Rigging The Force In Your Favor

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Gibson

Introduction

Upon completion you should be able to understand rigging techniques that are driven from industry standards such as:

- OSHA (29 CFR 1910.184)
- ASME (B30.9)
- ASME (B30.26)

Let's define...

- **Authorized/Designated**: Approved by an employer to perform a specific task
- **Approved**: Certified by a nationally recognized authority or agency
- **Qualified**: One who has successfully demonstrated the ability to resolve problems related to the work
- **Competent**: One who can identify existing and predictable hazards in the surroundings and has the authority to take prompt corrective measures to eliminate them
- **Shall**: Means mandatory
- **Should**: Means recommended
- **WLL**: Working Load Limit
- **SWL**: Safe Working Load Limit

What Is Overhead Lifting?

- The act of moving equipment or materials from one elevation to another with the assistance of a mechanical device.

ASME Rigging Standards

- ASME B30.9-2003 | Slings
- "…Sling users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices…"
- "…Sling identification shall be done by the manufacturer…should be maintained by the user so as to be legible during the life of the sling…slings shall be removed from service if…missing or illegible sling identification"
- "…Sling identification shall be done by the manufacturer…should be maintained by the user so as to be legible during the life of the sling…slings shall be removed from service if…missing or illegible sling identification"

ASME Rigging Standards

- ASME B30.26 | Hardware
- Users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices
- Identification shall be maintained by the user so as to be legible throughout the life, they shall be removed from service if missing or illegible identification
- Initial inspection prior to use, frequent inspection each day before used, periodic inspection at lease each year, written records are not required

Sling Tags

Sling Tags

Alloy Chain Slings

- Permanently affixed
- Size, length and grade
- Serial number
- Number of legs
- Working Load Limits
- Intended angles of use
- Sling manufacturer

Web Slings

- Type of material
- Size & Serial Number
- Working Load Limit
- Intended angles of use
- Sling manufacturer

Sling Tags

Wire Rope Slings

- Size, length & diameter
- Number of legs
- Working Load Limits
- Intended angles of use
- Sling manufacturer

Round Slings

- Type of material – Core & Cover
- Size & Serial Number
- Working Load Limit
- Sling manufacturer

Sling Tags

Sling Tags

Above all other things…

The Tags **MUST** Be **LEGIBLE!**

Common Rigging Gear Problems

Common Rigging Gear Problems

- Trained riggers not assigned
- Improper use of hand signals
- Not inspecting rigging properly
- Not knowing what to inspect for
- Missing or illegible tags on slings
- Capacities not known
- Improperly made below the hook devices

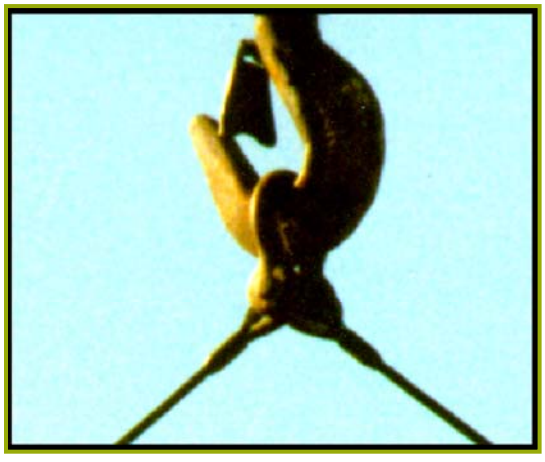
Common Rigging Gear Problems

- Wire rope slings formed with clips
- Overloading a sling because the center of gravity was not known
- Too small or large of hardware connected to sling eye
- Bunching or pinching of synthetic slings
- Loose shackle pins or connections
- Missing latches
- Placing too many slings on one piece of hardware

Common Rigging Gear Problems

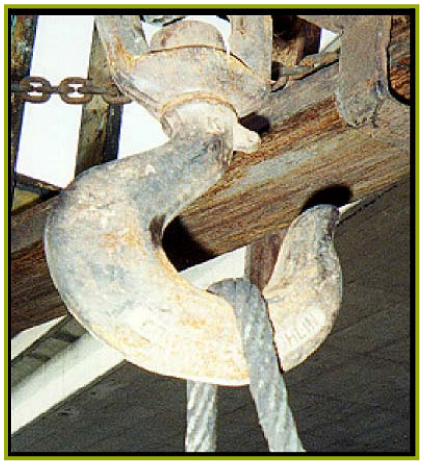
- Improper loading of the hardware
- Beating down the choker hitch
- Basket capacities used when not vertical
- Basket hitch (wire rope) over a small diameter
- Capacities of a bridal not adjusted for angle
- Sling loads not properly distributed
- Use of horizontal sling angles < 30 degrees
- Choker and basket hitches at horizontal sling angles < 60 degrees

What's wrong with this picture?



- Shackle is too small
- Shackle is upside-down

WHAT'S WRONG WITH THIS PICTURE?



- No latch

WHAT'S WRONG WITH THIS PICTURE?

- Shackle pin is wrong
- No latch on hook
- Shackle is upside down (depends on number of legs)

What's wrong with this picture?

- Eye bolts not seated properly
- Eye orientation
- Sharp angle
- Compound force on eye bolts
- Load is not secured
- Tip Loading

GIBSON
STRENGTH AGAINST RISK®

Wire Rope

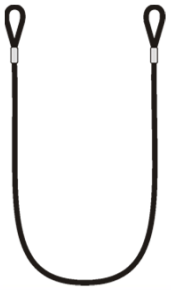
Hitches

3 types of hitches

Vertical

Choker

Basket



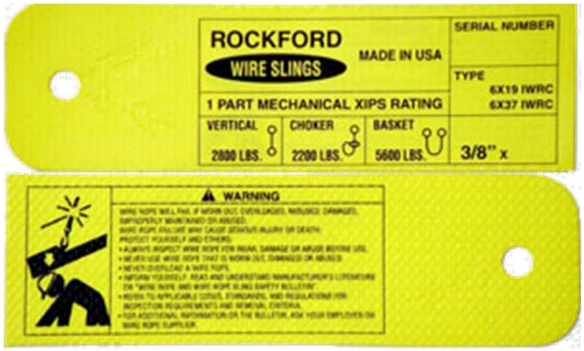
Hitches: Wire Rope

- All WLL's are based on the items being in new and unused condition

Hitches: Wire Rope

WLL on the manufacturer's tag is based on:

- True vertical
- True chocker
- True basket



Hitches: Wire Rope

What can reduce sling capacities?

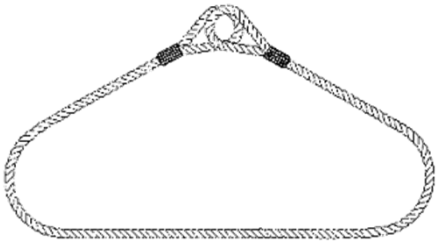
- Smaller "D/d" ratios on basket hitches
- Angles are applied to vertical hitches
- Beating down a choker

Rigging And Working Load Limits

- Wire Rope Sling Basket Hitch
- Doubles the vertical WLL…if the basket is configured correctly

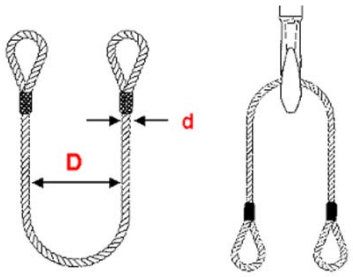
Rigging And Working Load Limits

- Wire Rope Slings Basket Hitch
- At a 30° angle a wire rope sling in a basket will have the same WLL as a single leg sling in vertical pick.



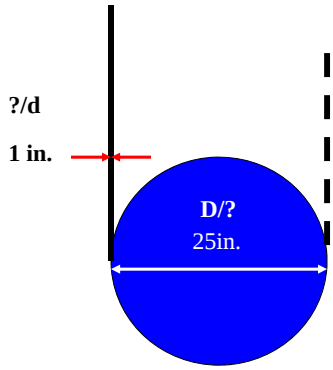
Rigging And Working Load Limits

- Wire Rope Slings D/d Ratio
- Basket hitch capacity must be reduced if D/d < 25/1



Hitches – Wire Rope D/d RATIO

An example of a D/d Ratio:



25=D

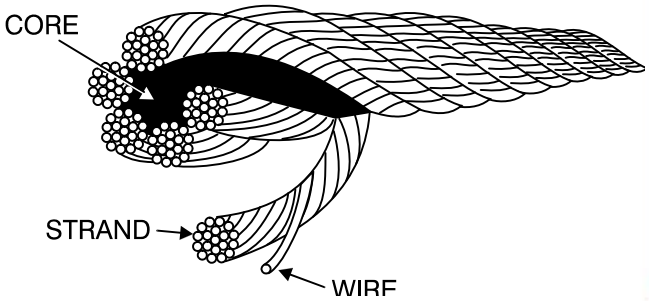
1=d

D/d	Efficiency
30	95%
20	92%
10	86%
5	75%
2	65%
1	50%

Wire Rope - Sling Construction

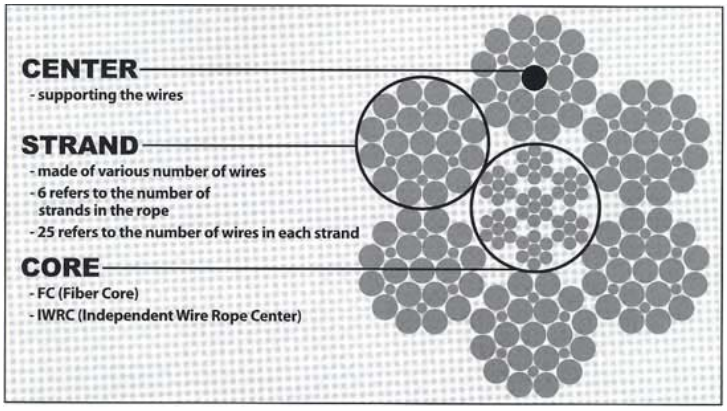
There are 3 major components to wire rope. They are:

- Wire
- Strands
- Core



Wire Rope - Sling Construction

Here's what it looks like…



Wire Rope – Sling Construction/Strand Classification

So what does this mean…

6 X 19

Wire Rope - Sling Construction

All Constructions are not created equal!

Classification	Number of Strands	Number of Wires
6 X 7	6	3 to 14
6 X 19	6	16 to 26
6 X 37	6	27 to 49
8 X 19	8	15 to 26

Wire Rope - Sling Construction

Would it be possible to have 2 slings with the same diameter, but have drastically different WLL?

YES!

But why?

Wire Rope - Sling Construction

Let's Talk Grades!

- **IPS** - (Improved Plow Steel) lowest grade
- **EIPS** - (Extra Improved Plow Steel) breaking strength 15% higher than IPS
- **EEIPS** - (Extra Extra Improved Plow Steel) 10% higher than EIPS

Wire Rope - Sling Construction/Core

Wire rope cores can either be:

- **Fiber** - Core composed of synthetic fibers
- **IWRC** - (Independent wire rope core) - another wire strand which is stronger than fiber and is most commonly used today.

Wire Rope - Sling Construction/Splicing

There are two common eye splices found on wire rope slings:

- **Hand Tucked** (**HT**)- a loop or eye that is tucked back into the main body of wire rope.
- **Mechanical Splice** (**MS**)- swaging one or more metal sleeves over the wire rope to form a loop or eye

Wire Rope - Sling Construction/Splicing

Hand Tucked Splice

Mechanical Splice

Wire Rope - Sling Construction/Length

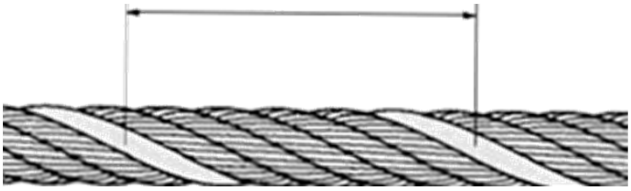
Let's see one made!

Let's see another!

Wire Rope - Sling Construction/Lays Of Rope

The lay length of a linear wire rope is defined as one complete revolution around the rope measuring only one strand.

ONE LAY OF ROPE



Wire Rope – Inspection Criteria

Who decides inspection criteria?

- Your Company
- ASME
- OSHA
- Manufactures

When do we inspect?

- Daily
- Periodic
- Annual

ASME B30.9, OSHA 1910.184

Wire Rope – Inspection Criteria/Periodic Inspection

A complete inspection of rigging hardware shall be performed by a competent person at an interval not exceeding a year.

Frequency of inspection is based on:

- Use
- Service condition
- Gained experience

Wire Rope – Inspection/Removal Criteria
(OSHA 1910.184)

- Exposure Temps:
  - Over 200°F (Fiber Core)
  - Over 400°F (Non-Fiber Core)
  - Under -60°F(Non-Fiber Core)
- 10 Random broken wires in 1 lay
- 5 Broken wires in 1 strand in 1 lay
- Wear or scraping of 1/3 of the original diameter

Wire Rope – Inspection/Removal Criteria
(OSHA 1910.184)

- Damage resulting in distortion: kinking, crushing, birdcaging, etc.
- Evidence of heat damage
- Cracked, deformed, or worn fittings/hardware
- Severe corrosion of the rope or fittings

Wire Rope – Inspection/Removal Criteria
(ASME B30.9)

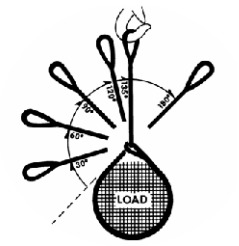
- Missing or illegible sling identification tags
- Excessive broken wires
- Severe localized abrasion or scraping
- Kinking, crushing, birdcaging, or any wire rope structure damage
- Evidence of heat damage
- Cracked, deformed, or worn fittings
- Severe corrosion of the rope or fittings

Wire Rope – Inspection/Removal Criteria
(ASME B30.9)

Wire Rope – Inspection/Samples Of Damaged Rope

Rigging And Working Load Limits

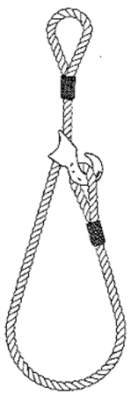
- Wire Rope Sling Choker Hitch

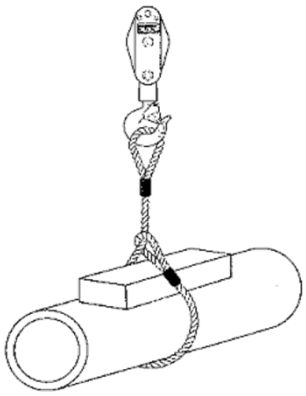


Angle of Choke (Degrees)	Capacity % of Choker (ASME B30.9)	Capacity % of Vertical (Estimated)
120 – 180	100%	75%
90 – 120	87%	65%
60 – 89	74%	55%
30 – 59	62%	46%
0 – 29	49%	36%

Rigging And Working Load Limits

- Wire Rope Sling Choker Hitch





Synthetic Slings

Synthetic Slings

Pros

- Gentle on surfaces
- Light weight
- Flexible
- Conforming
- Do not rust

Cons

- Delicate

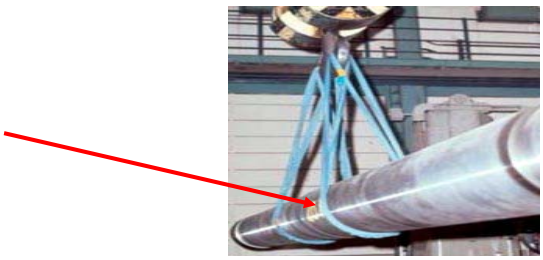
Synthetic Slings

The 2 common synthetic slings are…

- Nylon Web Sling
  - Nylon is more rigid and manufactured in a “flat web” configuration
- Polyester Round Sling
  - Polyester is more pliable and flexible

Synthetic Slings

Pipe handling illustrates the tendency of webbing slings to mold themselves to a load.

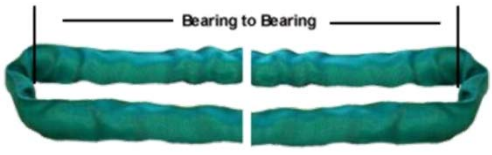


Hitches - Synthetic Slings

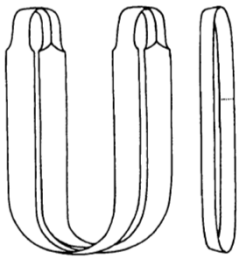
- **WLL** on the manufacturer's tag is based on:
  - True vertical
  - True chocker
  - True basket

Synthetics - Sling Construction/Length

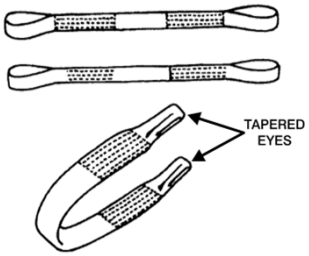
To determine the length of a given sling, the measurement of the sling is taken from one bearing point of one eye to the other.



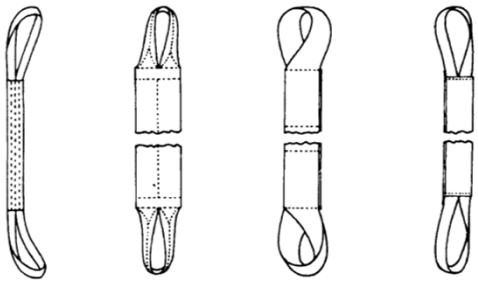
Synthetics - Sling Construction/Endless Or Grommet Sling



Synthetics - Sling Construction / Standard Eye And Eye

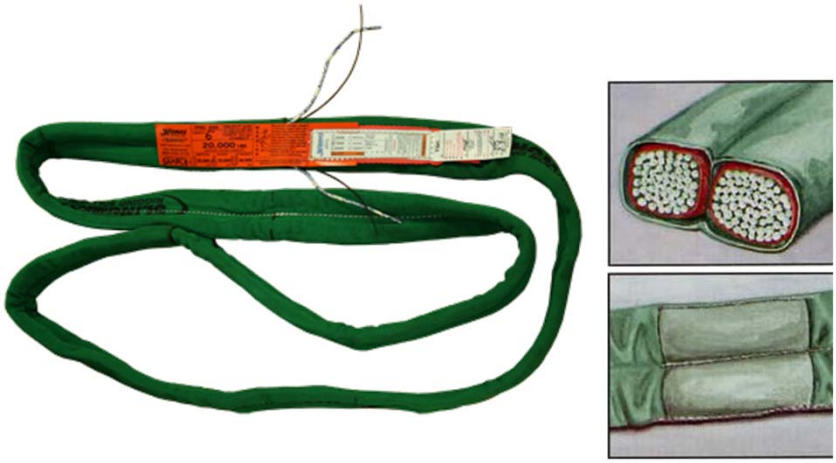


Synthetics - Sling Construction / Twisted Eye



Synthetics - Sling Construction / Round Sling Poly

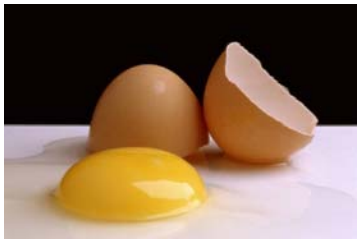
Synthetics - Sling Construction / Twin Path Poly



Always Protect Your Slings!

Synthetic slings are easy to damage!

Use the following items to protect your slings!



Synthetics - Sling Saver Hardware

Synthetics - Sling Construction / Round Sling Poly

Synthetics – Inspection Criteria

ASME B30.9 and OSHA 1910.184 require that two inspections be performed.

- Daily Visual Inspection
- Additional Inspections at Regular Intervals (Periodic)

Inspection Of Hardware & Slings

Removal Criteria For Web Slings

- Missing or illegible sling identification tags
- Acid or caustic burns
- Melting or charring of any part of the sling
- Holes, tears, cuts, or snags
- Broken or worn stitching in bearing splices
- Excessive abrasive wear

Inspection Of Hardware & Slings

Removal Criteria For Web Slings

- Knots in any part of the sling
- Chemical or Ultraviolet damage (discolored and/or brittle)
- Fittings that are pitted, corroded, cracked, bent, twisted, gouged, or broken

Inspection Of Hardware & Slings

Removal Criteria For Polyester Round Slings

- Missing or illegible sling identification tags
- Acid or caustic burns
- Evidence of heat damage
- Holes, tears, cuts, or snags that expose the core yarns

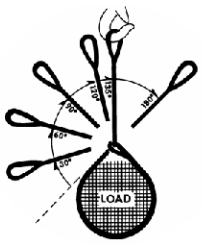
Inspection Of Hardware & Slings

Removal Criteria For Polyester Round Slings

- Knots in any part of the sling
- Chemical or Ultraviolet damage (discolored and/or brittle)
- Fittings that are pitted, corroded, cracked, bent, twisted, gouged, or broken

Rigging And Working Load Limits

Synthetic Web and Round Slings



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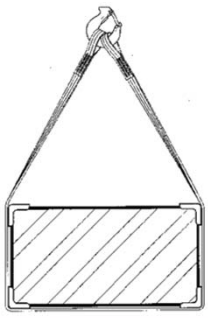
60 – 89	74%	59%
30 – 59	62%	49%
0 – 29	49%	40%

Rigging And Working Load Limits

Synthetic Web and Round Slings Basket Hitch

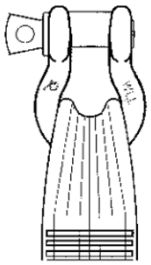
- At a 30° angle a synthetic sling in a basket will have the same WLL as a single leg sling in vertical pick.



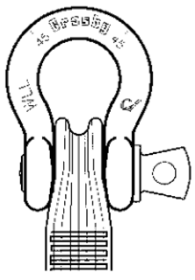
Rigging And Working Load Limits

Synthetic Web & Round Slings: Bunching & Pinching

- Be sure that your fittings are the right size for the sling and lift.



BUNCHING

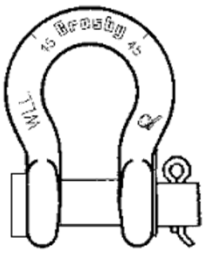


PINCHING

Application Of Shackles

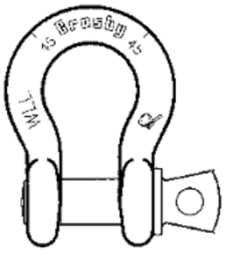
Application Of Shackles

Anchor Shackles



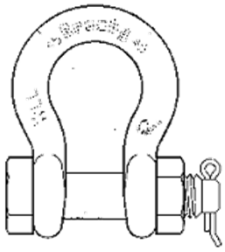
Round Pin

- Never side load
- Only use cotter pins



Screw Pin

- Only for picking and placing
- Tighten before each lift

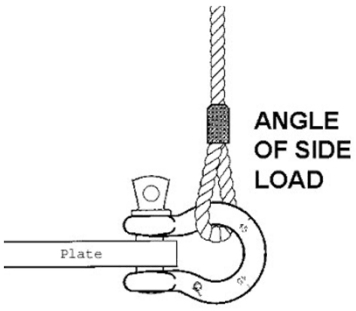


Bolt Type

- Permanent or long-term installations
- Always use nut & cotter pin

Application Of Shackles

Side Loading Of Anchor Shackles



Angle of Side Load	Loss Of W.L.L.
None, In Line	None
45 Degree	30% Loss
90 Degree	50% Loss

Never side load a Round Pin Shackle!

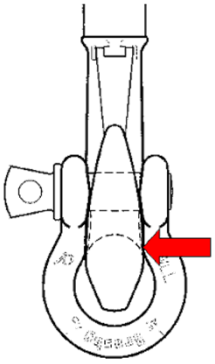
Applications of Shackles

Connecting A Sling To A Shackle

- If there is no thimble on the wire rope sling, the diameter of shackle must be larger than the diameter of the sling.

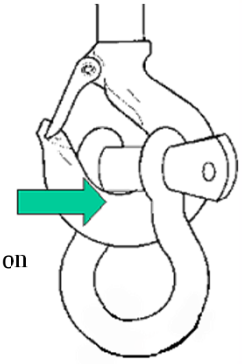
Applications of Shackles

Anchor Shackles Placed On Hooks



Shackle "Hung Up" on hook

Shackle Resting on base of hook



Applications of Shackles

Anchor Shackles Alignment

Incorrect Alignment

Correct Alignment

Eyebolts

Applications of Eyebolt

Eyebolt Types

Straight Shank

- No angles allowed

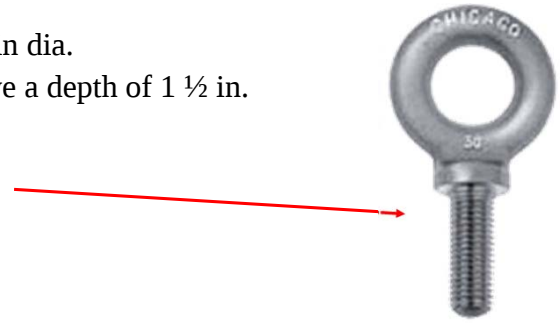
Shoulder Type

- Angles allowed

(consult the manufacturer)

Applications of Eyebolt

- Tapped holes for the screwed eyebolts must have a minimum thread engagement depth of 1-1/2 times the bolt diameter.
- Example: A 1in dia. shaft must have a depth of 1 ½ in.



Applications of Eyebolt

Eyebolt Extras

- Correct eyebolt alignment is a must
- WLL must be on the eyebolt
- Shackles vs. Hooks
- Lifting eyebolts must be forged from carbon or alloy steel

Hooks

Lots to choose from!

Hooks

- Choose the right hook for the job
- All appropriate markings must be legible
- Latch must be present and able to close
- Pay attention to angles
- Never back load
- Never side load
- Never tip load

Hooks

Side Note on Crane Hooks

- Be sure to have your crane hooks tested once a year by an outside source.

Rigging Formulas

Rigging

To determine rigging for any lift, the following **must be considered** and applied:

- Dimensional character(s) of the load
- Center of gravity
- **Angle tensions** of the rigging
- Weights and WLL of the rigging
- Static/dynamic effects of the load
- Hitch that the rigging will be configured/utilized

RIGGING

Center of Gravity (COG) The location where the center of the entire weight of the object theoretically concentrated.

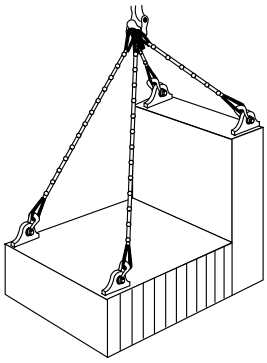
Where do we want this to be?

Directly below the hook!

RIGGING

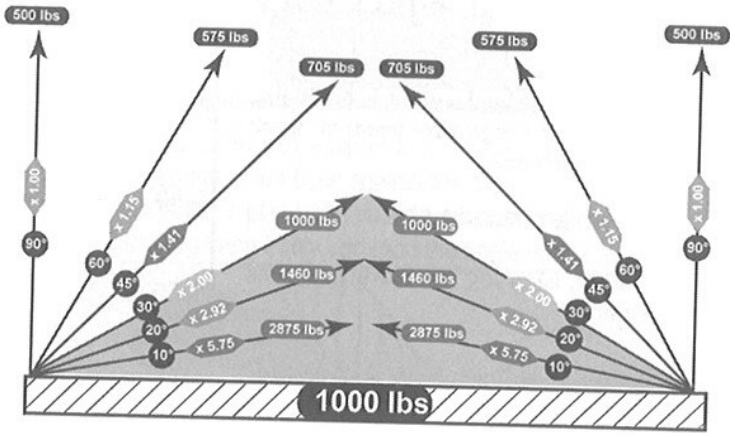
Center of Gravity

- A load will always try to find the center of gravity…with or without your help!



RIGGING

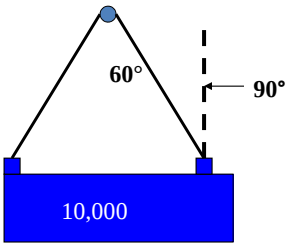
Sling Angle Tension

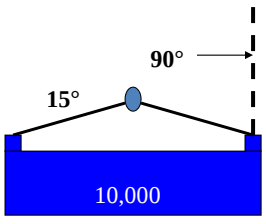


RIGGING

Formulas/Sling Angle Tension

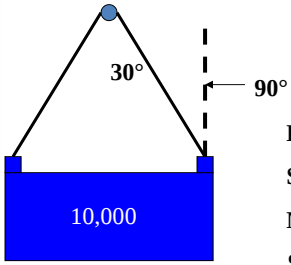
- Calculate **Sling Angle Tension** for the following configurations.





RIGGING

Formulas/Sling Angle Tension



Example 1

LAF: 2

Sling Angle Tension (Per Leg): 10,000

Min. Wire Rope Needed: 3/4" EIPS MS IWRC Vertical

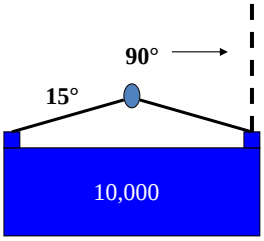
% of WLL used: 89.28%

One size bigger: 7/8" EIPS MS IWRC Vertical

% of WLL used: 65.78%

RIGGING

Formulas/Sling Angle Tension



Example 2

LAF: 3.861

Sling Angle Tension (Per Leg): 19,305

Min. Wire Rope Needed: 1" EIPS MS IWRC Vertical

% of WLL used: 98.49%

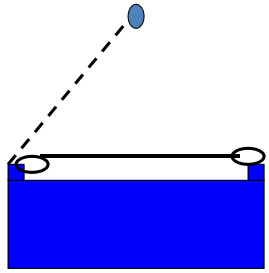
One size bigger: 1-1/8" EIPS MS IWRC Vertical

% of WLL used: 80.43%

RIGGING

Formulas/Sling Angle Tension (Quick Check)

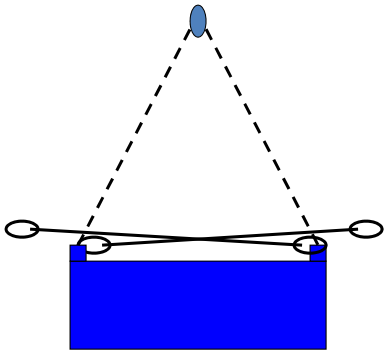
- To estimate a proper sling angle in the field, an easier method can be used. If both eyes of a lifting sling can touch both opposite lifting lugs, you will be able to form a 60° sling angle.



RIGGING

Formulas/Sling Angle Tension

- The more the connected sling passes over the opposite lifting lug, the better optimal sling angle factor. This will place the sling greater than 60°



Bad Ideas!

Rigging And Working Load Limits

Rigging And Working Load Limits

Rigging And Working Load Limits

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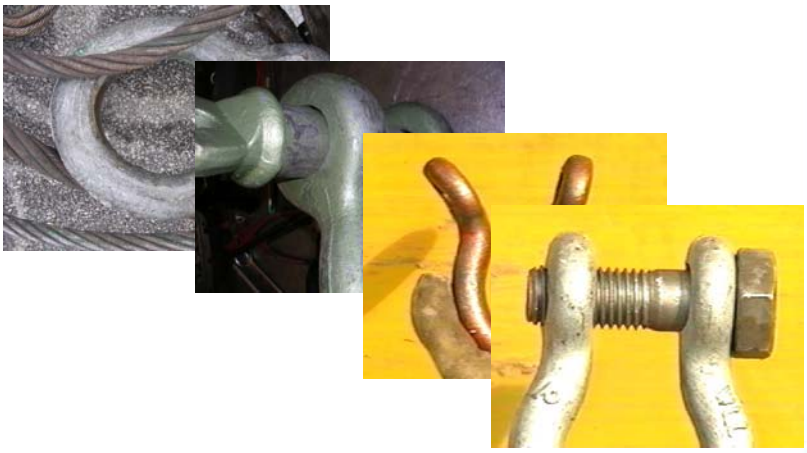

Rigging And Working Load Limits

Rigging And Working Load Limits

Rigging And Working Load Limits

Final Thoughts!

- When connecting slings and hardware to a load, it's imperative load stability be maintained.
- If a new lift plan is required, it must be communicated to all persons involved with the lift.

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