RIGGER AND SIGNAL PERSON

RIGGER FIELD GUIDE

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Determine Task and Job-Site Requirements

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 hoisting equipment and commonly available rigging components, such as slings, shackles, eye bolts, and turnbuckles.

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 Employer 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.

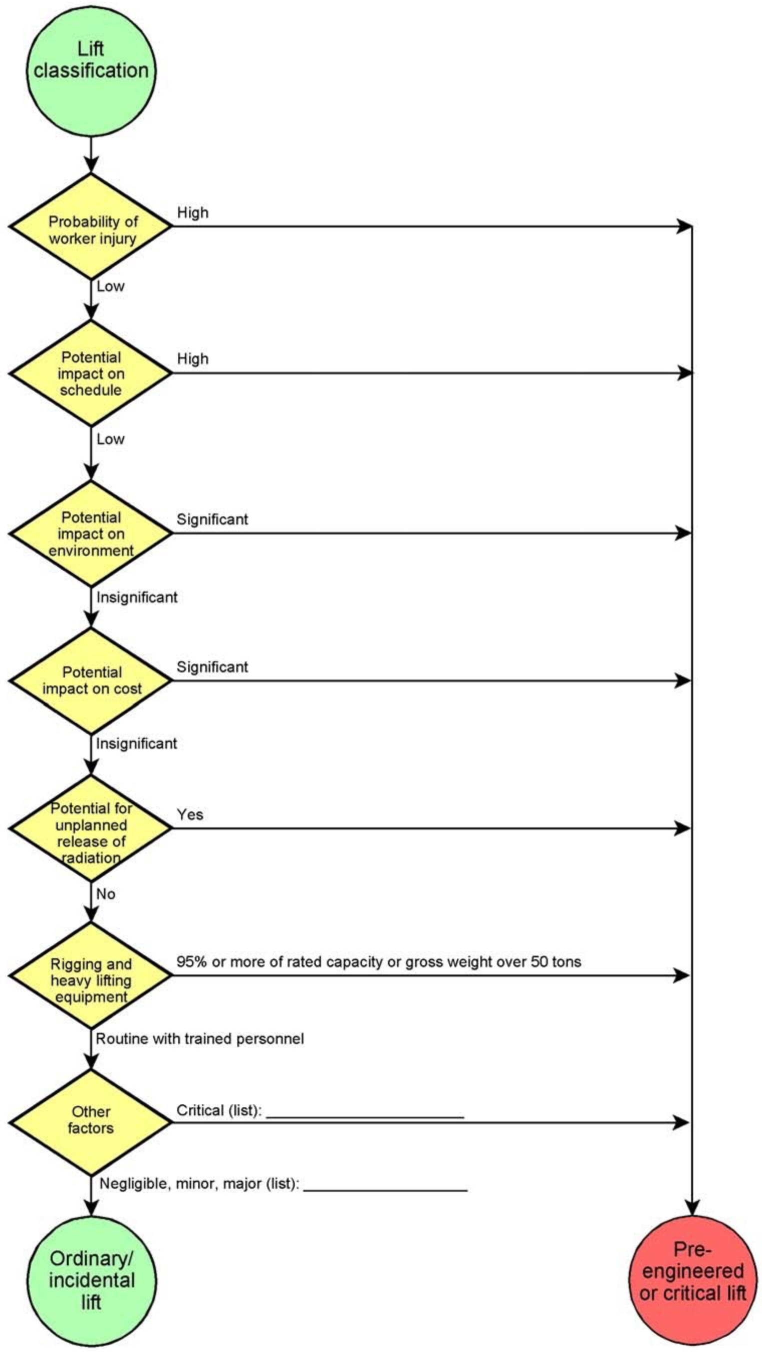
Symmetrical Load An object that, because of its uniform shape and composition, has its center of gravity located exactly in its middle.

Classifying Lifts

Before a lift can be planned, it must be analyzed to determine the lift's category. There are three common lift categories 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, will help to determine if a lift should be classified as incidental (ordinary), pre- engineered, or critical.

Follow your company policy and lift plan (if applicable) for more information.



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:

1. Weightlift•
2. Center of Gravity •
3. Lift points •
4. Crane capacity •
5. Speed, height, width, and length of lift
6. Wind, temperature, and visibility
7. Crane and Load foundation ratings
8. Sharp corners and angles on load Sling angles
9. Load angle factor

10.Travel route clearance 11. Floor loading capacity 12. 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 employer 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 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.

Calculating Weight of Load

Step 1: Determine volume

• Measure the object to get dimensions (length, width, and height) and determine volume.
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 Handbook
- – For concrete reinforcing rod, calculate as a cylinder.

Pipe

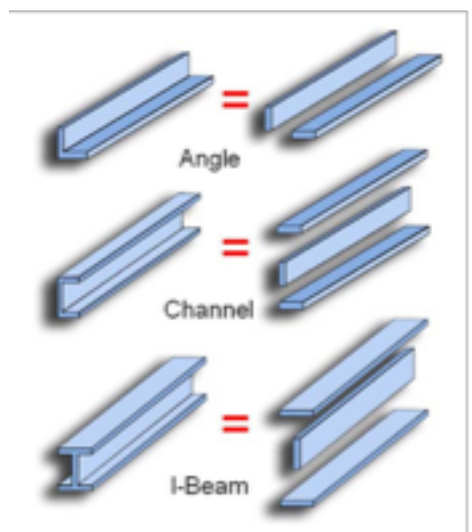
• Pipe calculations require actual measurements of diameter and wall thickness for accuracy

– 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



Step 2: Determine what material the object is made of

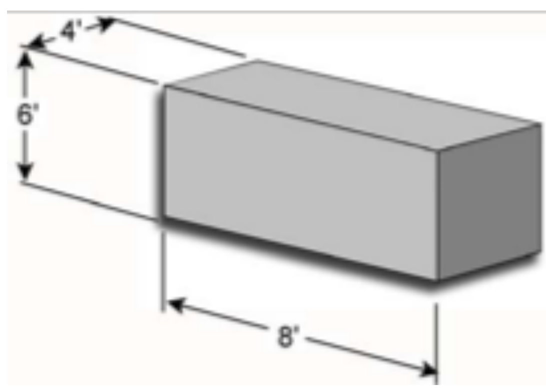
• Look up the weight per unit volume for that material.

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.

Example: Rectangular Load



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

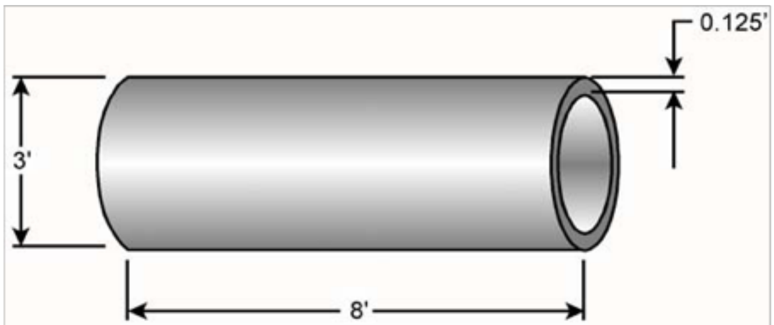
Volume of a rectangle is its length times its width times its height: **V = L x W x H = 8 ft x 4 ft x 6 ft = 192 cu ft**

Since concrete weighs 150 pounds per cu ft (see table on previous page), the load will weigh approximately:
Block weight = 192 cu ft x 150 lbs/cu ft = 28,800 lbs

Example: 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 =3.14xLxTx(D-T)**
= 3.14 x 8 ft x 1.5 in x (3 ft - 1.5 in)
V = 3.14 x 8 ft x 0.125 ft x (3 ft - 0.125 ft) = 9.03 cu ft



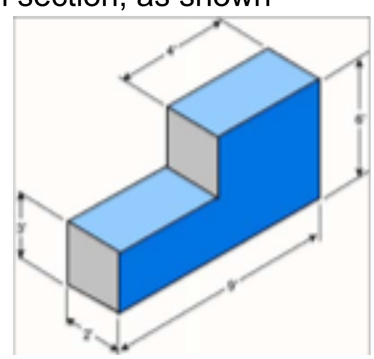
From the table
Steel weighs 490 lbs/cu ft Tube weight = 9.03 cu ft x 490 lbs/cu ft = 4425 lbs

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

Example: 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
$\mathbf{V_{top}}$ **=2ftx3ftx4ft=24cuft**

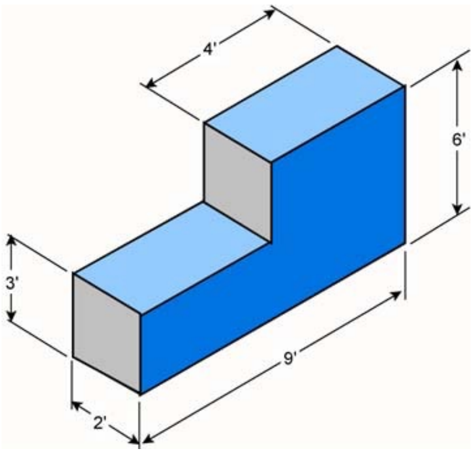
Bottom section
$\mathbf{V_{bottom}}$ **=2ftx3ftx9ft=54cuft**

Total volume
$\mathbf{V_{total}}$**= 24+54 = 78 cu ft**

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

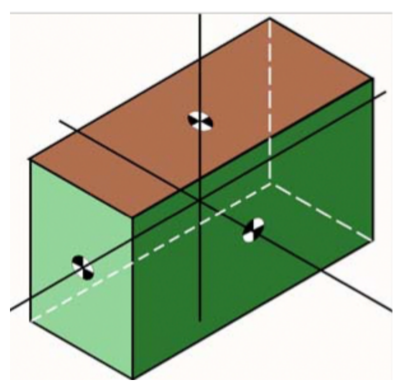
Center of Gravity Exercise

Calculate the center of gravity of this concrete block.



Calculating the Center of Gravity

Symmetrical loads



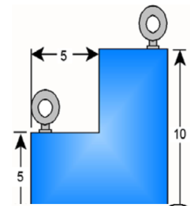
- The center of gravity of a rectangular, symmetrical load can be found by inspection.
- Measure each side of the rectangle.
- Divide each side in half to locate the center of gravity

  for that side.

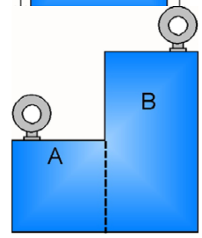
- After, combine the results to determine the overall center of gravity.

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.

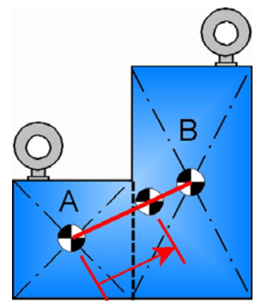


For the example here, the left rectangle measures 5 feet by 5 feet, while the right-side rectangle measures 5 feet by 10 feet.



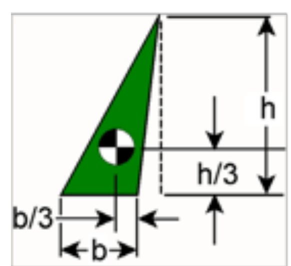
Since the right-hand rectangle is twice as large as the smaller on the left, and since both are made of the same material, we can tell that 1/3
of the object's weight is concentrated at the left center of gravity (labeled "A"), while 2/3 is concentrated at the right

(labeled "B").



Draw a line connecting the two centers of gravity a 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.

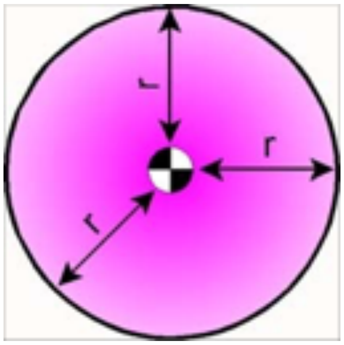
Other shapes

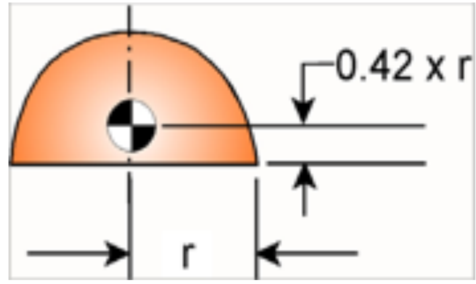


To find the center of gravity of a triangle, measure
1/3 the height from the base as well as 1/3 of the base from the steepest angle, as shown at right.

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

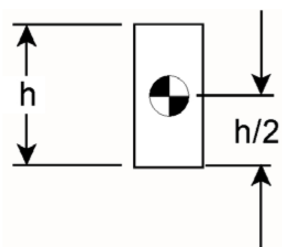
The center of gravity of a semi-circle may be determined as shown at right.

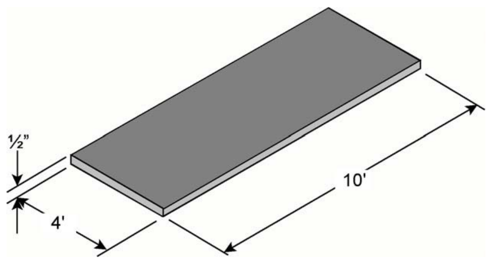




Rectangular Load
Calculate the center of gravity of a steel plate 4 ft wide x 10 ft long x 1/2 inch thick.

1. Measure "h" h_1 = 10 feet CG = 5 feet
2. h2 = 4 feet CG = 2 feet





Specify, Select, and Inspect Rigging Equipment

Wire Rope Slings

Pre-Use Inspection Checklist:

1. Inspect daily before use and frequently during use
2. Slings must be removed from service when any of the below listed substandard conditions exist.
3. Shock loading is prohibited

4. 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

5. Reduction in rope diameter (1/3 or more of the original wire diameter)
6. Severe localized wear, abrasion, or scraping
7. Kinking, crushing, under-stranding, bird-caging, core protrusion, and any other damage resulting in distortion of the rope structure
8. Evidence of heat damage
9. End attachments that are cracked, deformed, or worn

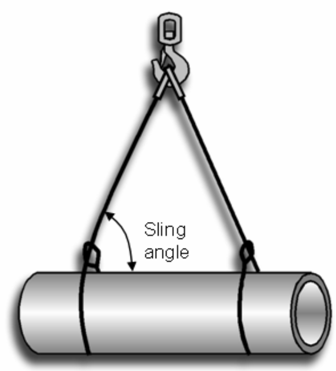
10. Hooks or latches deformed or damaged

11. Corrosion of the rope or end attachments

12. 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

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
11/8	24000	18200	48000	42000	34000	24000
11/4	30000	22000	60000	52000	42000	30000
13/8	36000	26000	72000	62000	50000	36000

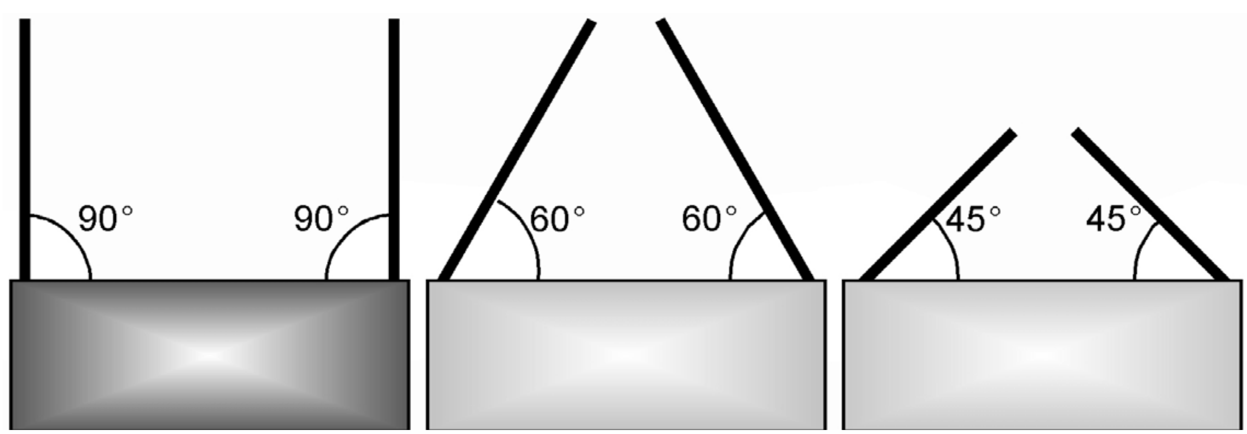


Sling angle	Load angle factor
90°	1.000
85°	1.004
80°	1.015
75°	1.035
70°	1.064
65°	1.103
60°	1.155
55°	1.221
50°	1.305
45°	1.414
40°	1.555
35°	1.742
30°	2.000
25°	2.366
20°	2.924
15°	3.864
10°	5.759
5°	11.47

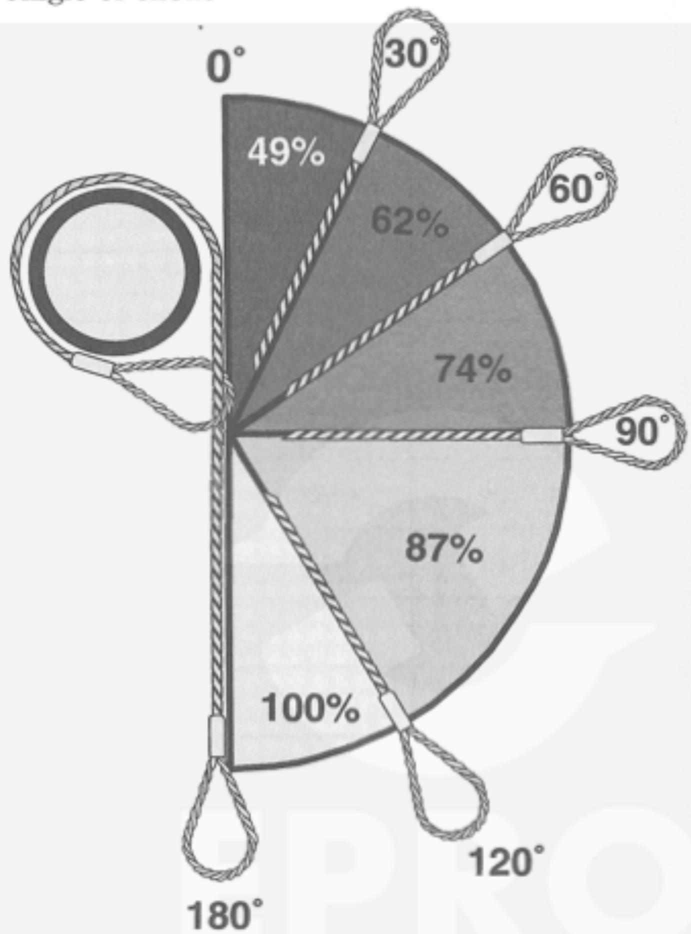
Sling Angle Factor

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°

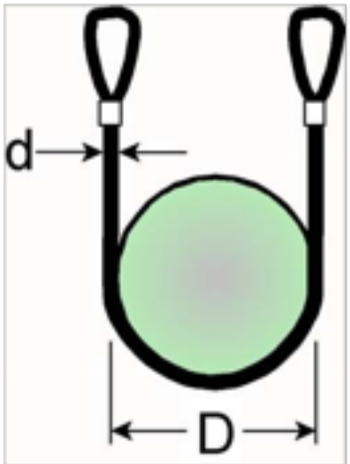


Angle of choke



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.



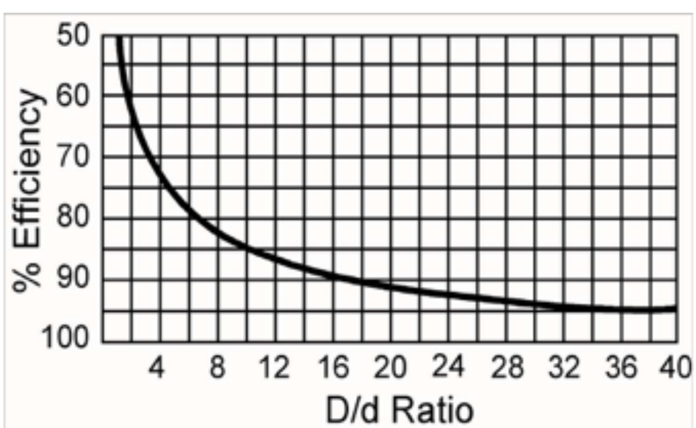
D/d Ratio

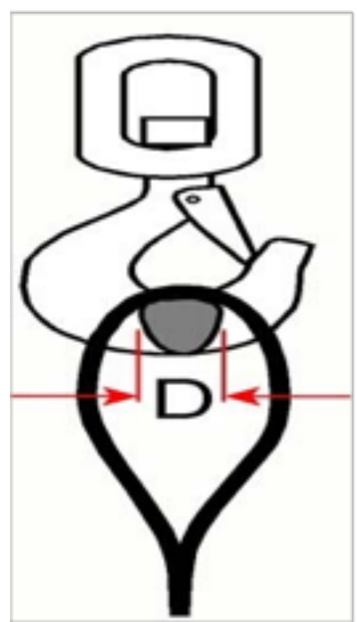
When a wire rope sling is used in a basket hitch, the diameter of the load where the sling contacts the load can reduce sling capacity. The method used to determine the loss of strength or efficiency is referred to as the D/d Ratio.

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.

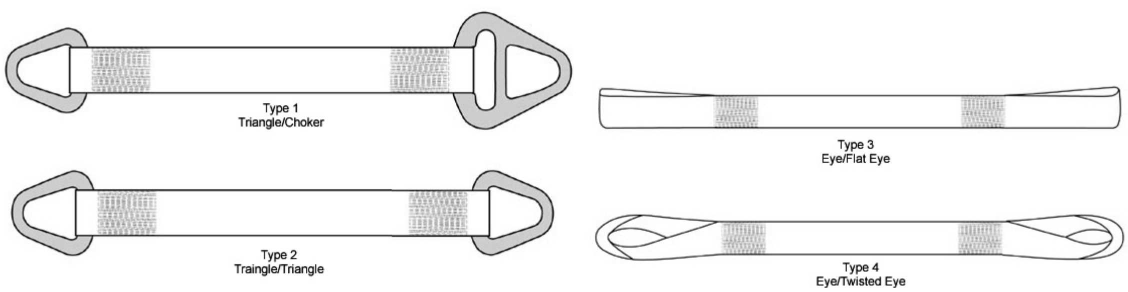




Synthetic Slings

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



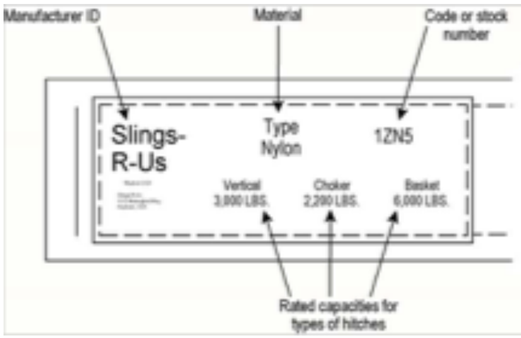
Synthetic Web Sling Pre-Use Inspection Checklist

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

1. Knots, snags, holes, tears, or cuts
2. Extensive abrasive wear
3. Melting or charring of any part of the sling surface
4. Visible red yarns or threads indicate excessive wear
5. Broken or worn stitches
6. Chemical damage including acid or caustic burns, brittle or stiff areas, and discoloration of any kind
7. Corrosive discoloration, or other damage to fittings

8. Missing, illegible, or incomplete sling identification
9. Synthetic web slings must have tags marked with the information shown at right

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



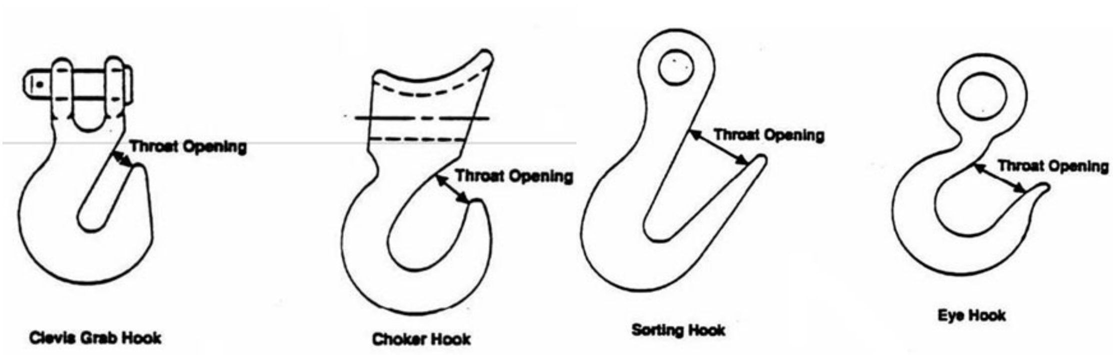
Endless and Eye-and Eye Synthetic Web Sling Pre-Use Inspection Checklist

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

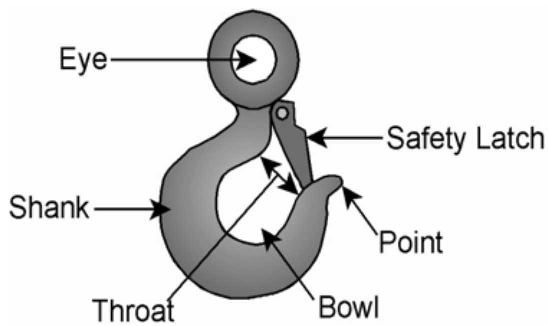
1. Chemical damage including acid or caustic burns, brittle or stiff areas, and discoloration of any kind
2. Melting, charring or weld spatter on any part of the fittings
3. Holes, tears, cuts, snags, broken or worn stitching, or any abrasion in the sling cover that exposes the core yarns
4. Knots in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

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

Hooks



Eye Hook Rated Capacity Table (Forged Alloy Steel) Hook Pre-Use Inspection Checklist



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

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

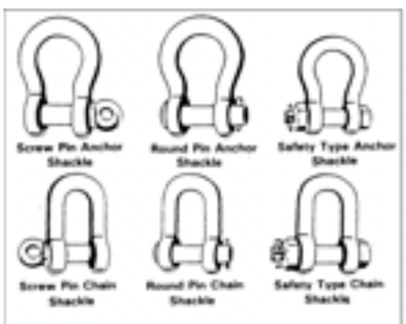
Shackle Pre-Use Inspection Checklist

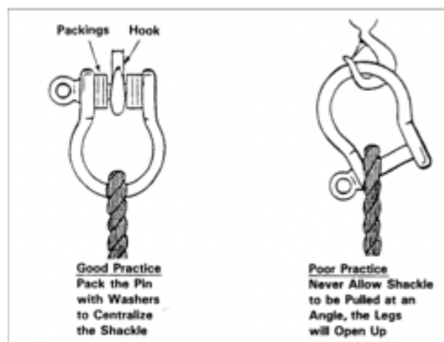
Inspect shackles daily before use and frequently during use.

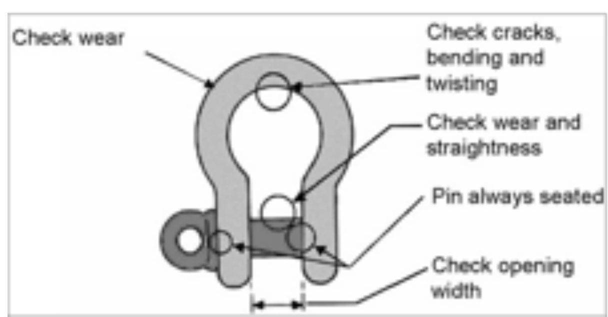
Each shackle body shall have forged, cast, or die stamped markings by the manufacture showing: name or trademark of the manufacturer, rated load/ capacity (WLL or SWL), and size. This information shall not be missing and must be legible.

Remove from service when any of the following conditions exist:

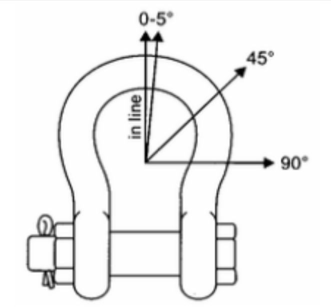
1. Indications of heat damage including weld spatter or arc strikes
2. Excessive pitting or corrosion
3. 10% reduction of the original or catalog dimension at any point around the body or pin
4. Body spread including bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components
5. Excessive nicks or gouges
6. Incomplete pin engagement, shoulder of pin is not flush with shackle body
7. Excessive thread damage
8. Evidence of unauthorized welding



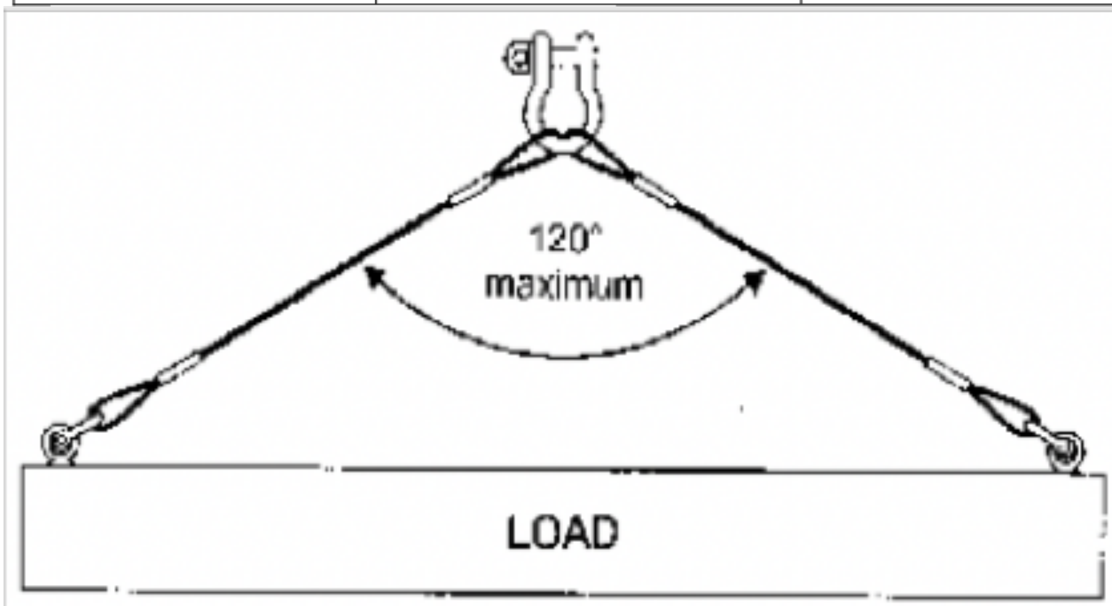




Side Loading Reduction Factors
Screw Pin and Bolt Type Shackles



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



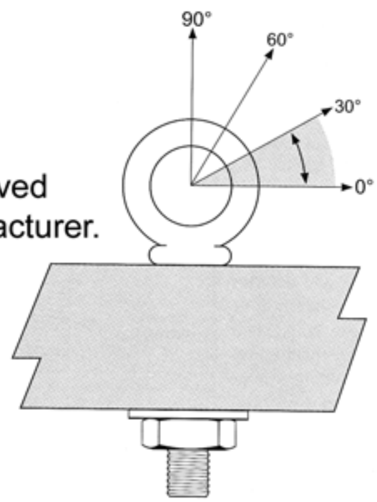
The rated capacity of shackles only applies when they are symmetrically loaded and the included angle between two sling legs is a maximum of 120°. Shackle capacity must be reduced when the angle is greater than 120°.

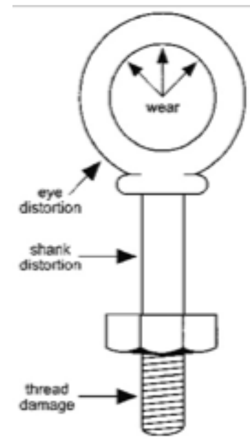
Eye Bolts **Forged Eye bolts**

Rated Capacity Table in Pounds

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

Straight Shoulder

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:

1. Nicks, gouges, bent or distorted eye, or shank
2. Obvious wear (10% reduction of original/catalog dimension at any point)
3. Worn, corroded and/or distorted threads
4. Indications of heat damage including weld spatter or arc strikes
5. 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.

Eye Bolt Installation and Applications

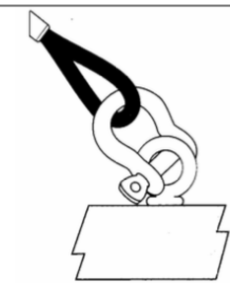
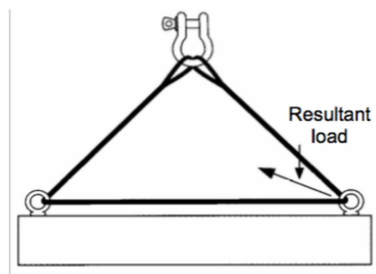
Shoulder eye bolts must always be positioned to take the load in the plane of the eye. An eye bolt that is “turned to the side” will have less capacity and may experience damage and failure when a load is lifted.

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.

 Do not use the point of a hook in an eye bolt.	 Use a shackle instead to attach the sling to the eye bolt.	 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.

Weight of Common Materials

Material	Lb / cu. ft.	Material	Lb / 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		

Values taken from Rigging by James Headley, Crane Institute of America, 2007 edition.

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

Plate Size (inches)	Steel	Alumunium
1/8	5	1.75
1/4	10	3.50
1/2	20	7.00
3/4	30	10.50
1	40	14.00


[redacted]
STANDARD UNIVERSALLY ACCEPTED
HAND SIGNALS
FOR MOBILE, OVERHEAD, GANTRY AND TOWER CRANES
An operator should respond to signals only from the signal person directing the lift.
However, the operator should obey an EMERGENCY STOP from any person at all times.
USE MAIN HOIST
Tap fist on head, then use regular signals.
USE WHIPLINE
(AUXILIARY HOIST)
Tap elbow with one hand, then use regular signals.
HOIST
With forearm vertical and forefinger pointing up, move hand in small horizontal circle.
LOWER
With arm extended downward and forefinger pointing down, move hand in small horizontal circle.
RAISE BOOM
Arm extended and fingers closed with thumb pointing upward.
LOWER BOOM
Arm extended and fingers closed with thumb pointing downward.
RAISE BOOM & LOWER LOAD
Arm extended and thumb pointing up, flex fingers in and out as long as load movement is required.
LOWER BOOM & RAISE LOAD
Arm extended and thumb pointing down, flex fingers in and out as long as load movement is required.
SWING
Arm extended, with fingers in direction of swing of boom.
EXTEND BOOM
(TELESCOPING BOOMS)
With both fists in front of body with thumbs pointing outward.
RETRACT BOOM
(TELESCOPING BOOMS)
With both fists in front of body with thumbs pointing toward each other.
MOVE SLOWLY
(EXAMPLE - "HOIST SLOWLY")
Use one hand to give any motion signal and place the other hand motionless in front of the hand giving the motion signal.
EXTEND BOOM
(TELESCOPING BOOMS)
ONE HAND SIGNAL: One fist in front of the chest with the thumb tapping the chest.
RETRACT BOOM
(TELESCOPING BOOMS)
ONE HAND SIGNAL: One fist in front of the chest with the thumb pointing outward and heel of fist tapping the chest.
STOP
Arm extended and palm down, move arm horizontally back and forth.
EMERGENCY STOP
With both arms extended and palms down, move arms horizontally back and forth.
TRAVEL
ONE TRACK - LAND CRANES ONLY
Indicate track to be locked by raising fist on that size. Rotate other fist in front of body in direction that opposite track is to travel (from the crane operator's perspective).
TRAVEL
BOTH TRACKS - LAND CRANES ONLY
Use both fists in front of body, making a circular motion about each other, indicating direction of travel, forward or backward.
TRAVEL/ BRIDGE TRAVEL
With arm extended forward and hand open and slightly raised, making a pushing motion in the direction of travel.
DOG EVERYTHING
Clasp hands in front of the body.
MULTIPLE TROLLEYS
Hold up one finger for block marked "1" and two fingers for block marked "2". Regular hand signals to follow.
MAGNET IS DISCONNECTED
Crane operator spreads both hands apart with palms up.
TROLLEY TRAVEL
With palm up, fingers closed and thumb pointing in the direction of motion, jerk hand horizontally.
For information about or to register for our training classes, Call: (703) 239-EPRO or visit WWW.EPROSAFETY.COM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