle between __________ and the centerline of the boom.

☐ vertical
✓ **horizontal** ***Page 299,300***

52. If the measured radius between crane rotation point and load center is 57 feet and the load chart only shows values at 55 feet and 60 feet, which value would be used?

☐ 55 feet
✓ **60 feet** ***Page 299***
☐ must consider boom length
☐ depends on load weight

53. Using the range diagram on page 302, determine the approximate load radius when the jib is at the offset shown and maximum boom extension at a 60° angle.

☐ 44 feet
☐ 50 feet
✓ **77 feet** ***Page 302***
☐ 55 feet

54. From the previous question, what load radius value would be used to calculate capacity?

☐ 45 feet
☐ 50 feet
✓ **80 feet** ***Page 302***
☐ 55 feet

55. Determine if this statement is true or false. The crane is always set up to specification; therefore the load chart does not have to be used to determine the required number of parts of line in the main load hoist to lift a load.

☐ true ✓ **false** ***Page 300***

56. Determine if this statement is true or false. In general terms, everything below the boom tip is considered load.

✓ **true** ☐ false ***Page 304***

57. What load chart weight term defines the main block, rigging hardware, the actual load and any attached jib and jib hook?

✓ **gross load** ***Page 305***
☐ net load

58. Using load calculation example one on pages 309 and 310 and a load weight of 33,400 pounds, what is the maximum radius allowed with the outriggers extended?

☐ 50 feet
✓ **55 feet** **Page 309,310**
☐ 60 feet
☐ 65 feet

59. Determine if this statement is true or false. The weight of a load being lifted by two cranes in tandem is only 50% of the lifting capacity of either crane. Therefore it is not a critical lift and does not require a lift plan.

❑ true ✓ **false** **Page 315**

60. Determine if this statement is true or false. For tandem crane lifts, the shared load requires the need for the cranes to be exactly alike.

❑ true ✓ **false** **Page 316**

61. Determine if this statement is true or false. On a tandem lift it is necessary for both cranes to lift the load off the ground simultaneously.

✓ **true** ❑ false **Page 317**

62. Page 322 illustrates a method of determining load share on a two-crane lift. Use the formula, crane capacities, dimensions from the example shown, but use a 100,000 pound load. The load on crane A and crane B would be:

✓ **CRANE A: = 57,711 lbs** **Page 322**
✓ **CRANE B: = 42,289 lbs**

63. Pages 325 and 326 illustrate a method of determining load share on a two-crane lift using an equalizer beam. Use the formula on page 326, crane capacities, and dimensions from the example shown, but use a 130,000 pound load including lifting beam and rigging. The load on crane A and crane B will be:

✓ **CRANE A: = 78,591 LBS** **Page 325,326**
✓ **CRANE B: = 51,409 LBS**

64. From question 63, determine if this is a safe lift for both cranes if crane A has a capacity of 36,400 lbs. and crane B a capacity of 42,300 lbs.

Crane A

❑ yes ✓ **no** **Page 326**

Crane B

❑ yes ✓ **no** **Page 326**

65. Which of these conditions will dramatically affect the values illustrated on load charts?

❑ improper outrigger set up
❑ changing radius
❑ wind
✓ **all of the above** **Page 328**

66. Determine if this statement is true or false. After a load is off the ground and the boom starts to swing, the actual swing rate of speed will never have any bearing on the conditions affecting the crane.

❒ true ✓ **false** **Page 321, 322**

67. Which of these weather conditions is more likely to restrict or completely stop hoisting activities.

✓ **wind gusts** **Page 334**
❒ light breeze
❒ light rain
❒ light snow

68. When a crane is traveling with a load, whenever possible the load should be:

✓ **tied off, low to ground, and close to carrier** **Page 338,339**
❒ low to ground and far out
❒ as high as possible without hitting boom
❒ always carried over the rear

69. When a hydraulic boom is not extended with equal section lengths, the effect is:

❒ damage the hydraulic system
✓ **overload the longest section** **Page 340**
❒ equal extension does not matter

70. Determine if this statement is true or false. It is permissible to let the boom of a crane rest on the edge of a building while lowering a load onto the roof.

❒ true ✓ **false** **Page 341**

71. Determine if this statement is true or false. As long as another person is on watch it is permissible to hoist personnel in a basket when the anti two-block device is not working.

❒ true ✓ **false** **Page 342, 343**

72. Determine if this statement is true or false. Even with high voltage power lines, it is not possible to have an electrical accident unless the crane or load actually hits the line.

❒ true ✓ **false** **Page 344**

73. Determine if this statement is true or false. A signal person must be used if a crane can swing within the minimum clearance of a power transmission line.

✓ **true** ❒ false **Page 345**

74. Determine if this statement is true or false. The operator should always jump out of the cab as quickly as possible if the crane makes contact with a power line.

❒ true ✓ **false** **Page 347**

75. Determine if this statement is true or false. It is not necessary for an equipment operator to check the recent log book entries before commencing operations as that is the responsibility of the supervisor.

❒ true ✓ **false** **Page 349**

76. Who is responsible to sign and date the crane log book when it is inspected?

❒ operator
❒ signal person
❒ mechanic
✓ **inspector** **Page 349**

77. Determine if this statement is true or false. It is safe to reach through the openings of a hydraulic boom if the machine is not running.

❒ true ✓ **false** **Page 359**

78. Determine if this statement is true or false. It is always safe to remove the hydraulic reservoir filler cap to check the level immediately after the machine is stopped.

❒ true ✓ **false** **Page 361**

79. Determine if this statement is true or false. The crane operating control positions are not regulated and every crane manufacturer locates the controls in relation to each other differently.

❒ true ✓ **false** **Page 362**

80. If the boom swing lever is pushed toward the boom it will:

❒ swing left
❒ swing right
✓ **could be either, depending on boom and control position** **Page 366**

81. Which of these items would not be necessary to check before starting the engine of a crane.

❒ transmission was in neutral
✓ **oil pressure gauge** **Page 367**
❒ parking brake was applied
❒ swing lock is engaged

82. Determine if this statement is true or false. Depending on the model, boom swing is stopped with the swing control lever or a foot pedal.

✓ **true** ❒ false **Page 368**

83. Determine if this statement is true or false. Hydraulic fluid and controls are not affected by cold weather, therefore a warm-up procedure is not required.

❒ true ✓ **false** **Page 374**

84. Determine if this statement is true or false. When extending a hydraulic boom, the load line will automatically lower to prevent the block from hitting the boom tip.

❒ true ✓ **false** **Page 379**

85. Determine if this statement is true or false. [illegible]

☐ true ✓ false Page 376

86. Determine if this statement is true or false. [illegible]

✓ true ☐ false Page 378

87. Determine if this statement is true or false. [illegible]

☐ true ✓ false Page 382

88. Determine if this statement is true or false. [illegible]

☐ true ✓ false Page 382

SECTION FIVE ANSWERS

Boom Trucks

Instructions: All answers are shown with the question. Correct answers (✓) are in bold. (**Reference Page #**)

1. Determine if this statement is true or false. Because boom trucks are not in the same category as a crane they do not require a log book or an inspection chart.
   - ☐ true
   - ✓ **false** — **Page 384**

2. When referring to the boom, what is one of the primary differences between a turret type and an articulating type?
   - ☐ all turret boom types have higher capacities
   - ☐ all turret types have more boom sections
   - ☐ only articulating type have remote control operation
   - ✓ **articulating boom has hinged boom sections** — **Page 384**

3. Determine if this statement is true or false. All articulating boom types do not have a hoisting wire rope with a drum.
   - ☐ true
   - ✓ **false** — **Page 384**

4. Determine if this statement is true or false. All boom trucks have four outriggers similar to a mobile crane.
   - ☐ true
   - ✓ **false** — **Page 387**

5. Determine if this statement is true or false. If a boom truck only has two outriggers, the turret must be located at the rear.
   - ☐ true
   - ✓ **false** — **Page 387**

6. Which piece of literature below would the quadrants of operation be found in?
   - ✓ **manufacturers manual or load chart** — **Page 385**
   - ☐ inspector check list
   - ☐ log book
   - ☐ quadrants not used in boom trucks

7. Determine if this statement is true or false. After setting the outriggers, boom truck stability does not change when swinging a load from an area supported by the outriggers to an area supported by springs and tires.
   - ☐ true
   - ✓ **false** — **Page 388**

8. Which condition below is a result of having higher blocking on one side when the truck is equipped with angled type outriggers?
   - ☐ unbalanced load on boom
   - ☐ boom truck not level
   - ✓ **tipping axis distance reduction** — **Page 389**
   - ☐ has no effect

9. Determine if this statement is true or false: If a boom truck has the outriggers extended, the unit does not have to be level.

❒ true ✓ **false** **Page 390**

10. Determine if this statement is true or false: When using all four outriggers on a boom truck, it is not necessary to use the reference weight of the crane.

❒ true ✓ **false** **Page 390**

11. A possible reason that does not hang dead center from an extended boom would indicate:

❒ outriggers not extended
❒ boom angle too high
✓ **unit is not level** **Page 391**
❒ boom not fully extended

12. Determine if this statement is true or false: When setting up a boom truck, the unit only has to be level from side to side, not front to rear.

❒ true ✓ **false** **Page 391**

13. Determine if this statement is true or false: The distance from the center line of rotation to the load center can change as the load clears the ground.

✓ **true** ❒ false **Pages 391, 392**

14. The radius number on the load chart is:

❒ the estimated distance from crane rotation point to load center
❒ the actual distance from crane rotation point to unlifted load center
✓ **the actual distance from crane rotation center to lifted load center** **Page 392**
❒ the distance from crane rotation pin to center of outrigger

15. Determine if this statement is true or false: Due to the smaller lifting capacities than mobile cranes, boom trucks do not require regular daily, weekly, monthly, or yearly inspections.

❒ true ✓ **false** **Page 392**

16. Which of the following applies when using the controls of a machine the operator is not familiar with?

❒ individual control positions may be different
❒ individual control movements may be different
❒ control and component movement may be different
✓ **all of above** **Page 393**

17. Determine if this statement is true or false: A stowed jib is kept in the stowed position with the use of pins and retaining clips.

✓ **true** ❒ false **Page 395**

18. Determine if this statement is true or false: Overloading or structural damage is not a factor with boom trucks as their load charts are based on the unit tipping before something breaks.

❑ true ✓ **false** ***Page 397***

19. Determine if this statement is true or false: It is a common and accepted practice to use a computerized load indicator to test weigh a load to get the actual weight.

❑ true ✓ **false** ***Page 397***

20. Changing the wire rope block reeving from a single line to multiple parts will:

✓ **increase the lifting capacity** ***Page 395***

❑ require the boom to be shortened

❑ require the jib to be attached

❑ all of above

21. Determine if this statement is true or false: It is possible the winch or hoist capacity could exceed the boom capacity.

✓ **true** ❑ false ***Page 401***

22. Which of the following could cause structural damage to or overload a boom?

❑ lifting a load positioned beyond the boom tip

❑ rapid swinging of a load

❑ lifting a load positioned off to one side of the boom tip

✓ **all of above** ***Page 402***

23. Determine if this statement is true or false: Boom trucks have shorter booms than mobile cranes, therefore fewer power line accidents. As a result, pre-lift planning meeting is not necessary.

❑ true ✓ **false** ***Page 403***

SECTION SIX ANSWERS

Material Handling / Rail Cranes

Instructions: All answers are shown with the question. Correct answers (✓) are in bold. **[Reference Page #]**

1. Determine if this statement is true or false. If the Variable Reach Boom Type Rough Terrain Forklift material handler is using a hoisting hook to lift the load, the operator is under the ANSI crane standard B30.5.
   ✓ **true** ❑ false **Page 408**

2. The above type of material handler can also be equipped with which type of attachment?
   ❑ stinger for lifting a reel
   ❑ pipe or lumber grapple
   ❑ rail car coupler
   ✓ **all of above** **Page 406-408**

3. Determine if this statement is true or false. Most of these handlers have a letter or number on the boom, visible from the cab, which indicates the boom section being used.
   ✓ **true** ❑ false **Page 408**

4. Determine if this statement is true or false. These variable reach forklifts have a telescopable boom; however, they do not require a load chart for different load positions because of the light loads involved.
   ❑ true ✓ **false** **Page 409**

5. Determine if this statement is true or false. Training for a variable reach forklift is standardized.
   ❑ true ✓ **false** **Page 410**

6. Determine if this statement is true or false. Training for variable reach forklifts could be either forklift training or crane training.
   ✓ **true** ❑ false **Page 410**

7. Determine if this statement is true or false. A scrap and material handler is similar to an articulating boom crane with the exception of a different ANSI standard.
   ✓ **true** ❑ false **Page 411**

8. Determine if this statement is true or false. Operator training for a scrap handler with a grappling hook is similar to that of an articulating crane.
   ✓ **true** ❑ false **Page 411**

9. Determine if this statement is true or false. All railway cranes are tracked or wheeled and cranes mounted on a flatcar.

❑ true ✓ **false** **Page 413**

10. Determine if this statement is true or false. Rail cranes are covered under the B30.5 ANSI Standard.

✓ **true** ❑ false **Page 414**

11. Determine if this statement is true or false. With outriggers extended, a rail crane load chart is rated at [illegible] of capacity.

✓ **true** ❑ false **Page 414**

12. Determine if this statement is true or false. If a rail crane is mounted on a flatcar it is not necessary to block up that car because railway flatcars are extremely stable.

❑ true ✓ **false** **Page 414**

13. Determine if this statement is true or false. When using a railway crane, the signals for the crane operator's hoisting movements are the standard railway colored flags.

❑ true ✓ **false** **Page 415**

14. A blue light or flag mounted on either end of a rail work site indicates:

- ❑ proceed slowly
- ✓ **workers on or under equipment ahead** **Page 415**
- ❑ hoist the load
- ❑ lower the crane boom

15. A green flag moved back and forth across a worker's chest indicates:

- ❑ proceed
- ❑ stop
- ❑ back up
- ✓ **slow down** **Page 416**

SECTION SEVEN ANSWERS

Aerial Platforms

Instructions: All answers are shown with the question. Correct answers (✓) are in bold. **(Reference Page #)**

1. Determine if this statement is true or false. Aerial work platforms are covered by four different ANSI Standards.
   ✓ **true** ❐ false **Page 420**

2. Which of the following is the primary safety item regarding aerial platforms?
   ❐ thorough operator training program
   ❐ thorough inspection and care of equipment
   ❐ understanding and protection against electrical contact
   ✓ **all of above** **Page 422**

3. Determine if this statement is true or false. Aerial platforms are designed to be used as working platforms for personnel and also as cranes to hoist material.
   ❐ true ✓ **false** **Page 422**

4. A person fully trained to operate one type of platform can adequately operate any other type of platform.
   ❐ true ✓ **false** **Page 423**

5. Determine if this statement is true or false. Due to the usually small basket size, a boom type aerial platform cannot be overloaded.
   ❐ true ✓ **false** **Page 423**

6. Determine if this statement is true or false. As an aerial platform is not classified as a crane, it does not require a pre-lift inspection.
   ❐ true ✓ **false** **Page 427**

7. Determine if this statement is true or false. A safety harness and lanyard are not required in an aerial platform.
   ❐ true ✓ **false** **Page 425**

8. Determine if this statement is true or false. Even when so equipped, outriggers are rarely required for hoisting personnel.
   ❐ true ✓ **false** **Page 425**

5. What is the regular inspection schedule for various components of an aerial platform?

- ☐ daily
- ☐ weekly
- ☐ monthly
- ✓ any of above depending on component

Page 427

11. Which of the following could disqualify a platform from being used?

- ☐ cracks in outriggers
- ☐ fiberglass boom & platform is secure
- ☐ safety harness & wheel chocks at hand
- ✓ all of above

Pages 429, 430

SECTION NINE ANSWERS[†]

Barge, Ship & Offshore Cranes

Instructions: All answers are shown with the question. Correct answers (✓) are in bold. **(Reference Page #)**

1. Determine if this statement is true or false: Land cranes mounted on a barge fall under the ANSI B30.5 standard.
   - ☐ true
   - ✓ **false** — **Page 444**

2. When determining barge movement sideways, the motion or movement is called:
   - ☐ trim
   - ✓ **list** — **Page 444**
   - ☐ wave dynamics
   - ☐ freeboard

3. When determining barge movement backward or forward, movement is called:
   - ✓ **trim** — **Page 444**
   - ☐ list
   - ☐ wave dynamics
   - ☐ freeboard

4. Determine if this statement is true or false: The distance between the waterline and the deck is called freeboard.
   - ✓ **true**
   - ☐ false — **Page 444**

5. For cranes designed for barge mounting up to 25 tons, the maximum allowed list is:
   - ✓ **5 degrees** — **Page 445**
   - ☐ 7 degrees
   - ☐ 10 degrees
   - ☐ must be level at all times

6. For cranes designed for barge mounting over 25 tons, the maximum allowed list is:
   - ☐ 5 degrees
   - ✓ **7 degrees** — **Page 445**
   - ☐ 10 degrees
   - ☐ must be level at all times

7. For land cranes mounted on a barge, the maximum allowed list is:
   - ✓ **5 degrees** — **Page 445**
   - ☐ 7 degrees
   - ☐ 10 degrees
   - ☐ must be level at all times

8. Determine if this statement is true or false: A land crane mounted on a barge will always have the same chart rating on the barge as it did on land.
   - ☐ true
   - ✓ **false** — **Page 446**

9. Determine if this statement is true or false. A land crane mounted on a barge will always retain the same chart rating regardless of the actual barge size.

❏ true ✓ **false** **Page 445**

10. Determine if this statement is true or false. When placing pad eyes on a barge deck for proper tie-down of a crane, the pad eyes must NEVER be welded to an area of deck directly over a reinforcing beam.

❏ true ✓ **false** **Page 445**

11. Determine if this statement is true or false. If a crane load chart and the permit list are based on the crane being positioned in the barge center, it is permissible to move the crane to the stern for hoisting.

❏ true ✓ **false** **Page 449**

12. Determine if this statement is true or false. Miscellaneous equipment on a barge deck is **NOT** permitted when hoisting with a crane on that barge.

❏ true ✓ **false** **Page 449**

13. Determine if this statement is true or false. If a crane load chart and the permit list are based on the crane being positioned at the stern of the barge, it is permissible to move the crane to the barge center for hoisting.

✓ **true** ❏ false **Page 449**

14. When mounting a land crane on a barge, who of the following should **NOT** determine the crane capacity?

✓ **operator** **Page 451**
❏ manufacturer
❏ marine engineer
❏ none of above

15. Determine if this statement is true or false. Floating cranes and derricks are **NOT** required to have a load limiting device (LLD).

❏ true ✓ **false** **Page 451**

16. Which one of the following is required for a floating crane?

❏ boom angle indicator
❏ wind speed indicator
❏ list and trim indicator
✓ **all of above** **Page 451**

17. Determine if this statement is true or false. A mobile crane fastened to a barge deck will be secured by a single block tie-down system.

✓ **true** ❏ false **Pages 446, 453**

18. Determine if this statement is true or false. Crane load chart capacity is rated the same for both clamshell, excavator and routine hoisting.

❏ true ✓ **false** **Pages 453-456**

19. Determine if this statement is true or false. [illegible] used on barge mounted cranes.

❑ true ✓ false Page 455

20. Determine if this statement is true or false. Partially filling with water is the method commonly used to ballast a barge [illegible].

❑ true ✓ false Page 455

21. Determine if this statement is true or false. Small [illegible] leaks are permitted provided all pumps are in good working order.

❑ true ✓ false Page 455

22. Cranes mounted on offshore drilling platforms and the platform supply boats are normally regulated by what standard?

❑ ANSI
❑ OSHA
✓ API Page 463
❑ none of above

23. When hoisting with a crane from a fixed offshore platform, the load weight coefficient is:

❑ 1.00
❑ 1.33
✓ 1.40 Page 461, 462
❑ 2.00

24. When hoisting with a crane from a supply boat in [illegible] sea conditions, the load weight coefficient is:

❑ 1.00
❑ 1.33
❑ 1.40
✓ 2.00 Pages 462, 463

25. Determine if this statement is true or false. When hoisting a load from a supply boat with a fixed platform crane, the load must be lifted from the deck slowly because of the wave action.

❑ true ✓ false Page 463

SECTION TEN ANSWERS

Tower Cranes

Instructions: All answers are shown with the question. Correct answers [✓] are in bold. **[Reference Page #]**

1. Determine if this statement is true or false. Very few areas in either the United States or Canada require certification to operate a tower crane.
   ❒ true ✓ **false** **Page 456**

2. Determine if this statement is true or false. Self-erecting tower cranes are easier to erect than a conventional tower crane, but erection time takes longer.
   ❒ true ✓ **false** **Page 465**

3. How does the crane rotate with a fixed tower base?
   ❒ slewing ring at the base
   ✓ **slewing ring beneath the jib** **Page 470**
   ❒ depends on the manufacturer
   ❒ does not rotate

4. Determine if this statement is true or false. A mono type of tower can be either fixed or slewing.
   ✓ **true** ❒ false **Page 470**

5. What best describes a tower crane saddle jib?
   ✓ **rolling trolley and supported by fixed pendant lines** **Page 472**
   ❒ stationary trolley and jib pivots at front of tower
   ❒ stationary trolley and jib pivots at rear of tower
   ❒ none of above

6. What best describes a tower crane front luffing jib?
   ❒ rolling trolley and supported by fixed pendant lines
   ✓ **stationary trolley and jib pivots at front of tower** **Page 474**
   ❒ stationary trolley and jib pivots at rear of tower
   ❒ none of above

7. Determine if this statement is true or false. In general tower cranes are designed to have the same lifting capacity regardless of the jib length and load radius.
   ❒ true ✓ **false** **Page 474**

8. Determine if this statement is true or false. A tower crane only requires one certification plate. All components are included in that one ID plate.
   ❒ true ✓ **false** **Pages 474, 475**

9. Determine if this statement is true or false. All tower cranes manufactured by a company will have a common manufacturer's manual that is generic to all cranes made by that company.

❒ true ✓ **false** ***Page 479***

10. Who of the following must sign a tower crane log book?

❒ operator
❒ service mechanic
❒ supervisor
✓ **all of above** ***Page 475***

11. What is the first step taken before erecting a tower crane?

❒ decide on type of erection bracing
❒ check for underground water mains
✓ **prepare a site plan** ***Pages 479,480***
❒ measure height of nearby buildings

12. Determine if this statement is true or false. Because of the generally high operating heights, tower crane operation is not affected by, and is therefore exempt from, power line clearance regulations.

❒ true ✓ **false** ***Page 479***

13. What method is often used to level and secure the tower structure being erected inside a building?

✓ **hardwood wedges** ***Page 480***
❒ steel wedges
❒ [illegible]
❒ hydraulic jacks

14. When erecting tower cranes how many times should the bolts be reused?

✓ **only once** ***Page 481***
❒ two times
❒ three times
❒ does not matter if in good condition

15. Determine if this statement is true or false. Guy lines are never used to secure a freestanding tower while it is being assembled.

❒ true ✓ **false** ***Pages 481,482***

16. Determine if this statement is true or false. When assembling the crane, spring clips are used to secure the pendant pins because of their ease and safety.

❒ true ✓ **false** ***Page 482***

17. [illegible]

✓ **turnbuckles** **Page 483**

☐ bolts

☐ pendants

☐ wedges

18. A tower crane fastened to the outside of a building should be secured a minimum of: [illegible]

☐ every floor

☐ every two floors

☐ every three floors

✓ **four floors** **Page 483**

19. What is the purpose of a jib [illegible] marker?

☐ indicate length of jib

☐ indicate height of jib

☐ indicate overlap of jibs of two adjacent cranes

✓ **indicate position of trolley on jib** **Page 485**

20. Determine if this statement is true or false: A limit switch is a safety device that restricts movements of the crane and prevents overloading or damage.

✓ **true** ☐ false **Pages 485-487**

21. Determine if this statement is true or false: [illegible]

☐ true ✓ **false** **Pages 485, 487**

22. Determine if this statement is true or false: [illegible]

☐ true ✓ **false** **Page 455**

23. Tower crane cranes must stop [illegible] when there is a power loss. These are called:

✓ **fail safe brakes** **Page 489**

☐ automatic lowering brakes

☐ hydraulic brakes

☐ mechanical brakes

24. Determine if this statement is true or false: Tower and mobile cranes are both load tested at [illegible] overload.

☐ true ✓ **false** **Page 489**

25. Tower crane operator controls should automatically return to [illegible] position when pressure is released:

☐ forward

☐ reverse

✓ **neutral** **Page 490**

☐ automatic lowering

26. Every tower crane cab MUST be equipped with a:
- ❐ serial number
- ❐ wire rope capacity chart
- ❐ drum capacity chart
- ✓ **load rating chart** ***Page 492***

27. Determine if this statement is true or false. Because of their light weight, it is not necessary to include slings and rigging hardware in the pre-lift load weight calculations.
- ❐ true ✓ **false** ***Page 495***

28. Determine if this statement is true or false. A tower crane can be safely operated in wind speeds exceeding 20-30 mph (30-50 km/h) if the load does not approach the crane capacity.
- ❐ true ✓ **false** ***Page 495***

29. Determine if this statement is true or false. If so equipped, the tower crane's computerized operator aid system can be used as a scale to test weigh a load.
- ❐ true ✓ **false** ***Page 496***

30. Determine if this statement is true or false. The person giving signals must always be in a position to see the load clearly at all times.
- ✓ **true** ❐ false ***Page 497***

31. The preferred method of contact between signal person and operator is by:
- ❐ wireless voice communication
- ✓ **hard wire voice communication** ***Page 498***
- ❐ hand signals
- ❐ flags

32. If the jibs of two adjacent tower cranes can overlap, which of the following conditions should apply?
- ❐ jibs set at different heights
- ❐ operators have voice contact
- ❐ one person organizes hoisting operations
- ✓ **all of above** ***Page 498***

33. Determine if this statement is true or false. The jib of an unattended tower crane is locked in position and never allowed to weathervane with the wind.
- ❐ true ✓ **false** ***Page 499***

34. Determine if this statement is true or false: A tower crane used regularly and in good working condition only requires inspection every 6 months.

❑ true ✓ false **Page 501**

35. When the tower base bolts are retorqued, the jib is rotated so the counterweight is positioned in what position relative to the bolts being torqued?

✓ **counterweight over the bolts** ***Pages 502,503***

❑ counterweight at 90 degrees to the bolts

❑ counterweight at 180 degrees to the bolts

❑ tower bolts never require retorquing

SECTION ELEVEN ANSWERS

Overhead Cranes

Instructions: All answers are shown with the question. Correct answers (✓) are in bold. **[Reference Page #]**

1. Determine if this statement is true or false. Because they are easy to operate, overhead crane operators seldom require operator certification.
   ❐ true ✓ **false** **Page 506**

2. A crane operating continuously at high speeds with capacity loads would most likely be of what class?
   ❐ A
   ❐ B
   ❐ D
   ✓ **E** **Page 507**

3. Determine if this statement is true or false. Monorail and jib cranes usually have more lifting capacity than a typical overhead crane.
   ❐ true ✓ **false** **Page 508**

4. A mobile straddle lift gantry crane will run on:
   ❐ [illegible]
   ❐ rails
   ✓ **rubber tires** **Page 513**
   ❐ none of above

5. A mobile straddle lift gantry crane is usually used for what purpose?
   ❐ in a steel foundry
   ❐ in a manufacturing plant
   ❐ in a ship repair yard
   ✓ **for moving shipping containers** **Page 513**

6. Determine if this statement is true or false. The bridge, trolley, and hoist are the three basic components of an overhead crane.
   ✓ **true** ❐ false **Page 515**

7. Keypad Adjustable Frequency Controls are used with what control method?
   ❐ cab mounted controls
   ❐ hanging pendant controls
   ❐ walkabout remote controls
   ✓ **all of above** **Page 523**

8. Determine if this statement is true or false. A disadvantage of a Keypad Adjustable Frequency control is that it cannot be programmed for what is known as a soft start program.
   ❐ true ✓ **false** **Page 524**

9. Other types of remote controls can be dangerous for what reason?
   - ❑ range too short
   - ❑ range too long
   - ✓ **conflicting low operating frequencies** ***Page 524***
   - ❑ conflicting high operating frequencies

10. When operating a radio controlled crane, the operator must never operate the crane:
    - ❑ at night
    - ✓ **blindly** ***Page 527***
    - ❑ without a load
    - ❑ without a signal person

11. What must happen to the transmitter box to avoid injury to personnel working in the vicinity of a remote control crane that is not in use?
    - ❑ antenna handle blocked open
    - ✓ **box placed in a secure location** ***Page 528***
    - ❑ operator must carry box at all times
    - ❑ none of above

12. Determine if this statement is true or false. If a radio controlled crane fails to operate properly, all movements must stop immediately and the master switch be turned off.
    - ✓ **true** ❑ false ***Page 530***

13. When a crew is repairing a radio controlled crane, who is responsible for the control box?
    - ✓ **designated repair crew member** ***Page 531***
    - ❑ any repair crew member
    - ❑ a designated person not on the crane
    - ❑ the shift supervisor

14. When hoisting in a critical load situation with a pendant control crane, what procedure should be followed so the operator can keep his eyes on the load?
    - ❑ have a second person advise which button to push
    - ✓ **memorize the button positions** ***Page 536***
    - ❑ stop and start with each separate movement
    - ❑ all of above

15. Determine if this statement is true or false. The primary advantage to a cab-controlled crane is a good overall view of the load.
    - ✓ **true** ❑ false ***Page 535***

16. Determine if this statement is true or false. The two disadvantages to a cab-controlled crane are possible depth perception difficulties and view obstruction with large loads.
    - ✓ **true** ❑ false ***Page 540***

17. A condition caused by possible rough operation whereby the crane girders are not perpendicular to the runway, resulting in one end being ahead of the other is called:

- ❒ inching
- ❒ icing
- ❒ plugging
- ✓ **skewing** ***Page 544***

18. Determine if this statement is true or false. All cab operated cranes should be stopped by using the same basic operation method.

❒ true ✓ **false** ***Page 544***

19. When slowing or stopping a cab-controlled crane bridge or trolley with reverse power, when the crane controls are designed for this purpose, the movement is called:

- ❒ inching
- ❒ icing
- ✓ **plugging** ***Page 545***
- ❒ skewing

20. Determine if this statement is true or false. The plugging operation is best achieved on controller points 3 and 4.

❒ true ✓ **false** ***Page 548***

21. Positioning the bridge and trolley over the load for hoisting is called:

- ✓ **centering** ***Page 548***
- ❒ aligning
- ❒ hooking
- ❒ icing

22. Determine if this statement is true or false. For overall efficiency, a load should be moved with the controller on a continuous intermediate point.

❒ true ✓ **false** ***Page 550***

23. When hoisting, which position of the hoist controller will result in the slowest speed?

- ✓ **first position** ***Page 552***
- ❒ second position
- ❒ third position
- ❒ fourth position

24. Determine if this statement is true or false. On first point hoisting, the load will increase in speed for light loads and start to move with heavy loads.

✓ **true** ❒ false ***Page 552***

25. Determine if this statement is true or false. On cranes equipped with a dynamic braking system, a light load is allowed to move while a heavy load is held back.
- ✓ **true**
- ☐ false

Page 553

26. Determine if this statement is true or false. To ensure the hoist brake will hold a heavy load, the operator should lift the load a short distance then stop and check the brake.
- ✓ **true**
- ☐ false

Page 554

27. Which term is used to describe very short load movements during hoisting operations?
- ✓ **inching** ***Page 554***
- ☐ jogging
- ☐ plugging
- ☐ slewing

28. As the operator of a cab can only move two control handles at the same time, one hand should always be on the
- ☐ bridge controller
- ☐ trolley controller
- ✓ **hoist controller** ***Page 556***

29. Determine if this statement is true or false. A slow start and a quick stop of the bridge is the best way to prevent a load from swinging.
- ☐ true
- ✓ **false**

Pages 557,558

30. Which of the following is a hazardous practice when using a magnet for hoisting?
- ☐ cool off with water
- ☐ allow to get excessively hot
- ☐ hoisting of high pressure cylinders
- ✓ **all of above** ***Page 561***

31. Determine if this statement is true or false. Overhead crane hooks do not require a safety latch.
- ☐ true
- ✓ **false**

Pages 563,564

32. Determine if this statement is true or false. A double hook is called a sister hook.
- ✓ **true**
- ☐ false

Page 564

33. Determine if this statement is true or false. The minimum number of wire rope wraps to remain on the hoist drum may vary and should be determined by the applicable OH&S/OSHA department.
- ✓ **true**
- ☐ false

Page 567

34. Determine if this statement is true or false: A 6 x 37 wire rope classification has good flexibility and is generally suitable for use on overhead cranes.

✓ true ❐ false **Page 566**

35. The hoist wire rope on an overhead crane will typically have a working load limit safety factor of

❐ 3 to 1
❐ 4 to 1
✓ **5 to 1** **Page 566**
❐ 10 to 1

36. Referring to the chart on page [illegible], what is the nominal breaking strength in tons for a 1 inch diameter, improved plow steel, wire core rope?

❐ 41.8
✓ **44.9** **Page 566**
❐ 51.7
❐ 57.5

37. What is the purpose of a hoist limit switch?

❐ prevent overloading
✓ **prevent pulling load block into drum** **Pages 566,567**
❐ prevent excessive bridge travel
❐ prevent excessive trolley travel

38. The hoist limit switch operation should be checked

✓ **each shift** **Page 568**
❐ daily
❐ weekly
❐ monthly

39. Determine if this statement is true or false: Two possible methods of overload detection for overhead cranes are a dynamometer attached to the crane hook or an in-load computerized digital readout.

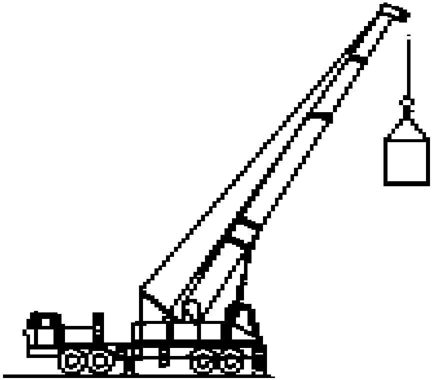
✓ **true** ❐ false **Pages 571,572**

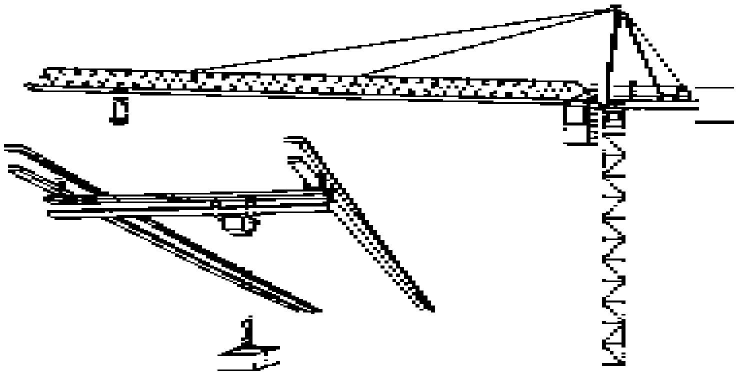
40. An overhead crane should have a visual inspection on what regular basis?
- ✓ **every shift** **Page 573**
- ❒ every week
- ❒ every month
- ❒ every year

41. What process must be followed prior to inspecting an overhead crane?
- ❒ lift hoist to highest level
- ❒ notify supervisor
- ❒ turn off power
- ✓ **use a lockout procedure** **Page 581**

42. Under what circumstances can an overhead crane lift 125% of its rated load?
- ✓ **for test purposes only** **Page 587**
- ❒ after approval by the superintendent
- ❒ on written approval by the OCHS/OSHA department

43. Determine if this statement is true or false: An outdoor storage bridge crane must be equipped with a parking brake or rail clamps for use when the crane is sitting idle.
- ✓ **true** ❒ false **Page 592**





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