



# **Basic Rigging Workbook**

Training and Qualifications Program Office

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## Determine Task and Job-Site Requirements

In order to ensure the safety of workers and the equipment involved, any operation involving the use of a crane to lift items must be planned thoroughly before being carried out. The purpose of this document is to discuss the requirements for planning and performing an incidental lift using an overhead crane and commonly available rigging components, such as slings, shackles, eye bolts, and turnbuckles.

The "Lifting Safety" Subject Area, found in the Brookhaven National Laboratory (BNL) Standards-Based Management System (SBMS), governs all lifts conducted at BNL. The Subject Area contains guidance that must be used in order to plan and perform a lift safely. This instructor handbook incorporates the Subject Area's requirements, as well as information from the Department of Energy's (DOE's) Hoisting and Rigging Manual and ANSI B30.9.

### Definitions

Asymmetrical load. An object with an off-center center of gravity due to the object's irregular shape and/or composition.

Critical lifts require confirmation of engineering, or merit additional engineering input because of an item's or location's size, weight, close-tolerance installation, or high susceptibility to damage. These lifts could be either ordinary lifts or pre-engineered lifts, but with additional hazards that could result in significant delays to a program, undetectable damage resulting in future operational or safety problems, a significant release of radioactivity or other hazardous material, present a risk of injury personnel. Critical lifts must be made by Plant Engineering riggers or by approved contractors, and as such are not covered in this program.

Incidental or ordinary lifts involve the use of basic hoisting equipment directly above the load. The load must also have certified lifting points or be relatively easy to sling.

Person-in-charge. Person appointed by the responsible manager or designee to direct critical or pre-engineered lifts. The person-in-charge must be present during the entire lifting operation and must have experience in handling similar types of equipment. The designated person-in-charge may be either a supervisor familiar with critical lift operations, or a person with special knowledge of the equipment and handling.

Pre-engineered lifts are repetitive lifts that meet the definition of a critical lift, defined below. If, however, the BNL Lifting Safety Committee determines that through the use of tooling, fixtures, sketches, analyses, and written procedures, the possibility of dropping, upset, or collision is reduced to an acceptable level, the lift may be designated as a pre-engineered lift.

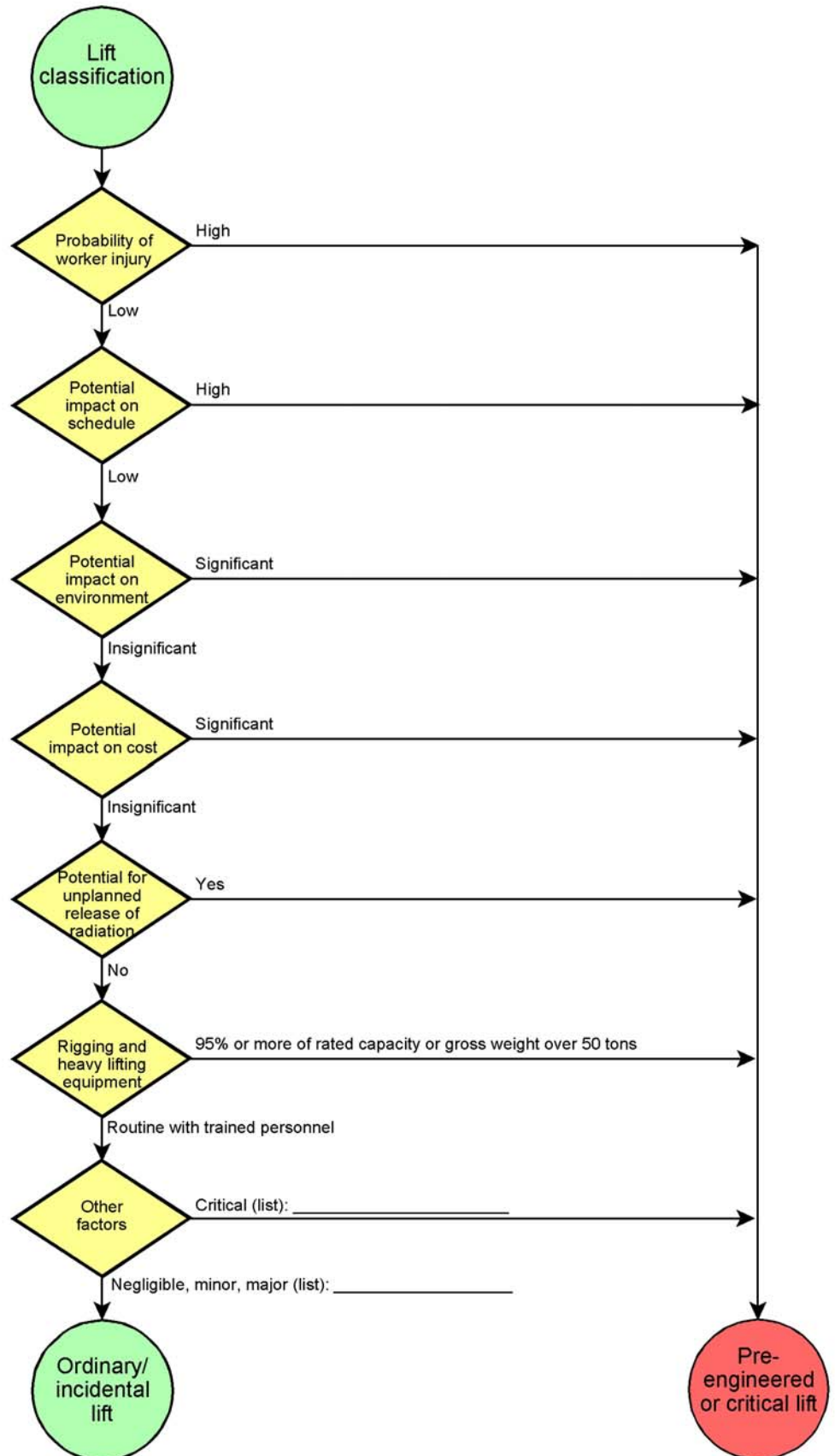
Symmetrical load. An object that, because of its uniform shape and composition, has its center of gravity located exactly in its middle.

## Classifying Lifts

Before a lift can be planned, it must be analyzed to determine the lift's category. There are three lift categories at BNL: incidental or ordinary lifts, pre-engineered lifts, and critical lifts. The responsible manager or designee determines the type of lift by conducting a lift assessment.

The flow chart here, adapted from the SBMS Lifting Safety Subject Area, will help to determine if a lift should be classified as incidental (ordinary), pre-engineered, or critical.

Refer to the Subject Area for additional guidance.



If the lift has been classified as a pre-engineered lift, then additional criteria must be met prior to operation. If determined to be a critical lift, Plant Engineering riggers or an approved contractor must be used.

Once the lift has been classified and determined to be an ordinary or incidental lift, use the Checklist for Lift Planning and Weather Factors exhibits, found in the Lifting Safety Subject Area, as tools for evaluating the area of operation and potential.

### **Ordinary Lift Plan Elements**

Once a lift has been planned and approved, the appropriate rigging equipment, including slings, shackles, turnbuckles, and the crane itself, must be selected, inspected, and connected correctly prior to beginning the lift itself.

The following items must be checked and confirmed before selecting rigging components:

- Weight of lift
- Center of Gravity
- Lift points
- Crane capacity
- Speed, height, width, and length of lift
- Wind, temperature, and visibility
- Crane and Load foundation ratings
- Sharp corners and angles on load
- Sling angles
- Load angle factor
- Travel route clearance
- Floor loading capacity
- Work zone safety

### **Planning and Performing Pre-Engineered Lifts**

Pre-engineered lifts are repetitive lifts that meet the definition of a critical lift, defined below. If, however, the BNL Lifting Safety Committee determines that through the use of tooling, fixtures, sketches, analyses, and written procedures, the possibility of dropping, upset, or collision is reduced to an acceptable level, the lift may be designated as a pre-engineered lift.

A Pre-Engineered Lift Plan must be completed and submitted to the Lifting Safety Committee chair prior to any work being performed. The Plan consists of as many drawings, specifications, and procedures as necessary to assess all important load factors and site factors relating to the lift. For further details, consult the Pre-engineered Lift Procedure found in the Lifting Safety Subject Area.

# Characterize the Load

## Calculating Weight of Load

### Step 1: Determine volume

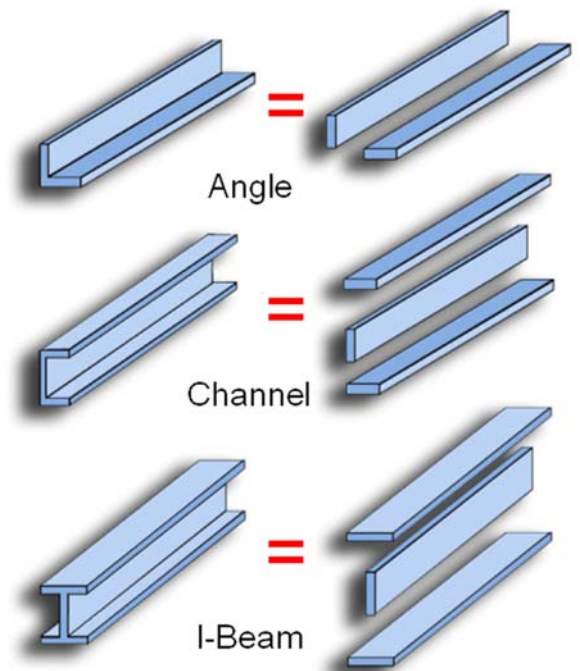
- Measure the object to get dimensions (length, width, and height) and determine volume.

Volume formulas:

- Rectangle/square: **Volume = Length x Width x Height**
- Hollow cylinder: **Volume = 3.14 x Length x Wall thickness x (Diameter wall thickness)**
- Complex shapes
  - In some cases, it's best to imagine that the whole object is enclosed by a rectangle and calculate the volume of that rectangle.
  - In other cases, break the object into two or more smaller rectangles
    - Calculate the weight of each part and add them
    - or-
    - Look up weight per foot for structural shapes in Steel Handbook
  - For concrete reinforcing rod, calculate as a cylinder.

### Pipe

- Pipe calculations require actual measurements of diameter and wall thickness for accuracy
  - Pipe sizes below 14 inches are given as nominal dimensions
    - Example: 6-inch pipe is actually 6.75 inches in diameter
  - Need to know actual wall thickness dimension
- Recommendation: use a table instead of calculations
- Typical pipe weight table is shown on page 32.



**Step 2: Determine what material the object is made of**

- Look up the weight per unit volume for that material.

Material	Pounds per cubic foot
Aluminum	165
Concrete	150
Copper	560
Lead	710
Paper	60
Steel	490
Water	65
Wood, pine	40

**Step 3: Determine weight of object**

- Multiply the weight per unit volume times the calculated volume to get the calculated weight of the object.

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**Example #1: Rectangular Load**

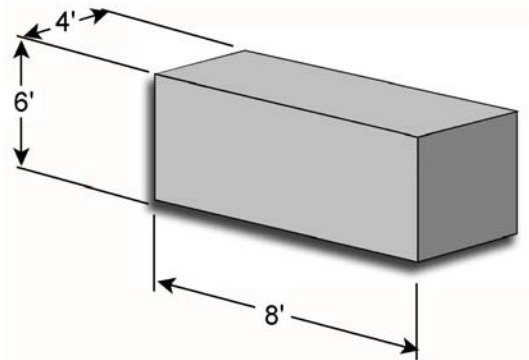
Object to be lifted: Concrete block, 8 feet long x 4 feet wide x 6 feet high.

- Volume of a rectangle is its length times its width times its height:

$$V = L \times W \times H = 8 \text{ ft} \times 4 \text{ ft} \times 6 \text{ ft} = 192 \text{ cu ft}$$

- Since concrete weighs 150 pounds per cu ft (see table on previous page), the load will weigh approximately:

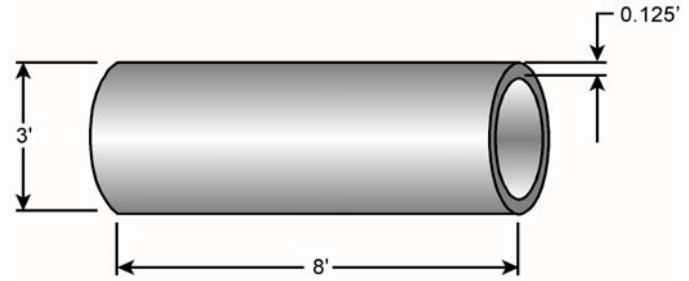
$$\text{Block weight} = 192 \text{ cu ft} \times 150 \text{ lbs/cu ft} = \underline{\underline{28,800 \text{ lbs}}}$$





### Example #2: Pipe

Object to be lifted: Hollow steel pipe, 8 ft. long x 3 ft outside diameter; wall thickness is 1.5 inches.



- Using the formula:  
 $V = 3.14 \times L \times T \times (D - T)$   
 $= 3.14 \times 8 \text{ ft} \times 0.125 \text{ ft} \times (3 \text{ ft} - 0.125 \text{ ft})$

Caution: Units not all the same: Need to convert inches to feet

$$V = 3.14 \times 8 \text{ ft} \times 0.125 \text{ ft} \times (3 \text{ ft} - 0.125 \text{ ft}) = 9.03 \text{ cu ft}$$

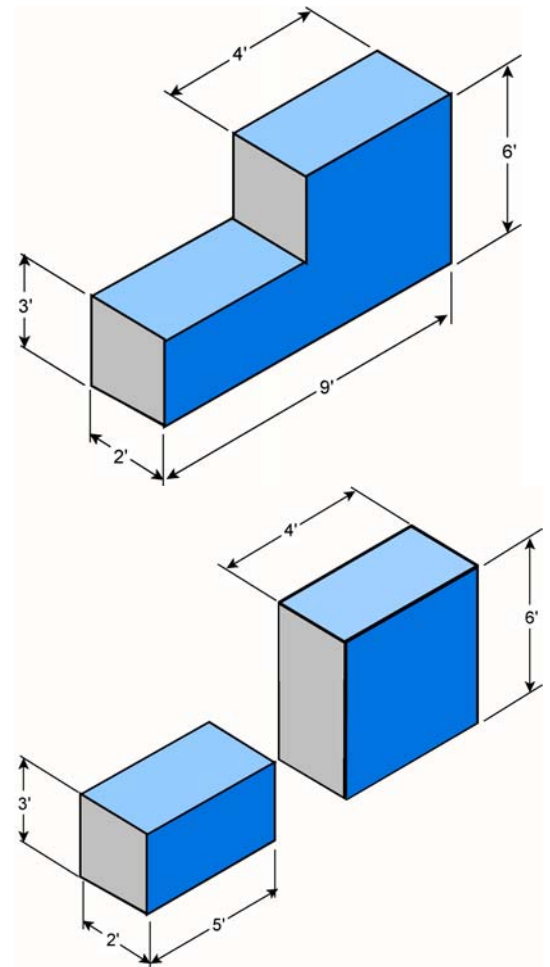
- From the table, steel weighs 490 lbs/cu ft

$$\text{Tube weight} = 9.03 \text{ cu ft} \times 490 \text{ lbs/cu ft} = \underline{4,425 \text{ lbs}}$$

### Example #3: Complex Shapes

Object to be lifted: Concrete widget shown at right

- Cut the object into rectangles, and then calculate the weight of each section, as shown below.

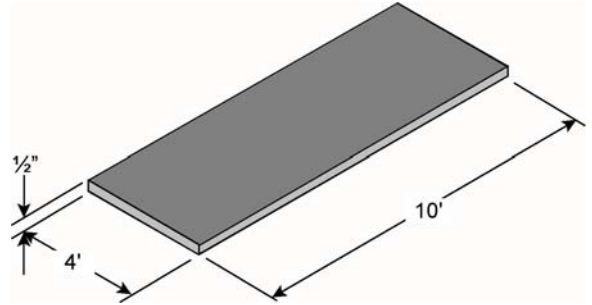


- Top section  
 $V_{\text{top}} = 2 \text{ ft} \times 3 \text{ ft} \times 4 \text{ ft} = 24 \text{ cu ft}$
- Bottom section  
 $V_{\text{bottom}} = 2 \text{ ft} \times 3 \text{ ft} \times 9 \text{ ft} = 54 \text{ cu ft}$
- Total volume  
 $V_{\text{total}} = 24 + 54 = 78 \text{ cu ft}$

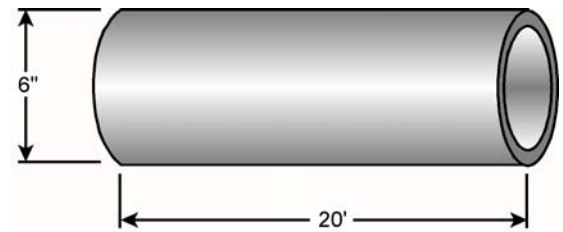
If this object were made of concrete, could it be safely lifted by a 5-ton hoist?

## Calculating Weight Exercises

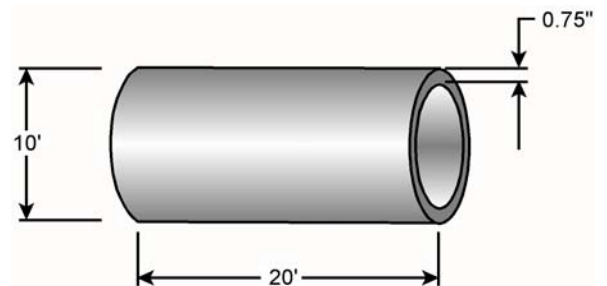
1. Use weights of common materials table on page 4 of this workbook to calculate the weight of a steel plate 4 ft wide x 10 ft long x 1/2 inch thick.



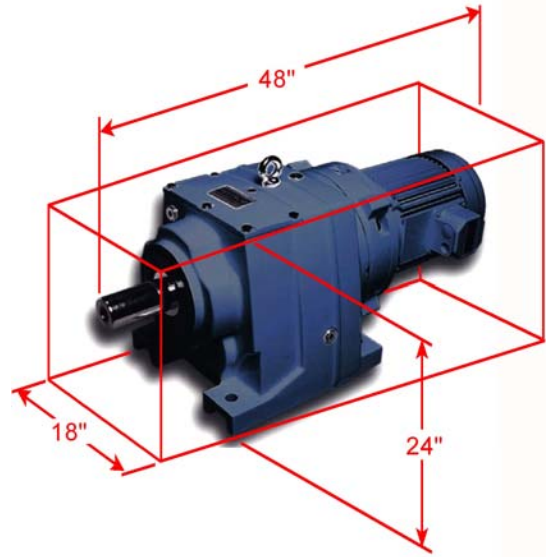
2. Use the weight table for pipe on page 32 to calculate the weight of a nominal 6-inch seamless steel pipe, Schedule 120, 20 ft long.



3. Using the formula for hollow cylinders, calculate the weight of an open-ended aluminum cylinder that is 20 ft long, 10 ft in diameter and with 3/4 (0.75) inch wall thickness.



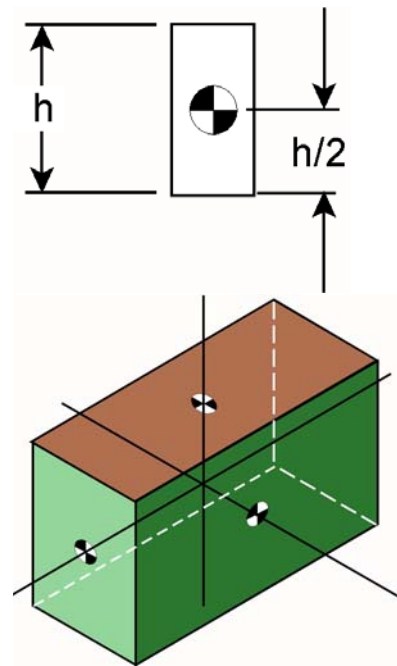
4. Calculate the weight of the motor shown at right.



## Calculating the Center of Gravity

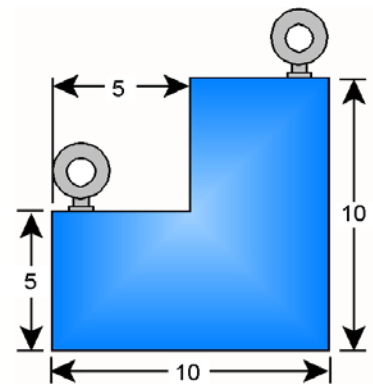
### A. Symmetrical loads

- The center of gravity of a rectangular, symmetrical load can be found by inspection.
- Measure each side of the rectangle.
- Divide each side in half to locate the center of gravity for that side.
- After, combine the results to determine the overall center of gravity.

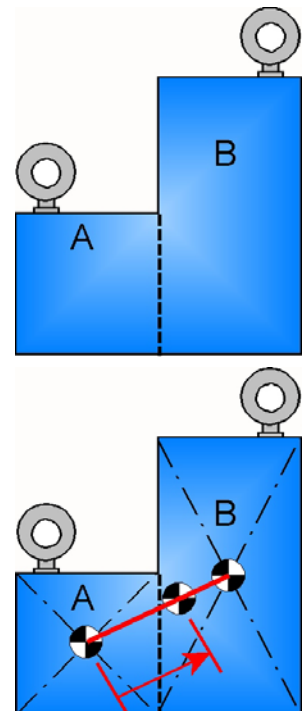


### B. Asymmetric loads

- The easiest method for finding the center of gravity of an asymmetrical load is to divide the object into rectangles and determine the center of gravity for each first, as shown at right.

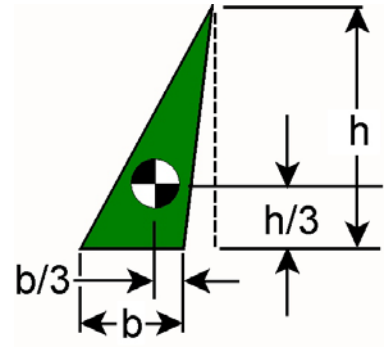


- For the example here, the left rectangle measures 5 feet by 5 feet, while the right-side rectangle measures 5 feet by 10 feet.
- Since the right-hand rectangle is twice as large as the smaller one on the left, and since both are made of the same material, we can tell that 1/3 of the object's weight is concentrated at the left center of gravity (labeled "A"), while 2/3 is concentrated at the right (labeled "B").
- Draw a line connecting the two centers of gravity as shown and measure 2/3 of the way from center of gravity A to center of gravity B, as shown by the red line at right. That is the location of the final, combined center of gravity for the block.

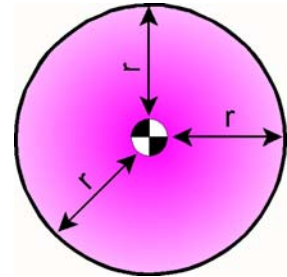


C. Other shapes

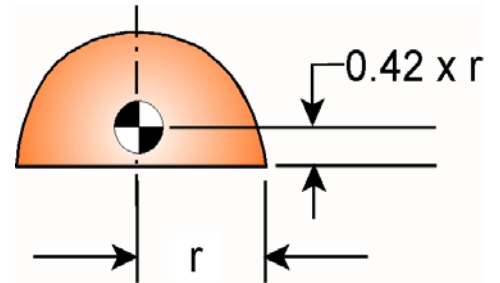
- To find the center of gravity of a triangle, measure 1/3 the height from the base as well as 1/3 of the base from the steepest angle, as shown at right.



- The center of gravity of a circle of uniform weight is located exactly at the center.



- The center of gravity of a semi-circle may be determined as shown at right.

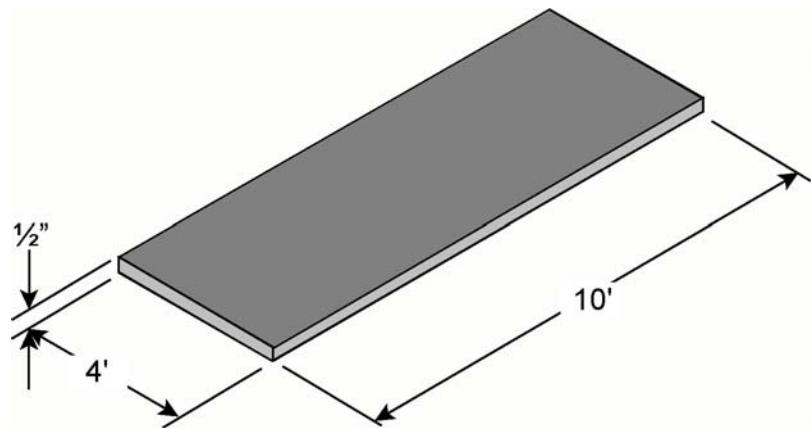
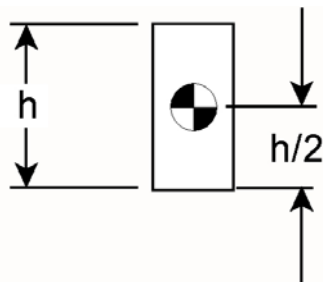


**Example #4: Rectangular Load**

Calculate the center of gravity of a steel plate 4 ft wide x 10 ft long x 1/2 inch thick.

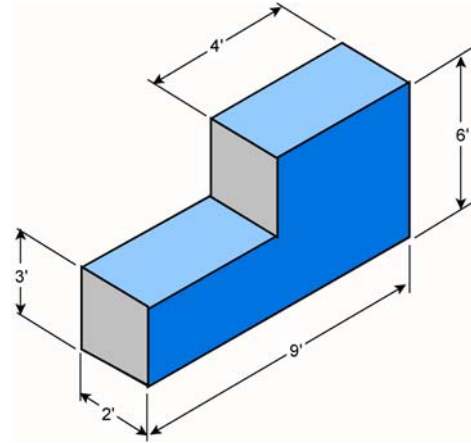
A. Measure "h"  
 $h_1 = 10$  feet  
 CG = 5 feet

B.  $h_2 = 4$  feet  
 CG = 2 feet



### Center of Gravity Exercise

5. Calculate the center of gravity of this concrete block.

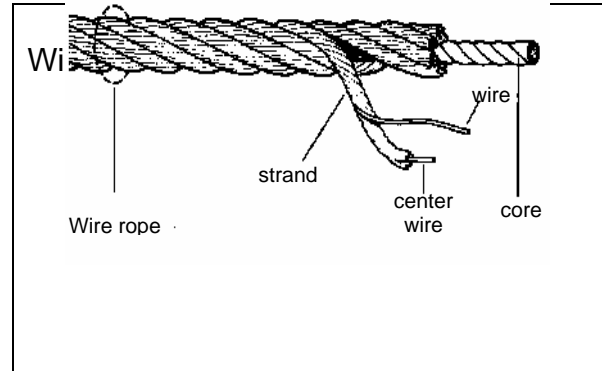


# Specify, Select, and Inspect Rigging Equipment

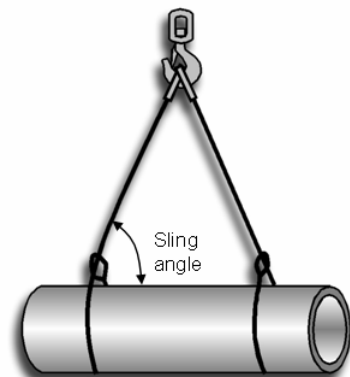
## Wire Rope Slings

### Pre-Use Inspection Checklist

- Inspect daily before use and frequently during use
- Slings must be removed from service when any of the below listed substandard conditions exist.
- Shock loading is prohibited
- Ten (10) randomly distributed broken wires in one (1) rope lay, or five (5) broken wires in one (1) strand in one (1) rope lay
- More than one broken wire at an end connection
- Reduction in rope diameter (1/3 or more of the original wire diameter)
- Severe localized wear, abrasion, or scraping
- Kinking, crushing, under-stranding, bird-caging, core protrusion, and any other damage resulting in distortion of the rope structure
- Evidence of heat damage
- End attachments that are cracked, deformed, or worn
- Hooks or latches deformed or damaged
- Corrosion of the rope or end attachments
- Each wire rope sling shall be marked to show:
  - Name or trademark of manufacturer
  - Rated load capacity for the types of hitches, and the angle upon which it is based
  - Diameter or size
  - BNL color-coded inspection tag or tape
    - 2008: Green
    - 2009: Red
    - 2010: Blue
    - 2011: Orange
    - 2012: Green
    - 2013: Red



Rope Dia. (Inches)	1 Leg		Vertical	2 Leg Bridle		
	Vertical	Choker	Vertical Basket	60°	45°	30°
3/8	2800	2200	5800	5000	4000	2800
7/16	3800	2800	7800	6800	5400	3800
1/2	5000	3800	10200	8800	7200	5000
9/16	6400	4800	12800	11000	9000	6400
5/8	7800	5800	15600	13600	11000	7800
3/4	11200	8200	22000	19400	15800	11200
7/8	15200	11200	30000	26000	22000	15200
1	19600	14400	40000	34000	28000	19600
1 1/8	24000	18200	48000	42000	34000	24000
1 1/4	30000	22000	60000	52000	42000	30000
1 3/8	36000	26000	72000	62000	50000	36000



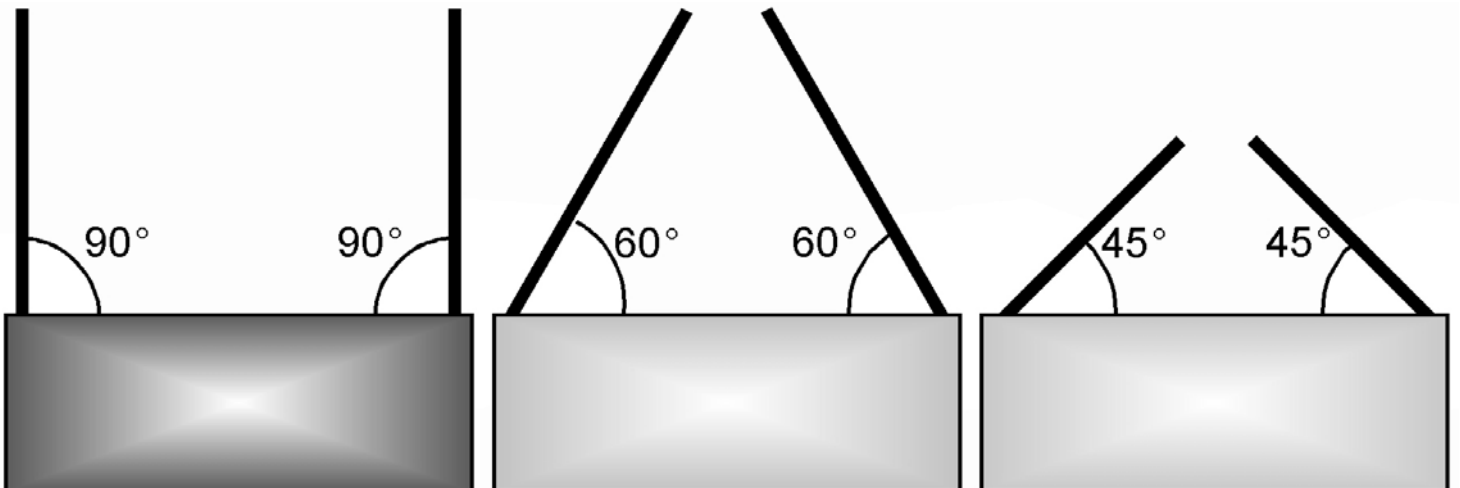
## Sling Angle Factor

The Sling Angle Factor is a multiplier used to determine the required sling size when angle formed between sling and load is less than 90°.

Need to estimate angle to nearest 5°

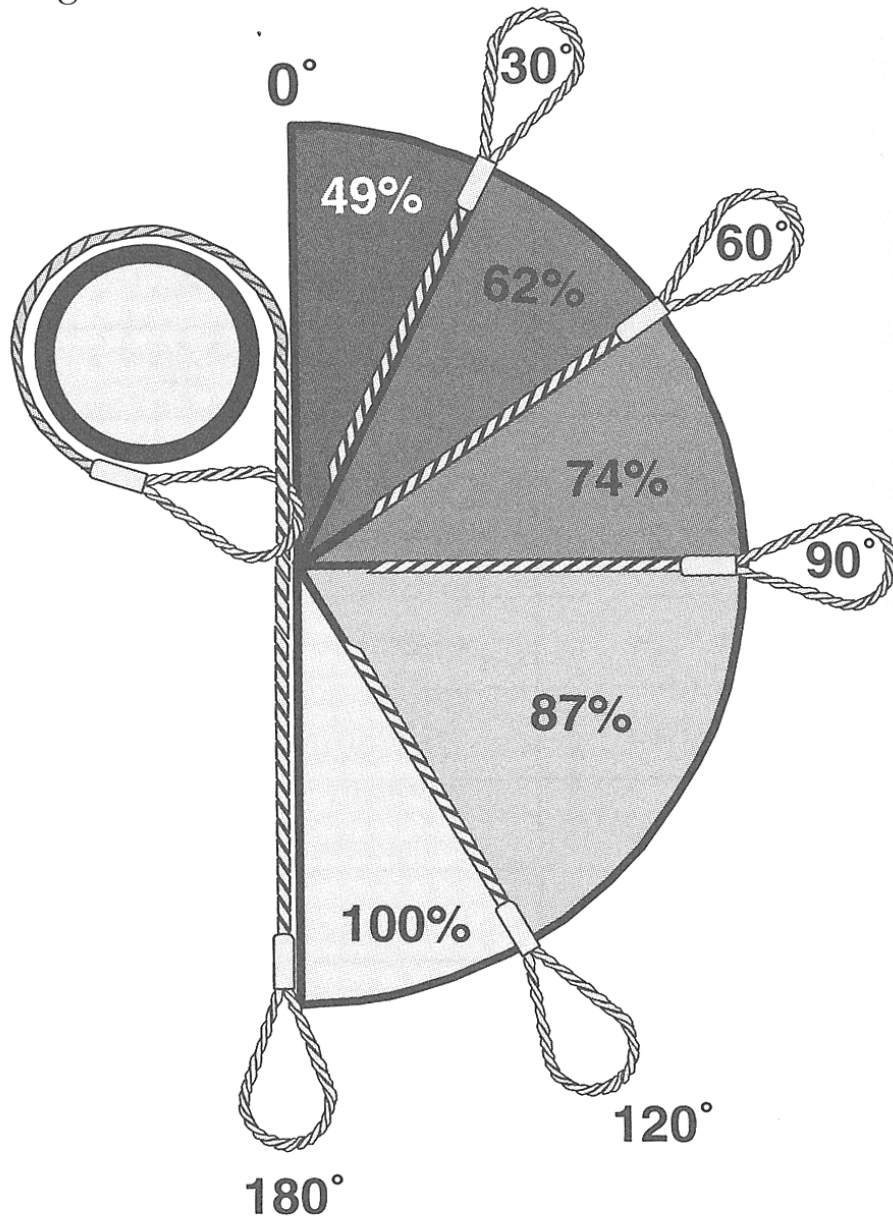
Avoid rigging loads where angle is less than 45°

Sling angle	Load angle factor
90°	1.000
85°	1.004
80°	1.015
75°	1.035
70°	1.064
65°	1.103
60°	1.155
55°	1.221
50°	1.305
45°	1.414
40°	1.555
35°	1.742
30°	2.000
25°	2.366
20°	2.924
15°	3.864
10°	5.759
5°	11.47





## Angle of choke



Choker hitch Rated capacity adjustment	
Angle of choke in degrees	Rated capacity
Over 120	100%
90 - 120	87%
60 - 89	74%
30 - 59	62%
0 - 29	49%

\*Values are for I.W.R.C. and fibre core wire rope, the percentage listed is the percentage of sling rated capacity in a choker hitch.

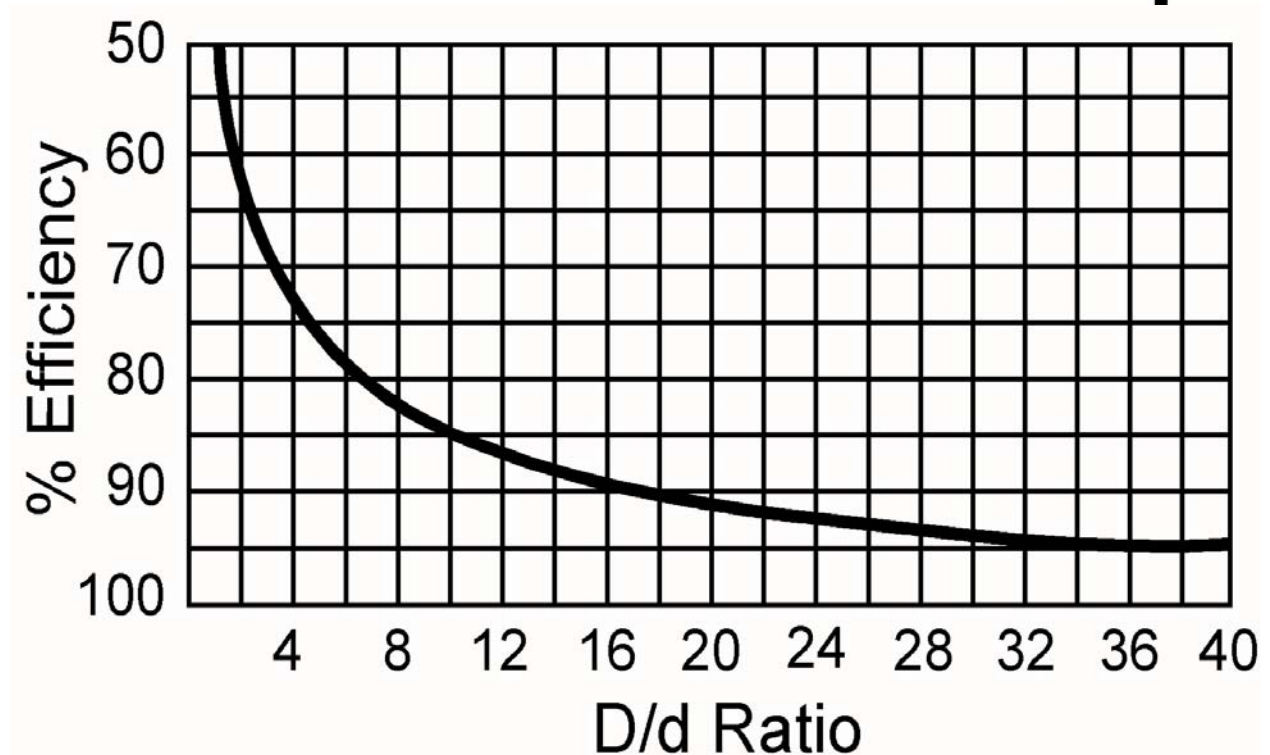
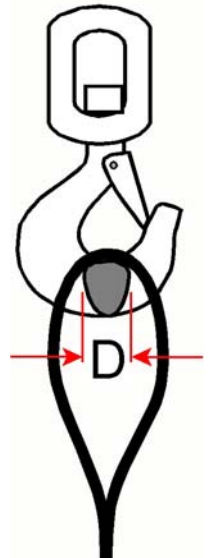
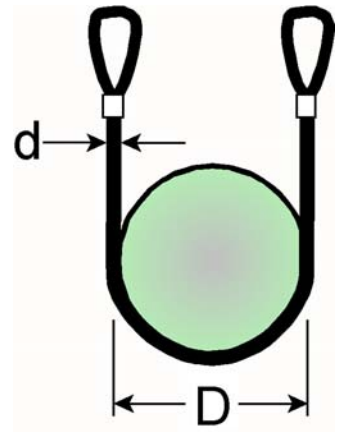
## D/d Ratio

When a wire rope sling is used in a basket hitch, the diameter of the load where the sling contacts the load can reduce sling capacity. The method used to determine the loss of strength or efficiency is referred to as the *D/d Ratio*.

The "D" refers to the diameter of the object being lifted, while the "d" refers to the diameter of the wire rope sling, as shown in the figure at the upper right. For example, when a 1-inch wire rope sling is used to lift an object that measures 25 inches in diameter, the D/d Ratio is 25-to-1 (written 25/1).

Alternatively, the "D" can refer to the cross-sectional diameter of the eye, hook, or other object being used to hoist the load, as shown in the figure at right.

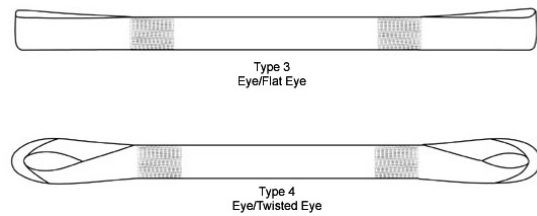
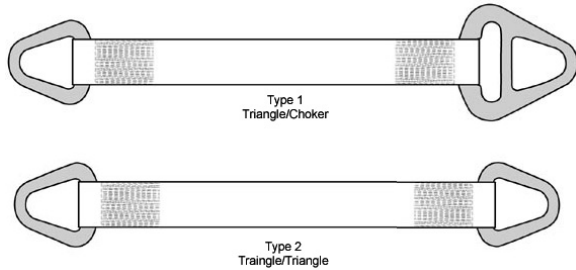
In both cases, the effective strength of the sling results. The table below shows the D/d Ratio and corresponding efficiency percentage.



# Synthetic Slings

## Synthetic Web Slings – 1 Ply Rated Capacities in Pounds

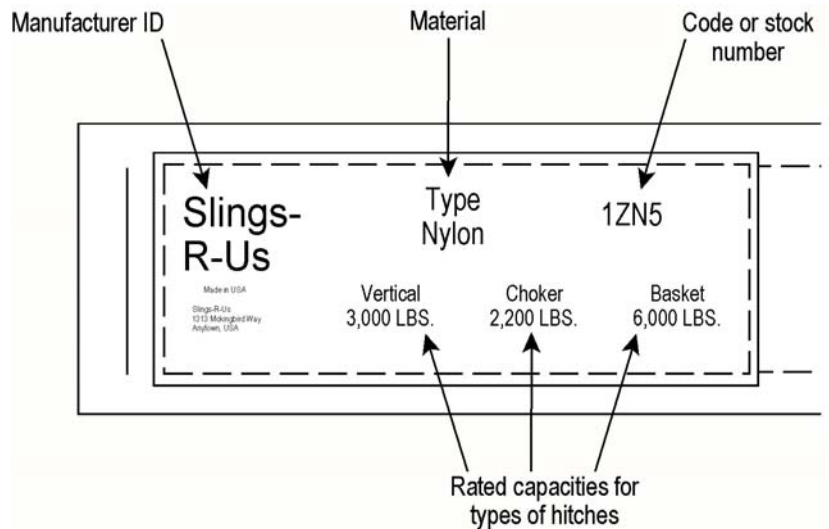
Sling Width (Inches)	1 Leg		Vertical Basket	2-Leg Bridle		
	Vertical	Choker		60°	45°	30°
1	1000	750	2000	1700	1400	1000
2	2000	1500	4000	3500	2800	2000
3	3000	2200	6000	5200	4200	3000
4	4000	3000	8000	6900	5700	4000
5	5000	3700	10000	8700	7100	5000
6	6000	4500	12000	10400	8500	6000



### Synthetic Web Sling Pre-Use Inspection Checklist

Inspect slings daily before use and frequently during use. Slings must be removed from service when any of the following substandard conditions exist.

- Knots, snags, holes, tears, or cuts
- Extensive abrasive wear
- Melting or charring of any part of the sling surface
- Visible red yarns or threads indicate excessive wear
- Broken or worn stitches
- Chemical damage including acid or caustic burns, brittle or stiff areas, and discoloration of any kind
- Corrosive discoloration, or other damage to fittings
- Missing, illegible, or incomplete sling identification
- Synthetic web slings must have tags marked with the information shown at right as well as a BNL color-coded inspection tag



**Synthetic Web Slings**  
 Endless and Eye-and Eye  
 Rated Capacities in Pounds

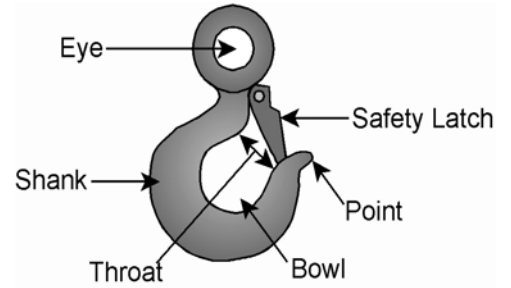
Sling Width (Inches)	1 Leg		Vertical Basket	2-Leg Bridle		
	Vertical	Choker		60°	45°	30°
1	2600	2100	5200	4500	3700	2600
2	5300	4200	10600	9200	7500	5300
3	6400	6700	16800	14500	11900	8400
4	10600	8500	21200	18400	15000	10600
5	13200	10600	26400	22900	18700	13200
6	16800	13400	33600	29100	23800	16800
7	21200	17000	42400	36700	30000	21200
8	25000	20000	50000	43300	35400	25000
9	31000	24800	62000	53700	43800	31000
10	40000	32000	80000	69300	56600	40000
11	53000	42800	106000	91800	74900	53000
12	66000	52800	132000	114300	93300	66000
13	90000	72000	180000	155900	127300	90000

**Endless and Eye-and Eye Synthetic Web Sling Pre-Use Inspection Checklist**

Inspect slings daily before use and frequently during use. Slings must be removed from service when any of the following substandard conditions exist.

- Chemical damage including acid or caustic burns, brittle or stiff areas, and discoloration of any kind
- Melting, charring or weld spatter on any part of the fittings
- Holes, tears, cuts, snags, broken or worn stitching, or any abrasion in the sling cover that exposes the core yarns
- Knots in the sling
- Extensive abrasive wear
- Stretching, cracking, pitting, distortion, or any other damage to the fittings
- Other visible damage that could affect sling strength
- Sling identification missing, illegible, or incomplete (required: manufacturer ID, code or stock number, rated capacity for hitches, core and cover material)

# Hooks



Sorting Hook



Eye Hook



Clevis Grab Hook

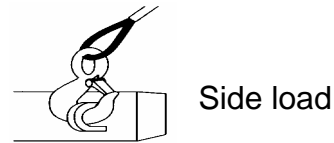


Choker Hook

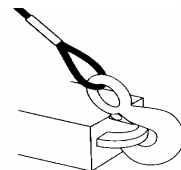
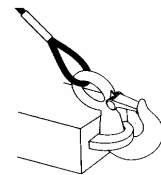
## Eye Hook Rated Capacity Table (Forged Alloy Steel)

Throat Opening	Safe Working Limit (SWL, in pounds)
5/8	600
11/16	800
1	1500
1-1/16	2000
1-1/4	4000
1-3/8	4500
1-13/32	5000
1-1/2	5500
1-17/32	6000

## Incorrect Hook Connections



Back load

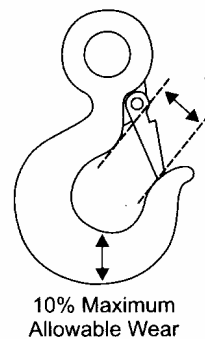


Point load

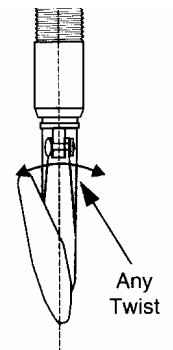
## Hook Pre-Use Inspection Checklist

Inspect hooks daily before use and frequently during use. Remove from service when any of the following conditions exist:

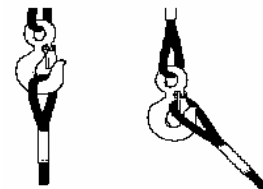
- Missing or illegible manufacturer identification
- Cracks, nicks, or gouges
- Damage from heat
- Unauthorized repairs
- Improper operation and locking of self-locking hooks
- Any twist from plane of un bent hook
- Distortion or wear – any increase in throat opening of 5% not to exceed 1/4 inch, or wear exceeding 10% of original dimension



5% not to exceed 1/4 in.



For added safety, hooks must be equipped with a latch or the throat opening closed-off/secured with a mouse. The latch or mouse is **not** intended to support the load.

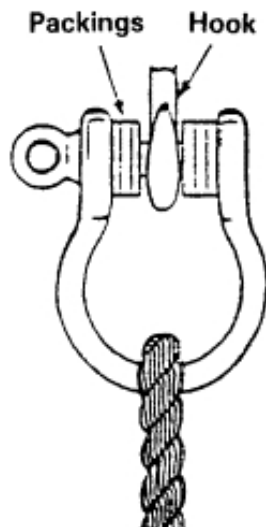
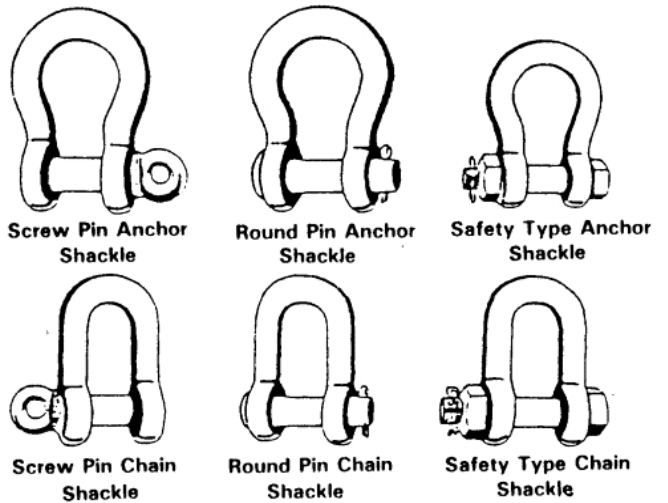


# Shackles

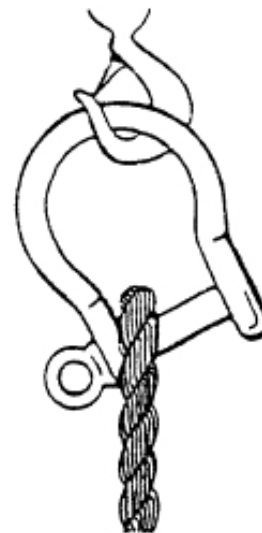
## Shackle Capacity Table (Forged with Alloy Pins)

Nominal Shackle Size	Rated Capacity (Pounds)
3/16	660
1/4	1000
5/16	1500
3/8	2000
7/16	3000
1/2	4000
5/8	6500
3/4	9500
7/8	13000
1	17000
1 1/8	19000
1 1/4	24000
1 3/8	27000
1 1/2	34000
2 1/2	110000

- If different from capacities listed above, use rated capacity marked on the shackle.
- If capacity marking is absent, shackle should be removed from service.



**Good Practice**  
Pack the Pin  
with Washers  
to Centralize  
the Shackle



**Poor Practice**  
Never Allow Shackle  
to be Pulled at an  
Angle, the Legs  
will Open Up

## Shackle Pre-Use Inspection Checklist

Inspect shackles daily before use and frequently during use.

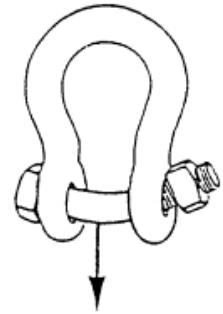
- Each shackle body shall have forged, cast, or die stamped markings by the manufacturer showing: name or trademark of the manufacturer, rated load/capacity (WLL or SWL), and size. This information shall not be missing and must be legible.



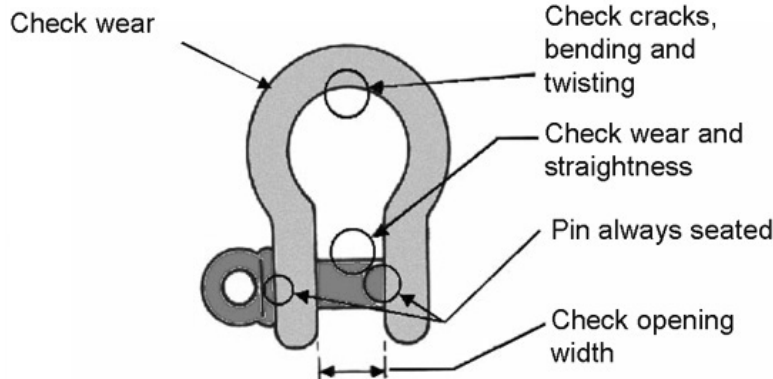
Remove from service when any of the following conditions exist:

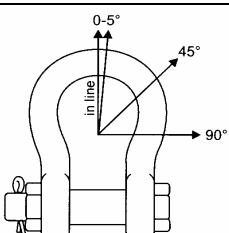
- Indications of heat damage including weld spatter or arc strikes
- Excessive pitting or corrosion
- 10% reduction of the original or catalog dimension at any point around the body or pin
- Body spread including: bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components
- Excessive nicks or gouges
- Incomplete pin engagement, shoulder of pin is not flush with shackle body
- Excessive thread damage
- Evidence of unauthorized welding

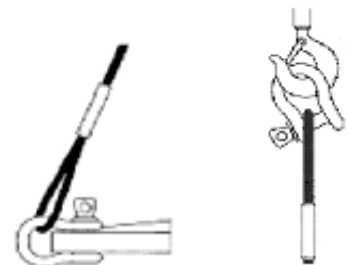
Never Replace a Shackle Pin with a Bolt



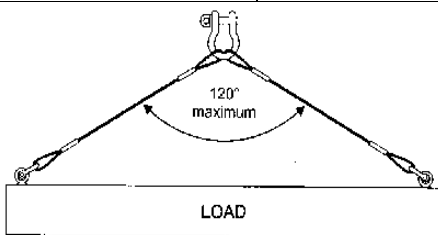
The Load will Bend the Bolt



Side Loading Reduction Factors Screw Pin and Bolt Type Shackles		
	Angle of Side Load from Vertical In-Line of Shackle	Percent Rated Load Reduction
	0° - 5°	0%
	5° - 45°	30%
	46° - 90°	50%
	Over 90°	Avoid



Incorrect Applications



The rated capacity of shackles only applies when they are symmetrically loaded and the included angle between two sling legs is a maximum of 120°. Shackle capacity must be reduced when the angle is greater than 120°.

## Eye Bolts

**Forged Eye bolts – Shoulder Type**  
Rated Capacity Table in Pounds

Nominal Eye Bolt Size (Inches)	90°	60°	30°
1/4	400	75	NR
5/16	680	210	NR
3/8	1000	400	220
7/16	1380	530	330
1/2	1840	850	520
9/16	2370	1160	700
5/8	2940	1410	890
3/4	4340	2230	1310
7/8	6000	2960	1910
1	7880	3850	2630
1 1/8	9920	4790	3840
1 1/4	12600	6200	4125
1 1/2	18260	9010	6040
1 3/4	24700	12100	8250
2	32500	15970	10910

## Types of Eye Bolts



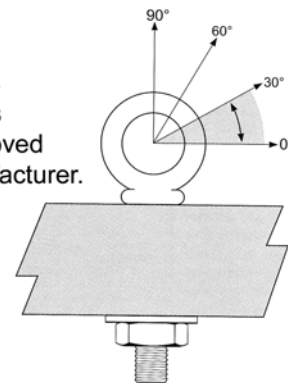
Straight



Shoulder

## Angle Loading Factors

It is recommended that shoulder-type eye bolts not be loaded at angles below 30° unless approved by the eye bolt's manufacturer.



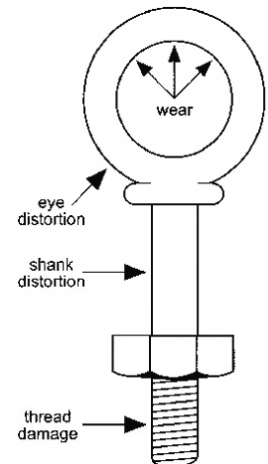
## Eye Bolt Pre-Use Inspection Checklist

All eye bolts must be forged, cast, or die stamped with the name or trademark of the manufacturer, size or capacity, and grade (alloy eye bolts only). This information shall not be missing and must be legible.

Inspect eye bolts daily before use and frequently during use.

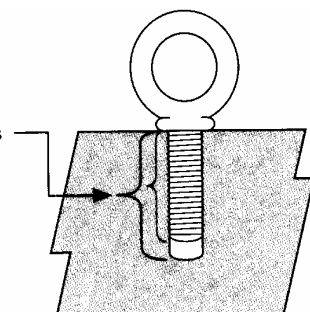
Remove from service if any of the following conditions exist:

- Nicks, gouges, bent or distorted eye, or shank
- Obvious wear (10% reduction of original/catalog dimension at any point)
- Worn, corroded and/or distorted threads
- Indications of heat damage including weld spatter or arc strikes
- Any alteration or repair to eye bolts, such as grinding, machining, welding, notching, stamping, etc. is not permissible.



Tapped receiving holes must be cleaned and inspected for thread wear and deterioration.

When using machinery type eye bolts, the minimum tap depth is basic shank length plus one-half the nominal eye bolt diameter.

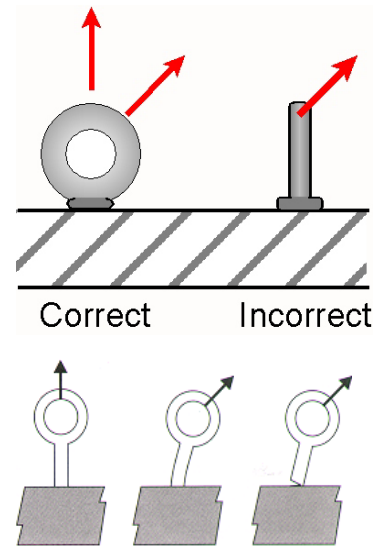


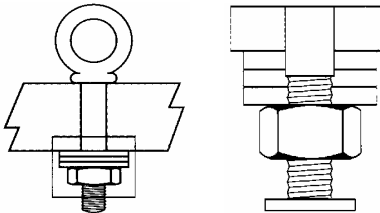
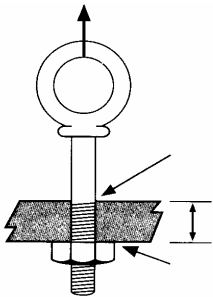
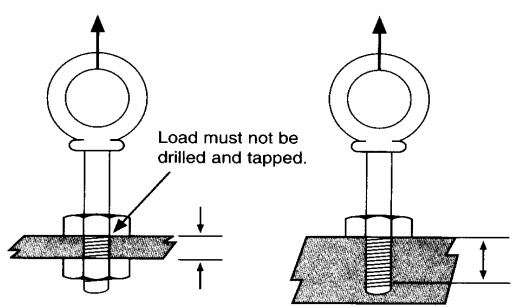


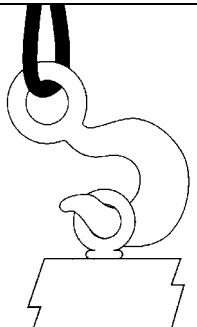
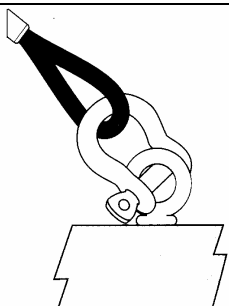
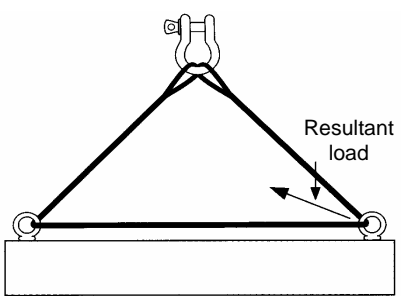
## Eye Bolt Installation and Applications

- Shoulder eye bolts must always be positioned to take the load in the plane of the eye. An eye bolt that is “turned to the side” will have less capacity and may experience damage and failure when a load is lifted.
- Shoulder eye bolts should not be loaded at angles below 30° unless approved by the manufacturer.
- Non-shoulder eye bolts are only designed for vertical loads. When loaded at angles, a non-shoulder eye bolt will bend or break.
- Eye bolts must be tightened securely, torqued to spec if required by the manufacturer.

For angular lifts, the shoulder must be flush, making full contact with the load. Otherwise, only vertical lifts are allowed.



 <p>If the nut cannot be tightened securely against the load, washers can be used to take up excess space between the load and nut.</p> <p>To ensure that the nut tightens securely, spacers must extend beyond the threaded portion of the eye bolt.</p>	 <p>Only one nut is required when there is more than one eye bolt diameter of threads engaging the load.</p>	 <p>Load must not be drilled and tapped.</p> <p>Two hex nuts must be used when one eye bolt diameter of threads or less engages the load.</p> <p>Only one hex nut is required when at least twice the eye bolt diameter of the threaded portion engages the load.</p>
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 <p>Do not use the point of a hook in an eye bolt.</p>	 <p>Use a shackle instead to attach the sling to the eye bolt.</p>	 <p>Do not lift or pull loads with slings reeved from one eye bolt to another. This will change the angle of loading on the eye bolts and create added tension.</p>
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# Hoist Rings

**UNC Threads – Hoist Rings**  
**Rated Capacity Table in Pounds**

Bolt Diameter (inches)	Bolt Length (inches)	Ring Diameter (inches)	Torque (ft-lbs)	Working Load Limits (pounds)
5/16	1.50	0.38	7	800
3/8	1.50	0.38	12	1000
1/2	2.00	0.75	28	2500
1/2	2.50	0.75	28	2500
5/8	2.00	0.75	60	4000
5/8	2.75	0.75	60	4000
3/4	2.25	0.75	100	5000
3/4	2.75	0.75	100	5000
3/4	2.75	1.00	100	7000
3/4	3.50	1.00	100	7000
3/4	2.25	0.75	100	5000
7/8	2.75	1.00	160	8000
7/8	3.50	1.00	160	8000
1	4.00	1.00	230	10000
1 1/4	4.50	1.25	470	15000
1 1/2	6.50	1.75	800	24000
2	6.50	1.75	1100	30000

- Tightening torque values shown are based upon threads being clean, dry and free of lubrication.
- Long bolts are designed for use with soft metal (i.e., aluminum) work pieces. While long bolts may be used with ferrous metal (i.e., steel and iron) work pieces, short bolts are designed for ferrous metal work pieces only.

## Incorrect Applications

Incorrect

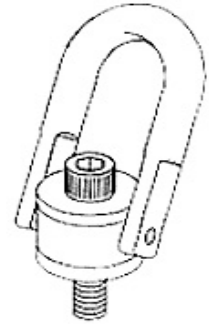


Incorrect

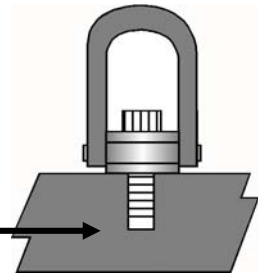


## Installation

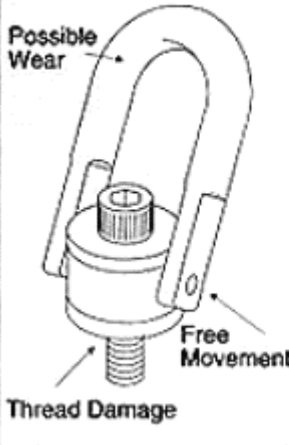

The following instructions must be followed when installing hoist rings, including any instructions provided by the manufacturer:



- Retention nuts, when used, must have full thread engagement. For the rated capacity to apply, SAE 8 standard hex or equivalent must be used.
- Spacers must not be used between the bushing flange and the mounting surface.
- Contact must be flush and in full contact with the hoisting ring, bushing mating, surface.
- Drilled and tapped hole must be 90° to the load surface.
- Using a torque wrench, install hoist ring to the torque value recommended and provided by the manufacturer.
- Drilled holes must be correct diameter. Depth must be threaded shank length plus one-half the threaded shank diameter.




## Hoist Rings Pre-Use Inspection Checklist

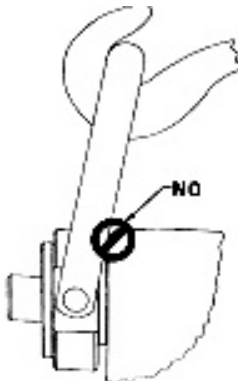
<p>Inspect daily before use and frequently during use. Remove from service if any of the following conditions exist:</p>	<p><b>External Inspection Points</b></p> 	<p><b>RIGHT</b></p> <p>180° Pivot</p>  <p>360° Rotation</p>
<ul style="list-style-type: none"> <li>• Missing or illegible manufacturer's name or trademark, capacity and torque values</li> </ul>	<ul style="list-style-type: none"> <li>• Bail must move freely (it should pivot 180° and swivel 360°)</li> </ul>	
<ul style="list-style-type: none"> <li>• Bail is bent, twisted, or elongated</li> </ul>		
<ul style="list-style-type: none"> <li>• Threads on the shank and receiving holes are unclean, damaged, or do not fit properly</li> </ul>		
<ul style="list-style-type: none"> <li>• Corrosion, wear, or damage</li> </ul>		
<ul style="list-style-type: none"> <li>• Tapped receiving holes must be cleaned and inspected for tread wear and deterioration</li> </ul>		
<ul style="list-style-type: none"> <li>• Any evidence of alteration or repair to hoist rings, such as grinding, machining, welding, notching, stamping, etc.</li> </ul>		
<ul style="list-style-type: none"> <li>• Indications of heat damage including weld spatter or arc strikes</li> </ul>		

## Application

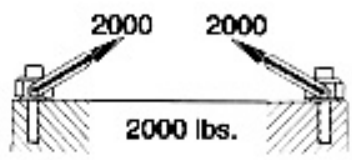
Unlike eye bolts, the rated capacity of hoist rings is not reduced when loaded at angles. It is important to remember that when hoist rings are loaded at angles (see illustration below) additional tension is created. This tension plus the actual load weight must not exceed the rated capacity of the hoist rings.



**Never use a hook or other lifting device which will pry or tend to open the "U" shaped bar on Center-Pull Hoist Rings!**



**After installation, check the Hoist Ring to be sure it swivels and pivots freely in all directions. The side of the ring must not contact anything!**



**Depending upon the sling angle, the applied load may be more than the weight being lifted. Two point lifting of a 2000 pound weight, with a sling angle of 30°, will result in an applied load of 2000 pounds to each hoist ring!**

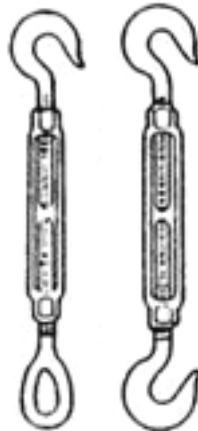
## Turnbuckles

### Turnbuckle Capacity Table

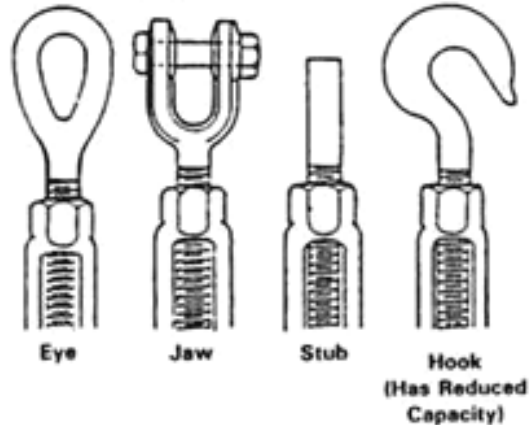
Alloy Steel or Equivalent

#### Hook-style Turnbuckles

Size (Inches)	Rated Capacity (Pounds)
1/4	400
5/16	700
3/8	1000
1/2	1500
5/8	2250
3/4	3000
7/8	4000
1	5000
1 1/4	6500
1 1/2	7500

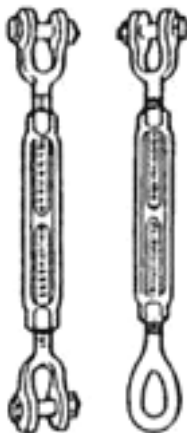


#### End Fitting Types



#### Jaw-style and Eye-style Turnbuckles

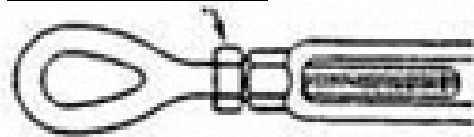
Size (Inches)	Rated Capacity (Pounds)
1/4	500
5/16	800
3/8	1200
1/2	2200
5/8	3500
3/4	5200
7/8	7200
1	10000
1 1/4	15200
1 1/2	21400
1 3/4	28000
2	37000
2 1/2	60000
2 3/4	75000



### Securing Turnbuckle End Fittings

End Fittings must be secured to prevent rotation

Do not use jam nuts

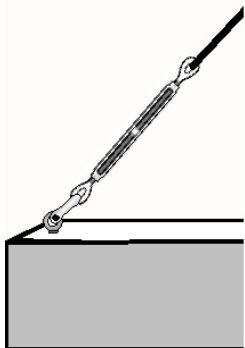


Instead, use a lock wire



### Applications

- Turnbuckles can be used to level and distribute the load among the sling.
- When used in hoisting and rigging applications, turnbuckles should be made from alloy steel or the equivalent, and not welded.
- Turnbuckles must be used in a straight or in-line pull only.



## Using Rope in Rigging Applications

- Allowable uses:
  - Hand hoisting of objects to elevated positions
  - Tag lines
  - Other acceptable uses
- Requires
  - Knowledge of knots
  - Knowledge of rope strength



### Fiber or Synthetic Rope Strength

- Rule of Thumb used to calculate safe working load in pounds
  1. Change rope diameter into 8ths of an inch
  2. Square the numerator of the fraction
  3. Multiply the result by N
    - a. N = 20 for manila
    - b. N = 60 for nylon and polyester

*Example: 3/4 inch manila rope*

- Convert to 8ths:  $3/4 = 6/8$
- Square the numerator:  $6^2 = 36$
- Multiply the result by N:  $36 \times 20 = \mathbf{720 \text{ lbs}}$
- Calculated safe working load applies to straight length of new rope
  - Additional reductions are required for knots, age, and condition

### Knots, Bends, and Hitches

- Knots, bends, and hitches reduce the working strength of a rope.
  - Knot 50%
  - Bend 50%
  - Hitch 75%

### Rope Condition

- Manila rope is affected by age.
  - Safe working load decreases 1% per year.
- All rope is to be removed from service if any of the following conditions are present:
  - Abnormal wear
  - Powder or grit between strands
  - Broken or cut fibers
  - Variations in size or roundness
  - Discoloration or rotting



## Useful Knots

- Figure-Eight Knot
  - at end to prevent from passing through object



- Reef or Square Knot
  - join two ropes of same size



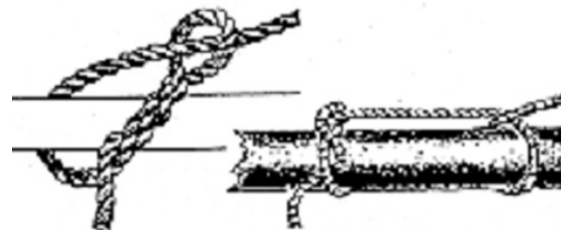
- Round turn and two half hitches
  - secure tag line to object



- Bowline
  - most widely used knot
  - will not slip, jam, or fail



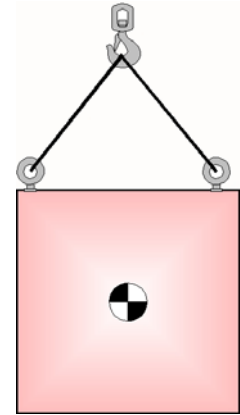
- Timber Hitch
  - used for hoisting planks or pipe
  - holds without slipping or jamming



# Lift, Maneuver, and Move Load

## Handling Symmetrical Loads

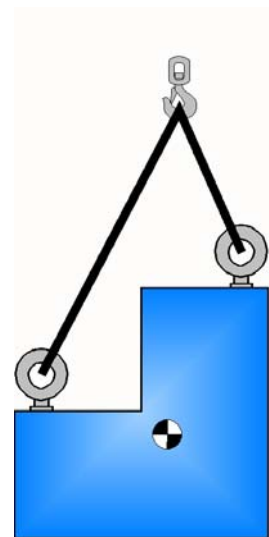
1. Check the following to ensure that all are up-to-date and in proper working condition prior to crane operation:
  - a. Annual BNL overhead crane inspection tag
  - b. Crane main disconnect switch
  - c. Supporting structure and rails for loose fasteners or unusual wear
  - d. Controls and operating mechanism (feeder cable strain relief, loose fasteners and damage to pendant controls)
  - e. Block for wear and lubrication
  - f. Hooks for cracks, throat spread, deformation, damage, wear and safety latch
  - g. Hoist rope for significant wear, kinks, broken wires, crushing, bird-caging, and corrosion
  - h. Hoist chain for nicks, gouges, distortion, wear, corrosion, and arc strikes
  - i. Hook latch for proper operation
  - j. Fluid leaks on floor, excess grease
  - k. Any other deficiency that may constitute a hazard
  - l. Main hoisting gear system for noise
  - m. Hoist upper-limit switch
  - n. Proper spooling of drums
  - o. Auxiliary hoist
  - p. Bridge travel - both directions
  - q. Bridge limit switch, or mechanical stop (both directions)
  - r. Bridge brakes
  - s. Trolley travel - both directions
  - t. Trolley limit switch, or mechanical stop - both directions
  - u. Load brakes
  - v. Any other deficiency that may constitute a hazard
2. Check the travel route to ensure there is sufficient clearance for the load.
3. Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.
4. Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan.
  - a. If the only available attachment points are below the center of gravity, stabilize the load using taglines.
5. Equalize loading on multiple leg slings and maintain a balanced load.
6. Protect rigging equipment and the load from sharp surfaces and damage.



7. Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt.
  - a. If the load tilts, lower immediately and reposition rigging components to prevent the load from listing.
  - b. Repeat the test lift. If problem recurs, stop the lift and reexamine the Lift Plan's recommendations for rigging equipment as well as the location of the load's center of gravity.
8. After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility's notification system (sounding an alarm, etc.).
9. Proceed by lifting the load slowly and moving the load slowly to its destination.
  - a. Keep load as low to ground as possible.
  - b. Use attendants to walk with the load if needed to keep it from impacting surrounding objects.
10. Lower the load slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.
11. Detach the rigging and secure the equipment.

## **Handling Asymmetrical Loads**

1. Check that all crane systems are up-to-date and in proper working condition prior to crane operation.
2. Check the travel route to ensure there is sufficient clearance for the load.
3. Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.
4. Determine and identify the location of the load's center of gravity.
5. Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan.
  - a. If the only available attachment points are below the center of gravity, stabilize the load using taglines.
6. Equalize loading on multiple leg slings and maintain a balanced load.
7. Protect rigging equipment and the load from sharp surfaces and damage.
8. Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt.



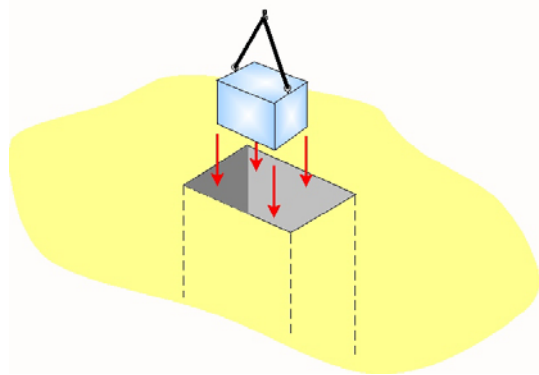


- a. If the load tilts, lower immediately and reposition rigging components to prevent the load from listing.
  - b. Repeat the test lift. If problem recurs, stop the lift and reexamine the Lift Plan's recommendations for rigging equipment as well as the location of the load's center of gravity.
9. After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility's notification system (sounding an alarm, etc.).
  10. Proceed by lifting the load slowly and moving the load slowly to its destination.
    - a. Keep load as low to ground as possible.
    - b. Use attendants to walk with the load if needed to keep it from impacting surrounding objects.
  11. Lower the load slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.
  12. Detach the rigging and secure the equipment.

## **Moving Loads through Vertical Openings**

Passing a load through a shaft, floor hole, or other vertical opening presents many challenges to the rigger. Often, because of tight clearances or the length of the opening, it is not practical to have an assistant help guide the load as it passes through. As a result, determining the size of the opening, the exact balance point, and the overall load footprint is the key to a successful operation.

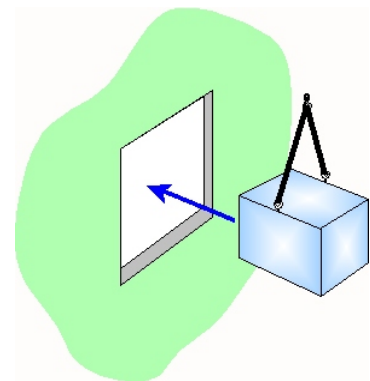
1. Check that all crane systems are up-to-date and in proper working condition prior to crane operation.
2. Check the opening to ensure there is sufficient clearance for the load.
3. Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.
4. Determine and identify the location of the load's center of gravity.
5. Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan.
  - a. If the only available attachment points are below the center of gravity, stabilize the load using taglines.



6. Equalize loading on multiple leg slings and maintain a balanced load.
7. Protect rigging equipment and the load from sharp surfaces and damage.
8. Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt.
  - a. If the load tilts, lower immediately and reposition rigging components to prevent the load from listing.
  - b. Repeat the test lift. If problem recurs, stop the lift and reexamine the Lift Plan's recommendations for rigging equipment as well as the location of the load's center of gravity.
9. After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility's notification system (sounding an alarm, etc.).
10. Proceed by lifting the load slowly and lowering the load slowly to its destination.
  - a. Keep load as low to ground as possible.
  - b. Use attendants to guide the load if needed to keep it from impacting the walls of the opening.
11. Lower the load slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.
12. Detach the rigging and secure the equipment.

### **Moving Loads through Horizontal Openings**

1. Check that all crane systems are up-to-date and in proper working condition prior to crane operation.
2. Check the opening to ensure there is sufficient clearance for the load.
3. Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.
4. Determine and identify the location of the load's center of gravity.
5. Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan.
  - a. If the only available attachment points are below the center of gravity, stabilize the load using taglines.
6. Equalize loading on multiple leg slings and maintain a balanced load.
7. Protect rigging equipment and the load from sharp surfaces and damage.
8. Position any catch equipment, such as rollers or a second crane, on the receiving side of the wall hole.



9. Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt.
  - a. If the load tilts, lower immediately and reposition rigging components to prevent the load from listing.
  - b. Repeat the test lift. If problem recurs, stop the lift and reexamine the Lift Plan's recommendations for rigging equipment as well as the location of the load's center of gravity.
10. After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility's notification system (sounding an alarm, etc.).
11. Proceed by lifting the load slowly and lowering the load slowly to its destination.
  - a. Keep load as low to ground as possible.
  - b. Use attendants to guide the load if needed to keep it from impacting the walls of the opening.
12. Once the load is partially through the wall opening, have an assistant ensure that it is lined up correctly with the receiving device.
13. Depending on the load's shape and center of gravity, stop the lift as needed to attach rigging devices on the receiving side.
14. Continue the lift until the load is on the receiving side of the wall opening, when it can be supported and controlled by that side's rigging apparatus.
15. Move the load to its final position.

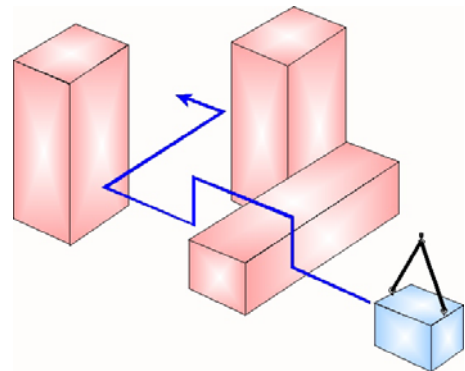
### **Moving Loads around or over Obstacles**

Depending on the work location, it may be necessary to lift a load around or over an obstacle that is blocking the travel path. When this happens, it is especially important to determine the potential effect of the load being dropped or otherwise damaged as a result of a fall or collision. Factors to consider include, but are not limited to, the nature of the obstacle and the item being lifted, cost, programmatic impact, safety hazard, and environmental impact.

If, by the nature of the work being performed, the lift is elevated to "critical," contact the BNL Riggers in the Plant Engineering Division to perform the lift.

If the lift is considered incidental or pre-engineered after careful analysis, then proceed as follows:

1. Check that all crane systems are up-to-date and in proper working condition prior to crane operation.
2. Check the opening to ensure there is sufficient clearance for the load.



3. Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.
4. Determine and identify the location of the load's center of gravity.
5. Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan.
  - a. If the only available attachment points are below the center of gravity, stabilize the load using taglines.
6. Equalize loading on multiple leg slings and maintain a balanced load.
7. Protect rigging equipment and the load from sharp surfaces and damage.
8. Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt.
  - a. If the load tilts, lower immediately and reposition components to prevent the load from listing.
  - b. Repeat the test lift. If problem recurs, stop the lift and reexamine the Lift Plan's recommendations for rigging equipment as well as the location of the load's center of gravity.
9. After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility's notification system (sounding an alarm, etc.).
10. Proceed by lifting the load slowly and lowering the load slowly to its destination.
  - a. Keep load as low to ground as possible. Only raise the load when it becomes necessary to move around or over an obstacle.
  - b. Use attendants and tag lines to guide the load if needed to keep it from impacting walls or other equipment.
11. Once the load is partially through the wall opening, have an assistant ensure that it is lined up correctly with the receiving device.
12. Lower the load as soon as the obstacle is cleared.
13. When the load is in its final location, lower it slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.
14. Move the load to its final.

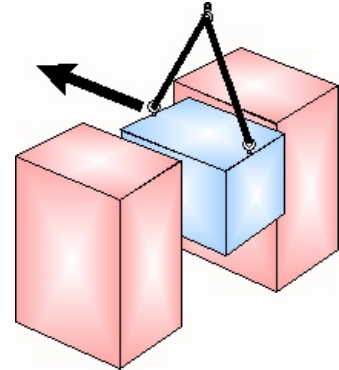
### **Moving Loads in Close Proximities**

Depending on the work location, it may be necessary to pass a load very near to stationary objects along the travel path. When this happens, it is especially important to determine the potential for damage to the load or nearby equipment as a result of a fall or collision. Factors to consider include, but are not limited to, the nature of the obstacle and the item being lifted, cost, programmatic impact, safety hazard, and environmental

impact. If, by the nature of the work being performed, the lift is elevated to "critical," contact the BNL Riggers in the Plant Engineering Division to perform the lift.

If the lift is considered incidental or pre-engineered after careful analysis, then proceed as follows:

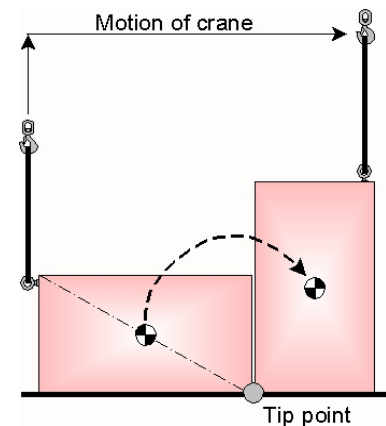
1. Check that all crane systems are up-to-date and in proper working condition prior to crane operation.
2. Check the clearance along the travel path to ensure there is sufficient clearance for the load.
3. Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.
4. Determine and identify the location of the load's center of gravity.
5. Attach slings/chains/wire ropes to the load above the center of gravity as specified on the Lift Plan.
6. If the only available attachment points are below the center of gravity, stabilize the load using taglines.
7. Equalize loading on multiple leg slings and maintain a balanced load.
8. Protect rigging equipment and the load from sharp surfaces and damage.
9. Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt.
10. If the load tilts, lower immediately and reposition components to prevent the load from listing.
11. Repeat the test lift. If problem recurs, stop the lift and reexamine the Lift Plan's recommendations for rigging equipment as well as the location of the load's center of gravity.
12. After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility's notification system (sounding an alarm, etc.).
13. Proceed by lifting the load slowly and lowering the load slowly to its destination.
  - a. Keep load as low to ground as possible.
  - b. Proceed very slowly when passing close to other equipment.
  - c. Use attendants and tag lines to guide the load if needed to keep it from impacting walls or other equipment.
14. When the load is in its final location, lower it slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.



## Upending, Inverting, and Rolling Loads

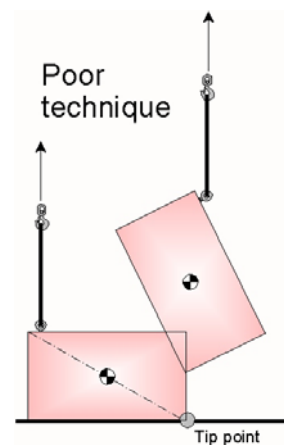
Upending a load refers to the process of rotating an object so that it rests on its side or end. Overhead cranes and hoists can be used to upend and invert loads, but before such an operation can be attempted, it is absolutely essential to know the load's weight, center of gravity, and tip point. A load's tip point is the corner on which it will pivot when upended. Only with these three facts known can rigging be selected and placed correctly to invert a load safely without shock loading.

When upending a load, the optimum lift/hitch point is just below a line extending through the tip point and the load's center of gravity, as shown at right. After attaching at the lift/hitch point, a load can be tilted on its side by raising the hoist and providing a slight amount of travel.

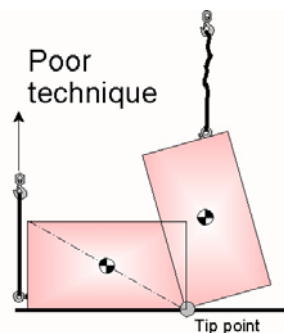


When tipping a load, be sure to move the hoist both vertically and horizontally. If the hoist is moved vertically only, the tip point will drag across the floor, possibly damaging the load or floor as it slides. When loads must be upended without hoist travel, the tip point must be protected by placing the load on a skid or a dolly. This way, the skid or dolly slides on the floor until the load is fully raised. The skid or dolly can then be removed and the load set down.

The tip point and lift point must be located precisely to prevent the load from raising and flipping uncontrollably. If the lift point is above the line extending from the tip point through the center of gravity, the load will flip and rise off the floor, causing it to swing uncontrollably, as shown at right.



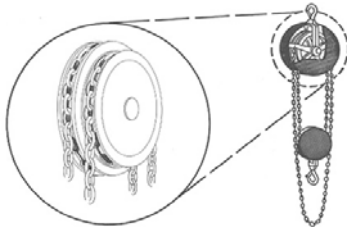
At the same time, if the lift point is too low, the wire rope will not be held in tension, and so cannot restrain the load as it tips. When this happens, the wire rope will go slack, allowing the load to tip over suddenly and crash onto the floor. A load upended in this fashion may be damaged as it falls over and may cause collateral damage to property or personnel.



## Lifting with Hand-Operated Chain Hoists

- Hand-operated chain hoists come in a variety of types, shapes, sizes, lifting capacities, and diverse features/controls.
- These manually operated hoisting devices enable one person to lift heavy loads (multiple tons) by using a series of reduction gears to provide a mechanical advantage and thereby reduce the amount of effort (muscle energy) needed to lift a load.
- There are 3 common types of hand-operated chain hoists used in rigging, shown below. Each operates on a different principle, and each has its own advantages and disadvantages to consider during the selection process.

### Differential Hoist



#### Operating Principle

- Operates with multiple sheaves, each with pockets cut out to fit chain links. One sheave has more pockets than the other so as it rotates of the same shaft it take up chain faster.

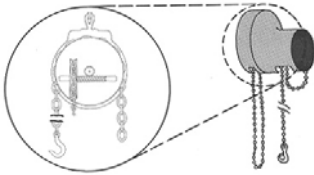
#### Advantages

- Relatively inexpensive
- Simple to operate

#### Disadvantages

- Least efficient hand-operated chain hoist
- Will slip when hand loop is released
- If load/hoist are jarred the load may fall

### Screw-Gear Hoist



#### Operating Principle

- The mechanism inside the block is a worm and pinion arrangement. The hand chain is an endless loop that rotates the mechanism. The load chain descends directly from the block.

#### Advantages

- More efficient than differential hoists
- Can safely suspend a load when the hand chain is released because the worm gear cannot be driven by its pinion.

#### Disadvantages

- Less efficient than a spur-gear hoist

#### Operating Principle

- Uses a gear arrangement called a sun and planetary gear set. The hand wheel is coupled to the sun gear. As the sun gear turns, the entire group of planetary gears slowly revolves. The load wheel rotates much more slowly than the sun gear, providing the reduction in speed necessary for the hoist to operate.

#### Advantages

- Most efficient hand-operated chain hoist
- Incorporates a clutch that slips if the hoist is overload beyond its safe lifting capacity to keep the load from being raised

#### Disadvantages

- Requires a friction brake (usually an automatic feature/some have a manual brake release) to hold a load aloft when the hand chain is released because of the reduced amount of friction.



- If improperly used or abused, hand-operated hoists can cause major production loss, and serious injury.
- Safe and sound rigging practices shall be used to conjunction with hoisting operations.

## **Hoisting Guidance**

Operation of a hand operated chain hoist involves more than pulling the hand chain. The use of these hoists is subject to certain hazards that cannot be met by mechanical means, but only by the exercise of intelligence, care, common sense, and experience in anticipating the motions that will occur as a result of operating the hoists.

## **Pre-Use Inspection Requirements**

- Pre-use inspections are to be conducted by a designated person who shall determine whether conditions found constitute a hazard and whether a more detailed inspection is necessary.
- Records not required for frequent inspections
- Inspect daily before use and frequently during use

## **Identification**

- The hoist shall be marked with the manufacturer's name, model, serial number, and rated load capacity attached on a plate or label, or cast, forged, or stamped on the hoist or load block

## **Warnings and Labels**

- Warnings shall be affixed to the hoist or block with labels displaying information concerning operating procedures
- Labels shall be in compliance with ANSI Z535.4 and include cautionary language against:
  - Lifting more than rated load capacity
  - Operating hoist with twisted, kinked, or damaged chain
  - Operating damaged or malfunctioning hoist
  - Lifting people or lifting loads over people
  - Operating hoist other than with human power
  - Removing or obscuring labels

## **Pre-Use Inspection Checklist**

The following items shall be inspected:

- Operating mechanism for proper operation, proper adjustment, and unusual sounds
- Hoist braking system for proper operation
- Hook, & latches if used, for ASME B30.10 compliance
- Hoist load chain, reeving, and hoist rope for compliance with manufacturer recommendations

## **Pre-Hoist Operations**

The operator must:

- Be trained
- Not make adjustments or repairs unless qualified
- Report substandard conditions
- Not operate a hoist that is tagged out of-service
- Not use the chain or rope as a welding ground
- Not allow welding electrodes to contact the hoist
- Operate only manually (hand power) by one operator



## **Hoist Operations**

- Hoist rope or chain shall not be wrapped around a load
- Before load movement, the operator shall be sure chains are not kinked or twisted around each other
- The hoist shall not be operated unless rope or chain is seated properly on the drum, sheaves, or sprockets
- The hoist shall not be operated unless centered over the load, except when authorized by a qualified person
- The operator shall not pick up a load in excess of the rated load bearing capacity on the hoist or load block, except during authorized tests or pre-engineered lifts
- A hoist overload limiting devices shall not be used to measure the maximum load to be lifted
- Each time a load approaching load capacity is handled, the operator shall check hoist brake action by lifting the load just clear of supports and continuing only after verifying the brake system is operating properly
- Unless a lower limit device is provided, the load shall not be lowered below the point where less than two wraps of rope remain on the anchorage of the hoist drum

# Appendices

## Carbon Steel Pipe Size Chart<sup>1</sup>

Nom. Size (in)	O.D. (in)	Schedule Number or Weight	Wall Thickness (in)	Inside Diameter (in)	Pipe Weight (lbs/ft)
1/4	0.540	40ST	0.088	0.364	0.424
1/4	0.540	80XS	0.119	0.302	0.535
3/8	0.675	40ST	0.091	0.493	0.567
3/8	0.675	80XS	0.126	0.423	0.738
1/2	0.840	40ST	0.109	0.622	0.850
1/2	0.840	80XS	0.147	0.546	1.087
3/4	1.050	40ST	0.113	0.824	1.13
3/4	1.050	80XS	0.154	0.742	1.47
1	1.315	40ST	0.133	1.049	1.68
1	1.315	80XS	0.179	0.957	2.17
1-1/4	1.660	40ST	0.140	1.380	2.27
1-1/4	1.660	80XS	0.191	1.278	2.99
1-1/2	1.900	40ST	0.145	1.610	2.72
1-1/2	1.900	80XS	0.200	1.500	3.63
2	2.375	40ST	0.154	2.067	3.65
2	2.375	80XS	0.218	1.939	5.02
2-1/2	2.875	40ST	0.203	2.469	5.79
2-1/2	2.875	80XS	0.276	2.323	7.66
3	3.500	40ST	0.216	3.068	7.57
3	3.500	80XS	0.300	2.900	10.25
4	4.500	40ST	0.237	4.026	10.78
4	4.500	80XS	0.337	3.826	14.97
6	6.625	40ST	0.280	6.065	18.96
6	6.625	80XS	0.432	5.761	28.55
8	8.625	30	0.277	8.071	24.68
8	8.625	40ST	0.322	7.981	28.53
8	8.625	80XS	0.500	7.625	43.35
10	10.75	30	0.307	10.136	34.21
10	10.75	40ST	0.365	10.202	40.45
10	10.75	XS	0.500	9.750	54.69
10	10.75	80	0.593	9.564	64.28
12	12.75	30	0.330	12.090	43.74
12	12.75	ST	0.375	12.000	49.52
12	12.75	40	0.406	11.938	53.48
12	12.75	XS	0.500	11.750	65.37
12	12.75	80	0.687	11.376	88.44
14	14.00	30ST	0.375	13.250	54.53
14	14.00	40	0.437	13.126	63.25
14	14.00	XS	0.500	13.000	72.04
14	14.00	80	0.750	12.500	106.05
16	16.00	30ST	0.375	15.250	62.53
16	16.00	40XS	0.500	15.000	82.71
18	18.00	ST	0.375	17.250	70.54
18	18.00	30	0.437	17.126	81.91
18	18.00	XS	0.500	17.000	93.38
18	18.00	40	0.562	16.876	104.59
20	20.00	20ST	0.375	19.250	78.54
20	20.00	30XS	0.500	19.000	104.05
20	20.00	40	0.593	18.814	122.82

<sup>1</sup> Based on ANSI B 36.10 and ANSI B 36.19

## Weight of Common Materials<sup>2</sup>

Material	lb. per cu. ft.	Material	lb. per cu. ft.
Aluminum	165	Lumber: Douglas fir	34
Asbestos, solid	153	Lumber: Oak	62
Asphalt	81	Lumber: Pine	30
Brass	524	Lumber: Poplar	30
Brick, soft	110	Lumber: Spruce	28
Brick, common red	125	Lumber: Railroad ties	50
Brick, pressed	140	Marble	98
Bronze	534	Motor oil	60
Coal	56	Paper	58
Concrete, slag	130	Petroleum: Crude	55
Concrete, reinforced	150	Petroleum: Gasoline	45
Copper	556	Portland cement (loose)	94
Diesel fuel	52	Portland cement (set)	183
Crushed rock	95	River sand	120
Earth, dry, loose	75	Rubber	94
Earth, dry, packed	95	Sand, wet	120
Earth, wet	100	Sand, dry	105
Glass	160	Sand, loose	90
Granite	96	Steel	490
Ice, solid	56	Tar	75
Iron	485	Tin	460
Lead	710	Water	63
Lime (Gypsum)	58	Zinc	437
Limestone	95		

### **Weights of Steel and Aluminum Plates (pounds per square foot)**

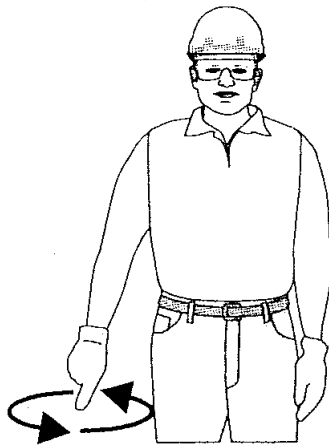
plate size (inches)	steel	aluminum
1/8	5	1.75
1/4	10	3.50
1/2	20	7.00
3/4	30	10.50
1	40	14.00

<sup>2</sup> Values taken from Rigging by James Headley, Crane Institute of America, 2007 edition.

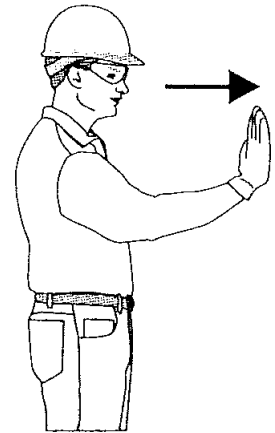
# Hand Signals



HOIST



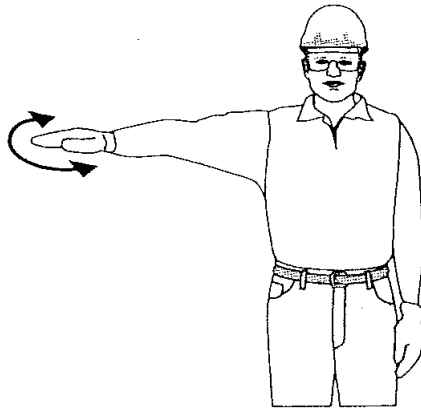
LOWER



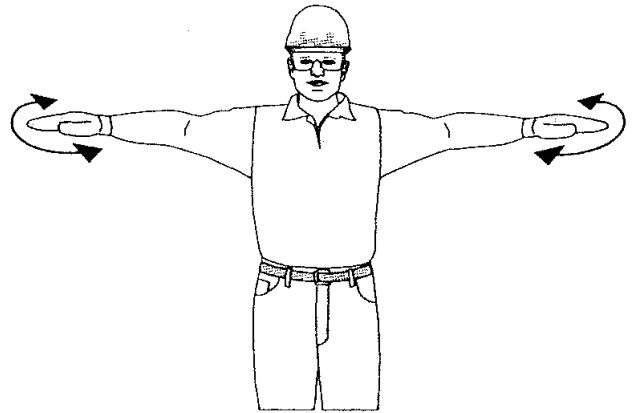
BRIDGE TRAVEL



TROLLEY TRAVEL



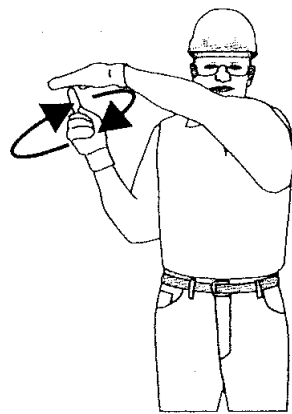
STOP



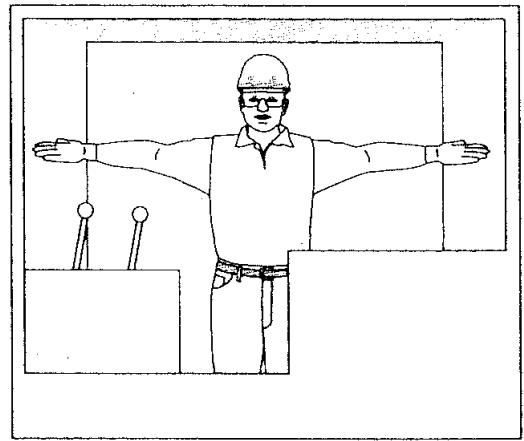
EMERGENCY STOP



MULTIPLE TROLLEYS



MOVE SLOWLY  
(i.e. HOIST SLOWLY)



MAGNET IS DISCONNECTED