U. S. NAVY
WIRE-ROPE HANDBOOK

VOLUME III

ON

INSTALLATION, MAINTENANCE,
AND INSPECTION OF WIRE ROPE

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table Number and Title — Page

1. INTRODUCTION

Volume III of the Wire-Rope Handbook is intended for the shipboard user or rigger of wire rope. It is basically a "how to do it" manual, covering the use of wire rope from initial delivery of new rope on a storage reel, through installation on the equipment and maintenance during use, to inspection and final removal. A separate section covers the installation of end fittings and terminations. The purpose of this volume is to present to the user all the important considerations for successful operation of a wire-rope system, and to illustrate the procedures which can prolong the useful life of the rope. Specific topics include handling and installation, operation and maintenance, inspection, and installation of fittings and terminations. Numerous illustrations are included to show step-by-step the operations discussed, as well as typical forms of rope damage.

2. HANDLING AND INSTALLATION

2.1. INITIAL EQUIPMENT INSPECTION

Equipment on which a new rope will operate, particularly machinery that handles heavy loads at high operating speeds, should be thoroughly inspected before the rope is installed. If a new rope is used on equipment which is in bad repair, or if it is forced onto grooves worn too small by the preceding rope, the new rope will not be able to give normal service.

Inspection should include a careful examination of all sheave grooves in which the rope will operate. Using a sheave groove gauge (see page 4-12), make certain the grooves are the proper size and contour to provide good support for the rope without pinching it. The tread diameter should be measured to insure that it conforms to specification. The groove should run true, with no lateral variation or out-of-roundness.

To avoid excessive rope wear, sheave grooves must be smooth and free from holes, cracks, pits, or uneven surfaces. Check especially for corrugations (Figure 2-1); the new rope lay differs from that of stretched rope and the strands of the new rope will not fit the grooves worn by the old rope. Severe outer-wire crushing can result if corrugated sheaves are used. Look also for cracked, chipped, or bent flanges, which can be caused by allowing a rope socket to pass over a sheave.

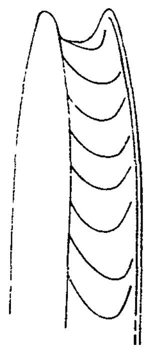


Figure 2-1. Sheave Groove Corrugations

Sheave bearings must be properly installed and in good condition. Worn bearings will allow the sheave to wobble, which in turn may cause the rope to scuff on the sheave-throat. A tight bearing can cause increased friction and wear between the sheave and the rope.

Check to make sure the alignment between sheaves and between the head sheave and drum is as specified to avoid rope scuffing or jumping out of the groove. Include a check of the maximum fleet angle between sheave and drum, particularly when a level-wind mechanism is used (see comments under "Reeving", page 2-13). If the new rope tends to close wind, scrubbing will result. Open winding will subject the rope to abnormal abuse as the second layer forces itself down between the open wraps of the first layer on the drum.

As with sheaves, grooved drums should be inspected for tight or corrugated grooves and for differences in depth or pitch that could cause a problem when more than one layer of rope is used on a drum. Sight across the top of the drum to check for symmetry of cylindrical shape. Make sure it is not concave; a straight-edge placed on the drum parallel to its axis can reveal irregularities. Worn grooves can develop extremely sharp edges which shave away small particles of steel from the rope wires. Correct this condition by grinding or filing to a rounded edge. Drum flanges, and starter, filler and riser strips should be checked for excessive wear which can lead to unnecessary rope abuse at the point of layer change and at the rope crossover points.

On installations where several ropes operate in parallel over multiple grooved sheaves or drums. the relative depth and alignment of the grooves should be checked for differences that might cause unequal tensions or movements between ropes during operation. Such differential action, which could induce unnecessary wear or a build-up of tension, should be eliminated before new rope is installed.

End fittings should be inspected to make certain they are in good condition. On poured sockets, look for cracks or wear patterns at the socket nose which might indicate that the rope is being bent at too sharp an angle. Check also for elongation of the attachment holes, indicating excessive wear or overload. Wedge sockets which are used repeatedly must be carefully checked. Each time the socket is used, a small amount of steel is worn away from both the wedge and socket grooves, primarily on the live or load side of the rope. As the fitting wears, the small end of the wedge protrudes further from the nose of the socket. Broken wires may develop on the live side of the rope as wear progresses, giving warning to replace the fitting. If replacement or repair is not made, holding efficiency will continue to drop and rope failure will occur in or near this clamp area. Carpenter stoppers and wedge-type end fittings should be checked to insure that unwanted corrugations have not developed, and that wear has not led to an oversized rope groove. Clamp-type fittings must be retightened regularly to insure a positive gripping action.

Rollers and guides should be inspected for wear and alignment in the same way that sheaves and drums are checked. Rollers should spin freely. In particular, make sure that sharp rope bends are prevented.

Operation of system machinery can have a significant effect on the service life of a wire rope. Check braking mechanisms; when brakes or clutches grab due to wear or misadjustment there can be momentary overloading, damaging the rope, sheaves, or drums. Check that limit switches on winches and hoists are functioning properly to prevent overtensioning and possible rope breakage.

2.2. UNCOILING AND UNREELING

Proper care of wire rope should start when the rope arrives at the site or warehouse. When transferring a reel or coil of rope from a truck or platform to a lower level, care should be taken not to drop the load. The rope weight may collapse the reel, especially if it is wooden, and cause kinks to form, which will make unspooling the rope difficult or impossible. The rope itself may be damaged by striking an object on the ground.

When handling a reel with an overhead crane, pass a shaft through the center hole of the reel and attach the chains or sling to the shaft (Figure 2-2). If for some reason the lifting must be done around the rope itself, wooden blocks must be placed between the rope and the sling. If possible, avoid rope distortion by using enough blocks to completely cover the rope and to spread the weight evenly around the reel.

If a reel is to be moved across a flat surface such as a loading platform, never slide it on one flange. Instead, roll it on its two flanges. Pry bars should be used against the flanges only and not on the rope. Be sure that the rope is always protected from hard objects that might cause nicks or scrapes. Also, guard against abrasive substances such as dirt, grit, and cinders, and fluids that can cause corrosion, such as water, seawater, and acids.

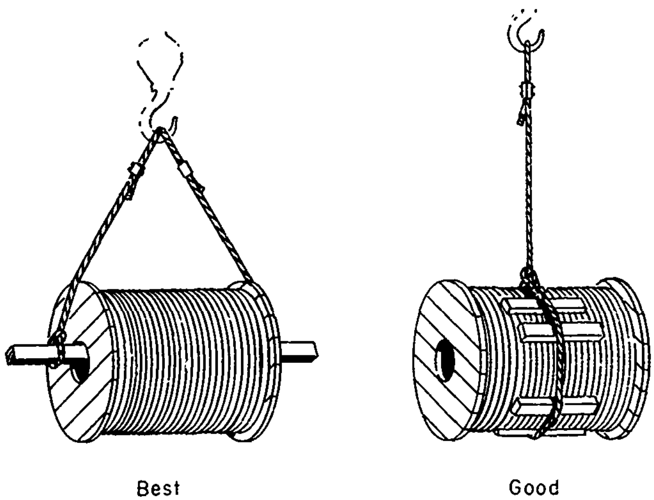


Figure 2-2. Handling a Reel With an Overhead Crane.

When unwinding rope from a reel or a coil, be careful to avoid rope slack, rope kinking, and dragging of the rope on the ground. If the wrong practices in uncoiling and unreeling are used, a twist may develop in the rope which is very difficult to remove. Usually this condition leads to kinking (Figure 2-3), which causes permanent damage to the rope. It is important to note this: once a kink has been tightened in a rope, irreparable damage is done. Kinking can be prevented by proper uncoiling and unreeling methods and by correct handling during installation.

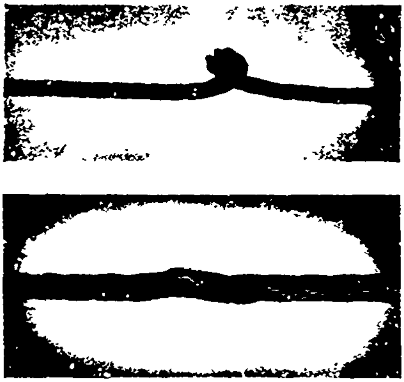


Figure 2-3. Formation of a Kink and Resultant Rope Damage.

In some cases, a slack rope may accidently be wound on the narrow shaft supporting the rope spool or coil and become sharply bent. Slack in the rope may also cause it to loop and kink, resulting in irreparable damage. When a rope is dragged on a floor it may pick up abrasive particles which will accelerate the wear to the rope as it runs over sheaves or rollers.

There are three proper methods of removing rope from a reel. In the method illustrated in Figure 2-4, a shaft is passed through the reel and supported on jacks at each end. The shaft must be high enough so that the flanges will not touch the ground when the reel turns. Position the reel so that the rope comes off the underside of the reel to prevent loops from forming on the floor if slack occurs. Pull the rope straight off the reel as it rotates. Slack can be prevented by using a piece of planking as a lever brake against one of the flanges.

A second method is to place the reel on a revolving turntable and to pull the rope off as the reel turns, as shown in Figure 2-5. It is important that tension is maintained in the rope to keep it from dropping below the lower reel flange.

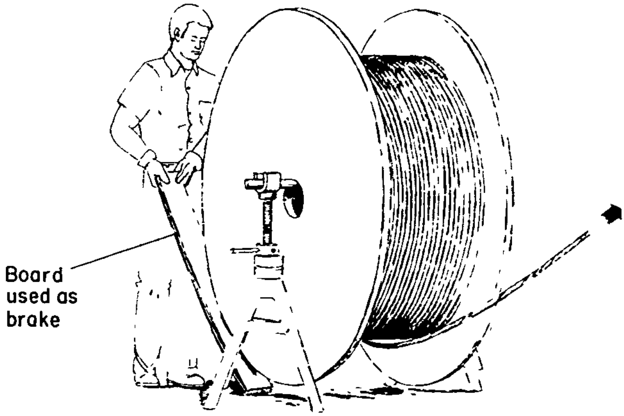


Figure 2-4. Unreeling a Rope: Shaft-and-Jack Method

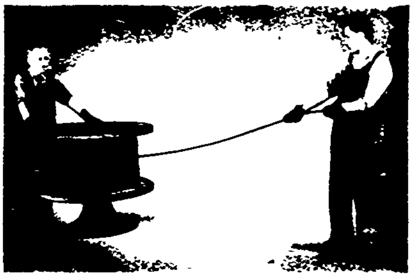


Figure 2-5. Unreeling a Rope: Turntable Method

A third method, shown in Figure 2-6, is to roll the reel across the ground on its flanges while the rope end is held. Care must be taken in this method that the rope does not pick up abrasive particles, and that rope tension is maintained. The reel should never be laid on its side and the rope pulled off over the flange in loops, as shown in Figure 2-7.

Coils of rope should be handled with as much care as reels. When uncoiling, there are two ways to extend lengths of rope while avoiding the loops which can form kinks. First, as shown in Figure 2-8, the rope coil can be rolled

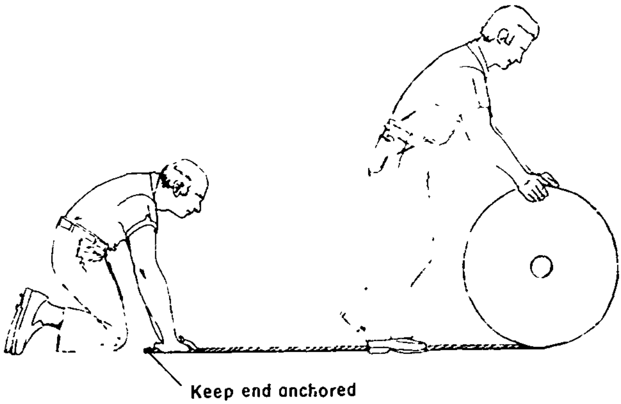


Figure 2-6. Unreeling a Rope: Rolling Reel Method

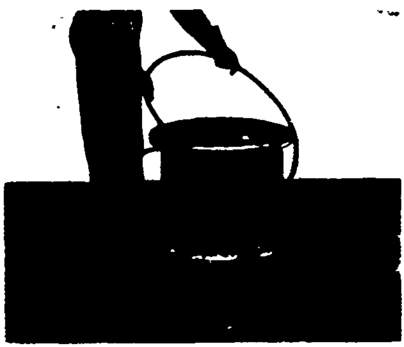


Figure 2-7. The Wrong Way to Unreel a Rope.

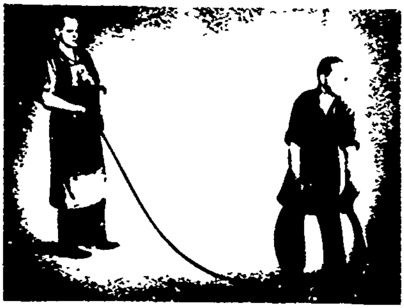


Figure 2-8. Uncoiling a Rope: Rolling Coil Method.

slowly along the floor like a wheel, leaving behind a straight untwisted rope. This is easier to do if the free end is secured first. Second, if a revolving turntable is available, the coil can be placed as shown in Figure 2-9 and pulled off. In this second method, tension must be maintained in the rope to keep it from slipping below the turntable and bending around the flange, base, or shaft. The turntable center should be the same diameter as the inside of the coil. Under no circumstances should the coil be laid on its side and the rope pulled off in loops, as shown in Figure 2-10, because kinks will be formed.

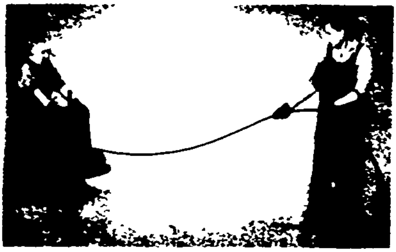


Figure 2-9. Uncoiling a Rope: Turntable Method.

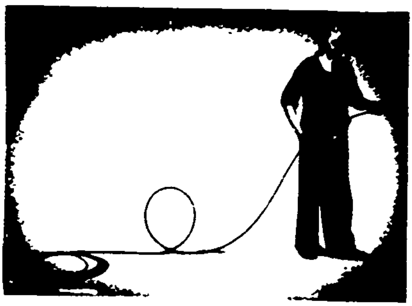


Figure 2-10. The Wrong Way to Uncoil a Rope.

2.3. CUTTING AND TERMINATION

When installing a wire rope, changing wear points, or attaching end fittings, it is frequently necessary to cut and terminate it. If these operations are not performed correctly, the strands may untwist and loosen near the cut and the rope structure may be damaged.

Prior to cutting, seizings must be applied to the rope on either side of the location of cut. This is recommended even though most ropes today are preformed, minimizing the chance that the wires will fly apart when the cut is made. (See Section 5.1. Seizing Wire Rope, page 5-1, for further instructions.)

There are four basic methods for cutting wire rope: shearing, abrasive cut-off, flame cutting, and electrical-resistance cutting. Shear-type wire cutters (Figure 2-11) may be used to cut through smaller diameter ropes and special blade-type tools may be used for the larger diameter ropes. These latter types of cutting tools are driven by hydraulic or pneumatic power, or by an impact hammer (Figure 2-12).

Abrasive cut-off wheels cut the wire rope cleanly without fusing the wires together (Figure 2-13). Flame cutting the rope using a welding torch with a cutting tip is generally an excellent method because the ends of the wires fuse together, preventing free wire ends (Figure 2-14). One exception is when wedge socket terminations are to be used. If the ends are welded when the rope is placed in a wedge socket, the rope strands may become unevenly loaded creating a bad end fitting. Electrical-resistance cutting is normally used on ropes smaller than 1/2 inch but is used in some cases for ropes up to 1-1/4 inches in diameter and even larger. In this method, an electric current heats the wires until they melt. Tension in the rope separates the two ends, each of which fuses when cool (Figure 2-15).

Wire rope ends which will not have fittings attached to them may be terminated as shown in Figure 2-16. Ends prepared in this way facilitate installation of rope on many types of equipment. Becket loops are particularly useful and timesaving since they can be used to pull the new rope into place as the old rope is removed and they allow the new rope to pass smoothly through guides and around sheaves. A welded or soldered end will not unlay or become unbalanced when a new rope is placed in clamps or in the termination hole of a drum. Furthermore, a tapered nose reduces the danger of fouling while reeving.

2.4. AVOIDING KINKING

One of the most common forms of damage due to improper handling of wire rope is the development of a kink. A kink starts with the formation of a loop in the rope from a combination of slack and twist. Slack and twist frequently occur during handling of the rope prior to its operation.

When such a loop develops, it must be removed immediately by uncrossing the rope and removing the twist. After removing the twist, tension may be applied to the rope, if care is taken to insure that the loop does not reform.

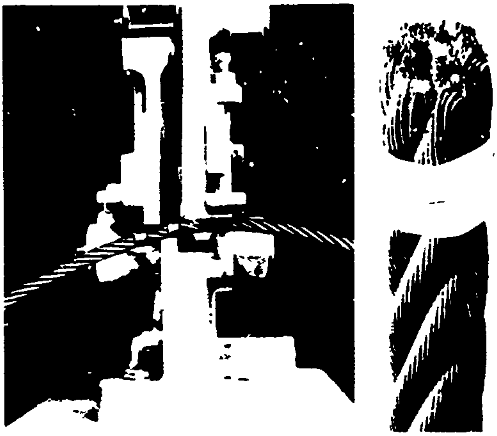


Figure 2-11. Shear-Type Wire-Rope Cutter and Resultant Wire-Rope Cut

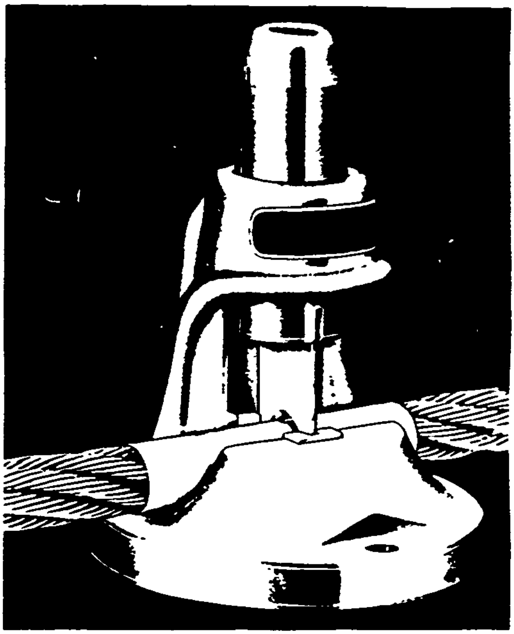


Figure 2-12. Impact-Type Wire-Rope Cutter

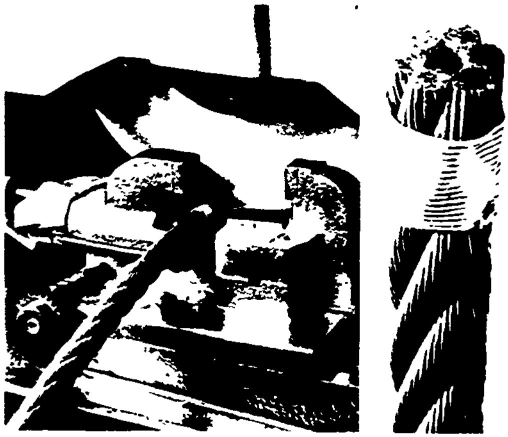


Figure 2-13. Abrasive-Type Wire-Rope Cutter and Resultant Cut

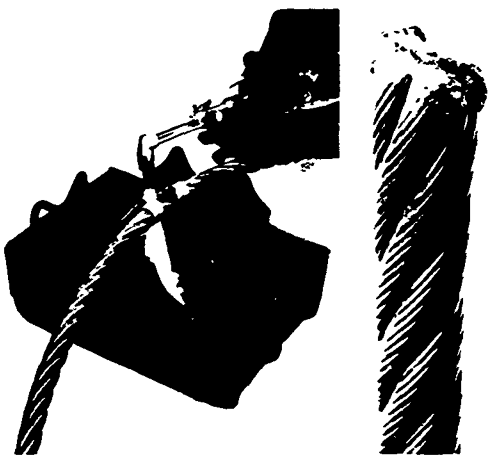


Figure 2-14. Flame Cutting a Wire Rope, Resultant Cut

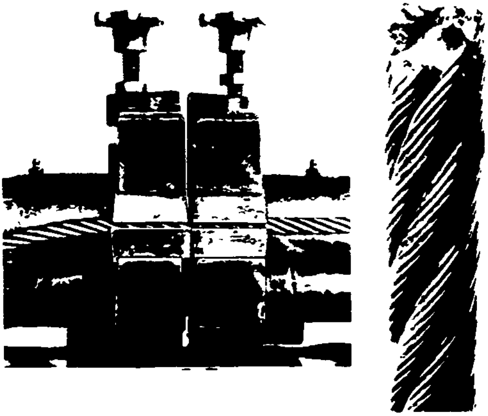


Figure 2-15. Electrical-Resistance Cutting of Wire Rope; Resultant Cut

Seized End

Welded Tapered End

Soldered End With Becket Loop

Welded Straight End

Figure 2-16. Some Wire-Rope End Preparations

If the loop is put under tension, or pulled down tight, a kink will form (see Figure 2-3), and the rope will be permanently damaged. Straightening the rope after kinking may allow it to be passed over sheaves or onto drums, but the distortion of the wires in the kink will cause excessive abrasive wear and fatigue at that spot in the rope, and broken wires will develop quickly. The rope will eventually fail at the kink in almost all cases. Operating a kinked rope may also damage the equipment over which it is cycled.

2.5. AVOIDING ROTATION

As mentioned in the previous section, twist or rotation in a wire rope can result in kinks in the rope when slack is present. Unfortunately, all wire ropes (except the 3 x 19 torque balanced construction) will rotate to some degree when used as a single-part line to support a free-hanging load. The amount of rotation depends upon the rope construction, the rope length, and the weight and shape of the load.

Although swivels are not normally recommended in wire rope systems, they are sometimes used to separate the rotation of the rope and load. If one is used it may greatly increase rope rotation and rope wear. In any case, this rotation may cause a kink-producing loop to form in the rope when the load is set down and the rope goes slack. Therefore, if no swivel is present, the load should be restrained from rotating (for example, with tag lines). If there is a swivel in the line, the load must be set down gradually to allow the rope to regain its natural orientation without forming a loop. Another method of avoiding the bad effects of rotation is to maintain some tension in the rope at all times.

2.6. REEVING

Proper reeving and spooling is essential for obtaining the maximum service life from wire rope. This includes making sure that the rope size is right for the equipment, the fleet angle is within recommended limits, and reeving orientation is correct. In addition, rope should be handled properly during installation. Several recommendations are given below.

To install a rope in a system, mount the rope reel with the axle parallel to the drum. If the system includes a number of sheaves, fairleads, or rollers which the rope must pass over, make sure that each component is in proper alignment; and the sheave grooves should line up as shown in Figure 2-17. Poor sheave alignment will result in severe wear of both the rope and the sheave flanges and may cause the rope to jump out of the sheave

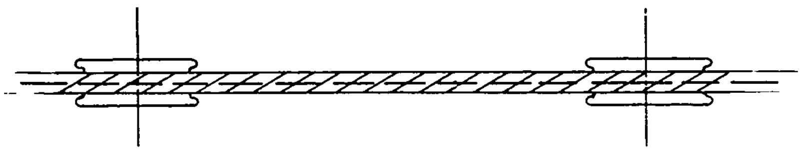


Figure 2-17. Properly Aligned Sheaves

groove. Even a small misalignment accelerates rope wear and shortens rope life. Poor alignment of the last sheave before a drum or restraint of a swivel fairlead may also result in poor spooling.

If possible, choose sheaves and snatch blocks with as large a diameter as possible to reduce rope bending stresses. However, these components should also be as light as possible; heavy sheaves and rollers build up inertia when turning, and slip if the rope starts or stops quickly. This slippage causes abrasive wear of the outer wires of the rope and can accelerate fatigue failure.

Make sure that the sheaves are properly grooved to fit the rope to be used, and that drum grooves (if used) are also of proper size and contour to fit the rope. A grooved drum guides the rope properly across the face of the drum and gives better support to the rope; however, not all drums are designed with this feature. This support is important when multiple wraps are wound on the drum. (See Section 4.2. INSPECTION OF EQUIPMENT, page 4-7, for groove-checking procedure.)

Proper rope and drum groove sizing is illustrated in Figure 2-18. If the drum groove is too large (or the rope too small), each subsequent layer may crowd down between the turns of the preceding layer, causing crushing and excessive wear on the rope (Figure 2-19). If the drum groove is too small, the rope will be crowded out of the proper groove at irregular intervals, as shown in Figure 2-20. Wire nicking may also result.

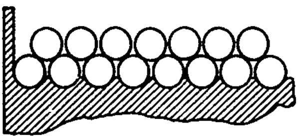


Figure 2-18. Typical Grooved Drum With Proper Sized Rope.

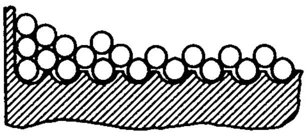


Figure 2-19. Typical Grooved Drum With Under-Sized Rope.

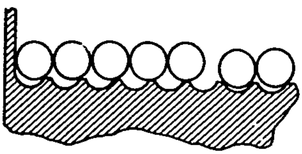


Figure 2-20. Typical Grooved Drum With Over-sized Rope.

Proper groove spacing, or pitch, is as important as using the right size rope on a drum. If the spacing is too large or small, decreased rope life will result in most installations. This spacing is generally the nominal rope diameter plus a small clearance to prevent crowding and scrubbing of the oncoming rope against rope already on the drum. The groove pitch listed in Table 2-1 is the minimum recommended for both helical and parallel grooving.

Table 2-1. RECOMMENDED GROOVE PITCH

Nominal Rope Diameter, Inches	Recommended Clearance, Inches	Groove Pitch, Inches
1/4	1/32	9/32
5/16	1/32	11/32
3/8	1/32	13/32
7/16	1/32	15/32
1/2	1/32	17/32
9/16	1/32	19/32
5/8	1/32	21/32
3/4	1/32	25/32
7/8	3/64	59/64
1	3/64	1 3/64
1 1/8	3/64	1 11/64
1 1/4	1/16	1 5/16
1 3/8	1/16	1 7/16
1 1/2	1/16	1 9/16
1 5/8	3/32	1 23/32
1 3/4	3/32	1 27/32
1 7/8	3/32	1 31/32
2	3/32	2 3/32
2 1/8	3/32	2 7/32
2 1/4	3/32	2 11/32

If the rope is wound onto the drum under exceptionally heavy loads causing extreme pressures on the drum, the clearance values shown in Table 2-1 may be halved. For example, for 1-inch rope the clearance at heavy loads would be 1/2 x 3/64 inch or about 0.023 inch; the groove pitch would therefore be 1.023 inch. With the reduced clearance, a new rope will undergo some scrubbing when it is wound on the drum, but will usually pull down in diameter after some usage and operate properly. The pitch may be accurately estimated by measuring the distance across ten turns and then dividing by ten. If the pitch is not correct for the rope to be used, either the rope must be replaced or the drum grooving changed.

One means of assuring correct and uniform winding of a rope on a drum is to incorporate a level-wind system. Such a system usually consists of a sheave mounted close to the drum between the lead sheave and the drum, and a full-width shaft across which the sheave may traverse. Level-wind systems are generally classified as either driven or passive.

A driven or mechanical level-wind system has the guide sheave mounted on a carriage assembly that rides on the cross-shaft. This shaft may also act as a lead screw, having threads cut in it that are both right- and left-hand. A pawl attached to the carriage fits in the thread groove so that as the screw is turned through a gear drive to the drum, the sheave is driven across the face of the drum. When the sheave reaches one flange, the pawl shifts to pick up the opposite threads, and the sheave is driven in the opposite direction. The carriage assembly may also be driven by other methods, but the important factor is the positive relation between drum revolution and carriage movement, such that one drum revolution moves the sheave over one groove pitch in the direction of winding. The design of such a system can be quite sophisticated, and its final adjustment is critical. If the carriage is misaligned so that it leads or lags the drum movement by too much, the rope will be forced to scrub severely or open-wind and the transition between layers will not be accomplished smoothly. Moreover, if the rope is allowed to go slack, the rope may open- or cross-wind and put the entire winding procedure out of phase. However, a properly adjusted and maintained level-wind system will improve drum winding efficiency and increase rope life, especially in high-speed winch systems.

A passive level-wind system also involves a sheave riding on a cross-shaft. In this case, however, the shaft pivots on short lever arms at its ends. The shaft is always pivoted in the direction that the rope is being layed or unlayed so that the combination of rope tension and position of the rope on the drum cause the sheave to move along the shaft. This system is also quite sensitive to the adjustment of the cross-shaft arms, and must be checked frequently. Careful and frequent lubrication of the moving parts is mandatory; any roughness or binding in their movement may result in non-uniform rope winding. As with the driven level-wind system, the rope must not be allowed to go slack or misspooling may occur.

If the system into which a rope is being reeved does not have a level-wind device to assure even spooling on the drum, care should be taken to insure that fleet angles are not too large or small.

As shown in Figure 2-21, the fleet angle is the angle between the center line of the first fixed sheave (or head sheave); and the line through the axis of the rope when it is closest to either drum flange. The maximum fleet angle should normally be limited to 1-1/2 degrees for both plain-faced and grooved drums. In some cases, however, with grooved drums that will carry only a single layer of rope when loaded, the maximum fleet angle may be as large as 2 degrees. On plain-faced or grooved drums of very large diameter maximum fleet angles of less than 1-1/2 degrees are required. A fleet angle larger than the recommended limit may cause a number of problems, including excessive rubbing of the rope against the sheave groove flanges, crushing

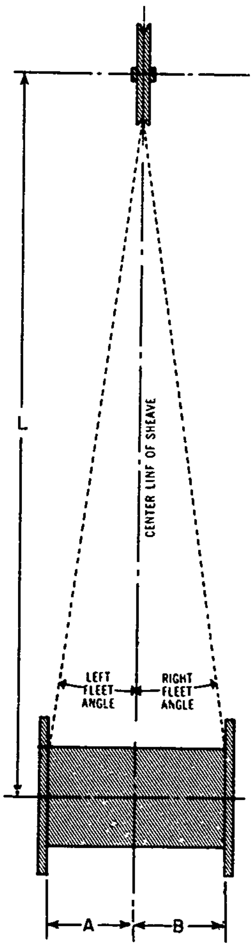


Figure 2-21. Fleet Angles Measured Between the Drum and Head Sheave.

and abrasion of the rope on the drum, increased drum groove wear, and improper rope winding.

If the minimum fleet angle is too small, the rope may not pull away from the drum flange but may wrap on top of itself. After several wraps have piled up next to the flange, they may collapse suddenly and cause a sudden jerk in the rope which could damage it or the equipment it is used on. The minimum fleet angle should, therefore, be limited to 1/2 degree.

The lengths A, B, and L in Figure 2-21 can be used to check the maximum and minimum fleet angles. This can be useful in determining where to set up the fixed sheave for proper reeling onto the drum. To remain within the maximum and minimum recommended fleet angles of 1-1/2 and 1/2 degrees, respectively, the distance from the sheave to the drum, L, should be at least 38 x B but no more than 115 x A (or vice versa).

When loading rope directly from the storage reel to the drum, it is often difficult to position the reel so that the fleet angle remains within normal limits. In this case, the reel should be placed as far away as possible and the rope guided by hand to assure correct spooling.

Rope reeving that minimizes direction changes, particularly reverse-bend changes, will result in the longest rope life. Ropes subjected to reverse bends have about 1/2 the life of ropes bent in only one direction. Figure 2-22 illustrates several reverse-bend situations which are to be avoided, if possible.

The proper way to spool from reel to drum is shown in Figure 2-23. If possible, spool over the top (left-hand picture) to prevent contamination from dragging rope on the ground.

Both plain-faced and grooved drums can benefit from the proper winding of the first and subsequent wraps. Proper winding can be promoted by the installation of starter, filler, and riser strips (Figures 2-24 and 2-25). On a plain-faced drum, the starter strip insures that the first wrap of rope will have the correct pitch. Since this first dead wrap is the foundation for succeeding layers, its pitch must be correct to provide the necessary rope support to minimize rope scuffing and abrasive wear. On a grooved drum, the filler and riser strips support the second wrap and assist the rope in changing from the first wrap to the second.

When wire rope is wound on a drum, there is a tendency for it to twist due to the lay of the strands. To take advantage of this tendency, use the following simple rule in determining where to begin winding (see Figure 2-26). Note the direction of the lay; it will determine with which hand the determination is performed. A right-lay rope uses the right hand and left-lay rope uses the left hand. Turn the appropriate hand so that the fingers are aligned the same way the rope would be wound on the reel. For overwinding, the hand goes palm down; for underwinding, the hand goes palm up. The thumb is then on the same side of the hand as the side of the reel on which winding should begin. On a plain-faced drum, this winding technique aids in keeping the turns close together and uniform and helps to prevent twisting of the rope. On a grooved drum, the technique prevents the rope from jumping out of the groove.

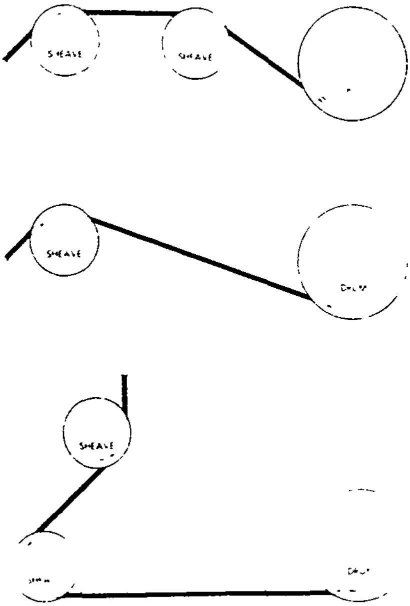


Figure 2-22. Reverse Bends

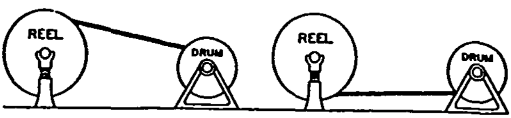


Figure 2-23. Correct Spooling Techniques

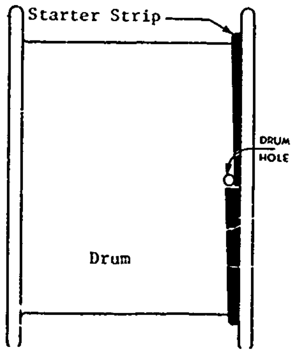


Figure 2-24. Use of Starter Strip

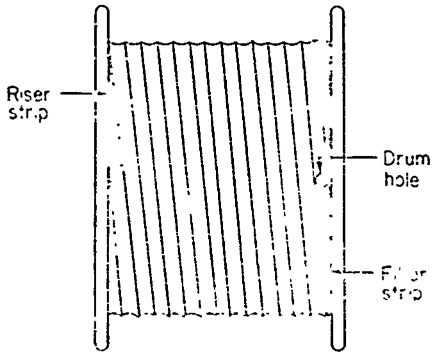


Figure 2-25. Use of Filler and Riser Strips

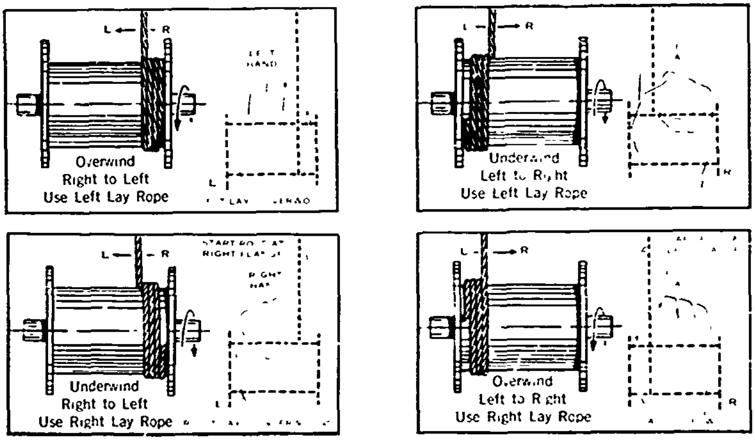


Figure 2-26. Determining Where to Begin Winding on a Drum

Current Navy specifications require that the rope be anchored to the drum in such a way that the rope construction is not damaged by kinking, crushing, or flattening. Usually a clip or a clamp is used. The anchoring device never develops more than a portion of the breaking strength of the rope, however. For this reason, 1-1/2 to 2-1/2 turns of rope, depending on system characteristics, should remain on the drum at all times to insure that the rope will not slip off the drum under load.

Several other important suggestions for reeving rope follow. If the rope is being wound on a smooth drum, the rope should be guided so that each turn winds tightly against the adjacent turn. Use a hammer with a head of soft material, such as brass or copper, to tap the rope over as it is being wound onto the drum. If possible, reel the rope in slowly so that each turn can be observed for smoothness as it winds onto the reel. Tension should be maintained in the rope to insure tight winding. Maintaining tension also keeps the rope from dragging on the ground and picking up grit or sand, and keeps kink-producing loops from forming. A wooden plank can often be used against the flange of a shipping reel to maintain proper tension. Make certain that the rope is not rubbing on anything, and that it is protected from damage from chafing gears and rollers. Do not fill a storage drum to the outer edge of the flanges because the rope will be damaged if the drum is later rolled on the flanges.

Rope whipping sometimes occurs during the reeving operation. This vibration of the rope is caused by the crossovers on multilayer installations and can become quite severe if the crossovers occur at the natural frequency of rope vibration. The rope may jump from a sheave groove, wind improperly, or scrub and pound on the drum. Reducing the rope speed or using rollers to shorten the free span should minimize whipping.

2.7. MULTIPLE-PART REEVING

Multiple-part reeving (illustrated in Figure 2-27) is used because of the great lifting power it gives to a hoist or rig. It allows heavy loads to be lifted with rope of a comparatively small diameter. Increasing the number of parts of line increases the lifting capacity but decreases the lead line efficiency and speed of lift.

A load is never equally distributed on all parts of the rope, whether lifting, holding, or slacking the load. When a load is picked up, the greatest tension is always on the lead line. On large rigs with greater than twenty parts of line, the tension on the lead line can be from three to five times greater than on the becket line. When the system is picking up or holding a load, the lead line tension is from 1-1/2 to 2-1/2 times greater than on the becket line. When the system is slacking a load, the greatest tension is on the becket line in about the same proportions.

On smaller rigs using one lead line, spool the rope on the drum as discussed in Section 2.6. REEVING, page 2-12. Never allow the rope to touch the ground or pick up abrasive material. Also, be careful that kinks or doglegs do not form in the new rope, as it is impossible to remove them completely.

With the exception of some topping lifts, large blocks should be suspended close together for reeving. If the new line is not becketed, cut the old line but leave the blocks still reeved. Remove the old line from the drum, spool the new line and connect the becket end of the new line to the old line still reeved in the blocks. Avoid a bulky connection between ropes. Then slowly pull the new line through. It is often necessary to fairlead the old line to avoid kinking the rope on one of the traverse bolts through the block, as well as to avoid pulling the block too far out of line.

Always use the recommended number of clips according to line size to secure the becket. If there is no becket on the rope, splice an eye to form one.

2.8. ADJUSTING INITIAL TENSION IN MULTIPLE ROPE SYSTEMS

If multiple ropes are put in operation under unequal tension, maximum service life cannot be obtained and equipment may be damaged. When new ropes are installed in parallel over multiple-grooved sheaves or drums, adjust them carefully so that each takes an equal share of the total load. It is important that the necessary tension adjustments be made by lengthening the tight rope or shortening the loose one, rather than by twisting or untwisting the end of the rope. When a length adjustment is obtained with turnbuckles, the rope lay can be forced to change, causing rope damage, unless the rope is prevented from turning.

Wire-rope tension should be adjusted properly during installation, and at regular intervals thereafter. It is particularly important to check the tension and to make the necessary adjustments during the period immediately after they are installed, since this is the time when tension differences are most likely to develop.

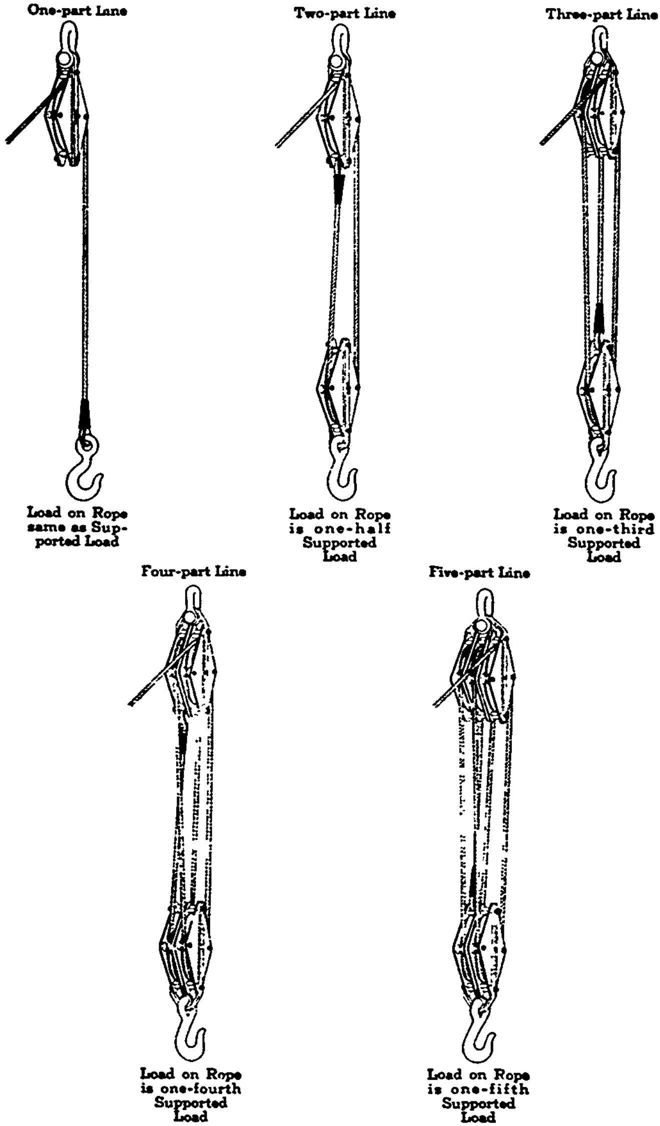


Figure 2-27. Multiple-Part Reeving

2.9. BREAKING-IN NEW ROPE

Once the new rope has been installed, it should be subjected to a break-in period prior to being used in service. Time for this period should be allocated so that break-in is accomplished before the system is needed.

The rope should be run through several cycles in the unloaded condition, then through several more cycles under a light load. The rope should be run at reduced speed, and the load applied smoothly. A slack condition should be avoided, as it can result in damage to the rope or equipment.

The purposes of this break-in process are to uncover functional problems in the system, such as improper reeving or faulty controls, which might lead to rope damage under full load; and to get the longest possible service life from the rope. Reeving under light loads allows the rope lay, core, wires, and strands to set properly, resulting in a more efficient system. The rope lengthens somewhat (constructional stretch) and deforms slightly as it passes over the sheaves and drum.

2.10. MAXIMUM LOAD TESTING OF A WIRE ROPE SYSTEM

It is normal Navy practice to load test a newly installed wire rope reeving system by subjecting it to a static test, a dynamic test, and an operating load test. For low-capacity hoisting rigs, these test loads are 200 percent of design capacity statically, 150 percent of design load dynamically, and 100 percent of design load under operating conditions. In some cases, the test loads should be reduced for high-capacity systems (20 tons or over).

Replacement of a wire rope in an already used reeving system is normally not considered cause for a complete retest of that system. In most cases only a 100 percent design load proof test would be made before beginning normal operation.

It is extremely important that personnel safety precautions be observed during proof testing: all persons near the system should be aware that a test is under way, and the area should be cleared. The operator must also be ready to shut the system down immediately if a failure or indication of failure should occur. Immediate shutdown can prevent unnecessary damage to the system.

3. MAINTENANCE

The main purpose of careful wire-rope systems maintenance is to minimize the effects or conditions which cause wire-rope deterioration. When deterioration is kept to a minimum, both economy and safety are increased.

Proper maintenance should begin when the rope is first received. Correct methods of preparing and storing new or deactivated rope will prevent contamination and corrosion and will avoid costly physical damage. When a wire rope is in use on a system, periodic rope cleaning and relubrication can reduce contamination and corrosion problems. Chafing gears can be used in some applications to reduce rope abrasion. Techniques for the redistribution of wear--for example, "cutting back" and "reversing ends"--can be used to eliminate damaged rope sections from the system or to evenly distribute the wear over the entire rope length.

3.1. STORAGE

3.1.1. Storage Preparations

New rope should be unwrapped and thoroughly inspected for defects or shipping damage (see Section 2.1. INITIAL EQUIPMENT INSPECTION, page 2-1). Be sure to handle the rope properly to prevent needless damage. If the rope is to be stored for some time, lubricate it with heavy lubricant; generally, the lubricant used to protect rope during shipping is insufficient protection for long-term storage. Do not rewrap the rope, as paper wrapping can trap moisture and lead to corrosion.

Make sure the storage environment will be clean, dry, cool, and free of corrosive fumes or materials. Temperatures should not exceed normal room temperature and fluctuations in temperature should be minimal. The storage area should be well ventilated but protected from the elements; indoor storage is ideal. Do not store rope near acids or on corrosive materials such as cinder. Rope stored out of doors needs special protection (see Section 3.1.2. Storage Configurations, page 3-2).

Identify each reel or coil with a legible tag for easy identification. The tag must contain at least the following information:

- positive identification of a used rope (e.g., identification number), so that its complete history may be obtained (see Section 3.9. RECORD KEEPING, page 3-10)
- rope diameter (nominal)
- rope construction
- rope material
- total rope length
- date rope was received (or date a used rope was put into storage)

- dates of in-storage lubrication
- dates and lengths of rope sections removed
- name and location of the person(s) or organization(s) responsible for the rope
- type and location of any rope defects.

3.1.2. Storage Configurations

Rope may be stored in coils, on reels, or directly on equipment. It is generally better to place rope on reels for storage than it is to leave it on equipment. The rope should be coiled carefully to prevent kinking (see Section 2.4. AVOIDING KINKING, page 2-9).

Keep rope reels off the ground on timber or blocks. Never rest bare rope on supports; instead, store the reel with its axis perpendicular to the ground or rest both flanges on pieces of timber. Smaller reels may also be stored on posts secured to racks. If reels must be stacked to save space, always store smaller, lighter reels on top of larger, heavier ones. Again, store with the reel axis perpendicular to the ground to keep the reel flanges from pressing against bare rope. Figure 3-1 shows some proper reel-storage methods.

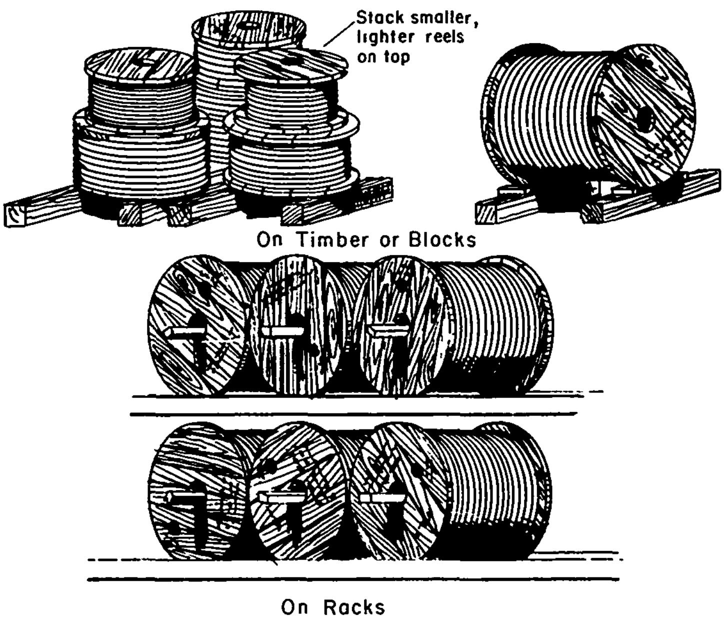


Figure 3-1. Proper Indoor Reel Storage Methods

Rope coils should be stored in one of three ways: flat on the floor, suspended on posts, or stored in racks. Never stack anything on top of a coil of rope.

Ropes stored outdoors must be kept at least a foot off the ground. The area under and around the reel should be cleared of grass or weeds. The rope should be protected from moisture, sunlight, and dust, but well ventilated. A small shed might be built to provide such protection or the rope may be covered with a waterproof tarpaulin.

Ropes stored directly on outdoor equipment must be treated like other ropes stored outdoors. Ropes stored as deck load for use at sea must be thoroughly lagged with wood slats, the rope thoroughly lubricated and the reels covered with tar paper. Additionally, the reels may also be covered with tarpaulins. Do not immerse any part of the reels in water.

3.1.3. Storage Maintenance

Relubricate stored ropes periodically to keep the rope lubricant from drying out. Use a heavy, grease-type lubricant as described in Section 3.4. LUBRICATION, page 3-5. Always clean and relubricate if any drying or cracking of old lubricant is evident. Ropes stored indoors should be lubricated at least twice a year, rope stored outdoors at least four times a year. Even more frequent lubrication is necessary for rope stored in severe environments (for example, near the ocean).

Reels or coils in long-term storage should be turned occasionally to prevent lubrication from settling on one side of the rope.

3.1.4. Restorage of Used Rope

Thoroughly clean a used rope which is to be stored: remove all dust, grit, and dried lubricant from exposed surfaces. Relubricate the rope liberally as it is being wound on the storage reel. Then store according to the same procedure used for new rope.

3.1.5. Storing Rope Directly on Equipment

Ropes stored directly on equipment should be run out occasionally, cleaned if necessary, and periodically relubricated.

3.1.6. Before Taking a Reel Out of Storage

Prior to unreeling a rope from a wooden storage reel, the flange bolts should be tightened to compensate for possible wood shrinkage.

3.2. CLEANING

Wire rope should be cleaned periodically to reduce the build-up of abrasives and to facilitate inspection and lubrication. Always keep a rope clean enough so that the valleys between the strands and those between the outer wires do not become caked with grit and old lubricant; if these become clogged, lubricant will not be able to penetrate the rope.

If the existing lubricant is too heavy it may be softened with kerosene or a light oil. NEVER use solvent; it will penetrate the rope and remove the internal lubricant.

3.3. CLEANING METHODS

3.3.1. Superheated Steam or Compressed Air

The most effective method of cleaning a wire rope involves blasting the rope with superheated steam or compressed air. Direct the cleaner towards the rope and slightly away from the direction of rope travel, forcing grit and other material away from the rope area already cleaned. Slowly move the rope past the gun. Be sure to direct the steam to all sides of the rope.

3.3.2. Power Brushing

(See Figure 3-2.) This method is good but less effective than air- or steam-cleaning. Powered wire brushes can be mounted so that they encircle the rope and brush it clean as it is pulled through the brush system.

3.3.3. Wiping With Rags or Scrapers

This is the least effective and the most tedious method, but it should be used if it is the only one available. Be sure to soften hardened grit, as described in Section 3.2. As mentioned before, never use solvent during cleaning.

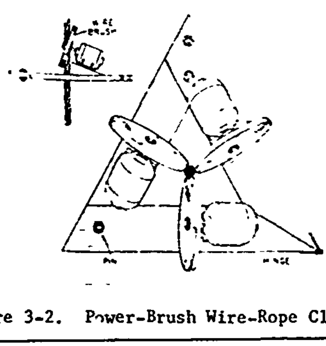


Figure 3-2. Power-Brush Wire-Rope Cleaning

Always relubricate the rope immediately after cleaning and inspection to protect it from wear and corrosion.

3.4. LUBRICATION

Lubrication is a vital maintenance activity because it protects wire rope from corrosion and contamination. Even galvanized rope loses its protective coating with time, and will benefit from frequent lubrication. Lubrication also keeps fiber cores from drying out and breaking up. A dry core also absorbs moisture which promotes inner-wire corrosion. Most importantly, lubrication maintains the flexibility which is necessary for normal usage of wire rope. Wire rope must bend over sheaves, rollers, and drums; this flexing requires that the individual wires move relative to one another. Periodic lubrication insures that this movement will occur easily and without excess friction. Low friction between wires reduces internal rope wear, and lubricant on the rope surface reduces abrasion on the rope crown wires, the sheaves, and the drum.

3.4.1. Choosing a Lubricant

There are two basic types of lubricants: the heavy, viscous greases; and the light, low-viscosity oils. Navy requirements for the heavy greases are covered under Military Specification (MIL-G-18458A, August, 1961) and requirements for the lighter oils are discussed in Federal Specification (RR-W-410C, September, 1968). Generally, the heavy lubricants offer the best corrosion protection when properly applied, but may provide poor lubrication for active ropes. They tend to build up and crack when the rope is flexed, and their adhesion to rope wires is relatively poor. For this reason, use of heavy grease is usually restricted to storage lubrication and to lubrication of ropes which must be immersed in seawater. For other operating conditions, light lubricants are normally recommended. Besides being better lubricants for reducing friction in bending ropes, light lubricants tend to pick up less grit, tend to cake less, and afford better visibility of the rope for inspection purposes.

There are additives which can be used with light lubricants to increase their corrosion-inhibition ability. Some oils can be bought with these additives already incorporated. In addition, additives can be obtained which can be used to "tailor" an oil which is specifically effective in controlling certain types of corrosion.

3.4.2. How to Apply Lubricants

3.4.2.1. Heavy Greases.

Heavy greases should be heated before application. To achieve best adhesion, the rope must be clean, moisture-free, and relatively warm. In the most common technique, the warm rope is guided into a trough containing the heated lubricant (see Figure 3-3). The rope should be moved slowly through the trough. As it comes out it should be wiped with leather, gloves, rags, or sheepskin to remove excess lubricant.

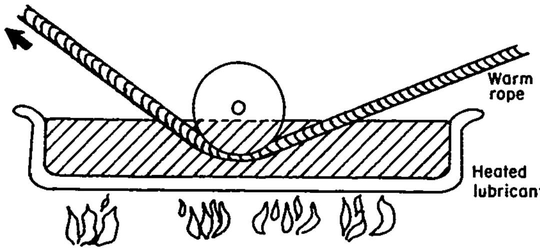


Figure 3-3. One Method of Applying Heavy Lubricants

Heavy lubricants may also be painted on ropes or applied with gloves or rags. Always apply a lubricant after the rope passes over a sheave rather than before the sheave to avoid catching rags, brushes, and fingers in equipment. Another technique is to pour lubricant over a rope on a drum, letting it stand for a length of time. Then, after the lubricant has penetrated, the drum is rotated one-quarter turn and then left to stand again. The process is repeated until the lubricant has penetrated the entire rope.

3.4.2.2. Light Lubricants.

It is most convenient to use an automatic device to apply light lubricant. Equipment down time for lubrication is all but eliminated, and automatic lubrication allows the best possible application schedule: light, frequent lubrication.

The simplest automatic lubricator is a box which fits around the rope (see Figure 3-4). The box is filled with lubricant or lubricant-soaked absorbent

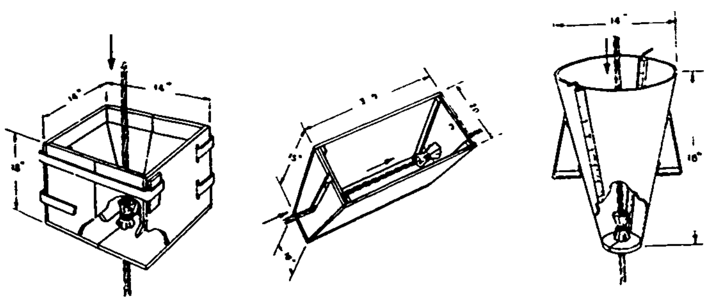


Figure 3-4. Box-Type Light Lubricators

material. The hole where the rope leaves the box is lined with burlap or some other liner. For the boxes in which the rope is oriented vertically, this lining seals with the rope, preventing too much lubricant leakage as well as minimizing rope abrasion in the hole. The rope moves slowly into the box, picks up lubricant, and is wiped as it leaves.

Other automatic devices can be used which drip lubricant onto the rope as it passes over a sheave (Figure 3-5). Lubricating at a bend improves penetration, because the strands part slightly. Lubricant may also be dripped by hand from a container (Figure 3-6). The rope should be wiped after it has passed over the sheave.

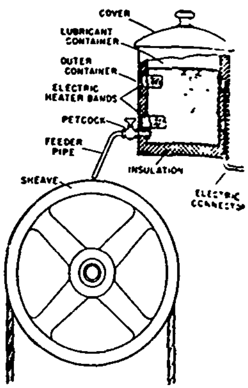


Figure 3-5. Automatic Drip Lubrication

A nozzle may be used to spray light lubricant continuously or intermittently over a rope (Figure 3-7). As with drip devices, these automatic lubricators should be mounted at the beginning of a bend over a sheave. Intensity and duration of spray is often adjustable and may be controlled automatically or by hand. It is important that the position of a spray nozzle is far enough away that the application covers completely the full diameter of the rope.

3.4.3. Frequency of Lubrication

How often and how much to lubricate is highly dependent on the characteristics of rope operation. In general, the higher the rope speed, operating load, number of bends, and the greater the exposure to corrosive conditions, the more frequent should be the lubrication. Rope should be well lubricated upon in allation to ease the breaking-in process. As the rope is operated, the lubricant gradually comes to the rope surface where it is contaminated

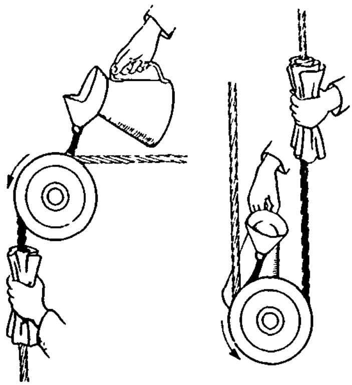


Figure 3-6. Hand-Drip Lubrication.

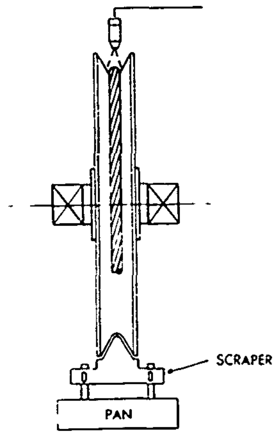


Figure 3-7. Automatic Spray Lubrication

and worn away; therefore, lubrication should be more frequent for continuously operated ropes. If a rope is exposed to corrosive influences such as seawater, it should be cleaned and lubricated each time it is used. Always remember that in general it is better to lubricate lightly and frequently, than occasionally and heavily.

Inactive ropes require special care, as they are particularly susceptible to corrosion (see Section 3.1.3. Storage Maintenance, page 3-3).

Determine how often to lubricate by checking ropes periodically for signs of wear, corrosion, amount of remaining lubricant, and the general condition of the core (see Section 4.1. INSPECTION OF WIRE ROPE, page 4-1). The following symptoms indicate that lubrication is needed:

- presence of cracks or valley breaks without any indication of uniform strand nicking
- rope creaking
- sparks flying off sheaves in the system, visible in dim light
- loss of elasticity without noticeable lay-length elongation
- patches of corrosion on ropes
- drying and cracking of the existing lubricant (applies mainly to ropes in storage).

If any of the above problems are noted, the frequency of lubrication should be increased.

It is often convenient to schedule both maintenance and inspection at the same time as lubrication, since prelubrication cleaning simplifies inspection.

While it is important to be sure that the entire rope is covered with lubricant, too much can pick up abrasive material, resulting in rope damage. If a rope is used on a traction-drive system, it is important to lubricate sparingly to prevent slippage.

3.5. USES OF CHAFING GEAR

A chafing gear is any material or device which can be used to prevent rope chafing (see Figure 3-8). Wherever a rope is subject to extreme abrasion and/or bent around a sharp corner, installation of some type of chafing gear may increase rope life. For example, towing ropes will benefit from chafing gear, as will lines which rub against the edge of a ship's deck or against a dock.

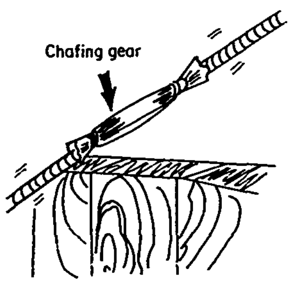


Figure 3-8. Chafing Gear for Stationary Rope

A stationary rope may be protected from chafing by wrapping it with heavy canvas and tying securely. The canvas should be thoroughly lubricated to prevent absorption of moisture. For moving ropes, hardwood-block scrubbing boards can be secured to the deck and impregnated or covered with grease to minimize rope wear.

Check any chafing gear frequently and renew as required.

3.6. CUTTING BACK

Another method of significantly increasing rope service life is to redistribute the points of greatest wear over the rope by "cutting back" rope from one end. If cut-backs are to be made, more rope should be installed on the drum than would normally be necessary. After the rope has operated for some time (but before serious deterioration occurs anywhere along the rope), a length of rope can be removed from either end. A length removed from the drum end should be about 1-1/4 times the length of one turn on the drum--this relocates the points of rope cross-over wear. Cutting the rope back at the load end removes fatigue-damaged rope portions near the terminations, and is especially effective when zinc sockets are used. A load-end cut should be made well away from the fitting. Care should be taken to find the areas on the rope where wear and fatigue damage are occurring, for example, over sheaves and rollers, and plan the cutting length to relocate these areas in less critical parts of the system.

When cutting back, inspect discarded portions of rope carefully (see Section 4.1. INSPECTION OF WIRE ROPE, page 4-1) for internal damage which might be invisible on the exterior of the rope.

3.7. REVERSING ENDS

If an operating rope wears, fatigues, and generally deteriorates more at one end than at the other (e.g., more at the drum than the load end), reversing ends may extend its service life. However, reversing ends is costly and time consuming. Rope reversal should be carried out before wear becomes severe, and should not be performed at all if a worn section will be placed at a stress or wear point or if the design factor of the system will be reduced below its minimum. Be sure to use correct reeling procedures when performing an end reversal to avoid damage to the rope.

3.8. TENSION ADJUSTMENT OF PARALLEL ROPES

Ropes operated in parallel should be of the same type and construction and preferably should come from the same production run so that their characteristics will be similar. Even ropes from the same reel, however, wear and stretch unevenly, leading to unequal load-sharing among the ropes. To prevent such an imbalance from becoming severe enough to cause an overload condition and an early rope failure, it is necessary to check and adjust rope tensions frequently.

While some wire-rope machinery includes an effective compensating device which automatically adjusts the tension in a set of parallel ropes, periodic checks of this device is necessary to be sure that the limit of travel has not been reached, and that excessive friction is not keeping components from properly taking up the stretch.

3.9. RECORD KEEPING

Careful records should be maintained for each rope installed in a system. These records should include, as a minimum, the following:

1. Manufacturer's reel number
2. Initial spooling date and conditions
3. All subsequent cleaning and lubrication dates.

It should be possible from these records to trace a complete rope history. Therefore, each time the rope is used, lengths and speeds should be noted where applicable, along with any remarks as to the physical condition of the rope (see Section 4.4. RECORD KEEPING, page 4-15).

4. INSPECTION OF WIRE ROPE AND ASSOCIATED EQUIPMENT

This section illustrates the methods of inspection used to determine the condition of wire rope and the equipment in which it is installed, so that repair or replacement may be carried out before rope damage jeopardizes safety. Inspection procedures include counting broken outer wires to determine remaining strength, measuring abrasive wear, evaluating damage from corrosion, and classifying such damage as kinking or crushing. Inspection of associated equipment includes sheaves, drums, level-winds, and end fittings. Methods are outlined for proof-testing a wire-rope system when necessary. Finally, recommendations are given for record keeping to allow constant monitoring of the system.

4.1. INSPECTION OF WIRE ROPE

As a wire rope is used in service, it undergoes changes in its physical condition. Individual wires break from fatigue, abrasion wears down outer wires, and corrosion may occur. These changes invariably cause a reduction in the strength of the rope. It is the purpose of careful and frequent inspection to observe the changes and to compare the rope with its as-new condition so that an estimate may be made of its remaining strength. This estimate is important, as it allows load limitations to be imposed on the rope to maintain a margin of safety based upon its actual (reduced) strength, rather than its original strength. Further, inspection is invaluable in determining when to retire a wire rope from service for maximum safety and economy. An additional benefit often results from careful inspection of a length of wire rope: the location and type of rope wear or damage can pinpoint a source of trouble within the equipment, allowing its correction and thus extending the life of future ropes. For instance, many broken wires occurring in a short time at one location on the rope might indicate a sheave in the system causing rapid fatigue damage due to its small size or misalignment.

The task of inspecting the rope should be assigned to experienced personnel. The inspector must be able to recognize normal rope wear and systematically record details, as well as distinguish abnormal wear and damage caused by rope abuse.

It is important to inspect the entire rope to find the location of the section in the worst condition; this section is the "weakest link" and determines the remaining strength of the rope. If the rope can be reeled in and out, it can be examined by running it very slowly past an observer who will inspect it under a strong light. Shiny areas may indicate excessive wear or distorted construction, while broken wires can be located by holding cotton against the surface and watching for tufts that are caught on the exposed edges. The entire circumference of the rope should be inspected.

Ropes are primarily inspected to locate wear and damage to the outer wires of the rope; this practice is normally adequate since the outer wires are subject to the most severe stresses and are exposed to the operational environment. However, caution should be used in making estimates of remaining strength on the basis of the condition of the outer wires. If lubrication has been inadequate, the inner wires or core may have deteriorated seriously. If an overstress condition has been experienced, the core may have been crushed and the inner wires damaged. And if corrosion has started internally, it is nearly impossible to determine how much metallic area has been affected.

Inspect each rope on a planned schedule based upon three considerations. First, what is the degree of hazard in operation, the possibility that loss of life or extensive property damage will occur if the rope should fail. Second, how severe are the operational conditions, what is the probability of rope abuse due to either operator error or outside causes. And third, what is the historical rate of rope deterioration in this application, and what service life may reasonably be expected. If possible, combine inspection with rope cleaning and lubrication, as a clean rope is necessary for an accurate assessment of rope damage. Remember, however, that it is far better to inspect a rope too often than not often enough.

Inspection does not end with the retirement of the rope. After retirement, it should then be taken apart carefully at several locations to check the interior for the condition of the core, the amount and location of internal corrosion (if any), and to determine if there are any hidden broken wires. This information is invaluable as an aid in detecting faults in the operation of the rope, and in predicting the service life of future ropes.

4.1.1. Broken Wires

To determine the remaining strength in a wire rope, inspect the rope for both wear and broken wires. To find the broken outer wires, the entire length of rope should be observed. Look particularly at locations along the rope that are subject to bending over sheaves, reverse bends, and also at the end fittings. When broken wires are found, clean old lubricant from the rope in that area, especially in the valleys between the strands.

It is important in determining the safe remaining strength of the rope to find the worst area of broken wires, the "weakest link". For this reason, a method has been devised to record the necessary information about each area with a large number of broken wires. For one lay length along the rope, as shown in Figure 4-1, count and record the number of broken wires in each strand. One rope lay is a convenient reference length, and is based on the fact that (due to internal wire friction) an individual broken wire may resume its load-carrying capability about a lay length from the break. Note that, as illustrated in the sample inspection log entry in Figure 4-2 for a six-strand rope, not only is the total number of broken wires important, but also the distribution between the strands. For example, six broken wires in one strand are more critical to the rope strength than 12 broken wires distributed evenly among six strands. Use the comments column to note whether the majority of the breaks are crown breaks on the outer surface of the rope, or valley breaks between adjacent strands. Note also the amount of wear on the outer wires, using the method given in the next section. Additionally, note the type of break, if possible, using Figure 4-3 as a guide.

When the broken wires have been located and recorded, the free ends that stick out should be removed so that no further damage is done to nearby wires. Cutting a wire with pliers often leaves a jagged end, so it is

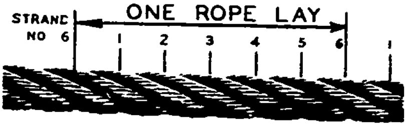


Figure 4-1. Lay Length; Six-Strand Rope

DATE	POSITION ALONG ROPE	WORST ROPE LAYS OBSERVED							COMMENTS
		NUMBER OF BROKEN WIRES, STRAND NUMBER							
		1	2	3	4	5	6	TOTAL	

Figure 4-2. Inspection Format for Broken-Wire Information

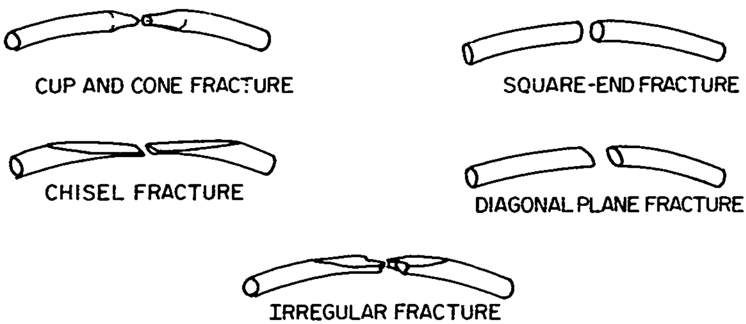


Figure 4-3. Types of Wire Breaks

advisable to bend the end back and forth until it breaks off down between the strands. Always keep the broken ends for further evaluation.

4.1.2. Abrasion and Wear

As mentioned above, a wire rope must be inspected for both broken wires and abrasive wear in order that an estimate may be made of its remaining strength. The areas of maximum wear are found by inspecting the entire rope length and looking for significant metal removal from the crowns of the outer wires. This wear is usually due to contact with sheaves, drums, other wires, or abrasive elements; the wire cross section remains round except for the worn outer surface. When the rope is new, this wear is initially rapid because of the line contact on the outer wires. Wear becomes more gradual with further rope usage. In many cases, more than half the diameter of the outer wires may be worn away before the rope strength is seriously joepardized.

On regular-lay ropes, the outer wires are parallel to the axis of the rope, and the flat wear surfaces on the wires assume an elliptical shape (see Figure 4-4). At each inspection, measure and record the length of this surface. An average of the longest wear surfaces may be taken; if this method is used, it should be clearly stated in the inspection record. Note also the number of broken wires, using the method given in the previous section.

On Lang-lay ropes, the outer wires are laid in the same direction as the strand, so that the wear pattern that develops on the outer wires is significantly different from that on regular-lay ropes. As a result, measure instead the distance from the end of the wear mark on one outer wire to the beginning of the wear mark on another outer wire several wires away. Figures 4-5 and 4-6 illustrate the correct method for measuring 6 x 17, 6 x 21, 6 x 25, and 6 x 19 Seale rope and 6 x 7 rope, respectively. As before, note and record the maximum number and distribution of broken wires in the lay length with the worst wear condition, and look also for any signs of nicking and scarring on the wires that might indicate improper spooling.

Measure the rope diameter carefully at several positions along its length at each inspection. The correct method, shown in Figure 4-7 is to determine the diameter of the smallest circle that can completely enclose the rope. The rope should be unloaded and straight when the measurement is made. Diameter reduction is an indicator of the wear and compression of the core. When the rope is new, there is a rapid diameter change as the strands seat into the core and compact against each other. After this initial period, the diameter reduction is due to both internal and external wear. However, a large decrease in diameter over a short time may indicate that the core has failed and can no longer support the strands properly.

Also measure the rope lay at each inspection. A large increase in lay length from one inspection to the next may indicate a deteriorating fiber core, or a yielding wire-rope core, both of which can cause a significant loss in the rope's strength.

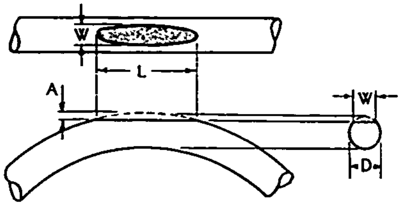


Figure 4-4. Measuring Abrasion on Regular-Lay Rope

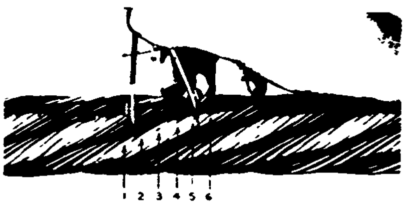


Figure 4-5. Measuring Abrasion on 6 x 17, 6 x 21, 6 x 25, and 6 x 19 Seale Lang-Lay Rope

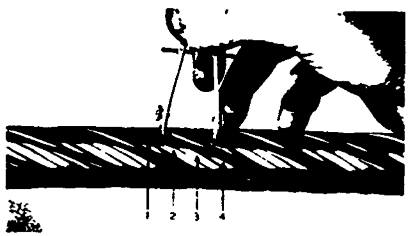
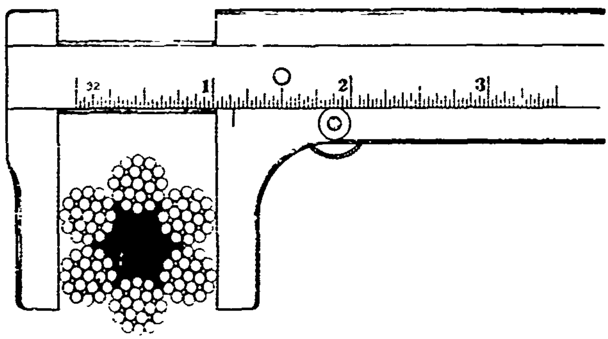
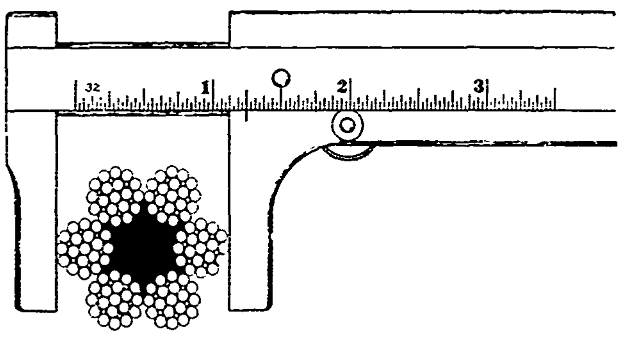


Figure 4-6. Measuring Abrasion on 6 x 7 Lang-Lay Rope



INCORRECT WAY



CORRECT WAY

Figure 4-7. Measuring Rope Diameter

4.1.3. Corrosion

Unlike wire rope with broken wires or abrasive wear, it is not possible to visually estimate the remaining strength of a corroded wire rope. The amount of unaffected metal in the wires cannot be accurately determined, and it is extremely difficult to detect internal corrosion. However, in many applications corrosive conditions cannot be avoided and corrosion will occur despite careful lubrication and maintenance. It is important that this corrosion be detected as early as possible so that it may be kept under close observation and the rope removed before failure in service. Lubrication can only retard corrosion once it starts, not halt it or restore lost rope strength. Corrosion causes increased interwire and interstrand friction, reduced load-carrying metallic area, and pitting which leads to early wire breakage.

Inspect the entire rope, as corrosion may occur only in certain places along the rope where conditions are most severe; this is particularly true for ropes that must stand idle for long periods of time.

Corrosion usually begins on the exterior of the rope, showing up as rust discoloration (usually redish-brown), scale, and pitting of the wire surfaces. When reporting exterior corrosion, note whether it is concentrated on the crown wires or down in the valleys between the strands.

Internal corrosion is far more serious, and more difficult to detect. Sometimes rust flakes can be seen working out between the strands during rope operation. As metal is lost from the inner surfaces of the wires, the outer wires may become loosened and stand away from the rope. When metal loss becomes significant, a large diameter reduction in the rope can be observed when it is under load. Internal corrosion frequently begins when heavy lubricant is used on the outside of the rope which cannot penetrate to the interior. A fiber core may then dry out and absorb moisture, thus creating a corrosive condition.

4.1.4. Other Rope Damage

There are many other types of rope damage that occur in service, usually requiring rope replacement. Whenever any serious damage is observed during rope inspection, the person responsible for deciding when to retire the rope should immediately be notified. Try also to determine the reason for the damage. Use Figures 4-8 through 4-16 and Table 4-1 to aid in identifying several of the more frequent forms of damage and their causes.

4.2. INSPECTION OF EQUIPMENT

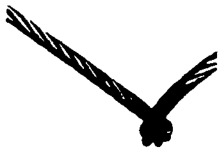
The condition of the equipment on which a wire rope is operated is an important factor in determining rope life. Therefore, equipment should be inspected as frequently and carefully as the rope itself if maximum rope service life is to be obtained. This section outlines inspection procedures for sheaves, drums, level-winds, and fittings.

4.2.1. Sheaves

Inspect all the sheaves in the system both before installing a new rope and during the operational life of the rope. First check the general condition of a sheave, looking for cracked or broken flanges, cracks, chips or pitting of grooves, or abnormal wear patterns. Perhaps the most serious wear is corrugation in the groove, often a sign that the sheave material is too soft. Corrugation, shown in Figure 4-17, can quickly destroy a rope by nicking the outer rope wires. Sheaves in poor condition should be reconditioned or replaced.

Figure 4-8. Crushed Rope

Start of a Kink



Kink

Result of a Kink

Figure 4-9. Kinked Rope

If the first check reveals no serious defects or damage, then measure the groove for both size and contour all the way around its circumference. Use a groove gauge as shown in Figure 4-18, holding it perpendicular to the groove. When a new rope is placed in service, check the sheave grooves with a new sheave gauge, made to the nominal rope diameter plus the allowable rope oversize. During the life of a rope, use a worn-sheave gauge*. The allowable and minimum sheave groove oversize are shown in Table 4-2. An exception is the oversize for sheave grooves with personnel elevator ropes; the groove is held between 1/32- and 1/64-inch oversize for all rope diameters. Figure 4-19 shows the groove size as measured with the gauge. Note that the gauge also indicates the contour of the groove; the groove should be round and give

* A worn-sheave gauge is designed to fit the rope diameter plus the minimum sheave groove oversize.

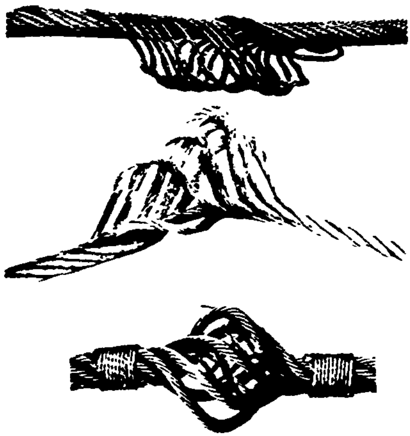


Figure 4-10. Birdcaged Rope

Figure 4-11. Cut Rope

Figure 4-12. High Strand

Figure 4-13. Snagged Wires

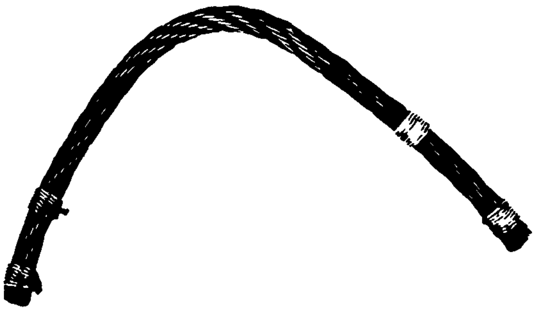


Figure 4-14. Dogleg

Figure 4-15. Popped Core

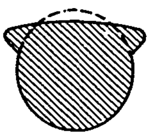


Figure 4-16. Cross Section of Peened Wire

Table 4-1. CAUSES OF ROPE DAMAGE

Type of Damage	Possible Cause	Figure Number
Crushing	Crossover on drum	4-8
	Poor drum winding	
	Rope Pinching	
	Pounding on equipment	
Kinking	Pulling on loop in slack rope	4-9
Birdcaging	Sudden load release	4-10
Cutting	Accidental localized shearing	4-11
High Strand	Dogleg	4-12
	Crushed area	
	Poor fitting attachment	
	Poor splice	
Snagged Wires	Rope movement over nails or protrusions	4-13
Dogleg	Jumping sheaves	4-14
	Bending rope around sharp corners	
	Poor drum winding	
Popped Core	Squeezing rope, which opens strands	4-15
	Bending over small sheaves	
	Crushing on drum	
Peening	Pounding rope on hard surface	4-16
	Pounding rope with hard object	

Figure 4-17. Sheave Corrugation

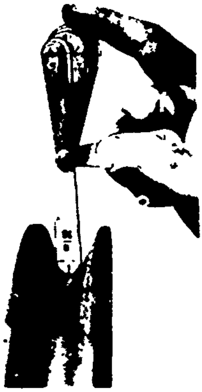


Figure 4-18. Sheave Groove Measurement

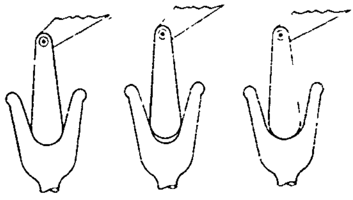


Figure 4-19. Determining Sheave Groove Size

Table 4-2. SHEAVE GROOVE OVERSIZE*

Nominal Rope Diameter, Inches	Allowable Oversize (New), Inch	Minimum Oversize (Worn), Inch
Up to 5/16	1/32	1/64
3/8 - 3/4	1/16	1/32
13/16 - 1 1/8	3/32	3/64
1 3/16 - 1 1/2	1/8	1/16
1 9/16 - 2 1/4	3/16	3/32
2 5/16 and Over	1/4	1/8

*Except for personnel elevator ropes. See text.

support to at least one-third (120 degrees) of the rope circumference. As both the rope and the groove wear, the groove becomes smaller and the actual tread diameter of the sheave (Figure 4-20) decreases.

Check the sheave bearings to insure that the sheave does not vibrate while running (loose bearings), or stick and cause excessive wear (tight or worn bearings). Check also that the sheave itself runs true so that the rope is not whipped back and forth. If running at high speed, also check the sheave balance to minimize vibration. Finally, check sheave alignment to insure that the rope will not rub on the flange, causing severe wear or possibly causing the rope to jump out of the sheave.

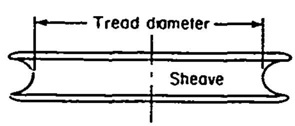


Figure 4-20. Tread Diameter

4.2.2. Drums

Inspection of grooved drums follows a procedure similar to that outlined above for sheaves. Look especially for nicked or chipped groove edges which may cause accelerated rope wear. Also, worn grooves often have extremely sharp edges which act as cutting surfaces against the outer wires of the rope; round off these edges. Check drum flanges, starter, filler, and riser strips for excessive wear.

Check smooth-faced drums for any pattern of wear or corrugation which might lead to improper winding or adverse rope wear.

4.2.3. Level-Winds

An incorrectly operating level-wind can severely damage a wire rope in a short time. Inspection of the level-wind is therefore very important. Check two items: adjustment and wear. Adjust the level-wind as specified in the operator's manual for the system. Time the level-wind so that the rope is fed onto the drum almost directly into the correct groove, neither leading nor lagging the groove enough to cause scuffing on the groove edge, drum flange, or adjacent rope. Wear in the level-wind can occur in sheave bearings, lead-screw, or driven pawl; and in guide shaft; serious wear makes proper adjustment impossible. When wear of any of these components is suspected, check it carefully to insure that it is within tolerance. Recondition or replace worn parts before serious damage is done to the wire rope.

4.2.4. Fittings

Fittings should be inspected regularly. Wedge sockets, particularly, tend to wear in the wedge and socket grooves so that the holding power is gradually reduced to the point that the rope may pull out. If wear is evident, measure the wedge socket grooves with a wear gauge and remove the socket from service if its holding power is substantially reduced. Carpenter stopper grooves wear in the same way; they should be inspected to insure that the rope can be clamped tight without slipping or rope damage. The tightness of the nuts on the carpenter stopper clips should also be checked, and retightened to the specified torque, if necessary. Checking and correcting nut tightness may be necessary at frequent intervals for a new rope. Other types of sockets and end fittings should be checked for cracks and the pin holes examined for elongation due to wear and overloading. Replace end fittings as necessary.

4.3. LOAD TESTING

It is useful periodically to test the load capacity of a wire rope system by tensioning the wire rope in the system to 100 percent of the system design load. This check will help determine whether the rope and terminations, deck fittings, sheaves, and associated equipment are still capable of working at their rated loading without unexpected failure. In some cases it may also be necessary to operate the system dynamically under carefully controlled, design-load conditions to check for system problem areas. (Further discussion is given in Section 2.10. Maximum Load Testing a Wire Rope System, page 2-23).

Personnel safety cannot be overemphasized during load-testing; only people essential to the testing procedure should remain in the area while the test is under way. The operator must be constantly alert for failure or incipient failure of a component and should shut the equipment down immediately in that event to prevent further damage.

4.4. RECORD KEEPING

As pointed out previously, it is the purpose of inspection to observe changes in the condition of the rope and its associated equipment and to compare the present condition with the as-new condition. The inspector or engineering officer may then determine the rate of deterioration and determine the safest and most economical time to remove the wire rope or repair the equipment. However, these decisions will be only as reliable as the records of lubrication, maintenance, and inspections. The things to look for and record have been outlined above, such as rope wear, broken wires. and sheave groove size. Always note in the record book the observed conditions and any other comments that might be important in assessing the rope condition; too much information is always better than too little. If possible, include photographs of the more seriously worn or damaged areas, providing a permanent record of actual conditions. Note any other information, such as dates, footage or cycles run (from counter), or abnormal environmental circumstances (for example, immersion in salt water). Be sure to record any changes in maintenance procedures; for example, the type of lubricant or frequency of lubrication; or changes in rope layout, sheave alignment, etc.

It is a good practice to keep two sets of records, one the official record of maintenance and inspection that stays with the machine, the other a separate, unofficial notebook for each rope. The rope notebook can be used for daily cursory examination as well as for detailed notes on possible improvements to existing situations.

5. INSTALLATION OF WIRE-ROPE FITTINGS AND TERMINATIONS

This section gives step by-step instructions for the correct installation of the fittings and terminations used with wire rope. Most types of terminations are discussed, from seizings and splices through the various types of sockets to carpenter stoppers and Fiege fittings.

5.1. SEIZING WIRE ROPE

When wire rope is manufactured, great care is taken to lay each wire in the strand and each strand in the rope under uniform tension. If the ends of the rope are not secured properly when the rope is cut, the wires and strands tend to loosen, not only at the ends but back within the rope. This loosening destroys the rope's original balance, causing some of the strands to be overloaded while others carry considerably less load. This results in broken wires, birdcaging, and high strands--in other words, shortened service life of the rope.

To maintain the proper balance of tension within a rope during and after cutting, the proper kind and number of seizings--tight wire wraps--must be applied to the rope on both sides of the cut. The correct size and type of seizing wire must be applied under proper tension, and in neatly laid parallel coils that are in close contact with one another. Only single wire may be used (a strand of fine wires may collapse or flatten and become slack), and the seizing wire must be soft enough so that it can easily be bent to the shape of the rope. Soft iron wire is used to seize bright ropes; galvanized iron wire is used for galvanized ropes. Although preformed ropes have little tendency to untwist, apply one seizing to each side of the cut to prevent distortion of the rope ends during cutting.

5.1.1. Hand-Cutter Seizings

Hand cutters may be used for applying seizings to ropes 1 inch in diameter and smaller. Following are instructions and illustrations for applying hand-cutter seizings (Figure 5-1):

1. Wind the seizing wire on the rope by hand in the opposite direction to the lay of the rope, keeping the coils together and maintaining considerable tension on the wire.
2. Twist the ends of the wire together counter-clockwise by hand so that the twisted portion of the wires is near the middle of the seizing.
3. Using hand cutters, tighten the twist just enough to take up the slack. Do not try to tighten the seizing by twisting.
4. Tighten the seizing by prying the twist away from the axis of the rope with the cutters.
5. Tighten the twist again as in (3). Repeat (4) and (5) as often as necessary to make the seizing tight. Cut off the ends of the wires and pound the twist flat against the rope.

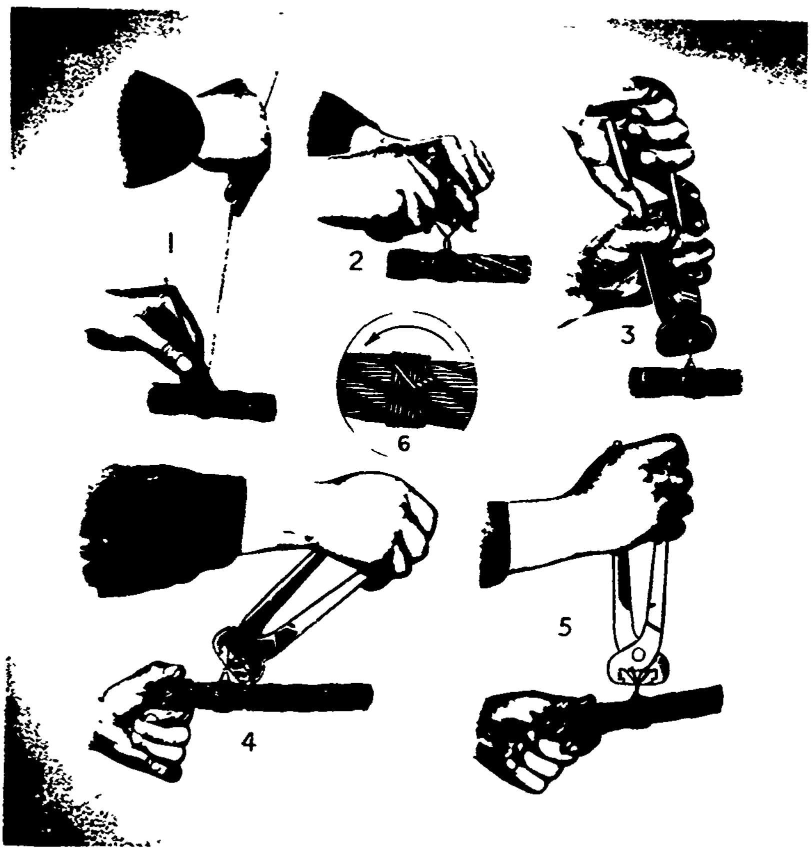


Figure 5-1. Applying Seizings With Hand Cutters

5.1.2. "Buried-Wire" Seizings

Ropes larger than 1 inch in diameter require "buried-wire"-type seizings, applied with a seizing mallet or round bar (usually 1/2 to 5/8" in diameter and about 18 inches long). In applying this kind of seizing, the loose end of the seizing wire is placed in the valley between two strands and the seizing coil is wound over it so that the two ends of the seizing wire finish at the same place and can be twisted together and cut off (see Figure 5-2). Tools required for this method of seizing include:

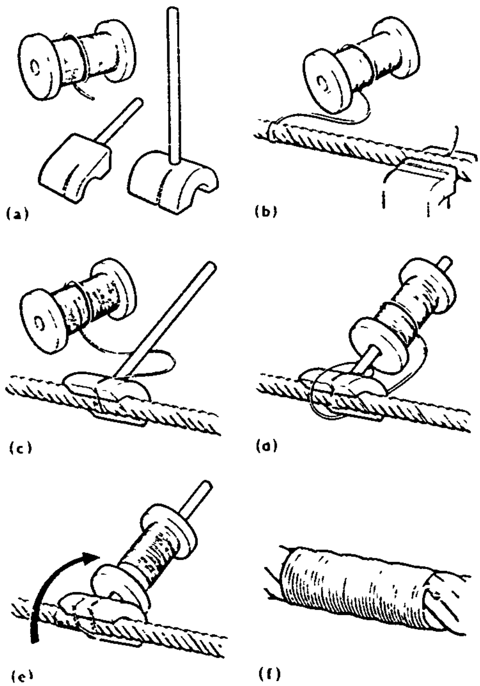


Figure 5-2. "Buried-Wire" Seizings

1. A vise, or other means of holding the rope.
2. A seizing mallet (see Figure 5-2a) with a grooved head that can be placed over the rope. It should be brass or some other soft material to avoid rope scoring.

3. A reel (Figure 5-2a) on which sufficient wire can be wound to complete a seizing.
4. Pliers and wire cutters, for twisting wire ends together and cutting them.
5. A small soft-head hammer for tapping the coils of a seizing into contact with one another and for "burying" the twisted ends of the seizing in a valley between strands of the rope.

To make a buried-wire seizing, pay out the free end of the seizing wire on the reel for the length of the seizing and clamp its extreme end in a vise together with the rope (Figure 5-2b).

Place the seizing mallet on top of these turns (Figure 5-2c), and:

1. Lead the wire over one edge of the head of the mallet and to the handle of the mallet and give it a half-turn around the handle (Figure 5-2c),
2. Lead it back to the rope over the same edge of the mallet (Figure 5-2d), and pass it under the rope to the other edge of the mallet, then
3. Lead the wire over the mallet edge, slip the reel onto the handle of the mallet, and turn the reel to take up the slack wire (Figure 5-2d and e).

As the mallet is rotated around the rope to continue the seizing (Figure 5-2e), the drag or friction of the wire in passing around the mallet handle insures that the seizing is applied to the rope under proper tension. As more and more coils are laid on the rope, keep the turns tight and in hard contact with one another. If the wire tends to form open coils, tap the coils into place with a softheaded hammer before continuing.

A guide-groove for the wire may be cut in the head of the mallet, as shown in Figure 5-2a. When the length to be seized is completed, twist together the wire from the final coil and the buried wire, pull tight, twist further to keep them tight, and cut off leaving about four twists remaining in the twisted end (Figure 5-2f). Then knock the remaining twisted end down with the hammer neatly against the rope. (For stranded ropes, locate the twist so that it can be hammered into a valley between two strands.)

If a round bar is used instead of a seizing mallet, tension the seizing wire by giving the free end one or two turns about the bar.

5.1.3. Soldered or Wiped Seizings

A third method of seizing which is strongly recommended for locked-coil ropes is the soldered or wiped seizing. This method is superior for these applications because the rope can be seized without any buried wire so that the two ends of the seizing wire lie at opposite ends of the seizing. The ends of seizing wire are not twisted or joined in any fashion. They, and the intervening coils of seizing, are fixed in position by "wiping" the seizing with molten solder along one side, or along two opposite sides. This solders each coil to the neighboring ones and to the rope itself.

Tinned annealed steel seizing wire is preferable to soft iron wire because it aids the soldering process.

Soldered seizing is similar to buried-wire seizing, except that the paid-out part of the seizing wire, which is fixed to the vise, is led to the nearest end of the seizing length. The seizing wire is then wrapped with the mallet. Before the mallet is removed and while the seizing is still under tension, the seizing must be wiped with solder along its length.

5.1.4. Length, Number, and Spacing of Seizings

For ropes up to 1 inch in diameter, the seizing length should equal or slightly exceed the rope diameter. For ropes larger than 1 inch in diameter, the seizing length should be about 1-1/2 times the rope diameter. The clearance between seizings should be about one rope diameter. Preformed rope requires one seizing on each side of the cut. Table 5-1 gives the size of seizing wire and the recommended number of seizings on each side of the cut on nonpreformed wire rope.

Table 5-1. NUMBER OF SEIZINGS FOR NONPREFORMED WIRE ROPE-SEIZINGS ON EITHER SIDE OF A CUT

Rope Diameter, Inches	Annealed Iron Seizing Wire Diameter, inch	Regular Lay With Fiber Core	Lang Lay and Rope With Strand or Individual Wire Rope Core, and 18 or 19 x 7 Constructions
1/2 and smaller	.035	3	4
9/16 to 7/8 inclusive	.063	3	4
1 to 1 1/2 inclusive*	.092	4	5
1 5/8 to 2 1/8 inclusive*	.120	5	6
2 1/4 and larger*	.135	5	6

*For ropes larger than 1-inch diameter, use the buried-wire or soldered seizings method.

Locked-coil ropes require special attention because of the considerable bursting force they exert against a seizing and because of their tendency to unlay violently if a seizing fails. For a large locked-coil rope, seizing length should be at least 20 times the rope diameter. The seizings should also be backed up with several U-bolt clamps beyond the seized length until the rope end is properly secured. If possible the seizings on locked-coil ropes should be left intact during service to minimize unlaying of the rope end and possible wire breakage near the termination.

5.1.5. Cable-Band Seizings

Soft steel sleeves are commercially available for seizing wire ropes before cutting. Made of pliable but strong steel indented with a groove and lock seam at one edge, these bands are applied to the rope quickly, as shown in Figure 5-3, with an ordinary pair of pliers. These bands are manufactured for wire ropes from 3/16 to 1-1/2 inches in diameter.

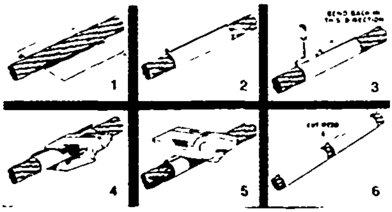


Figure 5-3. Attaching Cable-Band Seizings

5.2. THIMBLES AND CLIPS

Wire rope clips are normally not recommended for permanent installation, although they are excellent for emergency field attachments. When applied properly, they will develop up to 80 percent of the rope's catalog breaking strength. Disadvantages include high cost, bulk, poor adaptability to a variety of mating parts, need for hand manipulation and tightening, possibility of working loose under load or vibration, and difficulty in adjustment.

Clips are available in two basic types: the regular U-bolt clip shown in Figure 5-4, and the integral-saddle-and-bolt type shown in Figure 5-5. The U-bolt fitting consists of a U-bolt and a saddle or bridge that is grooved to fit the rope strands. The two parts are fastened together with nuts. The integral-saddle-and-bolt-type fitting, often called a "safety" or "fist-grip" fitting, has two L-shaped pieces grooved to fit the rope strands and fastened together with nuts. Fist-grip clips squeeze the rope evenly and do not tend to damage the rope as do U-bolt clips.

Install U-bolt clips as shown in Figure 5-6. As pictured, the U-bolt must exert its pinching on the short, or "dead", end of the rope only. Such pressure on the long, or "live", end results in early rope failure under load.

Fist-grip clips are installed as shown in Figure 5-7. The rope ends and fittings must be aligned, but there is less danger of squeezing the live end of the rope too tightly than there is with U-bolt clips.

The number of clips required for each rope size and the recommended tightening torques are given in Table 5-2. It is recommended that the spacing between clips be six times the rope diameter; the numbers in Table 5-2 reflect

Figure 5-4. U-Bolt Clip

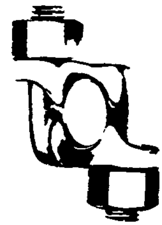


Figure 5-5. Integral-Saddle-and-Bolt Clip

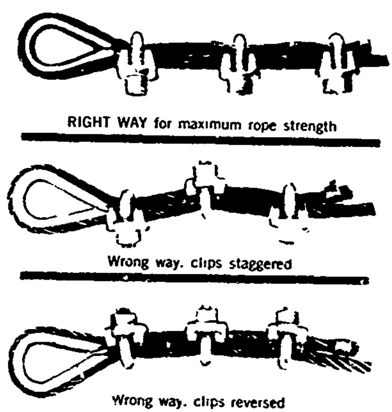


Figure 5-6. Proper Installation of U-Bolt Clips

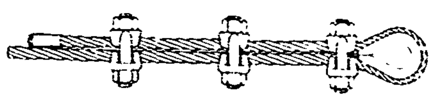


Figure 5-7. Fist-Grip or Safety-Clip Installation

Table 5-2. MINIMUM NUMBER OF WIRE ROPE CLIPS REQUIRED*

Rope Diameter, Inches	All 6 x 17 Ropes, All Ropes With Independent Wire Rope Cores	All 6 x 19 and 6 x 37 Fiber Core Ropes	Proper Torque Applied to Nuts of Clips, Foot-Pounds
3/8	4	3	25
1/2	4	3	40
5/8	4	3	65
3/4	5	4	100
7/8	5	4	165
1	6	5	165
1 1/8	6	5	165
1 1/4	7	6	250
1 3/8	7	6	375
1 1/2	8	7	375
1 3/4	8	7	560

* According to Naval Ships Technical Manual (NAVSHIPS 0901-270-0001) Wire Rope (September, 1967).

this ratio. If space or rope length is limited, however, the clip spacing may be reduced to as small as one clip width; some reduction in gripping efficiency may result.

Use at least as many clips as Table 5-2 recommends. The use of fewer clips means greater pressure on each clip, increased rope abuse and decreased breaking strength of the clipping attachment. A thimble must also be used to prevent rope wear in the eye and to avoid sharp rope bends. To be effective, the thimble must be strong enough to retain its shape under maximum load.

The following instructions are applicable to both U-bolt and fist-grip clips:

1. Turn back the required amount of rope from the thimble (measured from the base of the thimble to the first seizing).
2. Bend the rope around the thimble and secure temporarily.
3. Apply the first clip one base width from the dead end of the rope. (The U-bolt should go over the dead end with the live end of the rope resting in the clip saddle.) Tighten the nuts evenly to recommended torque levels.
4. Apply the next clip as near the loop as possible. Fasten nuts firmly but do not tighten them.
5. Space additional clips as required equally between the first two. Fasten nuts firmly and evenly but again do not tighten. Put the rope under light load to take up slack, then tighten all nust equally to recommended torque. (Oil the threads to allow the nuts to be drawn up completely.)

6. Apply the initial service load and retighten nuts to the recommended torque after a short period of service. The rope will stretch and shrink in diameter under initial loading.

The rope will continue to stretch and shrink in diameter during use, and clips may work loose because of vibration or load. To maintain efficiency and insure safety, clip attachments must be inspected at regular intervals and retightened as required. When an attachment has been in use for some time, remove the clips and examine the rope for broken wires. If any are found, cut the damaged length from the rope end and make a new attachment.

5.3. SPLICES

Wire rope is spliced either to make a loop (or "eye") in the end of a wire rope or to fasten two rope ends together ("endless" splicing). There are three types of eye splices: hand-tucked eye splices, Flemish (or Molly Hogan) eye splices, and mechanical eye splices. Endless splices are categorized according to the splice length. The standard short splice is used for most six-strand ropes. The long splice, used to splice haulage ropes and long lengths of rope operating under heavy loads, differs from the short splice in that the distance between "tucks" (passage of a rope strand through the other rope), the tuck length, and the total length of rope used are greater. Otherwise both endless splices are the same.

Reliable splicing is a difficult process and should only be done by experienced personnel. Improperly spliced rope may separate under relatively low loads and present a rope safety hazard.

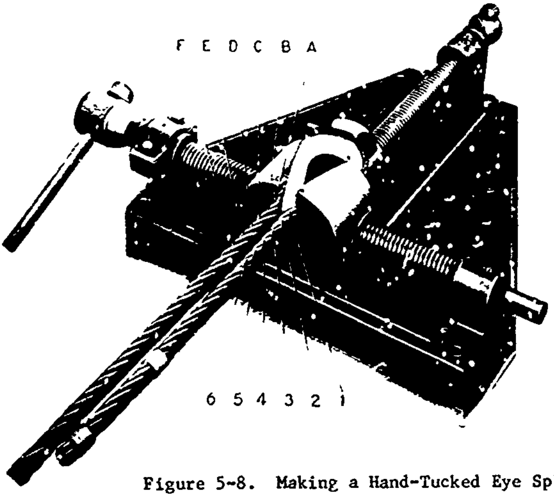
5.3.1. Hand-Tucked Eye Splices

Hand-tucked eye splicing is a process in which the dead end of the rope is tucked, strand by strand, into the live portion of the rope to form a loop. The finished splice, if performed properly, may develop as much as 95 percent of the rope catalog breaking strength.

A relatively short length of wire rope is required in making a hand-tucked eye splice. If standard-sized thimbles are used to form the loop, a rope length of from 30 to 40 times the rope diameter is required to form the loop and complete the splice. Oversize thimbles, or large loops without thimbles, require proportionally longer rope-end sections.

To make a hand-tucked eye splice begin by measuring the required rope length. Then bend the rope about the thimble (if one is used) at the point of measurement and place the rope and thimble in a vise as shown in Figure 5-8a.

For purposes of discussion the individual strands on the dead and live rope ends have been sequentially numbered and lettered respectively, (A six-strand rope is shown here, although a similar procedure could be used for an eight-strand rope). The splicing process essentially involves the tucking of Strand 1 under Strand A, Strand 2 under Strand B, Strand 3 under Strand C, etc. Normally each strand of the short end of the rope is tucked under the corresponding strand of the long end of the rope four times before the splice is complete.



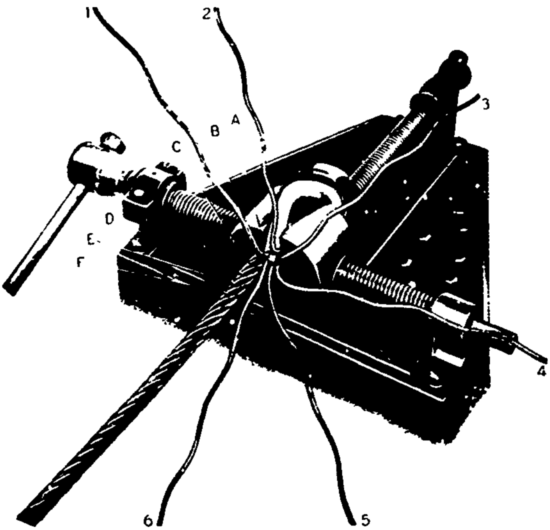
a.

Figure 5-8. Making a Hand-Tucked Eye Splice.

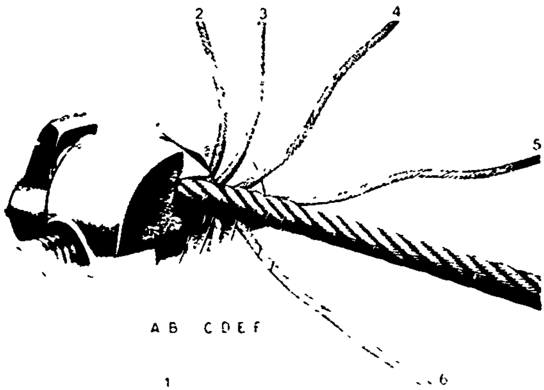
To facilitate the tucking of each strand, it is sometimes desirable to remove some of the "twist" from the long (or live) end of the rope. This can be done by forming a loop on one end of a piece of manila line, and wrapping the line securely around the rope in the direction of the rope lay between the vise and the anchor point. Then a length of pipe can be inserted in the loop and the rope unlayed by rotating the pipe in the loop around the rope two or three times. After the pipe is rotated it can be anchored in position until the splice is complete.

After the rope is mounted in the vise and the live rope end is unlayed, the seizings can be removed from the short end of the rope and the strands separated, as shown in Figure 5-8b. Following that step, insert a marlin spike under the first two strands nearest the point of the thimble (Strands A and B), and rotate the spike a half turn away from the thimble. Insert Strand 1 through the opening and rotate the spike back toward the thimble, taking Strand 1 with it so that Strand 1 will be pulled tightly in place. This completes one tuck of Strand 1 as shown in Figure 5-8c.

The next step is completed by inserting the marlin spike under the next single strand (Strand B) and tucking Strand 2 under Strand B. Strand C should be temporarily omitted for the third step. Instead, the marlin spike should be placed under the next two strands (Strands D and E) so that Strand 6 can be inserted through the opening in the direction opposite to which Strands 1 and 2 were tucked. After Strand 6 is in place the marlin spike should be rotated back to the tip of the thimble, rotating Strand 6 with it, so that it is pulled tightly in place. Figure 5-8d shows the splice at this stage of completion--with Strands 6, 1, and 2 tucked once under Strands F, A, and B, respectively.



b.



c.

Figure 5-8. (Continued)

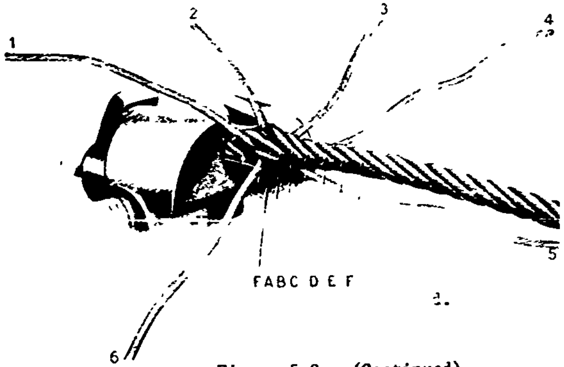


Figure 5-8. (Continued)

Next, the marlin spike should be inserted under Strand E so that Strand 5 can be tucked in the same manner as Strand 2 was tucked under Strand B. This process is shown in Figure 5-8e.

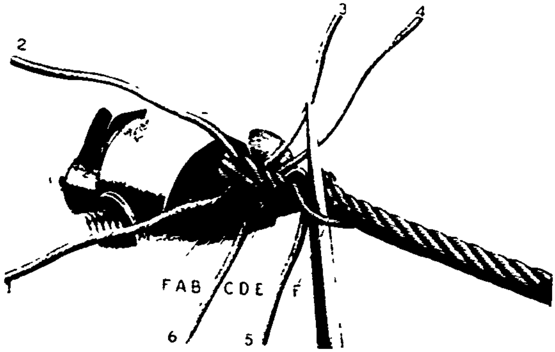
Without removing the marlin spike from under Strand E, Strand 5 should be given three additional tucks. This process can be accomplished by winding Strand 5 spirally around Strand E three times. Each time the spike is rotated a half turn. Strand 5 should be tucked through the opening, and the spike rotated back toward the thimble to tighten the tuck.

Strands 4 and 3 should then be tucked four times about Strands D and C, respectively; following the same procedure as described above for Strand 5. Figure 5-8f shows Strands 3, 4, and 5 after the completion of four tucks on each strand.

Strands 6, 1, and 2 should then be given three additional tucks about Strands F, A, and B, respectively, in the same manner as outlined for Strand 5. Figure 5-8h shows the splice with four completed tucks in each of the six strands.

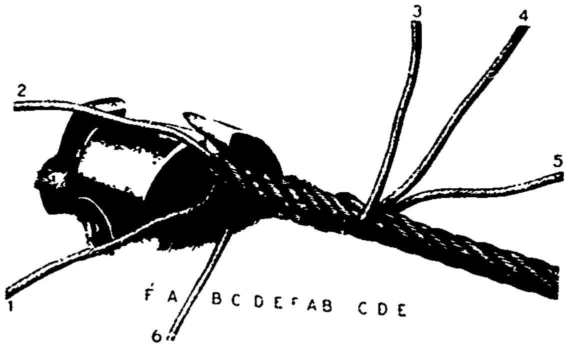
An eye splice made in this manner will have a slight taper as shown in Figures 5-8h and 5-8i. If a more pronounced taper is desired, a portion of the wires from each strand can be cut off before the final tuck is made.

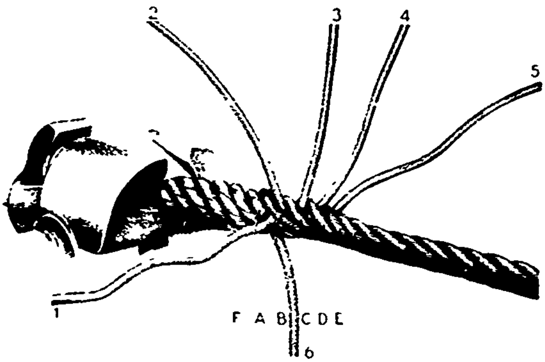
As a final step, the protruding strand ends should be cut off close to the rope and the tucked strands set tightly together by hammering them with wooden mallets. The applied torque to open the rope lay should then be removed and the splice wrapped with serving wire to protect the hands of workmen handling the rope. The serving wire can be applied easily with a "serving iron" as shown in Figure 5-8h. The completed hand-tucked eye splice is shown in Figure 5-8i.



e.

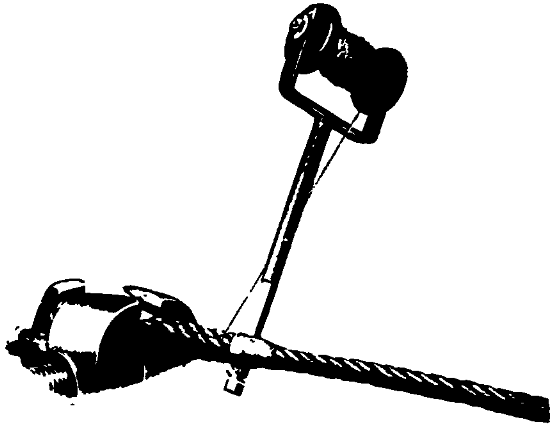
f.





g.

Figure 5-8. (Continued)



h.

i.

Figure 5-8. (Concluded)

5.3.2. Flemish Eye Splices

The Flemish eye splice is a commonly used handmade splice which is relatively easy to construct, and which, if properly constructed, withstands more than 90 percent of the rope's rated breaking strength. It is also sometimes known as a "Molly Hogan" or "Rolled In" eye splice. The splice is easiest to construct using preformed wire rope.

The construction of a Flemish eye splice is illustrated in Figures 5-9a, b, c, and d for a 6-strand wire rope. Figure 5-9a shows the dead end of the rope splayed into two 3-strand sections. The rope core should be retained in one of the sections. Before splitting, the rope should be seized at a distance from the end of the rope equal to the length of the loop desired, plus approximately 10 rope diameters.

After the rope is seized and split, the loop can be started as shown in Figure 5-9b. The sets of strands will interlock if properly positioned. Lay the strand sections alternately back into the rope grooves (Figure 5-9c) until the sections are laid as deep into the throat of the splice as

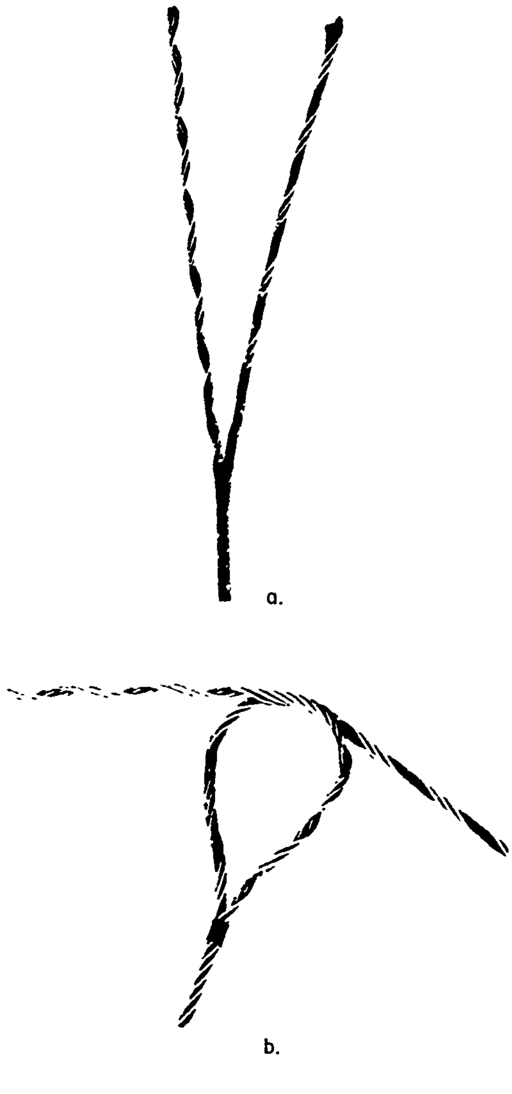
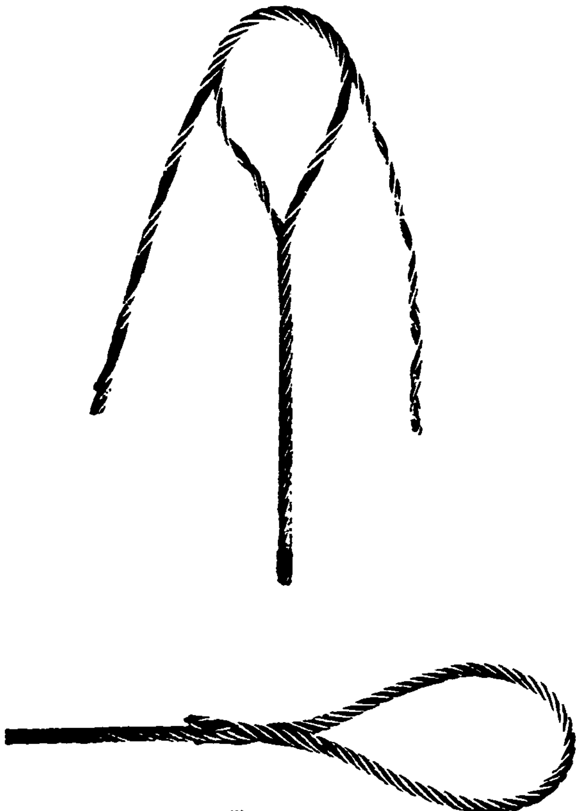


Figure 5-9. Flemish Eye Splice

possible. After this step is completed, the six strands and core should project past the throat of the loop. If the rope is fiber core, the remaining core section should be trimmed off.

The splice is normally completed in one of two ways. First, a compression-type fitting may be used to retain the strand ends. Second, the strand ends may be hand-tucked into the rope and subsequently over-wrapped with seizing wire. The first method has become increasingly popular. The splice just before completion is as shown in Figure 5-9d.



d.

Figure 5-9. (Concluded)

5.3.3. Mechanical Eye Splices

Mechanical eye splices can hold up to 100 percent of the rope's catalog breaking strength if properly constructed. They are, therefore, somewhat safer than hand-tucked splices, which normally retain about 90 percent of the rope's strength. Mechanical eye splices consist of a loop in the end of the rope--preferably with a Flemish eye splice--with the dead part of the rope swaged to the live part with at least one steel or aluminum sleeve. For a detailed discussion of mechanical eye splices, see Section 5.7. OTHER SWAGE FITTINGS, page 5-26.

5.3.4. Endless Splicing

In endless splicing, alternate strands from one rope are replaced with strands of the rope to which it is being joined, forming a section of "hybrid" rope. The strand ends which are left at the completion of this process are tucked into the rope center for a 6-strand rope; and split, tied, tucked and cut for an 8-strand rope. Ropes spliced in this manner may be nearly as strong as the original rope.

Two types of splices are commonly used; the standard short splice for ordinary conditions, and the long splice for ropes on haulages or inclines or wherever the duty is particularly severe. Splices of either type are never recommended for vertical shafts and are seldom recommended for inclines greater than 45 degrees.

The following instructions apply to fiber-core rope only. Directions for splicing IWRC and WCS ropes may be found in NAVSHIPS 0901-270-0001.

The total amount of rope to allow for making endless splices in 6-strand, regular-lay rope is given in Table 5-3. For Lang-lay ropes, increase values for the long splice is by 20 percent.

To begin the process, seize each end of the two ropes to be spliced at a distance from the end equal to the unlayed rope length given in Table 5-3. Then, unlay the rope strands to these seizings, as shown in Figure 5-10a. The fiber cores should then be cut off as near to the seizings as possible, and the six strands of each rope end interlocked in a finger-lock position, as shown in Figure 5-10b. The ends should be forced together so that the seizings are as near each other as possible, and the seizings removed.

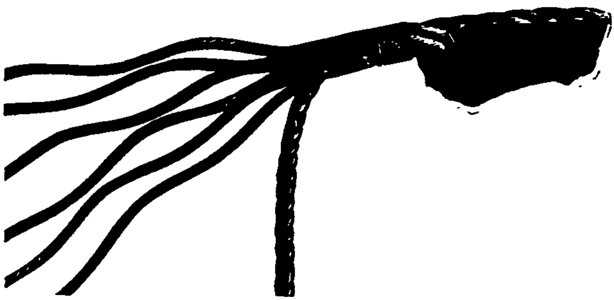
Next, unlay one strand, filling the groove vacated by this strand with a strand from the other rope end (see Figure 5-10c). Continue laying and unlaying these two strands until only strand equal to about one-half the length of tuck remains. The length of tuck should be approximately 1/12 the amount of rope allowed for the splice--values are given in Table 5-3.

This process should then be repeated with two more pairs of strands; stopping the laying/unlaying at a distance of twice the length of tuck from the point where the first two pairs of strands protrude. The last two pairs of strands should be laid/unlaid for a distance equal to the length of tuck. Figure 5-10d shows the laying/unlaying process completed.

Table 5-3. UNLAYED ROPE AND TUCK LENGTH REQUIRED FOR SIX-STRAND REGULAR-LAY WIRE ROPE*

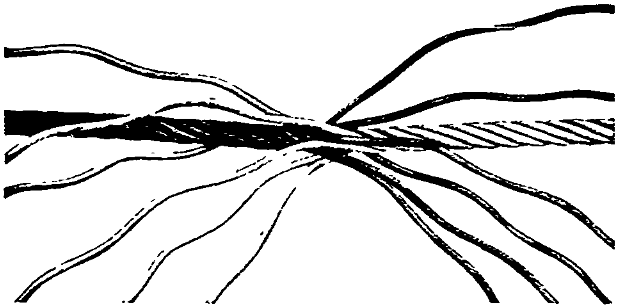
Rope Diameter, inches	Short Splice		Long Splice	
	Distance to Unlay, feet	Length of Tuck, inches	Distance to Unlay, feet	Length of Tuck, inches
1/4	7	10	15	15
3/8	8	12	18	18
1/2	9	14	21	21
5/8	10	16	24	24
3/4	11	18	27	27
7/8	12	20	30	30
1	13	22	33	33
1 1/8	14	24	36	36
1 1/4	15	26	39	39
1 3/8	16	28	42	42
1 1/2	17	30	45	45

* NAVSHIPS Technical Manual 0901-270-0001, Wire Rope.



a.

Figure 5-10. Making an Endless Splice



b.

c.

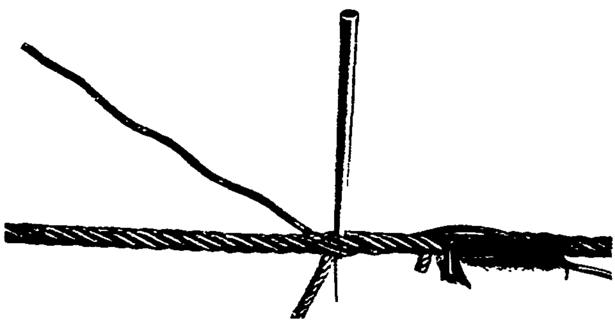
d.

Figure 5-10. (Continued)

Now the protruding strands must be "tucked" out of the way. When splicing regular-lay rope, do not cross the strands before tucking. For Lang-lay rope, however, cross the pairs of strands at the points where the tucks begin, because this normally increases the holding power of the splice.

The protruding strand ends must be cut to the length of tuck and straightened if the rope is preformed. The strand ends should then be wrapped with friction tape or twine. A layer of tape or twine enlarges the diameter of the strand and increases binding action within the rope which results in greater splice strength. After wrapping, bind the strands as firmly as possible without making the rope oversize when the ends are tucked (see below for tucking instructions).

Place the rope in a vise so that the rope and one of a pair of strands to be tucked are gripped just beyond the point where the pair protrude from the rope. A manila rope sling and a lever may be used to unlay and open the rope partially, as in "Hand Splicing". Drive a marlin spike under three strands, opening the rope. Cut the fiber core and pull one of the rope ends through the opening made by the spike. Rotate the spike to force out the fiber core and simultaneously force the strand end into the space left vacant by the fiber core (Figure 5-10e).

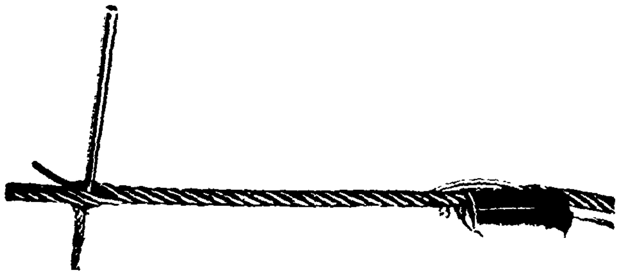


e.

Figure 5-10. (Continued)

By rotating the spike, tuck the entire strand (Figure 5-10f). Then regrip the rope in the vise to tuck the second strand end. A pair of splicing tongs or some other clamp may be necessary to force this strand into its proper position. Tuck the second strand in the same manner as the first. Repeat this tucking operation for the other five pairs of strand ends.

This rope will be somewhat deformed at the point where the tucks start. Reduce these high points by hammering the rope with a pair of wooden mallets (Figure 5-10g).



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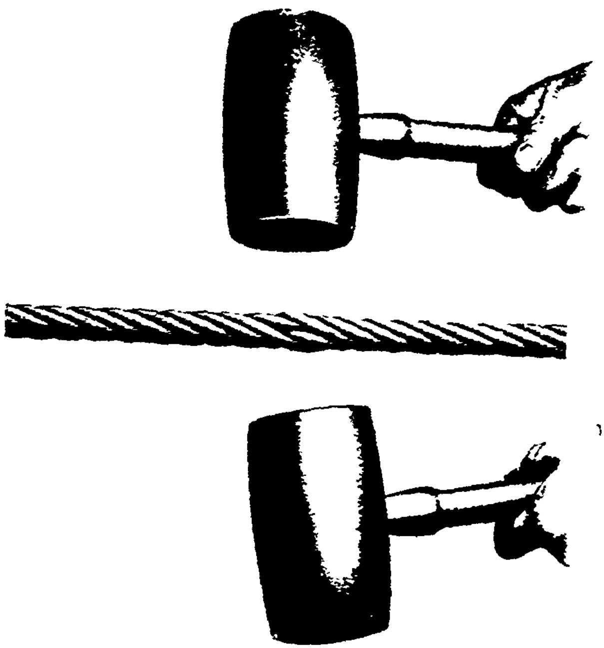


g.

Figure 5-10. (Concluded)

5.4. ZINC SOCKETS

Zinc sockets can develop the full catalog strength of a wire rope when they are properly installed. This section describes the correct method of preparing an adequate bond between the socket and the rope; other methods may be required in applications where extremes of safety or loading are found (e.g., aircraft arresting cables). It should also be mentioned that zinc sockets are not normally used by the Navy on stainless steel ropes--Flege or swage fittings are used, instead.

Measure from the end of the rope a length equal to the socket basket, and apply three seizings as shown in Figure 5-11a. It is important that these seizings be applied carefully and spaced to prevent any untwisting of the strands which might result in unequal tensions in the finished socket. Remove the seizing at the rope end and open up the rope. If the core is fiber or plastic, cut it off as near the first seizing as possible. Do not cut off a wire strand or independent wire rope core.

"Broom out" the wires in the outer strands and the metallic core as shown in Figure 5-11b to facilitate cleaning the individual wires. Untwist the strands and straighten out the individual wires somewhat so that they form a "brush". A short length of steel tubing may have to be used to help straighten larger wires, particularly if they have been preformed.

Careful cleaning of the wires is critical in obtaining a good bond between the zinc and the wires. Three methods of wire cleaning are commonly used. Ultrasonic cleaning of wires is used in some cases, and sand blasting of the the wire ends is used in some others. These two methods are both relatively self explanatory. The oldest method, however, is probably the acid-bath cleaning process. It is a more complicated process than the other two methods, and it is still used in some cases, so it is described in some detail in the following paragraphs.

To begin acid-bath cleaning, hold the broomed-out rope end down in a pail of mineral-based solvent, immersing the rope almost up to the seizing. Take care that the solvent does not run down into the rope itself. Wipe the wires dry. Then immerse the wires in a solution of 1/2 commercial muriatic acid and 1/2 water for between 30 seconds and one minute, or until the wires are thoroughly cleaned. The acid must not touch the fiber core or any part of the rope other than the wire ends which will be enclosed by the socket. Neutralize the acid by next dipping the wires into boiling water to which has been added a small amount of soda. Then place the rope into a boiling solution of ammonium chloride or zinc ammonium chloride. The latter technique is strongly recommended as it leaves a coating on the wires which improves the bond. Figure 5-11c illustrates how the broomed-out rope should be held end-down to prevent solvent, acid, or water from running down into the body of the rope. All three baths must be kept free from contaminants and renewed frequently.

Taking care not to touch the cleaned wires, place a temporary tie wire around the wire ends as shown in Figure 5-11d, pulling it tight enough so the wire ends may be slipped through the socket opening.

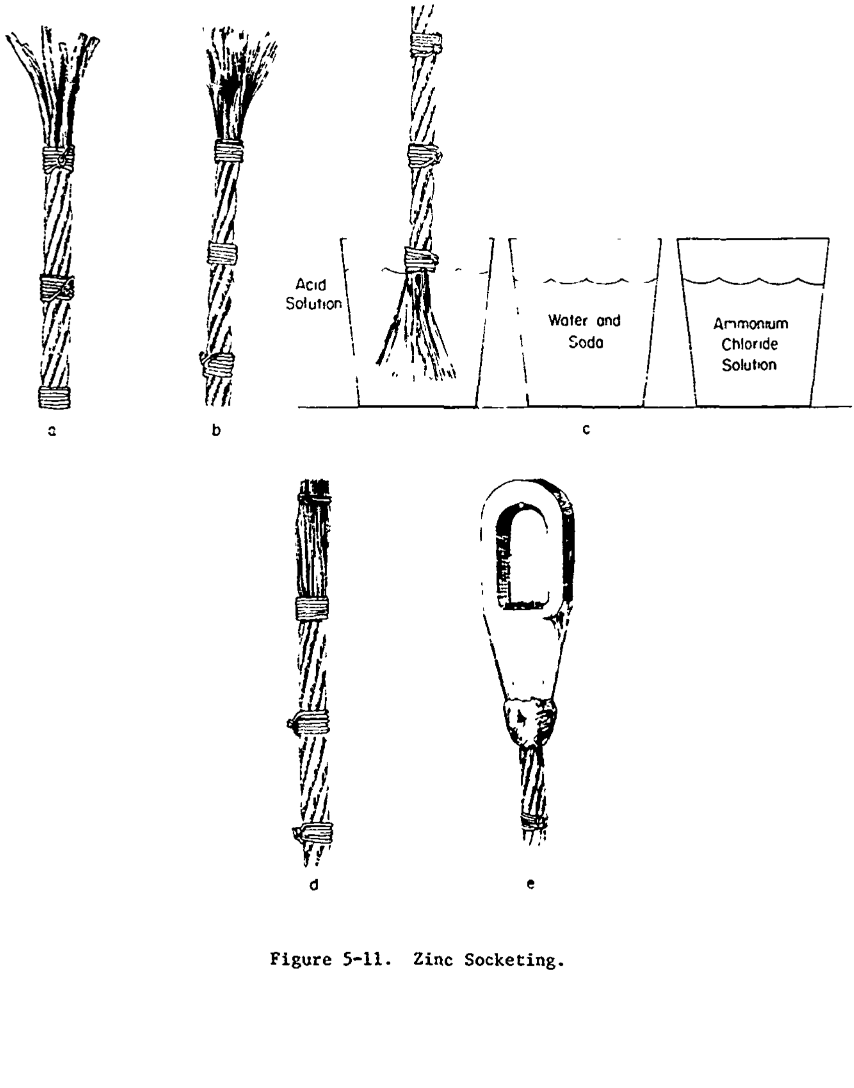


Figure 5-11. Zinc Socketing.

Clean the socket basket. Holding the wire rope in a vise, put the socket over the wire ends, remove the temporary tie wire, and drive the socket down to the first seizing so that the wire ends are even with the top of socket basket, as shown in Figure 5-11e. Then warm the socket. This drives off any moisture in the socket which might inhibit a good bond.

Seal the bottom of the socket basket with putty, clay, or asbestos wicking to keep the zinc from running out. Check that the socket is centered, and in line with the rope, and that the wires are uniformly distributed in the basket. Prepare pure zinc (meeting at least ASTM Specification B-6) by heating to a temperature of between 850 F and 1000 F; use the lower temperatures for smaller ropes and the higher temperatures for larger ropes. Test the cleanliness of the zinc by passing a cleaned and acid-dipped wire through it and rapping the wire against the edge of the ladle; a smooth galvanized surface should remain on the wire. A pyrometer should be used to monitor the zinc temperature. If the zinc is too hot, a brittle zinc-iron material can form in the socket, causing accelerated rope and socket fatigue. If the zinc is not hot enough, the bond will be poor. Check to make sure that the socket is still warm (about 200 F), and then pour the zinc filling to the top of the basket. Tap on the side of the socket to release any trapped air and to allow the zinc to flow into the crevices between the wires.

As soon as the zinc has solidified, the seizing and the sealing putty may be removed and the rope near the socket thoroughly relubricated.

5.5. OTHER POURED SOCKETS

Various types of epoxy resins are being used with increasing frequency for socketing wire rope. In most cases, no heating devices are necessary. In fact, many of the curing reactions between plastic and hardener are exothermic, providing their own heat to accelerate the cure. In addition, the epoxy resin seals and insulates the wires against corrosion. However, epoxy can provide less holding power than metallic socketing material. Extreme cleanliness of the wires is necessary for a reliable bond. Consult directions for specific epoxy types for socketing methods.

5.6. SWAGE SOCKETS

Swage sockets (terminations which are pressure-formed to the rope), are often applied to the wire rope at the factory and delivered as part of an assembly. However, increasing use is being made of Navy-owned presses for field installation of swage sockets. As with poured sockets, swage sockets are available in open and closed configuration.

Proper swaging technique is critical to the development of the full catalog strength of the rope. The correct method is outlined below.

To maintain the integrity of the rope structure, it is recommended that the end to be socketed be cut off with an abrasive wheel. Measure the rope and place a mark or piece of tape on it to assure that the rope goes into the socket at least as far as the end of the swaged portion. Select the correct size socket and install it on the rope, making sure that the rope goes completely into the socket (Figure 5-12). Select the correct dies for the socket. With the smaller sockets, the die will extend the full length of the swage; larger sockets will require two or three swaging operations. For larger sockets, swage the end of the socket nearest the live end of the rope first and work toward the pin end.

Before beginning the swaging process, lubricate the dies thoroughly. Then, position the socket in the lower die and press, closing the dies fully to obtain the best flow of metal around the rope wires. Open the dies, rotate the socket 1/8 turn, and reswage to eliminate any flash (Figure 5-13). Be sure that the flash is not positioned in the bottom of the lower die, and again close the dies fully to obtain the maximum strength of the socket.

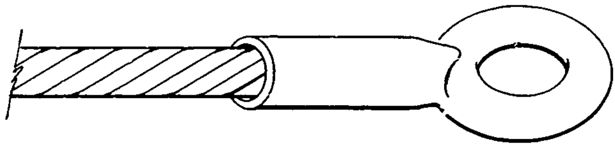


Figure 5-12. Swage Socket Slipped Over Rope

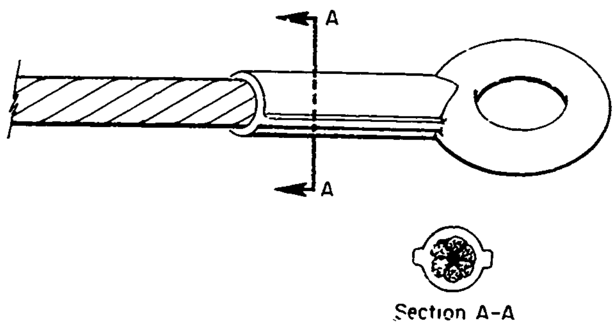


Figure 5-13. Swaging Flash

The swage press should occasionally be checked for proper performance by swaging three or more fittings of each size to be used and loading them to 100 percent of the tensile strength rating of the wire rope to which the fitting is swaged. If any slippage or pull-out occurs below this load, the swage fitting is not being applied at maximum efficiency. Rope pull-out before reaching rope breaking strength indicates a problem in the swaging press, the swage fittings, or the swaging procedure. These factors should be reviewed with the responsible individual.

5.7. OTHER SWAGE FITTINGS

Swage fittings other than sockets include sleeves for mechanically spliced eyes (both Flemish and fold-back eyes, Figures 5-14 and 5-15, respectively) and ferrules (Figure 5-16).

The method of applying these fittings is similar to that described for swage sockets in the preceding section. After the rope has been cut, preferably with an abrasive wheel, select a sleeve(s) or ferrule of the correct size and slip it onto the rope. For a regular fold-back eye, form a loop and pass the free rope end back through the sleeve (or sleeves; more than one sleeve is often used for larger ropes and/or limited press capacity) so that the rope end just protrudes from the sleeve. For a Flemish eye fitting, form the splice as described in Section 5.3.2. Flemish Eye Splice, and drive the sleeve completely over the strand ends. Choose the correct die size and generously lubricate the die cavity and/or the sleeve. Position the sleeve or ferrule in the lower die and press. For the smaller fittings the dies should not be closed completely on the first pressing (1/32 - 1/16 clearance), otherwise too much flash will form. If two sleeves are used, they should be positioned two to three sleeve-lengths apart. Three sleeves should each be placed two lengths apart. Swage the fitting furthest from the eye first. Open the dies, rotate the sleeve or ferrule 1/8 turn, and reswage to eliminate the flash, closing the dies completely this time. It is important to close the dies completely to develop full holding power. On multiple-sleeve applications, swage each sleeve individually. Be sure that the flash is not located in the bottom of the lower die. Sharp flash should not be allowed to form; if it begins to form, stop the press, rotate the sleeve another 1/8 turn and reswage. Some fittings require as many as four pressings to create a smooth finish.

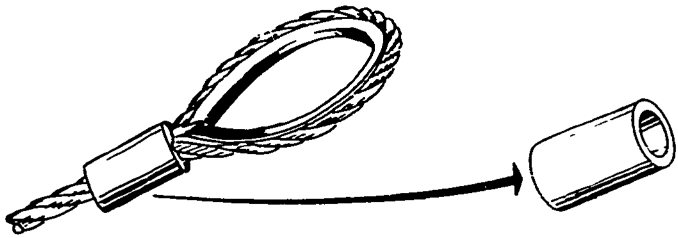


Figure 5-14. Sleeve for Flemish-Eye Mechanical Splice.

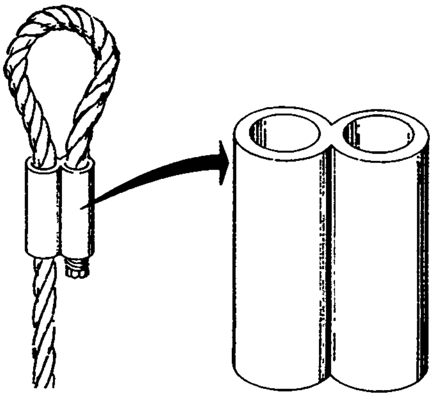


Figure 5-15. Sleeve for Fold-Back-Eye Mechanical Splice

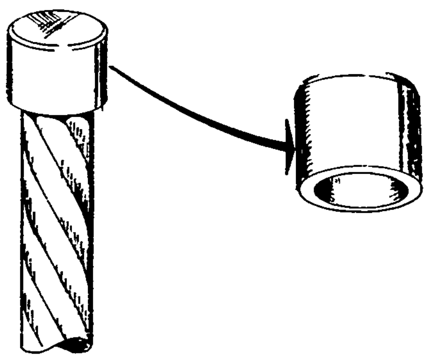


Figure 5-16. Swage Ferrule

5.8. WEDGE SOCKETS

A wedge socket, shown in Figure 5-17, has a tapered body with either an open or a closed end to attach to the machine or load, and a tapered wedge insert. One method of installation is detailed as follows:

Place the socket upright and form a large loop in the rope after passing it through the socket. Lead the live end of the rope out of the socket on the straight side; the dead end will extend from the offset side at least one rope lay. Then place the wedge within the loop. With the socket firmly secured, carefully load the live end of the rope until the wedge is seated firmly enough to prevent its moving during handling. The final wedge position is reached during initial operation under full load. When the rope is first used after installation of a wedge socket, increase the load gradually, avoiding any sudden shock loads.

Certain precautions should be taken when using wedge sockets. The dead end of the rope should be seized rather than welded, to allow the strands and wires to adjust themselves as the rope is bent around the wedge. Check that the wedge itself is free from corrugations from previous use; use a new or reconditioned wedge if there is any doubt about the wedge condition. Rope vibration creates fatigue in the wires at the socket nose, and trapped moisture in this area can cause accelerated corrosion. For these reasons, cut off and resocket the rope end at regular intervals.

One or more clips may be placed on the dead end of the rope to prevent rope pull-out if the wedge loosens. The clip should not be placed on the live end of the rope. The wedge can be released by striking it on its small end, or by driving it out with a small hydraulic ram.

5.9. CARPENTER STOPPERS

A carpenter stopper, shown in Figure 5-18, can be used to secure a rope under load along any straight portion of its length. Its use is described in detail in the Operation and Maintenance Instructions for carpenter stoppers (NAVSHIPS 0994-004-8010). It can be clamped to a rope already under load from a winch. By easing the load off the winch, the rope load can gradually be transferred to the stopper. The winch can then be released from the rope and be used in another application.

Before using the stopper, thoroughly clean the tapered sliding surfaces of both wedge and body. These surfaces must be kept clean and free from grit, metal particles, or other foreign substances. Otherwise, the wedge may not advance with the rope as the load increases, allowing the rope to slip through the stopper. After cleaning all sliding surfaces on the wedge, bearing strip, cover, and body, the carpenter stopper must be heavily coated with a good quality grease.

A carpenter stopper can be installed as follows:

With the stopper fully opened and the wedge extending about two-thirds of the way out, lay the rope in the stopper and bring together the two body halves until the cover can be closed. Hold the cover down by the U-shaped lock, which is swung up over the cover extension and secured with the taper

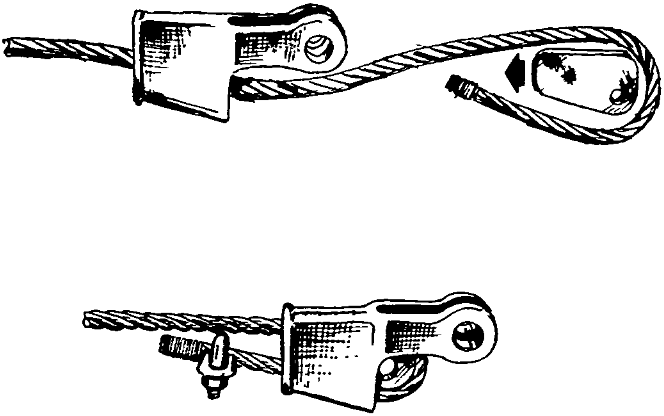


Figure 5-17. Wedge Socket Installation

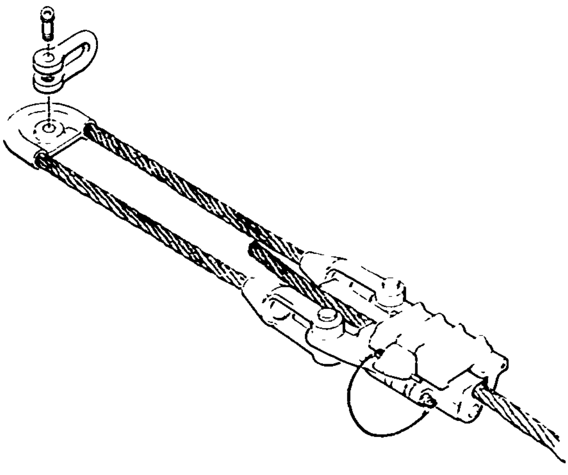


Figure 5-18. Carpenter Stopper

pin. Hammer the wedge tight against the rope to insure that it is drawn into the stopper. As the load is applied, the rope may slide until its contour matches that of the wedge, and both are drawn into the stopper and become securely gripped.

Open the stopper by driving out the taper pin after the load has been released or transferred to a winch. Care should be taken when opening a carpenter stopper. In some cases the stopper should be secured with a nylon rope before openi (see previously cited Navy document NAVSHIPS 0994-004-8010). Warn personnel to keep clear of the stoppers, especially the larger sizes, because they can open with considerable speed and violence when unlocked. When removing the lock, the operator should be at the end of the stopper opposite the pulling eyes. Smaller sized stoppers can be opened by striking the lock off with a sharp blow from a hammer (swinging across the top of the stopper). On larger stoppers, a different style of lock is used, and a heavy downward blow is required. The striking surface at the top of the lock deflects the hammer head outside of the path of the rapidly swinging cover if the blow is inaccurate. This feature provides added safety in opening larger stoppers.

The hinge joints of moving parts should be greased occasionally. Stoppers may be painted to prevent rusting, but be careful to keep the paint clear of the contact surfaces, especially the tapered surfaces of the wedge and body. Cover all contact surfaces with grease after each use to reduce friction and to prevent excessive wear. Generally speaking (with the exception of bridles), carpenter stopper parts are hand fitted and, therefore, should not be interchanged.

Do not grip a rope larger than the size the stopper was designed for. Serious crushing of the rope strands will result and early rope failure will almost certainly occur. A more thorough discussion of the carpenter stopper can be found in the U. S. Navy Ship Salvage Manual, NAVSHIPS 0994-000-3010.

5.10. CLAMPS

Wire rope clamps, as shown in Figure 5-19, may be used to form a temporary loop in a rope when the load is low. This type of fitting slips easily, however, and should be used with caution. The method of installation is straightforward: make a loop in the rope and trap both the dead and the live

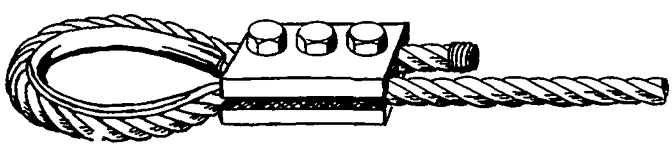


Figure 5-19. Clamp Installation

ends between the clamp plates. Leave at least one lay length protruding from the clamp at the dead end. Tighten the bolts to the recommended torque, starting with the center bolt. Do not over-tighten the bolts as this will distort the rope construction and cause premature failure. If more than one clamp is used, place them as close together as possible; generally, the larger the rope diameter, the greater number of clamps. If the clamps are corrugated, be sure that they are for the correct lay (right or left) and that the strands match the corrugations.

5.11. TWISTED CABLE GRIPS*

Figure 5-20 shows a twisted cable grip before application to a rope.

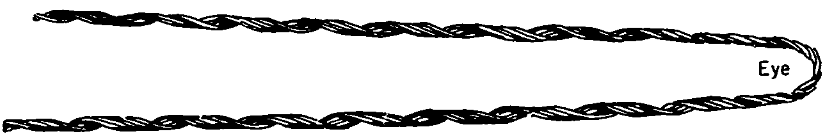


Figure 5-20. Twisted Cable Grips

The following discussion is applicable for ropes up to 5/8-inch in diameter. For larger ropes, refer to manufacturer's literature.

The first step in installing such a grip is to put the rope end into one leg about one to two inches past the crossover mark on that leg. Wrap about two lay lengths of the leg onto the rope. If a closed-end fitting is to be attached, slip it over the other grip leg at this time. Now install the correct-sized thimble and secure the eye so that the grip cannot rotate. To keep the rope reasonably straight, it can be tensioned slightly.

Taking care to match the two crossover marks, wrap about two lengths of the second leg onto the rope. This is most easily done by pulling the leg around in one continuous motion. Then use a marlin spike or screwdrive to split each leg into two sections, usually having three twisted rods per section. Split them all the way back to the part already wrapped onto the rope. Then wrap each of the four sections alternately, one lay length at a time, until they are fully wraped onto the wire rope, and snap the section ends into place. Do not allow any of the rods to get caught under each other. Finally, seize or tape the end of the finished grip to avoid catching the rods on equipment or personnel. A completed cable grip installation is shown in Figure 5-21.

* Patented by Preformed Line Products Company, Cleveland, Ohio; U. S. Patents 2,691,865 and 2,761,273.

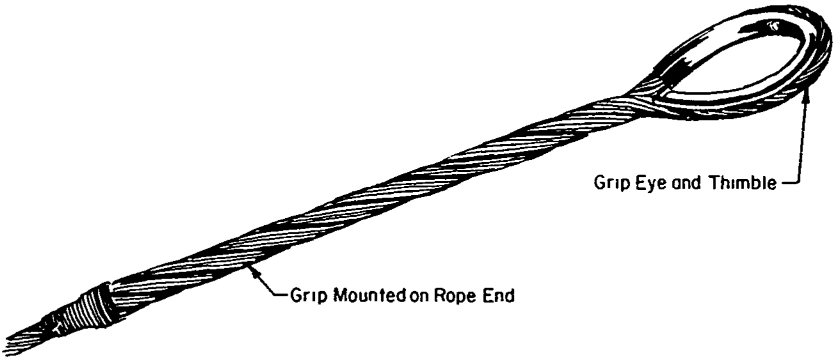


Figure 5-21. Installed Cable Grips

5.12. FIEGE FITTINGS

Fiege fittings consist of three parts: a plug which expands the rope diameter like a wedge; a sleeve which fits over the plugged rope; and a socket which fits over the rope and screws onto the sleeve. When the rope and fitting are loaded, the socket and attached sleeve are pulled in the direction of the end of the rope; however, the wedge-shaped plug prevents the fitting from pulling off (Figure 5-22).

Different plug types, shown in Figure 5-23, are available for different rope sizes and constructions.

Refer to Figure 5-24 for dimensions used in the installation procedures below. To apply fittings, first seize and cut at the attachment location. Measure a distance from the cut and apply a second seizing. Place the rope or strand vertically in a vise and drive the sleeve (threaded end last) down far enough to prevent the rope from fanning out. Remove end seizing.

The next step is different for each rope core construction:

-- For wire strand, drive the sleeve down so that the threaded end is a distance B from the end of the rope. Then fan out the outer wires and insert a hollow plug, narrow end first, over the center wire. Drive the plug to a solid seat, using a hollow punch.

-- For fiber-core rope, pry out the core with a screwdriver blade (or similar device) and remove a length E. Then push the stub back into the rope center. Now push the sleeve down only far enough to enable inserting the plug between the strands, narrow end first, making sure that the individual wires do not fan out.

* Manufactured by Superior Switchboard and Devices, Canton, Ohio.

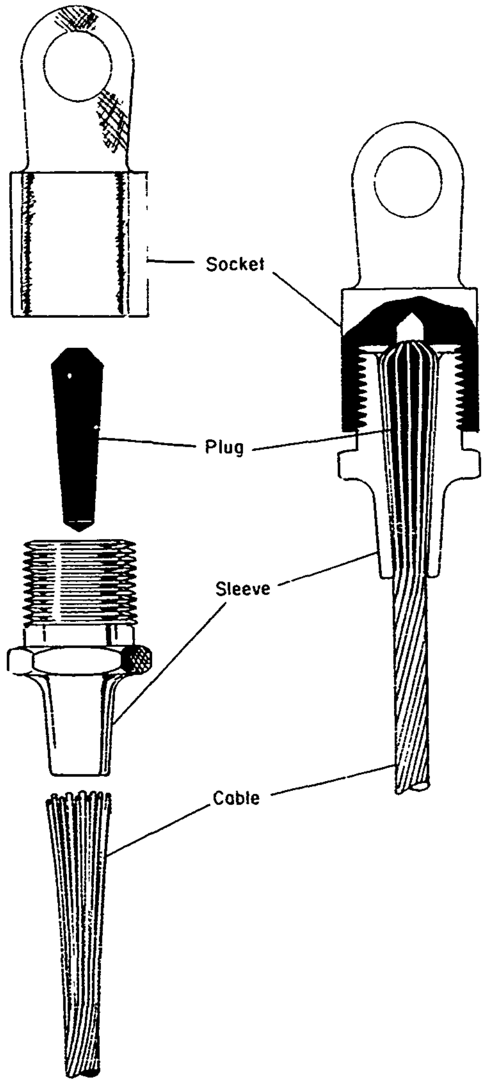
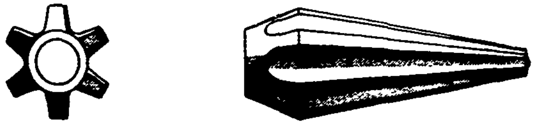
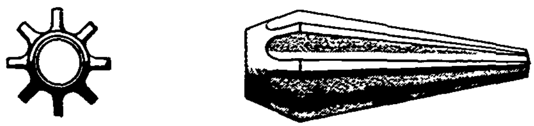


Figure 5-22. Fiege Fitting

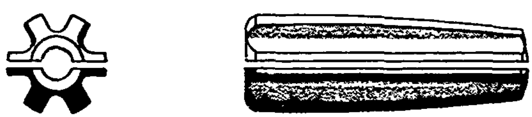


Hemp Center Plug. Six Groove



Hemp Center Plug. Eight Groove

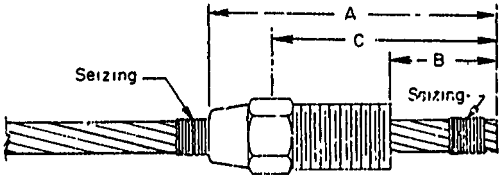
Wire Center Plug (Solid)



Wire Center Plug (Two Pieces)

Strand Plug (Hollow)

Figure 5-23. Different Plug Types (For Fiege Fittings)



Nominal Rope Diametral, Inches	Fiber Core						Strand and Wire Center	
	6-Strand			8-Strand				
	A	B	C	A	B	C	A	B
3/16	1 15/16	3/4	1 9/16	--	--	--	1 15/16	3/4
1/4	2 3/8	15/16	1 7/8	2 1/2	1 1/16	1 7/8	2 1/4	13/16
5/16	2 15/16	1 3/16	2 3/8	3 1/16	1 5/16	2 3/8	2 3/4	1
3/8	3 5/16	1 5/16	2 5/8	3 1/2	1 1/2	2 5/8	3 1/8	1 1/8
7/16	3 7/8	1 9/16	3 1/8	4 1/16	1 3/4	3 1/8	3 5/8	1 5/16
1/2	4 3/8	1 3/4	3 1/2	4 5/8	2	3 1/2	4 1/8	1 1/2
9/16	5 1/16	1 15/16	3 7/8	5 3/8	2 1/4	3 7/8	4 3/4	1 5/8
5/8	5 1/16	1 15/16	3 7/8	5 3/8	2 1/4	3 7/8	4 3/4	1 5/8
3/4	5 7/8	2 1/4	4 1/2	6 1/4	2 5/8	4 1/2	5 1/2	1 7/8
7/8	6 15/16	2 11/16	5 3/8	7 3/8	3 1/8	5 3/8	6 1/2	2 1/4
1	8 3/8	3 1/4	6 1/2	8 7/8	3 3/4	6 1/2	7 7/8	2 3/4
1 1/8	10	3 3/4	7 1/2	10 5/8	4 3/8	8 3/4	9 3/8	3 1/4
1 1/4	11 7/8	4 3/8	8 3/4	12 5/8	5 1/8	10 1/4	11 1/8	3 5/8
1 3/8	14 1/4	5 1/4	10 1/2	15 3/16	6 3/16	12 3/8	13 5/16	4 5/16
1 1/2	16 1/8	6 1/8	12 1/4	17 1/8	7 1/8	14 1/4	15 1/8	5 1/8
1 5/8	18 3/16	7 1/16	14 1/8	19 1/4	8 1/8	16 1/4	17 1/8	6

Figure 5-24. Cable Extension Dimensions for Installing Fiege Fittings

By alternately tapping the sleeve and plug, drive them both to distance B from the end of the rope.

-- For all wire-center ropes, 3/16" through 9/16", drive the sleeve down so that the threaded end is a distance B from the end of the rope. Fan out the individual wires uniformly. Then insert a solid plug, narrow end first, as near as possible to the center of the fanned wires. Drive the plug to a solid seat.

-- For all wire-center rope, 9/16" and over, drive the sleeve down so that the threaded end is a distance B from the end of the rope. Unlay the strands, but leave the individual wires intact. Insert a two-piece grooved plug around the strand or wire-rope core; lay each strand into an appropriate plug groove and--using a hollow punch--drive the plug to a solid seat, keeping each strand in its proper groove.

Now compress the extended wires or strands to permit the socket to slip over them. Grip the sleeve in a vise; slip on the socket threaded end first; and screw the socket to the sleeve, tightening securely. Remove the seizing, and finally check to see that the wires are visible in the inspection hole.

6. GLOSSARY

A

ABRASION -- Surface loss of metal on the wires of a wire rope.

ACCELERATION -- The time rate of change in the velocity of a moving body. "Acceleration" is usually applied to a positive change; "deceleration is applied to a negative change.

ACCELERATION STRESS -- Additional stress imposed on a wire rope due to increasing velocity of load.

ACTUAL BREAKING STRENGTH (OR LOAD) -- See BREAKING STRENGTH.

AERIAL CONVEYER -- See CABLEWAYS and TRAMWAYS.

AGGREGATE BREAKING STRENGTH (OR LOAD) -- See BREAKING STRENGTH.

ALBERT'S LAY -- See LANG-LAY.

ALTERNATE LAY -- Lay of rope in which the wires of alternate strands are laid in right- and left-hand helices.

ALTERNATE LAY (SPECIAL) -- Lay of rope that has two Lang-lay strands alternating with one regular-lay strand. Also called HERRINGBONE.

ALUMINIZING (OF WIRE) -- Coating of wire with aluminum to increase its corrosion resistance.

AREA (METALLIC) -- Cross-sectional area of all the wires in a wire strand or rope; the aggregate area of all load-carrying wires.

ARMORED ROPE -- See STEEL CLAD ROPE.

B

BACKSTAY -- Guy or guys used to support a boom or mast; section of a suspension-bridge cable leading from towers to anchorage.

BAIL (SOCKET) -- The U-shaped member of a closed socket.

BAIL SHEAVE -- Equalizing sheave on an excavator bucket.

BARREL AND DRUM HOOKS -- Wide, flat hooks used in hoisting barrels and drums.

BASKET (SOCKET) -- The conical bore of a socket into which the "broomed-out" end of the rope is inserted and secured with zinc or some other binding material.

BECKET -- A contrivance, such as a looped rope, large hook-and-eye, or grommet, used for fastening loose ropes.

BECKET LINE -- That part of the rope in a multiply reeved system that is dead-ended to one of the blocks.

BECKET LOOP -- (1) The fastening on a sheave block to which the dead end of a fall or rope is made fast; (2) a loop of small strand or rope fastened to the end of a rope to facilitate pulling in and anchoring the rope.

BENDING STRESSES -- The stresses imposed on the wires of a rope during bending over drums or sheaves.

BIGHT -- A curve or loop in a rope.

BIRDCAGE -- Enlargement of a rope due to the springing of the strands away from the core upon sudden release of load. Can also result from dragging a rope over a small diameter sheave under load.

BITT -- A deck fitting around which a rope is temporarily secured.

BLACK ROPE WIRE -- Uncoated (as drawn) wire. Commonly known as BRIGHT WIRE.

BLOCK -- The complete housing, attachments, and sheave or sheaves used with rope in a tackle.

BOOM -- A rigid structure extending from the center of a crane, shovel, or dragline.

BOOM LINES -- The wire ropes supporting the boom or jib on cranes, shovels, and draglines.

BOOM POINT SHEAVE -- The sheave on the end of the boom.

BREAKING STRENGTH (OR LOAD) -- (1) Ultimate or Actual: The load required to pull a wire, strand, or rope to destruction. (2) Aggregate: The sum of the individual breaking loads of all the wires in a strand or rope. (3) Catalog: The minimum breaking load of a rope or strand guaranteed by the manufacturer.

BREAKING STRESS -- The load per unit area induced in a rope at its point of failure.

BRIDGE CABLE -- Galvanized steel wire rope or strand usually used as a main suspension member in a suspension bridge.

BRIDGE -- See SADDLE.

BRIDGE SOCKET -- A steel casting with a basket for securing a rope end and equipped with an adjustable bolt. The closed type has a U-bolt, while the open type has two eyebolts and a pin.

BRIDLE CABLE -- A two-part wire-rope sling attached to a single-part line. The legs of the sling are spread to divide and equalize the load.

BRIGHT WIRE -- Wire made of iron or carbon-steel and not galvanized, aluminized, or otherwise coated.

BRONZE ROPE -- Rope made of phosphor-bronze wire.

BROOMING -- The unlaying and straightening of strands and wires in the end of a wire rope, usually in preparation for socketing.

BROW SHEAVE -- See KNUCKLE SHEAVE.

C

CABLE -- A rope-like assembly of electrical conductors insulated from each other but laid up together, usually by being twisted or stranded around a central core. The assembly is usually heavily insulated with outside wrappings and may contain nonconducting metal wires as strength members.

CABLE-BAND SEIZING -- A band of soft steel attached to a rope to serve as a seizing.

CABLE-GRIP -- A termination which is wrapped about the end of a wire rope using interlocking helical strands; designed so that tensile loads are resisted by induced radial pressures.

CABLE-LAID WIRE ROPE -- A compound-laid rope consisting of several ropes or several layers of strands laid together into one rope, such as 6 x 6 x 7, 6 x 42 (tiller rope), and 6 x 3 x 19 spring-lay mooring line.

CABLEWAY -- A conveyer system in which cars, buckets, or other carrier units are suspended from and run on wire cables strung between elevated supports.

CAPEL -- Term most often applied to a wedge and ringed-strand type rope end connection.

CAPSTAN -- A device for applying tension to a rope by friction between it and the rope.

CARGO HOOK -- Long, narrow hook with a short, inward-directed point and a metal protrusion on the eye or clevis.

CARPENTER STOPPER -- A wedge-type fitting which can be used to grip a rope anywhere along its length.

CENTERLESS STRAND -- A wire strand having no core.

CENTER WIRE -- A round or shaped wire used as the axial member of a strand.

CHAFING GEAR -- Any device or material which prevents a rope from chafing, rubbing, or scrubbing.

CHAIN HOOK (ALSO CALLED "S" HOOK) -- S-shaped steel rod used as a hook.

CHOKER -- A single-leg or endless sling formed into a slipping loop around a load to be moved or lifted. Sometimes called a reeved eye -- one eye being passed through another to form the slipping loop.

CHOKER HOOK -- One of a variety of hooks which are threaded onto a wire rope and allowed to move along its length.

CIRCUMFERENCE (OF A WIRE ROPE) -- Perimeter of the smallest cricle completely circumscribing the wires of a wire rope.

CLAMP (STRAND OR ROPE) -- A fitting for forming a loop at the end of a length of strand or rope, consisting of two grooved steel or heavy cast-iron plates and bolts.

CLAMSHELL BUCKET -- An openable container with two hinged jaws vertically suspended from chains, or more generally ropes, for lifting and transporting loose materials in bulk.

CLEVIS -- A U-shaped assembly with holes in the ends through which a pin is run for attaching ropes and equipment together.

CLIP (STRAND OR ROPE) -- A strand or rope fitting comprised of a malleable iron or forged steel saddle piece (grooved to suit rope lay) and a U-bolt by which the clip is held to two parallel ropes. Primarily used to anchor the dead end of a rope to the live side to form a loop.

CLOSE WINDING (ON A DRUM) -- Process of crowding more than the designed number of turns on a drum layer.

CLOSED SOCKET -- A socket in which the basket and the curved bail are connected.

CLOSING LINE -- The rope on a grab or bucket which closes the jaws of the bucket and serves as a hoisting rope to lift it and its contents.

CLOSER OR CLOSING MACHINE -- A machine in which wire strands are laid over a core to form a completed rope.

COARSE-LAID ROPE -- Term applied to ropes of the 6 x 7 classification, because of their large outer wires.

COIL -- Circular bundle of wire, strand, or rope with wire or strip ties--not fitted on a reel.

COMMON STRAND -- Strand made of galvanized iron wire.

CONSTRUCTION -- Term used to describe the design of a rope, covering the number of strands, number and arrangement of the wires in the strands, direction and type of lay, grade of wire material, and type of core.

CONSTRUCTIONAL STRETCH -- The permanent stretch which occurs in a new rope during initial loading. It results from the permanent deformations of the wires, strands, and core during loading.

CONVEYER ROPE -- Parallel spliced endless rope used to handle ores and materials.

CORDAGE -- Ropes made of vegetable fibers such as jute, hemp, or manilla, or synthetic fibers such as nylon, dacron, or polypropylene.

CORE -- The axial member of a wire rope about which the strands are laid. It may consist of wire strand, wire rope, synthetic or natural fiber, or solid plastic.

CORROSION -- The electrochemical decomposition (rusting or erosion) of the wires of a rope (or of any other metallic object) due to exposure to moisture, acids, alkalies, or other destructive agents.

CORRUGATED (SHEAVES AND DRUMS) -- Term describing the rope-wear marks visible on some extensively used sheaves or drums.

COTTON CENTER -- See FIBER CENTER.

COTTON CORE -- See FIBER CORE.

COUNTERWEIGHT ROPE -- Rope operating counterweights on a vertical hoist.

COVER WIRES -- Outer layer of wires in a wire strand.

CREEP (ON DRUM) -- The small continuing back movement of a hoisting rope on a drum as the rope load is released or reduced.

CROSS-LAY (ROPE OR STRAND) -- A multiple-layer rope or strand in which the lay of at least one of the layers is opposite that of another layer.

CROSSOVER -- For rope wound on a drum, the points at which the upper wraps cross over the crowns of the lower wraps.

CROSS-OVER WEAR -- The type of rope wear which is encountered at the cross-over points for multilayers of rope on a drum.

CROWD ROPE -- A wire rope used to pull the bucket of a power shovel into the material being handled.

CROWN WIRE -- A wire in a wire rope at the point where it would contact a circle circumscribed about the rope cross section.

CROWN WIRE BREAKS -- Wire breaks which occur on the crown wires.

CRUSHING -- Distortion of a wire rope due to pressure perpendicular to the rope axis.

CUTTING -- Severing of rope or strand by shearing.

CUTTING BACK -- Cutting off lengths of rope at terminations periodically in order to redistribute areas of severe wear.

D

DEAD END (OR PART OF A ROPE) -- Portion of an operating rope which carries no load. Often refers to the nonactive part of a rope protruding from a loop termination.

DEAD LOAD -- Constant load on a wire rope, not subject to change due to active forces. See LIVE LOAD.

DEAD WRAPS (ON A DRUM) -- Wraps on a drum which are never paid out during rope operation.

DEFLECTION SHEAVE -- A sheave that changes the direction of a rope. It usually has a wrap angle of less than 90°.

DEPTH (OF A SHEAVE OR DRUM) -- The vertical distance from the sheave groove throat or drum throat to the rim of the flange.

DERRICK -- General term for a fixed crane having a movable boom or jib as on structural erection cranes.

DESIGN FACTOR -- The ratio of unused rope breaking strength to rope load during operation. Standards are often set by statutory bodies for minimum design factors. Also known as FACTOR OF SAFETY.

DIAMETER (OF A ROPE) -- The diameter of the circle which circumscribes the rope cross section.

DOGLEG -- Permanent short bend or kink in a wire rope, caused by rope abuse.

DOUBLE SEALE STRAND -- A single-operation strand consisting of three wire layers in which the outer layer is made of uniformly sized wires, the middle layer of the same number of uniform size but smaller wires, and the inner layer of the same number of uniform size but still smaller wires.

DRUM -- A cylindrical, flanged barrel of cast iron or steel on which rope is wound for storage or operation. It may be smooth or grooved.

DRUM HOOK -- See BARREL AND DRUM HOOKS.

DUCTILITY -- The property of metals that enables them to be mechanically deformed.

E

EFFICIENCY -- (1) Wire Rope: Percentage ratio of the actual breaking strength of a wire rope to its aggregate breaking strength; dependent on rope construction and lay length. (2) Fittings: Percentage ratio of the actual breaking strength of the rope-fitting combination to the actual breaking strength of the rope with which the fitting is being used. Usually means the percentage of the rope's actual breaking load needed to pull the rope out of the fitting or fail the rope at the fitting.

ELASTIC LIMIT -- The tensile stress above which a permanent deformation takes place within a material.

END FITTING -- A device which is attached to the end of a rope, enabling the attachment of the rope to other equipment. Also called TERMINATION.

ENDLESS ROPE -- A rope whose ends are spliced together.

ENDLESS SPLICE -- A splice which connects the ends of a rope to form a loop.

EPOXY SOCKET -- A poured socket in which epoxy is used as the binding material.

EQUAL-LAY STRAND CONSTRUCTION -- A strand construction in which all the wires have an equal lay length and, hence, the contacts between the wires in the strand are linear.

EXTRA-IMPROVED PLOW STEEL -- See GRADES: WIRE ROPE.

EYE SPLICE -- A loop formed in the end of a rope by tucking the strand ends under or around the strands of the live part of the rope. A thimble is often used in the loop.

F

FACTOR OF SAFETY -- See DESIGN FACTOR.

FAIRLEADING -- The assembly of sheaves and rollers in a wire-rope system.

FALL ROPE -- The hoisting rope or ropes used in a single-part or multiply reeved rope tackle system.

FATIGUE (OF WIRE ROPE) -- The process of progressive localized wire damage caused by fluctuating stresses and which culminates in multiple wire failures (or fractures) and subsequent rope failure.

FERRULE -- A plug-like rope termination.

FIBER CENTER -- A sisal, cotton, manila, jute, or synthetic fiber rope used as the central member of a strand.

FIBER CORE -- A sisal, cotton, manila, jute, or synthetic fiber rope used as the axial center of a wire rope.

FID -- A large, tapered pin used to open the strands of a rope when splicing.

FIEGE FITTING -- A wedge-type fitting consisting of a plug which is used to expand the rope diameter, a sleeve which fits over the plugged rope from the live side, and a socket which screws onto the sleeve from the dead side. When rope and fitting are loaded, the fitting is held in place by the wedging action of the plugged rope against the sleeve.

FILLEP STRIP -- A long, wedge-shaped metal strip which helps to position the wraps of rope on a drum by filling in the space between the last turn of the first layer and the flange.

FILLER-WIRE STRAND -- A multiple-layer strand in which the outermost layer of wires has twice the number of uniformly sized wires as the layer beneath it, with small FILLER WIRES occupying the interstices between the wire layers.

FILLER WIRES -- Small auxiliary wires in a strand for spacing and positioning of other wires.

FIST-GRIP CLIPS -- See INTEGRAL SADDLE-AND-BOLT CLIPS.

FLAG -- Marker to designate the position or length of a rope.

FLANGE -- A rim on a sheave or drum for containing and/or supporting the rope.

FLAT DRUM -- A drum with an ungrooved face.

FLAT ROPE -- A wire rope made by sewing together a number of alternate right- and left-lay ropes. The sewing material is usually soft annealed iron wire.

FLATTENED-STRAND ROPE -- Rope made with oval or triangularly shaped strands.

FLEET ANGLE -- Angle between the position of the rope on a drum, and a line drawn perpendicular to the axis of the drum through the center of the nearest fixed sheave.

FLEMISH EYE -- A type of eye splice made by separating the rope end into two groups of strands and then rewrapping the strands to form a loop.

FLEXIBILITY -- The ease with which a rope may be bent.

G

GALVANIZED ROPES, STRANDS, AND WIRES -- Ropes, strands, and wires in which the individual wires are coated with zinc.

GRADES: ROPE -- Classification of wire rope according to wire breaking strength per unit area. In order of increasing strength the various rope grades are "iron", "traction", "mild plow steel", "plow steel", "improved plow steel", and "extra-improved plow steel".

GROMMET -- An endless 7-strand wire rope.

GROOVE -- Depression in the periphery of a sheave or drum for positioning and supporting a rope.

GROOVE GAUGE -- A flat, teardrop-shaped metal device for checking sheave or drum grooves for proper size and shape.

GROOVED DRUM -- Drum with grooved surface to accommodate and guide a rope.

GUYS OR GUY LINES -- Strands or ropes, generally galvanized, used to steady and support structures in position. They normally are adjustable in length to allow for stretch.

H

H-BITT -- An H-shaped steel or iron deck fitting around which rope is temporarily secured.

HAND-TUCKED EYE SPLICE -- See EYE SPLICE.

HAWSER -- Wire rope, usually galvanized, used for towing or mooring vessels.

HEAVY LUBRICANT -- Viscous, grease-type lubricant.

HEMP -- A plant fiber used in making ropes and fiber cores.

HERRINGBONE LAY -- See ALTERNATE LAY (SPECIAL).

HIGH STRAND -- An unevenly loaded strand abnormally raised above the rope surface.

HOCKLE -- A loop in a slack wire rope formed by applied torque or twist. Application of tension to a hockled rope will result in permanent deformation (kinking) and may even cause rope failure.

HOLDING LINE -- Wire rope on a clamshell or orange-peel bucket that holds the bucket while the closing line is released to dump the load.

I

IDLER (SHEAVE) -- A sheave or roller used to support or guide a rope.

IMPROVED PLOW STEEL -- See GRADES: WIRE ROPE.

INDEPENDENT WIRE-ROPE CORE (IWRC) -- A wire rope used as the core of a larger wire rope.

INTEGRAL SADDLE-AND-BOLT CLIP -- A clip consisting of two L-shaped bolts fastened together with nuts. Also called FIST-GRIP CLIPS and SAFETY CLIPS.

INTERNALLY LUBRICATED -- Wire rope or strand having all the wires and core coated with lubricant.

IRON ROPE -- See GRADES: WIRE ROPE.

IWRC -- See INDEPENDENT WIRE-ROPE CORE.

K

KINK -- Sharp permanent bend in a wire rope.

KNUCKLE SHEAVE (OR BROW SHEAVE) -- A sheave used at the summit of an inclined haulageway to change the rope direction from the surface down the incline.

L

LAGGING -- (1) External wooden covering on a reel of rope or strand to protect it in handling or in storage. (2) Components attached to the barrel of a drum to increase its diameter.

LANG-LAY ROPE -- Rope in which the direction of lay of the wires in the strands is the same as the direction of lay of the strands in the rope. Sometimes called ALBERT'S LAY.

LAYER -- A group of strands in a rope or a group of wires in a strand spun concentrically around the core in one operation. A center wire is not a layer, but a twisted strand center is a layer.

LAY ANGLE -- The arc tangent of the ratio of the rope circumference to the lay length.

LAY DIRECTION -- The direction of strand or wire helix, i.e., right or left.

LAY LENGTH (PITCH) -- The distance parallel to the axis of a rope (or strand) in which a strand (or wire) makes one complete helical revolution about the core (or center).

LEAD LINE -- That part of the rope tackle leading from the first or last sheave to the winch drum.

LEFT-LAY -- The direction of strand or wire helix corresponding to that of a left-hand screw thread.

LEVEL WIND -- A mechanism to assure even and uniform winding of a rope on a drum.

LIGHT LUBRICANT -- Low-viscosity, oil-type lubricant.

LINE -- A term frequently applied to a wire rope especially if it moves or is used to transmit a force.

LIVE LOAD -- An operating, moving, or changing load on a rope, as opposed to a dead or constant load. See DEAD LOAD.

LIVE (PORTION OF A ROPE) -- The portion of an operating rope which carries the load. Usually applied to a rope that is not cut at the termination, but passes through it, leaving an unloaded (dead) rope section.

LOAD CELL -- An instrument for measuring force or torque.

LOCKED-COIL ROPE -- A single-strand rope with a smooth surface, formed with interlocking shaped wires (FULL-LOCKED-COIL ROPE), or alternate round and shaped wires (HALF-LOCKED-COIL ROPE).

LONG SPLICE -- A splice which joins two ropes end-to-end and which involves about twice the rope length of a short splice.

LOOP SPLICE -- An eye splice without a thimble.

M

MANILA -- A hemp-like rope fiber made from the leaf stalks of the abaca plant.

MARLIN(E)-CLAD ROPE -- Marine trawling rope in which each steel strand is coated with fiber, usually manila yarns.

MARLIN SPIKE -- A pointed metal spike, used to separate strands of rope in splicing.

MECHANICAL SPLICE -- A splice made by swaging a sleeve to a loop or eye splice.

MILD PLOW STEEL -- See GRADES: WIRE ROPE.

MINIMUM BREAKING LOAD -- The minimum load which a new rope is designed to withstand without fracture when pulled to failure in tension.

MOLLY HOGAN -- See FLEMISH EYE.

MONEL -- A nickel-copper alloy sometimes used in special usage cables and wire ropes.

MOORING LINE -- Galvanized wire rope, usually 6 x 12, 6 x 24, or spring-lay construction, for holding ships to a dock.

MULTIPLE-LAYER STRAND -- A strand with two or more wire layers.

MULTIPLE-OPERATION STRAND -- A strand in which at least one wire layer has a different lay length or direction from the other layer(s), and is made in a separate stranding operation.

MULTIPLE-PART REEVING -- Reeving a rope over a block or blocks consisting of several sets of sheaves in parallel.

N

NASH TUCK -- Tucking process used in splicing an eight-strand rope.

NICKING (ALSO CALLED NOTCHING) -- Permanent surface deformation of wires at points of wire-to-wire contact.

NONROTATING WIRE ROPE -- A 19 x 7 (or 18 x 7) wire rope consisting of a 7 x 7 (or 6 x 7 fiber core) left Lang-lay inner rope covered by twelve 7-wire strands right regular lay.

NONSPINNING WIRE ROPE -- See NONROTATING WIRE ROPE.

NOSE (OF A SOCKET) -- The part of the socket from which the live rope protrudes.

NOTCHING -- See NICKING.

O

ONE-OPERATION STRAND (ALSO CALLED SINGLE-OPERATION STRAND) -- A strand in which all the wires are laid in one operation with the same direction and length of lay. A single-layer strand is always a one-operation strand.

OPEN SOCKET -- Wire-rope fitting with two integral lugs through which a pin connection is made to the load or anchorage.

OPEN WINDING (ON A DRUM) -- Process of winding too few turns on a drum in a single layer so that excessive gaps form between wraps.

ORANGE-PEEL BUCKET -- An openable container used in hoisting that consists of more than two segments or jaws.

ORDINARY-LAY ROPE -- See REGULAR-LAY ROPE.

OUTER WIRES -- See COVER WIRES.

OVERWOUND ROPE -- See UNDERWOUND ROPE.

P

PEENING -- Permanent surface deformation of outer wire(s) in a rope.

PELICAN HOOK -- An openable hook in which the point is hinged to the hook body and held close to the body when closed with a lock or loop.

PHOSPHOR BRONZE -- A metal alloy containing copper, tin, and some phosphorous, known primarily for its corrosion resistance and nonmagnetic properties.

PITCH -- (1) Length of Lay: The distance parallel to the axis of the rope (or strand) in which a strand (or wire) makes one complete helical revolution about the core (or center). (2) The spacing of grooves on a drum.

PITCH DIAMETER -- The diameter of a sheave or drum as measured across the sheave from centerline to centerline of an appropriately sized rope placed in the sheave groove.

PLAIN OR SINGLE DIRECTION BENDING -- The operation of a rope over drums and sheaves so that it bends in one direction only. Opposite of reverse bending.

PLASTIC CORE -- A round plastic member used as a wire-rope core.

PLOW STEEL -- See GRADES: WIRE ROPE.

PLUG -- A conical steel device which provides the wedging action in a fiege fitting.

POINT SHEAVE -- Boom-head sheave.

POLYPROPYLENE FIBER CORE -- A plastic rope core made of many polypropylene filaments.

POPPED CORE -- A section of core which protrudes between strands to the outer surface of a rope.

POSTFORMING -- A process in which a completed rope is passed through rollers in one or more planes to "set" the rope and reduce elongation under load.

POURED FITTING -- An end-fitting which is attached to the rope by pouring molten zinc, babbit, or epoxy into a cavity around broomed-out rope wires, and allowing the material to solidify.

PREFORMING -- Process in which the strands and wires receive a final helical shape before closing that matches the lay and set of the finished rope.

PRESTRESSING -- Stressing a wire rope or strand before use under such a tension and for such a length of time that the constructional stretch is largely eliminated.

PROOF-LOADING -- Preliminary loading of a rope to its maximum expected range to test the load bearing capability of the rope and associated equipment. Also called PROOF-TESTING.

R

RATED CAPACITY (ROPE OR SLING) -- The maximum load at which a rope or sling is designed to operate.

REEL -- The flanged spool on which a wire rope or strand is wound for storage or shipment.

REEVED EYE -- See CHOKER.

REEVING -- The threading of a wire rope through a block, sheave, or other parts of a wire-rope system.

REGULAR-LAY ROPE -- A rope in which the lay of the wires in the strand is opposite the lay of the strand in the rope.

RESERVE STRENGTH -- The strength of the inner wires in a strand, usually given as a percentage of the aggregate strength of all the wires.

RETRACT ROPE -- The rope used on some shovels to draw back the bucket during digging operations; sometimes used along with a crowd rope.

REVERSE BENDING -- Reeving of a wire rope over two sheaves so that it bends first in one direction and then again in the opposite direction.

RIGHT LAY -- The direction of a strand or wire helix corresponding to that of a right-hand screw thread.

RISER STRIP -- A tapered metallic strip used to raise the rope in the last wrap of a drum layer to the next drum layer.

ROLLERS -- Relatively small-diameter cylinders or wide-faced sheaves for supporting ropes and minimizing friction.

ROUND-STRAND ROPE -- A rope with round strands, as opposed to flattened-strand rope.

S

S-HOOK -- See CHAIN HOOK.

SADDLE -- That part of a U-bolt clip that bears against the live side of the rope. Grooved to fit the external surface of the rope, it is fastened to the U-bolt with nuts. Also called a bridge.

SAFETY CLIP -- See INTEGRAL SADDLE-AND-BOLT CLIP.

SAFETY FACTOR -- See DESIGN FACTOR.

SASH CORD -- Small 6 x 7 wire rope commonly made of iron, bronze, or copper wires.

SCRUBBING -- Displacement of wires from normal position due to relative motion between strands.

SCUFFING -- Rope damage caused by abrasion of a moving rope.

SEALE STRAND CONSTRUCTION -- A strand with uniformly sized wires laid parallel with the same number of uniformly sized but smaller wires in the inner layer(s).

SEALE-WARRINGTON CONSTRUCTION STRAND -- A strand in which the outer layer of alternately large and small wires (WARRINGTON CONSTRUCTION) is parallel laid with inner layers of uniformly sized wires in SEALE CONSTRUCTION. See WARRINGTON STRAND CONSTRUCTION, SEALE STRAND CONSTRUCTION.

SEIZE -- To bind a rope or strand securely with annealed wire. Also, to secure by wire two parallel portions of rope.

SEIZINE -- (1) The annealed wire used to seize a rope. (2) The completed wire wrapping itself.

SEIZING MALLET -- A mallet made of wood, brass, or other soft material with a grooved and notched head, used for applying seizings.

SERVE -- To cover a rope with a tight wrapping of marlin(e) or other fiber cord--as over the ends of the tucks on a splice.

SEWING WIRE -- See FLAT ROPE.

SHACKLE -- An U-shaped fitting with a screwed or cottered pin, used to attach a load to a rope or other lifting equipment.

SHEAVE -- A pulley with a rim, used to support or guide a rope in operation.

SHEAVE GROOVE GAUGE -- A flat, teardrop-shaped device used to check shape and size of sheave grooves.

SHORT SPLICE -- A splice used for attaching two rope ends together. See SPLICING.

SINGLE-LAYER STRAND -- A strand either with no center or a fiber or wire center and one layer of uniformly sized wires.

SINGLE-OPERATION STRAND -- See ONE-OPERATION STRAND.

SINGLE-PART LINE -- A rope in a block and tackle hoisting system which travels over a single sheave from the winch to the hoist.

SISAL -- A rope fiber made from the leaves of the agave plant.

SLEEVE -- A type of swage fitting usually employed in the formation of a loop or eye in the end of a wire rope. See MECHANICAL SPLICE.

SLING -- A wire rope made into a form, with or without fittings (thimbles, rings links), for handling and lifting loads. Generally made with an eye, bight, or hook at the end for attachment to loads and lifting equipment.

SLING, BRAIDED -- A very flexible sling composed of several individual wire ropes braided together.

SMOOTH-COIL TRACK STRAND -- Strand made entirely of round wires, used as an aerial track strand.

SMOOTH-FACED DRUM -- Drum with an ungrooved, plain surface.

SNAP HOOK -- A hook with a spring-loaded safety closure.

SOCKET -- A forged or cast device (usually steel) into which the end of a rope is placed and fastened to permit the rope to be attached to a load or anchor point.

SOCKETING -- The process of attaching a socket to the end of a wire rope.

SPECIAL ALTERNATE LAY -- See ALTERNATE LAY (SPECIAL).

SPELTER -- Zinc.

SPIN-RESISTANT WIRE ROPE -- An 8 x 19 wire rope usually made with Seale construction right regular-lay strands and a 7 x 7 left Lang-lay independent wire-rope core. This rope is usually considered to be somewhat stronger and crush-resistant than a 19 x 7 nonrotating construction but it does not have equal nonspinning properties.

SPINNING LOSS -- See STRANDING LOSS.

SPIRAL GROOVE -- Groove which follows the path of a helix around the drum, as the thread of a screw.

SPLICING -- Interweaving a rope end into a rope section or another rope end to form a loop termination (EYE SPLICE) or a longer or circular rope (ENDLESS SPLICING).

SPOOLING -- Winding a rope on a reel or drum.

SPRING-LAY ROPE -- Preformed cable-laid rope consisting of six ropes around a fiber core. Each individual rope consists of three galvanized steel strands and three fiber cores laid alternately around a fiber core. Spring-lay rope is often used for mooring.

STARTER STRIP -- A metallic, tapered strip which fills the gap between the flange and the first rope wrap on a drum and properly positions the beginning of the second wrap.

STIRRUP -- The U-bolt or eyebolt attachment on a bridge socket.

STRAND -- A number of wires in one or more layers laid around a center wire or fiber core, with a uniform lay length in each layer. The wires are laid helically and may be round or shaped or a combination of both.

STRAND CENTER -- Generally, a 4- to 7-wire strand used to replace a large single wire as the center of a strand.

STRAND CORE -- A wire strand used as the core of a rope. Sometimes called a WIRE STRAND CORE (WSC).

STRANDING LOSS (ALSO CALLED SPINNING LOSS) -- Ratio of the actual breaking strength of a rope to its aggregate breaking strength.

SUSPENSION BRIDGE CABLE -- See BRIDGE CABLE.

SWAGE FITTING -- A tubular steel or alloy fitting sized to accommodate one or more parts of rope or strand. The fitting is applied by squeezing it onto the rope, usually in a swaging press.

SWAGING -- The pressing process used to apply a swage fitting.

SWIVEL -- A termination or attachment for wire rope which permits rope rotation.

T

TACKLE -- An assemblage of ropes, sheaves, rollers, and fittings arranged for hoisting and/or pulling.

TAGLINE -- A small rope attached to an object being lifted to prevent rotation or to position the object.

TAPERED AND WELDED END -- The end of a wire rope with the wires welded together and tapered down to facilitate reeving through block and sheave systems and into drum anchorages.

TENSILE FAILURE -- Rope, strand, or wire failure caused by axial overload.

TERMINATION -- Any device or process applied to the end of a wire rope.

THIMBLE -- A grooved ring (usually teardrop-shaped) used to fit in a spliced loop in a rope as protection from chafing.

TILLER ROPE -- A very flexible operating rope, made by cable-laying six 6 x 6 or 6 x 7 ropes around a fiber core.

TINNED WIRE -- Wire coated with tin.

TORQUE-BALANCED WIRE ROPE*-- A 3-strand thermally-stabilized regular-lay rope (3 x 7, 3 x 19, or 3 x 46) in which the strand lays are designed to produce a torque in tension equal to that, but opposite in direction from, the torque created under load by the opposing rope lay. To be identified as a torque-balanced rope, some current Navy specifications require that this rope rotate less than 1 degree per foot under 60 percent rated breaking strength loads.

TOWLINE -- A line, cable, or chain used to tow a vessel or vehicle. Also called a towrope or towing hawser.

TRACK ROPE (STRAND) -- The suspended rope or strand on a cableway, skyline, or ropeway which supports the load-carrying carriage.

TRACTION ROPE -- Wire rope that propels the carriages on an aerial conveyor. Also, the hoisting rope on elevators, particularly those with traction drives.

TRACTION STEEL -- See GRADES: WIRE ROPE.

TRAMWAY -- Aerial conveying system for transporting loads.

TREAD DIAMETER -- The diameter of a sheave (or drum) measured between opposite low points of the groove.

TRIANGULAR-STRAND ROPE -- A flattened-strand rope whose wires are approximately triangular in cross section.

TURNBUCKLE -- A metal coupling device consisting of an oblong piece internally threaded at both ends, into each end of which a threaded eye is screwed. The thread direction of the ends of the rods are opposite so that when the eyes are connected to wire ropes and the oblong piece turned, the entire rope-turnbuckle assembly is made longer or shorter.

TUCK -- In splicing, the passage of a strand from a rope into or through another section of rope.

TWISTED WIRE-ROD GRIP -- A fitting consisting of a preformed hollow helix of wire strands which is slipped over the rope end. Tension on the rope induces radial compressive stresses on the rope end. See CABLE-GRIP.

U

U-BOLT CLIP -- A clip consisting of a U-bolt and a saddle or bridge which is fastened to the bolt with nuts.

ULTIMATE BREAKING STRENGTH -- See BREAKING STRENGTH.

*Patented by U. S. Steel Corporation, New Haven, Connecticut.

UNDERWOUND ROPE -- A rope which winds onto the underside of a winding drum or winch--as opposed to an overwound rope which winds onto the top of the drum or winch.

V

VALLEY -- The crevice between strands or between wires in a wire rope.

VALLEY BREAK -- A wire breaking occurring in the valley between two strands.

W

WARRINGTON CONSTRUCTION STRAND -- A strand in which the outer of two adjacent layers of wires is composed of alternating large and small wires. The large wires are placed in the valleys of the inner-layer wires and the small wires are placed on the crowns of the inner-layer wires. The two adjacent layers are laid in a single operation.

WARRINGTON-SEALE CONSTRUCTION STRAND -- A strand in which adjacent layers are laid parallel in one operation, the inner a Warrington construction and the outer a Seale construction.

WEDGE SOCKET -- Wire-rope fitting in which the rope is secured with a wedge.

WHIPPING -- (1) Term given to the vibration set up in an operating rope between the sheave and drum due to sudden acceleration, intermittent variation in speed, obstruction to the free movement of a load, or drum crossover points; dangerous and potentially damaging if the frequency of vibration approximates the natural frequency of the rope system. (2) A fiber-core wrapping on a wire rope (See WRAPPING).

WINCH -- Machine with one or more drums on which to coil wire rope for hauling or hoisting.

WIRE -- Single continuous length of metal drawn from a rod. May be "round" in cross section or "shaped" into ovals, triangles, helices, etc.

WIRE ROPE -- A number of wire strands laid helically about an axial core.

WIRE-STRAND CORE -- See STRAND CORE.

WORKING LOAD -- The load that a rope is designed to carry in a particular service.

WORN SHEAVE GAUGE -- A sheave groove gauge used to check sheave grooves over which a rope has been cycled to a worn condition.

WRAPPING -- Fiber core wrapping on a rope. Also see WHIPPING.

Y

YIELD POINT -- The lowest stress at which strain increases without increase in stress.

Z

ZEBRA LAY -- See ALTERNATE LAY.

ZINC SOCKET -- Wire-rope end fitting having a conical basket into which the broomed end of the rope is secured with zinc. May be either open or closed.

7. ALPHABETICAL INDEX

D

E

F

G

M