24 RIGGING

It is important that workers involved with hoisting and rigging activities are trained in both safety and operating procedures. Hoisting equipment should be operated only by trained personnel.

The cause of rigging accidents can often be traced to a lack of knowledge on the part of a rigger. Training programs such as CSAO's *Basic Safety Training for Hoisting and Rigging* provide workers with a basic knowledge of principles relating to safe hoisting and rigging practices in the construction industry.

A safe rigging operation requires the rigger to know

- the weight of the load and rigging hardware
- the capacity of the hoisting device
- the working load limit of the hoisting rope, slings, and hardware.

When the weights and capacities are known, the rigger must then determine how to lift the load so that it is stable.

Training and experience enable riggers to recognize hazards that can have an impact on a hoisting operation. Riggers must be aware of elements that can affect hoisting safety, factors that reduce capacity, and safe practices in rigging, lifting, and landing loads. Riggers must also be familiar with the proper inspection and use of slings and other rigging hardware.

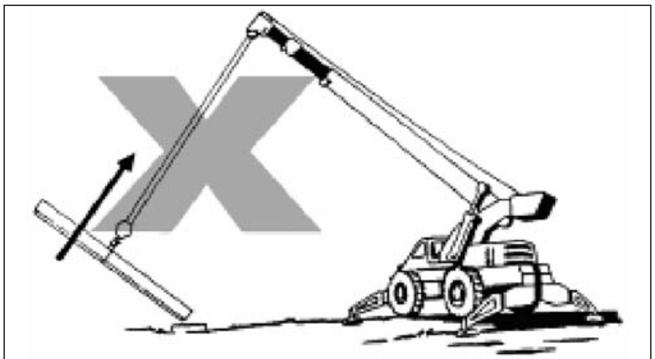
Most crane and rigging accidents can be prevented by field personnel following basic safe hoisting and rigging practices. When a crane operator is working with a rigger or a rigging crew, it is vital that the operator is aware of the all aspects of the lift and that a means of communication has been agreed upon, including what signals will be used.

Elements that can Affect Hoisting Safety

- **Working Load Limit (WLL) not known.** Don't assume. Know the working load limits of the equipment being used. Never exceed these limits.
- **Defective components.** Examine all hardware, tackle, and slings before use. Destroy defective components. Defective equipment that is merely discarded may be picked up and used by someone unaware of its defects.
- **Questionable equipment.** Do not use equipment that is suspected to be unsafe or unsuitable, until its suitability has been verified by a competent person.
- **Hazardous wind conditions.** Never carry out a hoisting or rigging operation when winds create hazards for workers, the general public, or property. Assess load size and shape to determine whether wind conditions may cause problems. For example, even though the weight of the load may be within the capacity of the equipment, loads with large wind-catching surfaces may swing or rotate out of control during the lift in high or gusting winds. Swinging and rotating loads not only present a danger to riggers—there is the potential for the forces to overload the hoisting equipment.
- **Weather conditions.** When the visibility of riggers or hoist crew is impaired by snow, fog, rain, darkness, or dust, extra caution must be exercised. For example, operate in "all slow", and if necessary, the lift should be postponed. At sub-freezing temperatures, be aware that loads are likely to be frozen to the ground or structure they are resting on. In extreme cold conditions avoid shock-loading or impacting the hoist equipment and hardware, which may have become brittle.

– **Electrical contact.** One of the most frequent killers of riggers is electrocution. An electrical path can be created when a part of the hoist, load line, or load comes into close proximity to an energized overhead powerline. When a crane is operating near a live powerline and the load, hoist lines, or any other part of the hoisting operation could encroach on the minimum permitted distance (see table below), specific measures described in the Construction Regulation must be taken. For example, constructors must have written procedures to prevent contact whenever equipment operates within the minimum permitted distance from a live overhead powerline. The constructor must have copies of the procedure available for every employer on the project.

– **Hoist line not plumb.** The working load limits of hoisting equipment apply only to freely suspended loads on plumb hoist lines. If the hoist line is not plumb during load handling, side loads are created which can destabilize the equipment and cause structural failure or tip-over, with little warning.



Wrong. The hoist line must be plumb at all times.

Factors that Reduce Capacity

The working load limits of hoisting and rigging equipment are based on ideal conditions. Such ideal circumstances are seldom achieved in the field. Riggers must therefore recognize the factors that can reduce the capacity of the hoist.

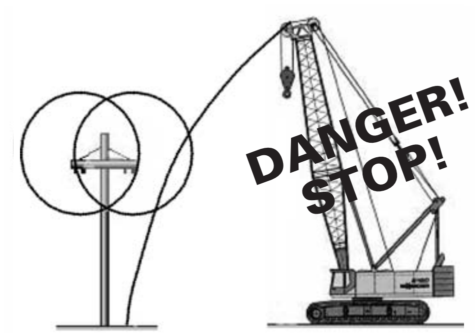
– **Swing.** The swinging of suspended loads creates additional dynamic forces on the hoist in addition to the weight of the load. The additional dynamic forces (see point below) are difficult to quantify and account for, and could cause tip-over of the crane or failure of hoisting hardware. The force of the swinging action makes the load drift away from the machine, increasing the radius and side-loading on the equipment. The load should be kept directly below the boom point or upper load block. This is best accomplished by controlling the load's movement with slow motions.

– **Condition of equipment.** The rated working load limits apply only to equipment and hardware in good condition. Any equipment damaged in service should be taken out of service and repaired or destroyed.

Keep the Minimum Distance from Powerlines

Normal phase-to-phase voltage rating	Minimum distance
750 or more volts, but no more than 150,000 volts	3 metres
Over 150,000 volts, but no more than 250,000 volts	4.5 metres
More than 250,000 volts	6 metres

Beware:
The wind can blow powerlines, hoist lines, or your load.
This can cause them to cross the minimum distance.



This crane boom could reach within the minimum distance.

– **Dynamic forces.** The working load limits of rigging and hoisting equipment are determined for static loads. The design safety factor is applied to account, in part, for the dynamic motions of the load and equipment. To ensure that the working load limit is not exceeded during operation, allow for wind loading and other dynamic forces created by the movements of the machine and its load. Avoid sudden snatching, swinging, and stopping of suspended loads. Rapid acceleration and deceleration also increases these dynamic forces.

– **Weight of tackle.** The rated load of hoisting equipment does not account for the weight of hook blocks, hooks, slings, equalizer beams, and other parts of the lifting tackle. The combined weight of these items must be added to the total weight of the load, and the capacity of the hoisting equipment, including design safety factors, must be large enough to account for the extra load to be lifted.

DETERMINING LOADS

The first step in planning a rigging operation is to calculate or estimate the weight of the material to be lifted or moved.

When this information is not included in shipping papers, design plans, catalogue data, or other dependable sources, it may be necessary to calculate the weight based on weight tables for specific materials.

Taking the time to calculate load weights can prevent serious accidents in rigging, hoisting, and moving material.

Remember: The weight of all rigging equipment must be included as part of the load to be lifted (Figure 1).

The next step is to select the right rope for the job — fibre rope or wire rope.

FIBRE ROPES

The fibres in these ropes are either natural or synthetic. Natural fibre ropes should not be used for rigging since their strength is more variable than that of synthetic fibre ropes and they are much more subject to deterioration from rot, mildew, and chemicals.

Polypropylene is the most common fibre rope used in rigging. It floats but does not absorb water. It stretches less than other synthetic fibres such as nylon. It is affected, however, by the ultraviolet rays in sunlight and should not be left outside for long periods. It also softens with heat and is not recommended for work involving exposure to high heat.

Nylon fibre is remarkable for its strength. A nylon rope is considerably stronger than the same size and construction of polypropylene rope. But nylon stretches and hence is not used much for rigging. It is also more expensive, loses strength when wet, and has low resistance to acids.

Polyester ropes are stronger than polypropylene but not as strong as nylon. They have good resistance to acids, alkalis, and abrasion; do not stretch as much as nylon; resist degradation from ultraviolet rays; and don't soften in heat.

All rigging equipment such as hooks, slings, blocks, spreader beams, and hoisting lines must be counted as part of the load.

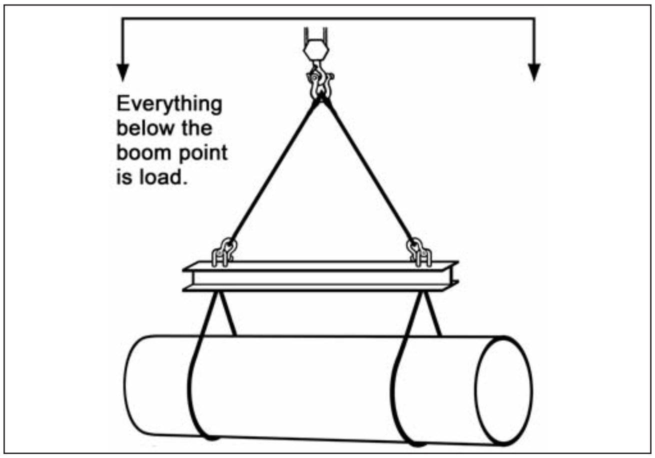


Figure 1

All fibre ropes conduct electricity when wet. When dry, however, polypropylene and polyester have much better insulating properties than nylon.

Inspection

Inspect fibre rope regularly and before each use. Any estimate of its capacity should be based on the portion of rope showing the **most** deterioration.

Check first for external wear and cuts, variations in the size and shape of strands, discolouration, and the elasticity or "life" remaining in the rope.

Untwist the strands without kinking or distorting them. The inside of the rope should be as bright and clean as when it was new. Check for broken yarns, excessively loose strands and yarns, or an accumulation of powdery dust, which indicates excessive internal wear between strands as the rope is flexed back and forth in use.

If the inside of the rope is dirty, if strands have started to unlay, or if the rope has lost life and elasticity, do not use it for hoisting.

Check for distortion in hardware. If thimbles are loose in the eyes, seize the eye to tighten the thimble (Figure 2). Ensure that all splices are in good condition and all tucks are done up (Figure 3).

Defective or damaged fibre rope should be destroyed or cut up so that it cannot be used for hoisting.

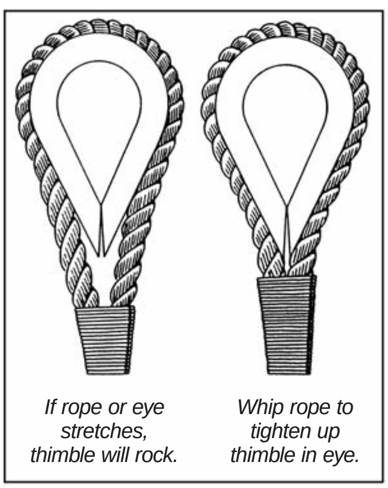


Figure 2

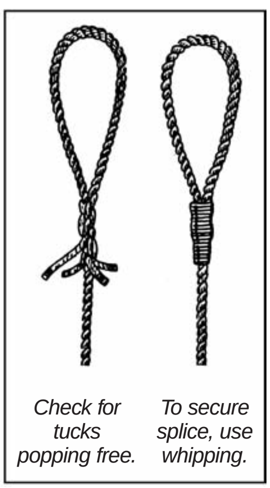


Figure 3

Manila Rope **Manila rope is not recommended for construction use and is illegal for lifelines and lanyards.**	
Dusty residue when twisted open	Wear from inside out. Overloading. If extensive, replace rope.
Broken strands, fraying, spongy texture	Replace rope.
Wet	Strength could be reduced.
Frozen	Thaw and dry at room temperature.
Mildew, dry rot	Replace rope.
Dry and brittle	Do not oil. Wash with cold water and hang in coils to dry.

Polypropylene and Nylon Rope	
Chalky exterior appearance	Overexposed to sunlight (UV) rays. Possibly left unprotected outside. Do not use. Discard.
Dusty residue when twisted open	Worn from inside out. If extensive, replace.
Frayed exterior	Abraded by sharp edges. Strength could be reduced.
Broken strands	Destroy and discard.
Cold or frozen	Thaw, dry at room temperature before use.
Size reduction	Usually indicates overloading and excessive wear. Use caution. Reduce capacity accordingly.

Design Factors

Fibre rope must have a design factor to account for loads over and above the weight being hoisted and for reduced capacity due to

- wear, broken fibres, broken yarns, age, variations in size and quality

- loads imposed by starting, stopping, swinging, and jerking
- increases in line pull caused by friction over sheaves
- decreases in strength caused by bending over sheaves
- inaccuracies in load weight
- getting wet and drying out, mildew and rot
- strength reductions caused by knots
- yarns weakened by ground-in dirt and abrasives.

The design factor for all fibre rope is 5. For hoisting or supporting personnel, the design factor is 10.

The design factor does **not** provide extra usable capacity. Working load limits must **never** be exceeded.

$$WLL = \frac{\text{Breaking strength}}{\text{Design Factor}} = \frac{\text{Breaking strength}}{5}$$

For example, a rope rated at 1500 lbs. breaking strength has a working load limit of 300 lbs.

$$\frac{1500 \text{ lbs.}}{5} = 300 \text{ lbs.}$$

Figure 4

Working Load Limits

Working load limits (WLLs) can be calculated as shown in Figure 4.

The two tables below (Figures 5 and 6) are for purposes of illustration only. Check manufacturer's ratings for the WLL of the rope you are using, which may well differ from what is shown in these tables.

Sample Working Load Limits of Fibre Ropes

APPROXIMATE WORKING LOAD LIMITS OF NEW FIBRE ROPES – POUNDS
3-Strand Ropes
Design Factor = 5

Nominal Rope Diameter (Inches)	Manila	Nylon	Polypropylene	Polyester	Polyethylene
3/16	100	200	150	200	150
1/4	120	300	250	300	250
5/16	200	500	400	500	350
3/8	270	700	500	700	500
1/2	530	1,250	830	1,200	800
5/8	880	2,000	1,300	1,900	1,050
3/4	1,080	2,800	1,700	2,400	1,500
7/8	1,540	3,800	2,200	3,400	2,100
1	1,800	4,800	2,900	4,200	2,500
1-1/8	2,400	6,300	3,750	5,600	3,300
1-1/4	2,700	7,200	4,200	6,300	3,700
1-1/2	3,700	10,200	6,000	8,900	5,300
1-5/8	4,500	12,400	7,300	10,800	6,500
1-3/4	5,300	15,000	8,700	12,900	7,900
2	6,200	17,900	10,400	15,200	9,500

***Caution:** This table contains sample values for the purposes of illustration only. Refer to the manufacturer of the equipment you're using for precise values.*

Figure 5

Sample Working Load Limits of Fibre Ropes cont'd

APPROXIMATE WORKING LOAD LIMITS OF NEW BRAIDED SYNTHETIC FIBRE ROPES (POUNDS)
Design Factor = 5

Nominal Rope Diameter (Inches)	Nylon Cover Nylon Core	Nylon Cover Polypropylene Core	Polyester Cover Polypropylene Core
1/4	420	–	380
5/16	640	–	540
3/8	880	680	740
7/16	1,200	1,000	1,060
1/2	1,500	1,480	1,380
9/16	2,100	1,720	–
5/8	2,400	2,100	2,400
3/4	3,500	3,200	2,860
7/8	4,800	4,150	3,800
1	5,700	4,800	5,600
1-1/8	8,000	7,000	–
1-1/4	8,800	8,000	–
1-1/2	12,800	12,400	–
1-5/8	16,000	14,000	–
1-3/4	19,400	18,000	–
2	23,600	20,000	–

***Caution:** This table contains sample values for the purposes of illustration only. Refer to the manufacturer of the equipment you're using for precise values.*

Figure 6

WLLs are for the common three-strand fibre ropes generally used for rigging. Figures are based on ropes with no knots or hitches.

When load tables are not available, the following procedures work well for new nylon, polypropylene, polyester, and polyethylene ropes.

Since rope on the job is rarely new, you will have to judge what figures to use.

If you have any doubt about the type or condition of the rope, don't use it. There is no substitute for safety.

Nylon Rope

1. Change the rope diameter into eighths of an inch.
2. Square the numerator and multiply by 60.

Example: 1/2 inch rope = 4/8 inch diameter

WLL = 4 x 4 x 60 = 960 lbs.

Polypropylene Rope

1. Change the rope diameter into eighths of an inch.
2. Square the numerator and multiply by 40.

Example: 1/2 inch polypropylene rope = 4/8 inch diameter

WLL = 4 x 4 x 40 = 640 lbs.

Polyester Rope

1. Change the rope diameter into eighths of an inch.
2. Square the numerator and multiply by 60.

Example: 1/2 inch polyester rope = 4/8 inch diameter

WLL = 4 x 4 x 60 = 960 lbs.

Polyethylene Rope

1. Change the rope diameter into eighths of an inch.
2. Square the numerator and multiply by 35.

Example: 1 inch polyethylene rope = 8/8 inch diameter

WLL = 8 x 8 x 35 = 2,240 lbs.

Care

- Remove kinks carefully. Never try to pull them straight. This will severely damage the rope and reduce its strength.
- When a fibre rope is cut, the ends must be bound or whipped to keep the strands from untwisting. Figure 7 shows the right way to do this.

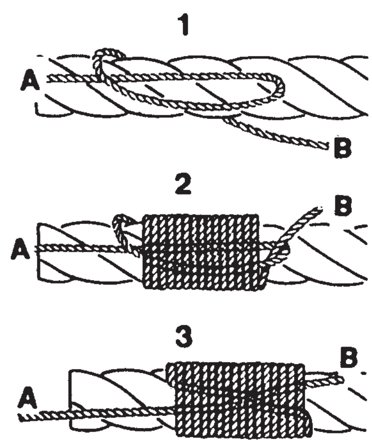


Figure 7

Storage

- Store fibre ropes in a dry cool room with good air circulation — temperature 10-21°C (50-70°F), humidity 40-60%.
- Hang fibre ropes in loose coils on large-diameter wooden pegs well above the floor (Figure 8).

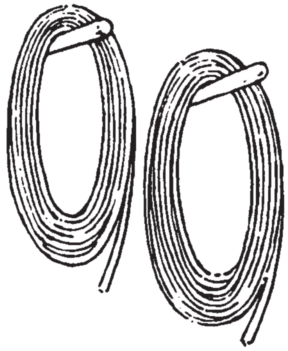


Figure 8

- Protect fibre ropes from weather, dampness, and sunlight. Keep them away from exhaust gases, chemical fumes, boilers, radiators, steam pipes, and other heat sources.
- Let fibre ropes dry before storing them. Moisture hastens rot and causes rope to kink easily. Let a frozen rope thaw completely before you handle it. Otherwise fibres can break. Let wet or frozen rope dry naturally.
- Wash dirty ropes in clean cool water and hang to dry.

Use

- Never overload a rope. Apply the design factor of 5 (10 for ropes used to support or hoist personnel). Then make further allowances for the rope's age and condition.
- Never drag a rope along the ground. Abrasive action will wear, cut, and fill the outside surfaces with grit.
- Never drag a rope over rough or sharp edges or across itself. Use softeners to protect rope at the sharp corners and edges of a load.
- Avoid all but straight line pulls with fibre rope. Bends interfere with stress distribution in fibres.
- Always use thimbles in rope eyes. Thimbles cut down on wear and stress.
- Never use fibre rope near welding or flame cutting. Sparks and molten metal can cut through the rope or set it on fire.
- Keep fibre rope away from high heat. Don't leave it unnecessarily exposed to strong sunlight, which weakens and degrades the rope.
- Never couple left-lay rope to right-lay.
- When coupling wire and fibre ropes, always use metal thimbles in both eyes to keep the wire rope from cutting the fibre rope.
- Make sure that fibre rope used with tackle is the right size for the sheaves. Sheaves should have diameters at least six — preferably ten— times greater than the rope diameter.

Knots

Wherever practical, avoid tying knots in rope. Knots, bends, and hitches reduce rope strength considerably. Just how much depends on the knot and how it is applied. Use a spliced end with a hook or other standard rigging hardware such as slings and shackles to attach ropes to loads.

In some cases, however, knots are more practical and efficient than other rigging methods, as for lifting and lowering tools or light material.

For knot tying, a rope is considered to have three parts (Figure 9).

The **end** is where you tie the knot. The **standing part** is inactive. The **bight** is in between.

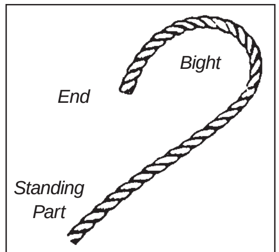


Figure 9

Following the right sequence is essential in tying knots. Equally important is the direction the end is to take and whether it goes over, under, or around other parts of the rope.

There are overhand loops, underhand loops, and turns (Figure 10).

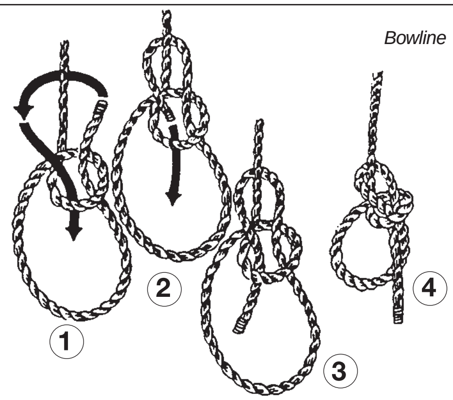
Figure 10

WARNING: When tying knots, always follow the directions *over* and *under* precisely. If one part of the rope must go under another, do it that way. Otherwise an entirely different knot — or no knot at all — will result.

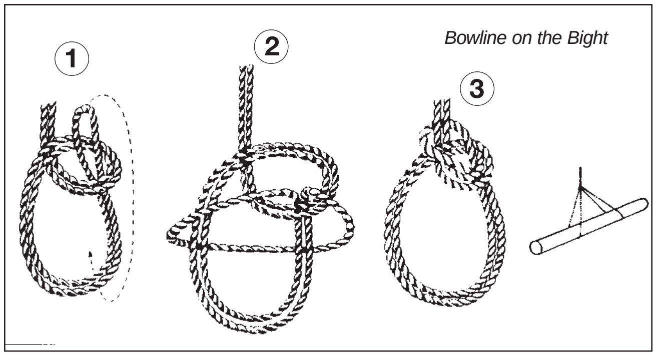
Once knots are tied, they should be drawn up slowly and carefully to make sure that sections tighten evenly and stay in proper position.

The following illustrations show how to tie some knots and hitches useful in the mechanical trades.

Bowline — Never jams or slips when properly tied. A universal knot if properly tied and untied. Two interlocking bowlines can be used to join two ropes together. Single bowlines can be used for hoisting or hitching directly around a ring.

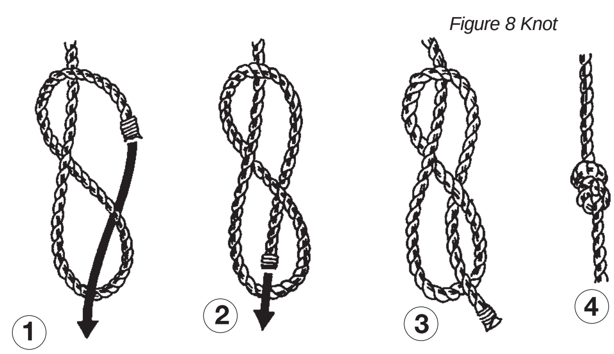


Bowline on the Bight — Used to tie a bowline in the middle of a line or to make a set

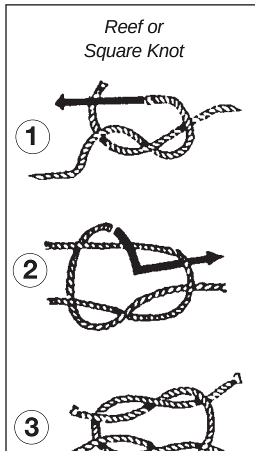


of double-leg spreaders for lifting pipe. Can also be used as a sling — sit in one loop and put the other around the back and under the arms.

Figure-Eight Knot — Tied at the end of a rope to keep strands from unlaying. Useful in preventing end of rope from slipping through a block or eye.

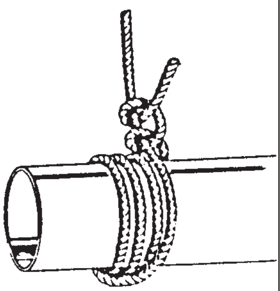


Reef or Square Knot — Can be used for tying two ropes of the same diameter together. It is unsuitable for wet or slippery ropes and should be used with caution since it unties easily when either free end is jerked. Both the live and dead ends of the rope must come out of the loops at the same time.

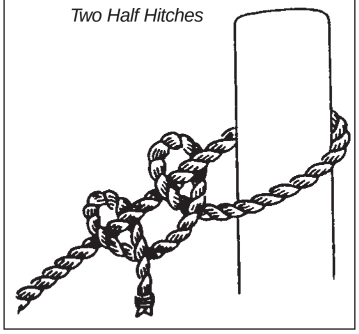


Two Half-Hitches — Two half hitches, which can be quickly tied, are reliable and can be put to almost any general use.

Pipe Hitch

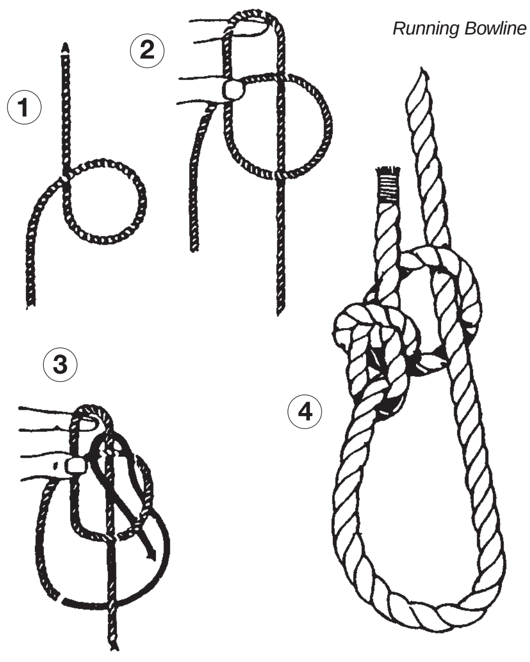


Two Half Hitches



Running Bowline — The running bowline is mainly used for hanging objects with ropes of different diameters. The weight of the object determines the tension necessary for the knot to grip.

Make an overhand loop with the end of the rope held toward you (1 in illustration). Hold the loop with your thumb and fingers and bring the standing part of the rope back so that it lies behind the loop (2). Take the end of the rope in behind the standing part, bring it up, and feed it through the loop (3). Pass it behind the standing part at the top of the loop and bring it back down through the loop (4).



Running Bowline

WIRE ROPE

Wire rope consists of three elements arranged in different ways to yield advantages for specific jobs. The three basics are

1. **wires** that form the strand
2. multi-wire **strands** laid helically around a core
3. the **core**, which can be fibre rope (FC), independent wire rope core (IWRC), or wire strand core (WSC). See Figure 11.

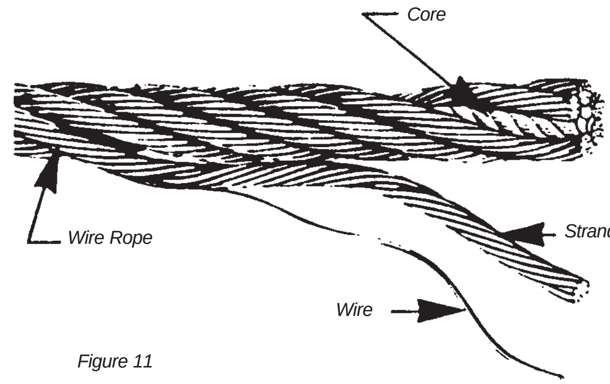


Figure 11

Strand Constructions

Wires in a strand are commonly arranged in one of four basic constructions or combinations (Figure 12).

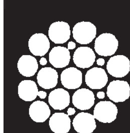
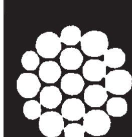
	**Ordinary**	The basic strand construction has wires of the same size wound around a centre.
	**Seale**	Large outer wires with the same number of smaller inner wires around a core wire. Provides excellent abrasion resistance but less fatigue resistance. When used with an IWRC, it offers excellent crush resistance over drums.
	**Filler Wire**	Small wires fill spaces between large wires to produce crush resistance and a good balance of strength, flexibility, and resistance to abrasion.
	**Warrington**	Outer layer of alternately large and small wires provides good flexibility and strength but low abrasion and crush resistance.

Figure 12

Lay

The strands of a rope can be configured in different arrangements by lay. Each lay has characteristics suited to certain applications.

Regular Lay 	Most common lay in which the wires wind in one direction and the strands the opposite direction (right lay shown).	Less likely to kink and untwist; easier to handle; more crush resistant than lang lay.
Lay Lay 	Wires in strand and strands of rope wind the same direction (right lay shown).	Increased resistance to abrasion; greater flexibility and fatigue resistance than regular lay; will kink and untwist.
Right Lay 	Strands wound to the right around the core (regular lay shown).	The most common construction.
Left Lay 	Strands wound to the left around the core (regular lay shown).	Used in a few special situations — cable tool drilling line, for example.
Alternate Lay 	Alternate strands of right regular lay and right lang lay.	Combines the best features of regular and lang lay for boom hoist or winch lines.

Grades of Steel

Ropes are not only of different sizes and construction but may also be made of different grades of steel.

EEIPS: Grade 125/140 Extra Extra Improved Plow Steel. Used chiefly in applications where resistance to fatigue is not an important factor.

SIPS: Grade 120/130 Special Improved Plow Steel, Type 2. Steel of remarkable strength and ductility, specially made for hoisting requirements where weight is not an important factor.

SIPS: Grade 115/125 Special Improved Plow Steel, Type 1. Used for special applications where breaking strengths somewhat higher than those of grade 110/120 are desired and where other conditions such as sheave and drum diameters are favourable to its use.

IPS: Grade 110/120 Improved Plow Steel. Because of its well-balanced combination of strength, wear resistance, and toughness, this is the most widely used grade of steel for general-purpose wire ropes.

PS: Grade 100/110 Plow Steel. Although it has lower tensile strength and wear resistance than grade 110/120, it retains high fatigue resistance and can be used when strength is secondary to wear resistance.

The most common grade is 110/120 improved plow steel. This intermediate grade combines flexibility with strength and is used for general rigging purposes in items such as slings.

Common Wire Ropes

Figure 13 shows the construction, characteristics, and typical applications for some common types of wire rope.

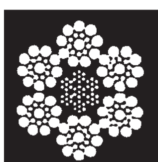
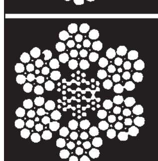
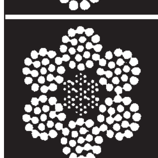
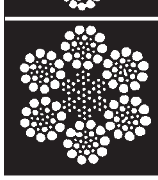
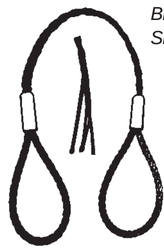
	**6 x 19 Seale** Resistant to abrasion and crushing; medium fatigue resistance.	Used for haulage rope, choker rope, rotary drilling line.
	**6 x 21 Filler Wire** Less abrasion resistance; more bending fatigue resistance.	Used for pull ropes, load lines, back-haul ropes, draglines.
	**6 x 25 Filler Wire** Most flexible rope in classification; best balance of abrasion and fatigue resistance.	Most widely used of all wire ropes — crane joists, skip hoists, haulage, mooring lines, conveyors, etc.
	**6 x 26 Warrington Seale** Good balance of abrasion and fatigue resistance.	For boom hoists, logging and tubing lines.

Figure 13

Wire Rope Slings

The use of wire rope slings for lifting materials provides several advantages over other types of slings. It has good flexibility with minimum weight. Outer wires breaking warn of failure and allow time to react. Properly fabricated wire rope slings are very safe for general construction use.

Braided Slings



Braided Slings

Fabricated from six or eight small diameter ropes braided together to form a single rope that provides a large bearing surface, tremendous strength, and flexibility in all directions. They are very easy to handle and almost impossible to kink. Especially useful for basket hitches where low bearing pressure is desirable or where the bend is extremely sharp.

Inspection

Wire rope must be inspected regularly and often. Figure 14 shows some of the more obvious warning signs to look for.

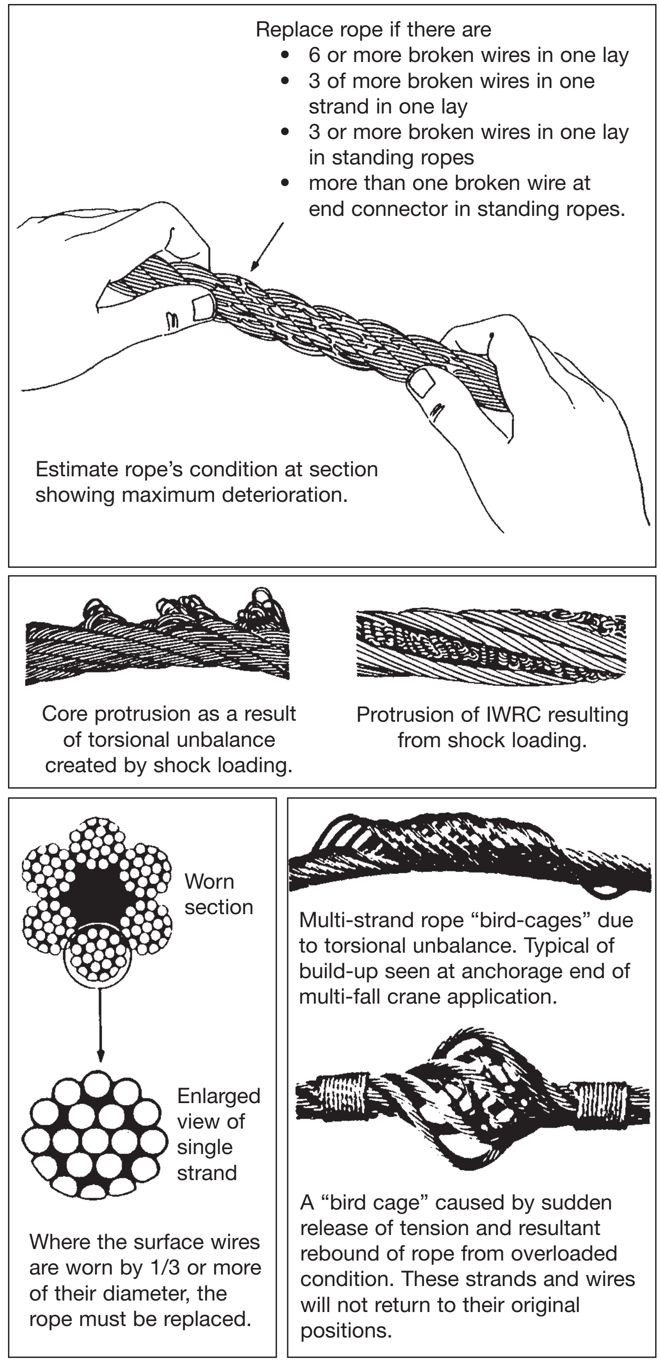


Figure 14 Wire Rope Inspection

Wire Rope	
Rusty, lack of lubrication	Apply light, clean oil. Do not use engine oil.
Excessive outside wear	Used over rough surfaces, with misaligned or wrong sheave sizes. Reduce load capacity according to wear. If outside diameter wire is more than 1/3 worn away, the rope must be replaced.
Broken wires	Up to six allowed in one rope lay, OR three in one strand in one rope lay, with no more than one at an attached fitting. Otherwise, destroy and replace rope.
Crushed, jammed, or flattened strands	Replace rope.
Bulges in rope	Replace, especially non-rotating types.
Gaps between strands	Replace rope.
Core protrusion	Replace rope.
Heat damage, torch burns, or electric arc strikes	Replace rope
Frozen rope	Do not use. Avoid sudden loading of cold rope.
Kinks, bird-caging	Replace rope. Destroy defective rope.

Wire Rope Slings	
Broken wires	Up to six allowed in one rope lay or three in one strand in one rope lay with no more than one at an attached fitting. Otherwise, destroy and replace rope.
Kinks, bird-caging	Replace and destroy.
Crushed and jammed strands	Replace and destroy.
Core protrusion	Replace and destroy.
Bulges in rope	Replace and destroy.
Gaps between strands	Replace and destroy.
Wire rope clips	Check proper installation and tightness before each lift. Remember, wire rope stretches when loaded, which may cause clips to loosen.
Attached fittings	Check for broken wires. Replace and destroy if one or more are broken.
Frozen	Do not use. Avoid sudden loading of cold ropes to prevent failure.
Sharp bends	Avoid sharp corners. Use pads such as old carpet, rubber hose, or soft wood to prevent damage.

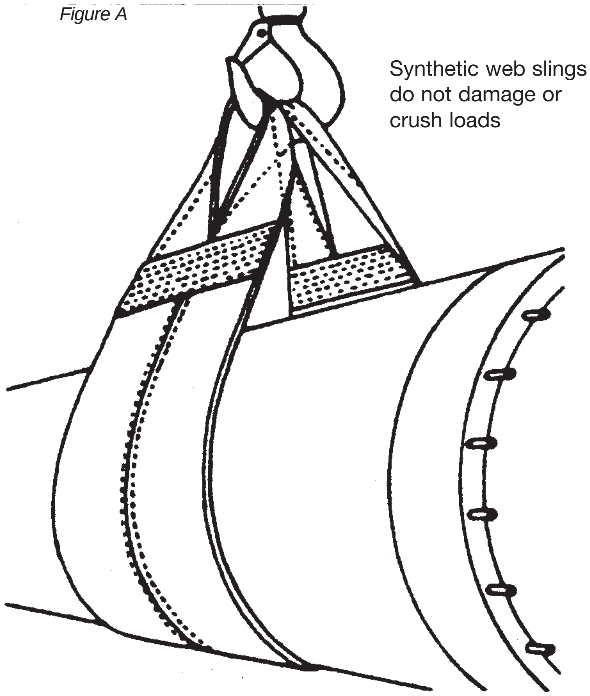
NYLON SLINGS

Polypropylene and Nylon Web Slings	
Chalky exterior appearance	Overexposed to sunlight (UV) rays. Should be checked by manufacturer.
Frayed exterior	Could have been shock-loaded or abraded. Inspect very carefully for signs of damage.
Breaks, tears, or patches	Destroy. Do not use.
Frozen	Thaw and dry at room temperature before use.
Oil contaminated	Destroy.

Synthetic web slings offer a number of advantages for rigging purposes.

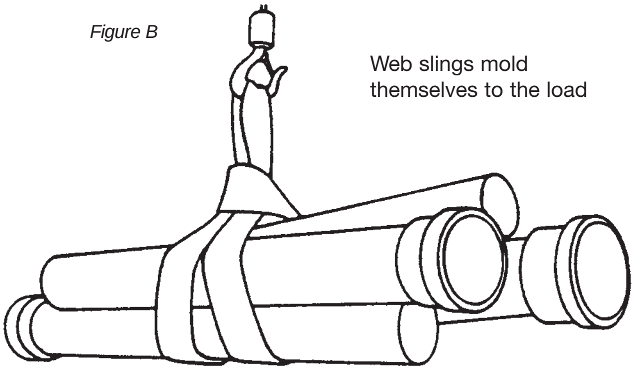
- Their relative softness and width create much less tendency to mar or scratch finely machined, highly polished or painted surfaces and less tendency to crush fragile objects than fibre rope, wire rope or chain slings (Figure A).

Figure A



- Because of their flexibility, they tend to mold themselves to the shape of the load (Figure B).

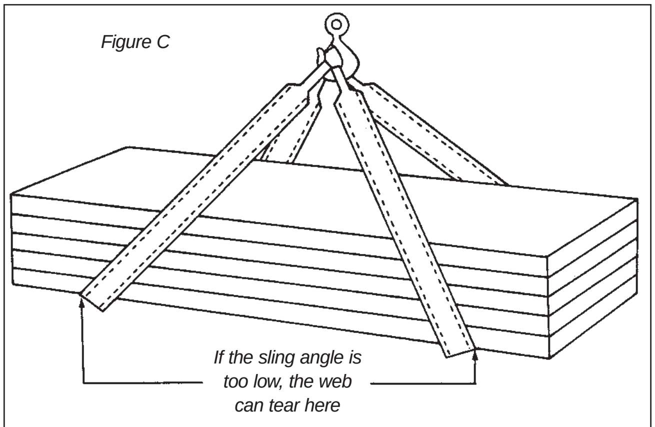
Figure B



The rated capacity of synthetic web slings is based on the tensile strength of the webbing, a design factor of 5 and the fabrication efficiency. Fabrication efficiency accounts for loss of strength in the webbing after it is stitched and otherwise modified during manufacture. Fabrication efficiency is typically 80 to 85% for single-ply slings but will be lower for multi-ply slings and very wide slings.

Although manufacturers provide tables for bridle and basket configurations, these should be used with extreme caution. At low sling angles, one edge of the web will be overloaded and the sling will tend to tear (Figure C).

Figure C



Effect of low sling angle on webbing

Nylon and polyester slings must not be used at temperatures above 90°C (194°F).

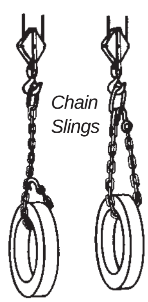
Inspect synthetic web slings regularly. Damage is usually easy to detect. Cuts, holes, tears, frays, broken stitching, worn eyes and worn or distorted fittings, and burns from acid, caustics or heat are immediately evident and signal the need for replacement. Do not attempt repairs yourself.

Synthetic web slings must be labelled to indicate their load rating capacity.

CHAIN SLINGS

Chain Slings Use only alloy steel for overhead lifting.	
Elongated or stretched links	Return to manufacturer for repair.
Failure to hang straight	Return to manufacturer for repair.
Bent, twisted, or cracked links	Return to manufacturer for repair.
Gouges, chips, or scores	Ground out and reduce capacity according to amount of material removed.
Chain repairs are best left to the manufacturer. Chain beyond repair should be cut with torch into short pieces.	

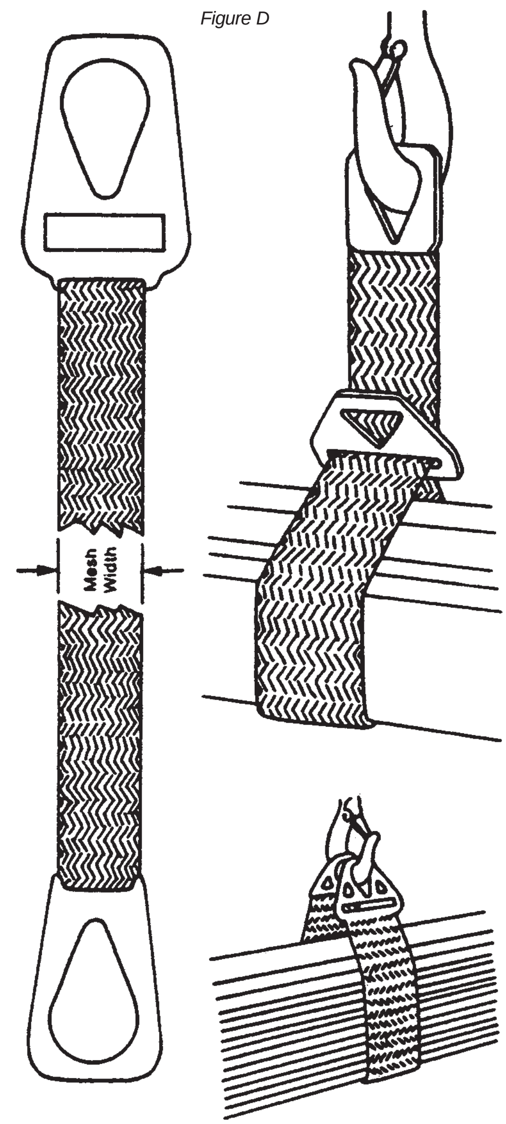
Chain slings are made for abrasion and high temperature resistance. The only chain suitable for lifting is grade 80 or 100 alloy steel chain. Grade 80 chain is marked with an 8, 80, or 800. Grade 100 is marked with a 10, 100, or 1000. The chain must be embossed with this grade marking every 3 feet or 20 links, whichever is shorter – although some manufacturers mark every link. Chain must be padded on sharp corners to prevent bending stresses.



METAL MESH SLINGS

Metal mesh slings, also known as wire or chain mesh slings, are well adapted for use where loads are abrasive, hot or tend to cut fabric slings and wire ropes. They resist abrasion and cutting, grip the load firmly without stretching and can withstand temperatures up to 288°C (550°F). They have smooth, flat bearing surfaces, conform to irregular shapes, do not kink or tangle and resist corrosion (Figure D).

Figure D



Chain mesh slings

For handling loads that would damage the mesh, or for handling loads that the mesh would damage, the slings can be coated with rubber or plastic.

Note that there is no reduction in working load limit for the choker hitch. This is because the hinge action of the mesh prevents any bending of individual wire spirals.

RIGGING HARDWARE

Know what hardware to use, how to use it, and how its working load limit (WLL) compares with the rope or chain used with it.

All fittings must be of adequate strength for the application. Only forged alloy steel load-rated hardware should be used for overhead lifting. Load-rated hardware is stamped with its WLL (Figure 15).

Inspect hardware regularly and before each lift. Telltale signs include

- wear
- cracks
- severe corrosion
- deformation/bends
- mismatched parts
- obvious damage.

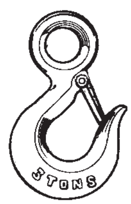
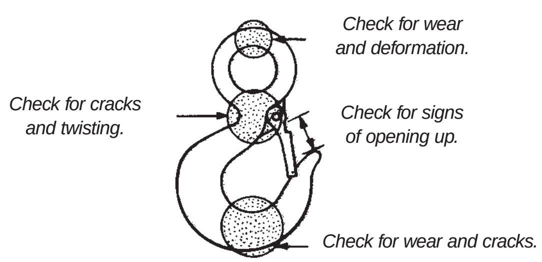


Figure 15



Hook Inspection Areas

Figure 16

Hoisting Hooks

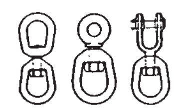
- Should be equipped with safety catches (except for sorting or grab hooks).
- Should be forged alloy steel with WLL stamped or marked on the saddle.
- Should be loaded at the middle of the hook. Applying the load to the tip will load the hook eccentrically and reduce the WLL considerably.
- Should be inspected regularly and often. Look for wear, cracks, corrosion, and twisting—especially at the tip—and check throat for signs of opening up (Figure 16).

Swivels

- Reduce bending loads on rigging attachments by allowing the load to orient itself freely.
- Should be used instead of shackles in situations where the shackle may twist and become eccentrically loaded.
- Can provide approximate capacities shown in Figure 17. See manufacturer's table for the exact WLL of the swivel you are using.

Swivels (All Types)

- Weldless Construction
- Forged Alloy Steel



Stock Diameter (Inches)	Maximum Working Load Limit (Pounds)
1/4	850
5/16	1,250
3/8	2,250
1/2	3,600
5/8	5,200
3/4	7,200
7/8	10,000
1	12,500
1-1/8	15,200
1-1/4	18,000
1-1/2	45,200

Caution: *This table contains sample values for the purposes of illustration only. Refer to the manufacturer of the equipment you're using for precise values.*

Figure 17

Shackles

- Available in various types (Figure 18).
- For hoisting, should be manufactured of forged alloy steel.
- Do not replace shackle pins with bolts (Figure 19). Pins are designed and manufactured to match shackle capacity.

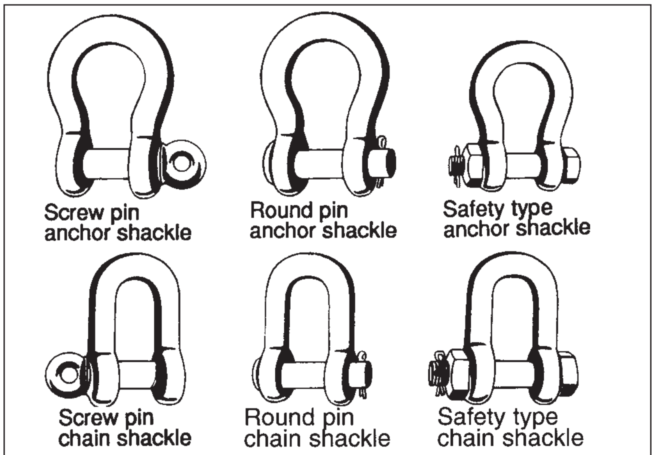


Figure 18

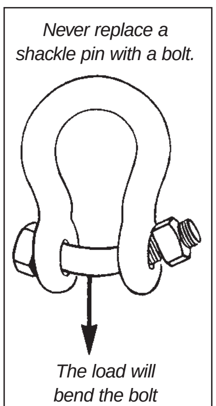


Figure 19

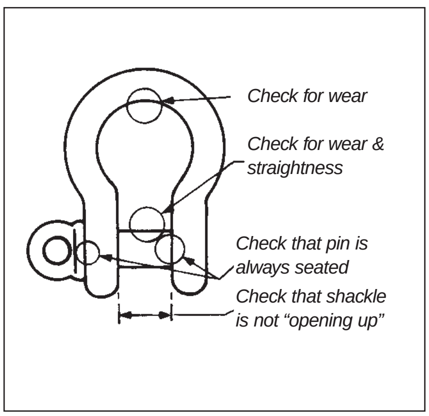


Figure 20

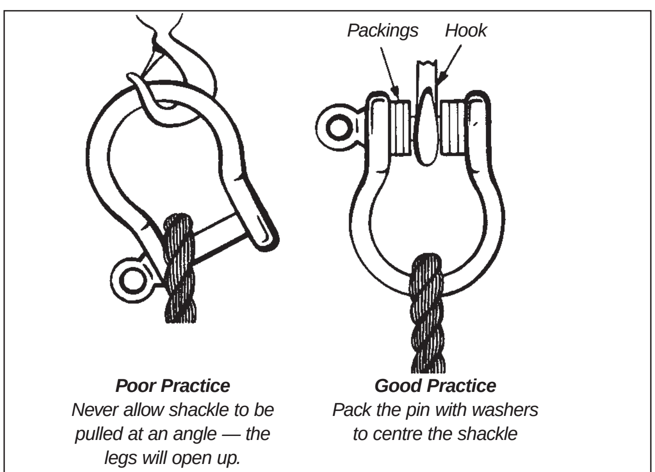


Figure 21

- Check for wear, distortion, and opening up (Figure 20). Check crown regularly for wear. Discard shackles noticeably worn at the crown.
- Do not use a shackle where it will be pulled or loaded at an angle. This severely reduces its capacity and opens up the legs (Figure 21)
- Do not use screw pin shackles if the pin can roll under load and unscrew (Figure 22).

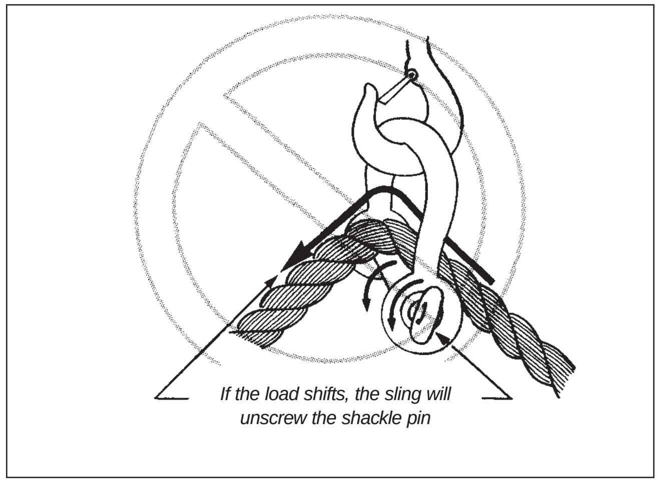


Figure 22

WARNING

Don't run the sling through a hook or shackle. The sling can slide in the hook or shackle and allow an unbalanced load to tip.

Turnbuckles

- Can be supplied with eye end fittings, hook end fittings, jaw end fittings, stub end fittings, and any combination of these (Figure 23).
- Rated loads are based on the outside diameter of the threaded portion of the end fitting and on the type of end fitting. Jaw, eye, and stub types are rated equally; hook types are rated lower.
- Should be weldless alloy steel.
- Lock frames to end fittings on turnbuckles exposed to vibration. This will prevent

turning and loosening. Lock or jam nuts are ineffective and can overload the screw thread. Use wire to prevent turning (Figure 24).

- When tightening a turnbuckle, do not apply more torque than you would to a bolt of equal size.
- Inspect turnbuckles frequently for cracks in end fittings (especially at the neck of the shank), deformed end fittings, deformed and bent rods and bodies, cracks and bends around the internally threaded portion, and signs of thread damage.

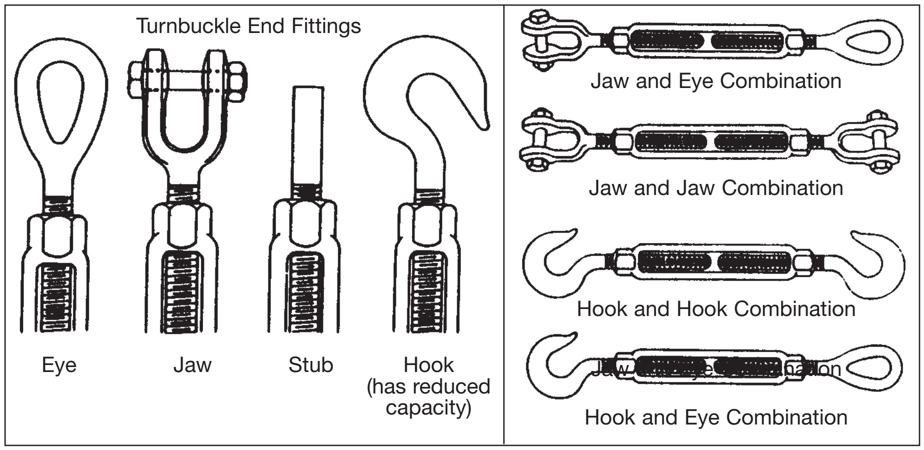


Figure 23

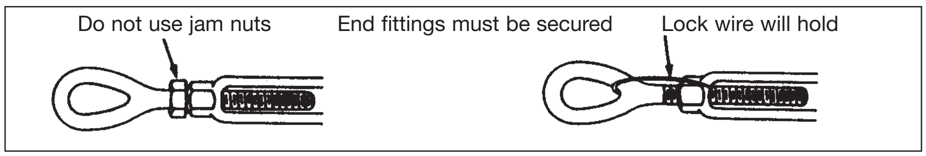
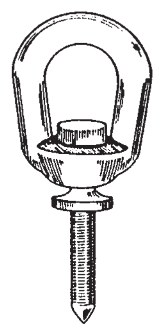


Figure 24

Eye Bolts

- For hoisting, use eye or ring bolts made of forged alloy steel.
- Use bolts with shoulders or collars. Shoulderless bolts are fine for vertical loading but can bend and lose considerable capacity under angle loading (Figure 25). Even with shoulders, eye and ring bolts lose some capacity when loaded on an angle.
- Make sure that bolts are at right angles to hole, make contact with working surface, and have nuts properly torqued (Figure 26).
- Pack bolts with washers when necessary to ensure firm, uniform contact with working surface (Figure 26).


Swivel eye bolt

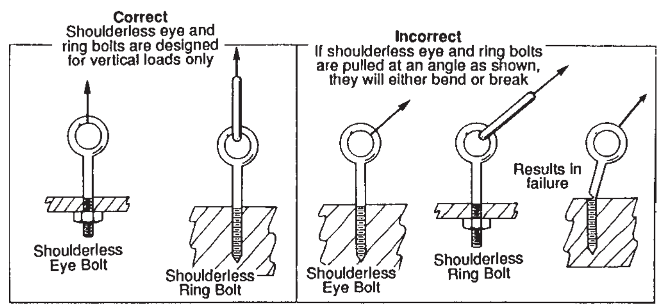


Figure 25

- Make sure that tapped holes for screw bolts are deep enough for uniform grip (Figure 26).
- Apply loads to the plane of the eye, never in the other direction (Figure 27). This is

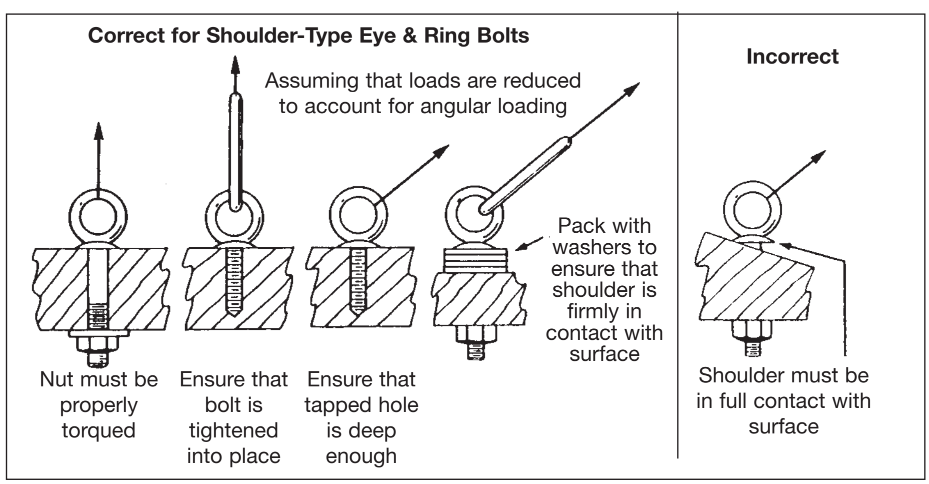


Figure 26

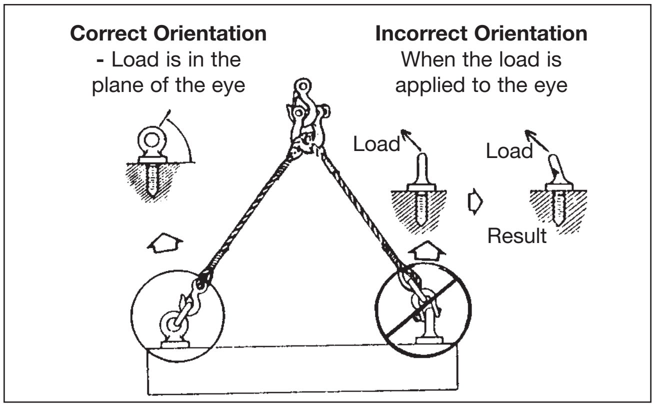


Figure 27

particularly important with bridle slings, which always develop an angular pull in eye bolts unless a spreader bar is used.

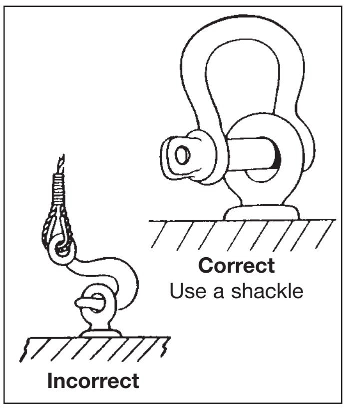


Figure 28

- Never insert the point of a hook in any eye bolt. Use a shackle instead (Figure 28).
- Do not reeve a sling through a pair of bolts. Attach a separate sling to each bolt.

Snatch Blocks

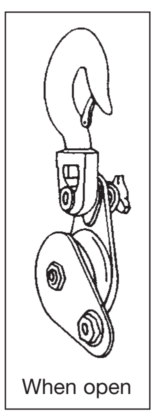


Figure 29

- A single or multi-sheave block that opens on one side so a rope can be slipped over the sheave rather than threaded through the block (Figure 29).
- Available with hook, shackle, eye, and swivel end fittings.
- Normally used when it's necessary to change the direction of pull on a line. Stress on the snatch block varies tremendously with the angle between the lead and load lines. With both lines parallel, 1000 pounds on the lead line results in 2000 pounds on the block, hook, and anchorage. As the angle between the lines increases, the stress is reduced (Figure 30).
- To determine the load on block, hook, and anchorage, multiply the pull on the lead line or the weight of the load being lifted

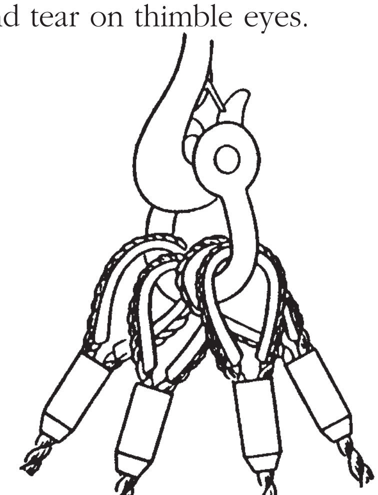
Multiplication Factors for Snatch Block Loads

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

Figure 31

Safety Tip

Whenever two or more ropes are to be placed over a hook, use a shackle to reduce wear and tear on thimble eyes.



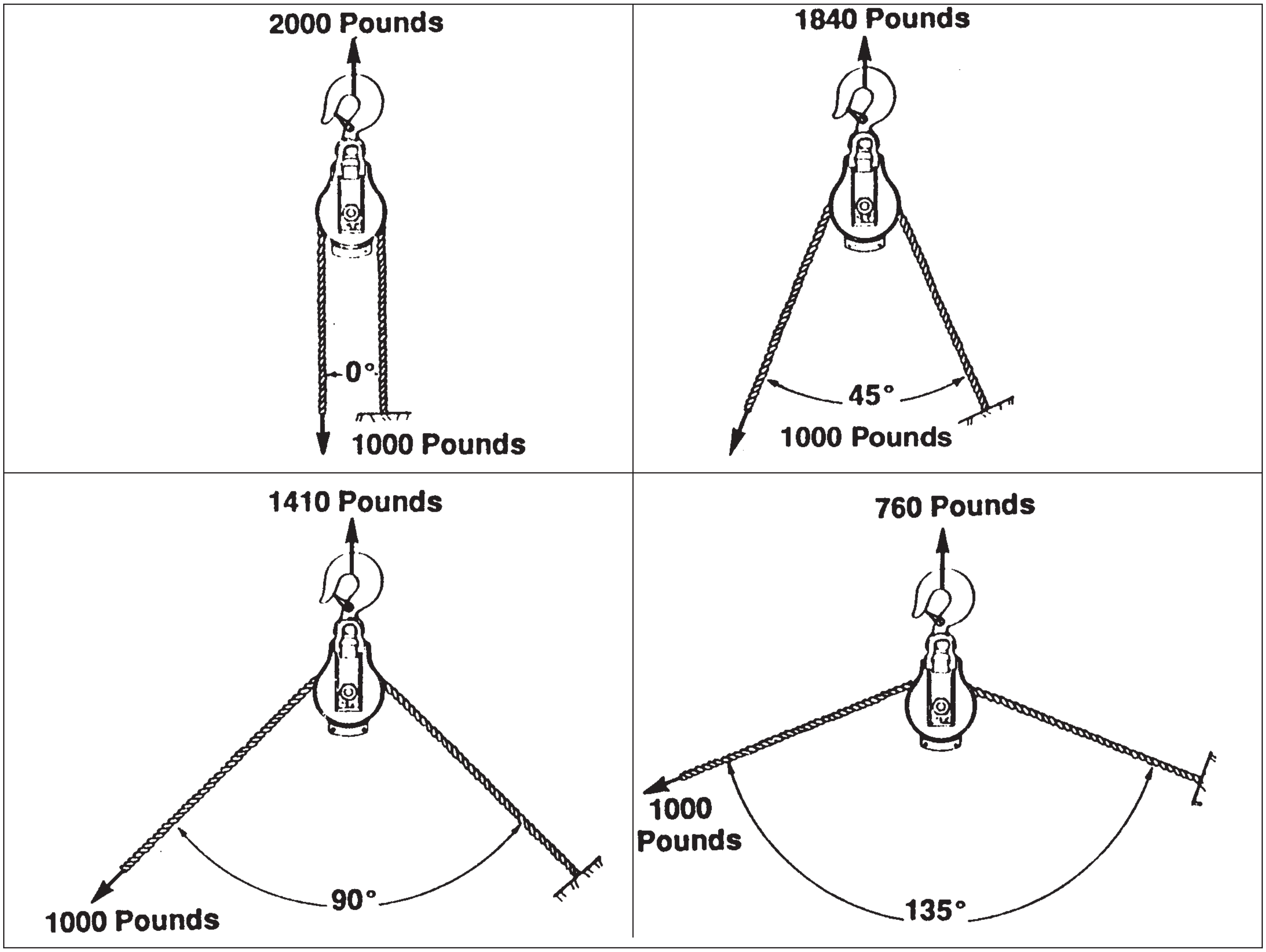


Figure 30

by a suitable factor from the table in Figure 31 and add 10% for sheave friction.

Wire Rope Clips

Wire rope clips are widely used for making end terminations. Clips are available in two basic designs: U-bolt and fist grip.

When using U-bolt clips, make sure you have the right clip. Never stock malleable wire rope clips. They may be inadvertently used for critical heavy-duty applications. Always make certain the U-bolt clips are attached correctly. The U-section must be in contact with the dead end of the rope. Tighten and retighten nuts as required by the manufacturer.

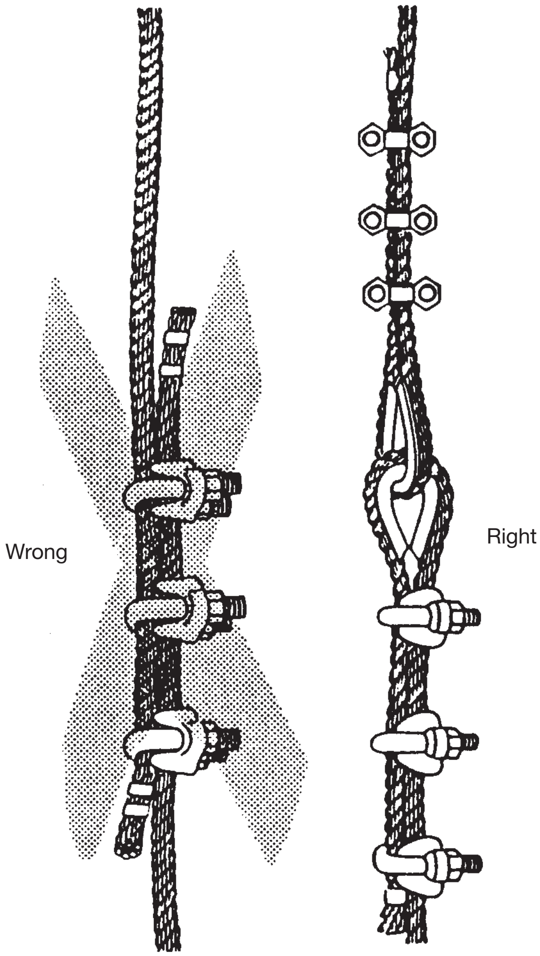
To determine the number of clips and the torque required for specific diameters of rope,

Installation of Wire Rope Clips

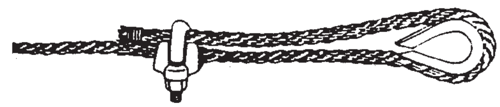
Rope Diameter (Inches)	Minimum Number of Clips	Amount of Rope Turn-back from Thimble (inches)	Torque in Foot-Pounds Unlubricated Bolts
5/16	2	5-1/2	30
3/8	2	6-1/2	45
7/16	2	7	65
1/2	3	11-1/2	65
9/16	3	12	95
5/8	3	12	95
3/4	4	18	130
7/8	4	19	225

Caution: *This table contains sample values for the purposes of illustration only. Refer to the manufacturer of the equipment you're using for precise values.*

Figure 32

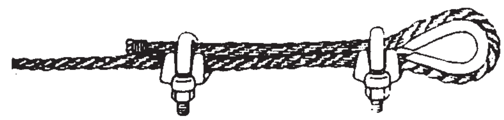


STEP 1



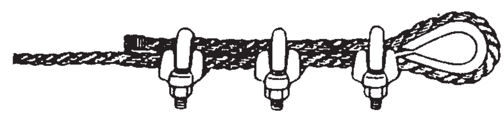
APPLY FIRST CLIP one base width from dead end of wire rope. U-Bolt over dead end. Live end rests in clip saddle. Tighten nuts evenly to recommended torque.

STEP 2



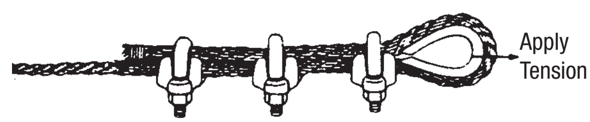
APPLY SECOND CLIP as close to loop as possible. U-Bolt over dead end. Turn nuts firmly but DO NOT TIGHTEN.

STEP 3



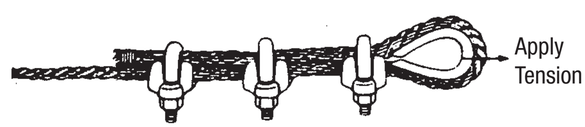
APPLY ALL OTHER CLIPS. Space evenly between first two and 6-7 rope diameters apart.

STEP 4



APPLY TENSION and tighten all nuts to recommended torque.

STEP 5



CHECK NUT TORQUE after rope has been in operation.

Figure 33

refer to Figure 32. For step-by-step instructions on attaching clips, refer to Figure 33.

SLINGS

Slings are often severely worn and abused in construction.

Damage is caused by

- failure to provide blocking or softeners between slings and the load, thereby allowing sharp edges or corners of the load to cut or abrade the slings
- pulling slings out from under loads, leading to abrasion and kinking
- shock loading that increases the stress on slings that may already be overloaded
- traffic running over slings, especially tracked equipment.

Because of these and other conditions, as well as errors in calculating loads and estimating sling angles, it is strongly recommended that working load limits be based on a design factor of at least 5:1.

For the same reasons, slings must be carefully inspected before each use.

Sling Angles

The rated capacity of any sling depends on its size and its design.

Keep sling angles greater than 45° whenever possible.

The use of any sling at an angle lower than 30° is extremely hazardous. This is especially true when an error of only 5° in estimating the sling angle can be so dangerous.

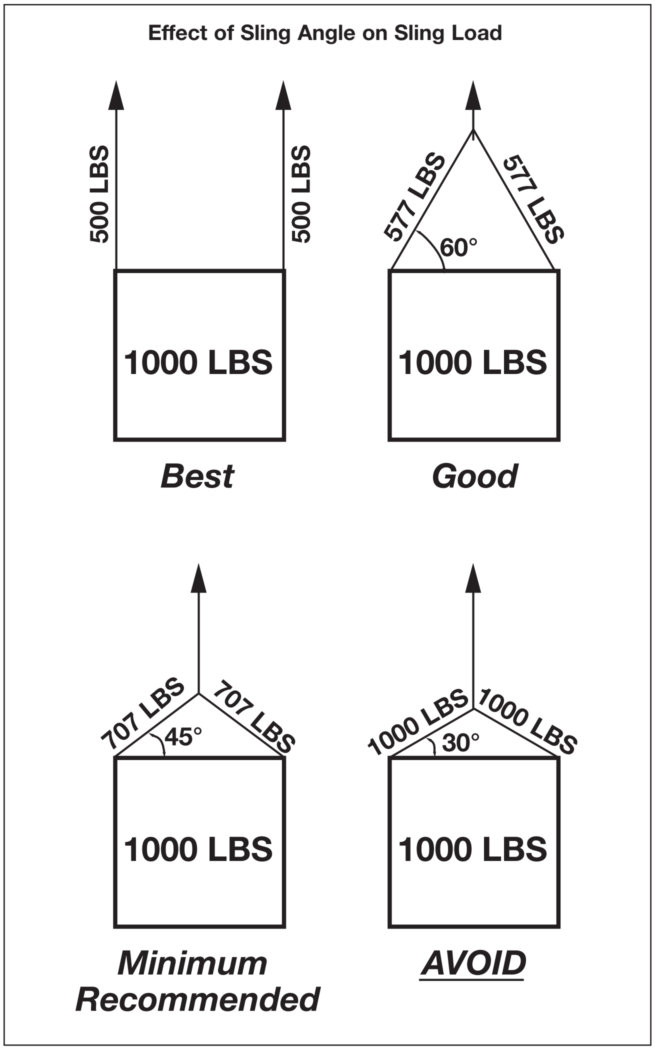


Figure 34

Sling Configurations

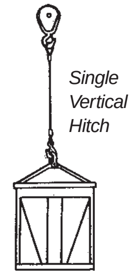
Slings are not only made of various material such as wire rope and nylon web. They are also used in various configurations for different purposes.

Common configurations are shown in the following illustrations.

The term “sling” includes a wide variety of configurations for all fibre ropes, wire ropes, chains, and webs. The most commonly used types in construction are explained here.

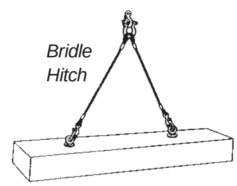
Single Vertical Hitch

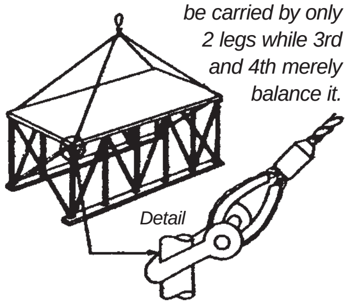
The total weight of the load is carried by a single leg. This configuration must not be used for lifting loose material, long material, or anything difficult to balance. This hitch provides absolutely no control over the load because it permits rotation.



Bridle Hitch

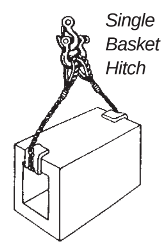
Two, three, or four single hitches can be used together to form a bridle hitch. They provide excellent stability when the load is distributed equally among the legs, when the hook is directly over the centre of gravity of the load, and the load is raised level. The leg length may need adjustment with turnbuckles to distribute the load.





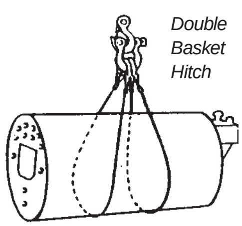
Single Basket Hitch

This hitch is ideal for loads with inherent stabilizing characteristics. The load is automatically equalized, with each leg supporting half the load. Do not use on loads that are difficult to balance because the load can tilt and slip out of the sling.

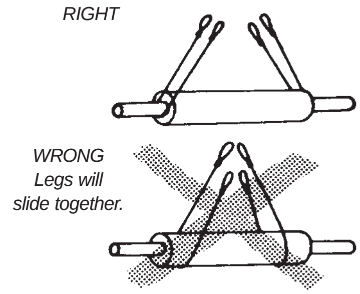


Double Basket Hitch

Consists of two single basket hitches passed under the load. The legs of the hitches must be kept far enough apart to provide balance without opening excessive sling angles.

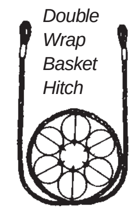


On smooth surfaces, the basket hitch should be snubbed against a step or change of contour to prevent the rope from slipping as the load is applied. The angle between the load and the sling should be approximately 60 degrees or greater to avoid slippage.



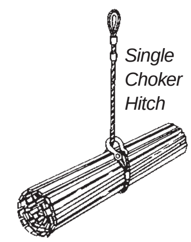
Double Wrap Basket Hitch

A basket hitch that is wrapped completely around the load. This method is excellent for handling loose materials, pipes, rods, or smooth cylindrical loads because the rope or chain exerts a full 360-degree contact with load and tends to draw it together.



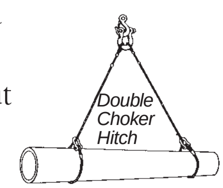
Single Choker Hitch

This forms a noose in the rope and tightens as the load is lifted. It does not provide full contact and must not be used to lift loose bundles or loads difficult to balance.



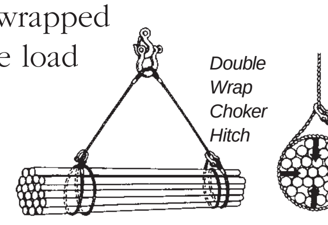
Double Choker Hitch

Consists of two single chokers attached to the load and spread to provide load stability. Does not grip the load completely but can balance the load. Can be used for handling loose bundles.

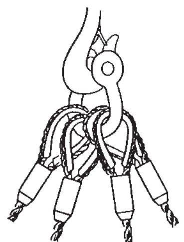


Double Wrap Choker Hitch

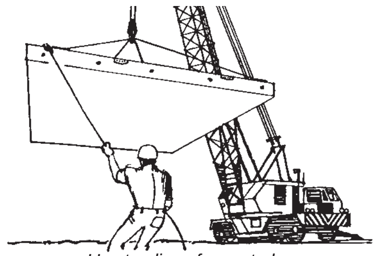
The rope or chain is wrapped completely around the load before being hooked into the vertical part of the sling. Makes full contact with load and tends to draw it together.



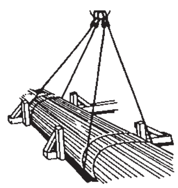
Rigging Safety Tips



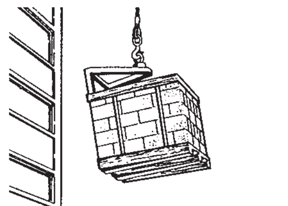
With two or more slings on a hook, use a shackle.



Use tag lines for control.



Block loose loads before unhooking.



Make sure loads are secure.

WORKING LOAD LIMITS

Tables

Working load limits (WLLs) for slings can be obtained from manufacturers' tables such as those in Figures 35 and 36 (one type of wire rope sling).

Rules

There are general rules for estimating the WLLs of common sling configurations. Each rule for a given configuration, material, and size is based on the WLL of that sling in a single vertical hitch.

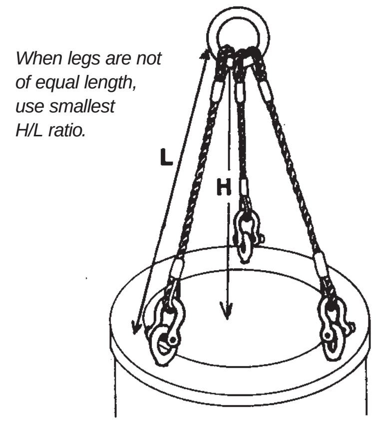
Bridle Hitches (2, 3, and 4 leg) — Measure the length of the sling legs (L) and measure the head room between the hook and the load (H).

WLL = WLL (of single vertical hitch) x H/L x 2 for a two-leg hitch

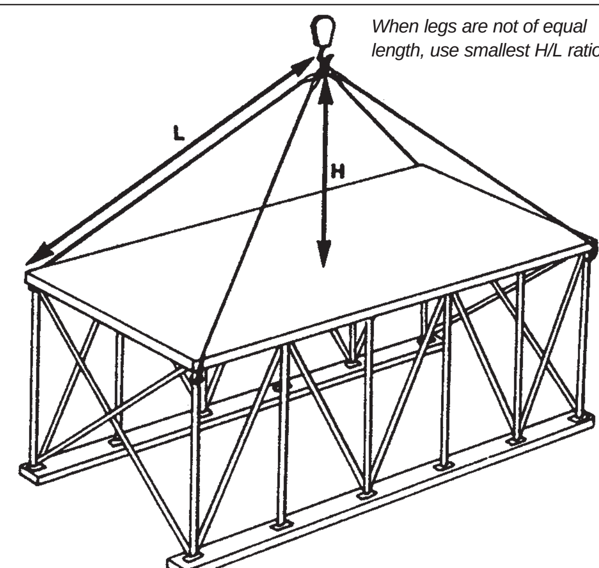
3- and 4-Leg Bridle Hitches

WLL = WLL (of single vertical hitch) x H/L x 3

Generally, 4-leg and 3-leg bridle hitches should be rated as 2-leg hitches because there is no way of knowing that all legs are sharing the load. It is possible for only 2 legs to carry the load while the others merely balance it.



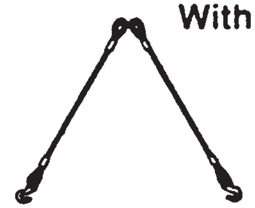
WLL = WLL (of single vertical hitch) x H/L x 2



Note: Load may be carried by only 2 legs while third and fourth legs merely balance it. Therefore: WLL = WLL (of single vertical hitch) x H/L x 2

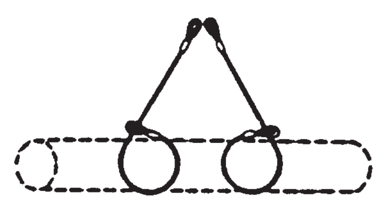
Determining capacity of 4-leg bridle hitch

WIRE ROPE SLINGS
6 x 19 Classification Group, Improved Plow Steel, Fibre Core

Rope Diameter (Inches)	MAXIMUM WORKING LOAD LIMITS – POUNDS (Design Factor = 5)					
	Single Vertical Hitch 	Single Choker Hitch 	Single Basket Hitch (Vertical Legs) 	2-Leg Bridle Hitch & Single Basket Hitch With Legs Inclined  		
				60°	45°	30°
3/16	600	450	1,200	1,050	850	600
1/4	1,100	825	2,200	1,900	1,550	1,100
5/16	1,650	1,250	3,300	2,850	2,350	1,650
3/8	2,400	1,800	4,800	4,150	3,400	2,400
7/16	3,200	2,400	6,400	5,550	4,500	3,200
1/2	4,400	3,300	8,800	7,600	6,200	4,400
9/16	5,300	4,000	10,600	9,200	7,500	5,300
5/8	6,600	4,950	13,200	11,400	9,350	6,600
3/4	9,500	7,100	19,000	16,500	13,400	9,500
7/8	12,800	9,600	25,600	22,200	18,100	12,800

NOTE: Table values are for slings with eyes and thimbles in both ends, Flemish spliced eyes, and mechanical sleeves.

If used with Choker Hitch multiply above values by 3/4.



Caution: *This table contains sample values for the purposes of illustration only. Refer to the manufacturer of the equipment you're using for precise values.*

Figure 35

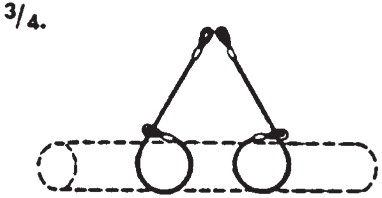
WIRE ROPE SLINGS

6 x 19 Classification Group, Improved Plow Steel, Fibre Core

Rope Diameter (Inches)	MAXIMUM WORKING LOAD LIMITS – POUNDS (Design Factor = 5)					
	Single Vertical Hitch	Single Choker Hitch	Single Basket Hitch (Vertical Legs)	2-Leg Bridle Hitch & Single Basket Hitch With Legs Inclined		
				60°	45°	30°
1	16,700	12,500	33,400	28,900	23,600	16,700
$1\frac{1}{8}$	21,200	15,900	42,400	36,700	30,000	21,200
$1\frac{1}{4}$	26,200	19,700	52,400	45,400	37,000	26,200
$1\frac{3}{8}$	32,400	24,300	64,800	56,100	45,800	32,400
$1\frac{1}{2}$	38,400	28,800	76,800	66,500	54,300	38,400
$1\frac{5}{8}$	45,200	33,900	90,400	78,300	63,900	45,200
$1\frac{3}{4}$	52,000	39,000	104,000	90,000	73,500	52,000
$1\frac{7}{8}$	60,800	45,600	121,600	105,300	86,000	60,800
2	67,600	50,700	135,200	117,100	95,600	67,600
$2\frac{1}{4}$	84,000	63,000	168,000	145,500	118,800	84,000
$2\frac{1}{2}$	104,000	78,000	208,000	180,100	147,000	104,000
$2\frac{3}{4}$	122,000	91,500	244,000	211,300	172,500	122,000

NOTE: Table values are for slings with eyes and thimbles in both ends, Flemish spliced eyes, and mechanical sleeves.

If used with Choker Hitch multiply above values by $\frac{3}{4}$.



Caution: *This table contains sample values for the purposes of illustration only. Refer to the manufacturer of the equipment you're using for precise values.*

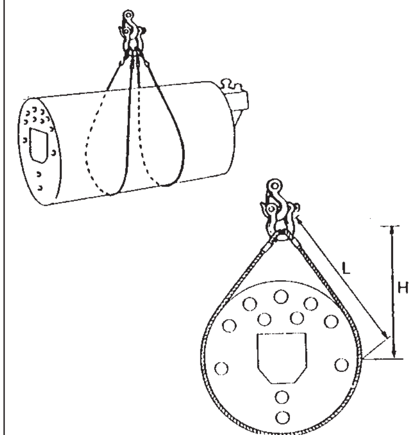
Figure 36

Single Basket Hitch

For vertical legs: WLL = WLL (of Single Vertical Hitch) x 2.
For inclined legs: WLL = WLL (of Single Vertical Hitch) x $\frac{H}{L}$ x 2.

Double Basket Hitch Figure 37

For vertical legs: WLL = WLL (of Single Vertical Hitch) x 4.
For inclined legs: WLL = WLL (of Single Vertical Hitch) x $\frac{H}{L}$ x 4.



WLL = WLL (of single vertical hitch) x H/L x 4

Figure 37

Double Wrap Basket Hitch

Depending on the configurations, the WLLs are the same as for the Single Basket Hitch or the Double Basket Hitch.

Single Choker Hitch Figure 38

For sling angles of 45° or more.
WLL = WLL (of Single Vertical Hitch) x 3/4.
Sling angles of less than 45° are not recommended.

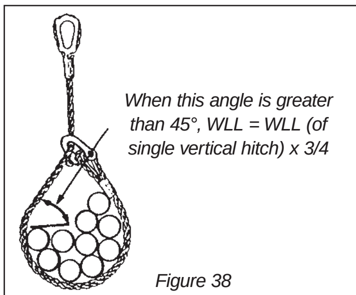


Figure 38

Double Choker Hitch Figure 39

For sling angles of 45° or more (formed by the choker).
WLL = WLL (of Single Vertical Hitch) x 3/4 x H/L x 2
Sling angles of less than 45° (formed by the choker) are not recommended.

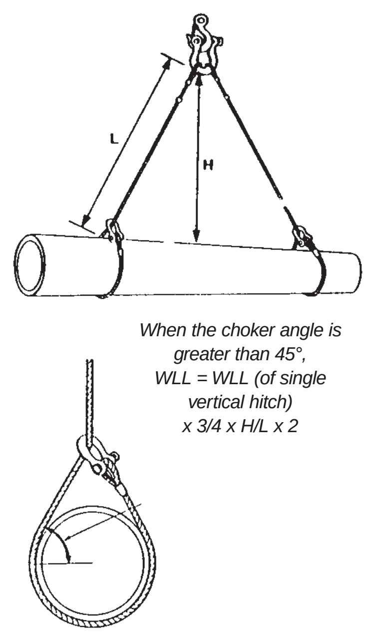


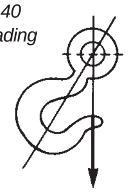
Figure 39

HOISTING TIPS

- Never wrap a wire rope sling completely around a hook. The tight radius will damage the sling.
- Make sure the load is balanced in the hook. Eccentric loading can reduce capacity dangerously.
- Never point-load a hook unless it is

designed and rated for such use. Point-loading can cut capacity by more than half (Figure 40).

Figure 40
Point Loading



Capacity Severely Reduced

- Never wrap the crane hoist rope around the load. Attach the load to the crane hook by slings or other rigging devices.
- Avoid bending wire rope slings near attached fittings or at eye sections.
- The hoist line must be plumb at all times.
- Know the standard hand signals for hoisting (Figure 41).

HAND SIGNALS FOR HOISTING OPERATIONS

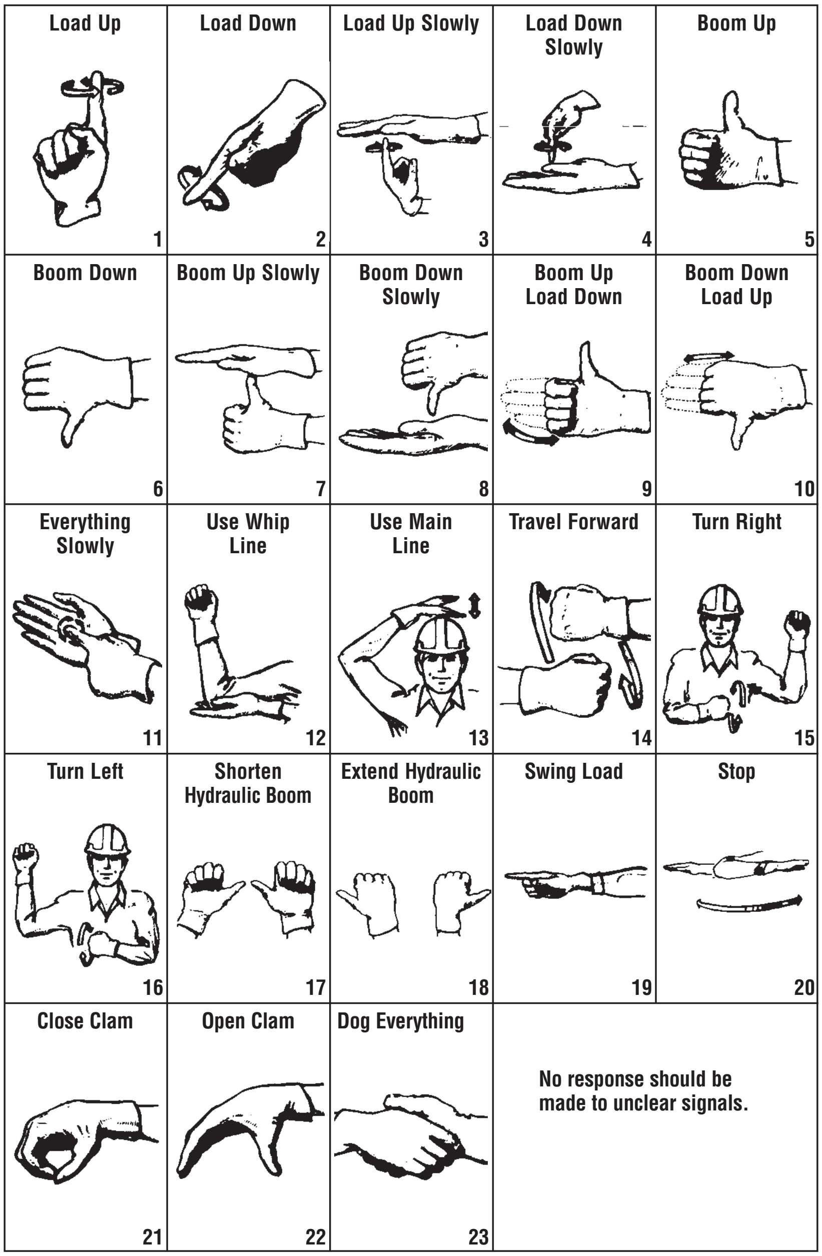


Figure 41