CHAPTER 3

Hoists

Section I. Chains and Hooks

Chains are much more resistant to abrasion and corrosion than wire rope; use them where this type of deterioration is a problem, as in marine work where anchor gear must withstand the corrosive effects of seawater. You can also use chains to lift heavy objects with sharp edges that would cut wire.

In lifting, chains, as well as fiber ropes or wire ropes, can be tied to the load. But for speed and convenience, it is much better to fasten a hook to the end of the lifting line. Also, you can use hooks are in constructing blocks.

CHAINS

Chains are made up of a series of links fastened through each other. Each link is made of a rod of wire bent into an oval shape and welded at one or two points. The weld ordinarily causes a slight bulge on the side or end of the link (see *Figure 3-1).* The chain size refers to the diameter, in inches, of the rod used to make the link. Chains usually stretch under excessive loading so that the individual links bend slightly. Bent links are a warning that the chain has been overloaded and might fail suddenly under a load. Wire rope, on the other hand, fails a strand at a time, giving warning before complete failure occurs. If a chain is equipped with the proper hook, the hook should start to fail first, indicating that the chain is overloaded.

Several grades and types of chains are available.

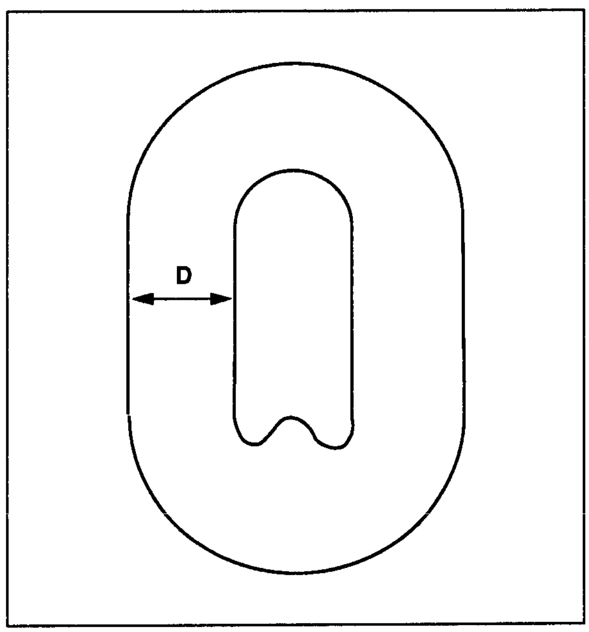

Figure 3-1. Link thickness

STRENGTH OF CHAINS

To determine the SWC on a chain, apply a FS to the breaking strength. The SWC ordinarily is assumed to be about one-sixth of the BS, giving a FS of 6. *Table 3-1* lists SWC for various chains. You can approximate the SWC of an open-link chain by using the following rule of thumb:

SWC = $8D^2$

SWC = Safe working capacity, in tons

D = Smallest link thickness or least diameter measured in inches (see Figure 3-1, page 3-1)

Example: Using the rule of thumb, the SWC of a chain with a link thickness of 3/4 inch is—

SWC = $8D^2 = 8\ (3/4)^2 = 4.5$ *tons or* 9,000 *pounds*

The figures given assume that the load is applied in a straight pull rather than by an impact. An impact load occurs when an object is dropped suddenly for a distance and stopped. The impact load in such a case is several times the weight of the load.

CARE OF CHAINS

When hoisting heavy metal objects using chains for slings, insert padding around the sharp corners of the load to protect the

Table 3-1. Properties of chains (FS 6)

Size*	Approximate Weight per Linear Foot (pounds)	SWC (pounds)			
		Common Iron	High-Grade Iron	Soft Steel	Special Steel
1/4	0.8	512	563	619	1,240
3/8	1.7	1,350	1,490	1,650	3,200
1/2	2.5	2,250	2,480	2,630	5,250
5/8	4.3	3,470	3,810	4,230	7,600
3/4	5.8	5,070	5,580	6,000	10,500
7/8	8.0	7,000	7,700	8,250	14,330
1	10.7	9,300	10,230	10,600	18,200
11/8	12.5	9,871	10,858	11,944	21,500
11/4	16.0	12,186	13,304	14,634	26,300
13/8	18.3	14,717	16,188	17,807	32,051

*Size listed is the diameter, in inches, of one side of a link.

chain links from being cut. The padding may be either planks or heavy fabric. Do not permit chains to twist or kink when under strain. Never fasten chain links chain together with bolts or wire because such connections weaken the chain and limit its SWC. Cut worn or damaged links out of the chain and replace them with a cold-shut link. Close the cold-shut link and weld it to equal the strength of the other links. Cut the smaller chain links with a bolt cutter; cut large chain links with a hack-saw or an oxyacetylene torch. Inspect the chains frequently, depending on the amount of use. Do not paint chains to prevent rusting because the paint will interfere with the action of the links. Instead, apply a light coat of lubricant and store them in a dry and well-ventilated place.

HOOKS

The two general types of hooks available are the slip hook and the grab hook (see *Figure 3-2*). Slip hooks are made so that the inside curve of the hook is an arc of a circle and may be used with wire rope. chains. or fiber rope. Chain links can slip through a slip hook so the loop formed in the chain will tighten under a load. Grab hooks have an inside curve that is nearly U-shaped so that the hook will slip over a link of chain edgeways but will not permit the next link to slip through. Grab hooks have a more limited range of use than slip hooks. They are used on chains when the loop formed with the hook is not intended to close up around the load.

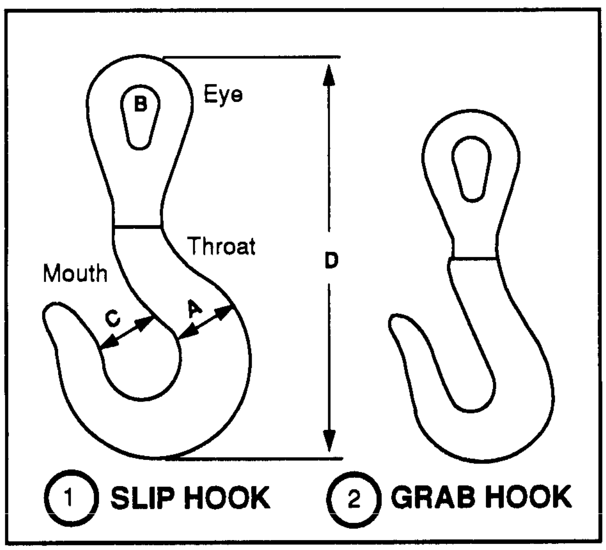

Figure 3-2. Types of hooks

STRENGTH OF HOOKS

Hooks usually fail by straightening. Any deviation from the original inner arc indicates that the hook has been overloaded. Since you can easily detect evidence of overloading the hook. you should use a hook that is weaker than the chain to which it is attached. With this system. hook distortion will occur before the chain is overloaded. Discard severely distorted. cracked. or badly worn hooks because they are dangerous. *Table 3-2. page 3-4.* lists SWCs on hooks. Approximate the SWC of a hook by using the following rule of thumb:

$SWC = D^2$

D = the diameter in inches of the hook where the inside of the hook starts its arc (see Figure 3-3. page 3-5)

Thus. the SWC of a hook with a diameter of 1 1/4 inches is as follows:

$SWC = D^2 = (1\ 1/4)^2$ *16 tons or 3,125 pounds*

MOUSING OF HOOKS

In general. always “mouse” a hook as a safety measure to prevent slings or ropes from jumping off. To mouse a hook after the sling is on the hook. wrap the wire or heavy twine 8 or 10 turns around the two sides of the hook (see *Figure 3-4. page 3-5).*

Table 3-2. Safe loads on hooks

Diameter of Metal A* (inches)	Inside Diameter of Eye B (inches)	Width of Opening C (inches)	Length of Hook D (inches)	SWC of Hooks, (pounds)
11/16	1/8	1 1/16	4 15/16	1,200
3/4	1	1 1/3	5 13/32	1,400
7/8	1 1/8	1 1/4	6 1/4	2,400
1	1 1/4	1 3/8	6 7/8	3,400
1 1/8	1 3/8	1 1/2	7 5/8	4,200
1 1/4	1 1/2	1 11/16	8 19/32	5,000
1 3/8	1 5/8	1 7/8	9 1/2	6,000
1 1/2	1 3/4	2 1/16	10 11/32	8,000
1 5/8	2	2 1/4	11 21/32	9,400
1 7/8	2 3/8	2 1/2	13 9/32	11,000
2 1/4	2 3/4	3	14 13/16	13,600
2 5/8	3 1/8	3 3/8	16 1/2	17,000
3	3 1/2	4	19 3/4	24,000

*For reference to A, B, C, or D, *see Figure 3-2.*

Complete the process by winding several turns of the wire or twine around the sides of the mousing and tying the ends securely. Mousing also helps prevent straightening of the hook but does not strengthen it materially.

INSPECTING CHAINS AND HOOKS

Inspect chains, including the hooks, at least once a month; inspect those that are used for heavy and continuous loading more frequently. Give particular attention to the small radius fillets at the neck of hooks for any deviation from the original inner arc. Examine each link and hook for small dents and cracks, sharp nicks or cuts, worn surfaces, and distortions. Replace those that show any of these weaknesses. If several links are stretched or distorted, do not use the chain; it probably was overloaded or hooked improperly, which weakened the entire chain.

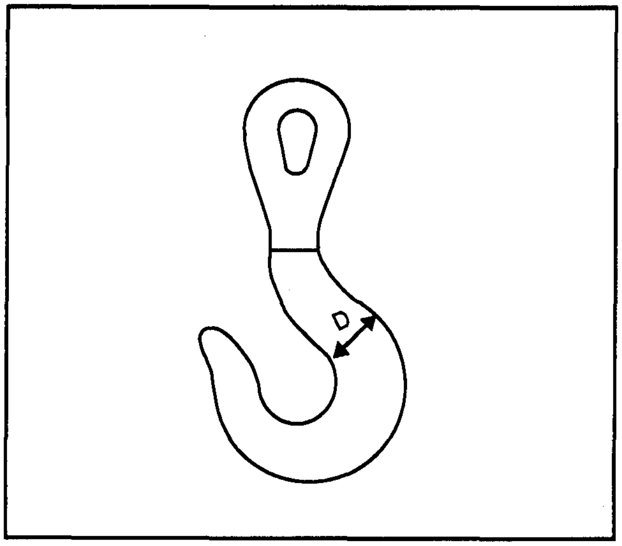

Figure 3-3. Hook thickness (diameter)

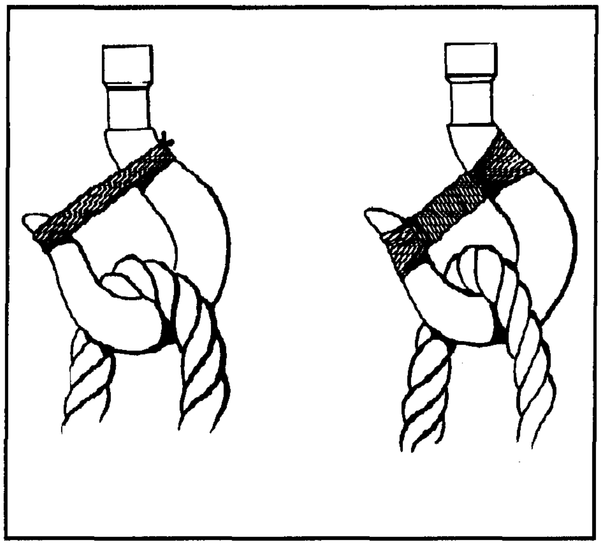

Figure 3-4. Mousing hooks

Section II. Slings

The term "sling" includes a wide variety of designs. Slings may be made of fiber rope, wire rope, or chain.

Fiber rope makes good slings because of its flexibility, but it is more easily damaged by sharp edges on the material hoisted than are wire rope or chain slings. Fiber-rope slings are used for lifting comparatively light loads and for temporary jobs.

Wire rope is widely used for slings because it has a combination of strength and flexibility. Properly designed and appropriately fabricated wire-rope slings are the safest type of slings. They do not wear away as do slings made of fiber rope, nor do they lose their strength from exposure as rapidly. They also are not susceptible to the "weakest link" condition of chains caused by the uncertainty of the strengths of the welds. The appearance of broken wires clearly indicates the fatigue of the metal and the end of the usefulness of the sling.

Chain slings are used especially where sharp edges of metal would cut wire rope or where very hot items are lifted, as in foundries or blacksmith shops.

Barrel slings can be made with fiber rope to hold barrels horizontally or vertically.

TYPES OF SLINGS

The sling for lifting a given load may be—

- An endless sling.
- A single sling.
- A combination sling (several single slings used together).

Each type or combination has its particular advantages that must be considered when selecting a sling for a given purpose.

ENDLESS SLINGS

The endless sling is made by splicing the ends of a piece of wire rope or fiber rope together or by inserting a cold-shut link in a chain. Cold-shut links should be welded after insertion in the chain. These endless slings are simple to handle and may be used in several different ways to lift loads (see *Figure 3-5, page 3-6).*

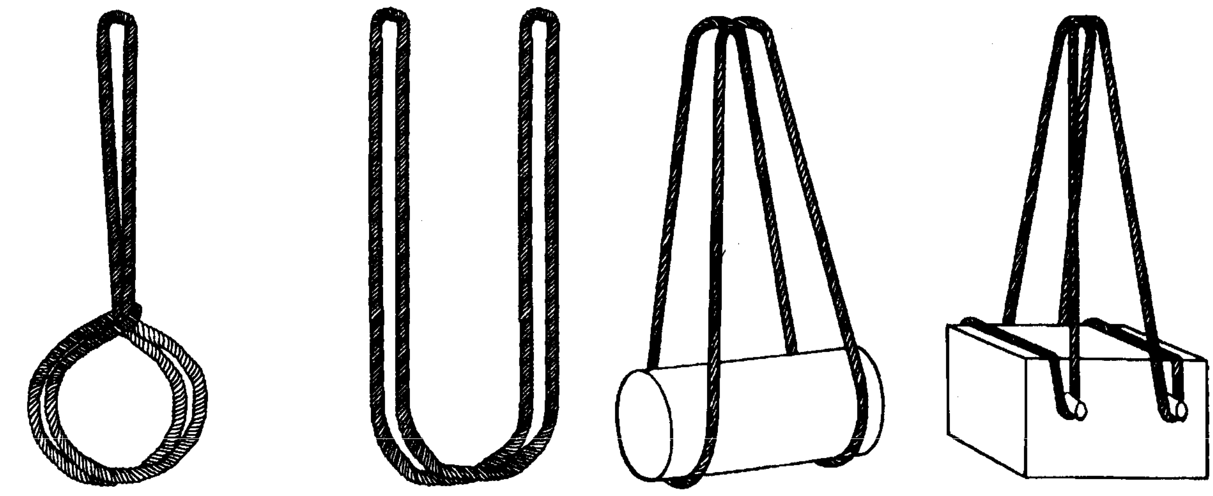

Figure 3-5. Endless slings

Choker or Anchor Hitch

A common method of using an endless sling is to cast the sling under the load to be lifted and insert one loop through the other and over the hoisting hook. When the hoisting hook is raised, one side of the choker hitch is forced down against the load by the strain on the other side, forming a tight grip on the load.

Basket Hitch

With this hitch, the endless sling is passed around the object to be lifted and both remaining loops are slipped over the hook.

Inverted Basket Hitch

This hitch is very much like the simple basket hitch except that the two parts of the sling going under the load are spread wide apart.

Toggle Hitch

The toggle hitch is used only for special applications. It is actually a modification of the inverted basket hitch except that the line passes around toggles fastened to the load rather than going around the load itself.

SINGLE SLINGS

A single sling can be made of wire rope, fiber rope, or chain. Each end of a single sling is made into an eye or has an attached hook (see *Figure 3-6).* In some instances, the ends of a wire rope are spliced into the eyes that are around the thimbles, and one eye is fastened to a hook with a shackle. With this type of single sling, you can remove the shackle and hook when desired. You can use a single sling in several different ways for hoisting (see *Figure 3-6).* It is advisable to have four single slings of wire rope available at all times. These can be used singly or in combination, as necessary.

Choker or Anchor Hitch

A choker or anchor hitch is a single sling that is used for hoisting by passing one eye

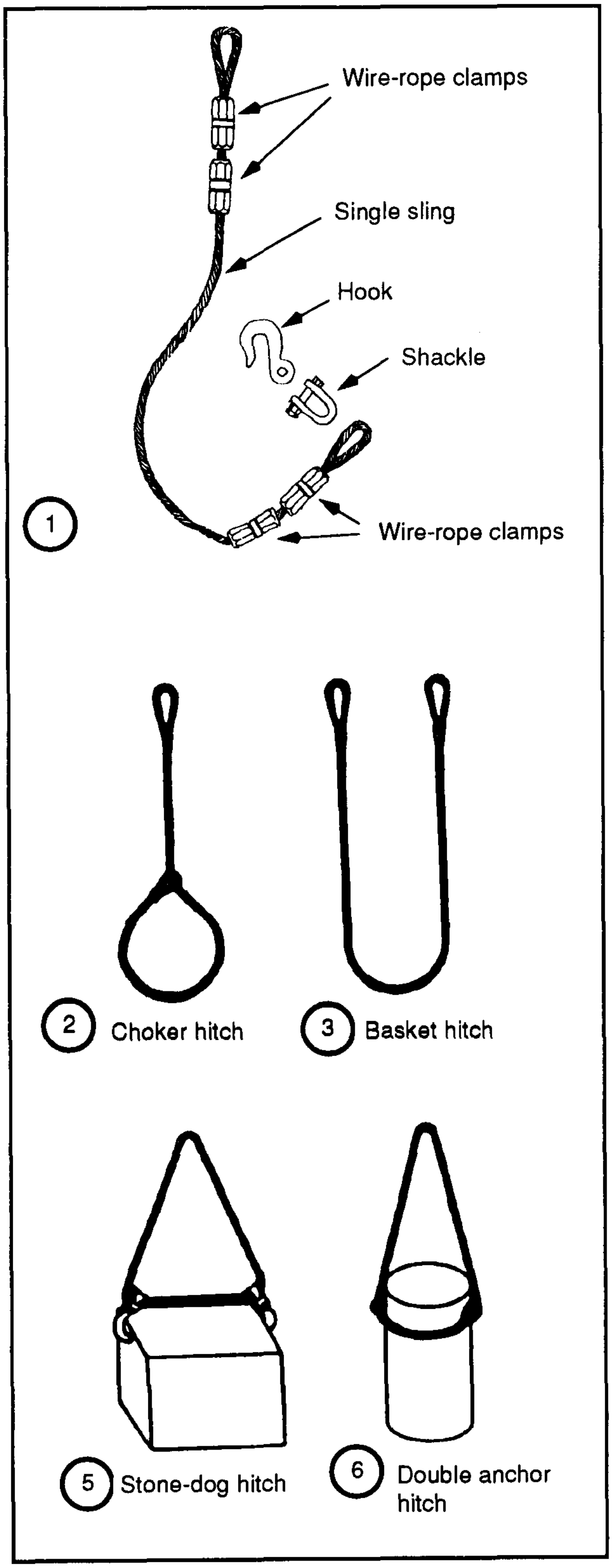

Figure 3-6. Single slings

through the other eye and over the hoisting hook. A choker hitch will tighten down against the load when a strain is placed on the sling.

Basket Hitch

A basket hitch is a single sling that is passed under the load with both ends hooked over the hoisting hook.

Stone-Dog Hitch

A stone-dog hitch is single slings with two hooks that are used for lifting stone.

Double Anchor Hitch

This hitch is used for hoisting drums or other cylindrical objects where it is necessary for the sling to tighten itself under strain and lift by friction against the sides of the cylinder.

COMBINATION SLINGS

Single slings can be combined into bridle slings, basket slings, and choker slings to lift virtually any type of load. Either two or four single slings can be used in a given combination. Where greater length is required, two of the single slings can be combined into a longer single sling. One of the problems in lifting heavy loads is in fastening the bottom of the sling legs to the load in such a way that the load will not be damaged. Lifting eyes are fastened to many pieces of equipment at the time it is manufactured. On large crates or boxes, the sling legs may be passed under the object to form a gasket sling. A hook can be fastened to the eye on one end of each sling leg to permit easier fastening on some loads. Where the load being lifted is heavy enough or awkward enough, a four-leg sling may be required. If a still greater length of sling is required, two additional slings can be used in conjunction with the four-leg sling to form a double basket.

PALLETS

A problem in hoisting and moving loads sometimes occurs when the items to be lifted are packaged in small boxes and the individual boxes are not crated. In this case, it is entirely too slow to pick up each small box and move it separately. Pallets, used in combination with slings, provide an efficient method of handling such loads. The pallets can be made up readily on the job out of 2- by 8-inch timbers that are 6 or 8 feet long and are nailed to three or four heavy cross members, such as 4- by 8-inch timbers. Several pallets should be made up so that one pallet can be loaded while the pallet previously loaded is being hoisted. As each pallet is unloaded, the next return trip of the hoist takes the empty pallet back for loading.

SPREADERS

Occasionally, it is necessary to hoist loads that are not protected sufficiently to prevent crushing by the sling legs. In such cases, spreaders may be used with the slings (see *Figure* 3-7). Spreaders are short bars or pipes with eyes on each end. The sling leg passes through the eye down to its connection with the load. By setting spreaders in the sling legs above the top of the load, the angle of the sling leg is changed so that crushing of the load is prevented. Changing the angle of the sling leg may increase the stress in that portion of the sling leg above the spreaders. The determining factor in computing the safe lifting capacity of the sling is the stress (or tension) in the sling leg above the spreader.

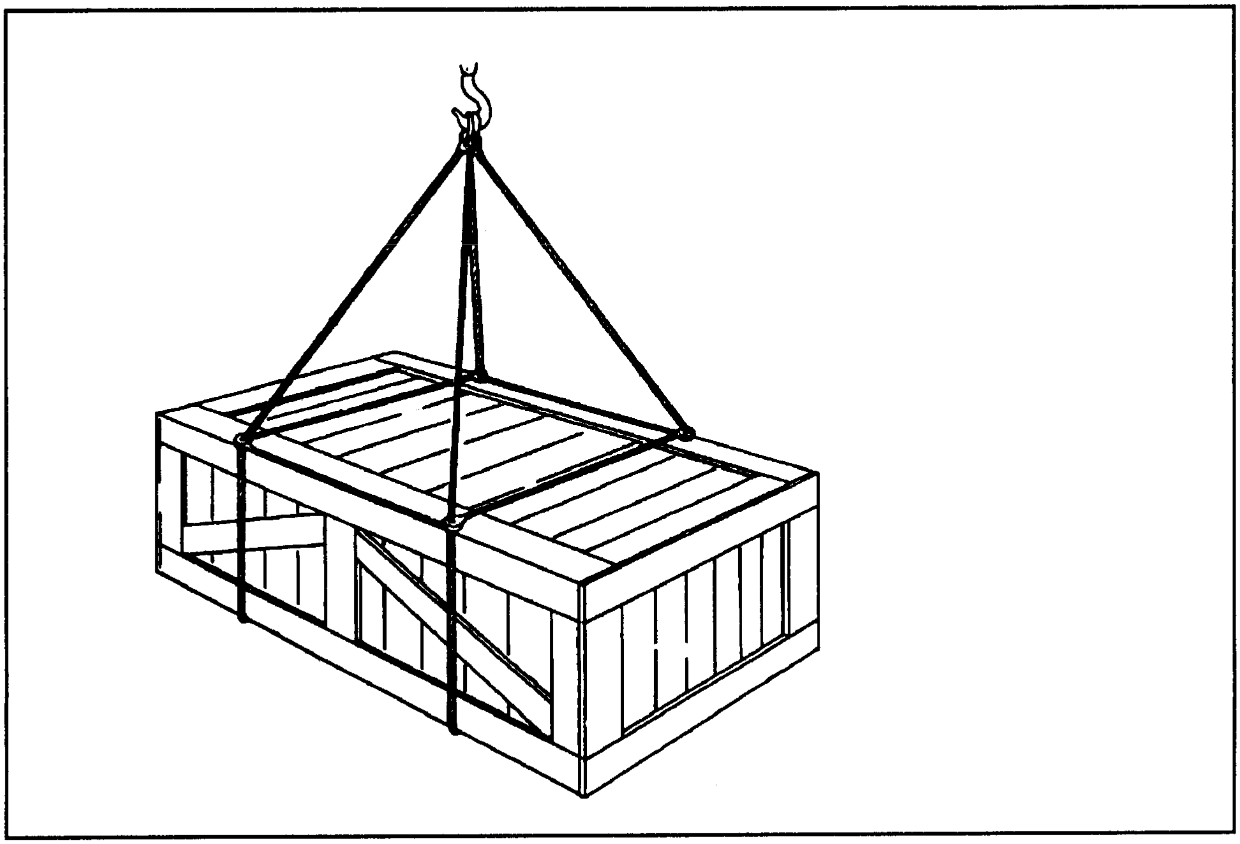

Figure 3-7. Use of spreaders in slings

STRESSES

Tables 3-3 through 3-5, pages 3-10 through 3-12, list the SWCs of ropes, chains, and wire-rope slings under various conditions. The angle of the legs of a sling must be considered as well as the strength of the material of which a sling is made. The lifting capacity of a sling is reduced as the angle of its legs to the horizontal is reduced (as the legs of a sling are spread) (see *Figure 3-7).* Thus, reducing the angle of the legs of a sling increases the tension on the sling legs. In determining the proper size of sling, you must determine the tension on each leg for each load (see *Figure 3-8, page 3-13).* You can compute this tension using the following formula:

$$T = \frac{W}{N} \times \frac{L}{V}$$

T = Tension in a single sling leg (which may be more than the weight of the load lifted)

W= Weight of the load to be lifted

N = Number of slings

L = Length of sling

V = Vertical distance, measured from the hook to the top of the load

NOTES:

1. L and V must be expressed in the same unit of measure.

2. The resulting tension will be in the same unit of measure as that of the weight of the load. Thus, if the weight of the load is in pounds, the tension will be given in pounds.

Example: Determine the tension of a single leg of a two-legged sling being used to lift a load weighing 1,800 pounds. The length of a sling is 8 feet and the vertical distance is 6 feet.

Solution:

$$T= \frac{W}{N} \times \frac{L}{V}$$

$$T= \frac{1,800}{2} \times \frac{8}{6} \quad \text{1,200 pounds or 6 tons}$$

By knowing the amount of tension in a single leg, you can determine the appropriate size of fiber rope, wire rope, or chain. The SWC of a sling leg (keeping within the safety factors for slings) must be equal to or greater than the tension on a sling leg. If possible, keep the tension on each sling leg below that in the hoisting line to which the sling is attached. A particular angle formed by the sling legs with the horizontal where the tension within each sling leg equals the weight of the load is called the critical angle (see *Figure 3-9, page 3-13).* Approximate this angle using the following formula:

$$\text{Critical angle} = \frac{60}{N}$$

N = Number of sling legs

When using slings, stay above the critical angle.

INSPECTING AND CUSHIONING SLINGS

Inspect slings periodically and condemn them when they are no longer safe. Make the usual deterioration check for fiber ropes, wire ropes, chains, and hooks when you use them in slings. Besides the usual precautions, declare wire ropes used in slings unsafe if 4 percent or more of the wires are broken. Pad all objects to be lifted with wood blocks, heavy fabric, old rubber tires, or other cushioning material to protect the legs of slings from being damaged.

Table 3-3. SWCs for manila-rope slings (standard, three-strand manila-rope sling with a splice in each end)

Size		Single Sling	Double Sling			Quadruple Sling		
Circumference (inches)	Diameter (inches)	Vertical Lift (pounds)	60° Angle (pounds)	45° Angle (pounds)	30° Angle (pounds)	60° Angle (pounds)	45° Angle (pounds)	30° Angle (pounds)
3/4	1/4	108	187	153	108	374	306	216
1 1/8	3/8	241	418	341	241	836	683	482
1 1/2	1/2	475	822	672	475	1,645	1,345	950
2	5/8	791	1,370	1,119	791	2,740	2,238	1,585
2 1/4	3/4	970	1,680	1,375	970	3,360	2,750	1,940
2 3/4	7/8	1,382	2,395	1,945	1,382	4,790	3,890	2,764
3	1	1,620	2,805	2,290	1,620	5,610	4,580	3,240
3 1/2	1 1/8	2,160	3,740	3,060	2,160	7,480	6,120	4,320
3 3/4	1 1/4	2,430	4,205	3,437	2,430	8,410	6,875	4,860
4 1/2	1 1/2	3,330	5,770	4,715	3,330	11,540	9,430	6,660
5 1/2	1 3/4	4,770	8,250	6,750	4,770	16,500	13,500	9,540
6	2	5,580	9,670	7,900	5,580	19,340	15,800	11,160
7 1/2	2 1/2	8,366	14,500	11,850	8,366	29,000	23,700	16,732
9	3	11,520	19,950	16,300	11,520	39,900	32,600	23,040

Table 3-4. SWCs for chain slings (new wrought-iron chains)

Link Stock Diameter (inches)	Single Sling	Double Sling			Quadruple Sling		
	Vertical Lift (pounds)	60° Angle (pounds)	45° Angle (pounds)	30° Angle (pounds)	60° Angle (pounds)	45° Angle (pounds)	30° Angle (pounds)
3/8	2,510	4,350	3,555	2,510	8,700	7,110	5,020
7/16	3,220	5,575	4,560	3,220	11,150	9,120	6,440
1/2	4,180	7,250	5,915	4,180	14,500	11,830	8,360
9/16	5,420	9,375	7,670	5,420	18,750	15,340	10,840
5/8	6,460	11,175	9,150	6,460	22,350	18,300	12,920
3/4	9,160	15,850	12,950	9,160	31,700	25,900	18,320
7/8	13,020	22,550	18,410	13,020	45,100	36,820	26,000
1	17,300	29,900	24,450	17,300	59,800	48,900	34,600
1 1/8	21,550	37,350	30,550	21,550	74,700	61,100	43,100
1 1/4	26,600	46,050	37,600	26,600	92,100	75,200	53,200
1 3/8	32,200	55,750	45,600	32,200	111,500	91,200	64,400
1 1/2	38,300	66,400	54,250	38,300	132,800	108,500	76,600
1 5/8	44,600	77,200	63,050	44,600	154,400	126,100	89,200
1 3/4	51,300	88,750	72,500	51,300	177,500	145,000	102,600
1 7/8	58,700	101,500	83,000	58,700	203,000	166,000	117,400
2	66,200	114,500	93,500	66,200	229,000	187,000	132,400

Table 3-5. SWCs for wire-rope slings (new, IPS wire rope)

Diameter (inches)	Single Sling	Double Sling			Quadruple Sling		
	Vertical Lift (pounds)	60° Angle (pounds)	45° Angle (pounds)	30° Angle (pounds)	60° Angle (pounds)	45° Angle (pounds)	30° Angle (pounds)
1/4	1,096	1,899	1,552	1,096	3,798	3,105	2,192
5/16	1,690	2,925	2,390	1,690	5,850	4,780	3,380
3/8	2,460	4,260	3,485	2,460	8,520	6,970	4,920
7/16	3,560	6,170	5,040	3,560	12,340	10,080	7,120
1/2	4,320	7,475	6,105	4,320	14,950	12,210	8,640
9/16	5,460	9,450	7,725	5,460	18,900	15,450	10,920
5/8	6,650	11,500	9,400	6,650	23,000	18,800	13,300
3/4	9,480	16,400	13,400	9,480	32,800	26,800	18,960
7/8	12,900	22,350	18,250	12,900	44,700	36,500	25,800
1	16,800	29,100	23,750	16,800	58,200	47,500	33,600
1 1/8	21,200	36,700	30,000	21,200	73,400	60,000	42,400
1 1/4	26,000	45,000	36,800	26,000	90,000	73,600	52,000
1 3/8	32,000	55,400	45,250	32,000	110,800	90,500	64,000
1 1/2	37,000	64,000	52,340	37,000	128,000	104,700	74,000
1 5/8	41,800	72,400	59,200	41,800	144,800	118,400	83,600
1 3/4	49,800	86,250	70,500	49,800	172,500	141,000	99,600
2	62,300	107,600	88,050	62,300	215,200	176,100	124,600
2 1/4	82,900	143,500	117,400	82,900	287,000	234,800	165,800
2 1/2	101,800	176,250	144,000	101,800	352,500	288,000	203,600
2 3/4	122,500	212,000	173,500	122,500	424,000	347,000	245,000

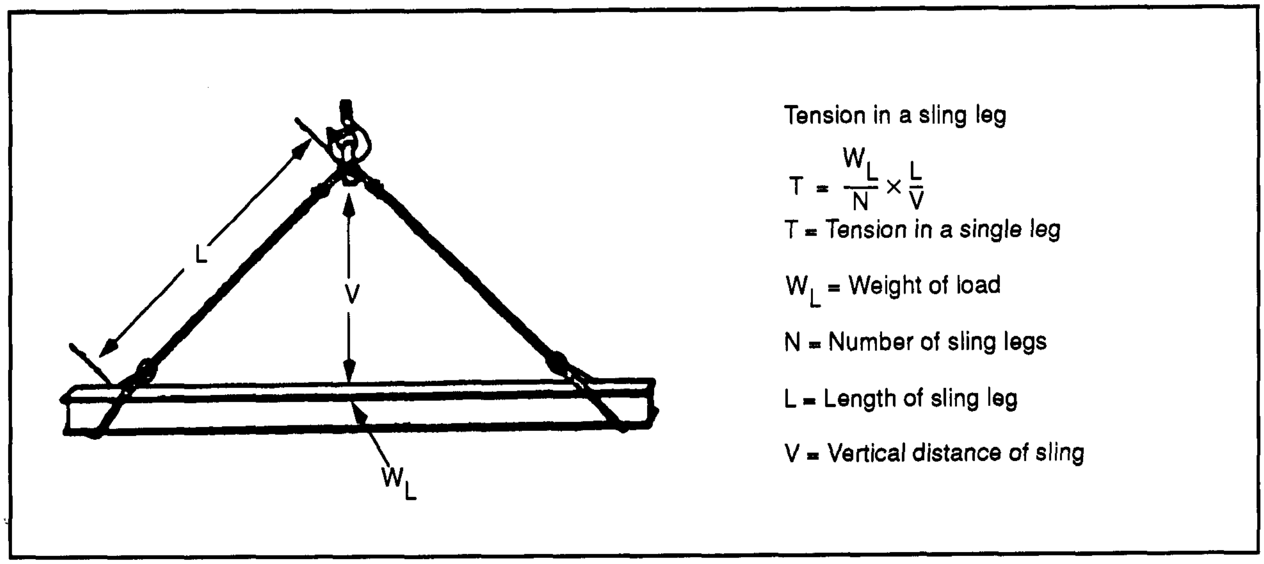

Figure 3-8. Computing tension in a sling

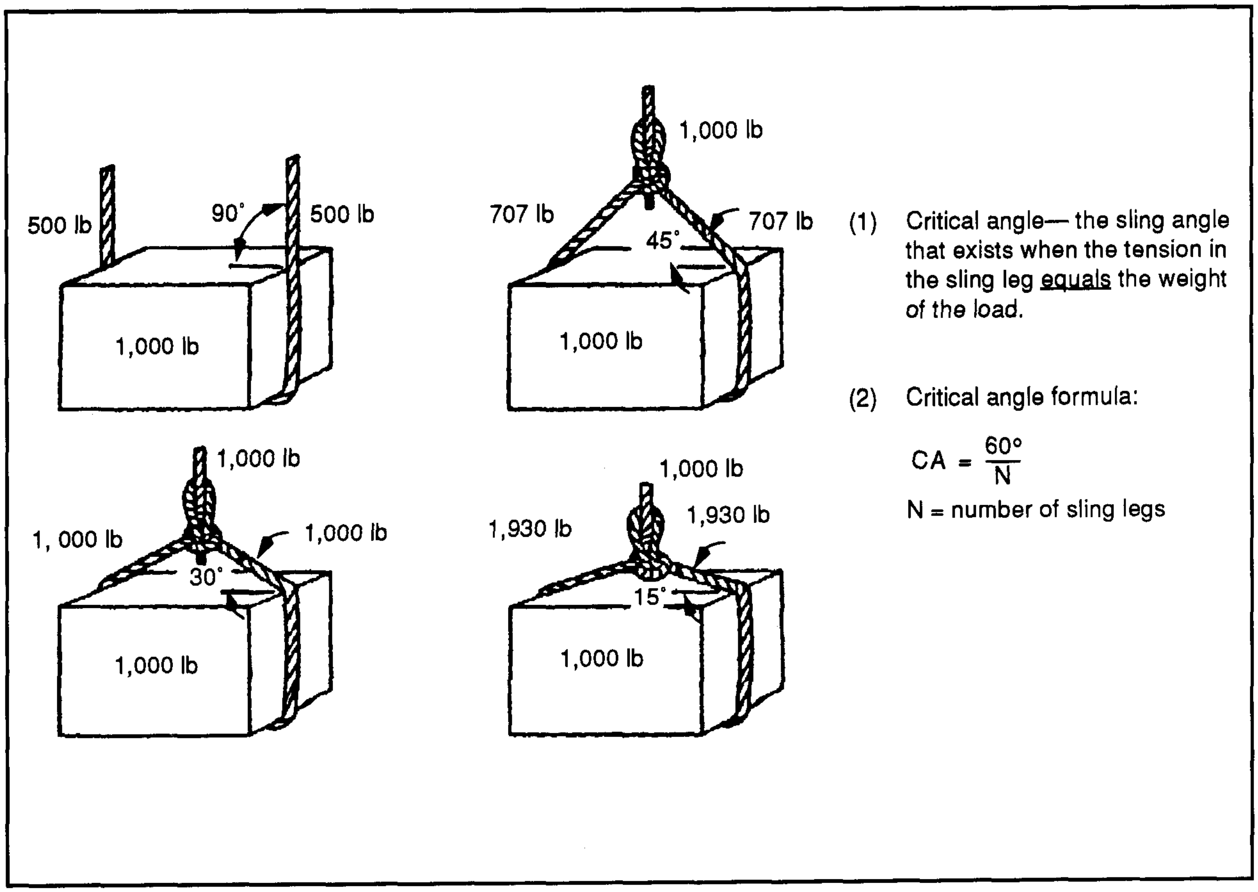

Figure 3-9. Sling angles

Section III. Blocks and Tackle Systems

A force is a push or pull. The push or pull that humans can exert depends on their weight and strength. To move any load heavier than the maximum amount a person can move, use a machine that multiplies the force exerted into a force capable of moving the load. The machine may be a lever, a screw, or a tackle system. The same principle applies to all of them. If you use a machine that exerts a force 10 times greater than the force applied to it, the machine has multiplied the force input by 10. The mechanical advantage (MA) of a machine is the amount by which the machine multiplies the force applied to it to lift or move a load. For example, if a downward push of 10 pounds on the left end of a lever will cause the right end of the lever to raise a load weighing 100 pounds, the lever is said to have a MA of 10.

A block consists of a wood or metal frame containing one or more rotating pulleys called sheaves (see *Figure* 3-10, *A).* A tackle is an assembly of ropes and blocks used to multiply forces (see *Figure 3-10, B).* The number of times the force is multiplied is the MA of the tackle. To make up a tackle system, lay out the blocks you are to use to be used and reeve (thread) the rope through the blocks. Every tackle system contains a fixed block attached to some solid support and may have a traveling block attached to the load. The single rope leaving the tackle system is called the fall line. The pulling force is applied to the fall line, which may be led through a leading block. This is an additional block used to change the direction of pull.

BLOCKS

Blocks are used to reverse the direction of the rope in the tackle. Blocks take their names from—

- The purpose for which they are used.
- The places they occupy.
- A particular shape or type of construction (see *Figure 3-11).*

TYPES OF BLOCKS

Blocks are designated as single, double, or triple, depending on the number of sheaves.

Snatch Block

This is a single sheave block made so that the shell opens on one side at the base of the hook to permit a rope to be slipped over the sheave without threading the end of it through the block. Snatch blocks ordinarily are used where it is necessary to change the direction of the pull on the line.

Traveling Block

A traveling block is attached to the load that is being lifted and moves as the load is lifted.

Standing Block

This block is fixed to a stationary object.

Leading Blocks

Blocks used in the tackle to change the direction of the pull without affecting the MA of the system are called leading blocks (see *Figure* 3-12, *page* 3-16). In some tackle systems, the fall line leads off the last block in a direction that makes it difficult to apply the motive force required. A leading block is used to correct this. Ordinarily, a

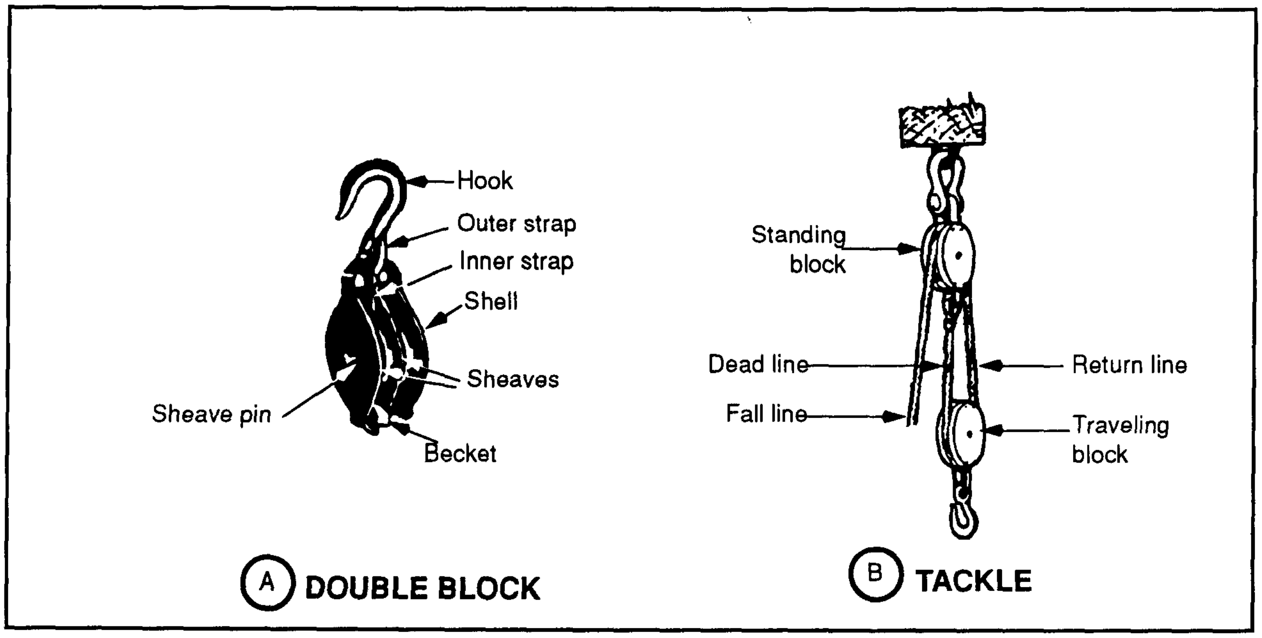

Figure 3-10. Double block and tackle system

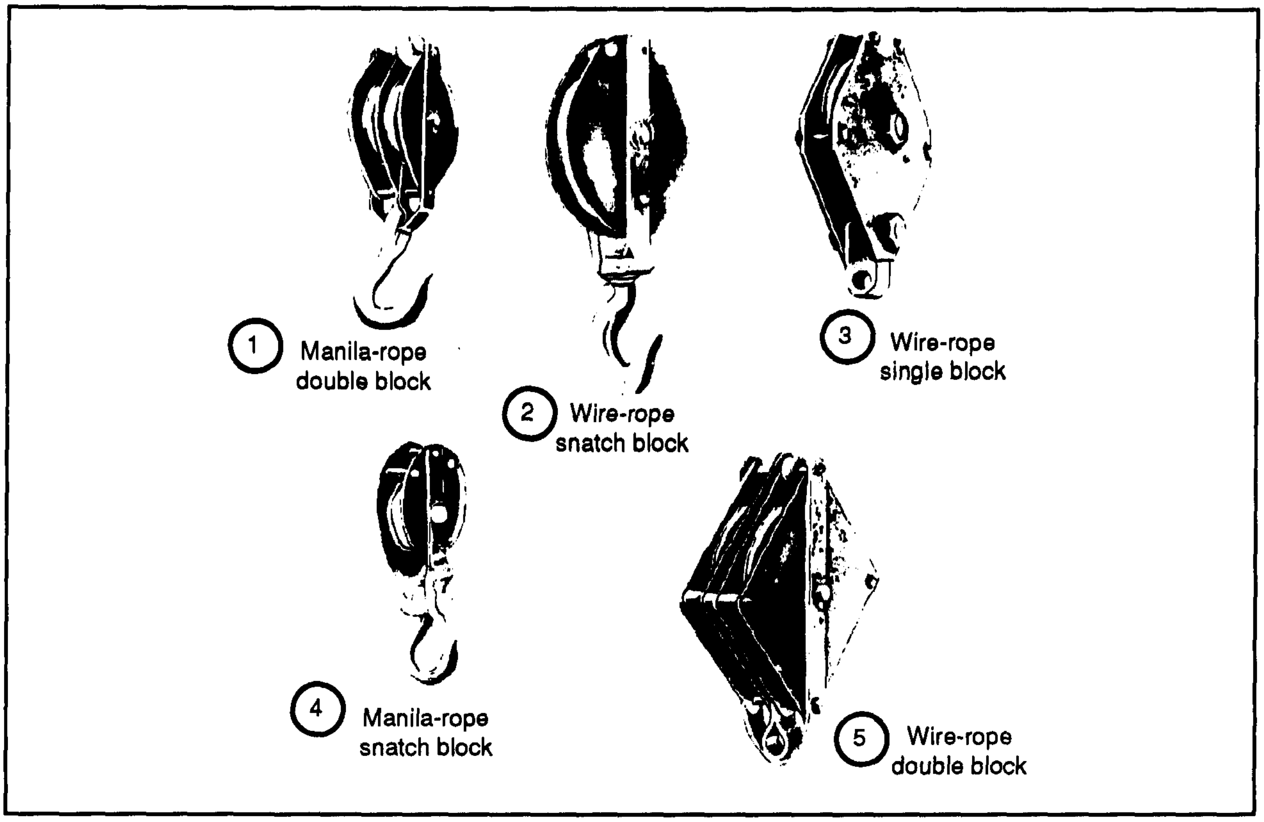

Figure 3-11. Types of blocks

snatch block is used as the leading block. This block can be placed at any convenient position. The fall line from the tackle system is led through the leading block to the line of most direct action.

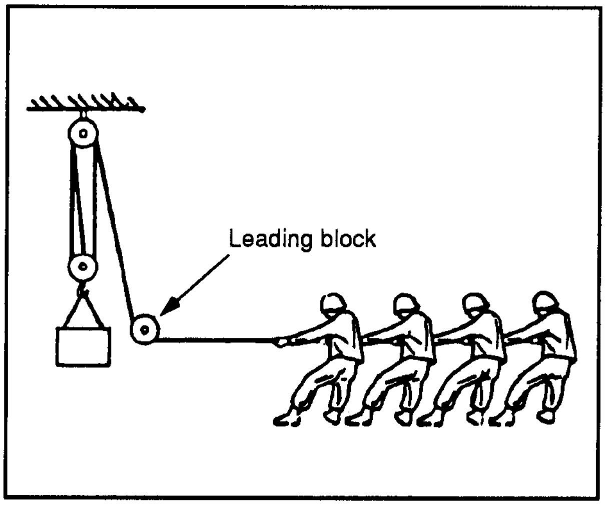

Figure 3-12. Use of leading block

REEVING BLOCKS

To prepare blocks for use, reeve, or pass a rope through, it. To do this, lay out the blocks on a clean and level surface other than the ground to avoid getting dirt into the operating parts, *Figure 3-13* shows the reeving of single and double blocks. In reeving triple blocks, it is imperative that you put the hoisting strain at the center of the blocks to prevent them from being inclined under the strain (see *Figure 3-14).* If the blocks do incline, the rope will drag across the edges of the sheaves and the shell of the block and cut the fibers. Place the blocks so that the sheaves in one block are at right angles to the sheaves in the other block. You may lay the coil of rope beside either block. Pass the running end over the center sheave of one block and back to the bottom sheave of the other block. Then pass it over one of the side sheaves of the first block. In selecting which side sheave to pass the rope over, remember that the rope should not cross the rope leading away from the center sheave of the first block. Lead the rope over the top sheave of the second block and back to the remaining side sheave of the first block. From this point, lead the rope to the center sheave of the second block and back to the becket of the first block. Reeve the rope through the blocks so that no part of the rope chafes another part of the rope.

Twisting of Blocks

Reeve blocks so as to prevent twisting. After reeving the blocks, pull the rope back and forth through the blocks several times to allow the rope to adjust to the blocks. This reduces the tendency of the tackle to twist under a load. When the ropes in a tackle system become twisted, there is an increase in friction and chafing of the ropes, as well as a possibility of jamming the blocks. When the hook of the standing block is fastened to the supporting member, turn the hook so that the fall line leads directly to the leading block or to the source of motive power. It is very difficult to prevent twisting of a traveling block. It is particularly important when the tackle is being used for a long pull along the ground, such as in dragging logs or timbers.

Antiwisting Devices

One of the simplest antitwisting devices for such a tackle is a short iron rod or a piece of pipe lashed to the traveling block (see *Figure 3-15, page 3-18).* You can lash the antitwisting rod or pipe to the shell of the block with two or three turns of rope. If it is lashed to the becket of the block, you should pass the rod or pipe between the ropes without chafing them as the tackle is hauled in.

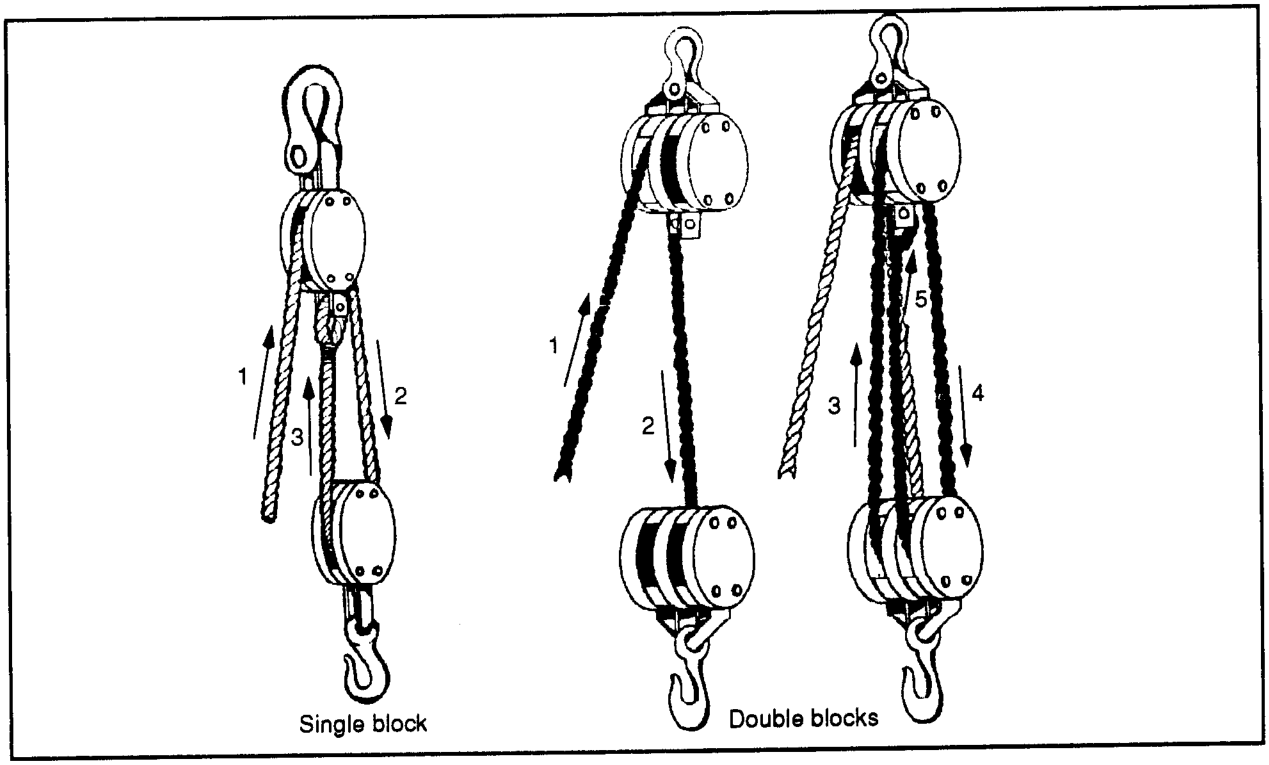

Figure 3-13. Reeving single and double blocks

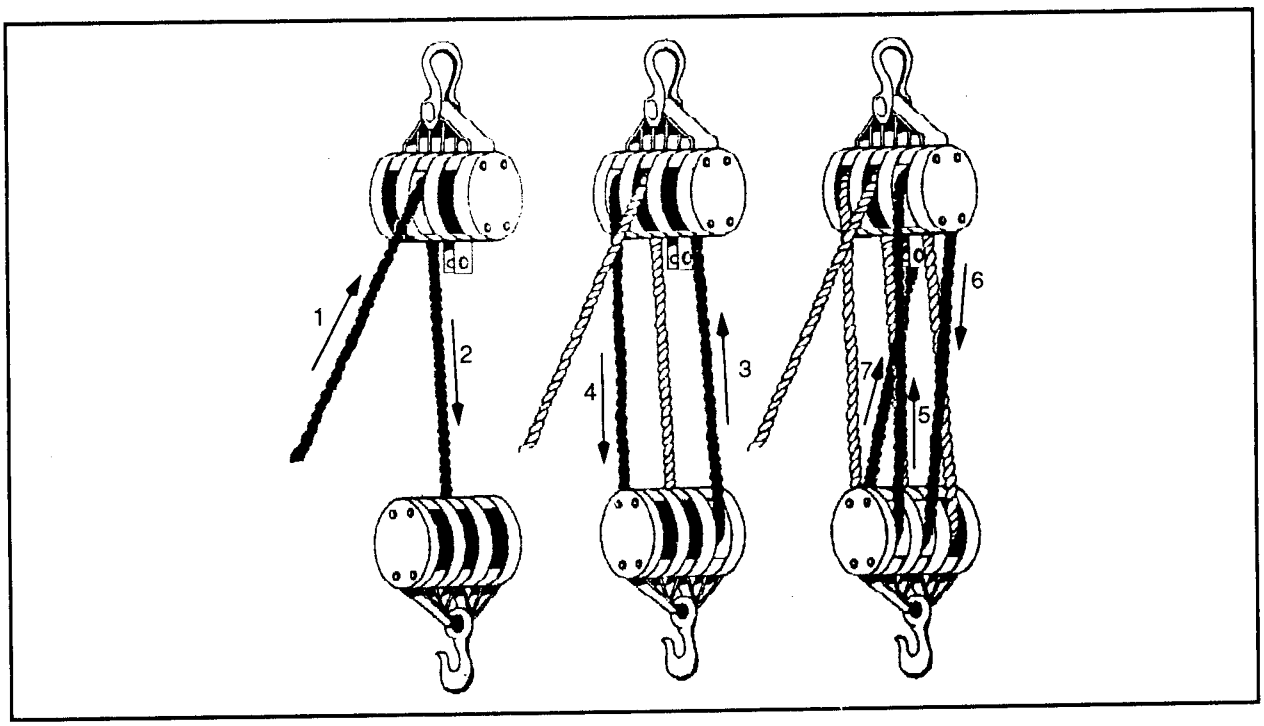

Figure 3-14. Reeving triple blocks

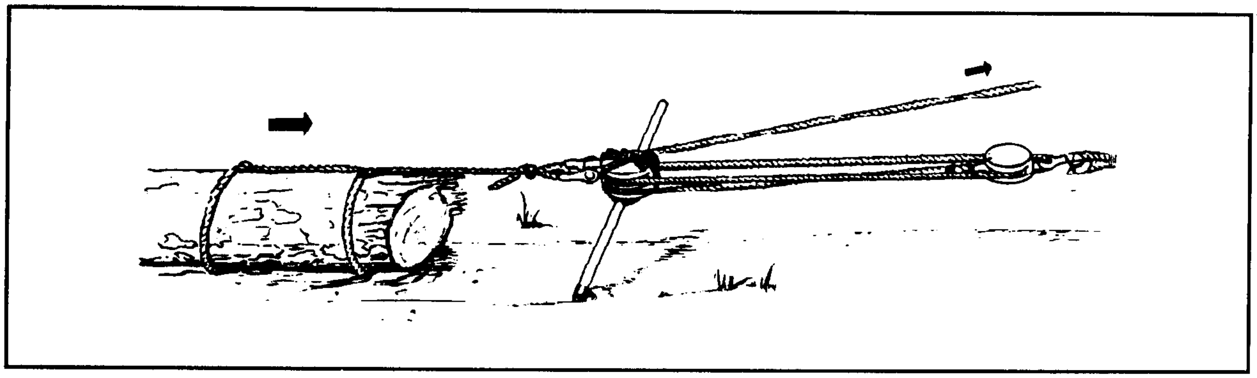

Figure 3-15. Antitwisting rod or pipe

TACKLE SYSTEMS

Tackle systems may be either simple or compound.

SIMPLE TACKLE SYSTEMS

A simple tackle system uses one rope and one or more blocks. To determine the MA of a simple system, count the number of lines supporting the load (or the traveling block) (see *Figure 3-16).* In counting, include the fall line if it leads out of a traveling block. In a simple tackle system, the MA always will be the same as the number of lines supporting the load. As an alternate method, you can determine the MA by tracing the forces through the system. Begin with a unit force applied to the fall line. Assume that the tension in a single rope is the same throughout and therefore the same force will exist in each line. Total all the forces acting on the load or traveling block. The ratio of the resulting total force acting on the load or traveling block to the original unit force exerted on the fall line is the theoretical MA of the simple system.

Figure 3-17 shows examples of two methods of determining the ratio of a simple tackle system. They are—

- Method I-counting supporting lines.
- Method II—unit force.

Method I—Counting Supporting Lines

There are three lines supporting the traveling block, so the theoretical MA is 3:1.

Method II—Unit Force

Assuming that the tension on a single rope is the same throughout its length, a unit force of 1 on the fall line results in a total of 3 unit forces acting on the traveling block. The ratio of the resulting force of 8 on the traveling block to the unit force of 1 on the fall line gives a theoretical MA of 3:1.

COMPOUND TACKLE SYSTEMS

A compound tackle system uses more than one rope with two or more blocks (see *Figure* 3-18, *page* 3-20). Compound systems are made up of two or more simple systems. The fall line from one simple system is fastened to a hook on the traveling block of another simple system, which may include one or more blocks. In compound systems, you can best determine the MA by using the unit-force method. Begin by applying a unit force to the fall line. Assume that the tension in a single rope is the same throughout and therefore the same force will exist in each line. Total all the forces acting on the

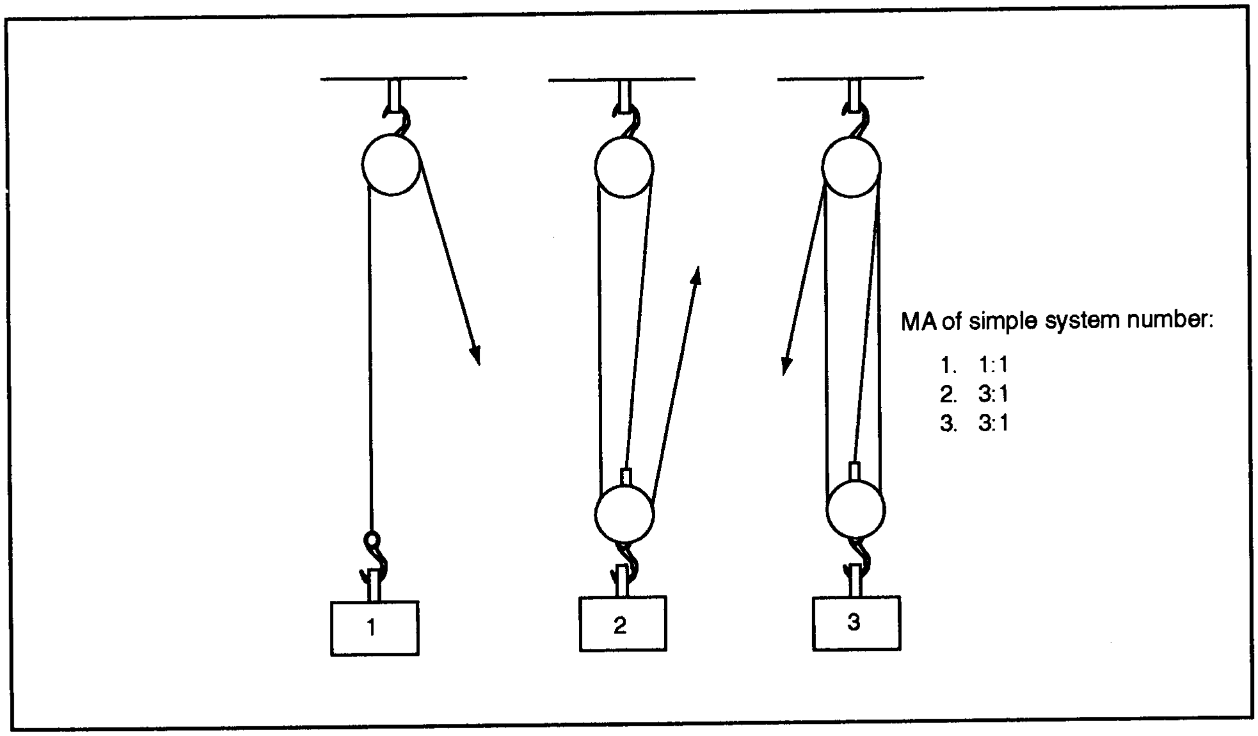

Figure 3-16. Simple tackle systems

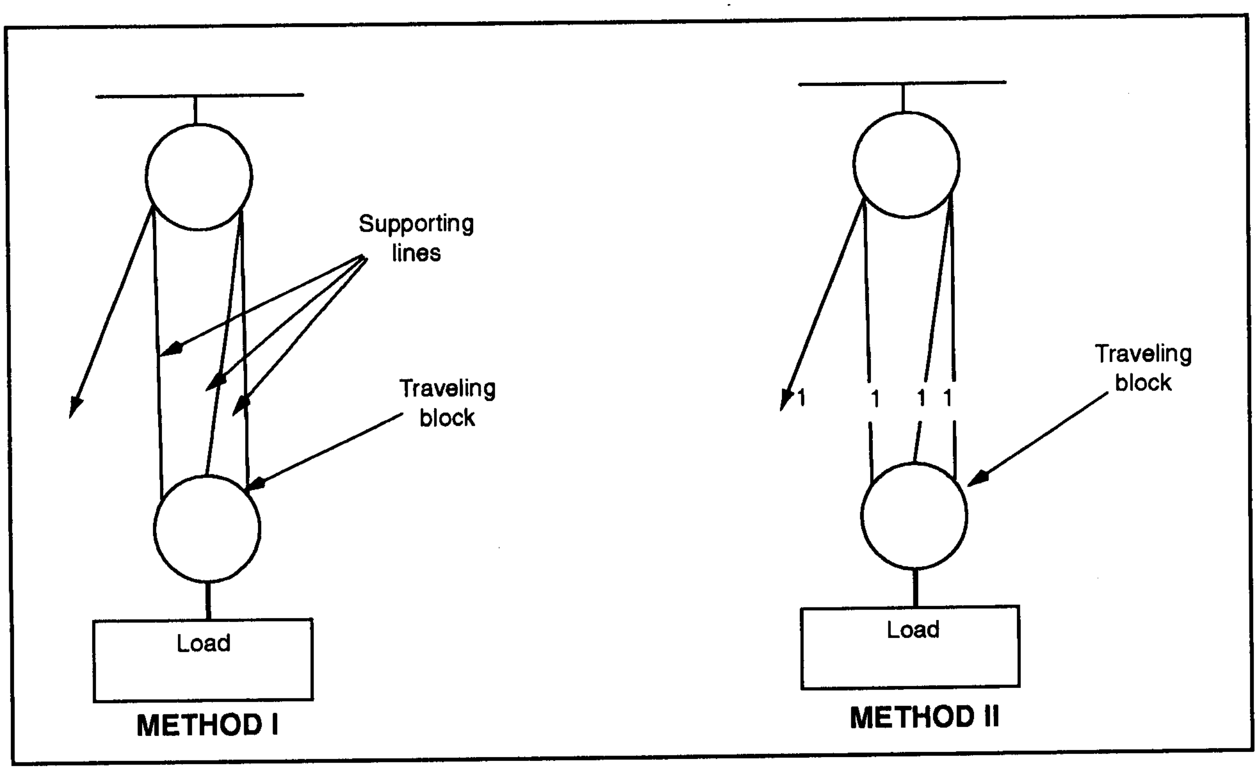

Figure 3-17. Determining ratio of a simple tackle

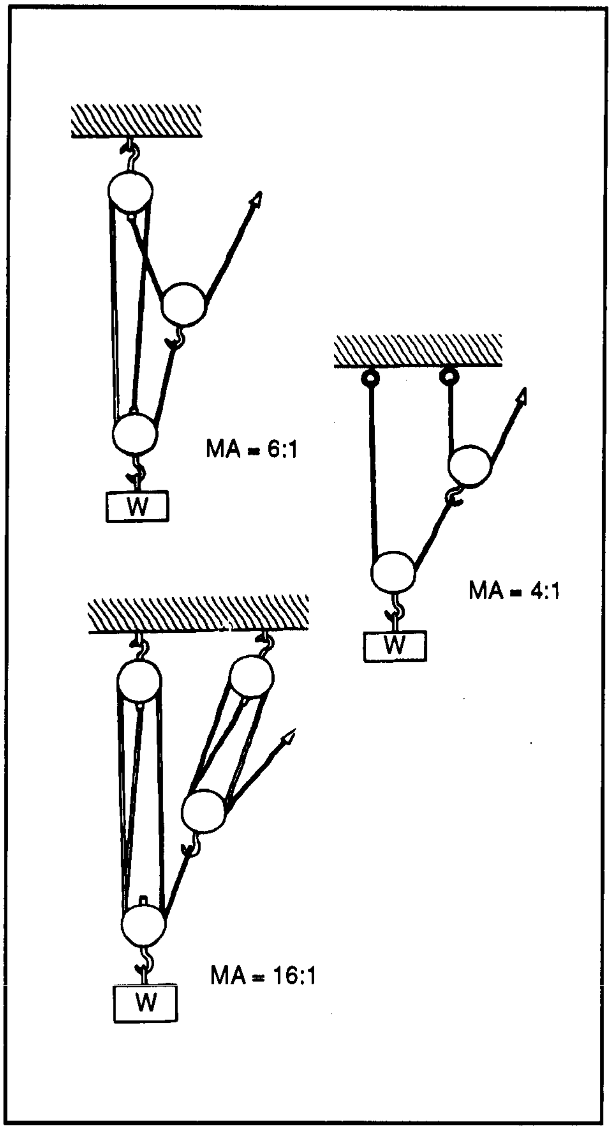

Figure 3-18. Compound tackle systems

traveling block and transfer this force into the next simple system. The ratio of the resulting total force acting on the load or traveling block to the original unit force exerted on the fall line is the theoretical MA of the compound system. Another method, which is simpler but less accurate in some cases, is to determine the MA of each simple system in the compound system and multiplying these together to obtain the total MA. *Figure 3-19* shows examples of the two methods of determining the ratio of a compound tackle system. They are—

- Method I—unit force.
- Method II—multiplying mechanical advantages of simple systems.

Method I—Unit Force

As in method II of simple tackle systems, a unit force of 1 on the fall line results in 4 unit forces acting on the traveling block of tackle system A. Transferring the unit force of 4 into the fall line of simple system B results in a total of 16 unit forces (4 lines with 4 units of force in each) acting on the traveling block of tackle system B. The ratio of 16 unit forces on the traveling block carrying the load to a 1 unit force on the fall line gives a theoretical MA of 16:1.

Method II—Multiplying MAs of Simple Systems

The number of lines supporting the traveling blocks in systems A and B is equal to 4. The MA of each simple system is therefore equal to 4:1. You can then determine the MA of the compound system by multiplying together the MA of each simple system for a resulting MA of 16:1.

FRICTION

There is a loss in any tackle system because of the friction created by—

- The sheave rolling on the pin, the ropes rubbing together.
- The rope rubbing against the sheave.

This friction reduces the total lifting power; therefore, the force exerted on the fall line must be increased by some amount to overcome the friction of the system to lift the load. Each sheave in the tackle system can be expected to create a resistance equal to about 10 percent of the weight of the load.

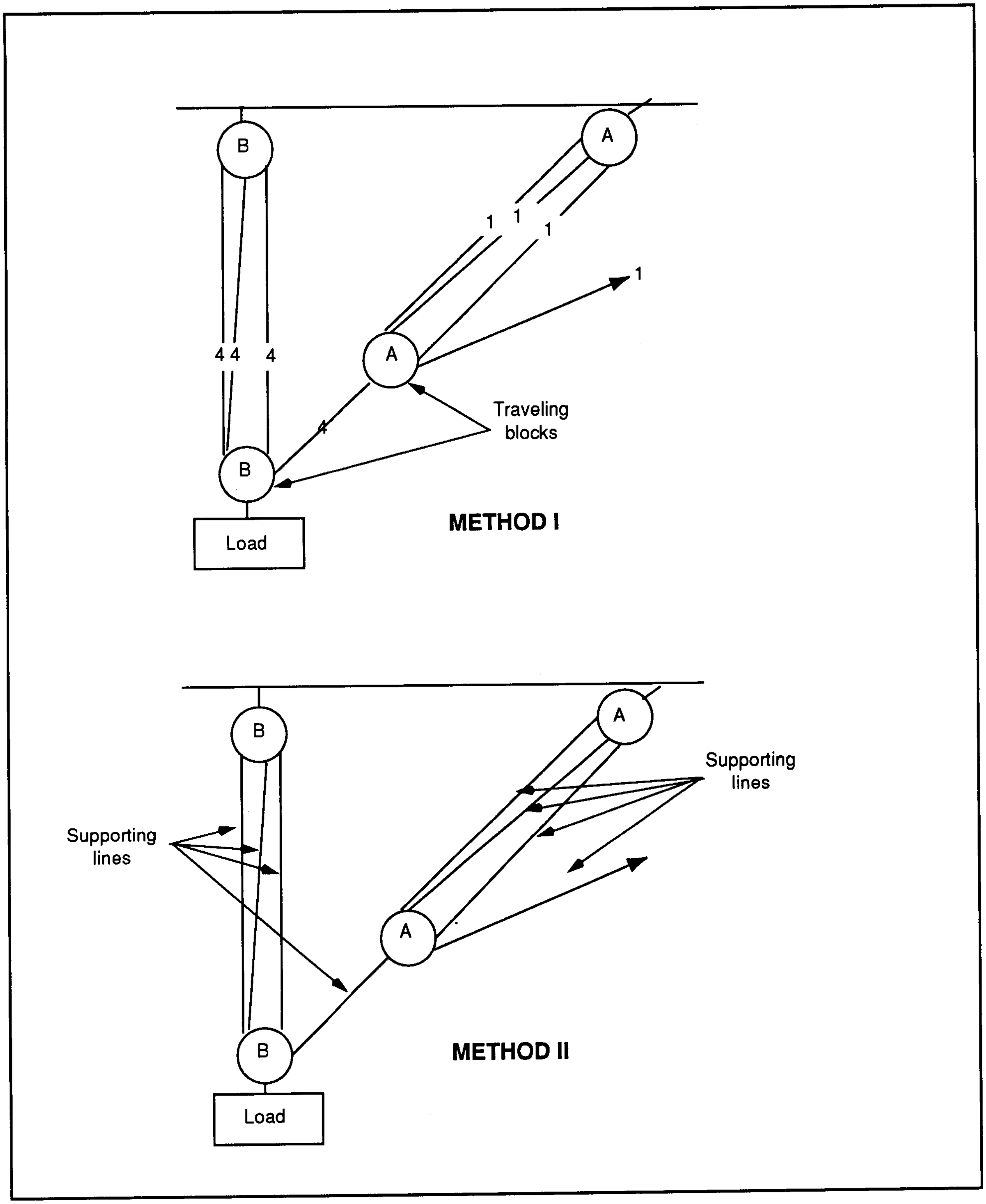

Figure 3-19. Determining ratio of a compound tackle system

Example: A load weighing 5,000 pounds is lifted by a tackle system that has a MA of 4:1. The rope travels over four sheaves that produce a resistance of 40 percent of 5,000 pounds or 2,000 pounds (5,000 x 0.40). The actual pull that would be required on the fall line of the tackle system is equal to the sum of the weight of the load and the friction in the tackle system divided by the theoretical. MA of the tackle system. The actual pull required on the fall line would be equal to the sum of 5,000 pounds (load) and 2,000 pounds (friction) divided by 4 (MA) or 1,750 pounds.

There are other types of resistance that may have to be considered in addition to tackle resistance. *FM* 20-22 presents a thorough discussion of resistance.

Section IV. Chain Hoists and Winches

In all cases where manpower is used for hoisting, the system must be arranged to consider the most satisfactory method of using that source of power. More men can pull on a single horizontal line along the ground than on a single vertical line. On a vertical pull, men of average weight can pull about 100 pounds per man and about 60 pounds per man on a horizontal. If the force required on the fall line is 300 pounds or less, the fall line can lead directly down from the upper block of a tackle vertical line. If 300 pounds times the MA of the system is not enough to lift a given load, the tackle must be rigged again to increase the MA, or the fall line must be led through a leading block to provide a horizontal pull. This will permit more people to pull on the line. Similarly, if a heavy load is to be lifted and the fall line is led through a leading block to a winch mounted on a vehicle, the full power available at the winch is multiplied by the MA of the system.

CHAIN HOISTS

Chain hoists provide a convenient and efficient method for hoisting by hand under particular circumstances (see *Figure 3-20).* The chief advantages of chain hoists are that—

- The load can remain stationary without requiring attention.
- One person can operate the hoist to raise loads weighing several tons.

The slow lifting travel of a chain hoist permits small movements, accurate adjustments of height, and gentle handling of loads. A retched-handle pull hoist is used for short horizontal pulls on heavy objects (see *Figure* 3-21). Chain hoists differ widely in their MA, depending on their rated capacity which may vary from 5 to 250.

TYPES OF CHAIN HOISTS

The three general types of chain hoists for vertical operation are the spur gear, screw gear, and differential.

Spur-Gear Chain Hoist

This is the most satisfactory chain hoist for ordinary operation where a minimum number of people are available to operate the hoist and the hoist is to be used frequently. This type of chain hoist is about 85 percent efficient.

Screw-Gear Chain Hoist

The screw-gear chain hoist is about 50 percent efficient and is satisfactory where less frequent use of the chain hoist is involved.

Differential Chain Hoist

The differential chain hoist is only about 35 percent efficient but is satisfactory for occasional use and light loads.

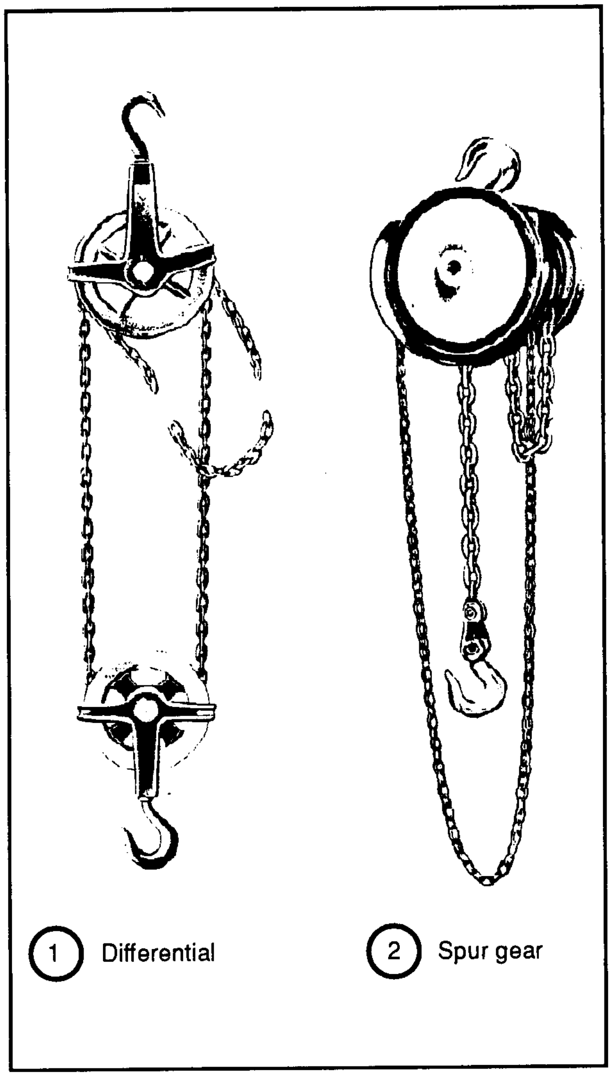

Figure 3-20. Chain hoists

LOAD CAPACITY

Chain hoists are usually stamped with their load capacities on the shell-of the upper block. The rated load capacity will run from one-half of a ton upward. Ordinarily, chain hoists are constructed with their lower hook as the weakest part of the assembly. This is done as a precaution so that the lower hook will be overloaded before the chain hoist is overloaded. The lower hook will start to spread under overload, indicating to the operator that he is approaching the over-load point of the chain hoist. Under ordinary

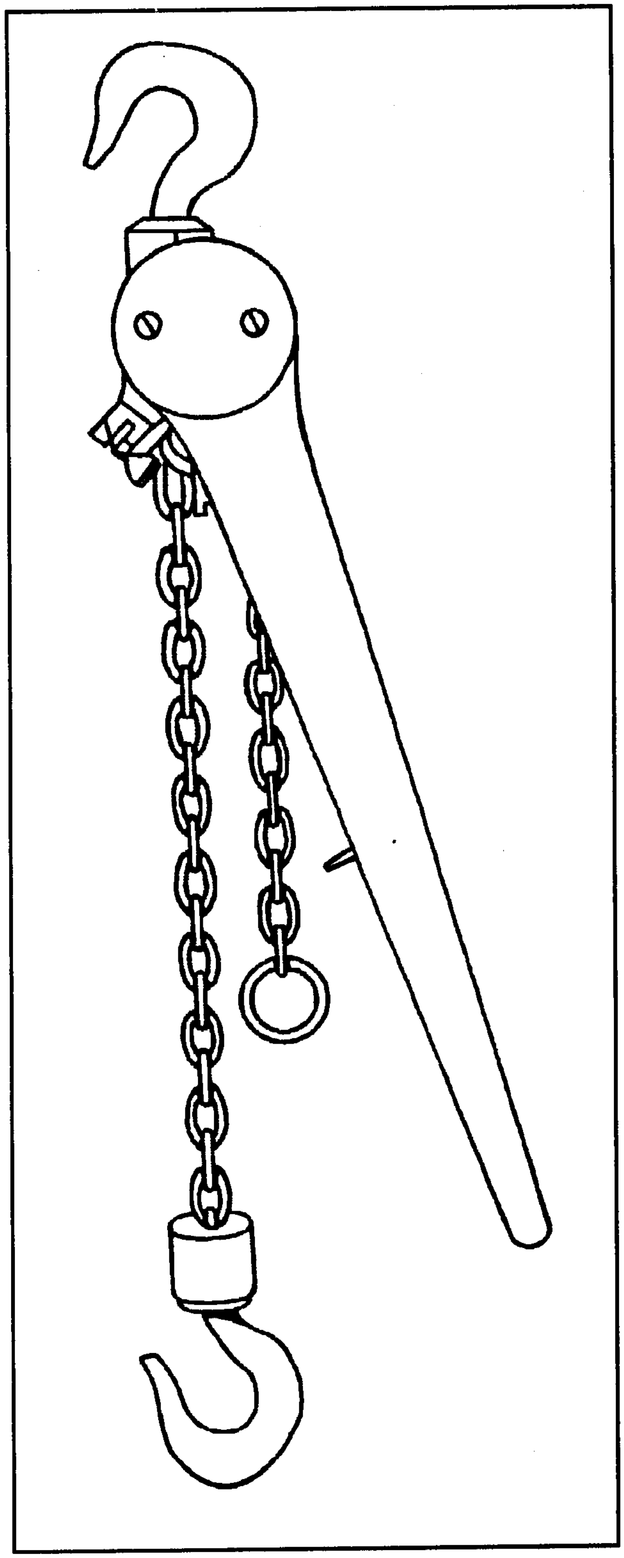

Figure 3-21. Ratched-handle chain hoist

circumstances, the pull exerted on a chain hoist by one or two men will not overload the hoist. Inspect chain hoists at frequent intervals. Any evidence of spreading of the hook or excessive wear is sufficient cause to replace the hook. If the links of the chain are distorted, it indicates that the chain hoist has been heavily overloaded and is probably unsafe for further use. Under such circumstances, the chain hoist should be condemned.

WINCHES

Vehicular-mounted and engine-driven winches are used with tackles for hoisting (see *Figure 3-22).* There are two points to consider when placing a power-driven winch to operate hoisting equipment. They are—

- The angle with the ground that the hoisting line makes at the drum of the hoist.
- The fleet angle of the hoisting line winding on the drum (see *Figure* 3-23).

The distance from the drum to the first sheave of the system is the controlling factor in the fleet angle. When using vehicular-mounted winches, place the vehicle in a position that lets the operator watch the load being hoisted. A winch is most effective when the pull is exerted on the bare drum of the winch. When a winch is rated at a capacity, that rating applies only as the first layer of cable is wound onto the drum. The winch capacity is reduced as each layer of cable is wound onto the drum because of the change in leverage resulting from the increased diameter of the drum. The capacity of the winch may be reduced by as much as 50 percent when the last layer is being wound onto the drum.

GROUND ANGLE

If the hoisting line leaves the drum at an angle upward from the ground, the resulting pull on the winch will tend to lift it clear of the ground. In this case, a leading block must be placed in the system at some distance from the drum to change the direction of the hoisting line to a horizontal or downward pull. The hoisting line should be overwound or underwound on the drum as may be necessary to avoid a reverse bend.

FLEET ANGLE

The drum of the winch is placed so that a line from the last block passing through the center of the drum is at right angles to the axis of the drum. The angle between this line and the hoisting line as it winds on the drum is called the fleet angle (see *Figure 3-23).* As the hoisting line is wound in on the drum, it moves from one flange to the other so that the fleet angle changes during the hoisting process. The fleet angle should not be permitted to exceed 2 degrees and should be kept below this, if possible. A 1 1/2-degree maximum angle is satisfactory and will be obtained if the distance from the drum to the first sheave is 40 inches for each inch from the center of the drum to the flange. The wider the drum of the hoist the greater the lead distance must be in placing the winch.

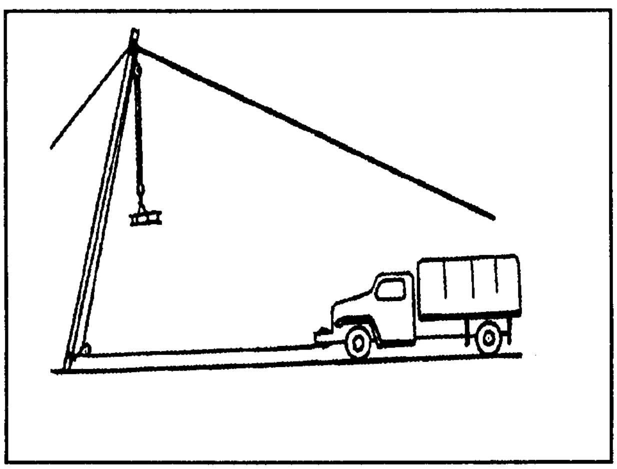

Figure 3-22. Using a vehicular winch for hoisting

SPANISH WINDLASS

In the absence of mechanical power or an appropriate tackle, you may have to use makeshift equipment for hoisting or pulling. You can use a Spanish windlass to move a load along the ground, or you can direct the horizontal pull from the windlass through the blocks to provide a vertical pull on a load. In making a Spanish windlass, fasten a rope between the load you are to move and an anchorage some distance away. Place a short spar vertically beside this rope, about halfway between the anchorage and the load (see *Figure* 3-24, *page* 3-26). This spar may be a pipe or a pole, but in either case it should have as large a diameter as possible. Make a loop in the rope and wrap it partly around the spar. Insert the end of a horizontal rod through this loop. The horizontal rod should be a stout pipe or bar long enough to provide leverage. It is used as a lever to turn the vertical spar. As the vertical spar turns, the rope is wound around it, which shortens the line and pulls on the load. Make sure that the rope leaving the vertical spar is close to the same level on both sides to prevent the spar from tipping over.

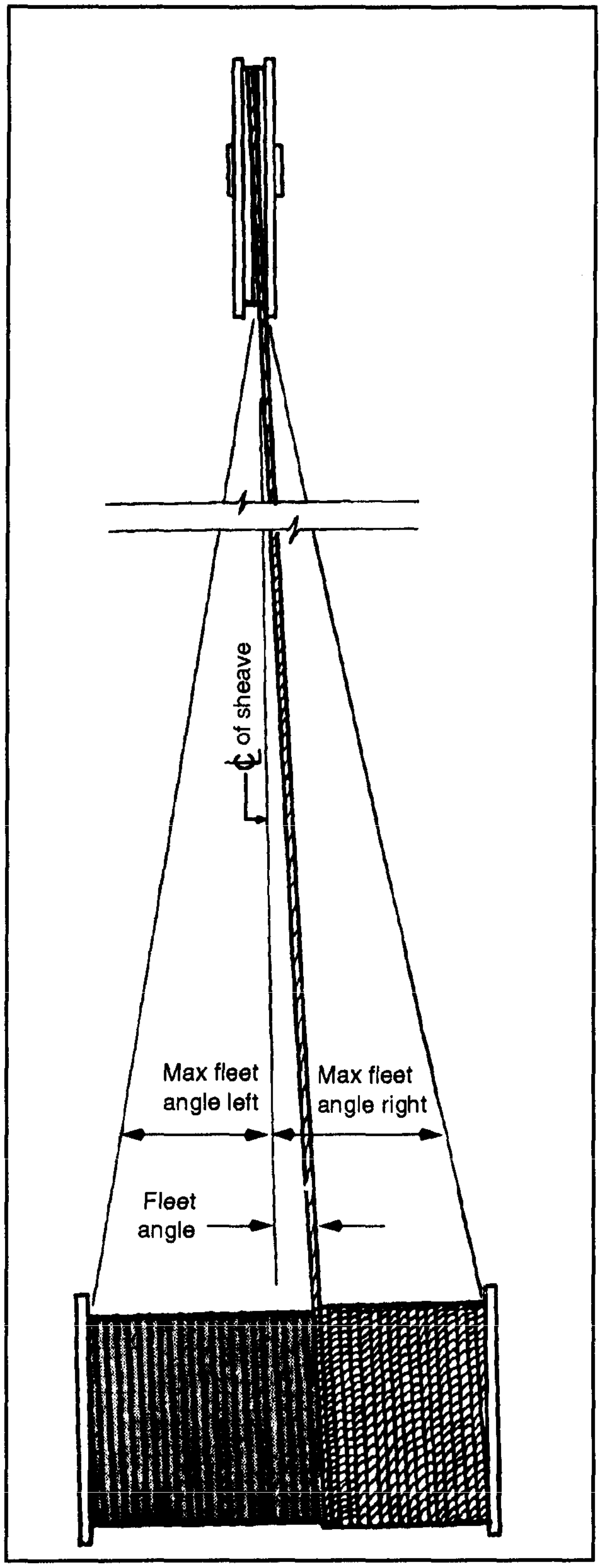

Figure 3-23. Fleet angle

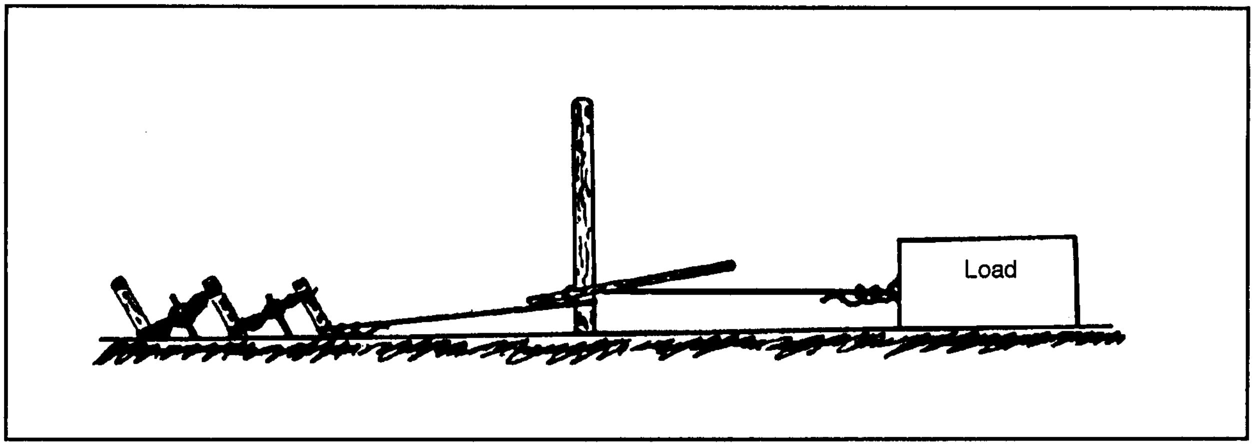

Figure 3-24. Spanish windlass