FREEPORT-McMoRAN

STUDENT GUIDE

RIG FCX1001C TECHNICAL RIGGING

SEPTEMBER 2016

VERSION 1.2

Proof of a passing knowledge assessment and required in-field assessments must be available for audit purposes.

ACKNOWLEDGEMENTS

This course content was gathered from Freeport-McMoRan sites across North America. A team of technical instructors then worked with the Mine Training Institute to build this course:

CONTENT GATHERING

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SPECIAL THANKS TO:

Dusty Gatlin for help with revised content for the Hardware, Slings and Hands Signals modules.

Ali Hammer for help with revised content for the Hitches, Hoists & Lifters, COG & Load Angle Factors, and the Exercises modules.

John Freeman for photographs and the Mechanical Advantage content.

Dusty Gatlin for hosting the pilot at Morenci. Mark Lozano for teaching the course, and thanks also to Elton Babb and Victor Goodman for the help with facilitation of assessments.

TABLE OF CONTENTS

LEARNING OBJECTIVES

Learning objectives have been identified and provided to students to establish guidance and focus throughout the course.

COURSE

Upon completion of this course, students will be able to:

- Identify different types of rigging equipment.
- Conduct rigging equipment inspections, and recognize defects.
- Recall safety regulations and apply safe rigging practices.

MODULE 1: BEST PRACTICE

Upon completion of this module, students will be able to:

- Understand the risks of rigging.
- Relate to rigging failure / fatality examples.
- Apply best practice to ensure safe rigging practices.

MODULE 2: HARDWARE

Upon completion of this module, students will be able to:

- Identify different types of rigging hardware, and their components.
- Conduct hardware inspections, and recognize defects.
- Recall hardware regulations and apply safe rigging practices.

MODULE 3: SLINGS

Upon completion of module, students will be able to:

- Identify different types of slings, and their components.
- Conduct sling inspections, and recognize defects.
- Recall sling regulations and apply safe rigging practices.

MODULE 4: HITCHES

Upon completion of module, students will be able to:

- Identify the different types of hitches and their uses.
- Recall hitch capacity reductions and apply safe rigging practices.

MODULE 5: HOISTS & LIFTERS

Upon completion of module, students will be able to:

- Identify the different types of hoists and lifters and their uses.
- Conduct hoist inspections, recognize defects, and understand maintenance requirements.
- Recall hoist regulations and apply safe rigging practices.

MODULE 6: SIGNALS

Upon completion of module, students will be able to:

- Understand the responsibilities of a signaler.
- Identify and recall the different crane hand signals.
- Recall signal regulations and apply safe rigging practices.
- Understand crane dynamics.

MODULE 7: WEIGHTS

Upon completion of module, students will be able to:

- Calculate the area and volume of loads.
- Use weight tables to calculate the weight of loads.

MODULE 8: CENTER OF GRAVITY & LOAD ANGLE FACTORS

Upon completion of module, students will be able to:

- Understand the effect the Center of Gravity and sling angles have on loads.
- Calculate sling angle tension and load angle factors, and apply safe rigging practices.
- Calculate Center of Gravity and sling tension, and apply safe rigging practices.

RIGGING EXERCISES

Upon completion of this module, students will be able to:

- Use Rigging Reference Guides to calculate the correct rigging equipment for a lift.

COURSE INTRODUCTION

During this course, we will look in detail at the different components used in rigging, and the selection of the correct hardware, slings and lifting equipment for a specific job. We will review safe Rigging practices, and describe how to conduct thorough inspections of Rigging Hardware for potential defects that could lead to an incident, injury or fatality.

The course will cover the use of weight tables and rigging cards to calculate load angles and measurements for safe lifting. We will also discuss the standards and regulations governing rigging.

There will be both a pre and post-course test: The pre-course test is to assess your current knowledge about rigging. After your post-course test, you will be able to compare your scores, and ultimately the knowledge / skills you have gained during training. Finally, a practical assessment will allow you will demonstrate your rigging skills to the trainer to achieve certification.

At the conclusion of the course, you will be able to identify rigging components, make load calculations, recognize and avoid common mistakes and hazards, and ultimately be able to Rig in a safe and professional manner.

MODULE 1:

Best Practice

MODULE 1: BEST PRACTICE

MODULE 1 LEARNING OBJECTIVES

Upon completion of this module, students will be able to:

- Understand the risks of rigging.
- Relate to rigging failure / fatality examples.
- Apply best practice to ensure safe rigging practices.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

DEFINITION OF RIGGING

The word rigging comes from the Anglo-Saxon word *wrigan* or *wringing*, which means "to clothe."

It was originally used to describe the mechanical sailing apparatus of a ship; sails, masts, ropes, blocks and pulleys.

Today the word is used to describe any equipment used for lifting. The quality of rigging equipment has changed dramatically over the years. However, the principals of rigging remain the same.

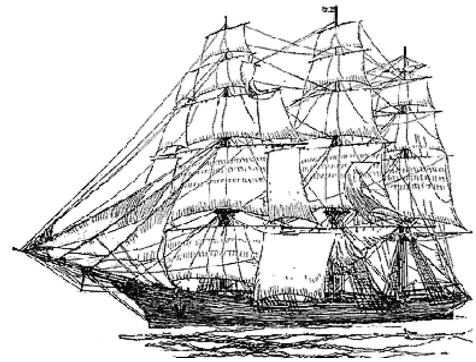


Figure 1.1: Sailing Ship Rigging

Riggers must know how to:

- Determine the weight of the load and its center of gravity.
- Select, inspect, and use equipment suitable to the load.
- Understand the stresses put on equipment.
- Understand the dynamics of the crane being used.
- Understand the risks of lifting a load.

RISKS OF RIGGING

Improper rigging practices have led to many deaths and injuries, because workers do not understand the different components of rigging equipment, their specific uses or capacities. Further incidents and fatalities occur when workers do not know how to secure loads properly, or they get caught between unpredictable moving loads.

Rigging is NEVER risk free! Anytime there is a suspended load there is risk.

Through training, leadership, and supervision we manage the risk associated with rigging and keep incidents to a minimum.

TRAINING [1]

OSHA states employers must use Qualified Riggers during rigging activities.

Who can be a Qualified Rigger? What qualifies a rigger?

A qualified rigger has:

- a recognized degree, certificate, or professional standing, or
- extensive knowledge, training, and experience, and
- can demonstrate the ability to solve rigging load problems.

A Qualified Rigger is determined by their employer to be qualified to perform specific rigging tasks. Each Qualified Rigger may have different qualifications and / or experience, therefore not every rigger is qualified to do every rigging job.

Upon completion of this course you will be considered a Qualified Rigger, however, each rigging task is unique, and has specific risks.

If you are ever in any doubt about the rigging task you are about to perform, stop and seek help from someone who is more qualified or experienced in that task.

Note: All specific regulation references are listed in the student guide, see 'references' pages 162, 163 and 164. There is also a general list of OSHA and ASME regulations in the appendices; page 156, Appendix 1: Federal Regulations.

RIGGING FATALITY: HARDWARE FAILURE

Figure 1.2: Hardware Failure [2]

The rigging hardware failure (shown in Figure 1.2), took place in an underground mine in Salina, Utah, and resulted in a fatality.

In the application it was being used, the safe working load of this hook was 14,473 pounds. But the actual force that was being applied to the hook was 127,840 pounds because the load was improperly rigged.

This resulted in the hook breaking and striking a worker in the head, killing him.

He left behind a wife and three children.

Who can stop an unsafe job? Anyone can!

Anyone who sees anything unsafe can and should stop a job.

BEST PRACTICE

- Always make sure the rigging card matches the rigging gear.
- When selecting a wire rope, chain, or nylon sling, always use the vertical column on the rigging card.
- When selecting an eye bolt always refer to the vertical 60° / 45° or less than 45° column on the rigging card.
- When a load falls between two angles, always go to the next lower angle or larger diameter sling.
- Remember—it is always better to over rig than under rig!

RIGGING FATALITY: CRUSHING INCIDENT

In this fatal rigging incident (shown in Figure 1.3), a 51-year-old master welder with 30 years mining experience was crushed by a suspended load.

The victim was fabricating a screen tower section. Using an overhead bridge crane he was positioning the 3-beam, right side component for assembly.

As he was communicating with the crane operator and positioning a chain sling, while standing on the bottom beam, the load shifted and fell, crushing him.

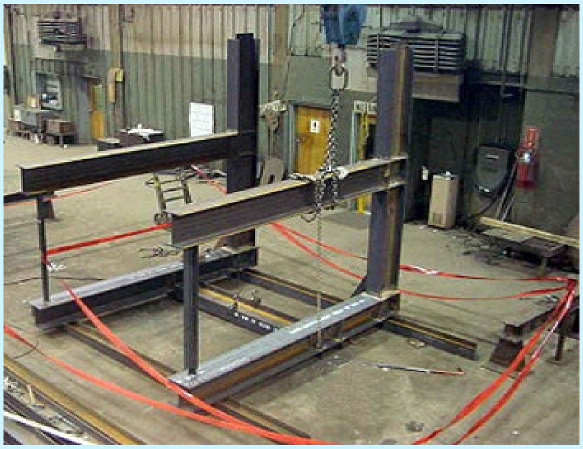


Figure 1.3: Fatal Crushing Incident [3]

BEST PRACTICE

- Never perform work on or have unstable structures / fabrications freestanding.
- Ensure slings are properly attached and hardware is properly rigged.
- Arrange the rigging to prevent shifting of the load being lifted. Balance the load by placing the crane or hook block directly above the load's center of gravity.
- Ensure persons are positioned in a safe location before tension is applied when pulling or lifting with chains, wire rope, or other rigging. This includes staying out of potential lines of flight of components if equipment were to fail.
- Secure loads before unhooking them.

RIGGING FAILURE: SLING FAILURE

Figure 1.4: Sling Capacity Tag

Figure 1.5: Broken Sling Leg

The capacity tag on this chain sling, (shown in Figure 1.4), states that its capacity is 6100 pounds. In Figure 1.5 we can see that the sling broke: When just one leg was used to lift a 5400 pound load!

The tag stated it was a 6100 pound capacity chain sling. However, it was being used as a single leg chain: 6100 pounds divided by two (legs) = 3050 pound per leg!

The bridle had a capacity of 6100 lbs. Each leg of the bridal would only have had a capacity of 3050 lbs. In this situation, the rigger used only a single leg to lift the 5400 lb load. Had both legs been used, there would have been more than enough capacity to lift the load.

BEST PRACTICE

- Ensure all rigging equipment is used correctly and safely.
- Always check the capacity tag, and follow the maximum load stated.
- Capacity, SWL (Safe Working Load), and WLL (Working Load Limit) all mean the same – the maximum load that can be applied to a piece of equipment.

BEST PRACTICE

In addition to being able to calculate the weight of a load, select the correct equipment for the job, inspect the equipment, use the equipment correctly, there are general procedures riggers should follow to ensure a safe lift and avoid common hazards.

RIGGING PLANS

EVERY lift should be planned!

You might assume that only complicated lifts require planning, and that a rigging plan would consist of a team meeting followed up with a typed document? No! Every lift should be planned, whether it is a typed document, a calculation on a scrap of paper, or the fact that you have thought it through – planned the lift - in your head.

Some lifts are more complicated than others: Critical Lifts and Engineered Lifts need more detailed planning, and will often require written plans, procedures and approval. However, even an ordinary lift requires thought and discussion, however informal.

The purpose of a rigging plan is to identify hazards and establish safety precautions. It is also a plan of the lift; requiring knowledge of the load and the correct rigging components for the job:

- The load:
    - Weight
    - Height, width and length
    - Center of gravity
- The equipment:
    - Correct hardware and slings
    - Crane capacity
- Conditions:
    - Weather
    - Surrounding objects
    - Hazards
    - Safe work zone
- The plan:
    - Sling angles
    - Load angle factor

INSPECTION LOGS

We are all familiar with Pre-Shift Inspections and Workplace Examinations, and recording our findings to document deficiencies and corrective actions.

All rigging equipment shall be inspected before, during, and after use, however, periodic inspection of equipment is also required:

- For normal service, this would be annual.
- For severe service quarterly to monthly.
- For special service – as recommended by a qualified person.

All periodic inspections are required to be documented, and documents retained as per FCX Records Retention Procedure. [4]

Rigging equipment has specific documentation requirements. Inspection Logs must be maintained, and contain the following information:

- The items inspected.
- The result of the inspection.
- The name and signature of the person who conducted the inspection.
- The date of the inspection.

TAGLINES

Figure 1.6: Taglines

When a load is lifted, it can swing into the objects around it, people on the ground, and even into the crane itself. Long ropes, called taglines, are attached to the load for the purposes of controlling load spinning and swinging.[5]

Note: Taglines should only be attached to a load by a qualified person who is trained in tagline attachment points and methods.

Taglines should not be used where there is a potential safety hazard: There is huge risk when working near powerlines. High voltage electrocution is the largest single cause of crane related deaths in construction.[6]

Taglines are generally made from a soft material such as nylon or natural fibers, as wire rope strands can cause serious injury, and also conduct electricity, which is a particular hazard if working near electricity lines.

TAGLINE USE

- Taglines should be used when loads that pose a hazard to employees are under control at all times. [7]
- Tag lines should not be used near power lines, or when the load is too large or heavy. Contact your Health & Safety representative, or supervisor, for clarification if a tagline is not to be used.
- Use taglines or a guide pole to guide the load into the desired position.
- Use only nonconductive materials near powerlines.
- A tagline should be long enough to safely get a hold of – never go under the load. Use a hook if necessary.
- Never wrap a tagline around a part of your body.
- Guiding a load into place by hand is only permitted when employees:
    - Have view of the height of the load.
    - Understand potential pinch points and trip hazards.
    - Understand the potential and actual swing hazards.
    - Not at risk of being struck should the load fall.
    - Maintain distance from the sling and load and between the sling and hook

Note: Each site has its own site procedure on Taglines. You should be aware of your site's procedure! Record details of your site's specific procedure in the space below.

SITE SPECIFIC NOTES

MODULE 1 QUIZ

Complete the following quiz questions:

1. Which type of lift requires a Rigging Plan?

   a) A Critical Lift
   b) An Engineered Lift
   c) All Lifts

2. According to OSHA regulations, when is a tagline necessary?

   a) For every lift
   b) Where a lift poses a hazard
   c) Near power lines

MODULE 2: Hardware

MODULE 2: HARDWARE

MODULE 2 LEARNING OBJECTIVES

Upon completion of this module, students will be able to:

- Identify the different types of rigging hardware, and their components.
- Conduct hardware inspections, and recognize defects.
- Recall hardware regulations and apply safe rigging practices.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

HARDWARE

All fittings / hardware must be inspected prior to each use. If load bearing components are bent, twisted, distorted, stretched, elongated, cracked or broken, this is evidence that the hardware has been overloaded and it must not be used.

The load capacity of rigging is determined by its weakest component. At a minimum, hardware must have a capacity that is equal to that of the sling, therefore, match hardware size and rated load to slings.

Figure 2.1: Hook with Safety Latch (circled)

Figure 2.2: Unshouldered Eye Bolt

Figure 2.3: Screw Pin Shackle

Figure 2.4: Vertical Plate Clamp

HARDWARE SELECTION

Hardware is an integral and important part of any rigging operation. For the lift to be made in a safe manner, all personnel must understand the rated capacity of hardware and be competent in the proper selection and inspection of hardware.

Figure 2.5: Hoist Ring

Figure 2.6: Master Link

Figure 2.7: Turnbuckle

Figure 2.8: Rigging Block

MAKESHIFT HARDWARE

No makeshift hardware should ever be used!

No makeshift hardware shall be used to perform ANY lifting operation!

Figure 2.9: Makeshift Hardware

CUSTOM HARDWARE

Custom hardware must be properly engineered and “shall be marked to indicate the safe working loads and shall be proof-tested prior to use to 125 percent of their rated load.” [8]

Completion of this course is not training or authorization to build custom hardware. Consult site SOPs regarding custom hardware requirements.

HOOKS

Hooks are the most commonly used piece of rigging hardware.

A rigger should be able to identify the parts of a hook, as shown in Figure 2.10.

- Eye
- Shank
- Spine
- Bowl
- Tip
- Throat

Figure 2.10: Hook Components

HOOK IDENTIFICATION

All hooks are stamped or embossed with:

- name or trademark of manufacturer
- rated load
- size

Hooks should be inspected prior to every use for these three pieces of information. If these are not present or legible - do not use the Hook!

HOOK INSPECTION [9]

Hooks shall be inspected and removed from service if conditions such as the following are present:

- Nicks, cracks or gouges
- Stretching
- Throat damage or stretching
- Latch engagement damage or malfunction
- Damage from heat i.e., evidence of heat exposure or welding
- Unauthorized repairs e.g., evidence of drilling, machining, grinding, or modification
- Or the manufacturer's identification absent

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

THROAT INSPECTION

Figure 2.11: Stretched throat opening

In addition to the items listed above, the throat opening of the hook must also be inspected:

If the opening is stretched to the point where the latch does not work, replace the hook – do not put on a larger latch!

Note: Latches should only be replaced by a qualified person and the hoist load tested, before it is put back into service.

Some increase in the throat opening is allowable:

Any distortion causing an increase in the throat opening of 5%, not to exceed ¼" (6mm) (or as recommended by the manufacturer). [9]

LATCH INSPECTION

Latches keep hardware and slings retained in hooks. In addition to the items listed above, it is important that the latch of the hook is also thoroughly inspected:

Latches should operate freely, be free of damage like cracks and bends, and should reach completely across the throat opening to touch the tip.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

SAFE RIGGING PRACTICES

In addition to being able to inspect and identify damage, a rigger must be able to use hooks correctly and understand safe rigging practices:

Figure 2.12: Tip Loading

- Ensure hooks are engaged and properly latched.

- Always face hooks out so that the load is on the thickest and strongest part of the hook.

  When hooks face in, we are tip loading. This reduces the capacity of the hook by as much as 60%.

- Slings should never overlap!
- When placing multiple slings on a hook, they should be laid side by side, and never overlap.

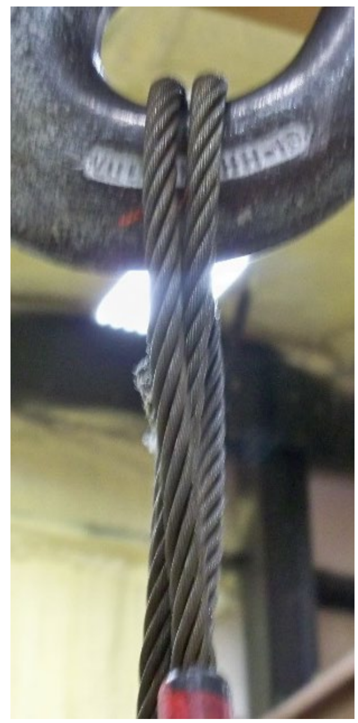


Figure 2.13: Incorrect Placing of Slings

MODULE 2 QUIZ

Complete the following quiz question:

1. All hooks shall be stamped / embossed with these pieces of information:

SHACKLES

Shackles are normally used to connect two lifting devices, and are an essential element of most rigging operations. They are highly versatile and can be connected from a sling to a hook, a sling to a sling, and even to connect a sling back to itself in some applications.

Figure 2.14: Sheet Pile (Skookum) Shackle

Figure 2.15: Synthetic Sling Shackle

Figure 2.16: Chain Sling Shackle

Different types of shackles are used to accommodate a wide array of slings and applications. Understanding how the many styles of shackles work in conjunction with different lifting devices will help you make the appropriate choices of rigging equipment.

Skookum Shackles (Figure 2.14) are designed for pulling sheet piling, (interlocking steel sheet sections). They are used at Freeport-McMoRan because the longer depth allows us to pin the shackle to much deeper holes in items, specifically HDPE (High Density Polyethylene) Pipe.

The Synthetic Sling Shackle is specifically designed for web slings (see page 57), that would normally bunch up in an anchor shackle. This type of shackle provides a wider bearing surface, resulting in an increased area for load distribution on the sling, and reduces the tendency of the sling to slide and bunch. (A screw pin anchor shackle can still be used, as long as the sling lays flat.)

ANCHOR SHACKLES

Anchor Shackles are excellent for attaching to hooks, master links, pad eyes and eye bolts.

There are three main types of anchor shackles:

Figure 2.17: Screw-Pin Shackle

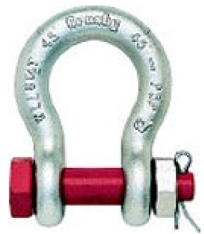


Figure 2.18: Bolted Shackle

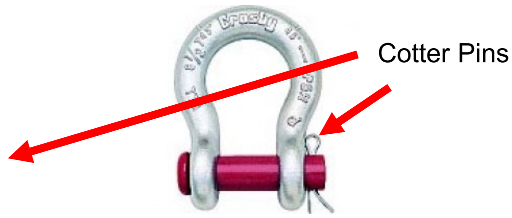


Figure 2.19: Round-Pin Shackle

Screw pin shackles (Figure 2.17), are the most commonly used anchor shackle due to the ease of inserting and removing the pin. Bolted Shackles (Figure 2.18), are used for more permanent applications. Best Practice is to never use Round Pin Shackles (Figure 2.19) for lifting. There may be appropriate uses for round pin shackles, like load tie down applications, however, extreme caution must be taken to NEVER SIDE LOAD A ROUND PIN SHACKLE.

In Figure 2.18, the cotter pin is in place to prevent the bolt from backing out of the shackle pin. In Figure 2.19, the only item preventing the shackle pin from displacement is the cotter pin.

SHACKLE COMPONENTS

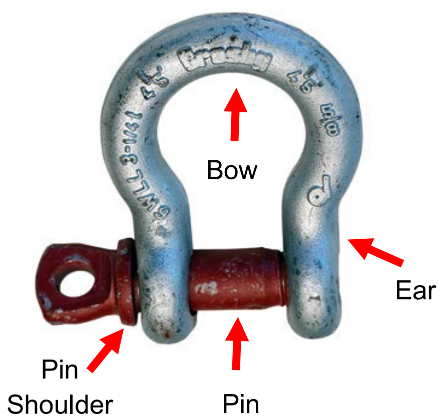


Figure 2.20: Shackle Components

A rigger should be able to identify the different parts of a shackle, as shown in Figure 2.20:

- Bow
- Ear
- Pin and Pin Shoulder

SHACKLE IDENTIFICATION [10]

All shackles used for lifting must have the manufacturer, the size, and the rated capacity stamped or embossed on them. The manufacturers I.D. can be shown as either the name or the trade mark / logo.

All shackles should be inspected prior to every use for these three pieces of information. If these are not present or legible - do not use the shackle!

Shackles should not be dragged across abrasive surfaces, such as the ground, or come into contact with sharp edges that could damage the shackle or its markings.

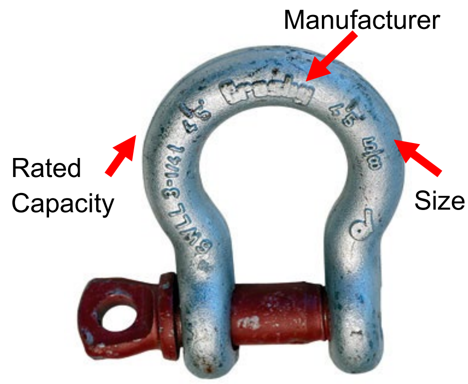


Figure 2.21: Shackle Identification

Shackle Body Identification

- name or trademark of manufacturer
- rated load
- size

Shackle Pin Identification

- name or trademark of manufacturer
- grade, material type, or load rating

SHACKLE INSPECTION [11]

Shackles shall be inspected and removed from service if conditions such as the following are present:

- pitting or corrosion
- a reduction of the original or catalog dimension at any point around the body or pin
- incomplete pin engagement
- thread damage
- evidence of unauthorized welding
- other conditions, including visible damage, that cause doubt as to the continued use of the shackle

Figure 2.22: Damaged Shackles

Some of these conditions have acceptable limits. These limits will differ between items and manufacturers. Manufactures recommendations should be consulted for specific removal criteria. Be sure that the recommendation you are referencing match the item you are inspecting.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

SHACKLE SIZE

To be able to select the correct sized shackle, the rigger must understand that shackle size is measured in the bow of the shackle and not by the pin.

The rigger must also understand that the shackle size must be larger than the size of the sling, for example when using a ¼" sling you would want to use at least a 5/16" shackle.

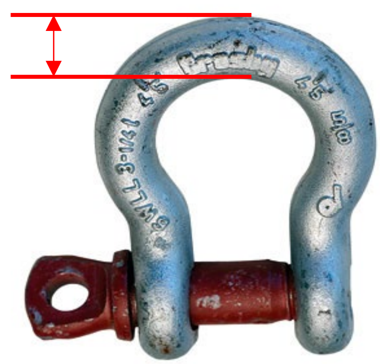


Figure 2.23: Measuring a Shackle

SAFE RIGGING PRACTICES [12]

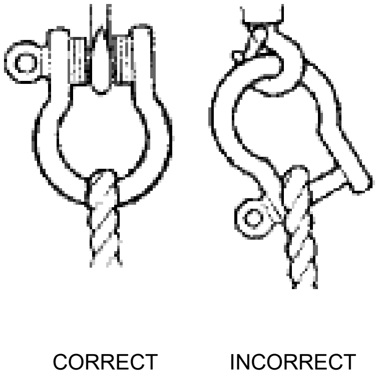


Figure 2.24: Correct Loading of a Shackle

CENTERING THE LOAD

The load applied to the shackle should be centered in the bow of the shackle to prevent side loading of the shackle.

Figure 2.24 shows washers (packing) being used as 'shims' to center the hook on the shackle. This practice of shimming or packing, prevents the shackle from sliding on the hook, and will eliminate potential angled loading. It also reduces the possibility of the load being applied to the pin and eye of the shackle.

MULTIPLE SLINGS

Multiple sling legs should not be applied to the shackle pin. Placing multiple slings in the bow prevents the possibility of the ears of the shackle being stretched by the weight of the load.

Multiple slings in the body of a shackle shall not exceed 120° included angle.

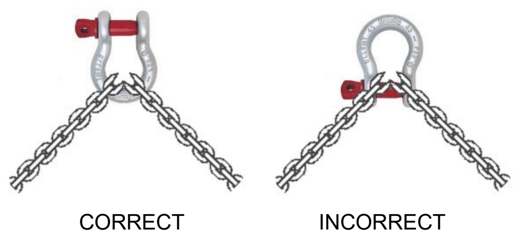


Figure 2.25: Correct use of Sling Legs on a Shackle

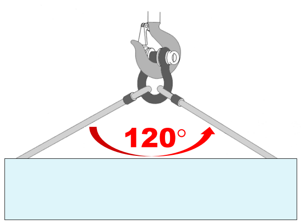


Figure 2.26: Maximum Sling Angles

SIDE LOADING

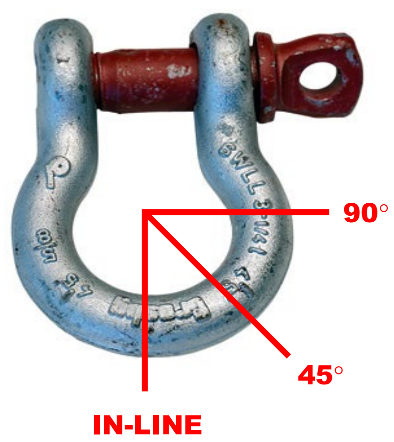


Figure 2.27: Side Load Angles

If the shackle is to be side loaded, the rated load shall be reduced according to the recommendations of the manufacturer, or the calculations of a rigger as shown in the chart below.

Side Loading Reduction Chart For Screw Pin & Bolt Type Shackles Only*	
Angle of Side Load	Adjusting Working Load Limit
0° In–Line 45° from In–Line 90° from In–Line	100% Rated Working Load Limit 70% Rated Working Load Limit 50% Rated Working Load Limit

Figure 2.28: Side Load Reduction Chart

PIN MANAGEMENT

The screw pin shackle shall not be rigged in a manner that would cause the pin to unscrew.

The shackle pin should fully engage in the eye. This means that the pin is easily threaded into both eyes, and the shoulder of the pin is seated against the eye. The threads on the pin should be within the threaded portion of the eye. Shackle pins should never be forced tighter through the use of a wrench. And pins, once seated, should never be "backed off."

Screw pin shackles are not to be used in permanent applications unless the pin is moused. A best practice is to use a bolted shackle for permanent or long term applications.

A moused pin is one in which the pin is secured from rotation. This is accomplished by wrapping a small piece of wire several times through the hole in the pin and to a point around the ear. The purpose is to prevent the pin from backing out.

Figure 2.29: Incorrect Rigging of a Screw Pin Shackle (pin not seated)

MODULE 2 QUIZ

Complete the following quiz questions:

2. What's wrong with the shackles in the photographs?

EYE BOLTS

When installing and using eye bolts the manufacturers' instructions must be followed.

EYE BOLT STYLES

There are two categories of eye bolts that are acceptable for rigging:

- Unshouldered Eye Bolts should only be used for vertical lifts, as angled loading will bend or break them.
- Shouldered Eye Bolts can be used for vertical and angled loading. Although angled loading is permissible, it should be done in the direction of the plane of the eye, and capacity reductions must be made.

Figure 2.30: Unshouldered Eye Bolt

Figure 2.31: Shouldered Eye Bolt

Pad Eyes are another option available to the rigger:

Pad Eyes are basically an eye on a flat pad. The pad is welded (or bolted) to the object you want to lift, and the rigging is then attached to eye as a lifting point.

Figure 2.31: Hook attached to a Pad Eye

EYE BOLT SELECTION

How do you select the right bolt?

- Eye Bolts are marked with their thread size, NOT with their rated capacity.
- The selection of an eye bolt should be based on its type and its capacity (i.e. its suitability for the lift you are conducting).

EYE BOLT IDENTIFICATION [13]

All eye bolts are marked with:

- name or trademark of manufacturer
- size or rated load
- grade for alloy eyebolts

Eye Bolts should be inspected prior to every use for these three pieces of information. If these are not present or legible - do not use the Eye Bolt!

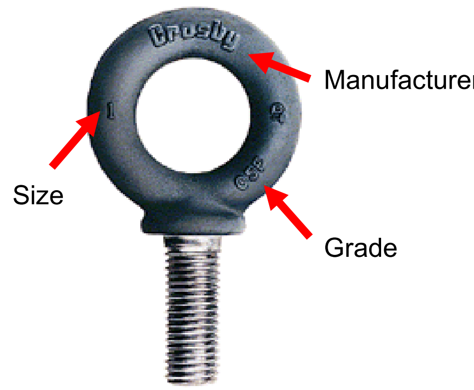


Figure 2.32: Eye Bolt Identification

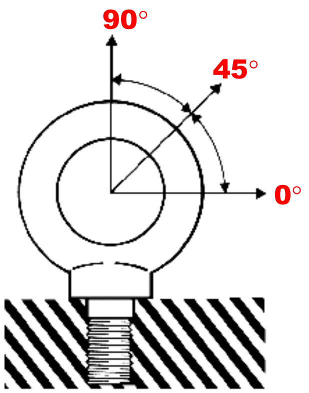
EYE BOLT INSPECTION

Eye Bolts shall be inspected and removed from service if conditions such as the following are present:

- missing or illegible identification
- heat damage, including weld spatter or arc strikes
- pitting or corrosion
- bending, twisting, distortion, stretching, or cracking
- nicks or gouges
- thread damage or wear
- evidence of unauthorized welding
- other conditions, including visible damage, that cause doubt as to the continued use of the shackle

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

SAFE RIGGING PRACTICES



Always use eye bolts at an angle greater than 45°.

- Eye bolt strength at a 45° angle drops down further to 30% of vertical lifting capacity.
- At 0° it drops to 25%!

Figure 2.33: Eye bolt Angle Considerations

Never reeve through two eye bolts - it will increase the stress on the eye bolt even more!

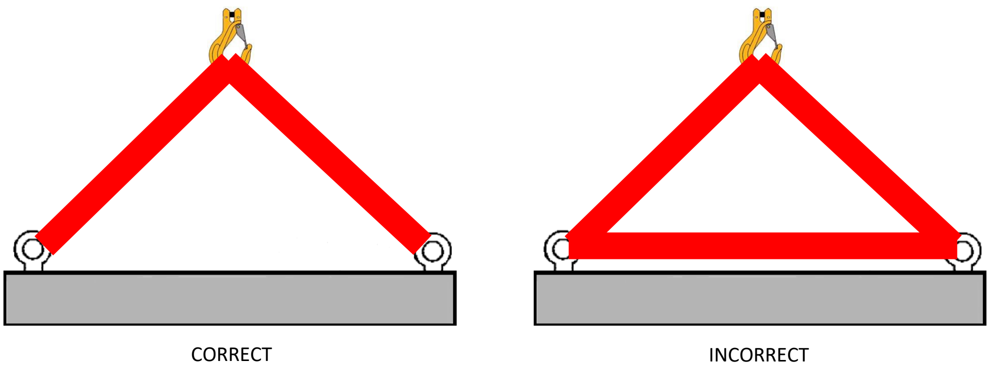
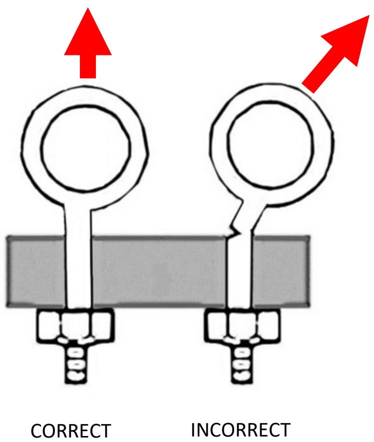


Figure 2.34: Correct use of slings and eye bolts



- Never angle an unshouldered eye bolt - it will deform.
- Do not use eye bolts that have worn threads or other flaws.
- Only attach one sling leg to each eye bolt.
- Do not use a single eye bolt to lift a load that could rotate.

Figure 2.36: Correct loading of unshouldered bolts

Shouldered Eye Bolts:

- It is ok to angle load shouldered eye bolts, however, the capacity will be greatly reduced.
- Never pull in the opposite plane of the eye - it will deform.
- Take care to screw the eye bolt all the way down, and properly seat by hand.

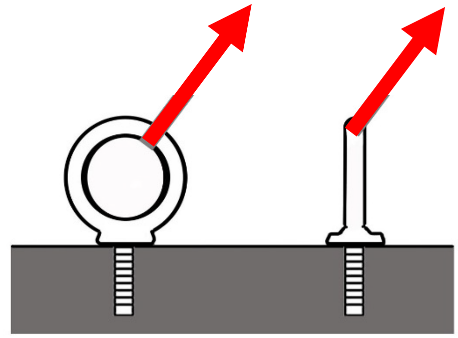
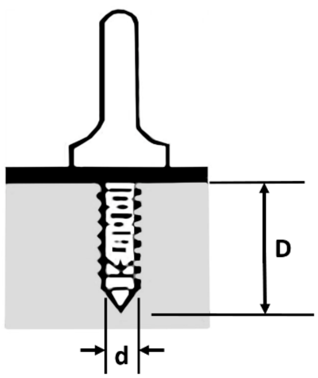


Figure 2.35: Correct loading of shouldered bolts



Tapped Holes:

- The tapped hole for any screw eye bolt must be as deep as required for the bolt, plus an additional one half the diameter.
- Inspect and clean the eye bolt threads and the hole. Note: Do not use compressed air to clean any component.
- The shoulder should be in full contact with the surface of the object being lifted and at a right angle to the axis of the hole.

Figure 2.36: Tapped hole considerations

Installing Eye Bolts:

- Always hand tighten bolts.
- Never use bars, grips or wrenches to tighten eye bolts.
- Never force slings through eye bolts.
- Never force fittings into the eye.
- Never paint an eye bolt.

A properly installed screw eye bolt must have at least 90% engagement of the threads. If the eye bolt must be indexed (spun to the proper direction to accept the hook or shackle for lifting without side loading), it is permissible to add shims (like washers) to the bolt. The total height of the shims must NOT be greater than 10% of the length of the threaded portion of the eye bolt.

Figure 2.39: Shimming / Indexing

MODULE 2 QUIZ

Complete the following quiz question:

3. Which type of Eye Bolt can be angle loaded?

   a) Shouldered

   b) Unshouldered

   c) Both

HOIST RINGS

A hoist ring is excellent for angled lifts, as the capacity is the same at every angle. A hoist ring will adjust to any sling angle by rotating around the bolt and the hoisting eye pivots 180°.

Note: When loaded at an angle, hoist rings create additional tension. The load weight plus the tension must not exceed the rated capacity of the hoist ring.

HOIST RING CONSIDERATIONS

A rigger should be familiar with the parts of a hoist ring, (shown in Figure 2.40), as well as how to install and use them, including any manufacturer's instructions:

- The tapped hole;
  - must be at an angle of 90° to the surface,
  - width must be the correct diameter for the bolt,
  - depth must be the threaded shank length, plus one half the threaded shank diameter.
- Retention nuts, if used, must have full thread engagement.
- The surface must be flush with the hoist ring. Spacers between the surface and bushing flange should not be used.
- Use a torque wrench to install, as recommended by the manufacturer.

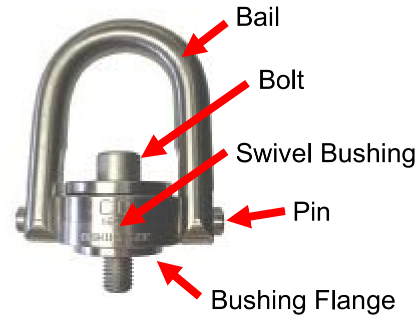


Figure 2.40: Hoist Ring Components

HOIST RING IDENTIFICATION

All hoist rings are stamped or embossed with:

- name or trademark of manufacturer
- rated load
- torque value (torque is the turning force of an object, the torque value is the amount of torque that can be applied to the bolt when installed)

All hoist rings should be inspected prior to every use for these three pieces of information. If these are not present or legible - do not use the hoist ring!

HOIST RING INSPECTION

In addition to inspecting for corrosion, wear and damage, and that manufacturers identification marks are present, as per all hardware, hoist rings should be removed from service if any of the following is present:

- The bail is bent, twisted or stretched.
- The bail does not move freely; it should pivot 180°, and rotate 360°.
- Threads on the shank and in the hole are not clean, or are worn or damaged.

No damage at all is allowed, and removal of damage is not permissible. Hoist rings that have signs of repair must also be removed from service.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

TURNBUCKLES

Turnbuckles are used where different sling leg lengths are required to allow the hook to be positioned over the center of gravity as shown in Figure 2.41.

They consist of a body, a right-hand threaded end fitting, and a left-hand threaded end fitting, and can have three different end fittings: Eye, hook or jaw.

Turnbuckles are adjustable devices; as the body is turned, the length of the turnbuckle increases or decreases.

Turnbuckles should always be used in a straight line pull. A straight line pull, or in-line is where the sling makes a straight line hook to hook.

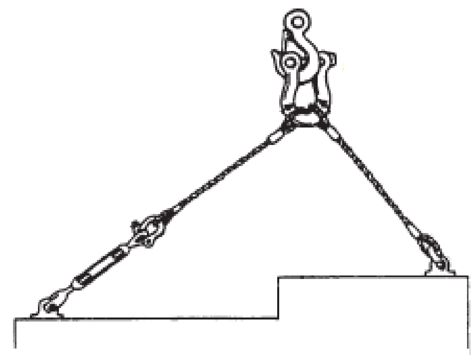


Figure 2.41: Turnbuckles used with different sling lengths

TURNBUCKLE IDENTIFICATION

All Turnbuckles are marked with:

- name or trademark of manufacturer
- size or capacity
- grade

All Turnbuckles should be inspected prior to every use for these three pieces of information. If these are not present or legible - do not use the Turnbuckle!

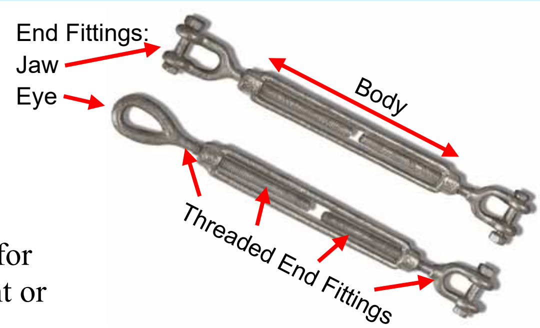


Figure 2.42: Turnbuckle Components

TURNBUCKLE INSPECTION

In addition to inspecting for corrosion, wear and damage, and that manufacturers identification marks are present, as per all hardware, Turnbuckles should be removed from service if any of the following are present:

- End fittings (eye, hook or jaw) are deformed, worn or damaged.
    - Hooks should be inspected for twisting or stretched opening of the throat.
    - Bolt and nut of the jaw should be inspected for damage or deformation, and the type and size should also be checked.
- Body is cracked, deformed or damaged.
- Rod is deformed, worn or there is thread damage.

Turnbuckles must not be repaired without approval from the manufacturer. If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

MASTER LINKS

A master link is a steel link or ring used to gather multiple sling legs together, without bunching the slings up.

Although Master Links can be side loaded up to 120°, care should be taken, as this will cause twice the stress of a vertical pick.

MASTER LINK IDENTIFICATION [14]

All Master Links are stamped or embossed with:

- name or trademark of manufacturer
- size **or** rated load
- grade (of steel – the material used)

All Master Links should be inspected prior to every use for these three pieces of information.

If these are not present or legible - do not use the Master Link!

Figure 2.43: Oblong, Round and Pear shaped Master Links

MASTER LINK INSPECTION [15]

Master Links shall be inspected and removed from service if conditions such as the following are present:

- missing or illegible identification
- heat damage, including weld spatter or arc strikes
- pitting or corrosion
- bending, twisting, distortion, stretching, or cracking
- nicks or gouges
- evidence of unauthorized welding
- other conditions, including visible damage, that cause doubt as to the continued use

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

MODULE 2 QUIZ

Complete the following quiz question:

4. Match the hardware to its use:

Hoist Ring	Used for multiple sling lifts
Turnbuckle	Used for angled lifts / slings
Master Link	Used for different sling lengths

OTHER LIFTING HARDWARE

There are many other below the hook lifting devices available to the rigger.

Figure 2.44: Vertical Plate

PLATE CLAMPS

There are two styles of plate clamps, those designed for vertical or horizontal orientation of the plate: Vertical plate clamps are to be used when the plate must be hoisted in a vertical orientation. Horizontal plate clamps are to be used when a plate must be hoisted in a horizontal orientation.
When hoisting plate in a horizontal orientation, two horizontal plate clamps MUST be used. When hoisting a long or flexible plate in a vertical orientation, two vertical plate clamps should be used.

Steel plates are inserted into the clamp, and locked in place – be sure to check that the clamp is locked before lifting the load!

Always refer to the manufacturer's manual before using, and as with all lifting gear, inspect thoroughly before using.

Figure 2.45: Horizontal Plate Clamp

LIFTING MAGNETS

An alternative to Plate Clamps is Lifting Magnets.

Lifting Magnets are quick and easy to set up – the magnet is centered on the load and the magnetic field turned on by a lever.

Lifting Magnets can be used for round loads as well as flat plates, however, the loading rate is different - the capacity is significantly reduced!

Always refer to the manufacturer's manual before using, and as with all lifting gear, inspect thoroughly before using.

Figure 2.46: Lifting Magnet

LIFTING BEAMS

Lifting beams are useful when overhead space is limited. They are generally used for long or heavy loads where the size, and more importantly the weight, can be spread across the beam.

The most common types of lifting beam are Lifting Beams and Spreader Bars. The names are often switched but they are actually different devices:

- Lifting Beams are rigid beams with a central pick point. The beam therefore has to be strong and rigid, as the pick point is central, but the load is attached to points at the ends of the bar.
- Spreader Bars are beams with pick points at the ends of the bar, which is also where the load is attached. The weight is therefore spread across the beam.

Figure 2.47: Rigid Lifting Beam

Figure 2.48: Spreader Bar

Always refer to the manufacturer's manual before using, and as with all lifting gear, inspect thoroughly before using.

Custom hardware must be properly engineered and "shall be marked to indicate the safe working loads and shall be proof-tested prior to use to 125 percent of their rated load." [8]

MODULE 2 QUIZ

Complete the following quiz question:

5. Spreader Bars have central pick point, but the load is attached to the ends of the bar.

   a) True

   b) False

RIGGING BLOCKS

Rigging blocks are used mainly on cranes, to give us Mechanical Advantage, by multiplying the effectiveness of the winch and amplifying force output. Examples of this would be gear boxes, chain and belt drives, levers, and the block and tackle systems.

A block and tackle system incorporates a fixed Sheave (pulley) or set of Sheaves (pulleys) and a movable sheave (pulley) or set of sheaves (pulleys). Sheaves (pulleys) need to be used in the correct application in order to give us mechanical advantage. Blocks range from one-sheave, up to 10 sheave blocks on larger cranes.

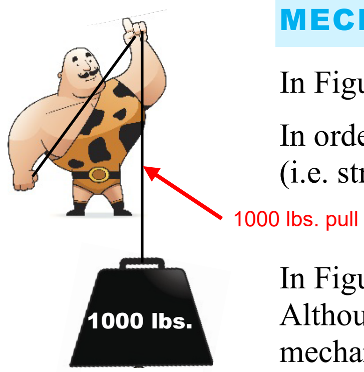


Figure 2.49

MECHANICAL ADVANTAGE

In Figure 2.49 we see a very strong individual lifting a load from above.

In order to lift the 1000 lb. load he needs to have an equal amount of pull (i.e. strength or force).

In Figure 2.50 we see a sheave (pulley) has been incorporated into the lift. Although this allows us to change direction of pull, it does not give us mechanical advantage. This is because the full weight of the load is still supported by only one line.

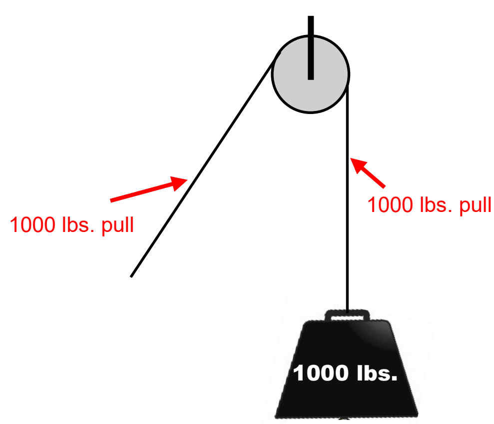


Figure 2.50

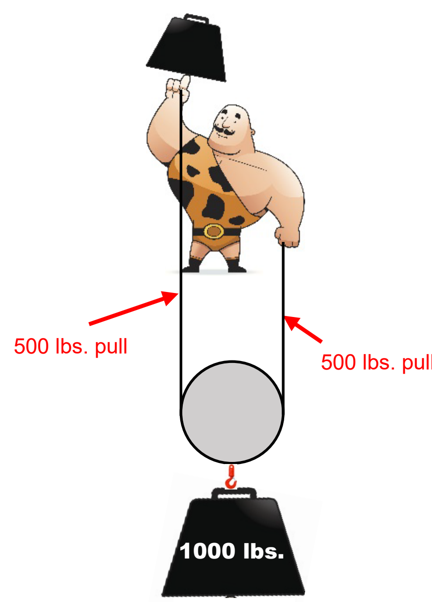


Figure 2.51

Figure 2.51 shows the use of one Sheave (Pulley), only this time attached to the load rather than in a fixed position as shown in Figure 2.50. We now have two lines sharing the load, resulting in half the force (500 lbs.) being required to lift the load.

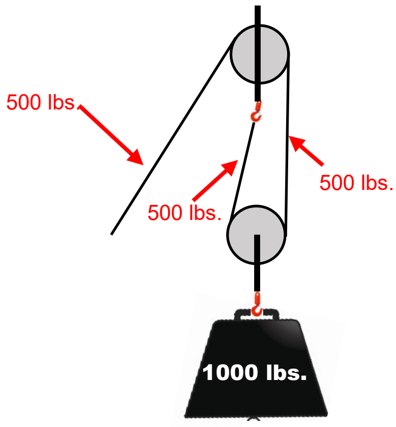


Figure 2.52

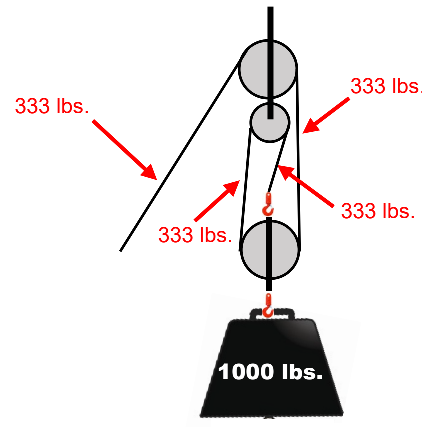


Figure 2.53

Figure 2.52 shows the use of two pulleys, one fixed and one movable (attached to the load). We still have only two lines attached to the load, but we have changed direction of pull as well.

Figure 2.53 shows a third Sheave (pulley) being used in the same fixed block above and the tail end of our load line being attached to our lower block. This gives us 3 lines directly attached to the load and further reduces the required force needed to approximately 333 lbs.

Figure 2.54 shows us incorporating a second sheave in the movable block allowing us to return the tail end of our load line to the top.

Now we have 4 lines directly attached to the load reducing our required force to a mere 250 lbs.

We can continue to add Sheaves (pulleys) to our block and tackle system resulting in the ability to lift many times more weight than we could otherwise.

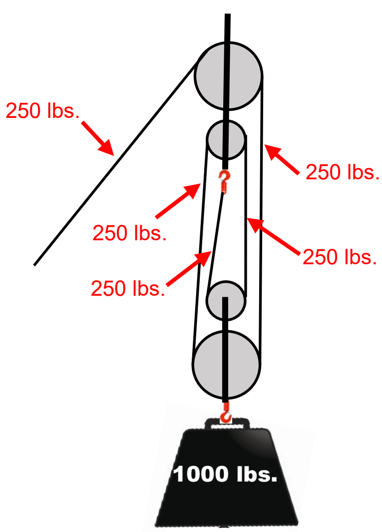


Figure 2.54

RIGGING BLOCK IDENTIFICATION [16]

All Rigging Blocks are marked with:

- name or trademark of manufacturer
- rated load
- rope size(s)

All Rigging Blocks should be inspected prior to every use for these three pieces of information.

If these are not present or legible - do not use the Block!

RIGGING BLOCK INSPECTION [17]

Rigging blocks shall be inspected and removed from service if conditions such as the following are present:

- missing or illegible identification
- wobble in sheaves
- sheave groove corrugation or wear
- loose or missing nuts, bolts, cotter pins, snap rings, or other fasteners and retaining devices
- indications of heat damage, including weld spatter or arc strikes
- pitting or corrosion
- bent, cracked, twisted, distorted, stretched, elongated, or broken load-bearing components
- wear, nicks, or gouges
- a reduction of the original or catalog dimension at any point
- damage to load-bearing threads
- evidence of welding or modifications
- other conditions, including visible damage that cause doubt as to the continued use of the rigging block

Figure 2.55: Rigging Block

Some of these conditions have acceptable limits. These limits will differ between items and manufacturers. Manufactures recommendations should be consulted for specific removal criteria. Be sure that the recommendation you are referencing match the item you are inspecting.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

SAFE RIGGING PRACTICES

Damage to the rigging block should be avoided. Rigging blocks should not be dragged on abrasive surfaces, or have contact with sharp edges.

Before use, check that all rigging block components are fully engaged, with all fasteners and retaining devices in place and in good working order. Ensure the line load multiplied by the block load factor does not exceed the rated load of the rigging block.

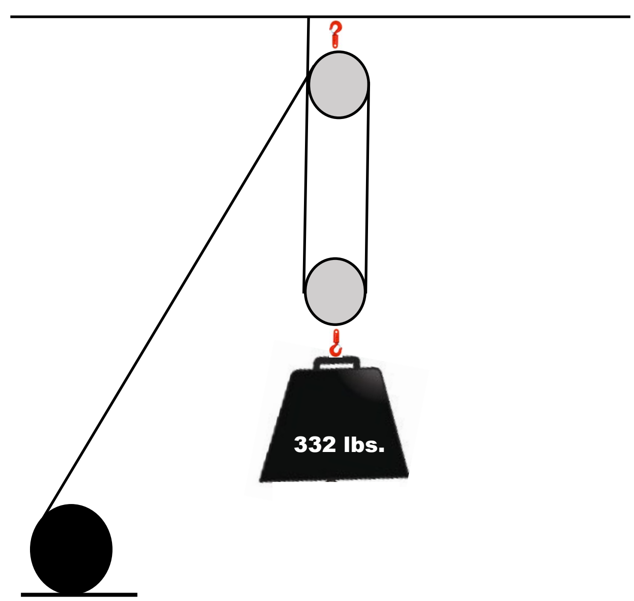
Check that the rope is in the sheave groove when the rigging block begins to take load, and that the load is in-line with the sheave and fitting(s) to prevent side loading of the block.

Shock loading should be avoided. Shock loading is when a sudden intense force is placed on a crane, and the crane cannot handle the pressure, which would not only damage the rigging, but cause structural damage to the crane itself.

MODULE 2 QUIZ

Complete the following quiz question:

6. When using two pulleys one fixed and one moveable, how much pull is required to lift this 332lbs. load?



MODULE 3:

Slings

MODULE 3: SLINGS

MODULE 3 LEARNING OBJECTIVES

Upon completion of this Module students will be able to:

- Identify different types of slings, and their components.
- Conduct sling inspections, and recognize defects.
- Recall sling regulations and apply safe rigging practices.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

SLINGS

Slings are an essential part of rigging. There are many different sling types and variations available to the rigger. Each type has its advantages and disadvantages.

These are types of slings commonly used at Freeport-McMoRan:

- Alloy Steel Chain Slings
- Wire Rope Slings
- Synthetic Slings include Web Slings and Round Polyester Slings

Figure 3.1: Wire Rope Sling

Figure 3.2: Chain Sling

Figure 3.3: Synthetic Round Slings

Figure 3.4: Synthetic Web Sling

SLING SELECTION

Always select the correct sling for the load and the environment. Each type has its advantages and disadvantages:

SYNTHETIC SLINGS

Synthetic slings are the most commonly used sling. They are easy to use and inexpensive compared to other materials. Made from nylon or polyester, the fabric is strong yet flexible.

WIRE ROPE SLINGS

Wire rope slings are also strong and flexible. Smaller diameter wire rope offers more resistance to wear and abrasion. Larger diameter rope with a higher number of strands is more flexible.

ALLOY STEEL CHAIN SLINGS

Chain slings are strong, flexible, and durable. They can be used in environments that would destroy other types of slings, such as high temperatures, however, chain slings are a lot more expensive than synthetic or wire rope slings.

Always refer to the manufacturers specifications when using slings in adverse conditions, for example near chemicals or heat sources.

Note: Not all slings are used at all sites. You should be aware of your site's procedure! Record details of your site's specific procedure in the space below.

SITE SPECIFIC NOTES

SAFE RIGGING PRACTICES

Whichever sling you chose for your lift, the following safe rigging practices shall be observed:

- Do not used worn, damaged or defective slings
- Do not exceed the rated load of the sling, as shown on the Capacity Tag
- Do not lengthen or shorten slings by knotting or twisting
- Securely attach the sling to the load
- Do not place fingers or hands between the sling and the load while tightening the sling around the load
- Use softeners to protect slings from rough or sharp edges of the load (see Figure 3.5)
- Be alert for possible snagging during a lift (sharp edges, corners and protrusions)
- Do not pull a sling from under a load if the load is resting on it
- Do not drag slings across abrasive surfaces
- Store slings appropriately

Figure 3.5: Softeners

MANUFACTURERS CAPACITY TAGS

Figure 3.6: Manufacturers Capacity Tag

All slings must have a manufacturer's capacity tag. Slings shall be inspected prior to every use - including the capacity tag. If it is illegible or missing - do not use the sling!

As the name suggests, the capacity tag shows the capacity of the sling, displayed as: Capacity, SWL (Safe Working Load), or WLL (Working Load Limit). All of these terms mean exactly the same thing – it is the maximum load that can be placed on any piece of rigging equipment.

The tag in the photograph (Figure 3.6), shows the capacity using different types of hitches: Vertical, Choker, and Basket Hitch.

The tag will also contain information regarding the manufacturer, a description of the sling, the material it is made from, and its size.

Most tags will eventually become hard to read with time, so when buying slings make sure they have a sturdy capacity tag that will stand up to normal wear and tear. Placing the tag to the hook (rather than the load) will protect the tag from damage, however, if the tag has become illegible, then it is likely the rest of the sling is in equally poor condition.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

Any modification to a sling, will mean that the Working Load Limit is no longer valid, therefore the sling should be B/O.

INSPECTION

All slings shall be inspected before, during and after use.

Start at one end and work your way around the sling to the other end. Start your inspection at the end with the capacity tag, checking first that it is attached, and that all information is legible.

Each type of sling has specific inspection criteria, as listed in the individual sections of this module. Additionally a qualified person performs a periodic inspection, which is determined by:

- frequency of use
- severity of conditions in which the sling is used
- nature of the lifts being made
- comparison to slings used in similar circumstances

Periodic inspections shall take place at intervals no greater than 12 months, however, slings in severe use shall be inspected monthly to quarterly. Inspection logs are used to record details and ensure regular inspections are conducted.

MODULE 3 QUIZ

Fill in the blank:

1. Use ____________ to protect slings from rough or sharp edges.

ALLOY STEEL CHAIN SLINGS

Chain slings are strong, flexible, and durable. They can be used in environments that would destroy other types of slings, such as high temperatures, however, chain slings are a lot more expensive than synthetic or wire rope slings.

Chain slings used for overhead lifting are always made from Alloy Steel only.

ALLOY STEEL CHAIN SLING IDENTIFICATION [18]

All chain slings must have a capacity tag which is marked with:

- manufacturers name or trademark
- grade
- size
- number of legs
- rated load for types of hitches and angles
- length or reach

All slings shall be inspected prior to every use for these six pieces of information.
If these are not present or legible - do not use the sling!

ALLOY STEEL CHAIN INSPECTION [19]

Every chain used for lifting must be inspected before, during, and after use.

Monthly, chains must be inspected link by link. This inspection must be documented so that any changes are monitored. For this reason, it is advisable to identify each chain or bridle with a unique number or identifier.

Figure 3.7: Chain Inspection

In order to do a thorough inspection, we must inspect each link of the chain individually for: Wear, cracks, nicks, cuts, gouges, crushing and stretching. Chains shall also be inspected for heat damage (discoloration, slag, weld splatter) and corrosion.

There are several methods for measuring chains during an inspection. Overall length can be measured by hanging the chain and measuring top to bottom. A representative sampling of the chain can be taken by measuring several links in one section, then another section, and so on, and an average link size determined. Some manufacturers provide "go/no-go" gauges for users to use in inspections. Regardless of the method used to inspect chains, complete inspections are required to be documented.

Never repair a chain – only the chain manufacturer can repair a chain!

And remember - just one bad link can cause the chain to fail!

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

ALLOY STEEL CHAIN SLING STORAGE

Never store slings on the ground! In addition to being a tripping hazard, there is also risk of mechanical damage.

Slings should be hung, ideally on a storage rack sorted by size, purpose etc. This keeps slings out of the way of potential damage, but it also makes retrieval and selection much quicker and easier.

Chain slings can be damaged by abrasion and sharp corners, as well heat and corrosion, and so should be stored in a cool dry place, away from any environmental damage such as corrosion, moisture, or extreme temperatures.

Proper storage can increase the life of slings as well as help to avoiding rigging failure.

Figure 3.8: Chain Storage

MODULE 3 QUIZ

Complete the following quiz questions:

2. What is the Working Load Limit on a Capacity Tag?
    a) The minimum load
    b) The maximum load
    c) What will break the sling

3. Which type of sling can be used in high temperatures?
    a) Web Sling
    b) Round Sling
    c) Wire Rope Sling
    d) Alloy Steel Chain Sling

WIRE ROPE SLINGS

Wire rope is strong, durable and offers some resistance to abrasion. Wire rope slings have the ability to adapt to the shape of the load, and can also be used to lift hot loads.

WIRE ROPE COMPONENTS

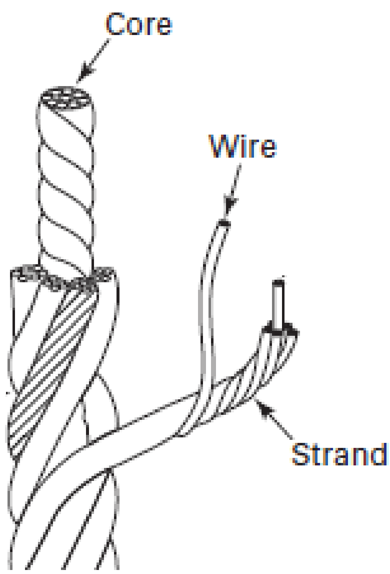


Figure 3.9: Wire Rope Components

All wire rope has three basic components: Wires, strands and core.

Types of wire ropes are identified by number, and the type of core. The numbers are nominal: A 6 x 19 rope will have 6 strands of approximately 19 wires wrapped around the core (depends upon the manufacturer). A 6 x 37 rope will have 6 strands of approximately 37 wires wrapped around the core (depends upon the manufacturer). That core may be independent, wire, or fiber.

The lower the second number, the more abrasion resistant the rope will be. The higher the number, the more fatigue resistant the rope will be. Knowing and understanding the differences in the various ropes can help a rigger identify which rope is best in various applications.

Generally, the greater the number of wires and the smaller the diameter, the more flexible the rope will be.

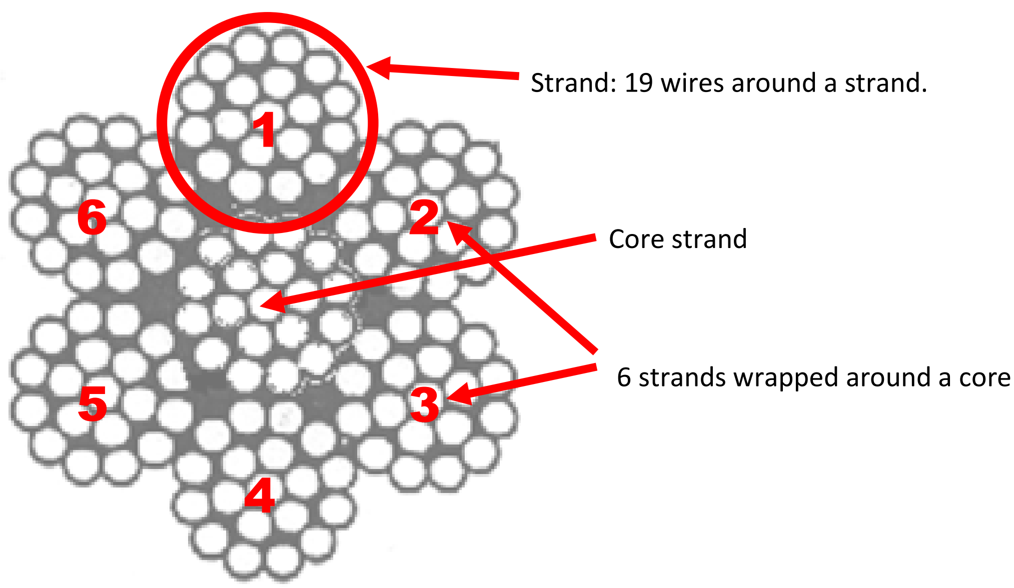


Figure 3.10: Strands wrapped around a Core of a 6 x 19 Wire Rope

MEASURING WIRE ROPE

Wire Rope is specified by its length and diameter. The measurement systems used for length, width and grade are specific to Wire Rope, and must be understood by the rigger.

DIAMETER

Wire rope is measured across its diameter. The true diameter of a piece of wire rope is the diameter of a circle that will just enclose all of its strands, as shown in Figure 3.11.

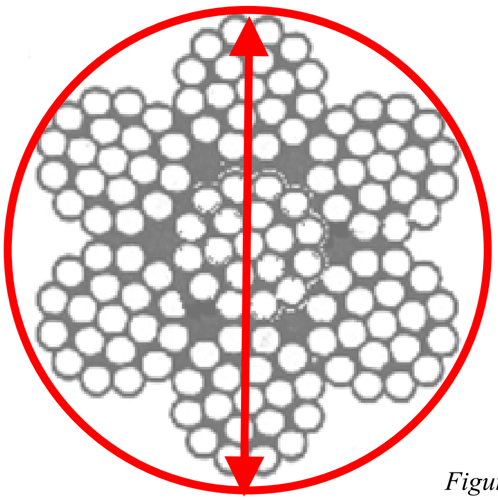


Figure 3.11: True Diameter of Wire Rope

The illustrations in Figure 3.12 below, compare the correct and incorrect ways to measure wire rope: The correct way to measure is from the top edge of one strand to the bottom edge of the opposite strand. Do not measure across where the two strands are side by side.

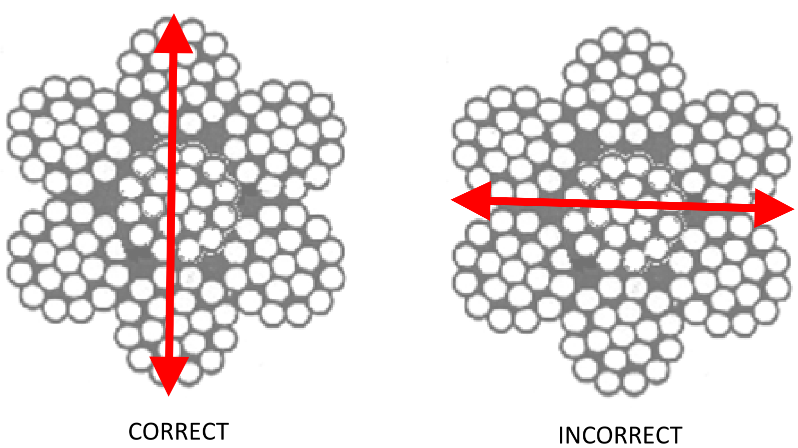


Figure 3.12: Correct and Incorrect Ways to Measure of Wire Rope

Use calipers to measure wire rope. For accuracy, measure the rope in at least three places, several feet apart, and use the average of all three measurements as the diameter of the rope.

LENGTH

The length of a rope is measured in “lays.” A lay length refers to the distance it takes for a strand to make a complete revolution around a core, (i.e. the distance from where a strand spirals down and back up).

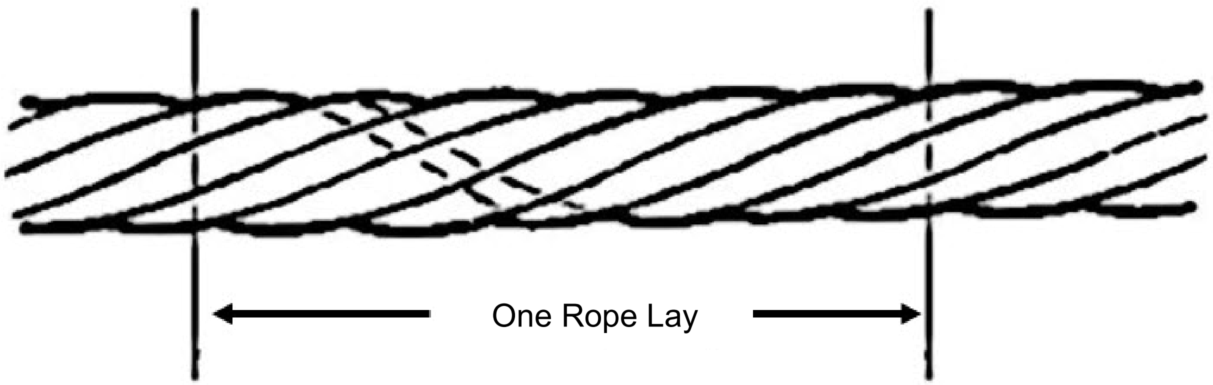


Figure 3.13: Measuring the Length of Wire Rope

GRADE

Wire rope is generally made from high-carbon steel, which is manufactured at different grades:

- Improved Plow Steel (IPS)
- Extra Improved Plow Steel (EIPS)
- Extra Extra Improved Plow Steel (EEIPS)

EIPS is the most commonly used grade.

LAYS OF WIRE ROPE

Wire rope is identified not only by its components, but also by how it has been manufactured. Individual wires are laid to form strands, and the strands are laid around the core. The direction of the wires and strands determines the "lay."

DIRECTION OF LAY

Left hand lay or right hand lay describe how the strands are laid to form the rope. To determine the lay of strands, look at the rope as it points away from you. If the strands appear to turn in a clockwise direction, (or like a right-hand thread), the rope has a right hand lay. If the strands appear to turn in an anti-clockwise direction, the rope has a left hand lay.

Rotation resistant wire rope has the inner and outer strands laid in opposite directions.

Figure 3.14: Examples of Right Hand Lay Rope

TYPES OF LAYS

With **regular lay** ropes, the direction of the wires in the strands is in the opposite direction to the strands. The wires appear to run parallel to the axis of the rope. As a commonly used multipurpose rope, regular lay has good resistance to kinking, crushing and distortion.

Wires in **lang laid** rope are laid in the same direction as the strands, with the outside wires providing good resistance to abrasion. To prevent unwinding, lang rope must have both ends attached and should never be used in a single part or used with a swivel.

An **alternate lay** and **left lay rope** is where regular lay and lang laid strands are alternately laid around the core. These special ropes are used on cranes as they have a greater surface which results in less wear on the sheave, however, they are not as stable as regular lay ropes and will often crush or bird cage (see page 60).

The lay of wire rope affect its resistance to wear and flexibility. Generally the greater the number of wires and the smaller the diameter, the more flexible the rope will be.

WIRE ROPE IDENTIFICATION [20]

All wire rope slings must have a capacity tag, which is marked with:

- name or trademark of the manufacturer
- rated load for the types of hitches and angles
- diameter or size

All slings shall be inspected prior to every use for these three pieces of information.

If these are not present or legible - do not use the sling!

Figure 3.15: Manufacturers Capacity Tag

WIRE ROPE INSPECTION [21]

All slings shall be inspected before, during and after use.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

Eventually all wire rope slings deteriorate to the point that they are no longer safe for use, therefore, slings must be rigorously inspected and removed from service if any of the following conditions are present:

SLING DAMAGE

Inspect the sling itself and remove from service if there is evidence of damage.

If there is any damage which causes doubt as to the capacity of the sling, it is cause for removal from service – do not use!

Figure 3.16: Eye damage

ROPE DAMAGE

Wire rope shall be inspected and removed from service is there is evidence of:

- abrasion or scraping
- heat damage
- corrosion

Figure 3.17: Kinked Wire Rope

Inspect for kinks, crushing, or bird caging. Bird caging (where outer strands stand up) can be caused by shock loading, or when rope is opened up by twisting. In addition to damaging the slings, shock loading can cause structural damage to the crane, therefore all shock loading is prohibited.

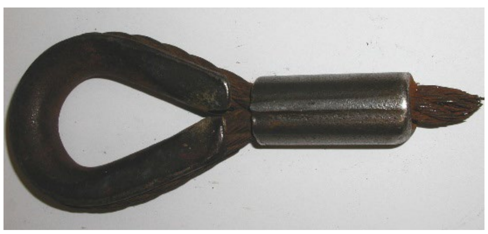


Figure 3.18: Rope failure at fitting due to corrosion and broken wires

In addition to inspecting the wire rope itself, end attachments or fittings shall be inspected for crushing, damage and corrosion (see Figure 3.18).

Figure 3.19: Dry brown rope which needs lubrication

Wire Rope is lubricated during manufacture. To lengthen service it is regularly lubricated in the field. If a rope looks dry and brown, it should be removed from service for lubrication by a qualified person.

Dirt and dust also affect the lubrication of slings – store slings correctly and do not leave slings on the ground.

WIRE DAMAGE

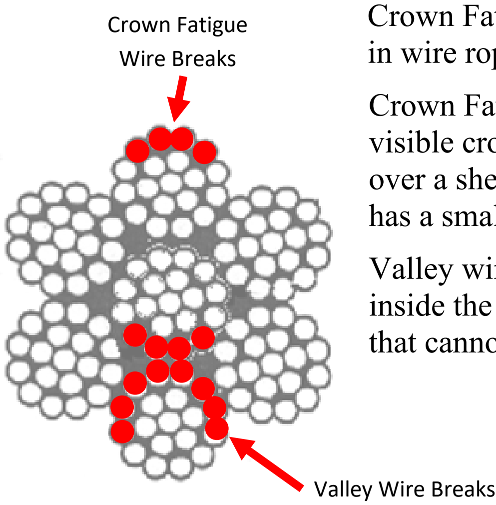
Wire rope slings must be removed from service when the outside wires are worn one third or more of the original diameter.

For strand laid wire rope slings, when there are ten broken wires in one rope lay, or five broken wires in one strand per lay, then the sling must be destroyed and disposed of. Most sites will destroy slings if there are any signs of damage, i.e. if there is one broken wire it could be considered B/O.

Wires shall also be inspected at the fittings, and replaced if you see more than one broken wire.

Figure 3.20: Multiple Broken Wires

CROWN FATIGUE & VALLEY WIRE BREAKS



Crown Fatigue and Valley wire breaks are two common defects found in wire rope slings.

Crown Fatigue wire breaks are where wires are damaged on the visible crown of the strand. This is usually caused by running the rope over a sheave that is too small, or placing the rope over a shackle that has a smaller diameter than the rope.

Valley wire breaks are on the lower part of the strand and hidden inside the wire. If there is one valley wire break, there may be others that cannot be seen, and the rope shall be removed from service.

Figure 3.21: Wire Rope Defects

WIRE ROPE CLIPS

You have probably heard the saying: “Never Saddle a Dead Horse”? This refers to properly applying hardware when forming an eye at the end of a wire rope. The live end of a rope is the end which will carry the weight of the load. The dead end is the end which has been cut.

A U-bolt is applied to the dead-end of the rope, and a clip to the "live" end. The "saddle" is therefore on the live end. The saddle should never be placed on the dead end or "horse" because as the U-bolt is tightened down, it often crushes the wire rope – we want the crushing to be on the dead end. The saddle never goes over the dead end.

The spacing of the clips is also important: The first clip should be one body width away from the dead end. The second clip should go as close to the thimble as possible. The remaining clips should be equally spaced between the first and second clips.

Note: For overhead lifting, suspension and fall protection life lines, do not use a U-bolt style clip, always use a Fist Grip Clip.

THIMBLES

Wire Rope is wrapped around a thimble to create an eye. Thimbles help form and keep the form of the eye of wire rope slings.

In addition to keeping the eye from crushing, they help to protect wire rope from damage by offering a strong surface for attaching hardware. Use of thimbles can extend the life of wire rope and wire rope slings.

Figure 3.22: Thimble

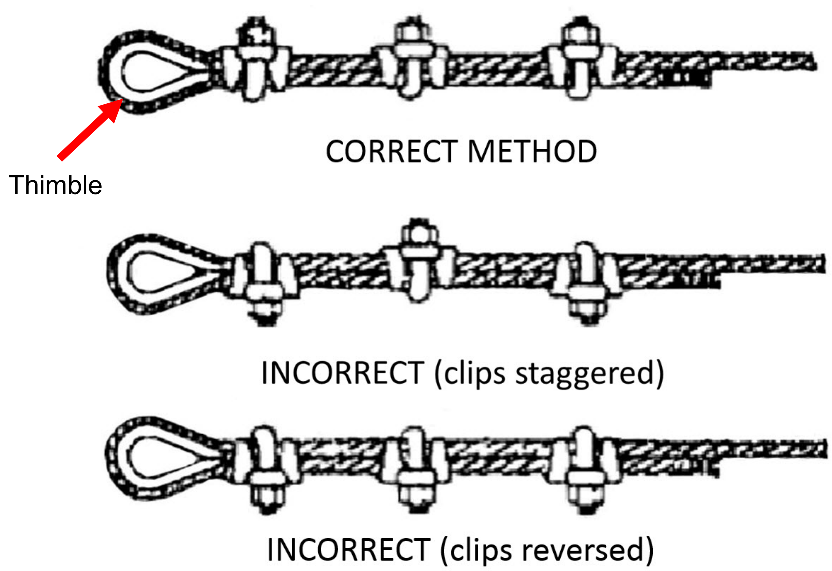
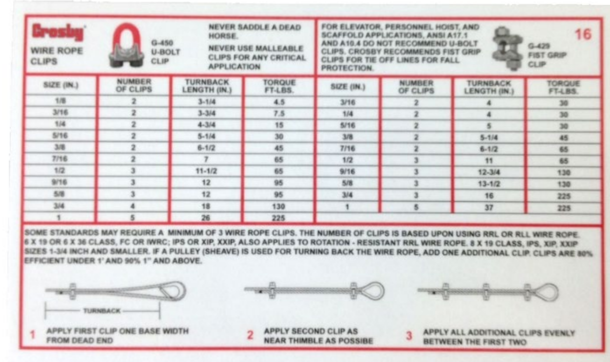


Figure 3.23: Correct and Incorrect application of wire rope clips and thimbles.

INSTALLATION

To ensure the correct installation of wire rope clips, riggers refer to manufacturers' guides. (See page 142 for Rigging Reference Guides.)

Panel 16 of the Crosby Users Lifting Guide (The Crosby Card - a reference guide produced by rigging equipment manufacturer Crosby), lists wire rope sizes, number of clips, the turnback length, and torque required (see Figure 3.24).


Crosby

WIRE ROPE CLIPS

G-450 U-BOLT CLIP

NEVER SADDLE A DEAD HORSE.

NEVER USE MALLEABLE CLIPS FOR ANY CRITICAL APPLICATION

SIZE (IN.)	NUMBER OF CLIPS	TURNBACK LENGTH (IN.)	TORQUE FT-LBS.
1/8	2	3-1/4	4.5
3/16	2	3-3/4	7.5
1/4	2	4-3/4	15
5/16	2	5-1/4	30
3/8	2	6-1/2	45
7/16	2	7	65
1/2	3	11-1/2	65
9/16	3	12	95
5/8	3	12	95
3/4	4	18	130
1	5	26	225

FOR ELEVATOR, PERSONNEL HOIST, AND SCAFFOLD APPLICATIONS, ANSI A17.1 AND A10.4 DO NOT RECOMMEND U-BOLT CLIPS. CROSBY RECOMMENDS FIST GRIP CLIPS FOR TIE OFF LINES FOR FALL PROTECTION.

G-429 FIST GRIP CLIP

16

SIZE (IN.)	NUMBER OF CLIPS	TURNBACK LENGTH (IN.)	TORQUE FT-LBS.
3/16	2	4	30
1/4	2	4	30
5/16	2	5	30
3/8	2	5-1/4	45
7/16	2	6-1/2	65
1/2	3	11	65
9/16	3	12-3/4	130
5/8	3	13-1/2	130
3/4	3	16	225
1	5	37	225

SOME STANDARDS MAY REQUIRE A MINIMUM OF 3 WIRE ROPE CLIPS. THE NUMBER OF CLIPS IS BASED UPON USING RRL OR RLL WIRE ROPE. 6 X 19 OR 6 X 36 CLASS, FC OR IWRC; IPS OR XIP, XXIP, ALSO APPLIES TO ROTATION - RESISTANT RRL WIRE ROPE. 8 X 19 CLASS, IPS, XIP, XXIP SIZES 1-3/4 INCH AND SMALLER. IF A PULLEY (SHEAVE) IS USED FOR TURNING BACK THE WIRE ROPE, ADD ONE ADDITIONAL CLIP. CLIPS ARE 80% EFFICIENT UNDER 1" AND 90% 1" AND ABOVE.

TURNBACK

1 APPLY FIRST CLIP ONE BASE WIDTH FROM DEAD END

2 APPLY SECOND CLIP AS NEAR THIMBLE AS POSSIBE

3 APPLY ALL ADDITIONAL CLIPS EVENLY BETWEEN THE FIRST TWO

Figure 3.24: Crosby Card Panel 16

Using the left hand table (U-bolt wire rope clips) as a reference, riggers shall complete the following steps when installing wire rope clips:

- Find the size of wire rope you are using in the first column, and the recommended turnback length required for that size in the third column.
  - Install a thimble on the underneath of the wire rope, and then pull the rope around the thimble until you have the recommended turn back length. This length is the measurement from the end of the thimble to the end of the wire rope.
- In the second column, check the number of clips recommended for that wire rope size. When installing wire rope clips, remember:
  - That the spacing of clips is also important, (see Figure 3.23 previous page).
  - Never saddle a dead horse.
- The fourth column lists the torque required for the bolts of the clip. Check the amount of torque required for that wire rope size.
  - Use a torque wrench to torque the bolts to the required torque per ft.-lbs.

Note: The right hand chart of panel 16 lists recommendations for Fist Grip Clips. It is not recommended that U-bolt wire rope clips are used on wire rope for fall protection. Also note that Freeport-McMoRan requires that any fall protection system is only installed by a qualified person in accordance with FCX02.

DIAMETER / DIAMETER

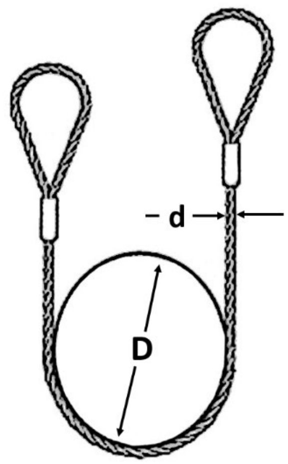


Figure 3.25: Diameter

"D" = diameter of the object

"d" = diameter of the wire rope

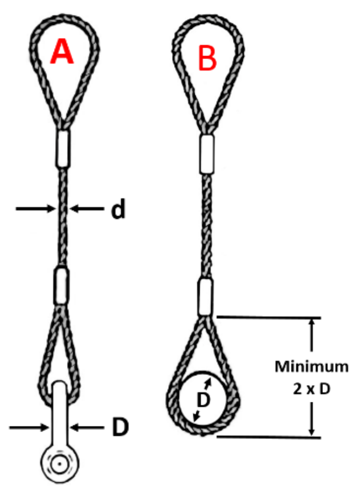
D:d = 25:1

Rope damage is also caused by placing wire rope around an object or a sheave that is too small. In figure 3.25, the large "D" represents the diameter of the object, and the small "d" represents the diameter of the wire rope.

The object diameter to rope diameter ratio should be 25 to 1, meaning that the object that you are choking should be 25 times larger than the diameter of the rope being used.

Never use a shackle smaller than the diameter of the rope as it places abnormal tension on the outside wires, shortening the life of the sling. Wire rope should always have a shackle with a diameter larger than the wire rope, and it should never be placed over anything that is more than half of the length of the eye.

If the shackle or object has only 2 times the diameter of a 6-strand wire rope sling (D/d 2:1) the basket sling capacity must be reduced by 40%. It is better to use a larger shackle or a Wide Body shackle type. If the shackle or object has at least 5 times the sling diameter (D/d 5:1) the basket sling capacity must still be reduced by about 25%.



The big D, little d also applies to the eyes of wire rope slings, however, is a 1:1 ratio instead of a 25:1 for a basket or choker hitch, (see Figure 3.26).

A. If the shackle body has AT LEAST the same diameter as the sling when attached to the eye (D/d 1:1) the capacity need not to be adjusted.

B. Eye length must NOT be smaller than twice the object diameter whether it is a shackle, pad eye or hook.

The real danger for wire rope sling eyes is that putting an object in that is too large, will put tension on the fitting and try to pull it apart.

Figure 3.26: Diameter

A. 'D' = Diameter of the shackle
'd' = Diameter of the wire rope
D:d = 1:1

B. 'D' = Diameter of the object
Eye length = 2:1

WIRE ROPE SLING STORAGE

Never store slings on the ground! In addition to being a tripping hazard, there is a high risk of mechanical damage such as kinking, crushing and strand displacement. Dirt and dust on the ground will also affect the lubrication of wire rope slings.

Slings should be stored in a cool dry place away from environmental damage such as corrosion, moisture, extreme temperatures and electrical sources.

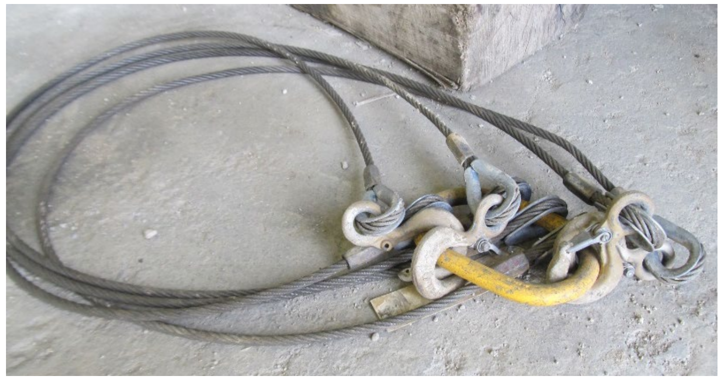


Figure 3.27: Poor Wire Rope Sling Storage

Figure 3.28: Good Wire Rope Sling Storage

Slings should be hung, ideally on a storage rack sorted by size, purpose etc. This keeps slings away from potential damage, but also makes selection quicker and easier. Proper storage can also increase the life of slings and help avoid rigging failure.

Figure 3.28 shows the correct storage of wire rope slings: Off the ground, away from hazards and not causing a hazard itself. This is not an expensive manufactured rack, but it clearly serves the purpose of keeping the slings away from potential damage, and also separating slings into different lengths / sizes for ease of selection.

MODULE 3 QUIZ

Complete the following quiz questions:

4. "Never Saddle a Dead Horse," refers to properly applying a wire rope clip when forming an eye at the end of a wire rope sling:

    a) The clip is applied to the live end, and the bolt to the dead (cut) end of the wire rope.

    b) The bolt is applied to the live end, and the clip to the dead (cut) end of the wire rope.

5. Damage is caused to wire rope by placing the rope around an object or sheave that is too small. What is the correct ratio of the diameter of an object to the diameter of the wire rope sling?

    a) 2:1

    b) 5:1

    c) 25:1

SYNTHETIC SLINGS

Synthetic slings are strong, convenient and economical, and are generally made from nylon or polyester type yarns.

There are two types of synthetic slings used at Freeport-McMoRan: Web Slings and Round Slings.

SYNTHETIC FLAT NYLON OR WEB SLINGS

As per their name, Synthetic Flat Nylon Slings are flat, and made from nylon or polyester yarns, i.e. synthetic fibers. They are also known as Web Slings.

Web slings tend to have an eye at either end:

WEB SLING EYES

There are several types of web sling eyes, each with a different design and / or hardware for use in specific applications.

Figure 3.29: Triangle and Choker has hardware on each end - the most effective choker hitch.

Figure 3.30: Triangle and Triangle has hardware on each end for use in a basket or vertical hitch.

Figure 3.31: Flat Eye and Eye is a versatile sling used in vertical, choker and basket hitches.

Figure 3.32: Twisted Eye and Eye has eyes turned at a right angle to sling body, forming a superior choker hitch, allowing a better fit on a hook in a basket hitch.

Figure 3.33: Flat endless slings are economical and adaptable with no fixed wear points, and can be used in all hitches.

Figure 3.34: Reversed Eye is extremely strong and durable for continuous and / or abusive applications, and has wear pads on both sides of body.

WEB SLING IDENTIFICATION [22]

All web slings must have a capacity tag which is marked with:

- name or trademark of the manufacturer
- manufacturer's code or stock number
- rated load for the types of hitches and angles
- type of synthetic web material

Figure 3.35: Damaged illegible capacity tag

All slings shall be inspected prior to every use for these three pieces of information.

If these are not present or legible - do not use the sling!

WEB SLING INSPECTION [23]

Every sling used for lifting must be inspected before, during, and after use.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

Synthetic Web Slings shall be inspected and removed from service if conditions such as the following are present:

PUNCTURED, SNAGGED AND CUT SLINGS

Figure 3.36: Snagged Sling

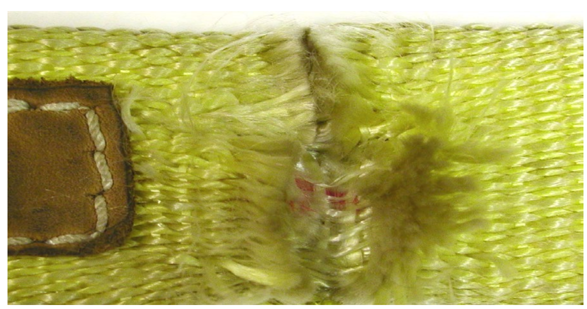


Figure 3.37: Cut Sling

Punctured, snagged or cut slings are the most common type of damage. Usually this is caused by dragging slings across abrasive surfaces. You should also never set loads down on top of slings, or pull slings out from under loads. You should always protect slings when they are wrapped around sharp corners or protrusions.

EXPOSED COLORED YARNS

Sometimes when slings are damaged, we can see exposed colored yarns. This is a warning built into the sling.

Note: Not all manufactures provide colored marker threads to indicate removal is necessary!

Regular and detailed inspection is the only way to check that slings are good for use.

Figure 3.38: Exposed Red Yarns

BROKEN STITCHES

Broken stitches usually occur when stitching is put against sharp corners, or bent while in a tight choker. Always protect this part of the sling, and do not place stitch patterns (laps) on hooks, around sharp corners, or at choker bearing points.

Figure 3.39: Broken Stitches

KNOTS

Do not be tempted to lengthen or shorten synthetic flat slings by tying knots!

Figure 3.40: Knots in Sling

CHEMICALS

The strength of synthetic slings can also be affected by chemically active environments. Slings may be susceptible to damage from caustic or acid substances, vapors, or fumes. When slings are required to be used in these conditions the manufacturer should be consulted.

HEAT DAMAGE

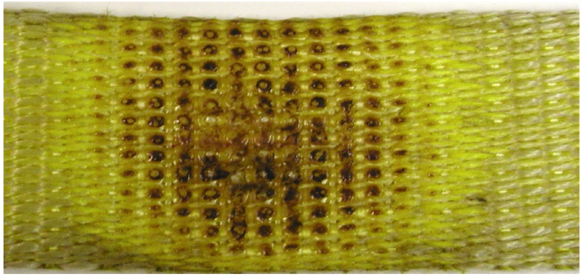


Figure 3.41: Heat Damage

Web Slings should never be in contact with an object or temperatures above 194°F or -45° F.

Heat damage can also be caused by friction: If the load is not properly centered in a choker or basket hitch, the sling can slide while being lifted trying to adjust. This friction will cause the sling to heat up and possibly fail.

WELD SPLATTER

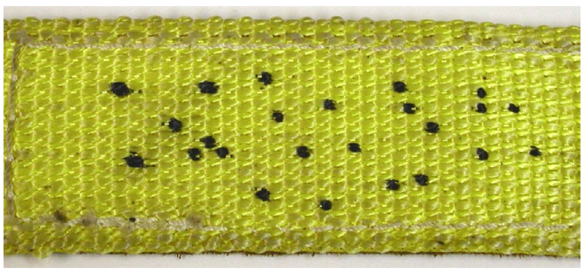


Figure 3.42: Weld Splatter

Weld splatter is also lethal to synthetic slings. Never weld anything hung from a sling, and keep synthetic slings away from areas where hot work is taking place. Regardless of potential splatter slings can sustain UV damage from welding too.

UV DAMAGE

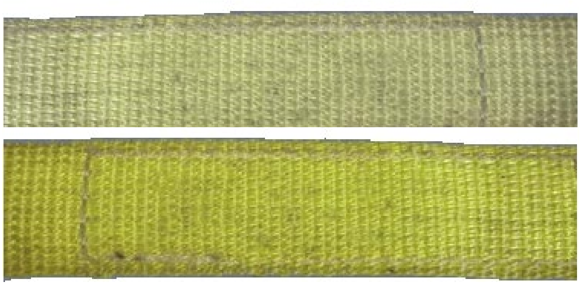


Figure 3.43: UV Damage Discoloration

Nylon and polyester slings are susceptible to damage from ultra-violet light.

Store slings in a dark, cool, dry location - always keep them out of the sun when not in use.

Never throw slings in the back of a truck!

Discoloration is an indicator of UV damage or caustic chemical exposure. When slings start to look bleached it is time to replace them.

CHAFFING

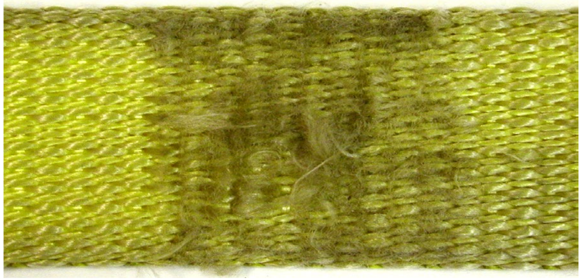


Figure 3.44: UV Damage Discoloration

Chaffing, excessive abrasive wear, and strands that have been stretched or smashed, are an indication of overloading or improper storage.

All synthetic slings, over time, will eventually start to chaff. Often this will be in the bite of the sling, if it is used in a tight basket.

Inspect chaffed slings often, by bending them in worn areas to see if there is internal damage. If the sling bends easier in one location than the rest, then it is damaged and should be discarded.

EYE FAILURE

Figure 3.45: Eye Failure

Figure 3.46: Chaffed Lifting Eye

The eye failure in Figure 3.45 is probably due to the sling being placed over a sharp corner, or being forced over a hook or pick point that was too wide. Slings that have twisted eyes will fit into hooks and shackles without bunching up and failing. Sling eyes should also be inspected for chaffing and wear.

SAFE RIGGING PRACTICES

Always use the correct shackle for the sling. Synthetic Sling Shackles are specifically designed for Web Slings. The web sling lays flat in the shackle without bunching.

Note: Synthetic Sling Shackles are not always available. When using an anchor shackle make sure that the sling is not bunched or folded in the bow of the shackle.

Always select the correct sized Synthetic Sling Shackles as too small a shackle will result in bunching too.

Web Slings are often used for towing – **slings used for towing must NEVER then be used for rigging!** If a sling has been used for towing or pulling it should be marked with some sort of identifier so that it can never be used for lifting.

SYNTHETIC ROUND SLINGS

Also made from synthetic materials, a Synthetic Round Sling is a continuous loop of yarn, encased in a tough synthetic round woven sleeve.

SYNTHETIC ROUND SLING IDENTIFICATION [24]

All synthetic round slings must have a capacity tag, which is marked with:

- name or trademark of the manufacturer
- manufacturer's code or stock number
- rated load for the types of hitches and angles
- core material
- cover material

All slings shall be inspected prior to every use for these pieces of information.

If these are not present or legible - do not use the sling!

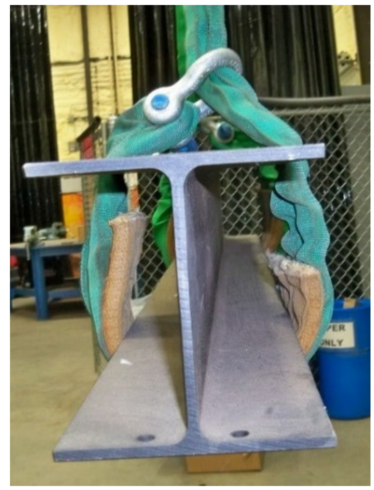


Figure 3.47: Synthetic round sling

SYNTHETIC ROUND SLING INSPECTION [25]

Every sling used for lifting must be inspected before, during, and after use.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

Synthetic round slings shall be inspected as per web slings (shown on pages 68 to 71), however, slings shall also be removed from service if conditions such as the following are present:

- Holes, tears, cuts, abrasive wear, or snags, that expose the core yarns
- Broken or damaged core yarns
- Welding splatter that exposes core yarns
- Knots in the round sling body, except for the core yarn knots inside the cover

SYNTHETIC ROUND SLING STORAGE

Figure 3.48: Synthetic round slings can be hung

Never store slings on the ground! In addition to being a tripping hazard, there is also risk of damage.

Slings should be stored away from high temperatures, and out of direct sunlight, UV light, and even fluorescent lighting. Keep away from atmospheric or direct contact with chemicals.

Synthetic round slings can be hung, ideally on a storage rack sorted by size, purpose etc., like other types of slings. Web slings can also be rolled for storage. Large web slings are typically rolled and stored on pallets.

Figure 3.49: Web slings can be rolled for storage

MODULE 3 QUIZ

Complete the following quiz questions:

6. How often must Web Slings be inspected?
    a) Once a month
    b) Once a week
    c) Once a day
    d) Before each use
    e) Before, during and after each use

7. What type of eyes does this sling have?
    a) Flat eye and eye
    b) Twisted eye and eye
    c) Reversed eye and eye

MODULE 4: Hitches

MODULE 4: HITCHES

MODULE 4 LEARNING OBJECTIVES

Upon completion of this Module, students will be able to:

- Identify the different types of hitches and their uses.
- Recall hitch capacity reductions and apply safe rigging practices.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

TYPES OF HITCHES

A rigging hitch is simply the method by which a sling is attached to a load.

You have selected the correct hardware and sling for your lift. Now as part of your rigging plan, you must select the correct hitch for the job.

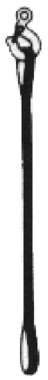


Figure 4.1: Vertical Hitch

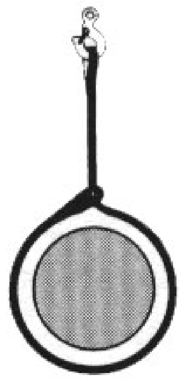


Figure 4.2: Choker Hitch

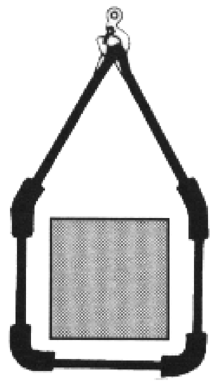


Figure 4.3: Basket Hitch

Figure 4.4: Bridle Hitch

There are four main types of hitches:

VERTICAL HITCH: Also known as a single leg hitch, this is the most basic of hitches, where one eye is attached to the load and the other to the hook, on a vertical (90°) sling angle.

CHOKER HITCH: Where the sling passes around the load and through one eye, and therefore has less than 360° contact with the load. This also creates an 'angle of choke' resulting in a choker hitch having only 70 – 80% of the capacity of the vertical hitch.

BASKET HITCHES: The sling passes around the load, but both legs are attached to a hook (or hooks), allowing twice the capacity of a vertical hitch, however, the load must be balanced. (When using a choke or basket hitch, a double wrap method can be used to help prevent slippage.)

BRIDLE HITCHES: Where two or more legs are attached to one master link. This provides good stability and weight distribution, as the lifting hook is directly over the load's center of gravity. Note: When three or four sling legs are used, two legs will be carrying the weight of the load while the other legs act to balance it.

SINGLE LEG (VERTICAL) HITCH

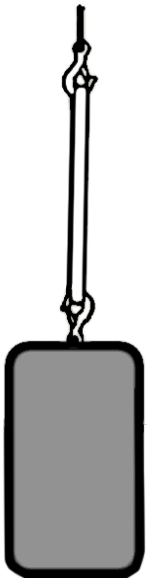


Figure 4.5: Vertical Hitch

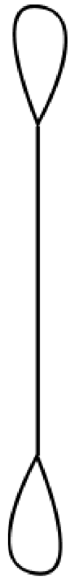


Figure 4.6: Vertical Hitch

The Single Leg Vertical Hitch supports the total weight of the load on a single leg, and the sling angle is 90°.

The single leg vertical hitch should not be used for lifting loose or lengthy loads, such as pipes or rods, or loose bundles of materials, as it provides very little control over the load. It also offers poor control of the swing and spin of the load.

Single leg vertical hitches by themselves should only be used on loads where the bulk of the weight is concentrated directly below the hook, and the load is equipped with a rated eye bolt, shackle or attachment point.

Multiple single leg vertical hitches can be used in tandem, on a spreader bar or lifting beam, (see page 39).

CHOKER HITCH

Figure 4.7: Choker Hitch

A choker hitch has minimal grip because it has less than 360° contact with the load. (A double choker however, has excellent grip because it has full contact with the load. See page 82.)

When a sling is being used in a choker hitch there is a reduction in its rated capacity, usually to around 75% of a vertical hitch, due to the 'angle of choke'.

If a load is hanging free, the normal choke angle is approximately 135°. This is a "true" choker hitch - approximately 75% of the capacity of the vertical hitch, e.g., if the capacity of a sling in a vertical hitch is 12,000 lbs., then the capacity in a true choker hitch would be around 9,000 lbs. The key word here is "true."

Choker hitches offer excellent control of the load, with little swing or spin.

SAFE RIGGING PRACTICES

The following are examples of best practice and practices to avoid when using choker hitches:

Beating Down the Eye

If the eye of the sling is beat down on the load, the capacity is further reduced. Beating the eye down means that the sling eye has been forced down the other side of the sling and onto the load. This reduces the capacity of the sling as it further reduces the sling angle.

Shackles

Always use a shackle when choking, and always connect the pin to the choking eye of the sling, as shown in Figure 4.8. Connecting the pin to the choking eye of the sling will avoid spinning the pin as the load tightens, which would tighten or loosen it.

Figure 4.8: Choking with a shackle

Reverse Choke

Always reverse choke multiple hitches: One sling shall be choked in one direction around the load, and the other sling is choked in the opposite direction, as shown in Figure 4.9.

This keeps the load even and symmetrical stopping it from twisting or rolling over.

Figure 4.9: Reverse Choking

If you are in any doubt as to the effectiveness or safety of the hitch, stop work, and seek advice from a qualified individual.

ANGLE OF CHOKE

When a choker hitch is used at an angle of less than 120°, you must reduce the hitch's rated capacity, as shown in the table below (Figure 4.11).

Manufacturers recommend a choker hitch is never used in an angle less than 30°, however, an angle of 120° or more is ideal. Although we can calculate low angles of choke, we should always avoid using them!

Some hitches used with specific hardware can avoid a reduction in capacity, for example when using cradle grab hooks with chain slings, the reduction in capacity is 0.

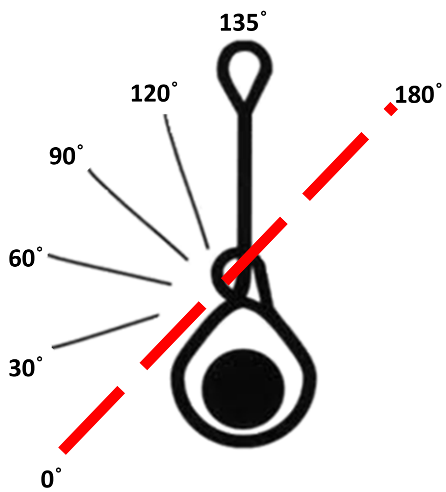


Figure 4.10:
Angle of Choke

Angle of Choke	Reduction in Capacity
120° - 180°	100%
90 - 119°	87%
60 - 89°	74%
30 - 59°	62%
0 - 29°	49%

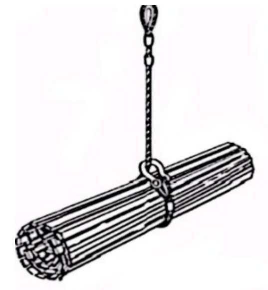
Figure 4.11:
Angle of Choke Capacity Reduction Table

TYPES OF CHOKER

There are four main variations of chokers that are commonly used:

Single Wrap Chokers

The Single Wrap Choker hitch forms a noose around the load. It does not provide full 360° contact with the load, and therefore should be avoided when lifting difficult to balance or loosely bundled loads. It also offers poor control of the swing and spin of the load.



The single wrap choker can be doubled up to provide twice the capacity, however doubling a single choker hitch is not the same as using a double choker hitch.

Figure 4.12: Single Wrap Choker

Double Wrap Chokers

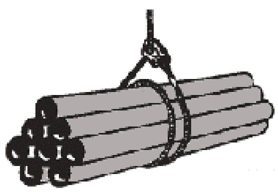


Figure 4.13: Double Wrap Choker

A double wrap choker is completely wrapped around the load. This hitch is therefore in full 360° contact with the load, drawing it tightly together which is particularly good for loose bundles. However, it offers poor control of the swing and spin of the load.

It can be used either singly on short easily balanced loads, or in pairs on longer loads. If two slings are used, the second sling should be reverse choked.

Double Choker Eyes Up

A double choker eyes up, is made by putting the eyes through the bite of the sling and hanging them on the hook. However, if you are going to double up the slings into a double choker it is better not to have the eyes up, since the sling won't be able to adjust itself, resulting in one of the legs having more tension than the other, thus reducing its capacity.

It offers poor control of the swing and spin of the load.

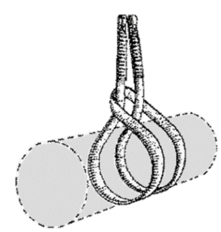
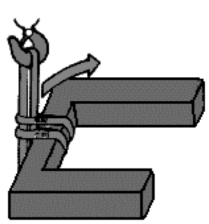


Figure 4.14: Double Wrap Choker Eyes Up

Double Choker Bite Up



The double choker, bite up, is a better choice than eyes up, and can be used to turn loads. However, the Double Choker Bite Up offers poor control of the swing and spin of the load.

Figure 4.15: Double Wrap Choker Bite Up

BASKET HITCH

Here are four commonly used variations of basket hitches:

TRUE BASKET HITCH

A basket hitch has a cradle configuration which allows the two extending ends (legs) of the sling to function as if they were two separate slings. Therefore the capacity of the sling is twice that of the same sling in a vertical hitch, but only if the sling angle of each leg is 90°. Lifting with both legs at 90° would normally require two lifting devices or a spreader bar, (see page 39).

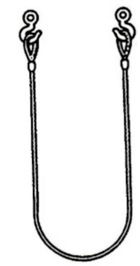
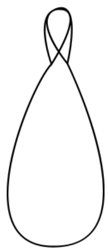


Figure 4.16: True Basket Hitch

REDUCED BASKET HITCH



A reduced basket is where both eyes are attached to the hook. The capacity is reduced depending on the angle of the two legs. Like the vertical hitch the basket hitch is excellent for loads that have a pick point directly above the center of gravity, which means that the hook is then directly centered above center of gravity.

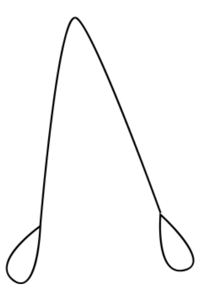
Figure 4.17: Reduced Basket Hitch

DOUBLE WRAP BASKET HITCH

The double-wrap basket is wrapped completely around the load, compressing it rather than just supporting it. Double wrap basket hitches can be used in pairs, which is particularly useful for loose loads, long loads, and/or smooth cylindrical loads such as pipe or rods. Because the sling is in full 360° contact with the load and tends to draw it together.

Figure 4.18: Double Wrap Basket Hitch

INVERTED BASKET HITCH



An inverted basket hitches main advantage is that it adjusts on the hook so you get equal leg loading. However, this hitch has several disadvantages: It adjusts on the hook and so provides poor load control. It complicates the D:d ratio (page 64). It affects the shackle. It can crimp and bend the rope.

The use of an Inverted Basket hitch should therefore be avoided.

Figure 4.19: Inverted Basket Hitch

BRIDLE HITCH

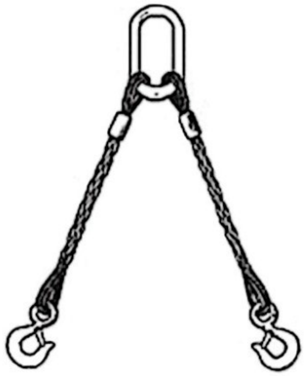


Figure 4.20:
Two Leg Bridle Hitch

Hitches can be used together to form a two, three or four leg bridle for hoisting loads that are equipped with the rated attachment points. The legs are then attached in a fitting, to a lifting hook or gather.

In multiple leg slings, where three or four legs are used, two legs will carry the weight of the load while the other legs balance it. A bridle hitch proves better load control NOT increased capacity!

Bridle hitches provide excellent load stability when the load is distributed equally among the legs: The hook is positioned directly over the load's center of gravity; and the load is raised level, however, to distribute the load equally it may be necessary to adjust the leg lengths.

Proper use of a bridle hitch requires that the increased tension caused by sling angles be carefully measured to ensure that the sling is not overloaded.

Bridle hitches can have complex load angles and an offset center of gravity. Also, remember that three and four legged bridles require calculating the lift capacity on two legs.

Figure 4.21:
Four Leg Bridle Hitch

MODULE 4 QUIZ

Complete the following quiz questions:

1. Choker hitches have approximately _____ % capacity compared to the single leg (vertical) hitch.

   a) 50
   b) 75
   c) 100

2. Which type of hitch has 360° contact with the load?

   a) Single Wrap Choker
   b) Double Wrap Choker
   c) True Basket
   d) All of the above

3. Which type of basket hitch requires a 90° angle?

   a) True Basket
   b) Reduced Basket
   c) Double Wrap Basket
   d) Inverted basket

MODULE 5:

Hoists & Lifters

MODULE 5: HOISTS & LIFTERS

MODULE 5 LEARNING OBJECTIVES

Upon completion of this Module, students will be able to:

- Identify the different types of hoists and lifters and their uses.
- Conduct hoist inspections, recognize defects, and understand maintenance requirements.
- Recall hoist regulations and apply safe rigging practices.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

MANUALLY OPERATED HOISTS

Lever Hoists / Come Alongs / Chain Fall, Chain Hoists and I Beams are miscellaneous lifting devices used by riggers.

LEVER HOISTS / COME ALONGS

Lever Operated Hoists are a portable way to lift loads. They can also be used to pull loads short distances, (which is why they are also often referred to as come alongs.) They can be used at any angle in place of a sling, or in addition to a sling to increase its length.

A hoist that requires the use of a cheater, or the help of another worker to move a load, is inadequate for the job - a hoist with the correct capacity should be used!

Figure 5.1: Lever Operated Hoist or Come Along

CHAIN HOISTS

Chain hoists are useful as they travel slowly, and can be stopped and kept stationary at any point, allowing precise vertical placement of loads.

- Chain hoists should always be rigged so that there is a straight line between the upper and lower hooks.
- They are intended for use in a vertical or near vertical position only. If rigged at an angle, the upper hook can be damaged at the shank and the throat may open up.
- If the gear housing is resting against an object while under load it can be damaged or broken. Always make sure that the hoist is hanging freely.

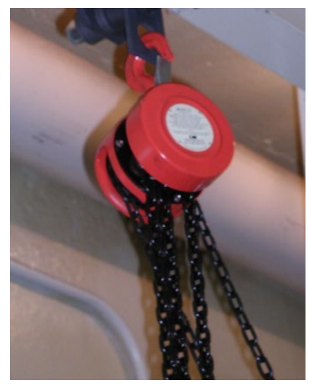


Figure 5.2: Chain Hoists

I BEAMS

Beam clamps provide a very secure anchorage point if used correctly. They should be centered on the beam flange and properly seated. Beam clamps are available with capacities up to 12 tons, with various jaw widths, and are designed for use at 90° to the flange. For applications requiring angled loading, make sure that the clamp is designed for it and the beam can withstand it. Be careful that the load does not deform the flange, particularly in light sections where the flange is wide and thin.

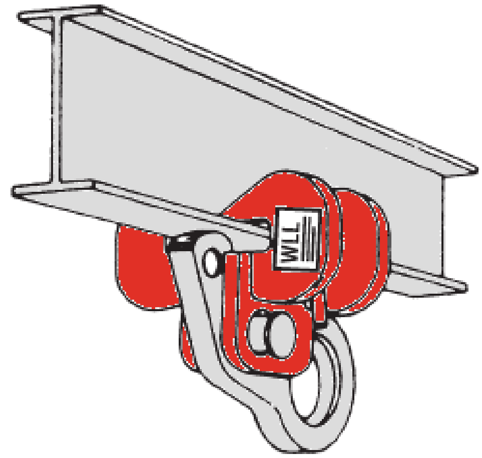


Figure 5.3: I Beam

Manufacturers are required to mark beam clamps with working load limits but the ratings apply only to the clamps - the capacity of the beam must be evaluated separately.

Chain hoists, come-alongs, and other rigging devices all require secure anchorage points. Anchor points could be overhead, in the floor, or in walls or other structures. The rigging could involve a variety of devices, such as beams, slings, or blocks. Whatever the method, the working load limit needs to be applied to the anchorage as well as the rigging devices.

Note: Never use an anchorage point which is intended for fall protection.

BEAM TROLLEYS

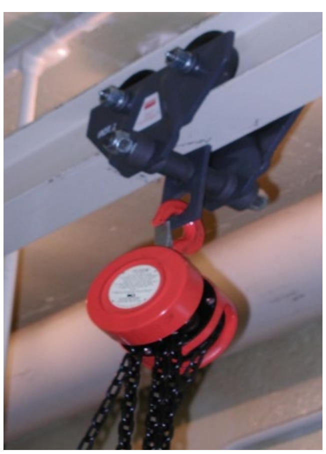


Figure 5.4: Beam Trolley

Trolleys are designed for both manual and electric operated hoists with a top hook suspension. Both the Push Trolley and Hand Geared Trolley are easily adjusted for a wide range of flange widths, and are available in many different capacities.

Hand-pushed overhead i-beam trolleys are suitable for carrying a wide range of equipment such as: Tools, Power Tools, Hoists, and Welding Apparatus

Determining the correct size of Overhead Beam Trolley will depend upon: The capacity you require, or the total load that the trolley will be carrying, and the type and size of beam the overhead trolley be riding on.

SAFE RIGGING PRACTICES

How should you use a hoist safely?

- Hoist from directly over the load - if not centered, the load may swing when lifted.
- Hang hoists solidly in the highest part of the hook area - the hook support is then directly in line with the hook shank.
- Only one person should pull on hand, chain and lever hoists.
- When loading the lower hook, place the load directly in line with the hook shank - the load chain then makes a straight line from hook shank to hook shank.
- Hoists can be used to pull in any direction, but a straight line pull must be maintained - Side pulling increases wear and dangerous stress levels on the hoist.

Note: Refer to Appendix 2, pages 157 and 158 at the back of the Student Guide, for a comprehensive list of 'Hoist Operators Do's & Don'ts.

STRAIGHT LINE PULL

Figure 5.5: Poor rigging practices

In Figure 5.5 we can see that the chain is wrapped around the handrail - not in a straight line pull. Also the hook is hooked onto the beam, and tip loaded.

Figure 5.6 shows the other end of the rigging with the chain wrapped around the conduit that energizes the fire protection alarm!

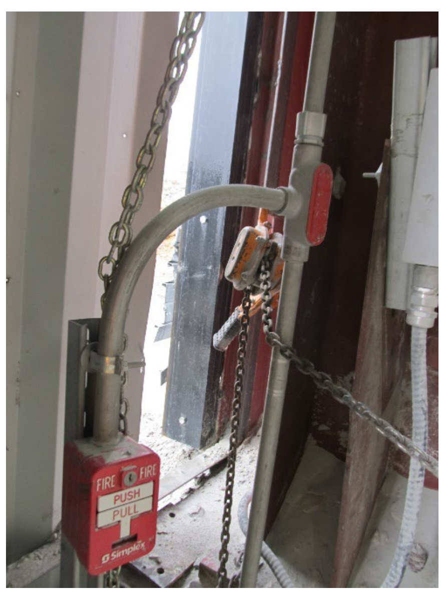


Figure 5.6: Poor rigging practices

HOIST MAINTENANCE

Hoists should be inspected and maintained in accordance with the manufacturer's manual and at the intervals stated in ASME B30.20. The frequency of inspections depends upon whether the hoist is used frequently or periodically, and it's exposure to wear, deterioration and malfunction.

Hoist inspection, maintenance, and repair depends upon the conditions, policies, and practices of the owner, which are determined by the size of the operation and number of employees, and the availability of trained and experienced in-house maintenance persons, and the type of hoist.

Hoists should be visually inspected prior to each use, and a complete inspection performed annually. Covers are removed for the thorough annual inspection, which includes all internal components. A detailed inspection report records the annual inspection.

Inspection, maintenance, and repair should be performed only by trained, experienced, and qualified personnel. The hoist operator cannot provide maintenance or repair, unless they are trained, qualified and designated by the hoist owner.

Note: Some sites have trained personnel, but not all. Record details of your site's specific procedure in the space below.

SITE SPECIFIC NOTES

HOIST IDENTIFICATION [26]

All below-the-hook lifting devices are marked with:

- The rated load - on the main structure and all detachable lifting parts
- The manufacturers name, the device weight, serial number, and rated capacity.
  - If the lifting device has been fabricated onsite, it should be marked with the contractor's name.
  - Mechanical lifting devices shall also be marked with the cold Current and Rated Voltage.
- Safety labels which provide warnings against; exceeding the rated load, operating a damaged hoist, making alterations to a hoist, lifting people, lifting over people, leaving suspended loads unattended, lifting loads too high, and removing said labels.
- Operating labels describing the function and result of each control.

Hoists should be inspected prior to every use for these pieces of information. If these are not present or legible - do not use the Hoist!

Repaired or altered hoists shall also be marked with the repairers name and address and unit identification number, and any of the following if altered; weight, current and voltage, rated load, design category and service class.

HOIST INSPECTION [27]

The operator or designated person shall visually inspect each lifting device at the beginning of each shift, or prior to use if the hoist has not been in regular service. Inspection of the following items or conditions is required:

Hoists should be inspected every working day for the following:

- Cracks, wear, damage and deformed structure
- Loose or missing guards, fasteners, covers, stops and nameplates
- All functional mechanisms and controls

Hoists should be inspected periodically for:

- Loose bolts or fasteners
- Cracked or worn gears, pulleys, sheaves, sprockets, bearings, chains and belts
- Wear or mechanical parts including chains
- Wear of hooking / load supporting points

If ANY malfunction or damage is noted during inspection, the hoist should not be operated, and the operator should contact their supervisor immediately so that malfunction / damage can be corrected. Defective items should be tagged and removed from service for repair by a competent person.

Operators should also be aware that damage / malfunction can occur during operation, even after a thorough inspection. If so, the operator should immediately stop working and contact their supervisor so that malfunction / damage can be corrected.

If there is any doubt as to the condition or serviceability of any piece of equipment, remove it from service until a further inspection can be conducted by a qualified individual.

PERIODIC INSPECTION [28]

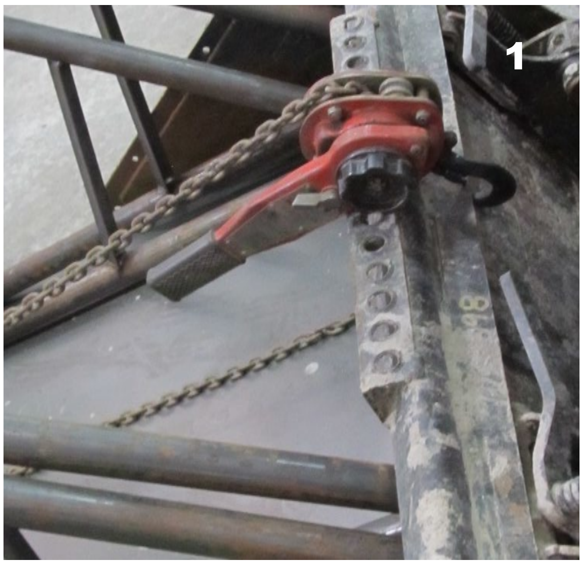
Periodic inspection of lifting devices, by a qualified inspector, is also required. If ANY malfunction or damage is noted during inspections, the deficiencies must be corrected before the device is used.

- Normal service (annually): Inspect equipment at site of use.
- Heavy service (semiannually): Inspect equipment at site of use unless external conditions indicate that disassembly should be done to permit detailed inspection.
- Severe service (quarterly): Inspect equipment at site of use unless external conditions indicate that disassembly should be done to permit detailed inspection.
- Special or infrequent service – as recommended by a qualified person before the first such use and as directed by the qualified person for any subsequent uses.

MODULE 5 QUIZ

Complete the following quiz questions:

What's wrong with the hoists in the photographs?



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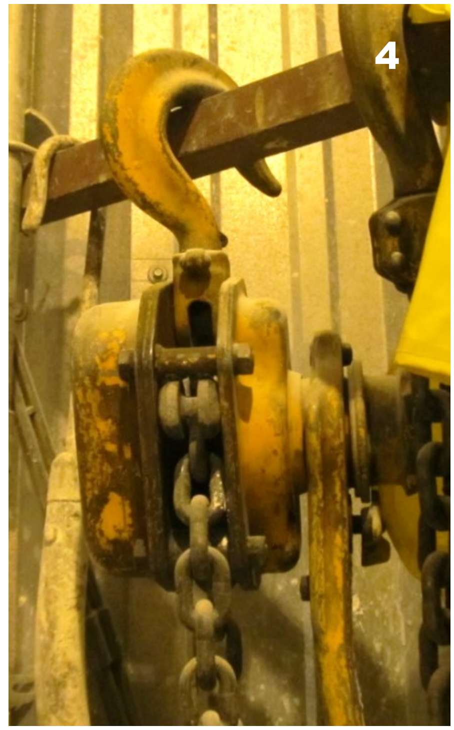

3.

4.

MODULE 6:

Signals

MODULE 6: SIGNALS

MODULE 6 LEARNING OBJECTIVES

Upon completion of this module, students will be able to:

- Understand the responsibilities of a signaler.
- Identify and recall the different crane hand signals.
- Recall signal regulations and apply safe rigging practices.
- Understand crane dynamics.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

SIGNALS [29]

If any part of a lift is not in view of the operator, a signal person must be present to direct the lift. Although the crane operator is physically operating the crane, the signal person is directing the lift, and therefore the crane. The signaler is therefore the most important part of a lift.

Only a person who is qualified can give signals. A signaler must be trained and evaluated through a written and practical test. As well as demonstrating knowledge of signals, the signaler must understand Crane Dynamics:

Crane Dynamics is the behavior of the crane, particularly in response to the actions of the operator. Any sudden movement, such as stopping the crane abruptly, can cause shock loading. Shock loading is when a sudden intense force is placed on a crane, and the crane cannot handle the pressure, which would not only damage the rigging, but cause structural damage to the crane itself.

Note: While only a person who is qualified can give signals, ALL persons working near cranes must understand how to stop a lift when they see a problem - by giving the Emergency Stop or Stop signal.

GENERAL REQUIREMENTS

A signal person must be provided in each of the following situations:

- If any part of the lift, travel of the load, or placement of the load is not in full view of the operator.
- When the load is traveling, if any part of the direction of travel is obstructed.
- If the rigger and / or operator deem it necessary.

Signaling must be consistent throughout the whole operation. If the operator is unable to receive signals at any point, he/she must stop the operation until communication is restored.

Only one person may give signals at any given time, except for the Stop or Emergency Stop Signals: Anyone who sees a safety problem must alert the operator or signal person by giving the stop or emergency stop signal.

If signalers are changing shifts, the one in charge should wear a clearly visible badge of authority. This could be a colored hard hat; highly visible gloves, or a unique vest.

Where loads are picked at one point and lowered at another, two signalers may be required – one to direct the lift and one to direct the descent. Where a signaler is in communication with more than one operator, a system must be used to identify the operator each signal is for.

TYPES OF SIGNALS

Signals to operators must be by hand, or voice, or audible, (radio, telephone or other electronic transmission). Site conditions will determine the type of signal chosen. The signal always remains the same, the method of signaling will depend upon the conditions.

HAND SIGNALS

Hand signals should only be used where there is clear visibility and the distance between the operator and the signaler is not great. When using hand signals, the Standard Method must be used:

MOBILE CRANE HAND SIGNALS

A hand signal chart must be posted either on the equipment or in the immediate vicinity of the hoisting operations. [30]

The poster on page 104 was produced by Hard Hat Training and illustrates the Standard Hand Signals used across sites, as approved by OSHA, MSHA, and ASME.

Swing: Extend your arm out horizontally to the side, and point your index finger in the direction the boom is to swing.

Crane Dynamics: When swinging, centrifugal force will affect the load and attempt to make it swing out from below the boom tip extending the load radius and decreasing capacity. Also, when stopping the swing, the load will want to continue to swing and will pass the point you want it to stop, therefore you should begin slowing the load before it gets to the point you actually want it to stop.

Stop: Extend your arm and hand out horizontally to the side, with your palm down, moving your arm back and forth horizontally.

Crane Dynamics: Stopping the load suddenly can shock load the crane, this should be avoided as shock loading may not only damage the rigging but can also cause structural damage to the crane itself.

Emergency Stop: Extend both arms and hands out horizontally to the side, with palms down, moving both arms back and forth horizontally.

Crane Dynamics: Stopping the load suddenly can shock load the crane, this should be avoided as shock loading may not only damage the rigging but can also cause structural damage to the crane itself.

Travel: Raise your arm out in front of you, holding your hand upwards with your palm flat, and make a pushing motion in the direction of travel.

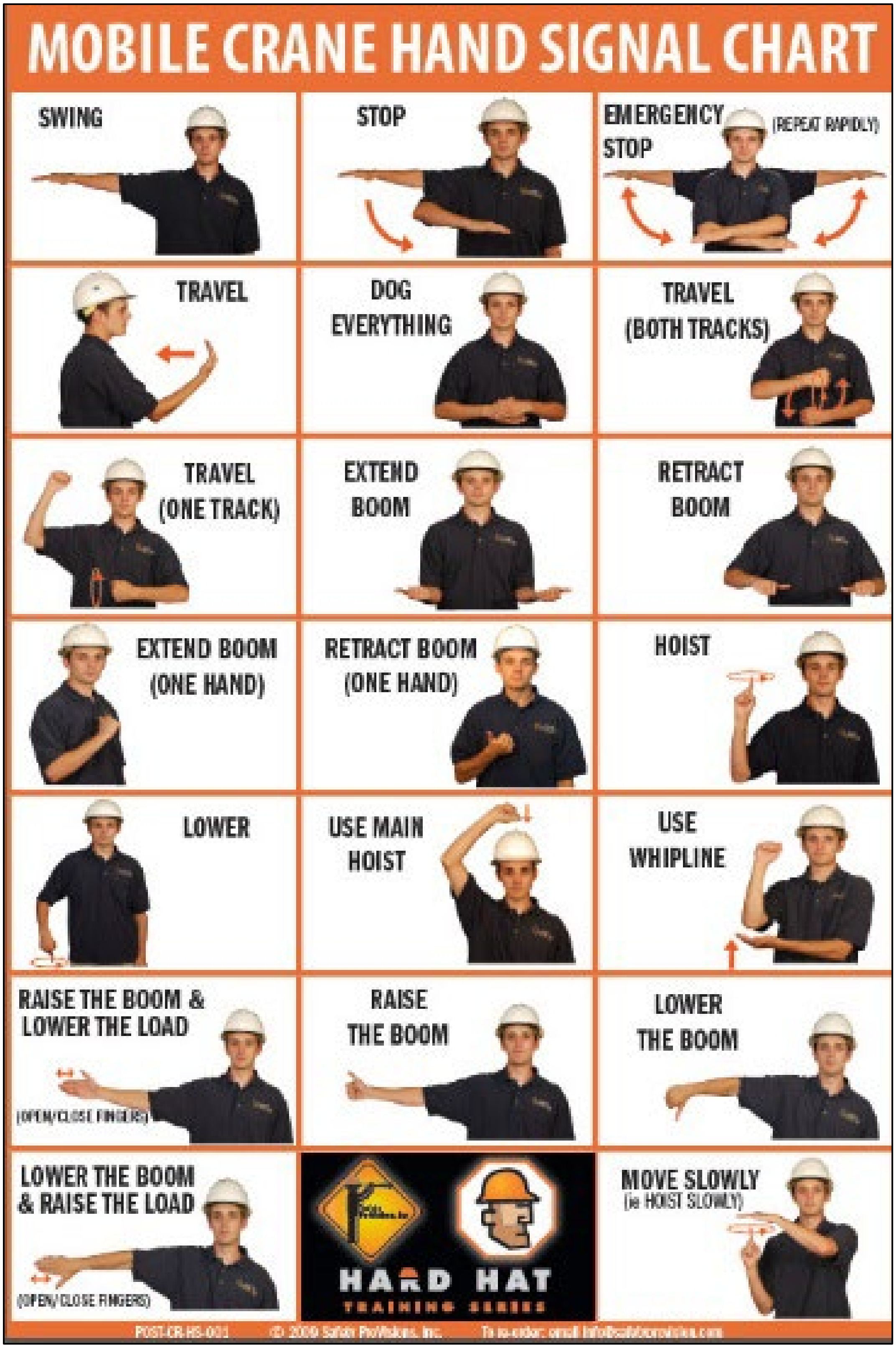
MOBILE CRANE HAND SIGNAL CHART
SWING
STOP
EMERGENCY STOP
(REPEAT RAPIDLY)
TRAVEL
DOG EVERYTHING
TRAVEL (BOTH TRACKS)
TRAVEL (ONE TRACK)
EXTEND BOOM
RETRACT BOOM
EXTEND BOOM (ONE HAND)
RETRACT BOOM (ONE HAND)
HOIST
LOWER
USE MAIN HOIST
USE WHIPLINE
RAISE THE BOOM & LOWER THE LOAD
(OPEN/CLOSE FINGERS)
RAISE THE BOOM
LOWER THE BOOM
LOWER THE BOOM & RAISE THE LOAD
(OPEN/CLOSE FINGERS)
HARD HAT
TRAINING SERIES
MOVE SLOWLY
(ie HOIST SLOWLY)
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Figure 6.1: Hard Hat Mobile Crane Hand Signal Chart

Dog Everything: Clasp your hands together in front of body at waist level.

Crane Dynamics: This signal is telling the operator to set all brakes.

Travel (Both Tracks): Make two fists in front of your body, moving them in a circular motion around each other, forwards or backwards to indicate the direction of travel. Rotating fists towards the body indicates moving forward. Rotating fists away from the body indicates travelling backwards.

Travel (One Track): Raise your forearm to indicate the track to be locked. Make a fist in front of your body to indicate the track to be moved, moving it in a circular motion forwards or backwards to indicate the direction of travel.

Extend Boom: With hands to the front at waist level, make fists with thumbs pointing outwards. Note: Always refer to the operator's manual.

Crane Dynamics: Extending the boom will increase the load radius, therefore decreasing the capacity of the crane as the load is moving away from the crane and up away from the ground.

Retract Boom: With hands to the front at waist level, make fists with thumbs pointing inwards. Note: Extending and retracting of hydraulic booms is prohibited due to boom deflect - always refer to the operator's manual.

Crane Dynamics: When retracting the boom, the load radius will decrease, increasing the capacity of the crane as the load is moving closer to the crane and downward toward the ground.

Extend Boom (one hand): When only one hand is available, make a fist in front of your chest with your thumb tapping the chest. Note: Always refer to the operator's manual.

Crane Dynamics: Extending the boom will increase the load radius, therefore decreasing the capacity of the crane and making it less stable as the load is moving away from the crane and up away from the ground.

Retract Boom (one hand): When only one hand is available, make a fist in front of your chest, with your thumb pointing outward and the heel of your fist tapping the chest. Note: Extending and retracting of hydraulic booms is prohibited due to boom deflect - always refer to the operator's manual.

Crane Dynamics: When retracting the boom, the load radius will decrease, increasing the capacity of the crane and making it more stable as the load is moving closer to the crane and downward toward the ground.

Hoist: With your arm out to the side, raise the forearm upward and point your index finger up making horizontal circles.

Crane Dynamics: When hoisting a load from the ground it is important to remember that the boom will deflect (bend) some before the load comes clear of the ground. To prevent this from swinging the load out from under the boom tip and increasing the load radius, the boom should be retracted as the hoist is raised to keep the boom tip directly above the load.

Lower: Extend your forearm downward and point your index finger down and making horizontal circles.

Crane Dynamics: This signal will lower the load/hoist. Care should be taken so the load is not lowered at a speed which would shock load the crane in the event of an emergency stop or a stop.

Use Main Hoist: Tap you fist on your head, then follow with the regular signals.

Use Whipline / Auxiliary Hoist: With your arm bent up at the elbow, tap your elbow with the other hand, then follow with the regular signals.

Raise the Boom & Lower the Load (or raise the boom & hold the load): Extend your arm out to the side, point thumb upwards, open and close fingers for as long as the movement is required.

Crane Dynamics: The effect this signal has on the crane and its capacity is to increase capacity and make the crane more stable as the load is moving closer to the crane and should be remaining at the same height as the load is lowered at the same time the boom is raised.

Raise the Boom: Extend your arm out horizontally to the side, close fingers and point thumb upwards.

Crane Dynamics: Raising the boom will bring the load closer to the crane increasing stability and capacity of the crane.

Lower the Boom: Extend your arm out horizontally to the side, close fingers and point thumb downwards.

Crane Dynamics: Lowering the boom will move the load further from the crane decreasing stability and capacity.

Lower the Boom & Raise the Load (or lower the boom & hold the load): Extend your arm out horizontally to the side, point thumb downwards, open and close fingers for as long as the movement is required.

Crane Dynamics: The effect this signal will have on the crane is to move the load away from the crane and should stay the same height. This will decrease the capacity of the crane and make it less stable.

Move Slowly / Hoist Slowly: A motionless hand is placed above of the hand which is giving the signal.

OVERHEAD CRANE HAND SIGNALS

A hand signal chart must be posted either on the equipment or in the immediate vicinity of the hoisting operations.

Trolley Travel: With your arm bent at the elbow, make a fist with the thumb pointing and the hand jerking in the direction of travel.

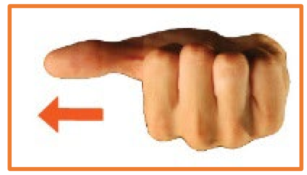


Figure 6.2: Trolley Travel Hand Signal

Bridge Travel: Raise your arm out in front of you, holding your hand upwards with your palm flat, and make a pushing motion in the direction of travel.

Figure 6.3: Bridge Travel Hand Signal

Multiple Trolleys: For overhead cranes that have multiple trolleys, the signal person needs to signal which trolley, then follow with the regular signal. Raise your forearm and hand and hold one finger up for trolley 1, or two fingers up for trolley 2.

Figure 6.4: Multiple Trolley Hand Signal

Figure 6.5: Magnet Disconnect Hand Signal

Magnet Disconnect: Extend both arms and hands out horizontally to the side, with palms up, to signal that the magnet is disconnected.

ELECTRONIC SIGNALS [31]

Radio, Telephone or Other Electronic Transmission of Signals Additional Requirements

Devices must be tested before beginning the operation to ensure the signal is effective, clear, and reliable.

The operator must be able to receive signals via a hand a hands-free system.

Transmission must be through a dedicated channel, except where a signaler is in communication with more than one operator e.g. where two cranes are being used, multiple operators can share a dedicated channel for coordination purposes.

VOICE SIGNALS [32]

Voice Signals – Additional Requirements

The operator and signaler must contact each other prior starting an operation, and agree on the voice signals that will be used. They must be able to effectively communicate in the language used. Each voice signal must contain the following three elements given in the following order:

- Function and Direction (such as hoist, boom, *etc*.).
- Distance and/or Speed.
- Function: Stop command.

MODULE 6 QUIZ

Complete the following quiz questions:

1. What does this hand signal mean?
   a) Extend Boom (1 hand)
   b) Extend Boom (2 hands)
   c) Emergency Stop
   d) Dog Everything

2. What is this hand signal mean?
   a) Raise the Boom
   b) Retract the Boom
   c) Lower the Boom
   d) Extend the Boom

3. How would you signal to the operator to use the Auxiliary Hoist?
   a) Tap your fist on your head.
   b) With your arm bent up, tap your elbow with the other hand.

4. Crane Dynamics: Any sudden movement, such as stopping a crane abruptly, can cause:
   a) Shock loading
   b) Structural damage to the crane
   c) Damage the rigging equipment
   d) Remove kinks and knots from slings

MODULE 7: Weights

MODULE 7: WEIGHTS

MODULE 7 LEARNING OBJECTIVES

Upon completion of this module, students will be able to:

- Calculate the area and volume of loads.
- Use weight tables to calculate the weight of loads.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

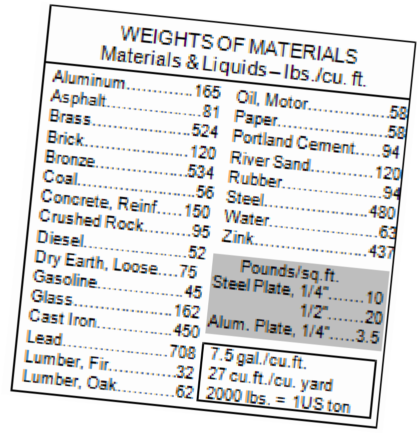
WEIGHT TABLES

Unit weight is measured by pounds per cubic feet, or pounds per square feet, based on the density of the material.

Weight tables, like the example Figure 7.1, list common materials and their unit weight. Many shops / tool rooms have lists or books containing weights of objects that might be handled often, e.g. Pulleys, Liners, Mantles, and Main Shafts.

It is a good idea to have similar "cheat sheets" for materials that you handle frequently. Having weight tables will save time when making calculations.

Different weight tables may have slightly different figures for the same materials. Always calculate load weight using the highest figure.



WEIGHTS OF MATERIALS
Materials & Liquids – lbs./cu. ft.

Aluminum	165	Oil, Motor	58
Asphalt	81	Paper	58
Brass	524	Portland Cement	94
Brick	120	River Sand	120
Bronze	534	Rubber	94
Coal	56	Steel	480
Concrete, Reinf.	150	Water	63
Crushed Rock	95	Zink	437
Diesel	52	Pounds/sq.ft.	
Dry Earth, Loose	75	Steel Plate, 1/4"	10
Gasoline	45	1/2"	20
Glass	162	Alum. Plate, 1/4"	3.5
Cast Iron	450		
Lead	708	7.5 gal./cu.ft.	
Lumber, Fir	32	27 cu.ft./cu. yard	
Lumber, Oak	62	2000 lbs. = 1US ton	

Figure 7.1: Weight Table example

CALCULATING WEIGHT

To calculate the weight of an object, you need to know its volume and unit weight.

Volume x Unit Weight = Load Weight

EXAMPLE

The Weight Table above, (Figure 7.1) lists steel weights per sq. foot. We can use this table to calculate the weight of steel plates and beams.

According to the table ½" thick steel plate weighs approximately 20 lbs. per sq. ft.

Therefore a 1" thick steel plate would weigh around 40 lbs. per sq. ft.

20 sq. ft. of 1" thick steel plate would weigh approximately 800 lbs.

Volume x Unit Weight = Load Weight

20 ft. x 40 lbs. = 800 lbs.

MODULE 7 QUIZ

Complete the following quiz question:

1. How much does ¼" thick steel plate weigh per sq. ft.? Refer to your Weight Tables.

   How much would 17 ft. sq. ft. of ¼" thick steel plate weigh?

CALCULATING VOLUME & LOAD WEIGHT

Load weight can be determined from manufacturers documents, approved calculations, scales (dynamometer), bill of lading, blueprints, the data base in the planners office, weight tables kept in some tool rooms, or it is sometimes written or stamped on the load, data plates or on the equipment. But when all else fails – do the calculations!

In order to find the weight of an object you must know its volume and unit weight:

Volume x Unit Weight = Load Weight

CALCULATING VOLUME

To calculate the volume of an object multiply its length by its width, by its height.

Length x Width x Height = Volume

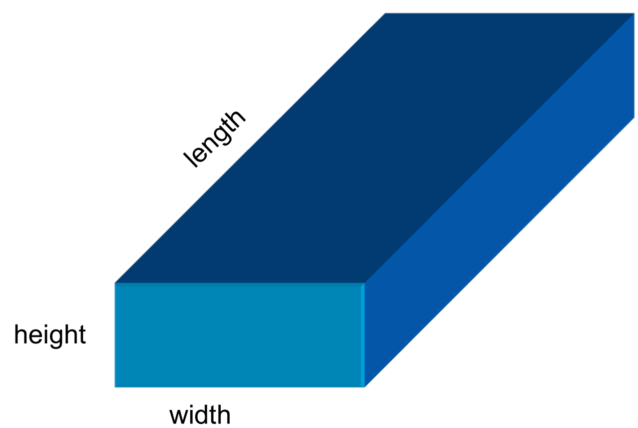


Figure 7.2: Calculating the volume of an object

EXAMPLE

A block of wood that is 8ft. long, by 4ft. wide, and 2ft. high has a volume of 64 cu. ft.

- Length x Width x Height = Volume

  8 x 4 x 2 = 64 cu. ft.

CALCULATING LOAD WEIGHT

To calculate the weight of a cube you multiply its volume by its unit weight.

Volume x Unit Weight = Load Weight

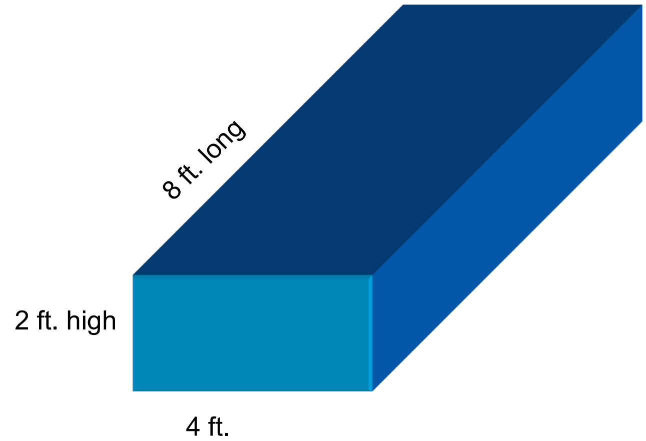


Figure 7.3: Calculating the weight of an object

EXAMPLE

A block of fir that is 8 ft. x 4 ft. x 2 ft. has a volume of 64 cu. ft.

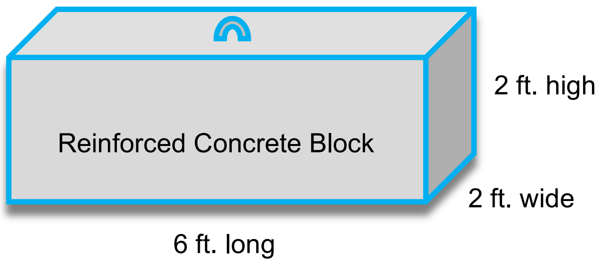
Fir weighs 32 lbs. per cu. ft.

- Volume x Unit Weight = Load Weight
  64 x 32 = 2,048 lbs.

MODULE 7 QUIZ

Complete the following quiz question:

2. You are lifting a reinforced concrete block, which is 2 ft. high x 2ft. wide x 6 ft. long.



What is the unit weight of reinforced concrete? Refer to your Weight Tables.

What is the volume of this block?

What is the weight of the block?

AREA OF A CIRCLE

Determining the area of a circle is not difficult, but it does require knowledge of terms such as Pi, Diameter, Radius, Circumference and Squared:

- Pi is the ratio of the circle's circumference to its diameter i.e. 3.14
- Diameter is the distance across the circle at its widest point
- Radius is the distance from the center of the circle to the outside (or half of the diameter)
- Circumference is the distance around the circle or Pi x diameter
- Squared is multiplying a number by itself

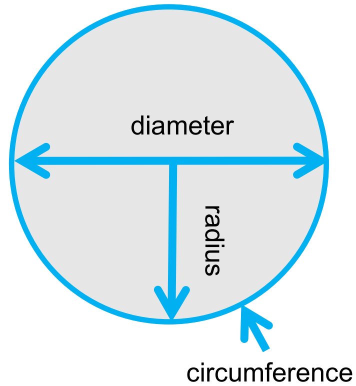


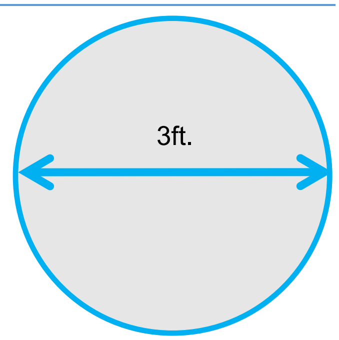
Figure 7.4: Calculating the area of a circle

The area of a circle is calculated by multiplying the radius squared x Pi

Pi (3.14) x Radius Squared = Area

EXAMPLE

If the diameter of the circle is 3ft.

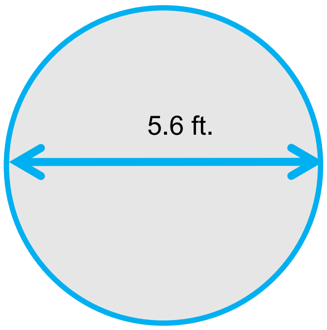


- The radius is half of the diameter: 1.5 ft.
- The Circumference is Pi x diameter: 3 ft. x 3.14 = 9.42 ft.
- Area is radius squared x Pi:
  - Radius squared is 1.5 x 1.5 = 2.25
  - 2.25 x 3.14 = 7.065 sq. ft.

MODULE 7 QUIZ

Complete the following quiz questions:

3. If the diameter of a circle is 5.6 ft.:



What is the radius of the circle?

What is its circumference of the circle?

What is its area of the circle?

WEIGHT OF A CYLINDER

Determining the weight of a cylinder is easy once you know how to find the area of a circle:

Pi x Radius Squared = Area

Then you multiply the area of the circle by the length of the cylinder:

Area x Length = Volume

Then to find the weight, multiply the volume by its unit weight:

Volume x Unit Weight = Load Weight

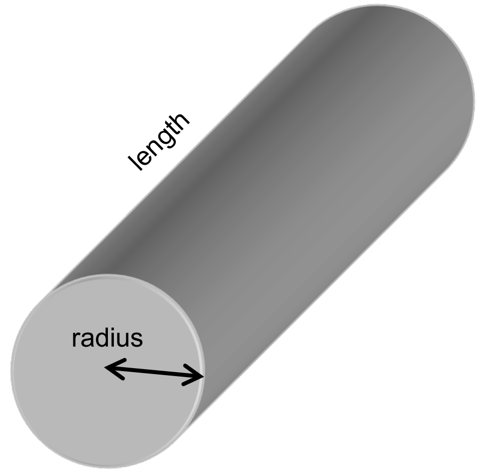


Figure 7.5: Calculating the weight of a cylinder

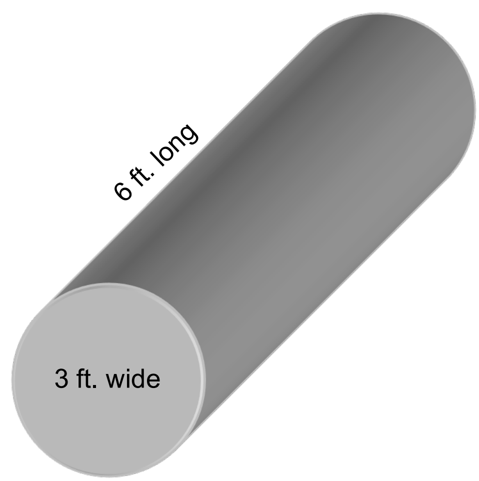
EXAMPLE

If a cylinder is 3ft. wide by 6ft. long and is made of reinforced concrete, what does it weigh?

- The area of the circle is the radius squared x Pi:
  - The radius is half the diameter = 1.5
  - Radius squared is 1.5 x 1.5 = 2.25
  - 2.25 x 3.14 = 7.065 sq. ft.
- The volume is the area x length:

  7.065 sq. ft. x 6 ft. long = 42.39 cu. ft.
- The unit weight of reinforced concrete is 150 lbs. per cu. ft.

  42.39 cu. Ft. x 150 lbs. = 6358.5 lbs.



MODULE 7 QUIZ

Complete the following quiz questions:

4. What is the volume of a 22 ft long x 7 ft wide cylinder?

   If the cylinder is made of aluminum, what is its estimated weight? Refer to the weight table on page 114.

FINDING LOAD WEIGHT OF A PIPE

To determine the volume of a pipe, we are only interested in the volume of the actual material of the pipe, and not the empty space inside it. Note: For rigging purposes, though not exact, "Volume of Pipe" and "Load Weight" are considered equal.

One way to do this is to determine the volume of the pipe as if it were a solid cylinder, then determine the volume of the hole, and subtract this from the volume of the pipe.

Volume of solid pipe - Volume of hole = Volume of the pipe

An easier way to determine the volume of a pipe is to imagine the pipe split down its length, and flattened it out into a rectangle. The circumference becomes its width.

Diameter x Pi = Circumference

Circumference = Width

Multiplying its width by its length gives you its area. Multiplying the area by the unit weight gives you the load weight.

Width x Length = Area

Area x Unit Weight = Load Weight

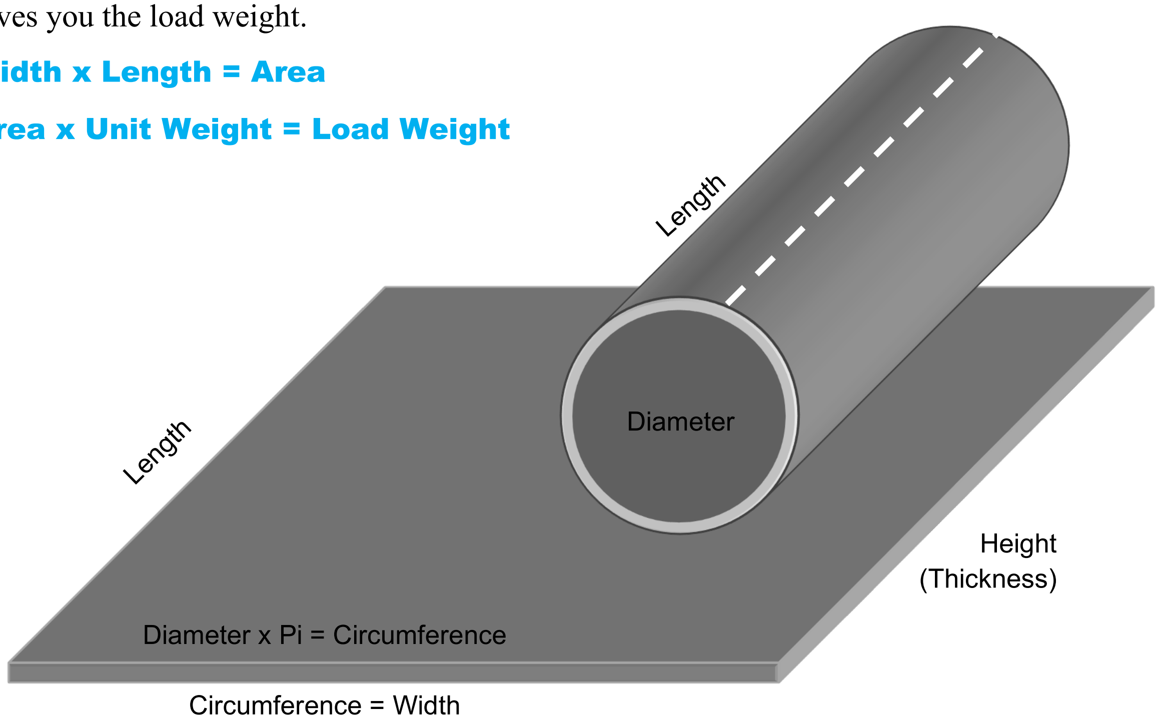


Figure 7.6: Calculating the load weight of a pipe - flatten

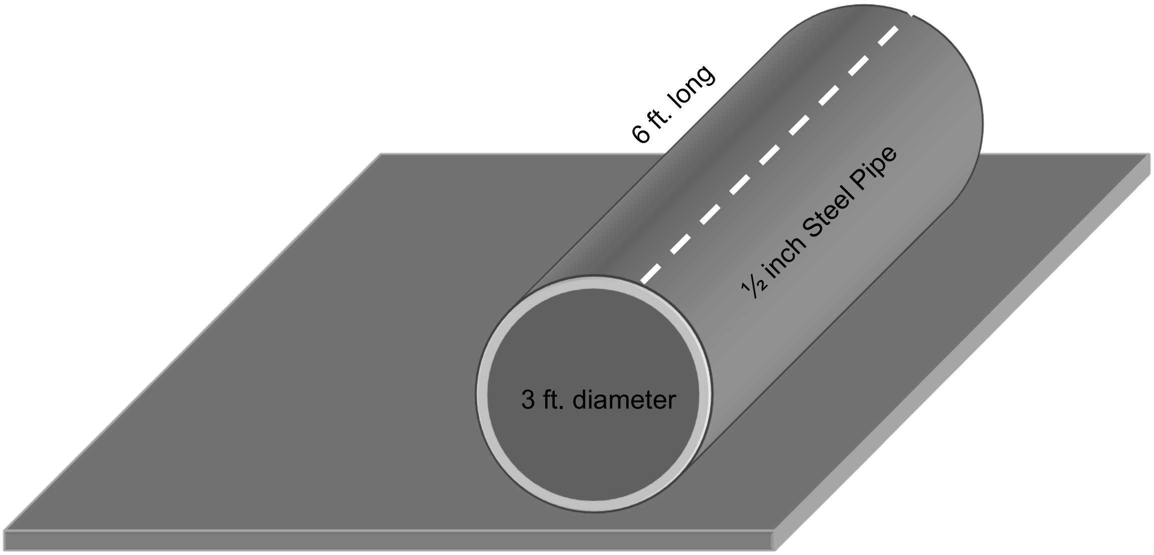
Note: Where the unit weight is not specified in plate thickness, e.g. ½" steel plate weighs 20 lbs. per sq, ft, you must calculate the volume, and multiplying its width, by its length, by its height (or thickness).

Width x Length x Height = Volume

Volume x Unit Weight = Load Weight

EXAMPLE

If a ½” steel pipe is 3ft. wide by 6ft. long, what is its load weight?



- Circumference = Pi x Diameter

    3.14 x 3 ft. = 9.42 ft.

- Area = Circumference x Length (Note: width = circumference)

    9.42 ft. x 6 ft. = 56.52 sq. ft.

- Load Weight = Area x Unit Weight

    According to the weight table its unit weight is 20 lbs. per sq. ft.

    56.52 sq. ft. x 20 lbs. = 1,130.4 lbs.

Note: This is not the actual weight of the pipe, but you will be within a few percentage points. It is much better than just guessing!

Knowing the weight now allows you to determine if the crane has enough capacity to make the pick, and allows you to choose the proper slings and rigging gear for the lift.

MODULE 7 QUIZ

Complete the following quiz question:

5. What is the weight of a 5.5 ft. wide, 18 ft. long, ¼" thick aluminum pipe?

MODULE 8:

COG & Load Angle Factors

MODULE 8: CENTER OF GRAVITY & LOAD ANGLE FACTORS

MODULE 8 LEARNING OBJECTIVES

Upon completion of this module, students will be able to:

- Understand the effect the Center of Gravity and sling angles have on loads.
- Calculate sling angle tension and load angle factors, and apply safe rigging practices.
- Calculate Center of Gravity and sling tension, and apply safe rigging practices.

Title page image: "Crane Hook" by Zozzzzo / iStock / Thinkstock by Getty Images

CENTER OF GRAVITY & LOAD ANGLE FACTORS

In addition to being able to calculate the weight of a load, and identify which sling(s) and hitch to use, riggers must understand the effect of the angle of the slings, and the effect an unbalanced load will have on the individual sling:

- The angle of the slings increases tension on the slings.
- A load with an offset center of gravity adds different tension.

SLING ANGLES & TENSION

When slings are used at an angle, the tension on the sling is increased, which decreases capacity. The tension depends on the angle of the sling; the lower the angle, the higher the tension, and the lower the capacity.

We should never rig loads without knowing the tension that is put on slings when lifting at angles. When a rigger chooses a sling he / she must take into account not only the weight of the load it will be lifting, but also the tension it will see when used at an angle.

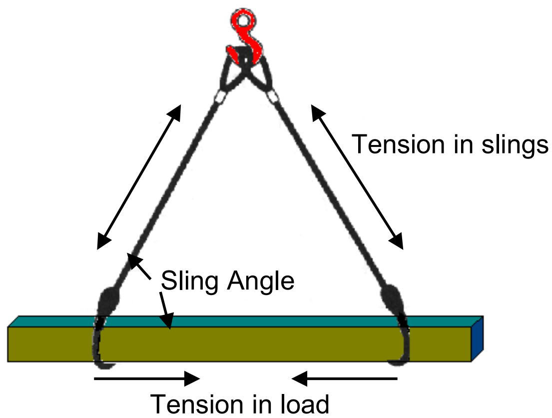
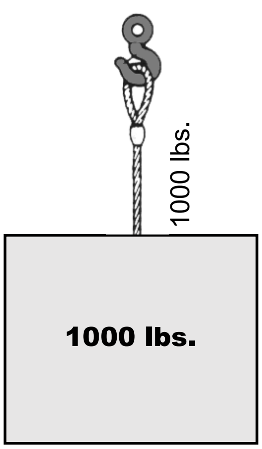


Figure 8.1: Sling angles and tension

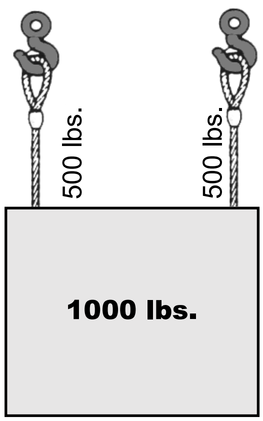
SINGLE – VERTICAL SLING TENSION



When a 1,000 lb. load is lifted with one sling in the vertical (90°), we know that there will be 1,000 lbs. of tension on that sling.

Figure 8.2: Single vertical sling tension

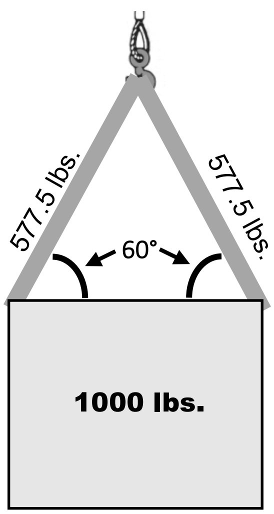
DOUBLE VERTICAL SLING TENSION



If we use two slings to lift a 1,000 lb. load, and both legs are vertical (90˚), then each sling will see exactly half of the load i.e. 500 lbs.

Figure 8.3: Double vertical sling tension

DOUBLE ANGLED SLING TENSION



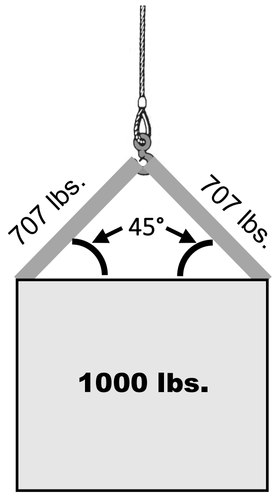
When two slings are used together on a hook, shackle or master ring, the load is shared equally, but the angle adds tension above the 500 lbs. of the vertical (90°) sling, therefore, the sling capacity is reduced.

As you increase tension you must increase sling capacity by selecting a sling which has equal or greater capacity than the load weight PLUS the tension. The amount of reduction will depend on the angle. In the example on the left (Figure 8.4) each sling picks up an additional 78 lbs. of tension at a 60˚ angle.

Figure 8.4: Double angled sling tension - 60°

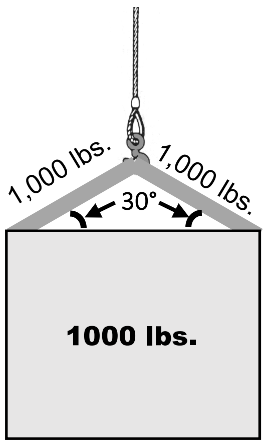
Note: The ideal angle is 60˚ as there is a minimum capacity reduction.

To determine whether you have sling legs at 60˚, lay one sling down between the pick points on the load. If it is equal to or extends longer than the distance between the pick points then you have an angle that is equal to or greater than 60˚.



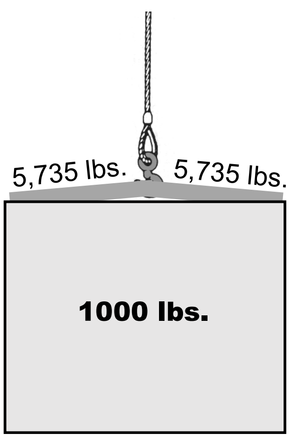
At a 45˚ angle the capacity is reduced even further; each sling will see an additional 207 lbs. of tension!

Figure 8.5: Double angled sling tension - 45°



At 30˚ each sling will see the equivalent of the whole load; an additional 1000 lbs. of tension on each sling!

Figure 8.6: Double angled sling tension - 30°



When the angle is decreased to 5˚ there is an astounding 5,735 lbs. of tension on each leg of the sling!

Two slings whose capacities are 1,000 lbs. in the vertical, (or even at an angle of 60°), would be plenty to pick up a 1,000 lb. load. There is a good chance these slings will fail if we use them at this angle!

Figure 8.7: Double angled sling tension - 5°

Note: The ideal lift does not use extreme sling angles. Slings should not be used at an angle below 30˚! If in doubt, stop work, and seek advice from someone who is more qualified.

CALCULATING SLING ANGLE TENSION

To calculate the amount of tension placed on the slings, you must determine the load angle factor, and then multiply that by ½ the load.

Load Angle Factor x ½ the Load = Tension in Sling

The load angle factor can be calculated, or for some simple angles, refer to the chart below:

Sling Angle	Load Angle Factor
90°	1.000
60°	1.155
45°	1.414
30°	2.000

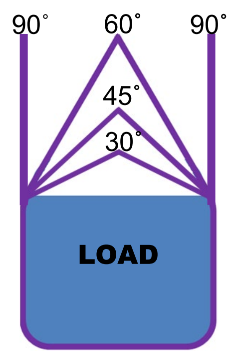
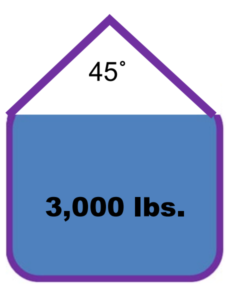


Figure 8.8: Load Angle Factor Chart

EXAMPLE

If a 3,000lb. load is lifted by slings at a 45° angle, what is the tension on each sling?



Load Angle Factor x ½ the Load = Tension on Sling

45° Load Angle Factor = 1.414

1.414 x 1,500 lbs. (half of 3,000 lbs.)

= 2,121 lbs. tension on each sling

CALCULATING LOAD ANGLE FACTORS

Most likely, you will not know the angle of the sling, and therefore will need to calculate it.

To calculate the load angle factor, divide the length of the sling by the vertical distance of the hook to the load.

A ÷ B = Load Angle Factor

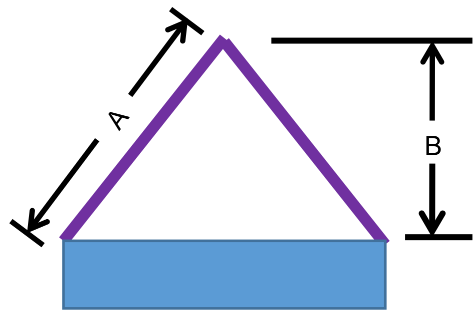


Figure 8.9: A ÷ B = Load Angle Factor

EXAMPLE

If 8ft. slings are used to lift a 2,000lb load, and the load is 6ft. from the hook, what is the tension on each sling?

A ÷ B = Load Angle Factor

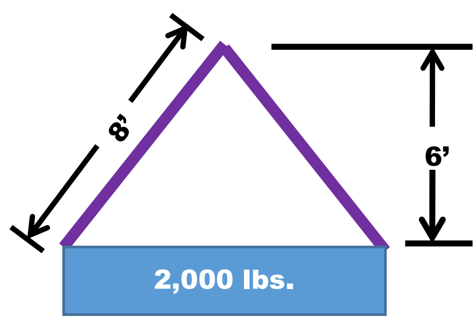
Load Angle Factor x Load = Tension on Slings

Tension on Slings ÷ Number of Sling Legs

Load Angle Factor: 8 ÷ 6 = 1.33333

1.33333 x 2,000 lbs. = 2,666 lbs. Tension on Slings

2,666 lbs. ÷ 2 Slings = 1,333 lbs. per Sling



CENTER OF GRAVITY

Figure 8.10: Effects of an offset center of gravity on a load [34]

It might seem silly that someone would overload a cart to the point that it could lift a donkey off of the ground, but overloading equipment is not unheard of in the industry. How many times have you seen pictures or videos of cranes tipped over on their side?

The center of gravity is the point in a load where the weight is concentrated. This is not necessarily the center of the shape of the load!

When the weight of a load is not distributed evenly, the tension on each sling is not distributed evenly. We should never rig loads without knowing the center of gravity of a load, and the tensions on the individual slings.

All of the factors and formulas on the previous pages are good for regular shaped loads with equally distributed weight. But what if you are lifting an irregular shaped / weighted load?

CENTER OF GRAVITY & TENSION

When a load is rigged and lifted, the center of gravity will always end up directly under the hook. This can result in tilted loads and unsafe lifts.

If a load tilts more than 5° after it is lifted clear of the ground, it should be landed, the center of gravity calculated, and the load rigged over again.

If the load is lifted abruptly, it will swing past the center of gravity an equal distance and then continue swinging back and forth. This can result in dangerous load shifting and additional stress on lifting hardware and rigging.

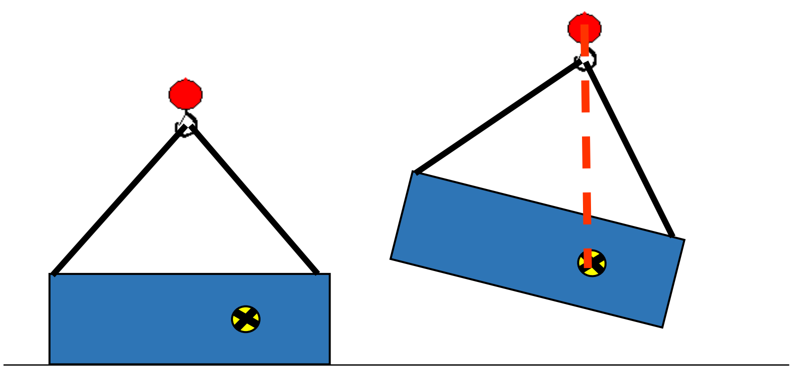
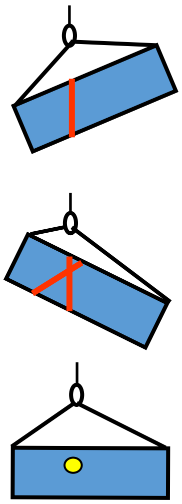


Figure 8.11: The center of gravity is always directly under the hook

CALCULATING CENTER OF GRAVITY



Using the "test pick" method to find the Center of Gravity:

1 On the initial pick, the load tilts to one side. Mark a line on the load in line with the hoist line.

2 On the second pick, select slings of unequal length which will tilt the load in the opposite direction. Mark a line on the load in line with hoist line.

3 Where the two lines intersect is the Center of Gravity in the horizontal (east/west).

4 Position the hook directly above the Center of Gravity and select the proper size slings.

Note: The load should only be lifted a few inches off the ground!

Figure 8.12: Trial Test Pick

CALCULATING CENTER OF GRAVITY & TENSION

To calculate the amount of weight placed on each vertical sling, you must determine the distance of each sling from the center of gravity, divide it by the total distance, and then multiply that by the load.

If the load is rigged with angled slings, you must determine the distance of each sling from the center of gravity, divide it by the total distance, multiply it by the length of the sling, and then multiply that by the load.

DOUBLE VERTICAL SLING TENSION

The formula below is used to determine the tension on each sling when picking up a load using vertical slings attached to a spreader bar or lifting beam.

The key to determining the weight on each vertical sling is knowing the total weight of the load, where its center of gravity is, and the distance between the two attachment points of the slings.

Note: The distance between the two attachment points NOT the length of the load.

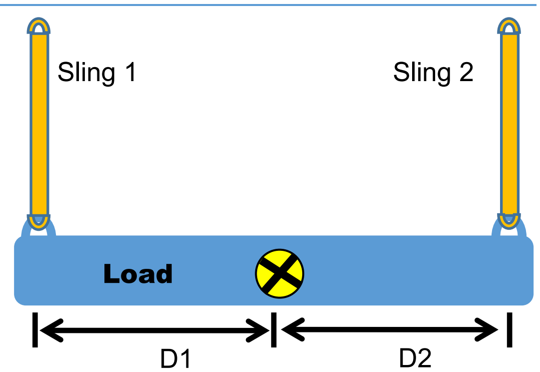


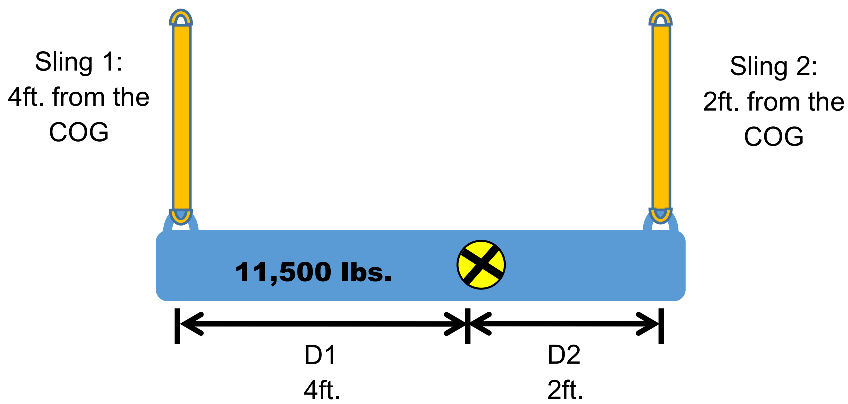
Figure 8.13: Calculating the weight on each vertical sling

D2 ÷ (D1 + D2) x load = Weight on Sling 1

D1 ÷ (D1 + D2) x load = Weight on Sling 2

EXAMPLE

If the Center of Gravity is 4 ft. from Sling 1 and 2 ft. from Sling 2, and the load weighs 11,500 lbs., how much weight is on each sling?



D2 ÷ (D1 + D2) x load = Weight on Sling 1

2 ft. ÷ 6 ft. (4 ft. + 2 ft.) = 0.33333

0.33333 x 11,500 lbs. = 3,833.33333 lbs.

The weight on sling 1 is 3,833 lbs.

D1 ÷ (D1 + D2) x load = Weight on Sling 2

4 ft. ÷ 6 ft. (4 ft. + 2 ft.) = 0.66666

0.66666 x 11,500 lbs. = 7,666.66666 lbs.

The weight on sling 2 is 7,667 lbs.

Note: When calculating the tension / weight placed on each sling, it is useful to remember that the sling closest to the center of gravity carries the most weight.

Note: It is also useful to know that when calculating the tension / weight placed on each vertical sling, the two figures added together equal the total weight. To check that your figures are correct, add the sling tensions together, to see if the equal the total weight . However, this is only true of vertical slings. Using angled slings adds weight above the total weight.

DOUBLE ANGLED SLING TENSION

The formula below, is used to determine the tension on each sling when picking up a load using angled slings attached to a single hook, shackle or masterlink, etc.

The key to determining the tension on each angled sling is knowing the total weight of the load, where its center of gravity is, the distance between the two attachment points of the slings, the vertical distance of the hook to the load, and the length of the slings.

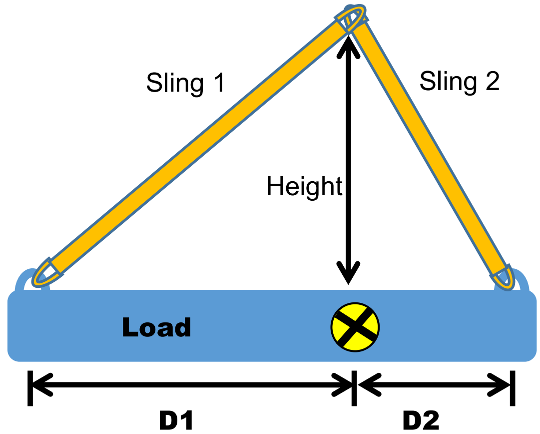


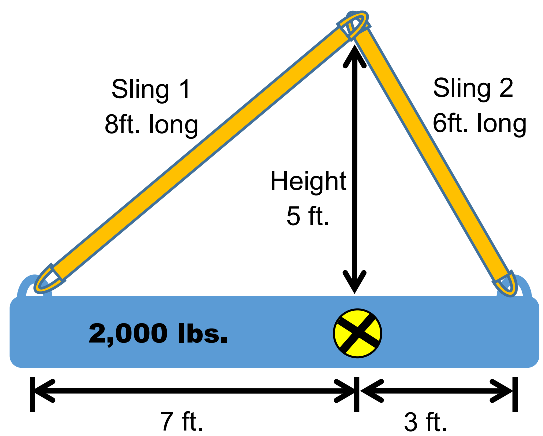
Figure 8.14: Calculating the weight on each angled sling

Load x D2 x S1 ÷ [H(D1 + D2)] = Tension on S1

Load x D1 x S2 ÷ [H(D1 + D2)] = Tension on S2

EXAMPLE

Sling 1 is 8 ft. long and 7 ft. from the center of gravity. Sling 2 is 6 ft. long and 3 ft. from the center of gravity. The hook is 5 ft from the 2,000 lbs. load. How much tension is on each sling?



Load x D2 x S1 ÷ [H(D1 + D2)]

= Tension on S1

2,000 lbs x 3ft. x 8ft. ÷ (5ft. x 10ft.) = 960 lbs.

Load x D1 x S2 ÷ [H(D1 + D2)]

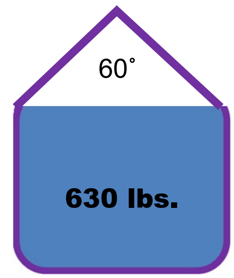
= Tension on S2

2,000 lbs. x 7ft. x 6ft. ÷ (5ft. x 10ft.) = 1680 lbs.

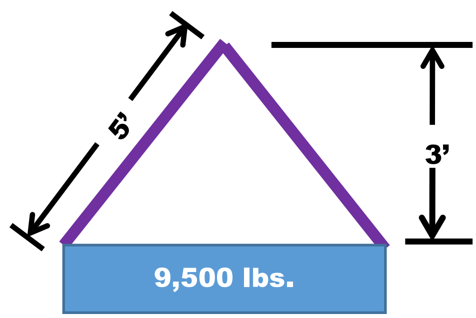
MODULE 8 QUIZ

Complete the following quiz questions:

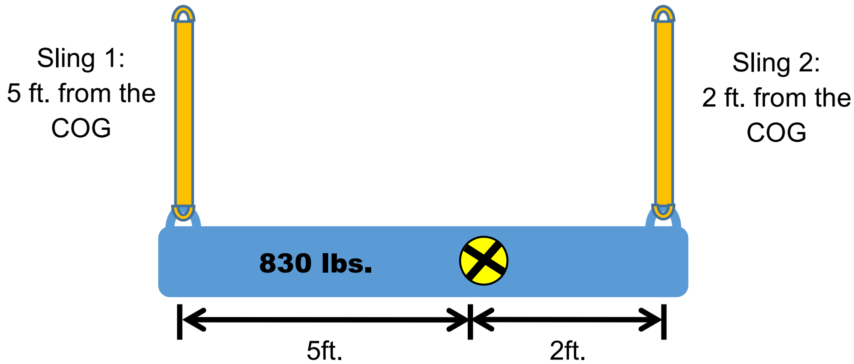
1. If a 630 lb. load is lifted with slings at a 60˚ angle, what is the tension on each sling?



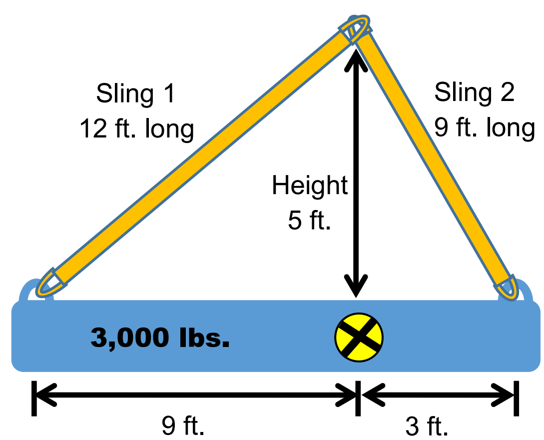
2. If a 9,500 lbs. load is lifted with 5ft. slings, and the vertical distance between the load and the hook is 3ft., how much tension is on each sling?



3. If the Center of Gravity is 5 ft. from Sling 1 and 2 ft. from Sling 2, and the load weighs 830 lbs., how much weight is on each sling?



4. Sling 1 is 12 ft. long and 9 ft. from the center of gravity. Sling 2 is 9 ft. long and 3ft. from the center of gravity. The hook is 5ft from the 3,000 lbs. load. How much tension is on each sling?



Rigging Exercises

RIGGING EXERCISES

Throughout this course we have introduced you to rigging equipment, and how to safely use it. However, the most important job of a rigger is to select the correct equipment for the job.

Selection of equipment requires calculating the load weight, the sling angle, and the load angle factor, only then can a rigger select the correct slings and hardware to conduct a safe lift.

RIGGING REFERENCE GUIDES

Rigging reference guides are an essential tool used on a daily basis by riggers.

Rigging Cards such as The Crosby Card produced by hardware manufacturer Crosby, or the CIA cards produced by The Crane Institute of America, are durable weatherproof laminated cards that can be folded down to easily fit in a pocket or wallet.

They are quick reference guides which include capacity charts and load angle factor lists for slings, hardware and hitches. They also include checklist reminders for important items such as risks, plans, and inspection criteria.

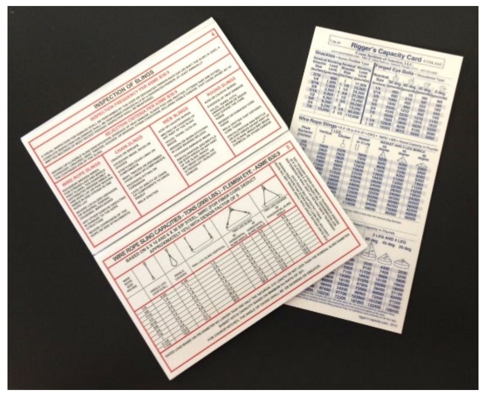


Figure 9.1: Examples of Rigging Cards

Some hardware manufacturers and training institutes produce mini pocket books.

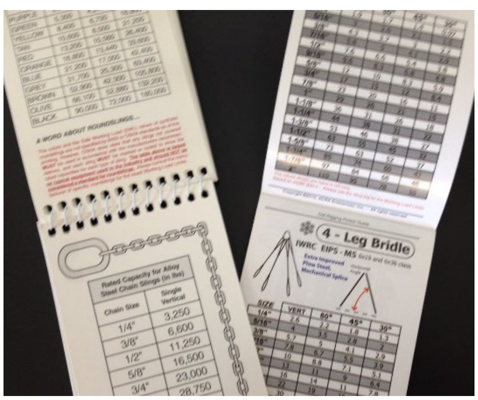


Figure 9.2: Examples of Mini Pocket Books

Note: Some Rigging Reference Guides list weights in pounds, others in tons. Some sections of the Crosby Card list weights in Metric Tons! A conversion chart has been provided to assist you in your calculations; see Appendix 3: Pounds/US Tons/Metric Tons Conversion Chart, page 157.

Note: The Crosby Card contains calculation tables for all slings and hardware, except for Synthetic Slings. Refer to the CIA Riggers Capacity Card for Synthetic Sling calculations.

Using the Rigging Cards that have been provided, complete the following exercises in class.

Note: When selecting slings and hardware use the Single Leg Vertical columns of your Rigging Cards. The first step in each exercise is to work out the Load Angle Factor. You do not need to apply the increased tension again.

EXERCISE 1

Use your Rigging Card to determine the Wire Rope and Shackle size required:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EIP Wire Rope size required =

Shackle size required =

EXERCISE 2

Now use your Rigging Cards to determine the Wire Rope, Shackle and Eyebolt size required:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each Sling Leg =

EIP Wire Rope size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 3

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Synthetic Web Sling size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 4

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EEIP Wire Rope size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 5

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EIP Wire Rope size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 6

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Grade 10 (100) Chain size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 7

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EEIP Wire Rope size required =

EXERCISE 8

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Synthetic Web Sling size required =

Shackle size required =

Eye bolt size required =

EXERCISE 9

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each Sling Leg =

Grade 8 Chain size required =

Shackle size required =

Eye bolt size required =

EXERCISE 10

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Type V Synthetic Round Sling size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 11

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EEIP Wire Rope size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 12

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EIP Wire Rope size required =

Shackle size required =

Eye Bolt size required =

Carbon Links and Rings size required =

EXERCISE 13

Use your Rigging Card to fill in the blanks and circle which should be used between Eye Bolt or Hoist Ring:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EIP Wire Rope size required =

Shackle size required =

Eye Bolt / Hoist Ring size required =

EXERCISE 14

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Synthetic Web Sling size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 15

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Type V Synthetic Round Sling size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 16

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

EEIP Wire Rope size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 17

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Grade 8 Chain size required =

Shackle size required =

Eye Bolt size required =

EXERCISE 18

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Grade 8 Chain size required =

Shackle size required =

Eye Bolt/ Hoist Ring size required =

EXERCISE 19

Use your Rigging Card to fill in the blanks:

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Type V Synthetic Round Sling size required =

Shackle size required =

Eye bolt size required =

EXERCISE 20

Use your Rigging Card to fill in the blanks (circle which is best for the lift: Eye Bolt or Hoist Ring):

Load Weight =

Sling Angle =

Load Angle Factor =

Tension on each sling leg =

Grade 8 Chain size required =

Shackle size required =

Eye Bolt/Hoist Ring size required =

COURSE CONCLUSION

There are many situations we come across on a work site that can cause serious injury and even death. Rigging is never risk free – equipment can be misused, components can fail, workers can become complacent, and incidents happen.

So many elements of rigging are potentially hazardous. Lack of knowledge, improper training, inadequate inspection, and incorrect use of equipment, can all have serious consequences.

Safety is the responsibility of all workers; each employee has a duty to identity the correct piece of equipment for the job, and understand the limitations of the equipment and individual components.

Workers should also be able to recall rigging regulations and follow safe working practices. Rigging rules, regulations, policies and procedures, are all designed to keep you safe – mistakes cost lives.

If you are ever in any doubt about the rigging task you are about to perform, stop and seek help from someone who is more qualified or experienced in that task.

KNOWLEDGE & PRACTICAL ASSESSMENT REQUIREMENTS

Proof of a passing knowledge assessment and required in-field assessments must be available for audit purposes.

Resources

APPENDICES

APPENDIX 1: FEDERAL REGULATIONS

Rigging practices are covered by regulations from several federal agencies. Your site has a library of these documents for you to access.

OSHA 1910.179 - Overhead and gantry cranes
OSHA 1910.180 - Crawler locomotive and truck cranes
OSHA 1910.181 - Derricks
OSHA 1910.184 – Slings

OSHA 1926.1400 – Cranes and Derricks in Construction

OSHA 1926.1419 - Signals

Why OSHA regulations and not MSHA? The Department of Labor has a regulation which states “if MSHA does not have a regulation which covers a specific task the OSHAct shall be applied”.

https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=standards&p_toc_level=0

ASME B30 - Covers all cranes and rigging equipment

ASME B30.5 - Covers Mobile Cranes

ASME B30.9 - Covers Slings

ASME B30.10 - Covers Hooks

ASME B30.20 – Covers Below-the-Hook Lifting Devices

ASME B30.26 – Covers Rigging Hardware

Additionally for overhead crane: B30.2 covers Overhead & Gantry Cranes

APPENDIX 2: HOIST OPERATORS DO'S & DON'TS [33]

The hoist operator shall:

- Be familiar with operating controls, procedures, and warnings.
- Inspect the hoist regularly, keeping records of inspection.
- Immediately shut down damaged or malfunctioning hoists.
- Report damaged or worn parts identified during inspection.
- Report malfunctions or unusual performances.
- Maintain a firm footing or be otherwise secured when operating the hoist.
- Check brake function by tensioning the hoist prior to each lift or pulling operation.
- Avoid lever "fly-back" by keeping a firm grip on the lever until operating stroke is completed and the lever is at rest.
- Make sure the load is free to move and will clear all obstructions.
- Avoid swinging the load or hook.
- Protect the hoist's load chain from damage.
- Use hooks with latches, ensuring that the latches are closed and not supporting any parts of the load.

The hoist operator shall NOT:

- Operate the hoist until they have thoroughly read and understood the manufacturer's Operating Manual.
- Operate a hoist on which the safety placards or decals are missing or illegible.
- Remove or obscure the warnings on the hoist.
- Operate a damaged, malfunctioning or unusually performing hoist.
- Operate a hoist which has been modified without the manufacturer's approval or certification.
- Adjust or repair the hoist – only a qualified perform can perform such work.
- Permit more than one operator to pull on lever at the same time, causing hoist overload.
- Operate hoist when it is restricted from forming a straight line from hook to hook in the direction of loading.
- Allow the hoist to be subjected to sharp contact with other hoists, structures, or objects through misuse.
- Operate a hoist which has not been securely attached to a suitable support, to support the hoist rigging and load.
- Lift or pull more than rated load for the hoist.

- Use the hoist load limiting or warning device to measure load.
- Operate with any lever extension such as a cheater bar.
- Use the hoist to lift, support, or transport people.
- Lift loads over people and make sure all personnel remain clear of the supported load.
- Operate a hoist unless all persons are and remain clear of the supported load.
- Attempt to "free-chain" the hoist while a load is applied.
- Use hoist with twisted, kinked, damaged, or worn load chain.
- Use load chain as a sling or wrap load chain around load.
- Attempt to lengthen the load chain or repair damaged load chain.
- Apply load unless load chain is properly seated in the chain wheel(s) or sprocket(s).
- Apply load if bearing prevents equal loading on all load supporting chains.
- Operate beyond the limits of the load chain travel.
- Allow the chain or hook to be used as an electrical or welding ground.
- Allow the chain or hook to be touched by a live welding electrode.
- Apply the load to the tip of the hook or to the hook latch.
- Operate a hoist unless load slings or other approved single attachments are properly sized and seated in the hook saddle.
- Lift loads that are not balanced.
- Leave load supported by the hoist unattended unless specific precautions have been taken.
- Allow your attention to be diverted from operating the hoist.

APPENDIX 3: POUNDS/US TONS/METRIC TONS CONVERSION CHART

POUNDS	SHORT TONS (US)	METRIC TONS
100	0.05	0.0454
200	0.1	0.0907
300	0.15	0.1361
400	0.2	0.1814
500	0.25	0.2268
600	0.3	0.2722
700	0.35	0.3175
800	0.4	0.3629
900	0.45	0.4082
1000	0.5	0.4536
1100	0.55	0.499
1200	0.6	0.5443
1300	0.65	0.5897
1400	0.7	0.635
1500	0.75	0.6804
1600	0.8	0.7257
1700	0.85	0.7711
1800	0.9	0.8165
1900	0.95	0.8618
2000	1	0.9072
3000	1.5	1.3608
4000	2	1.8144
5000	2.5	2.268
6000	3	2.7216
7000	3.5	3.1751
8000	4	3.6287
9000	4.5	4.0823
10000	5	4.5359

GLOSSARY

Area	The surface area of a two dimensional shape.
ASME	American Society of Mechanical Engineers
Below-the-hook lifting device	See Hoists, and Lifters
B/O	Bad Order: Remove the item from service.
Capacity Tag	Label applied to a piece of rigging equipment which states the capacity / maximum load to be applied to the piece of equipment.
Capacity	The weight that can be lifted e.g. the capacity of a sling is the maximum weight that can be lifted.
Center of Gravity	The midpoint of the weight of an object; the point where the weight is evenly dispersed on all sides of an object.
Choker Hitch	Type of hitch where the sling passes around the load and through one eye.
Circumference	The distance around a circle or circular object.
Diameter	The measurement across the center of an object.
Federal Agencies	MSHA, OSHA
Fittings	Hardware: Shackles, hooks, eye bolts, hoist rings, latches, master links, plate clamps, turnbuckles, and rigging blocks are used to connect a sling to a hitch.
Hardware	Shackles, hooks, eye bolts, hoist rings, latches, master links, plate clamps, turnbuckles, and rigging blocks are used to connect a sling to a hitch.
Hitch	The arrangement of slings, i.e. the method by which a sling is attached to a load.
Hoist	A device which connects the load to the hook, which also lifts the load.
Lift	The raising of a load.
Lifter	A device which connects the load to the hook, which also lifts the load.
Load	The item that is being lifted.
Load Angle Factors	Reduction in capacity due to the angle of the sling.
Load Weight	The weight of an object / load: Volume multiplied by Unit Weight.
MSHA	United States Department of Labor, Mine Safety & Health Administration
OSHA	United States Department of Labor, Occupational Safety & Health Administration
Radius	The measurement from the center of an object to the edge (half of the diameter)
Rated Load	The weight that can be lifted e.g. the rated load of a sling is the maximum weight that can be lifted.
Side Loading	Where the sling is at an angle on the hardware, which reduces capacity.
Slings	A component made from steel chain, wire rope, or synthetic material which connects the load to the hook.
Stress	The force, i.e. stretching or straining, applied to rigging equipment.
SWL	Safe Working Load: The weight that can be lifted e.g. the safe working load of a sling is the maximum weight that can be lifted.
Tension	The force, i.e. stretching or straining, applied to rigging equipment.

Travel	The movement of a load
Unit Weight	The weight per unit volume e.g.
Vertical	Upright, at a 90° angle, at a right angle to the horizontal.
Vertical Hitch	Basic hitch, also known as a Single Leg Hitch, where one eye is attached to the load, and the other to the hook, on a vertical (90°) sling angle.
Volume	The quantity of a three dimensional space: Length multiplied by width, multiplied by the height of an object.
WLL	Working Load Limit: The weight that can be lifted e.g. the working load limit of a sling is the maximum weight that can be lifted.

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TECHNICAL RIGGING END OF COURSE QUESTIONNAIRE

Course Date		Site	
Facilitator			

Survey Questions
1. How could the course be improved?
2. What did you enjoy most about the course?
3. What did the facilitator do well?
4. What could the facilitator improve?