CHAPTER 4

MARLINESPIKE SEAMANSHIP

LEARNING OBJECTIVES

Upon completion of this chapter, you should be able to do the following:

1. Describe the different types of line that the Navy uses.
2. Describe the care and handling of natural and synthetic lines. Identify how to work out kinks and twists in line.
3. Explain how to splice line.
4. Identify the practical knots, bends, and hitches that are used in typical Seamans work.
5. Describe different types of seizing and explain their uses.
6. Explain how wire rope is constructed and used.

INTRODUCTION

This chapter deals with the art of knotting and splicing, an age-old craft in which all mariners must be proficient. Rope is manufactured from wire, fiber, and combinations of the two. After completion of this chapter, you should be able to explain the construction of line and wire rope and understand their use and care. You will gain knowledge in supervising line-handling details, along with the terminology and safety factors to be observed. You will also learn how to tie many useful knots and how to splice line.

FIBER ROPE (LINE)

Fiber rope—or *line,* as it is commonly called—is fashioned from natural or synthetic (man-made) fibers. When we refer to line, we mean rope made from either of these two fibers. Lines made from a variety of natural fibers (cotton, agave, jute, hemp, and abaca) have seen service in the Navy in the past, and some still are used. For example, tarred hemp is known as marline and ratline. Manila (made from the fibers of the abaca plant) formerly was authorized for use only where great strength was required. Now, manila is authorized for general purposes and serves as lashings, frapping lines, steadying lines, and riding lines on fueling rigs. Synthetic lines made of nylon, armaid (Kevlar®), polyester (Dacron®), and polypropylene have been substituted for manila in most applications.

CONSTRUCTION OF LINE

Line currently used in the Navy may be three-strand, four-strand, braided, or plaited. In three-strand line, the fibers are fast twisted to the right to form yarns. Next, the yarns are twisted to the left to form strands. Then, the strands are twisted to the right to form line.

The procedure just described is standard and is used in making right-laid line. Figure 4-1 shows how three-strand right-laid line is made. The system is reversed when left-laid line is made. In either instance, the

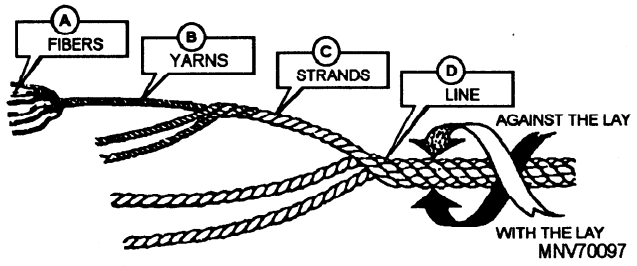

Figure 4-1.—Fiber groupings in a three-strand line.

principle of opposite twists must be observed. The reason for this is to keep the line tight or stable and to prevent the parts from inlaying when a load is suspended on it. All Navy line 1 3/4 inches in circumference or larger must be right laid. This requirement is important because if a left-laid line and a right-laid line were bent together, they would unlay each other under strain.

Braided lines have certain advantages over twisted lines. They will not kink or cockle (explained later), nor will they flex open to admit dirt or abrasives. The construction of some braids, however, makes it impossible to inspect the inner yarns for damage. The more common braided lines are hollow-braided, stuffer-braided, solid-braided, and double-braided.

Hollow-braided lines usually consist of an even number of parallel, tapelike groups of small yarns braided into a hollow, tubelike cord. This type of construction, formerly in cotton, was used for signal halyards-a purpose now served largely by plaited polyester. Other uses are parachute shroud lines and shot lines for line-throwing guns.

Stuffer-braided lines are manufactured in a similar manner except that the braid is formed around a highly twisted yarn core, which rounds out and hardens the line. This type of construction in cotton is used for sash cord (heaving lines).

Solid-braided lines are fashioned in various ways. One familiar solid-braided line is the one used for lead lines, taffrail log lines, and the like. This braid is of large yarns, either single or plied, tightly braided to form a hard, relatively stiff line that will not kink, snag, or swell in water.

Double-braided line is, essentially, two hollow-braided ropes, one inside the other. The core is made of large single yarns in a slack, limp braid. The cover also is made of large single yarns but in a tight braid that compresses and holds the core. This line is manufactured only from synthetics, and 50 percent of its strength is in the core. Double-braided line is used for mooring ships, towlines, and many other purposes.

Plaited line is made of eight strands—four right-twisted and four left-twisted. These strands are paired and worked like a four-strand braid (fig. 4-2). Thus two pairs of right-laid strands and two pairs of left-laid strands are formed into a line that is more or less square. Plaited line is used for towlines, ship mooring lines, messengers, and many other applications. Plaited line is available in nylon, polyester, and polypropylene.

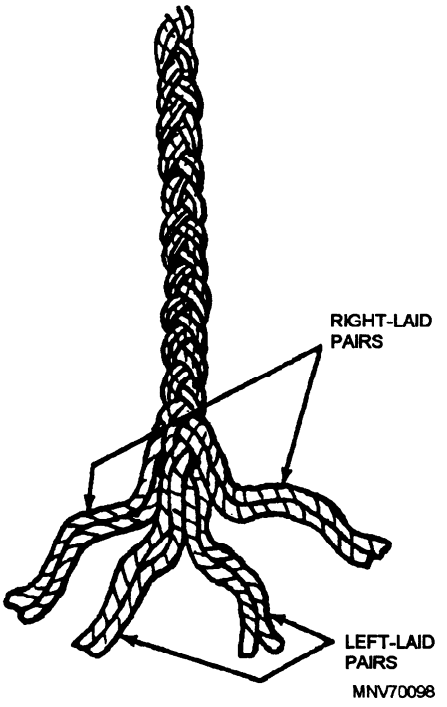

Figure 4-2.—Plaited line.

SIZE DESIGNATION

Line 1 3/4 inches or less in circumference is called *small stuff*. Its size is designated by the number of threads (or yarns) that make up each strand. You may find anywhere from 6 to 24 thread, but the most commonly used sizes are from 9 to 21 thread. See figure 4-3. Some small stuff is designated by name. One type is *marline*, a left-laid, two-strand, tarred hemp. Marline is mainly used for seizings. When you need something stronger than marline, use *houseline*, a left-laid, three-strand, tarred hemp. Rope yarns can be used for temporary whippings, seizings, and lashings. The yarns are pulled from strands of old line that has outlived its usefulness. Pull the yarn from the middle, away from the ends, or it will get fouled.

	* CIRCUMFERENCE		THREAD
	INCHES	MILLIMETERS	
	3/4	19.05	6
	1	25.40	9
	11/8	28.58	12
	11/4	31.76	15
	11/2	38.10	21
	13/4	44.45	24

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Figure 4-3.—Small stuff.

Line larger than 1 3/4 inches is designated by its circumference, in inches. A 5-inch line, for example, is constructed of natural or synthetic fibers and measures 5 inches in circumference. In general, lines larger than 5 inches are called *hawses*, which are available in sizes up to 21 inches.

CARE AND HANDLING OF LINE

It is not news to experienced Seamen that misuse and abuse of their gear shortens its life. Yet, because of carelessness and lack of knowledge, line is the one item that receives more abuse than any other equipment the Seaman uses. Also, line in a doubtful condition puts more lives in jeopardy than any other gear. Therefore, you should learn and exercise the proper care and methods of handling line.

NATURAL-FIBER LINES

Coils of line should always be stowed on shelves or platforms clear of the deck. They should never be covered with an accumulation of junk that may prevent the evaporation of moisture, because line composed of vegetable (natural) fiber is susceptible to mildew and rotting if it stays wet.

Coils of large line should be stowed with their proper side up for opening. Line from 2 to 4 inches, which will be needed in various lengths on deck, should be opened, and a few feet of the end led out. Mooring line should not be opened until it is needed.

Whenever possible, line that has become wet in use should be dried thoroughly before it is stowed. Sometimes this is impossible, as with mooring lines, which must be stowed before the ship clears port. If line must be stowed wet, it should be laid up on grating in long fakes or suspended in some way that will allow it to dry as quickly as possible. It should never be covered before it is dry.

Stretch and, usually, elongation occur when natural-fiber line under tension is wetted down. The line shrinks in diameter, adding more strain. When the line dries, it does not recover to its original size and shape. Thus its length is increased and its diameter and strength are decreased. New line, which still contains a large amount of its original waterproofing oil, does not shrink as much as old line, from which much of the oil has dissipated through exposure. Nevertheless, whatever the condition, taut lines, such as boat falls, must be slacked when it begins to rain or when spray begins to wet them.

Distortions, Kinks, and Twists

Most damage to a line occurs as the line is being hauled in under a strain. The initial load on the line is created as the line coils onto the winch. If a line does not lead fairly to a winch drum (90° to the drum axis), it will become badly distorted as it is heaved in. Notice in view 1 of figure 4-4 that the line from the load approaches the drum at an angle other than 90°. If a strain is put on the line in this situation, the line will become fouled on the drum and may be damaged. To keep the line from fouling and becoming damaged, it must be changed as shown in view 2 of figure 4-4. This involves putting turns of line inside (toward the base of the drum) of the part from the load so the line feeds onto the drum at a 90° angle. Because the outside end is attached to the load and is unavailable, enough slack must be hauled up in the hauling part to make the necessary number of turns. The turns should be started inboard, as shown in the figure.

Whenever possible, a right-laid line should be put on a winch drum or capstan right-handed or in clockwise turns. Heaving on a right-laid line with left-handed turns will eventually kink the line. About the only time left-handed turns cannot be avoided is when a winch is heaving on two lines at once, one on each drum.

A line with a kink in it or a cockle that is twisted from having a dip in it should never be heaved hard while that condition exists. A strong strain on a kinked or twisted line will put a permanent distortion in the

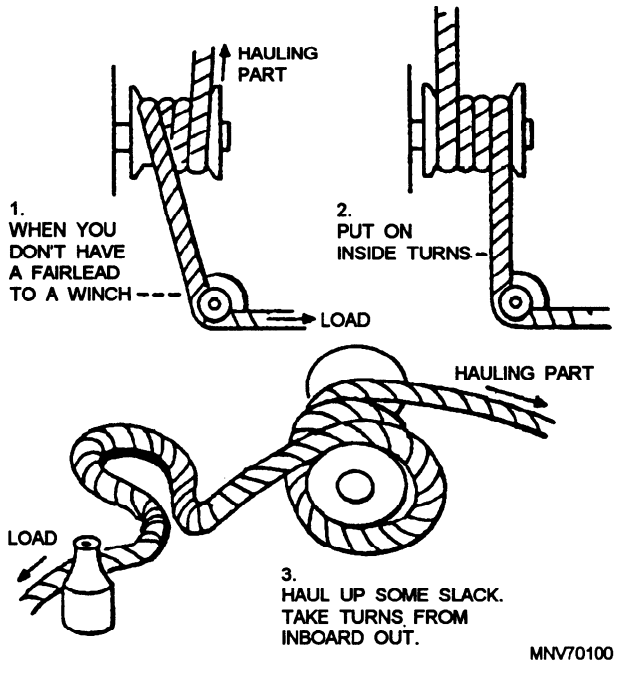

Figure 4-4.—Putting on inside turns to get a fair lead.

line. Figure 4-5 shows what frequently happens when a line with a kink in it is heaved on. The kink, which could have been worked out, is now permanent, and the line is ruined.

A condition similar to a kink is the cockle (or hockle), which actually is a kink in an inner yarn that forces the yarn to the surface. When a strain is applied to a twisted rope with the load free to rotate, the lay of the rope lengthens as the turn runs out of the rope. Actually, what happens is that the turn is transferred to the strands. When the twist in the strand builds to a point where it can take no more, the inside yarns pop through the outer ones. Cockles also can be formed in a line wound on a capstan or gypsy head in the direction that tends to unlay the line. You can correct a cockle by stretching the line and twisting the free end to restore the original lay.

Securing lines improperly can cause drastic reduction in strength. The strength of a line can be reduced by as much as 50 percent for knots and bends and 40 percent for hitches. Figure-eight bends on cleats and H bitts have the same effect. See figure 4-6 for the correct way to secure a line on H bitts. When lines are properly secured with round turns on H bitts, the line will retain 90 percent of its strength. When lines are used on double bitts, figure eights reduce the rope strength by only 25 percent.

Deterioration

In addition to being damaged by mechanical factors during service, natural-fiber lines also suffer the effects of aging under storage conditions. Natural-fiber lines basically consist of cellulose and have the same aging properties as paper. That is, they turn yellow or brown and become brittle with time, even under the best storage conditions. The color change indicates that the line has lost breaking strength (BS). The loss usually amounts to 1 to 2 percent per year of storage.

However, BS is not a true index of the line's utility. More important is the loss of bending strength, indicated by the fibers' becoming brittle and stiff. Bending strength decreases five times as rapidly as BS. Deterioration of bending strength causes the fibers to rupture easily when bent over sheaves or other holding devices. Once deterioration begins, the line breaks down with each successive bend, even under light loading conditions. Because of this, it is important that the age of unused lines be determined from the manufacturer's identification marker tape within the line strand. The marker tape will tell you who made the line, the date the line was made, and the fiber type.

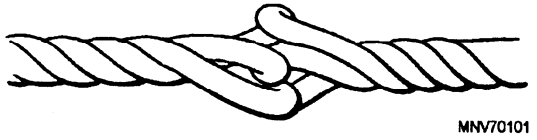

Figure 4-5.—Result of a strong strain on a line with a kink in it.

WARNING

If natural-fiber line's age exceeds 5 years, do not use the line for critical operations or operations involving the lives of personnel. Natural-fiber ropes more than 5 years old (even though unused) may only be used for lashing, fenders, or matting.

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It is a good idea to maintain a rigging log to help you determine when to remove natural-fiber lines from service and replace them with serviceable lines. Unless you maintain a log, you may have to cut a line open to determine its age.

The following are some pointers on the use and care of natural-fiber and synthetic line. Remember them.

- Coil right-laid line right-handed, or clockwise.
- Keep line from touching stays, guys, and other standing rigging.
- When you surge line around bitts or capstans, take off enough turns so the line will not jerk, but will surge smoothly.
- If line becomes chafed or damaged, cut out the damage and splice the line. A good splice is safer than a damaged section.
- Do not lubricate line.
- Whip all line ends.

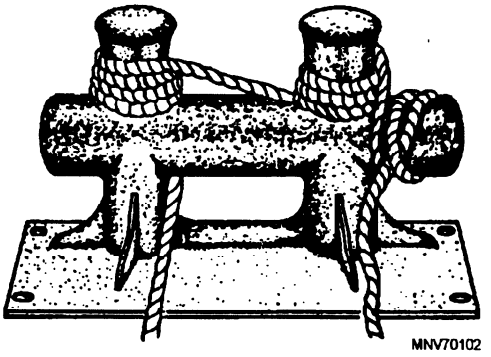

Figure 4-6.—Securing lines to H bitts.

- Inspect line frequently for deterioration. Open the lay and inspect the fibers. White powdery residue indicates internal wear.
- Do not drag a line over sharp or rough objects; doing so can cut or break the outer fibers. When line is dragged on the ground, dirt and other particles are picked up and eventually work into the line, cutting the inner strands.
- The strength of line exposed to the atmosphere deteriorates about 30 percent in 2 years from weathering alone.
- Line loaded in excess of 75 percent of its breaking strength will be damaged permanently. Inspect the inside threads to see if all or a portion of the fibers in the threads are broken.
- Keep bitts, chocks, and cleats in smooth condition to minimize abrasion.
- Use chafing gear on rough, hard surfaces and sharp metal edges.
- Apply loads slowly and carefully.

SYNTHETIC-FIBER LINES

The synthetic fibers currently in use for making line are (in descending order of strength) nylon, aramid, polyester (Dacron®), polypropylene, and polyethylene.

The characteristics of synthetic line differ from those of manila line. This causes the safety precautions for synthetic-fiber line to be more exacting than those for manila line. A complete list of precautions is given in chapter 613 of the *Naval Ships' Technical Manual (NSTM)*, but the more important precautions you should observe are as follows:

- Because of the lower coefficient of friction of synthetic-fiber line, you must exercise extreme care when you pay a line out or ease it from securing devices (bitts, capstans, cleats, gypsy heads, etc.). For control in easing out, take no more than two round turns on cleats or bitts. For checking a line under strain, take two round turns followed by no more than two figure-eight bends. Any more than this will present a danger to personnel and cause difficulty in handling the line.
- To minimize the hazard of pulling a line handler into a securing device when a line suddenly surges, have safety observers ensure that all the line handlers stand as far as possible from the device, with a minimum distance of at least 6 feet from the securing device being tended or worked. Note that this is particularly critical in mooring operations.
- Since a snap-back action inevitably occurs when a line parts under tension, never allow personnel to stand in the direct-line-of-pull of the line when it is being pulled or when it is under tension. A synthetic line parting under tension will snap back at near the speed of sound, and there will be no time to clear the area. Where possible, position line handlers a minimum of 90° from the direction of the tension force (fig. 4-7).

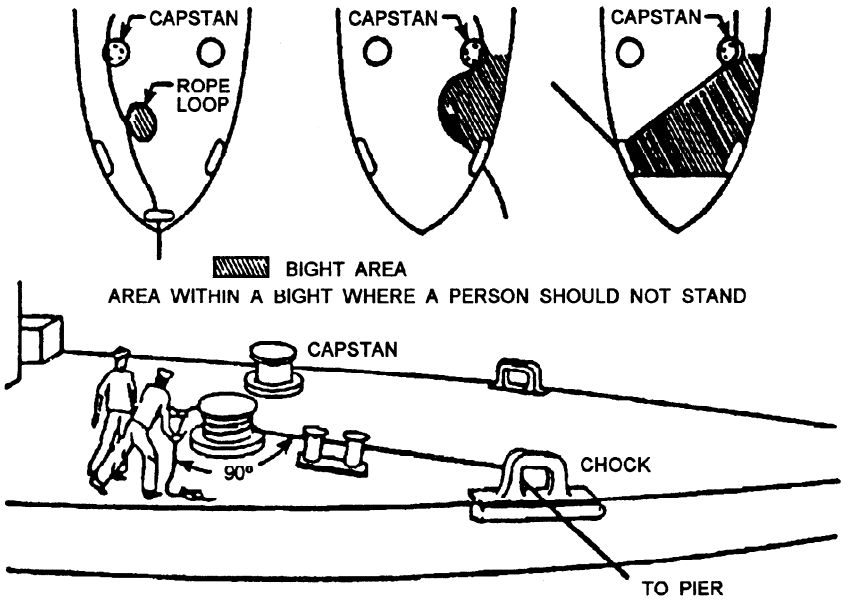

Figure 4-7.—Safe working area.

Table 4-1.—Synthetic-fiber-line Constructions and Characteristics

Rope Construction	Breaking Strength	Abrasion Resistance	Stretch	Cost	Rotation Under Load
Three Strand	Medium	Good	Highest	LOW	Yes
Double Braided	High	Good	LOW	High	No
Plaited	Medium	Good	High	Medium	No

- Before you begin an operation using synthetic line, determine the capacity of all the gear and fittings used with the line, such as blocks, pad eyes, shackles, and line couplings, to ensure that their strength exceeds the minimum breaking strength of the rope. Synthetic lines have higher breaking strengths than equal sizes of manila line. Since many of the fittings used in the fleet were designed for natural-fiber line, they may fail if used improperly with synthetic line. Where the substitution of synthetic-fiber line for manila line is authorized, *NSTM,* chapter 613, provides the appropriate guidance for the substitution.
- Synthetic line has poor knot-holding characteristics. Some knots that offer good characteristics for securing manila line, such as the square knot, are not adequate for belaying or securing synthetic line. The bowline is one knot known to offer reasonable security when you are bending together or securing synthetic line.

Regardless of the line fiber material, you must heed the following safety rules whenever you handle line:

- Never stand in the bight of a line or in the direct-line-of-pull when the line is being pulled or under tension. See figure 4-7 for examples of danger areas.
- Never continue to increase the load on a line after the rigs have been two-blocked or tightened. Many injuries and fatalities have occurred when operators have not observed this rule.
- Be sure that a safety observer is posted in every case where lines are being worked.

Line Characteristics

Lines are classified by both their construction and their material. The most common line constructions currently used in the Navy are three-strand, double-braided, and plaited. The most common properties of the three constructions are shown in table 4-1. The most common properties of the three materials are shown in table 4-2. You can use the information in these tables to determine the construction and material needed for a particular application.

If, for example, a line must be able to withstand abrasion (abrasion being the condition a line is subjected to in a chock or around a capstan head), the best choice is a three-strand nylon line. Notice that one of the characteristics listed in the tables is stretch. Stretch is a misunderstood characteristic in synthetic line. In some applications of line, excessive stretch is a disadvantage. In other applications, stretch is an advantage. When a line is subjected to impact loading, as it is in towing, the more stretch the line has, the better it can absorb impact.

Table 4-2.—Synthetic-fiber-line Materials and Characteristics

Rope Material	Breaking Strength	Abrasion Resistance	Stretch	Cost	Resistance toSunlight
Nylon	High	Good	High	High	Good
Polypropylene	Low	Fair	Medium	LOW	Medium
Polyester (Dacron)	Medium	Best	Least	High	Good

Although line stretching can be beneficial to a job, it can also be detrimental to the line, when overdone. The amount a line stretches is directly related to the load placed on the line. As long as the load is within the line's safe working load (SWL), the line will be safe to use. To ensure the longest life, use a line within its SWL. The SWL of line ranges from one-sixth to one-tenth of the minimum breaking strength (BS) of new line, allowing for the type of application, the weather, and the blocks and other gear being used with the line.

If a line is loaded beyond its SWL, it may reach a critical point, which is near the BS of the line. A line may repeatedly be brought to its SWL without impairing the line or reducing its useful life. From the standpoints of safety and economics, it makes sense to take precautions not to surpass the SWL of a line. A simple device that will keep you from exceeding a line's SWL is a *tattletale cord.* A tattletale cord is a bight of six-thread manila hanging from two measured points on the working line. The line, when tensioned to its stretch limit, will stretch to a certain percentage of its elastic length. When this point is reached, the tattletale cord becomes taut, warning that there is danger of exceeding the stretch limit of the line. Figure 4-8 shows a tattletale cord on a three-strand nylon line. Table 4-3 shows standard lengths of tattletale cords and the distances between suspension points for various lines. Use tattletale cords and every other guide available to you to ensure that you do not ignore the SWLs.

Concerning the BS of line, the current practice in the Navy is to use the minimum BS. Minimum BS is defined as the lowest BS encountered in all of the test samples broken. Line manufacturers usually publish average BSs, which may be 10 to 25 percent higher than the minimum BSs. The actual BS of a line can be anywhere from the minimum BS to 35 percent higher.

Table 4-3.—Dimensions for Tattletale Cords

Type of Synthetic Rope	Length of Tattletale (Inches)	Distance Between Marks (Inches)
Nylon Three-Strand	35 1/2	30
Nylon Plaited	43 1/2	40
Nylon Double-Braid	43 1/2	40
Polyester Three-Strand	63 1/2	60
Polyester Plaited	62 1/2	60
Polyester Double-Braid	62	60

Normally, synthetic-fiber line is furnished on reels and is unreeled in the same fashion as wire rope. (We discuss wire rope in detail later in this chapter.) If you receive a synthetic line made up in a coil, do not open the coil and pull the end up through the tunnel as with natural-fiber lines. Set the coil on a turntable and pull on the outside end while somebody rotates the turntable. Should a coil collapse and the line kink and tangle, do not try to untangle it by pulling on the line. Secure one end and drop the remainder of the coil into the sea. In the water, the line will relax and gradually uncoil without forming permanent kinks or cockles. (DO NOT TRY THIS WHILE THE SHIP IS UNDER WAY.) This water treatment also removes bulges in new, soft-laid line and hardens the line structure.

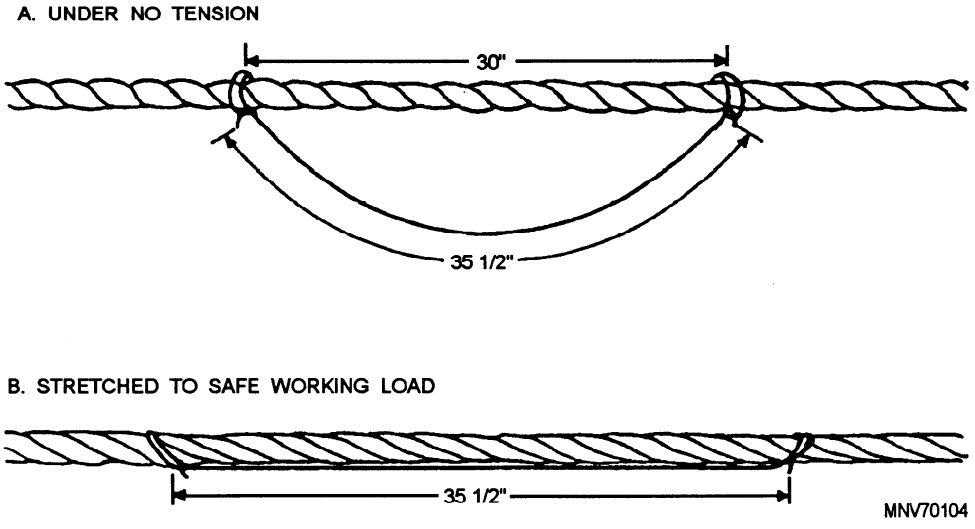

Figure 4-8.—Tattletale cord on a twisted nylon line.

Before you use a new three-strand synthetic-fiber line, fake (coil) it down on deck and allow it to relax for 24 hours. The shorter the line, the less time the relaxing process takes; for example, a length of less than 50 feet will relax in 1 hour.

When wet, synthetic line shrinks slightly and may swell slightly. When the line is tensioned, the water squeezes out; under working loads, it appears as vapor. Because line under tension develops friction, and thus heat, the water has a beneficial cooling effect. However, nylon loses 15 percent of its strength from water being absorbed by nylon molecules.

Nylon, aramid, and polyester lines exhibit almost no decrease in strength due to sunlight, but polypropylene does. Polypropylene line may lose as much as 40 percent of its strength in 3 months when exposed to tropical sunlight if the line is made without ultraviolet inhibitors. Ultraviolet inhibitors can be added to the line at the time of manufacture to reduce the effects of sunlight. White polypropylene line has almost no inhibitors added, while black polypropylene has the most inhibitors added. However, just because a polypropylene is black does not mean that it has had ultraviolet inhibitors added. If a polypropylene line has had ultraviolet inhibitors added, it should meet military specification MIL-R-24049. Line obtained through the Naval Supply System (stock system), meets the proper specifications.

Oil and grease do not cause synthetics to deteriorate, but they may make them slippery. When this happens, the line should be scrubbed down.

Table 4-4.—CID-A-A-50435 Aramid Rope Characteristics

CIRCUMFERENCE (INCHES)	BREAKING STRENGTH (POUNDS)
3 3/8	50,000
3 1/2	60,000
3 3/4	70,000
4 1/8	96,000
4 3/4	135,000
5 3/8	180,000
5 7/8	225,000
6 1/4	280,000
7 5/8	350,000
8 3/16	420,000

Four-Strand Aramid Line

Four-strand aramid lines are designed to fail sequentially, meaning that one of the four strands will fail before the other strands. This line has been proven to work better than a three-strand mooring line, and less line handlers are required due to the smaller size of line required to moor a ship. Table 4-4 shows the characteristics of aramid rope.

Aramid line is being phased into the Navy as a substitute for three-strand nylon; table 4-5 compares equivalent sizes of lines, from three-strand nylon to polyester double-braided line.

Table 4-5.—Aramid Rope Substitution

ARAMID 4-STRAND CID-A-A-50435	NYLON 3-STRAND MIL-R-17343	NYLON PLAITED MIL-R-24377	NYLON DOUBLE-BRAIDED MIL-R-24050	POLYESTER DOUBLE-BRAIDED MIL-R-24677
3 3/8	4 1/2	4	4	4
3 1/2	5	4 1/2	4 1/2	4 1/2
3 3/4	5 1/2	5	5	5
4 1/8	6	6	5 1/2	6
4 3/4	7	7 1/2	7	7
5 3/8	8	9	8	8
5 7/8	9	10	9	9
6 1/4	10	11	10	10

The following is an inspection guideline. Rope technology has not yet advanced to the point where a rope can be inspected visually to determine the exact extent of damage. Therefore, you must use sound judgement to determine the serviceability of a given section of rope.

CHARACTERISTICS	RESPLICE (IF LOCALIZED)	REPLACE
1. Rope suspected of being shock loaded.		X
2. Rope has exceeded 75 percent of its minimum breaking strength.		X
3. Bulk of surface yarns or strands reduced by approximately 50 percent for a linear distance equal to four times the rope's circumference.	X	X
4. Three or more adjacent cut yarns in the strands of ropes 5 inches or less in circumference.	X	X
5. Four or more adjacent cut yarns in the strands of ropes 5 inches of more in circumference.	X	X
6. Stretch out: Circumference reduced by 5 percent from circumference when new.		X
7. Chockling	X	
8. Oil and grease	Wash in mild detergent	
9. Heavy surface fuzz progressive.	X Remove source of abrasion	X
10. Burns or melting visible for a length of over four times the rope circumference.	X	X
11. Rust on nylon.	X (or clean)	
12. More than four adjacent pulled cover strands (which cannot be reincorporated into cover braid).	X	X
13. Core visible through cover because of cover damage(except single braids).	X	X
14. Core damage - pulled, cut, abraded, or melted strands.		X
FOR THREE-STRAND AND EIGHT-STRAND PLAITED ROPES		
15. Damage in valley between strands.	X	X
16. Powdering between adjacent strand contact surfaces.	X	X
WHEN IN DOUBT REMOVE FROM SERVICE!		

Table 4-6.—Rope Elongation

TYPE	APPROXIMATE ELONGATION AT BREAK (PERCENT)		
	NYLON	POLYESTER	ARAMID
Three-strand	55	35	—
Double-braided	30	30	—
Plaited	65	45	—
Four-strand	—	—	6

Nylon rope, on parting, is stretched nearly one-half of its original length. This length is recovered instantaneously on parting, causing snap back with hazardous force. In view of this danger, it is imperative that no one stand in direct line of the pull when a heavy load is applied to the line. Polyester rope is stretched nearly one-third of its original length and is as dangerous as aramid rope, which stretches six percent. Table 4-6 shows the approximate elongation of nylon, polyester, and aramid ropes at break. These elongation percentages were taken from the mil specs and commercial item descriptions for the ropes.

SPLICING LINE

The ends of line may be joined permanently by a long splice or by a short splice. Whether a long or a short splice is used depends on how the line is to be used. The short splice is described in the NSTM, Chapter 613 and will not be repeated here. In this manual, we will discuss only the long splice.

LONG SPLICE

A long splice does not change the diameter of a rope materially; therefore, it is used to join two ropes when the rope will run over sheaves in a block. To make a long splice, take the following steps:

1. Unlay the end of each rope 15 turns.

2. Place the ends together, as shown in view A of figure 4-9, and seize five of the strands together.

3. Unlay the loose strand ten more times.

4. Lay the opposite strand from the other rope in the groove left by inlaying the first strand (view B).

5. Tie an overhand knot, as shown in view C.

6. Cut out the seizing and unlay a strand in the opposite direction.

7. Repeat steps 4 and 5.

8. Tie an overhand knot in the two remaining strands.

9. Take a tuck with each strand or split each strand and make tucks in opposite directions with the halves.

View D shows the completed long splice.

ALONGSIDE MOORING

Mooring alongside a pier and getting under way from a pier are basic, yet extremely critical, functions performed by the deck department. Mooring a ship safely takes preparation, training, and the teamwork of all hands. A sound working knowledge of capstans, gypsy heads, deck and pier fittings, and the proper use of mooring lines is a must.

MOORING LINES

Ships are moored to piers, wharfs, and quay walls, and nested with other ships by mooring lines, which vary in size depending on the type of ship. For instance,

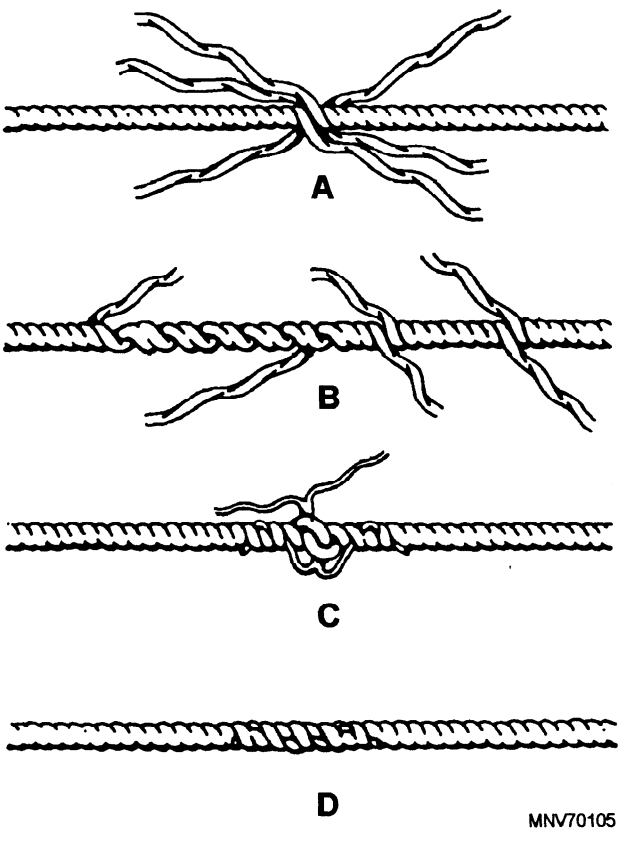

Figure 4-9.—Long splice in fiber line.

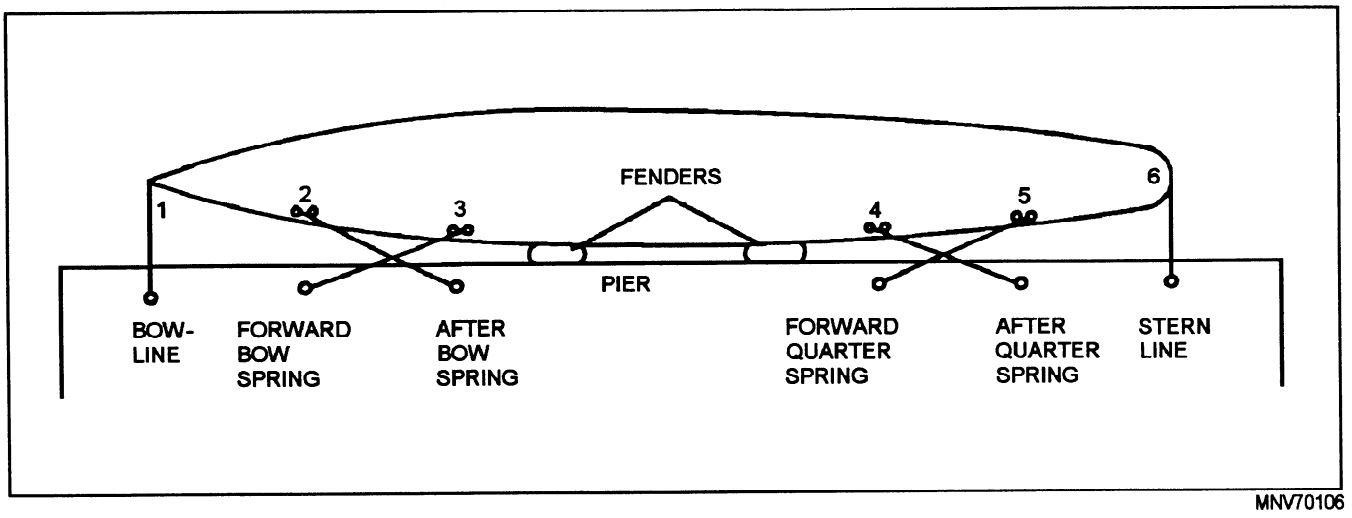

Figure 4-10.—Mooring lines of a ship.

a destroyer uses a 5-inch synthetic line, while a carrier uses an 8-inch synthetic line. In general, mooring lines must satisfy two requirements. First, they must be as light as possible for ease in handling; and second, they must be strong enough to take the strain of mooring, getting underway, and holding the ship in heavy weather.

Mooring lines are named, according to their use, as bowlines, stem lines, breast lines, or spring lines. The bowline runs through the bullnose or chock nearest the eyes of the ship and holds the bow in. The stern line runs through the stem chock or quarter chock, holding the stem in. A breast line is led nearly straight across to the pier, controlling the distance of the ship from the pier. Breast lines are called bow, waist, or quarter breasts. A spring line leads at an angle of about 45 degrees from the ship to the pier and controls fore-and-aft movement. Spring lines leading forward are the forward bow spring or the forward quarter spring. These lines keep the ship from going aft. Spring lines tending aft are the after bow spring or the after quarter spring. Their purpose is to keep the ship from moving forward.

The standard moor on most ships is six mooring lines. These lines are numbered from forward to aft and are called by number in line-handling evolutions because numbers are shorter and more precise than names. See figure 4-10. A ship may use fewer or more lines as necessary, in which case the numbers are changed accordingly. When the ship is in position and secure, the mooring lines are doubled up, which means that a bight of line is passed to the pier or to another ship, giving three parts of line. The bight is evened up with the single part of line so that each of the three parts is taking an equal strain. See figure 4-11.

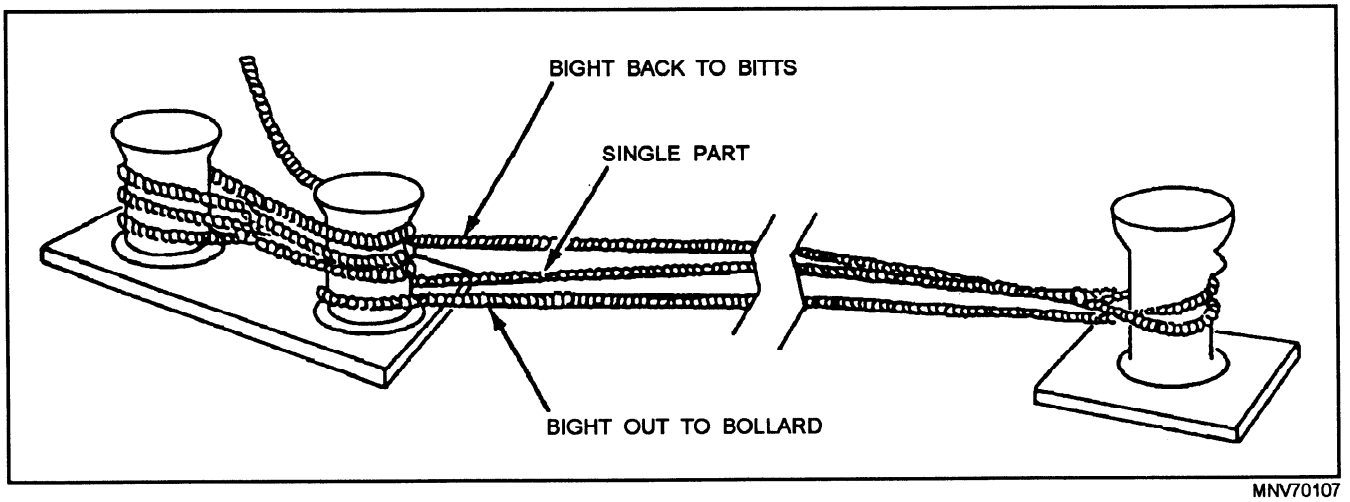

Figure 4-11.—Correct method of doubling up.

Preparing to Moor

Well in advance of mooring, the lines are broken out and faked down, each near the chock through which it will pass (fig. 4-12). An eye is passed through the chock and laid back over the lifeline. During this breakout phase, all the lines should be checked for abrasion, wear, breaks, or decomposition. The tattletale cord spliced into the synthetic lines must be checked.

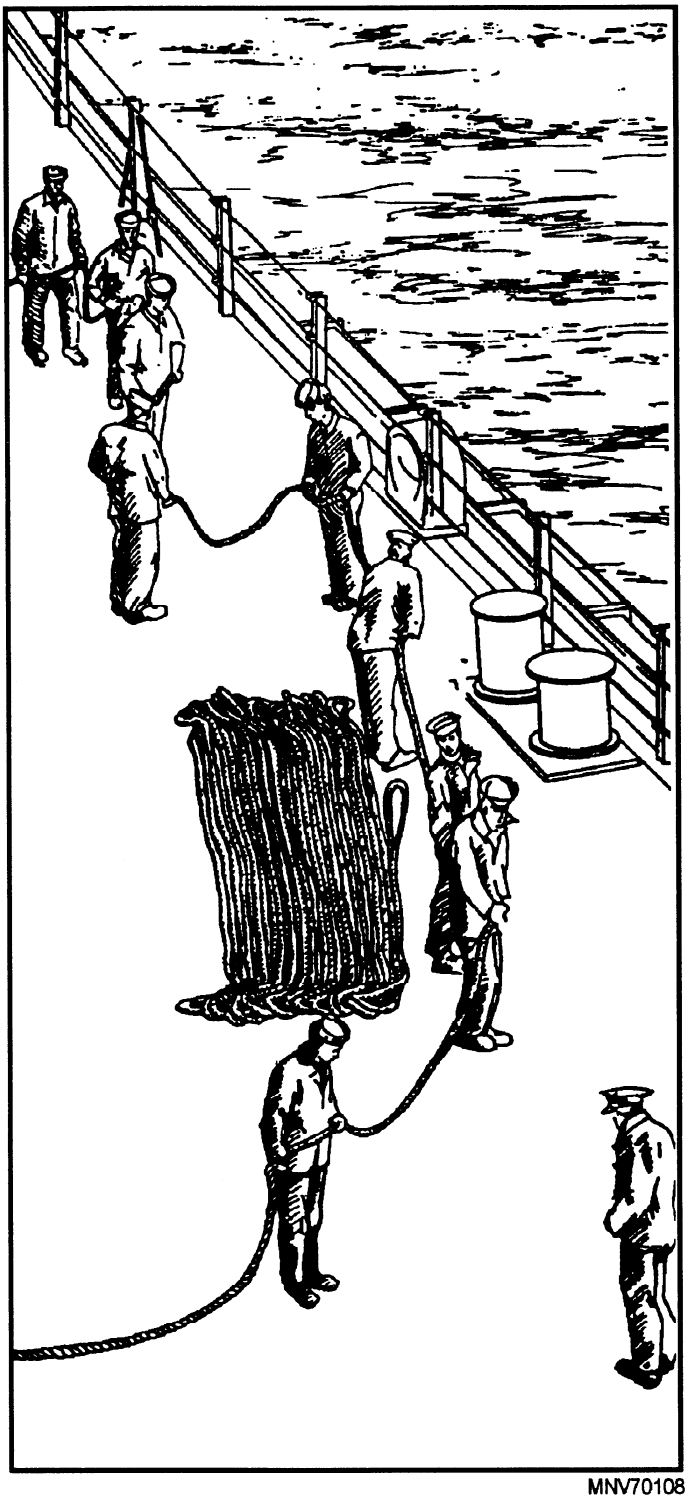

Figure 4-12.—Preparing to moor.

CAUTION

No synthetic line, other than four-strand aramid line, may be used as a mooring line without having a tattletale cord attached. The tattletale cord shows line handlers when the line is stretching toward its safe working load and to the danger point. Since four-strand aramid fiber rope stretches only 6 percent at minimum breaking strength, tattletale cords cannot be used to determine the strain on these mooring lines. Do not use a tattletale with natural-fiber rope.

Mooring Line Delivery Lines

Since mooring lines are usually too heavy to heave properly, lighter weight lines are thrown from the ship to the pier and used as delivery lines to pull the mooring lines from the ship to the pier. These lines include heaving lines, bolos, and line-throwing gun lines. The speed with which the lines are sent to the pier is often critical, especially in strong winds or currents.

HEAVING LINES.—A heaving line is basically a line that is thrown by hand from the ship to the pier. It is important to have more than one heaving line on station. A second heaving line should be made up and kept ready to throw in case the first throw fails. Once the heaving line is successfully cast to the pier, it can be bent to the mooring line needed first. All mooring lines larger than 5 inches must have messengers of 1 1/2 inches in circumference, and 12 to 18 inches long attached to them so that the heaving line does not part during delivery to the pier.

BOLO.—In addition to the heaving lines, it is useful to have bolo lines ready, both fore and aft.A bolo consists of a padded weight attached to the end of a nylon shot line. An experienced, skillful sailor can throw a bolo twice the distance of a heaving line, and because of its size and weight, a bolo is more effective in the wind. However, a bolo can be *very dangerous*, especially when large numbers of people are on the pier With its size and speed of delivery, a bolo could seriously injure someone who happened to be in its way. For this reason, its use is discouraged and sometimes prohibited by some commanding officers.

LINE-THROWING GUN LINE.—A third delivery line, also posing danger to those on the pier, is the line-throwing gun line. In mooring, it is used when the heaving line or bolo will obviously not be effective.

CAUTION

The line-throwing gun may not be loaded until it is actually needed. When the gun is loaded, it must bepointed outboard, barrel up.

DECK MACHINERY

When the sea detail is set and the line-handling stations are manned, it is important to test the capstans and gypsy heads. The anchors will also be made ready to let go. This is done for emergencies on approach, or an anchor can be used as a poor-man's tug when laid underfoot in a mooring evolution. Anchors and anchoring are covered in chapter 7 of this manual. Once the capstans and gypsy heads are satisfactorily tested, the mooring lines may be fairled to power if desired

FENDERS

The main purpose of fenders is to protect the ship from contact with the pier or another ship.

The most common ship fender is a pneumatic fender made of rubber, about 4 feet long and 3 feet in diameter. It should be positioned amidships at the extreme beam. This fender is normally the only one the ship rides against when it is

alongside of another ship. A number of additional fenders, depending on the size and type of ship, are kept ready on the forecastle and on the fantail. These are normally smaller pneumatic fenders or homemade manila fenders about 4 feet long and 1 foot in diameter.

COMMANDS TO LINE HANDLERS

Commands to a ship's line handlers originate on the bridge. These commands must mean the same thing to the line handlers as they do to the originators on the bridge. Further, the commands must be carried out immediately. Therefore, the more common commands have been standardized. The following examples and definitions are in common use and form the basis for orders to line handlers:

STAND BY YOUR LINES	Man the lines and stand ready to work.
PASS ONE	Pass line number one to the pier; place the eye over the appropriate bollard but take no strain.
TAKE A STRAIN ON ONE	Put line number one under tension.
SLACK ONE	Take all tension off of line number one and let it hang slack but not in the water.
EASE ONE	Let number one line out until it is under less tension but not slacked
TAKE NUMBER TWO TO THE CAPSTAN	Lead the end of line number two to the capstan; take the slack out of the line but take no strain.
HEAVE AROUND ON TWO	Apply tension on number two line by hauling on it with the capstan.
AVAST HEAVING	Stop the capstan, or stop heaving around.
HOLD FIVE	Do not allow any more line to go out on number five even though the risk of parting the line may exist.
CHECK FIVE	Hold number five line but not to the breaking point; allow only enough line to render around the deck fitting to prevent it from parting.
SURGE FIVE	Hold moderate tension on number five line but allow it to slip enough to permit movement of the ship (used when moving along the pier to adjust position).
DOUBLE UP	Pass an additional bight on all mooring lines, or line indicated, so that there are three parts of each line to the pier. To ensure that the three parts take an equal strain, pass a stopper on the standing part and take a round turn on the barrel of the bitts closest to the chock. Next pass a bight of the line to the pier, then take the standing part to power, remove the stopper and take the slack out of the line (equalizing all three parts). Once this is done, pass the stopper and fairlead the standing part to the second barrel and figure-eight the line over both barrels to secure it.
SINGLE UP	Take in all bights and extra lines so there remains only a single part of each of the normal mooring lines.
TAKE IN ALL LINES	Used when secured with your own lines, it means to have the ends of all lines cast off from the pier and brought aboard.
TAKE IN ONE (OR NUMBER ONE)	When used by the Boatswain's Mate in charge on the forecastle, it is preceded by the commands slack one and cast off one, which mean merely to retrieve line number one and bring it back on deck.
CAST OFF ALL LINES	When secured with your own lines, it is a command to those tending the mooring lines on the pier or on another ship to disengage or throw off the lines from the bollards or cleats. When secured with another ship's lines in a nest, it means to cast off the ends of her lines and allow the other ship to retrieve her lines.
TAKE IN THE SLACK ON THREE (OR NUMBER THREE)	Heave in on number three line but do not take a strain.

Often, the ship must move up the pier or wharf in short steps; in this case, the command “Shift lines on the dock forward (or aft)” or "Walk number one forward (or aft)” is given. Supplementary information about the distance of the move is also sent down from the bridge. Caution must be used in this movement, since control of the ship’s position is still being exercised by the use of the mooring lines, and the ship’s propulsion or tugs will be used to make the move.

If the ship’s auxiliary deck machinery should be used to haul in on a line, the command “Take one (number one) to the capstan” is given. This may be followed by “Heave around on one (number one)” and then, “Avast heaving on one (number one)“.

DIPPING THE EYE

If two mooring lines are placed over the same bollard, the second one should be led up through the eye of the first, then placed over the bollard. This procedure makes it possible for either line to be cast off without disturbing the other.

FRAPPING LINES AND RAT GUARDS

When a ship is pierside or inboard in a nest, she will normally frap her lines. This is done by wrapping the mooring line snugly with small stuff, marrying the three parts of the mooring line together.

When the frapping is complete, the rat guards are placed on the lines. Canvas chafing gear must first be lashed to the mooring line to protect it from the metal rat guard. Rat guards are circular metal disks, lashed together on a mooring line with the concave side to the pier. Rat guards should not be used when the ship is moored outboard in a nest; however, lines that are run to the pier must have them installed.

LINE-HANDLING SAFETY PRECAUTIONS

Whenever you handle lines, observe the following safety precautions:

- Tend the lines well behind the bitts in case the line surges or parts.
- Do not stand in the direct line of pull of a working line. Under no circumstances stand in the bight of a line.
- Do not even try to check a line that is running out rapidly by stepping on it.
- When you handle lines, fake down the standing part to prevent fouling.
- Remember that nylon, polyester, and other synthetic lines are characterized by high elasticity and low friction. The following rules apply:
  a. Add an extra turn when you are securing a line to a bitt, cleat, capstan, or other holding device.
  b. When you ease synthetic line out from holding devices, use extreme caution because of the high elasticity, rapid recovery, and low friction.
  c. Remember, three strand nylon line, on parting, is stretched to about 1 1/2 times its original length and snaps back at near the speed of sound.
  d. Know your gear and its capabilities; train deck personnel; quiz line handlers on their duties and on safety on station.
  e. Make sure all the hands involved are safety briefed before and critiqued after an evolution.
  f. Never use synthetic mooring lines without a tattletale cord.

KNOTS, BENDS, AND HITCHES

Among Seamen, the landsman’s all-inclusive term *knot* must give way to *knot* in its more specific meaning and to the terms *bends* and *hitches.* Seamen, in addition, must know which knot, bend, or hitch will serve best in a particular circumstance.

KNOTS AND BENDS

A knot, according to a Seaman’s use of the term, is usually a line bent to itself. The knot forms an eye or a knob or secures a cord or line around something, such as a package.

A bend ordinarily is used to join two lines together.

Reeving Line Bend

Frequently it is necessary to bend together two lines that must reeve around a capstan or winch drum. The best knot for this purpose is the reeving line bend, as

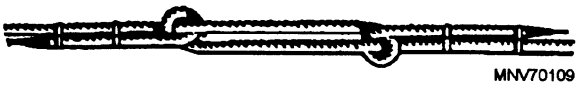

Figure 4-13.—Reeving line bend.

shown in figure 4-13. As you can see, it consists of taking a half hitch with the end of each line around the standing part of the other and seizing the bitter ends. Make sure the seizings are tight; otherwise, the knot might pull out.

Double Matthew Walker

The double Matthew Walker has many uses in fancy work, but it also has practical applications, such as keeping the end of a line from coming unlaid. This use should be considered only a temporary measure, because a proper whipping should be put on the line at the earliest opportunity and the knot cut off. Take a look at figure 4-14 before reading further.

To tie a double Matthew Walker, unlay 6 or 8 inches of line. Take the right strand, pass it around the other two and up through itself (view 1 of fig. 4-14). Next, pass the center strand around the third, under the first, and up through its own bight, as shown in view 2. Then pass the last strand around and under the other two, and up through its own bight (view 3). Tighten the knot by working out the slack and pulling tight. After tightening the knot, cut the ends off short or re-lay and whip them, as shown in view 4.

Fisherman's Bend

The fisherman's bend is a knot used to bend a line to a becket or an eye. To tie it, simply take two turns

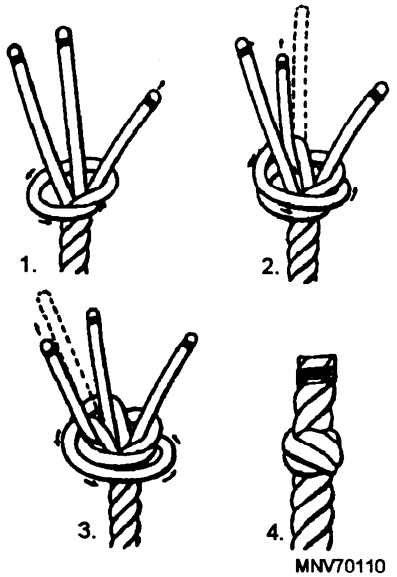

Figure 4-14.—Tying a double Matthew Walker.

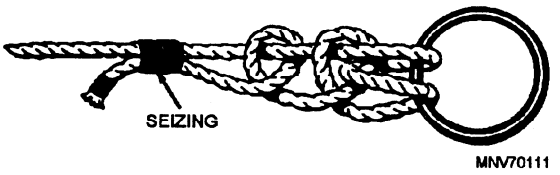

Figure 4-15.—Fisherman's bend.

through the eye. Tie a half hitch through the turns and another half hitch around the standing part (fig. 4-15).

Single Bowline on a Bight

The single bowline on a bight comes in handy whenever you need an eye in the center of a line. It can be tied quickly, does not jam tightly, and you do not need an end of the line to tie it. To get your securing lines taut, use a single bowline on a bight for securing equipment or cargo.

Tie the knot well up on the standing part and run the bitter end around a stanchion or through a pad eye and back through the eye of the knot. Heave back on the bitter end in a line between the knot and stanchion or pad eye. This gives the same effect as having a block on the line at the knot and, discounting friction, doubles your pull. Heave it taut and secure the end. To tie this knot, form bights A and B, as shown in view 1 of figure 4-16. Next, lay part C between bights A and B, as shown in the second view. Then reach through bight A, over part C, and pull bight B back through A. Tighten by pulling on part D and bight B. (The completed knot is shown in view 3.)

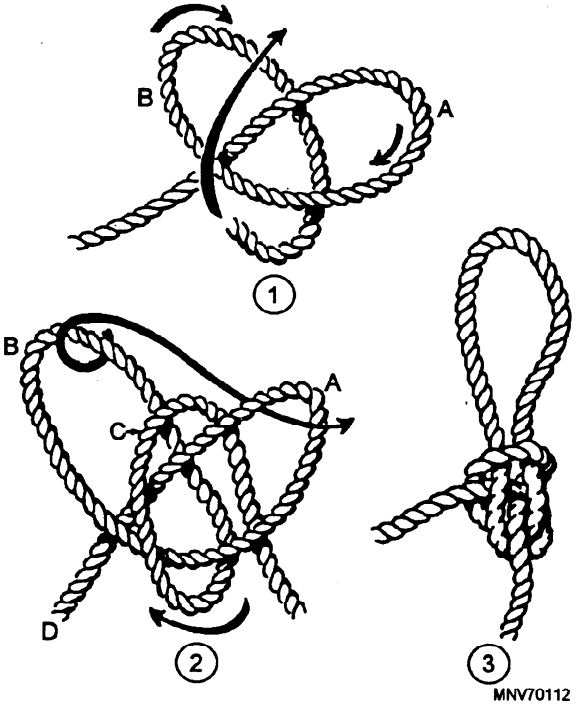

Figure 4-16.—Single bowline on a bight.

Spanish Bowline

The Spanish bowline can be used whenever it is desirable to have two eyes in the line. Its primary use, however, is as a substitute for the boatswains chair. Many prefer it to the French bowline because the bights are set and will not slip back and forth when the weight is shifted.

To tie this knot, take a bight and bend it back away from you, as shown in view 1 of figure 4-17, forming two bights. Then lap one bight over the other, as shown in view 2. Next, grasp the two bights where they cross (point a in view 2), and fold this part down toward you, forming four bights, as shown in view 3. Next, pass bight c through bight **e** and bight **d** through bight **f** (view 4). See the complete knot in view 5.

A word of caution here: ALWAYS use manpower to hoist a person in a boatswain's chair (or any substitute). Otherwise, if the chair or a part of the knot catches on a projection and the hoisting cannot be stopped in time, injury to the person seated is almost inevitable. Use enough personnel for the job, but no more.

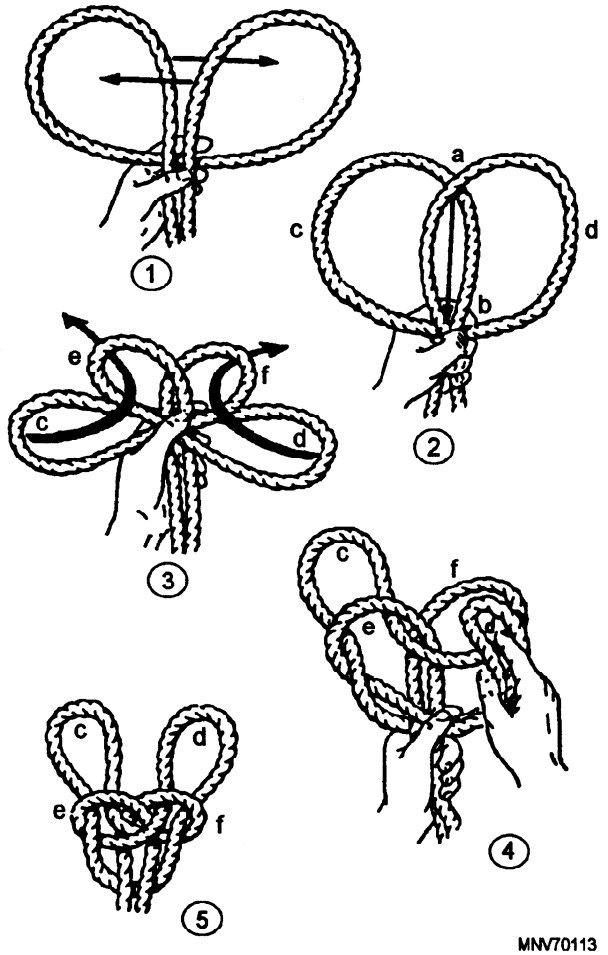

Figure 4-17.—Spanish bowline.

Masthead Knot

The masthead knot is seen usually in fancy work, but it also has a practical purpose. In the days of sailing ships, masthead knots were set at the top of the masts, and the stays and shrouds were secured to the eyes of the knots. It is a good knot to remember if you ever have to rig a jury mast.

In tying the masthead knot, fast lay up three underhand bights, the second on the first, and the third on the second, as shown in view A of figure 4-18. Then thread the inboard parts of the outboard bights under and over the parts of the other two bights, working each to the outside. Pull both bights tight. Work the slack into the knot to equalize the size of the three eyes (view B, fig. 4-18). Splice the two ends together and you have four eyes to which you can secure stays and shrouds.

Rolling Hitch

The rolling hitch is one of the most useful and most important hitches used on deck. It can be used for

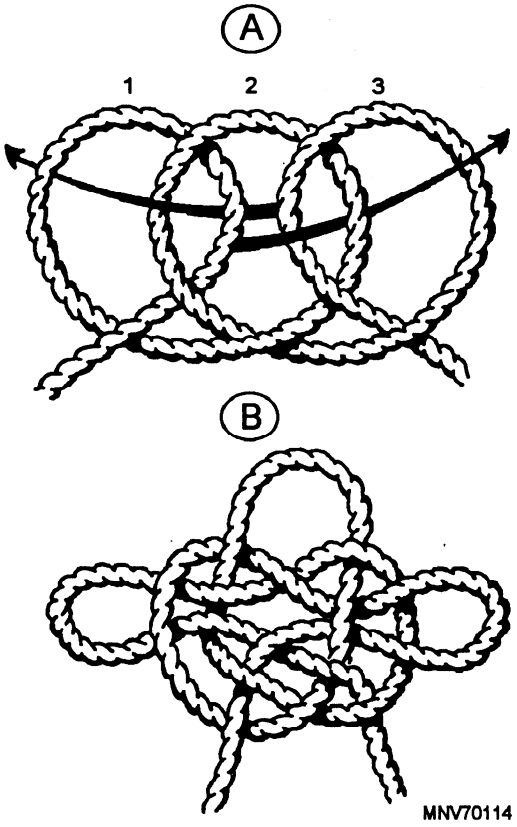

Figure 4-18.—Masthead knot.

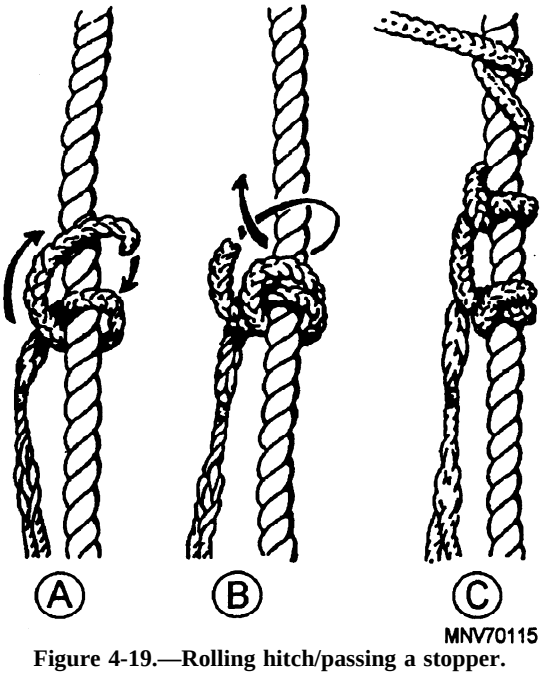

Figure 4-19.—Rolling hitch/passing a stopper.

passing a stopper on a boat fall or mooring line when you are shifting the fall or line from the winch or capstan to a cleat or bitt. It also may be used to secure a taut line back on itself. If properly tied, it will hold as long as there is a strain on the hitch.

To tie a rolling hitch, take a half hitch around the line with the stopper, as showninview A of figure 4-19. pull tight and take another turn. This turn must cross over the first (view A) and pass between the first turn and the stopper (view B). This completes the rolling hitch itself, but it must be stopped off in one of several ways.

One way is to take two or more turns with the lay of the line and then marry the stopper to the line by hand or seize the stopper to the line with marline. Another way is to tie a half hitch directly above the rolling hitch. A third way is to tie a half hitch about a foot above the rolling hitch (view C), then take a couple of turns against the lay, and marry or seize the stopper to the line.

Timber Hitch

The timber hitch is used on logs, spars, planks, or other comparatively rough-surfaced material. It should not be used on pipes or other metal.

Look at figure 4-20 to see how to tie a timber hitch. Take one or more half hitches around the timber to cant the timber if it must be hoisted through a small hatch or other small opening.

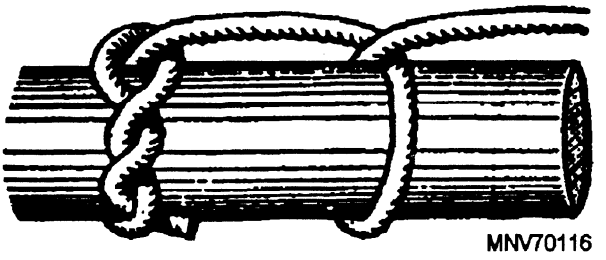

Figure 4-20.—Timber hitch and a half hitch.

Marline Hitch

Another hitch that requires no detailed explanation is the marline hitch. (Just remember that the end of the line goes over the standing part and under the round turn so that it binds itself.) This hitch is used to secure on furled sails and to frap awnings and doubled-up mooring lines (fig. 4-21). When cinched up, it will hold itself tight.

Blackwall Hitch

The Blackwall hitch, single or double, is used to secure a rope to a hook. It can be made quickly and, when tied properly, is secure. Except when there is insufficient rope end remaining to make a bowline, it seldom is used.

To tie a Blackwall hitch, make an underhand loop, slip it up over the hook, pull it tight around the back of the hook, then slide it down onto the hook. In tying the double Blackwall hitch, pass the strap around the hook and eye in the whip, as shown in figure 4-22. Make sure the standing part binds the bitter end at the back of the hook and in the hook, as shown. Notice that the bight stays around the eye in the whip and is not slid down onto the hook.

Round Turn with Two Half Hitches

The combination of a round turn with two half hitches may be used in a ring, in a pad eye, or on a spar. It is particularly useful on a spar because it grips tightly and holds its position (fig. 4-23).

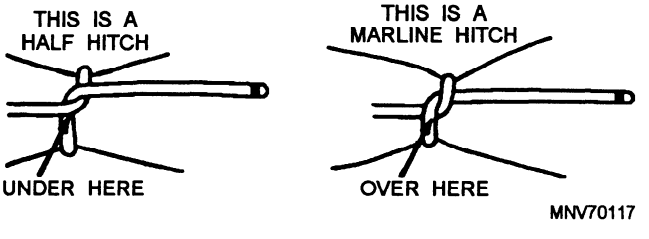

Figure 4-21.—Difference between a marline hitch and a half hitch.

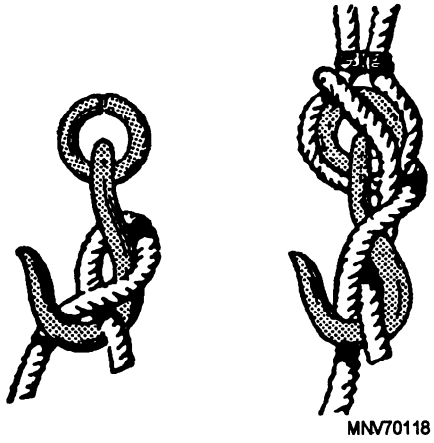

Figure 4-22.—Blackwall hitch, single and double.

Sheepshank

The sheepshank knot is generally thought of as merely a means to shorten a line, but in an emergency, it can also be used to take the load off a weak spot in the line.

To make a sheepshank, form two bights and then take a half hitch around each bight (fig. 4-24). If you are using the sheepshank to take the load off a weak spot, make sure the spot is in the part of the line indicated by the arrow.

SEIZINGS

Seizings are used when two lines or two parts of a single line are to be married permanently. This should be done with seizing stuff, which is generally rope-laid, tarred American hemp of 6, 9, or 12 threads. For seizing small stuff, however, sail twine is adequate.

Many types of seizings were used for special purposes in old sailing ships, but the four described here should suffice for Seamen in modern ships.

FLAT SEIZING

Flat seizing is light and is used where strain is not too great.

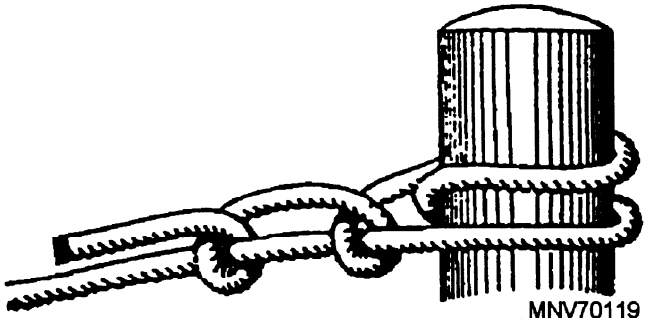

Figure 4-23.—Round turn with two half hitches.

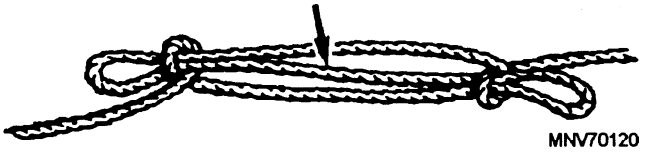

Figure 4-24.—Sheepshank.

First, as in all seizings, splice an eye in the end of the seizing stuff. Take a turn around the line, and pass the end of the stuff through the eye. Pull it taut and double the stuff back, taking several turns around the line. Then pass the end under the turns and again through the eye. Last, tie a clove hitch over the turns and between the two parts of the line. See views A and B of figure 4-25 for the steps in making a flat seizing.

ROUND SEIZING

View C of figure 4-25 shows the completed round seizing. Stronger than the flat seizing, it is used where strain is greater.

Start it as you did the flat seizing, taking your turns and leading the end under them and back through the eye. Then take another row of turns over the top of the first row. Finish by tucking the end under the last turn and heaving taut or with a crossed clove hitch as in the flat seizing.

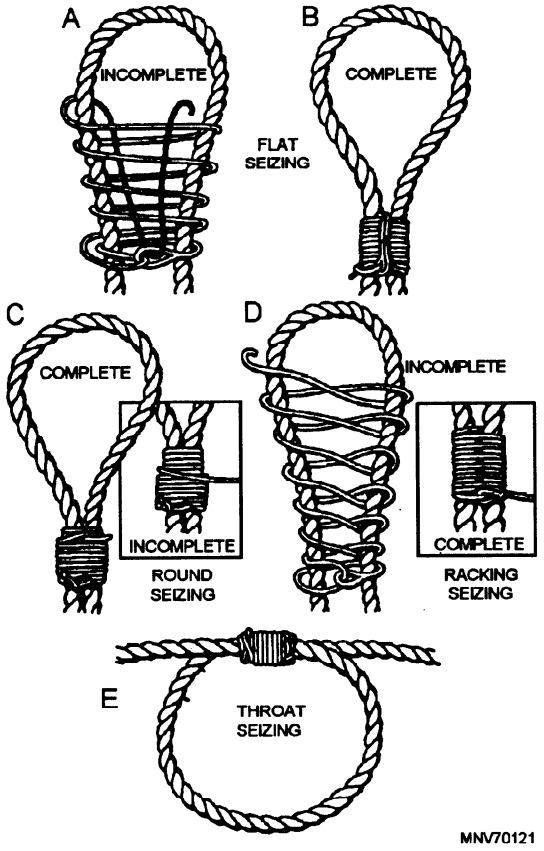

Figure 4-25.—Seizings.

RACKING SEIZING

Use racking seizing where there is an unequal strain on the two parts of the line. Lay turns around the line in figure-eight fashion for about ten turns. Then pass the seizing stuff back in the opposite direction, and take a row of turns over the top of the racking as is done in a round seizing (fig. 4-25, view D). Finish off by passing the endthroughthe eye again, and tie an overhand knot.

THROAT SEIZING

Throat seizing is actually a round seizing and is used wherever a temporary eye is needed in the middle of a line. View E of figure 4-25 shows a completed throat seizing.

MOUSING HOOKS AND SHACKLES

A hook is moused to keep slings, straps, and so forth, from slipping out of the hook and to strengthen the hook if there is the danger that the load will bend it. If the purpose of the mousing is to keep a strap or sling from escaping, marline or rope yarn may be used. If the purpose is to strengthen the hook, seizing wire or a shackle may be used. the proper method for each purpose is shown in figure 4-26.

Shackles are moused whenever there is the danger that the shackle pin will work loose and come out because of vibration. Several turns are taken through the eye of the shackle pin and around the shackle itself with seizing wire so the pin cannot turn.

WIRE ROPE

Wire rope may have few applications on some Navy ships, but on minesweeping ships, wire rope is extremely important. The following information on wire rope is of a general nature. Wire rope used in minesweeping operations will be discussed in later chapters on minesweeping.

CONSTRUCTION OF WIRE ROPE

The basic unit of wire rope construction is the individual wire made of steel or other metal in various sizes. These wires are laid together to form strands. The number of wires in a strand varies according to the purpose for which the rope is intended. A number of strands are laid together to form the wire rope itself. Wire rope is designated by the number of strands per rope and the numbers of wires per strand. Thus a 6 x 19 rope has 6 strands with 19 wires per strand but can have the same outside diameter as a 6 x 37 wire rope, which has 6 strands with 37 wires of much smaller size per strand. Wire rope made up of a large number of small wires is flexible, but the small wires break so easily that the wire rope is not resistant to external abrasion. Wire rope made up of a smaller number of larger wires is more resistant to external abrasion but is less flexible.

The strands of the wire rope are laid up around a central core, which may be fiber, a single strand of wire, or an independent wire rope. A fiber core contributes flexibility, cushions the strands as the wire rope contracts under strain, and holds a portion of lubricant for continuous lubrication. A wire core is stronger than fiber and can be used where conditions such as high temperatures would damage fiber. Some end views of the arrangements of strands in wire ropes are shown in figure 4-27.

Wire rope may be fabricated by either of two methods. If the strands of wires are shaped to conform to the curvature of the finished rope before their laying up, the wire rope is termed preformed. If the strands are not shaped before fabrication, the wire rope is termed non-preformed. When cut, preformed wire rope tends not to untwist and is more flexible than non-preformed wire rope.

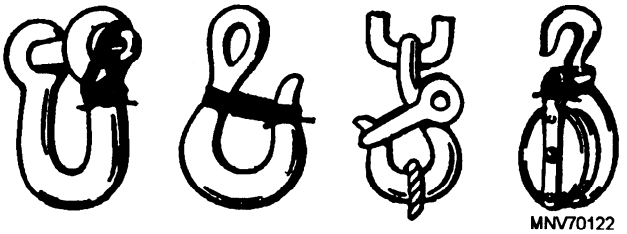

Figure 4-26.—Methods of mousing.

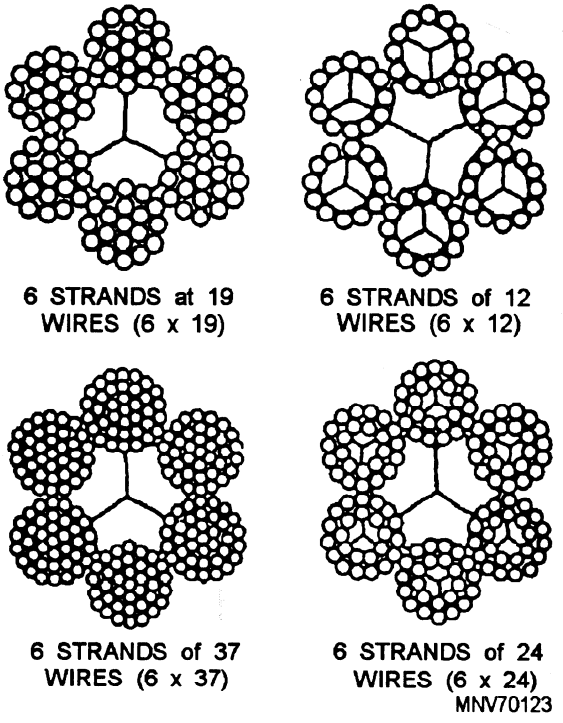

Figure 4-27.—Arrangement of strands in wire rope.

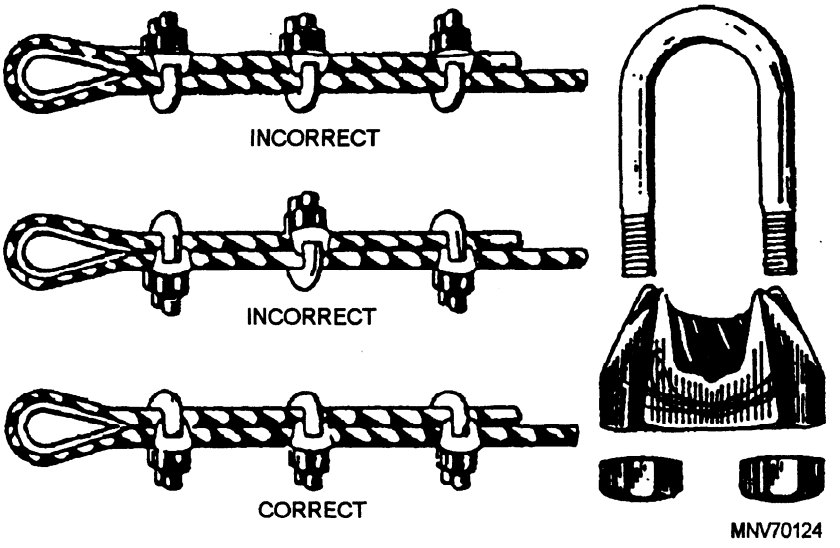

Figure 4-28.—The correct use and incorrect uses of wire rope clips.

WIRE ROPE CLIPS

A temporary eye splice may be put in wire by using wire rope clips. The correct and incorrect ways of using these clips are shown in figure 4-28.

Always place the U-bolt over the bitter end and the roddle (saddle) on the standing part. (Never saddle a dead horse.) Space the clips a distance apart equal to six times the diameter of the wire. After a rope is under strain, tighten the clips again. On operating ropes, tighten the clips every few hours and inspect the rope carefully at points where there are clips. Pay particular attention to the wire at the clip farthest from the eye, because vibration and whipping are damaging here, and fatigue breaks are likely to occur.

To obtain maximum strength in a temporary eye splice, use the correct size and number of wire clips. The size is stamped on the roddle between the two holes. The correct number of clips to use for various sizes of wire ropes is shown in table 4-7.

For more detailed information on wire rope, refer to NSTM, Chapter 613, *Wire and Fiber Rope.*

Table 4-7.—Minimum Number of Clips Required

Rope Diameter (inches)	All 6 × 7 Ropes; All Ropes With Independent Wire Rope Centers	All 6 × 19 and 6 × 37 Ropes	Proper Torque to be Applied to nuts of clips [ft/lb (Dry)]
3/8	4	3	45
1/2	4	3	65
5/8	4	3	95
3/4	5	4	130
7/8	5	4	225
1	6	5	225
1 1/8	6	5	225
1 1/4	7	6	360
1 3/8	7	6	360
1 1/2	8	7	360
1 3/4	8	7	590