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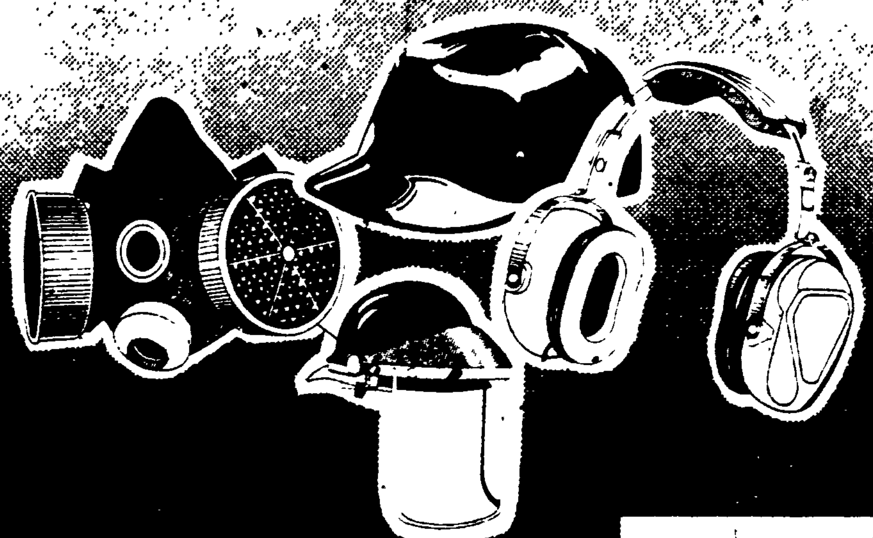
ABSTRACT

This student module on using ropes, chains, and slings safely is one of 50 modules concerned with job safety and health. This module covers ropes (types, use, deterioration); slings (mesh and metal); chains; and safe storage and handling techniques for each. Following the introduction, 18 objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., Discuss four advantages of us[illegible] wire rope). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

SAFETY AND HEALTH

USING ROPES, CHAINS AND SLINGS SAFELY



MODULE SH-14

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INTRODUCTION

"A stitch in time saves nine" is an old adage that could easily have been written for workers involved in the use of ropes, chains, and slings. Each of these devices is used in the lifting of heavy loads; to use the devices safely each of them needs to be inspected thoroughly and frequently. Such inspections are the key to personnel safety and to prolonging the life of the rope, chain, or sling.

Before a load is lifted, many factors should be considered. If a rope is to be used in the hoist, should it be of natural or synthetic fiber? Would a chain be more appropriate? What type of chain is best? If a sling is needed, should it be made of rope, chain, metal mesh, or synthetic mesh?

Once the correct device is selected, there are other procedures to be carried out. Inspecting the ropes, chains, or slings daily, before use, is imperative, since many conditions affect their strength and safety. These conditions vary according to the device used, and workers using ropes, chains, or slings must be aware of what these conditons are.

This module deals with many of the factors involved in the use of ropes, chains, and slings. The types or rope in use, factors which cause their deterioration, and practices or conditions to be avoided in their use are discussed. Synthetic mesh and metal mesh slings are compared, as are the four types of metal chains. Since regular, careful inspection is essential to the safe use of chains, ropes, and slings, inspection procedures are discussed. Safe working practices are outlined, as well as storage and handling techniques. Safety factors are mentioned, and some description of sling attachments is given. With the identification of seven hazards associated with the use of slings in materials handling, the reader is introduced to the safety procedures necessary in the use of ropes, chains, and slings.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. Identify seven hazards associated with the use of slings in materials handling. (Page 5)
2. List four regulations and thirteen safety procedures that relate to rigging equipment and handling. (Page 8)
3. Describe the two natural and five synthetic fiber ropes commonly used. (Page 10)
4. Describe coiling damage, mechanical and chemical injury, and biological damage related to fiber ropes. (Page 14)
5. List eleven items to be considered when inspecting a fiber rope. (Page 17)
6. Discuss four advantages of using wire ropes. (Page 18)
7. List and define eight causes of wire rope deterioration. (Page 20)
8. State seven items to be examined when conducting a wire rope inspection. (Page 21)
9. Compare the use of wire rope, natural and synthetic fiber, and synthetic webbing for rope slings. (Page 25)
10. Describe the hook and ring method and the swaged sleeve method of sling attachment, and define safe load limits for slings. (Page 27)
11. State the proper inspection intervals for rope slings and briefly describe points that should be checked. (Page 30)
12. Discuss and differentiate between the four types of metal chains. (Page 32)
13. Describe five points of inspection that should be carried out daily on chains. (Page 33)
14. Outline seven safe working practices to follow when using chains and chain slings. (Page 35)
15. Describe the inspection, testing, repairing and attachment mechanisms for alloy steel chains. (Page 36)
16. Describe storage procedures and identification methods for steel alloy chains. (Page 38)
17. Identify the advantages and disadvantages of metal and nylon mesh slings. (Page 40)

18. Name four safe work practices using metal and nylon mesh slings. (Page 42)

OBJECTIVE 1: Identify seven hazards associated with the use of slings in materials handling.

A sling is an assembly that cradles a load and allows it to be lifted by mechanical means. The sling may consist of ropes, chains, metal mesh, or synthetic mesh (webbing). The way these materials are attached to the load and then to the lifting device is called rigging. Since rigging is frequently used to support large and cumbersome loads, there are many dangers involved in its use.

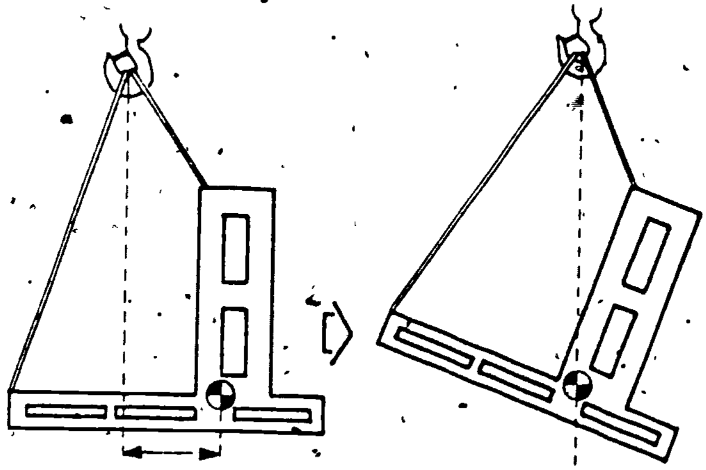

Figure 1. When center of gravity is not directly below the hook, the load will shift until center of gravity is below the hook. This could cause the load to swing out of control.

One of the primary causes of accidents in rigging is load shifting. This frequently happens when the load is unbalanced to begin with. As the load is raised, it can create an improper lifting angle on the sling and cause the load to shift, as shown in Figure 1. Such a situation will create an undue strain on the sling. This strain could cause the load either to swing through the air out of control, or to fall. The consequences of either of these two accidents could be very serious. A falling load could strike personnel, causing injury or death, or it could hit other material that, in turn, could cause inury. Similarly, a load swinging out of control could strike a worker, causing an impact injury or a fall; or it could hit other material and cause them to fall onto a worker or workers.

Accidents are also caused by the dangerous practice of placing hands or fingers between a sling and a load while the sling is being tightened around the load. When the point of contact is at a corner where the sling comes around the load, it could cut a hand or finger in two. Although it is a situation that presents obvious danger, placing hands and fingers between slings and loads continues to cause accidents in rigging.

Pulling a sling from under a load when the load is resting on the sling creates great potential for accidents. (See Figure 2.) Because of the intense force required to pull the sling out from under the load, when the sling finally becomes free, it can snap violently in a counter direction with enough force to kill or, at least, to injure someone badly.

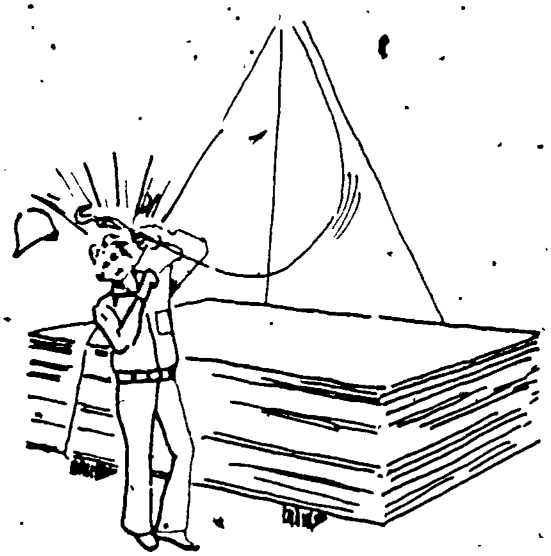

Figure 2. The danger of pulling a sling from under a load resting on the sling.

Loads with sharp edges present special problems in rigging. The sharp edges can sometimes cut right through a seemingly strong rope or sling and drop the load at random onto the floor below. The problem may be avoided by padding the corners, as shown in Figure 3, but riggers in a hurry sometimes fail to do this.

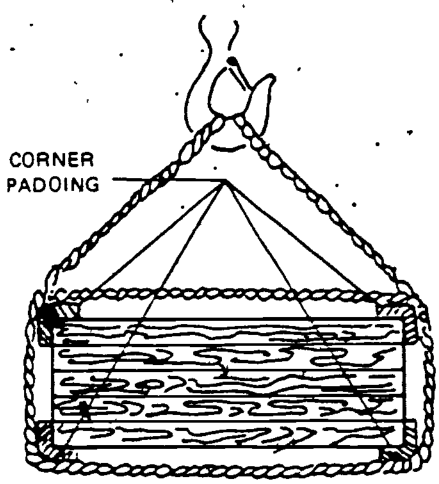

Figure 3. Loads with sharp edges need corner padding.

Poorly designed slings, or slings that are attached insecurely, can also cause accidents. When a load that is not securely rigged is lifted, it may slip through the rigging and fall. If it does not fall, it may create an improper lifting angle, with all the dangers inherent in that situation.

Bad weather conditions also contribute to accidents. When visibility is impaired by snow, fog, or rain, rigging activities should be carefully supervised, and in some cases stopped. Dust and darkness also create poor visibility. Wind is especially troublesome around rigging operations. Winds beyond 25 to 30 mph can move a load dangerously about in the air, sometimes causing it to shift. In other words, when environmental conditions merit, rigging operations should be stopped.

It would seem that the greatest danger in rigging operations would be a falling load. This is not true. The most repeated killer of riggers and persons handling loads is electrocution. When the boom, the load line, or even the load of a crane contacts an electric power line, electrocution is almost certain. This is why any crane working within a boom's length of a power line should have a competent signalman (see Figure 4) stationed in clear view of the operator to issue a warning when any part of the machine or its load is approaching beyond a safe distance from a power line.

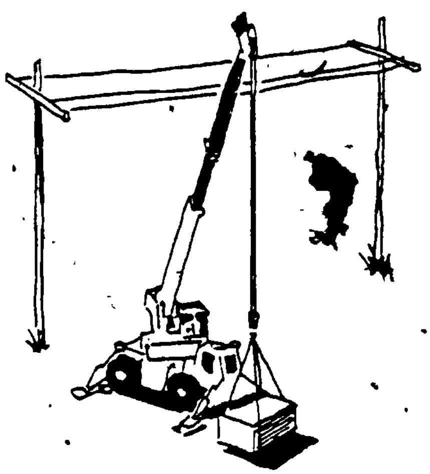

Figure 4. The greatest danger in rigging operations is electrocution.

On windy days, power lines with long spans between supports are especially dangerous. One moment they could be at a safe distance, and the next moment they could blow right into the boom or the load line. Because they pose such a great potential for sudden, certain death, power lines demand special attention when they are anywhere near rigging operations.

ACTIVITY 1:*

(Fill in the blank.)

1. a. One of the primary causes of accidents in rigging is ______________ ______________.
   b. If an unbalanced load is lifted, it can create an improper ______________ ________ on the sling.

*Answers to Activities appear on page 44.

c. The strain on the sling could cause the load either to ________ ________ or to ________.

2. List six other hazards associated with the use of sling.

a. ________________

b. ________________

c. ________________

d. ________________

e. ________________

f. ________________

OBJECTIVE 2: List four regulations and 13 safety procedures that relate to rigging equipment and handling.

In an attempt to minimize accidents, OSHA guidelines have been written that establish common sense procedures relating to rigging equipment.

- Rigging equipment for materials handling should be inspected at the beginning of each shift prior to use, and as often as necessary during use to ensure its safe condition.
- Rigging equipment should not be loaded in excess of its recommended safe working load.
- Rigging equipment, when not in use, should be removed from the immediate work area so that it will not present a hazard to workers.
- Special custom design lifting accessories (grabs, hooks, clamps, and so on) for modular panels, prefabricated structures and similar materials, should be marked to indicate safe working loads. Such accessories should also be proof-tested to use up to 125 percent of their rated load.

Other guidelines spell out manufacturing requirements, load limitation requirements, use requirements, and inspection requirements for alloy steel chains, wire ropes, and natural and synthetic fiber ropes. Of more direct concern to the worker are a number of safety procedures that should be followed when dealing with loads and rigging equipment. Some of these procedures are listed below.

- Never exceed the safe working load of lines, attachments, or equipment, and be sure to add the weight of these items when figuring the true weight of the load because the hoisting equipment is a part of the load.
- Avoid lifting loads that are not plumb and balanced.
- Avoid situations that will cause a suspended load to swing in the air.
- Always use a signalman when working near electric power lines.
- Store all ropes and slings in proper places safe from moisture, acids, or other materials that could cause mechanical damage.
- Inspect all ropes and slings at regular intervals, daily if service conditions require it, and keep a written record of such inspections.
- Rig a load so that no part of it can be dislodged in lifting.
- Use tag lines to secure cumbersome loads that may be subject to swinging.
- Safely land and block all loads before unhooking ropes or slings.
- Never ride on a load that is being lifted.
- Never use bolts or makeshift devices to repair chains or slings.
- Avoid impact loading; do not suddenly jerk the slack out of a line, but lift gradually until the slack is taken up.
- Beware of ropes, slings, and attachments without markings or identifying tags; they are probably unsafe.

ACTIVITY 2:

1. a. When should rigging equipment be inspected?

   ____

   b. When rigging equipment is not in use, why should it be removed from the immediate work area?

   ____

   c. Special lifting accessories have two safety requirements. What are they?

   (1) ______________________________

   (2) ______________________________

2. List six of the safety procedures which should be followed when dealing with loads and rigging.

   a. ______________________________

   b. ______________________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

OBJECTIVE 3: Describe the two natural and the five synthetic fiber ropes commonly used.

To understand some of the factors that must be considered in the selection of rope for rigging, a knowledge of the qualities of different ropes is essential.

NATURAL FIBER ROPES

There are two basic natural fiber ropes: manila and sisal. There are several grades of manila, but for hoisting purposes, only a rope of first-grade manila fibers should be used. High quality manila ropes are easy to identify because they are ivory to light yellow in color, they have a waxy luster to them, and they feel firm but pliable.

A good manila rope is usually marked with a trade mark. Sometimes this mark is simply a paper ribbon with a trade name on it twisted around the rope, but some manufacturers place a colored strand of one or more colored yars in the rope. A manila rope without a trade mark should not be use for hoisting.

Sisal ropes, which cost less than manila ropes, should not be used in hoisting. Sisal rope is easy to identify because its color varies from white to yellowish white, it lacks the glossy look of high-grade manila, and it is stiff and harsh to the touch.

SYNTHETIC ROPES

Of synthetic ropes, the strongest is nylon. Nylon rope has two and a half times the breaking strength of manila rope, and four times the working elasticity of manila rope. Nylon rope is fairly easy to distinguish from other synthetic ropes because of its chalky white color, its smooth surface, and its soft, pliant feel. The strongest rope is a rope with a braided nylon sheath over a braided nylon core. These 2-in-1 braided nylon ropes come in several varieties. Those with nylon core/nylon cover have high strength and greater elongation, those with polypropylene core/nylon cover have lower strength and more stretch, and those with polypropylene core/polyester cover have very low stretch and high strength. Where the highest possible strength is required, nylon braided ropes should be used.

Synthetic ropes made of polyester are heavier than nylon ropes of the same size, but they are not as strong. Because they have a tendency to stretch, polyester ropes need a "breaking-in" period. Although polyester ropes look very much like nylon ropes, the lack of elastic feeling that nylon ropes have identifies them.

Other synthetic ropes are made of polypropylene. This synthetic rope will float in water, but its light weight makes it less strong than nylon or polyester. Polypropylene rope can be used in situations where manila rope would not be strong enough for the job but where the extra strength of nylon or polyester is not required. Polypropylene ropes are easy to identify because they come in bright reds, greens, blues, as well as several other colors, and they are somewhat slippery.

The lowest in strength of all synthetic ropes is polyethylene. It is about half as strong as nylon, but still 15% stronger than manila. These ropes have specialty uses because they are resistant to both acids and alkalis, to alcohol, and to bleaching solutions. Polyethylene ropes are easy to identify because they too come in many different bright colors, and have a very slippery, almost eel-like, feel.

As a group, both polypropylene and polyethylene are members of the "polyolefin" rope family, but the names polypropylene and polyethylene are more commonly used to identify them. Many synthetic ropes are known by the trade name of the fiber used in their manufacture. The most common of these names are probably Dacron and Terylene. These are polyester ropes and have the qualities discussed above.

COMPARATIVE QUALITIES OF ROPES

Synthetic ropes are superior to natural fiber ropes in some areas. However, number-one grade manila is still a much used hoisting rope because of its ability to play out (release) evenly when used around capstans or bits.

One quality that makes synthetic ropes effective is their ability to take shock loads (severe sudden strains) repeatedly. This quality makes nylon a great rope for safety lines. Synthetic fiber ropes can also sustain dead loads (those gradually lifted, as opposed to suddenly weighted) for longer periods. Because the fibers in synthetic ropes are continuous throughout, they recover from stretch and strain faster and better than do natural fiber ropes. Both manila and sisal are held together by surface contact and twist. When exposed to extended use with dead loads, manila and sisal tend to slip, and the ropes eventually break.

Several other factors have to be considered when selecting a rope for a specific job. In some cases, the rope will need a high "flexing endurance"; that is, the ability to take repeated bending. Here, once again, the synthetic ropes are generally a better choice for conditions that demand flexing endurance. The effects of temperature on rope must also be considered. The effects of heat are potentially the most damaging to rope. This is because the damage done by heat may not be apparent at the time of normal inspection. Heat buildup is especially critical at points where a moving rope passes over and makes contact with a stationary rope. The stationary rope will usually break down first, and nylon rope is particularly prone to this kind of breakdown. On the other hand, manila holds up better in heat-friction wear and the breakdown is slower.

The effects of cold are not nearly as bad as the effects of heat. However, if a natural fiber rope is wet and then cools in cold, dry air, it loses considerable tensile strength. Synthetic ropes lose very little tensile strength under these conditions.

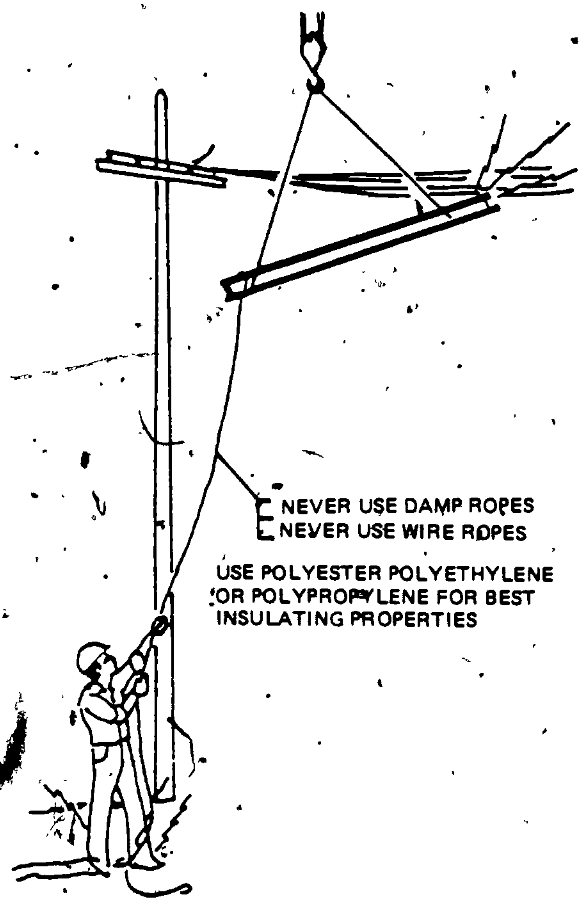

Figure 5. Around power lines, polyester, polyethylene or polypropylene ropes are best.

Another factor to be considered is the possibility of shock when ropes have to be used around electrical power lines. (Figure 5.) It is best to use ropes made of polyester, polyethylene, or polypropylene, since these three ropes retain their insulating qualities even in high humidity. Nylon rope which has a tendency to pick up moisture from the air, is not recommended for use around electric power lines.

Whether made of natural or synthetic fibers, the factor of safety for all fiber ropes is five, and if the rope is used to hoist or support personnel, the factor of safety is 10. A safety factor of five means that the rope must be capable of handling five times the weight of the actual load.

ACTIVITY 3:

1. Name the two natural fiber ropes that are commonly used: ______________ ______________
2. (Circle the correct answer.)
   The strongest of the synthetic ropes is:
   a. Polypropylene.
   b. Polyester.
   c. Polyethylene.
   d. Nylon.

3. Other than strength, the factors to consider when choosing a rope are: (Name four)

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

OBJECTIVE 4: Describe coiling damage, mechanical and chemical injury, and biological damage related to fiber ropes.

To get the longest life and safest use out of a fiber rope requires that it be handled and stored properly. When a new rope is removed from the shipping coil, a three-step procedure should be followed. (1) Reach down inside the coil, (2) pull the inside rope end up through the coil, then (3) unwind the rope in counterclockwise direction. (Figure 6.) This procedure avoids adding twists to the rope and destroying its balance. Kinks are also kept out of the rope by this method.

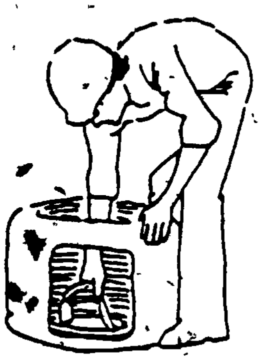

Figure 6. Store fiber rope properly.

Ropes should always be recoiled in a clockwise direction. (See Figure 7.) The best way is to loop the rope over the left arm a number of times in even lengths until about 15 feet of the rope remains. This rope should then be looped about six times around the center of the other loops, the rope end should be secured with a knot, and enough of

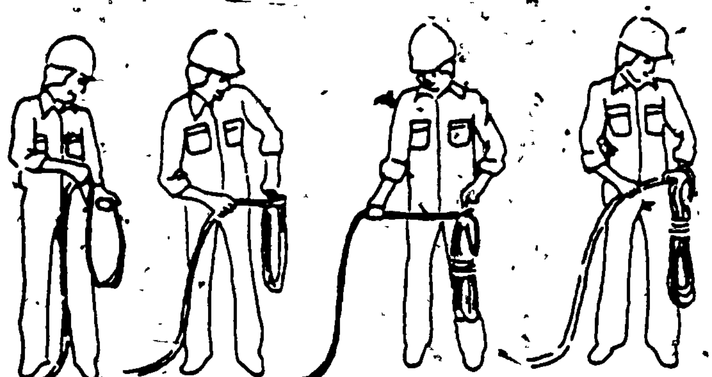

Figure 7. Recoil rope in a clockwise direction.

the rope should be left to tie the coiled rope safely to a holding peg.

A dirty rope should never be recoiled. It should be washed with a moderate stream of water from a hose. Some dirt may remain, but that can be shaken out when the rope dries. A wet rope should never be hung up in an enclosed area; it must get plenty of air so it can dry. If the rope cannot be hung up, it should be laid in a loose coil in a ventilated area where it will dry.

Ropes are subject to other forms of mechanical damage. They should never be dragged on the ground or against rough or sharp objects. When a rope is pulled over a hard surface with a sharp edge, burlap padding should be used along the edge. Pulling a rope over a hard-surfaced bend can cause extreme tension on the fibers.

Chemicals can cause rope deterioration. Generally, rope should not be stored or used where it will be exposed to acids, or even acid fumes. Strong alkali, drying oil, and paint can also injure a rope. Black or brown spots on a rope indicate exposure to acids or caustics, both of which are sources of quick deterioration.

While nylon rope is highly resistant to alkalis, it is subject to injury by most acids, paints, and linseed oil. Nylon ropes should be kept out of contact with these substances. When contamination is suspected, the rope should be washed in cold water and inspected for evidence of fiber weakening.

Like nylon, polyester rope is resistant to alkalis, but unlike nylon, it is also resistant to acids. However, all chemicals should be avoided around polyester ropes, and these ropes should be washed often in cold water.

Certain ropes are more subject to injury from specific sources. Even though they are chemically treated to resist mildew and dry rot, manila ropes are still very subject to rot. This is why they must be cleaned and stored with care. Prolonged exposure to sunlight will also cause a manila rope to deteriorate, so when it is possible, it is wise to shade or cover a manila rope that is exposed to sunlight for long periods.

Polypropylene ropes are not subject at all to rot and mildew, and they are highly resistant to acids and alkalis, although industrial solvents do have a softening effect on these ropes. Polypropylene has good insulating qualities, and it makes an excellent nonconductor of electricity. The one problem with polypropylene is that is softens progressively with a rise in temperature; it even degrades in sunlight, so it should not be used in hot conditions.

Polyethylene ropes are also subject to softening in rising temperatures and should not be used under such conditions. Otherwise, polyethylene ropes are resistant to alkalis and all acids except nitric acid and are also resistant to alcohol and bleaching.

Generally, synthetic ropes tend to melt at high temperatures and should not be used where they are likely to encounter excessive heat, or where friction is concentrated enough to melt the fibers. Thus, synthetic ropes should not be used around welding operations.

On the other hand, a frozen rope should never be used until it has been allowed to thaw and dry. In using synthetic ropes, extra caution is needed because they stretch more than manila ropes, they have a low melting point, and they are naturally slippery.

ACTIVITY 4:

1. List three practices to avoid in usage and storage of manila rope. Begin each rule with the words "do not."

   a. ____________________

   b. ____________________

   c. ____________________

2. (Circle the correct answer.)
   Which rope is subject to damage by most acids, paints, and linseed oil but not by alkalis?

   a. Polyester.

   b. Nylon.

   c. Polypropylene.

   d. Polyethylene.

3. Where welding is being done in the immediate work area, which ropes should not be used?

   ____________________ ____________________

OBJECTIVE 5: List eleven items to be considered when inspecting a fiber rope.

Fiber ropes used in hoisting demand careful inspection on a regular schedule. Before a rope is put into service, it should be carefully inspected along its entire length. Even a new rope can sometimes have defects and should not be put into service. After the initial inspection, a rope should be inspected at least every 30 days after it has been put into service if it is subjected only to ordinary wear. Ropes that support workers on scaffolds should be inspected weekly, and all ropes exposed to acids or caustics need to be inspected daily.

Rope inspections should not only be timely, they should include careful examination of specific areas where injury and deterioration are most likely to take place. The entire length of the rope should first be inspected for the following:

- Wear.
- Abrasion.
- Broken or cut fibers.
- Displacement of yarn or strands.
- Variation in roundness or size of strands.
- Discoloration.
- Rotting.

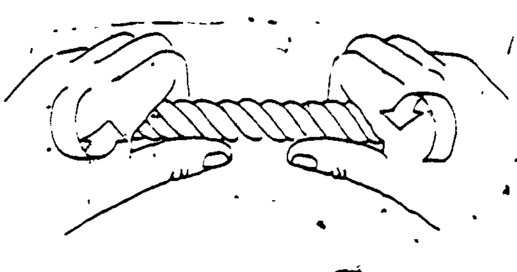

Figure 8. Open up rope during inspections.

After the exterior of the rope has been inspected, the inside should be examined by twisting the strands to open up the rope as shown in Figure 8. This should be done with care to avoid kinding the rope or disturbing the lay.

If the interior of the rope is not bright and clean, check for the following:

- Broken yarns.
- Excessively loose yarns or loose strands.
- An accumulation of powder-like dust that indicates excessive wear between the strands.
- Inside yams that pull out easily, indicating that the rope has been overstressed.

Rope that is suspected of having been exposed to acid requires special care. A manila rope that has been in contact with acid will have dark brown spots. Acid usually eats away synthetic ropes, but very brittle fibers in synthetic ropes indicate exposure to acid.

A rope that is suspected of deterioration should be replaced. Evaluation of the rope should be based on the section showing the most deterioration.

When a rope is weak in just one spot, it may be cut, properly spliced and kept in service. However, when a rope has been condemned, it should be taken out of service immediately and cut into short lengths. Cutting it will prevent its being accidently placed back into hoisting service.

ACTIVITY 5:

List nine items to be considered when inspecting a fiber rope.

1. ____________ 6. ____________
2. ____________ 7. ____________
3. ____________ 8. ____________
4. ____________ 9. ____________
5. ____________

OBJECTIVE 6: Discuss four advantages of using wire ropes.

Wire ropes have two qualities that give them a high degree of dependability and uniformity. First, wire ropes are made from large numbersof individual wires, most of which are not exposed. Secondly, the wires are continuous in any given length of rope. For these and other reasons, safety engineers recommend that, for general construction rigging, a wire rope should always be used in preference to a fiber rope or chain.

Wire ropes of "improved plow steel" grade are the standard for hoisting ropes. Where a greater factor of safety is required, "extra improved plow steel" grade is even better because it resists abrasion, shock, vibration, and fatigue.

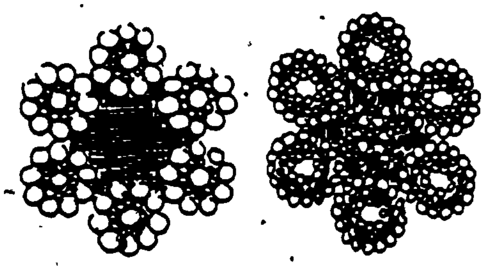

Figure 9. Cross sections of wire rope. Most wire ropes are composed or more than 100 individual wires.

The reason safety engineers prefer wire ropes over chains for general construction rigging is the added degree of safety they provide. One link of chain can fail in a moment and cause a serious accident. Most wire ropes, on the other hand, are composed of more than a hundred individual wires and the failure of one wire alone does not cause an accident. The cross sections in Figure 9 show wire ropes composed of 114 wires (left), and 313 wires (right). Every one of them has to fail before the rope can break. This reserve strength gives workers a chance to notice a hazard before it turns into a disaster. Even when a wire rope is severely overloaded, it still takes several seconds for all the wires to break, and in these circumstances, the breaking wires make so much noise that workers near the load will still have time to lower the load and get out of the way before it falls.

Wire ropes come in several varieties and combinations of core and exterior. Despite their strength and dependability, wire ropes are still subject to tension, abrasion, fatigue, cutting, and corrosion, and must be carefully selected for the job they have to do.

ACTIVITY 6:

1. What is the most important added degree of safety that a wire rope has over a chain? ______________________

____

2. List two qualities of wire rope that result in its high degree of dependability and uniformity.

a. ______________________________________

b. ______________________________________

OBJECTIVE 7: List and define eight causes of wire rope deterioration.

Wire rope is subject to deterioration and damage from a number of causes. One of these is incorrect coiling (reeling) and uncoiling. The shipping coil or reel of a wire rope must turn as the rope unwinds. Trying to remove a wire rope from a stationary reel will almost always result in a kink that cannot be repaired. Even when a wire rope is being reeled onto a drum or another reel, care must be taken to wind from the top of one reel to the top of the other or from the bottom of one reel to the bottom of the other.

Beyond the initial "kinking" damage that can be caused from improperly unreeling a wire rope, there are seven other major causes of wire rope deterioration:

1. Wear from contact with sheaves or drums; this shows especially on the outside wires.
2. Corrosion that tends to accelerate wear. This dangerous condition is hard to detect because it often happens to interior wires, but it is usually indicated by pitting.
3. Fatigue due to excessive bending stresses from sheaves and drums that have a small radius. Fatigue is usually indicated by a square break in a wire. Such a break will show the granular structure of the wire.
4. Drying out of lubrication, a condition often speeded up by heat.
5. Overloading and overwinding in acceleration and deceleration.

6. Mechanical abuses such as pinching down and cutting wires, or conditions where ropes are being subjected to dragging.
7. Tension, when a rope has been subjected to too great a strain. This happens when a load is applied suddenly to a slack rope, causing severe impact stresses.

Finally, the factor of safety should always be respected. The minimum acceptable factor of safety for wire ropes is five. When the rope is used with personnel carrying equipment, the factor should be raised to ten. The factor of safety DOES NOT mean that the rope has a great deal of reserve strength, and can be used for additional capacity, even for a short time. In fact, lowering the factor of safety will only accelerate every element of wear and deterioration to which a wire rope is subject.

ACTIVITY 7:

1. Describe the correct procedure for transferring wire rope from one reel to another.

   ____

   ____

   ____

2. Name four reasons for wire rope deterioration, other than "kinking."

   a. ____________________________________

   b. ____________________________________

   c. ____________________________________

   d. ____________________________________

OBJECTIVE 8: State seven items to be examined when conducting a wire rope inspection.

Inspecting wire ropes demands a great deal of expertise and some good judgment. Taking a rope out of service before it is really worn may be costly; leaving a rope in service when it is suspected of significant deterioration may be even more costly in terms of human life. This is why wire

Rope inspections should be made only by qualified people.

The principal basis on which the condition of a wire rope is judged is the number of broken wires per lay. A lay of rope is the length along the rope in which one strand makes a complete revolution around the rope. When most of the broken wires in a lay are concentrated in several strands, that section of the rope is weaker than it would be if the broken wires were uniformly distributed throughout all strands and along the entire length of the rope. In other words, the pattern of broken wires is significant. If the number of broken wires along the length of the rope increases rapidly between inspections, it is a sure sign that the rope is at the point, or near the point, at which it should be taken out of service.

In addition to inspecting for broken wires, wire ropes need to be carefully inspected for these other signs of wear:

- Wear of crown wires (outside wires).
- Kinking.
- High strands.
- Loose wires.
- Nicking.
- Lubrication.

Wear of crown wires is so important that it should be checked with rope calipers and micrometers. Reduction of the rope diameter is a critical deterioration factor. While all new ropes stretch and experience a slight reduction in diameter, a rope should be replaced if the diameter is reduced by more than:

- 3/64" for rope diameters of up to and including 3/4".
- 1/16" for rope diameters of 7/8 to 1 1/8".
- 3/32" for rope diameters of 1 1/4 to 1 1/2".

Figure 10. A wire rope which has been kinked. Early rope failure can occur at this point.

Severe kinking (Figure 10) may demand that the rope be discarded. In some cases a kink can be cut out, and after proper splicing, the rope can remain in service.

High stranding, when one or two strands are worn before the adjacent

Figure 11. A wire rope with a high strand.

Figure 12. A "bird cage" may require replacement of the rope.

ones, (Figure 11), affects the lay of the rope and causes other strands to become overloaded. If the rope is not replaced, a new end connection should be placed on the rope to remove the high strand and reset the rope lay.

Loose wires usually result from a torsional unbalance in the rope. Because these wires frequently bunch up in a loose pattern around the rope, the condition is called "bird caging." (See Figure 12.) This buildup is often seen at the anchor end of multifall crane operations. If bird caging is severe, the rope should be replaced; in some cases the bird cage can be cut out and the rope can be spliced and kept in service.

Nicking refers to the injuries a rope suffers from coming in contact with other ropes or obstructions. It can also be caused by movement over drums and sheaves. Nicking is a clue that the interior of the rope demands inspection.

Lack of proper lubrication will quickly put a rope out of service. Wire ropes are usually lubricated internally by the saturated fiber core. This core can sometimes dry out from heat, or may actually be squeezed out. In these cases, the grooves between the strands must be inspected. If these grooves are filled with hard packed grease or dirt, the lubricant cannot penetrate to prevent internal friction. The rope should then be scrubbed and a viscous coat of warm oil applied to it. Once the oil has been allowed to enter the inside of the rope and the rope is dry enough that the oil will not be thrown off, the rope is usually serviceable again.

Several other factors have to be considered in wire rope inspections. The speed at which the rope travels in its work is a very important element. Fast moving ropes are naturally subjected to greater stress from friction and abrasion, and these factors must be taken into account when such ropes are inspected. Particular attention should be paid to the areas of wire ropes close to terminal fittings. Even rope that might remain on a drum all the time should be inspected because of the increased potential for wear at terminal fittings.

The final and most important factor is corrosion. Corrosion is even more dangerous than visible wear because it so often affects wires inside the rope that are hidden from visual inspection. Yet corrosion can often be detected by discoloration of the wires, and especially by the presence of pitting. Any evidence of extensive corrosion means the rope should be replaced.

All wire ropes should be inspected at intervals determined by their service conditions. Wire ropes used in situations where human life depends on them should be inspected more often than other types of wire ropes. But all wire ropes should be inspected at regular intervals and records should be kept of the inspection findings.

Finally, two rules should govern the inspection of wire ropes. One, every inch of the rope should be inspected with care. Two, the rope's condition should be judged at the point that shows the greatest deterioration.

ACTIVITY 8:

1. A reduction in wire rope diameter is very important in judging how much the rope has deteriorated. How should the diameter be measured? ______________________

   ____

2. Name five other causes of wire rope deterioration.
   a. ______________________
   b. ______________________
   c. ______________________
   d. ______________________
   e. ______________________

OBJECTIVE 9: Compare the use of wire rope, natural and synthetic fiber, and synthetic webbing for rope slings.

In most rigging and hoisting operations, slings get the roughest wear. Slings are especially subject to abrasion, impact loading, crushing, kinking, and overloading. Because slings are subject to such rough wear, their composition, manufacture, application, and inspection are all vital elements of their safe and proper use.

Properly manufactured wire rope slings are the safest slings for general construction use. Wire rope slings combine minimum weight with strength and flexibility. They do not wear as rapidly as fiber rope slings, and they do not have the potential weak link problem of chain slings. Wire rope slings are especially safe because the breaking of the outer wires gives advance warning of failure. The protected inner wires have reserve strength enough to get the load safely down. However, wire rope slings should still be carefully selected for specific service. They should be of improved plow steel, and should be preformed with a wire rope core. In railroad shops or other places where slings of great strength are required, braided wire rope slings are recommended. They are flexible, they resist kinking, and they are easy to handle. All wire rope slings should have a factor of safety of at least five.

Natural fiber rope slings should always be made from manila rope. Rope slings made from manila work well in some applications because they are flexible, grip the load well, and will not mar the surface of a load as some metal slings do. However, manila rope slings have limitations, and these must be given careful consideration.

Synthetic fiber rope slings have certain advantages over natural fiber slings, but they, too, have limitations that must be considered. Both synthetic and natural fiber rope slings are affected by chemicals, freezing, high temperatures, and sharp bends. Fiber rope slings deteriorate much more rapidly than wire rope slings, and they should be used only on light loads. Sharp corners can cut the slings and should always be padded.

Synthetic webbing slings are versatile and durable, and have such flexibility that they are popular for rigging activities. Because of their flexibility, synthetic webbing slings tend to mold themselves to the shape of the load. This means they are less likely to mar the surface material of a load than are wire, fiber, or chain slings. Synthetic webbing slings have desirable safety qualities, too. Since they are non-sparking they can be used in workplaces with explosive hazards, and they minimize twisting and spinning during lifting. Synthetic webbing slings are softer than other types of slings; therefore, workers do not cut their hands on them, and a bump on the head from a free-swinging slip is not usually severe.

Other qualities of synthetic webbing slings make them adaptable to specific jobs. They are not affected by moisture and can be used in high humidity situations. Because they do not rust and, therefore, will not stain, they make good rigs for working with ornamental precast concrete or with finished stone of any kind. The elasticity of synthetic webbing slings enables them to absorb heavy shocks and still cushion the load. Slings that undergo such stresses will, of course, wear at points of impact, but buffer strips of leather, edge guards, and other devices to prolong the life of a sling and increase its safety are available. Sliding tube pads to cushion slings that are used to handle materials with sharp edges are available, and there are even certain coatings that can be applied to the slings to provide added resistance to abrasion and chemicals.

Synthetic webbing slings should have a safety factor of at least five.

ACTIVITY 9:

1. What type of slings are the safest slings for general construction use? ______
2. List two situations in which synthetic webbing slings might be more appropriate for use than fiber rope, wire rope, or chain slings.

   a. ______

   b. ______

OBJECTIVE 10: Describe the hook and ring method and the swaged sleeve method of sling attachment, and define safe load limits for slings.

There are many different methods of attaching a rope to a hook, and a hook to a load. Different methods of attachments offer various percentages of strength in relation to a rope or a sling load. Since these percentages must be considered when figuring the load limit, it is important to understand some basic features of different attachments.

The hook and ring method of attaching a wire rope fitting achieves a load capacity that ranges from 70 to 100 percent of the breaking strength of the rope. Swaged sleeve attachments, usually made only by the manufacturer, offer about 90 to 95 percent of the efficiency of the rope. When they are properly made, compression fittings and zinc-poured sockets can develop 100 percent of the strength of the rope. Zinc-poured sockets are efficient in straight extension, but swaged sockets are more resistant to fatigue. (See Figure 13.) Clamps, when properly installed, develop about 75 to 80 percent of the rope efficiency, and hand-tucked splices develop efficiencies up to 90 percent depending on the diameter of the rope.

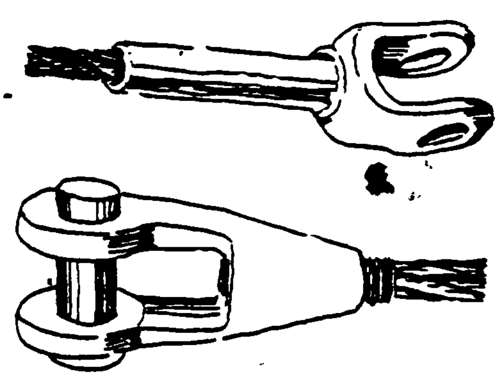

Figure 13. Swaged sockets (a) are more fatigue-resistant than zinc-poured sockets (b).

The really important element about attachments is that they must be considered when figuring the load limit for a sling. In other words, the recommended load for a sling assembly is not more than one-fifth the strength of the assembly, but to accurately determine the overall strength, the efficiency of the rope connections must also be taken into account. Figure 14 shows various types of connections and gives the percentage efficiency of each.

Stating the safe working load for a sling is a complex affair that is related to sling strength, load weight, and lifting angle. But when a sling

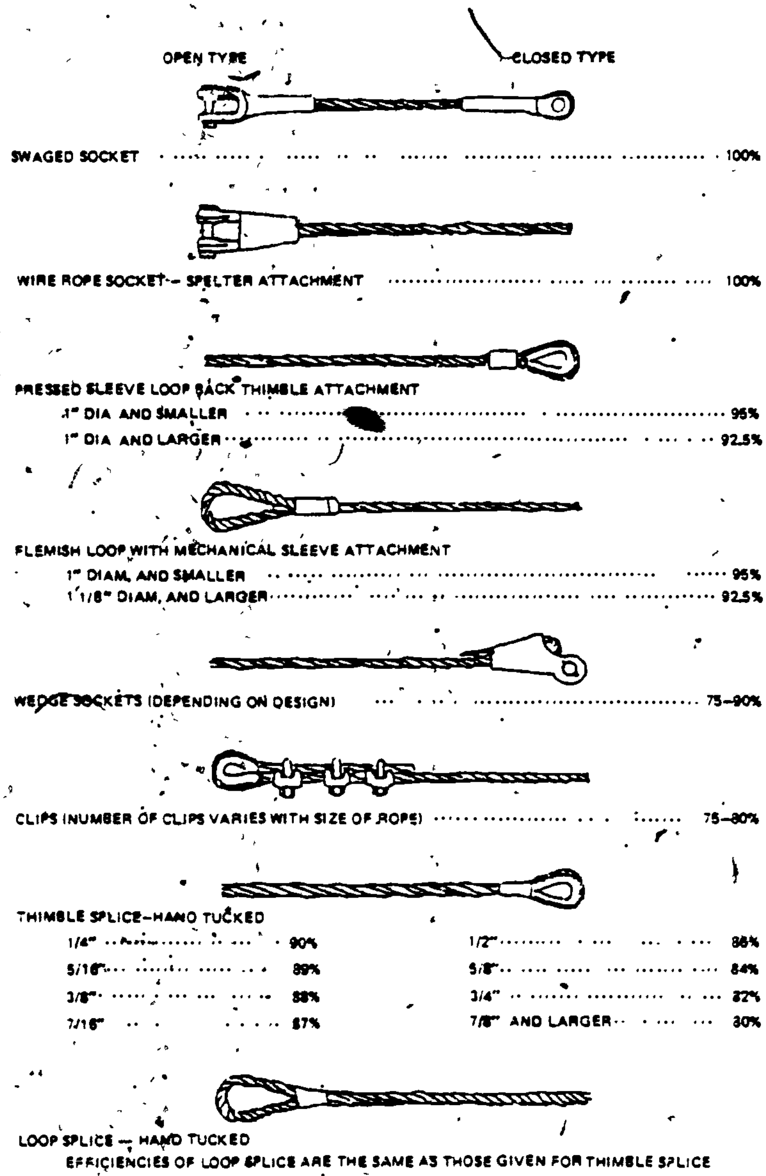

Figure 14. When figuring the load limit for a sling, the efficiency of the rope connections must be taken into account.

bears a tag listing its safe vertical load limit, the other elements are not difficult to determine.

When determining the safe load limit for slings, a minimum safety factor of five must always be used. This is a general rule, but there are some exceptions that demand attention.

If a one-leg vertical sling can safely lift 200 pounds, then a two-leg vertical sling can safely lift twice that amount, or 400 pounds. If a three-leg vertical sling is used, then it can safely lift one and a half times as much as the two-leg sling, or 600 pounds. The capacity of a four-leg vertical sling, under ideal conditions, would be twice that of the two-leg sling, or 800 pounds. However, it is important to realize that working conditions are seldom ideal. The preceding numbers are guidelines to illustrate the changing load capacities for slings with varying leg configurations.

Another important factor is the angle formed by the ropes and the horizontal top of the load when the sling is placed in position on a load. This angle should always exceed 45 degrees to avoid excessive stresses on the sling. The safe load limit of a sling decreases sharply as the angle formed by the legs and the horizontal becomes smaller (Figure 15). This problem with the lifting angle can frequently be avoided by using longer slings. In cases where head room will not permit a longer sling, it is usually best to lighten the load.

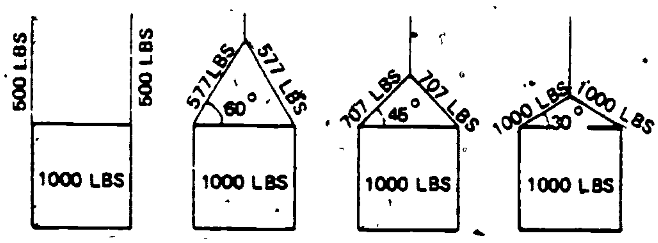

Figure 15. Changing load capacities for slings with varying leg configurations.

It cannot be repeated often enough that the safe working load of any sling depends on the sling's condition. A sling in obvious need of repair should not be used at all, and slings in frequent use should have thimble splices at the sling ends to materially reduce wear. It is essential that the people who work with slings be able to judge their condition and relate the load capacity to that condition.

ACTIVITY 10:

(Mark these statements True or False.)

1. ____ The efficiency of rope connections and attachments has to be taken into consideration when figuring the safe load limit of a sling.

2. ________ Swaged sockets are less resistant to fatigue than are zinc-poured sockets.

3. ________ The diameter of the rope is a factor in the efficiency of hand-tucked splices.

4. ________ The recommended load for a sling assembly is never more than one-fifth the strength of the assembly.

5. ________ The angle formed by the ropes and the horizontal top of a load, when a sling is placed in position on a load, should never exceed 45 degrees.

OBJECTIVE 11: State the proper inspection intervals for rope slings and briefly describe points that should be checked.

In most rigging and hoisting operations slings get the roughest wear, and the inspection of slings is one of the elements vital to their safe and proper use. Rope slings should be inspected daily, or more often if needed. Riggers and persons handling loads should inspect slings daily, before using them, and at any other time during the working day when a sling undergoes excessive shock loading or is subjected to any use that could contribute to more than regular wear. Inspection does not mean merely looking things over; it means examination by an employee trained in what to look for and how to look for it.

All slings in regular service should be inspected thoroughly every six months, by a person knowledgeable enough to identify all slings that do not meet minimum standards. Such slings should be immediately withdrawn from service or, if possible, reconditioned in accordance with manufacturer's recommendations.

Some of the factors that should be checked during inspection of wire ropes include the following:

- Any deterioration of end attachments.
- Exposure to excessive temperatures.
- Minimum clear lengths of rope between splices, sleeves, or end fittings.

Fiber ropes, too, should be inspected for wear around end attachments, where fiber rope slings are very subject to cutting. A fiber rope sling should be removed from service if inspection reveals any of the following:

- Abnormal wear.
- Powdered fiber between strands.
- Broken or cut fibers.
- Variations in the size and roundness of strands.
- Discoloration or rotting.
- Distortion of hardware in the sling.

Synthetic webbing slings are not difficult to inspect. If they look good, they usually are good. If they are worn, the wear is usually obvious. The eyes or end fittings wear most frequently with synthetic webbing slings, and although these can sometimes be repaired, repair should not be attempted on the job site; the sling should be sent back to the manufacturer.

There are problems that call for a synthetic webbing sling to be removed from service. These include:

- Acid or caustic burns.
- Melting or charring of any part of the sling surface.
- Snags, punctures, or cuts.
- Broken or worn stitches.
- Distortion of fittings.

In general, the inspection of a sling, regardless of type, should indicate that it is standing up under service conditions. Any indication of excessive wear is a certain clue that the sling is too weak or somehow improper and probably unsafe for its operating conditions. In such cases, inspection should lead to a review of service conditions and recommendations for a sling more suitable to the job.

ACTIVITY 11:

1. Name one area of potential wear that is common to all types of slings. ________________
2. How often should rope slings be inspected?

____

3. List six conditions that would indicate that a fiber rope sling should be removed from service.
   a. ______
   b. ______
   c. ______
   d. ______
   e. ______
   f. ______
4. Complete the following list of problems that should cause a synthetic webbing sling to be removed from service.
   a. Acid or caustic burns.
   b. ______
   c. Snags, punctures, or cuts.
   d. ______
   e. ______

OBJECTIVE 12: Discuss and differentiate between the four types of metal chains.

While it is true that wire ropes rather than chain should generally be used in rigging, there are some situations that call for the use of chains.

One case in which chains have the advantage over wire ropes is in lifting rough loads such as heavy castings. Wire rope slings weaken quickly in this kind of service because of the sharp bends over the edges of castings, but chain slings grip such loads well.

Certain qualities render chains more suitable for certain jobs: chains will withstand rough handling, will not kink, are easily stored, and have dead flexibility. Chains even resist abrasion and corrosion better than wire rope. However, chains should be selected carefully, since they come in several grades and types, each of which is designed for specific service.

Alloy steel chains are the only chains suitable for general construction work, and particularly for hoisting. These chains are made of heat-treated alloy steel and they are the strongest chains commonly available. They can tolerate temperatures up to 500°F without a reduction in safe working load. Alloy steel chains can be used even at 1000°F temperature although the reduction in safe working load is then 50%.

Heat-treated carbon steel is sometimes used for chain slings. Slings made from heat-treated carbon steel are exceptionally strong and have high impact resistance. Like alloy steel chains, they also have a high resistance to abrasion.

Proof coil chains are the kinds most often seen in the local hardware store. They can be used for various purposes so long as their use would not endanger life or result in serious property damage if they failed. Proof coil chain should never be used for slings.

There is yet another variety of chains that are made from specialized or exotic metals. Some are made from stainless steel, monel metal, and bronze. Essentially, these chains are used where resistance to corrosive substances is required or where their other special qualities would serve to good advantage.

ACTIVITY 12:

1. What are the only types of chains suitable for general construction work and particularly for hoisting? ______________________________

   ____

2. List three other types of metal chains, giving one quality of each.

   a. ______________________________

   b. ______________________________

   c. ______________________________

OBJECTIVE 13: Describe five points of the inspection that should be carried out daily on chains.

The causes of most chain failures can usually be detected before failure occurs. A regular inspection schedule must be set up and a proper inspection procedure must be followed if chain failure is to be prevented. The basic inspection rule is that chains that are used daily should be inspected daily. The inspection should be made link-by-link in order to detect any of the following:

- Bent links.
- Cracks in weld areas, shoulders, or in any other section of the link.
- Transverse nicks and gouges.
- Corrosion pits.
- Elongation caused by stretching.

Stretching (or elongation) is a big problem with chains, and its detection requires careful inspection. This means that enough links must be examined that elongation can truly be detected. The maximum allowable wear at any point of a link is related to the chain size, and the table of allowable wear is shown in Table 1.

TABLE 1. MAXIMUM ALLOWABLE WEAR TO ANY POINT OF LINK.

Chain Size (inches)	Maximum Allowable Wear (inch)	Chain Size (inches)	Maximum Allowable Wear (inch)
1/4	3/64	1	3/16
3/8	5/64	1 1/8	7/32
1/2	7/64	1 1/4	1/4
5/8	9/64	1 3/8	9/32
3/4	5/32	1 1/2	5/16
7/8	11/64	1 3/4	11/32

Beyond daily inspections, some safety authorities recommend that all chains used regularly be inspected by a skilled operator no less than once a month. In all cases, chains in regular use should be inspected every six months by an experienced inspector.

ACTIVITY 13:

1. State the basic inspection rule for chains.

___

___

2. Link by link inspection should detect any of the following five problems:

a. ___

b. ___

c. ___

d. ___

e. ___

OBJECTIVE 14: Outline seven safe working practices when using chains and chain slings.

Regular inspection ensures that a chain or chain sling will render safe service. Safe working practices with chains and chain slings promotes longer chain life, saves money, and makes rigging and hoisting activities easier. But most of all, safe working practices contribute greatly to the prevention of chain failure. Some of the most important considerations in working with chains and chain slings are included in the following list:

- Never splice a chain by inserting a bolt between two links.
- Never put a strain on a kinked chain; take up the slack slowly and see that every link in the chain seats properly.
- Never use a hammer to force a hook over a chain link.
- Never remove an identification tag from a chain.
- Avoid decreasing the angle between the legs of a chain sling and the horizontal; this increases the load in the legs.
- Never set the load on the point of the hook; set the load in the bowl of the hook.
- Never use chain attachments such as rings, shackles, couplings, or end links that are not specifically designed for the chain to which they are attached.

The way a chain is stored will affect its service life and service safety; consequently, all chains should be stored where they will be safe from corrosion or any mechanical damage.

ACTIVITY 14:

List four safe working practices with chains. Begin each rule with "Never."

1. ____

____

2. ____

____

3. ____

____

4. ____

____

OBJECTIVE 15: Describe the inspection, testing, repairing and attachment mechanisms for alloy steel chains.

The regular inspection of chains and chain slings is basic to their safe use. Beyond the daily check done by personnel working with chains and slings, there is the thorough inspection that should be carried out every six months. For this inspection, a skilled inspector is required. The chain's condition must be accurately determined, and to do this, the inspector uses special devices and procedures.

First, the inspector cleans the chain thoroughly in a solvent solution and lays it out on a clean surface or hangs it up in a well-lit area. Then, he or she uses a magnifying glass to inspect every link. The inspector has available a card that relates the life history of the chain, especially the measured length of the chain when new. With this information the inspector can measure the chain after a specified use period, perhaps two months, and determine exactly how much the chain has stretched. The information is a guideline to how long the chain will be serviceable; it may indicate that the chain should be taken out of service immediately.

A skilled inspector also looks for bent, twisted, or cracked links in a chain. If a crack is suspected, the link is soaked in a thin oil and then wiped dry. After that, a coating of white chalk is put on the link and allowed to stay there for a few hours. If there is a crack in the link, the thin oil that was first used works its way out of the link and discolors the white chalk. In this way, the skilled inspector finds a cracked link that even months of daily visual inspections can never reveal.

A skilled inspector never resorts to visual guessing. A caliper is used to determine link wear at the point where links bear on each other. When this check is finally finished, the degree of wear at the most badly worn link is the factor that decides whether the chain should be discarded, repaired, or left in service with specifications that its load limits be decreased.

Information concerning the basic testing of the chain at the time of its manufacture is used to make a judgment of the chains serviceability.

Just as wire and fiber ropes can be properly spliced and continue in service, so chains can be repaired and continue in service. The big difference is that wire and fiber ropes can be spliced on the job, while no one should ever attempt to weld an alloy steel chain that needs repair. Because alloy chains are heat-treated at the time of manufacture, the heat from even electric welding would destroy the temper of the chain and make it unserviceable. Alloy steel chains that need repair should always be sent back to the manufacturer.

Since the strength and durability of alloy steel chains is almost in the bragging category, it is logical that lifting attachments for chains and chain slings are constructed of alloy steel, too. In fact, most lifting attachments are made of forged alloy steel, including attachments for wire and fiber slings. Such attachments include eye hooks, shank hooks, swivel hooks, rings, master links, end links, and swivels of all types. Chains and chain slings are used most frequently in straight vertical lifting; therefore, rings, links, and hooks are extremely important items. Attachments made of any material other than forged alloy steel should never be used with chains.

In fact, job or shop hooks and links, or makeshift fasteners, formed from bolts, rods, or other such attachments, must not be used. The attachments have to be as strong as the alloy steel chains themselves.

ACTIVITY 15:

List four procedures that a skilled inspector will use in a check of chains.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

OBJECTIVE 16: Describe storage procedures and identification methods for steel alloy chains.

Maintaining alloy steel chains properly contributes to long and safe serviceability of the chains. Chains or chain slings covered with dirt and grease should be cleaned with a light solvent and wiped dry. Cleaning is especially important when a chain or sling has been exposed to any chemical or agent that could promote deterioration or corrosion. A chain wet from rain should always be dried before it is stored.

Maintaining attachments may sometimes mean replacing them, but this is often practical in terms of economics as well as safety. Faulty hitches and slipping hook-ups can create impact conditions that significantly add to the stress in a chain. When attachments are properly maintained and properly used, such attachments contribute to the service life of chains and chain slings.

The rule for storing alloy steel chains is a simple one: they should be stored where they will not be damaged, or subject to moisture or dampness that could cause corrosion. A chain should not be carelessly thrown into a storage area, particularly if the chain is greasy or dirty. When they are not too cumbersome, chain slings should be placed on sturdy pegs where they can hang free, so long as they are not exposed to moisture or other corrosive agents.

One final area that should be studied concerning alloy steel chains and chain slings is their identification. In most alloy steel chains, every link is marked with an "A" to indicate it is alloy steel. The other significant identification is usually a tag which lists the serial number of the chain along with its maximum vertical load rating, and the date the chain was manufactured. This tag is usually securely attached to the master link as shown in Figure 16.

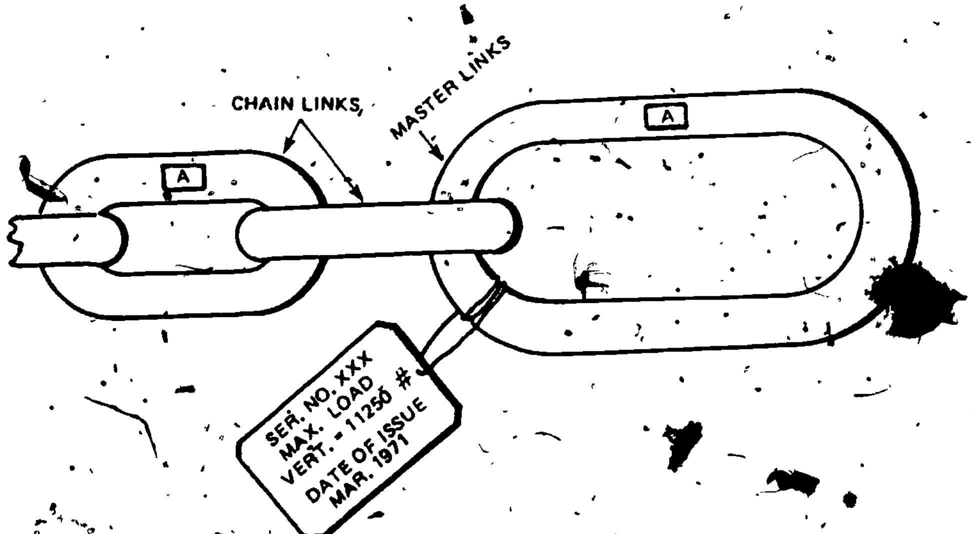

Figure 16. Identification tag attached to master link.

ACTIVITY 16:

1. What should be done with chains that are covered with dirt or grease? ______________________

   ____

2. What two identification methods exist for steel alloy chains?

   a. ______________________

   b. ______________________

OBJECTIVE 17: Identify the advantages and disadvantages of metal and nylon mesh slings.

Metal mesh and nylon mesh slings are widely used in modern industry because they are both strong and dependable when selected for the types of service for which they are intended.

Metal mesh slings are especially suitable for loads that are abrasive; loads that are hot, or loads that would cut fabric slings and wire ropes. Because of the smooth, flat, bearing surfaces of metal mesh slings, (see Figure 17), they readily conform to loads with irregular shapes. They grip

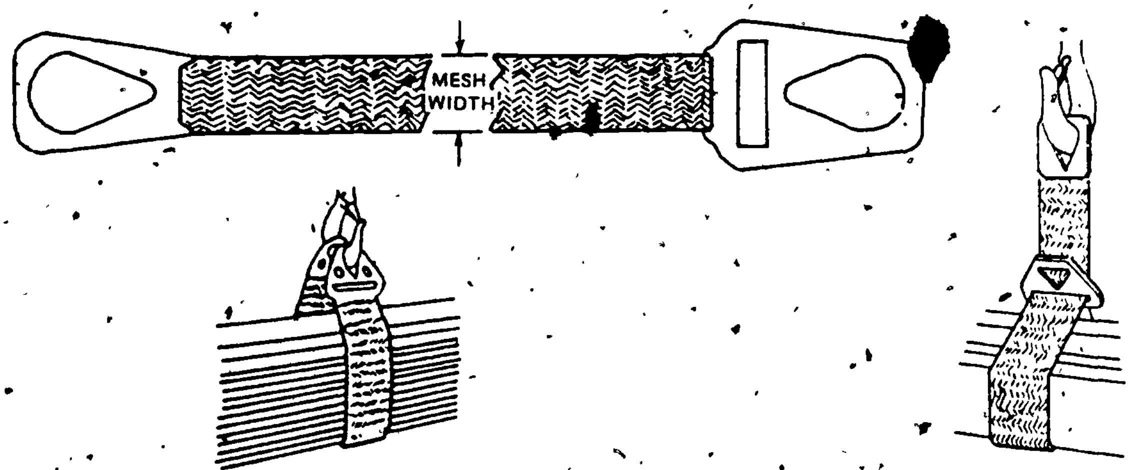

Figure 17. Metal mesh slings.

the load firmly and can withstand temperatures up to 5000°F. Even though metal mesh slings resist corrosion and will not kink or tangle, they must still be selected only for the service for which they were intended. Sling type and service capability are generally listed in the following three categories:

1. 10 gage mesh — For heavy duty general purpose lifting.
2. 12 gage mesh — For medium duty applications.
3. 14 gage mesh — For light duty applications.

The only disadvantages of metal mesh slings stem from their improper use. Faulty loading can damage the spirals at the edges of a metal mesh sling; dragging a sling out from under a load can cause excess wear to the spiral and tends to reduce wire diameter to a point that the sling will have to be removed from service.

Safe lifting loads for metal mesh slings are stamped on the handles of the slings, and these load limitations should always be respected. When a metal mesh sling is placed into service where it will be subject to excessive abrasion or cutting, it should be coated with a rubber and plastic coating to protect the sling, thereby increasing its service life.

One definite advantage of using nylon mesh slings is that they are inexpensive; another is that they are lightweight. Also, the smooth surface of nylon slings makes them outstanding in one particular area. They are literally made to order for the lifting of polished metal, and in service of this nature they are widely accepted. (See Figure 18.) However, nylon slings do have limitations that require their service to be carefully correlated to their capacity. In no case should a nylon sling be used to lift materials that have been heated beyond that point. Nylon can be dangerous when used around machinery, even steel racks, as it is very subject to being cut by sharp-edged metals. Wear pads can be installed to reduce the risk of severing, but nylon is always subject to this taut cutting hazard. All metal mesh and nylon slings should be used with a safety factor of five.

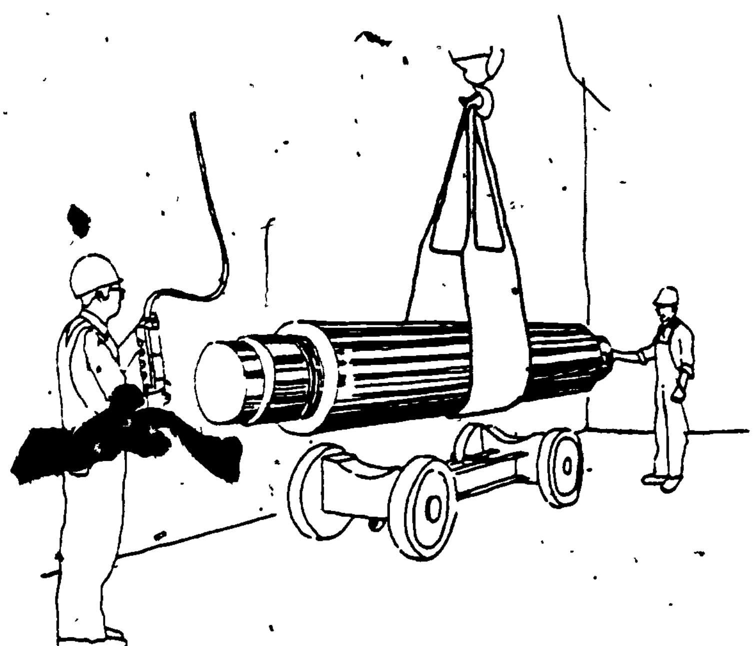

Figure 18. Nylon slings are outstanding in the area of lifting polished metal.

ACTIVITY 17:

1. List three advantages of metal mesh slings:
   a. ______________________
   b. ______________________
   c. ______________________
2. List three advantages of nylon mesh slings:
   a. ______________________
   b. ______________________
   c. ______________________
3. If a load has a temperature of 350°F is to be lifted, which sling would be chosen?
   a. Metal mesh.
   b. Nylon mesh.

OBJECTIVE 18: Name four safe work practices that should be followed when using metal and nylon mesh slings.

To ensure safe working conditions and to prolong the service life of both metal mesh and nylon mesh slings, they should never be overloaded. When the weight of a load cannot be correctly estimated, a safety professional or someone skilled in materials handling should be called to check the load and approve the sling for that specific use.

The length of metal mesh slings should always be sufficient to provide the maximum practical angle between the sling leg and the horizontal. (See Figure 19.) When vertical angles are used, there should also be a minimum practical angle at the crane hook.

Metal mesh slings should never be shortened with knots, bolts, or other unapproved methods. In fact, the manufacturer should be consulted before any sling is shortened. No attempt should ever be made to twist or kink the legs of a metal mesh sling, or to use a sling when the spirals are locked. This is because a sudden jolt could break a spiral, cause the load to shift, and create an extremely dangerous situation on the floor below the load. Another

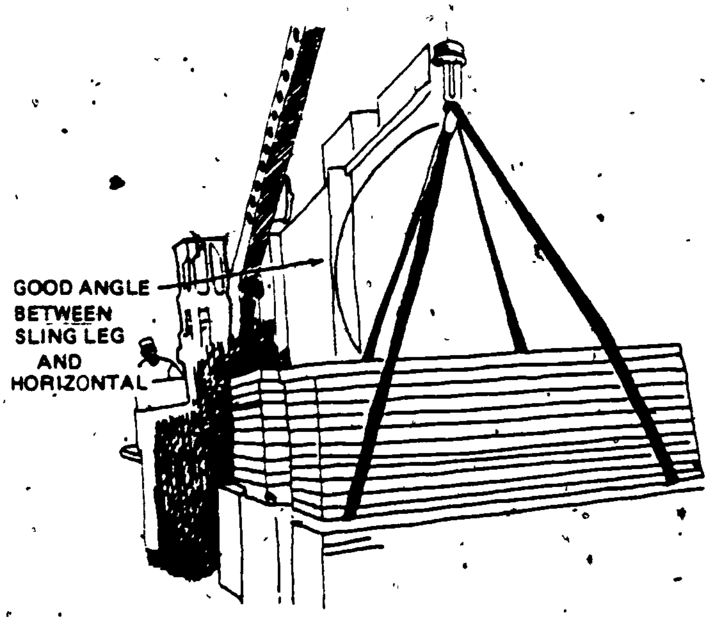

Figure 19. The maximum practical angle between sling leg and the horizontal should be provided.

extremely important rule about metal mesh slings is that a hammer should NEVER be used to straighten a spiral or a cross rod. Hammering spirals or rods causes immediate damage to the sling, reduces its capabilities, and shortens the sling's service life.

All rules for safe hookups and hitches that apply to other types of slings apply to both metal mesh and nylon mesh slings. Short cuts or makeshift hookups create immedicate safety hazards as well as stresses for which the slings were not designed.

Many of the rules concerning metal mesh slings apply to nylon slings as well. In addition, nylon mesh slings should be used only in environments below 180°F. Other than that, the basic rules that call for no knotting, sufficient sling length, and balancing the load apply to nylon mesh slings as they do to metal mesh slings.

A final reminder about nylon mesh sling usage is that nylon is very subject to damage from acidic or caustic materials. Metal mesh slings can be easily washed and cleaned of acid or caustic, but nylon is not as easy to clean and will deteriorate rapidly in acidic or caustic environments. Even when a nylon mesh sling has to be used around corrosive chemicals for just a short period of time, it is wise to check with the manufacturer for safe procedures and limitations.

ACTIVITY 18:

Which of the following items do not apply to metal mesh slings?

1. a. A hammer should never be used to straighten a spiral.
   b. Do not shorten the sling with knots.
   c. Use only in environments below 180°F.
   d. These slings are easily washed and cleaned of acid or caustic.
2. State the rule basic to prolonging the life of metal mesh and nylon mesh slings.

   ____

   ____

REFERENCES

Construction Safety Association of Ontario. Rigging Manual. 1st ed. 1975.

National Safety Council. Accident Prevention Manual for Industrial Operations. Chicago: 7th ed. 1978.

________ Supervisors Safety Manual. Chicago: 5th ed. 1978.

U.S. Department of Labor. Safety and Health Regulations for Construction. Revised February 9, 1979. OSHA Safety and Health Standards (29 CFR 1926.)

ANSWERS TO ACTIVITIES

ACTIVITY 1

1. a. Load shifting.
   b. Lifting angle.
   c. Swing out of control (through the air); fall.
2. a. Placing hands between a sling and a load while the sling is being tightened.
   b. Pulling a sling from under a load when the load is resting on the sling.

c. Loads with sharp edges.

d. Poorly designed slings.

e. Bad weather conditions.

f. Electrocution.

ACTIVITY 2

1. a. Prior to use at the beginning of each shift and as necessary during use.

   b. So it will not present a hazard to workers.

   c. (1) They should be marked to indicate safe working loads.
      (2) They should be proof-tested to use up to 125 percent of their rated load.

2. Any six of the thirteen listed on page 9.

ACTIVITY 3

1. Sisal and manila.

2. d. Nylon

3. Stretch; effects of temperature; ability to release (play out); ability to take shock loads; ability to sustain dead loads; flexing endurance (ability to take repeated bending); insulating ability.

ACTIVITY 4

1. a. Do not store manila rope in the sun.

   b. Do not drag ropes along the ground.

   c. Do not recoil a dirty rope.

2. b. Nylon

3. Synthetic ropes.

ACTIVITY 5

(Any nine.)

1. Wear.
2. Abrasion.
3. Broken or cut fibers.
4. Displacement of yarn or strands.
5. Variation in size of strands.
6. Discoloration.
7. Rotting.
8. Broken yars.
9. Excessively loose yarns.

10. An accumulation of powder-like dust.

11. Inside yarns which pull out easily.

ACTIVITY 6

1. Every strand in a wire rope must fail before it breaks; if one link in a chain fails, the entire chain fails.

2. a. They are made from large number of wires.
   b. The wires are continuous in any given length of rope.

ACTIVITY 7

1. Wind from the top of one reel to the top of the other reel, or from the bottom of one reel to the bottom of another.

2. (Any four.)
   a. Corrosion.
   b. Fatigue due to excessive bending sbresses.
   c. Drying out of lubrication.
   d. Overloading.
   e. Overwinding tension from shock loads.

ACTIVITY 8

1. With a rope caliper or a micormeter.

2. a. (Severe) Kinking.
   b. High stranding.
   c. Loose wires.
   d. Nicking.
   e. Lack of proper lubrication.

ACTIVITY 9

1. Properly manufactured wire rope slings.

2. a. Where explosives are in use.
   b. When hoisting ornamental concrete or finished stone.

ACTIVITY 10

1. True.
2. False.
3. True.
4. True.
5. False

ACTIVITY 11

1. Around end attachments.
2. Daily, or more often, as needed.
3. a. Abnormal wear.
   b. Powdered fiber between strands.
   c. Broken or cut fibers.
   d. Variations in the size and roundness of strands.
   e. Discoloration or rotting.
   f. Distortion of hardware in the sling.
4. b. Melting or charring of any part of the sling surface.
   d. Broken or worn stitches.
   e. Distortion of fitti

ACTIVITY 12

1. Alloy steel chains.
2. a. Heat-treated carbon steel.
   b. Proof coil chains.
   c. Exotic metals (stainless steel, monel steel, bronze).

ACTIVITY 13

1. Chains used daily should be inspected daily.
2. a. Bent links.
   b. Cracks in weld areas shoulders, or in any other section of the link.
   c. Transverse nicks and gouges.
   d. Corrosion pits.
   e. Elongation caused by stretching.

ACTIVITY 14

(Any four.)

1. Never splice a chain by inserting a bolt between two links.
2. Never put a strain on a kinked chain.
3. Never use a hammer to force a hook over a chain link.
4. Never remove an identification tag from a chain.
5. Never decrease the angle between the legs and the horizontal.
6. Never set the load on the point of the hook.
7. Never use chain attachments which are not designed for the chain to which they are attached.

ACTIVITY 15

(Any fo[illegible]

1. a. Tho[illegible] cleaning in a solvent solution.

   b. Inspection of links with a magnifying glass.

   c. Measurement of the chain's length for elongation.

   d, Check for bent, twisted, or cracked links.

   e. If a crack is suspected, the link is soaked in oil and wiped dry. Then a coating of white chalk is put on the link. Oil will ooze out of any crack and discolor the chalk.

   f. A caliper is used to determine link wear at the points where links bear on each other.

ACTIVITY 16

1. They should be cleaned with a light solvent and wiped dry.

2. a. Every link is marked with an "A".

   b. A tag listing the serial number of the chain and its maximum vertical load rating is attached to the master link.

ACTIVITY 17

(Any three.)

1. a. They are especially suitable for loads that are abrasive, are hot, or that would cut fabric slings and wire rope.

   b. They conform readily to loads with irregular shapes.

   c. They can withstand tmeperatures up to 5000°F.

   d. They resist corrosion, and will not kink or tangle.

2. a. They are inexpensive.

   b. They are lightweight.

   c. They are superb for lifting polished metal.

3. a. Metal mesh.

ACTIVITY 18

1. c. Use only in environments below 180°F.

2. They should never be overloaded.