Slings: Chain, Web, and Wire Rope

Introduction

In technical rescue there is many times where we need to move a load or attach to it for stabilization, these loads are normally heavy and range from passenger vehicles to concrete slabs to heavy machinery and everything in between. So that we may perform these functions safely we use many of the tools used in heavy rigging, specifically slings. Slings enable us to create anchors, attach to loads, lift loads, pull loads, and lower loads. The use of slings in technical rescue allows for the safe and efficient mitigation of the rescue incident.

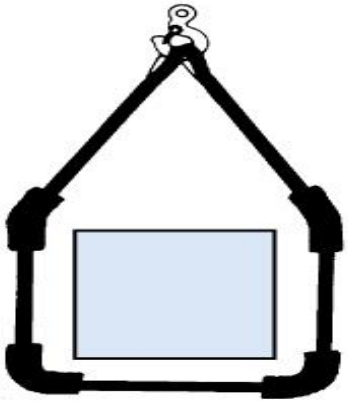
The dominant characteristics of a sling are determined by the components of that sling. For example, the strengths and weaknesses of a wire rope sling are essentially the same as the strengths and weaknesses of the wire rope of which it is made.

Slings are generally one of six types: chain, wire rope, metal mesh, natural fiber rope, synthetic fiber rope, or synthetic web. In general, use and inspection procedures tend to place these slings into three groups: chain, wire rope and mesh, and fiber rope web. Each type has its own particular advantages and disadvantages. Factors that should be taken into consideration when choosing the best sling for the job include the size, weight, shape, temperature, and sensitivity of the material to be moved, as well as the environmental conditions under which the sling will be used for rescue operations chain and synthetic web slings see the majority of use. While wire rope does have its place in rescue it is mainly used in winching operations.

Definitions

Angle of loading is the inclination of a leg or branch of a sling measured from the horizontal or vertical plane, provided that an angle of loading of five degrees or less from the vertical may be considered a vertical angle of loading.

Basket hitch is a sling configuration whereby the sling is passed under the load and has both ends, end attachments, eyes or handles on the hook or a single master link.



Braided wire rope is a wire rope formed by plaiting component wire ropes.

Braided wire rope sling is a sling composed of multiple wire rope legs with the top ends gathered in a fitting that goes over the lifting hook

Breaking Strength/Ultimate Strength Do not use breaking strength as a criterion for service or design purposes. Refer to the Working Load Limit instead. Breaking Strength is the average force at which the product, in the condition it would leave the factory, has been found by representative testing to break, when a constantly increasing force is applied in direct line to the product at a uniform rate of speed on a standard pull testing machine. Proof testing to twice the Working Load Limit does not apply to hand-spliced slings. Remember: Breaking Strengths, when published, were obtained under controlled laboratory conditions. Listing of the Breaking Strength does not mean the Working Load Limit should ever be exceeded.

Bridle wire rope sling is a sling composed of multiple wire rope legs with the top ends gathered in a fitting that goes over the lifting hook.

Cable laid endless sling-mechanical joint is a wire rope sling made endless by joining the ends of a single length of cable laid rope with one or more metallic fittings.

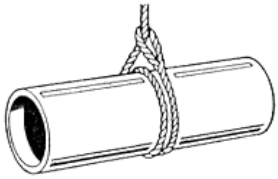
Cable laid grommet-hand tucked is an endless wire rope sling made from one length of rope wrapped six times around a core formed by hand tucking the ends of the rope inside the six wraps.

Cable laid rope is a wire rope composed of six wire ropes wrapped around a fiber or wire rope core.

Cable laid rope sling-mechanical joint is a wire rope sling made from a cable laid rope with eyes fabricated by pressing or swaging one or more metal sleeves over the rope junction.

Center: The center is the axial member of a strand about which the wires are laid. It may be cotton or polypropylene fiber or one or more wires

Choker hitch is a sling configuration with one end of the sling passing under the load and through an end attachment, handle or eye on the other end of the sling.



Coating is an elastomer or other suitable material applied to a sling or to a sling component to impart desirable properties.

Combined Patterns: When a strand is formed in a single operation using two or more of the above constructions it is referred to as a combined pattern.

Core: The core of a wire rope is the axial member around which the strands are laid to form a wire rope. It may be either steel, natural fibers, or polypropylene.

Design Factor (sometimes referred to as safety factor): An industry term usually computed by dividing the catalog Breaking Strength by the catalog Working Load Limit and generally expressed as a ratio. For example: 5:1.

Filler Wire: This construction has two layers of uniform-size wire around a center wire, with the inner layer having half the number of wires as the outer layer. Small filler wires, equal in number to the inner layer, are laid in the valleys of the inner layer.

Hitch is a sling configuration whereby the sling is fastened to an object or load, either directly to it or around it.

The LAY: The word "lay" is used to describe three physical characteristics of wire rope. It is both an engineering term and a descriptive term. Lay describes:

1. The **direction** strands "lay" in the rope – Right or Left. When you look along a rope strands of a Right Lay rope follow a right-turning pattern. Left Lay is the opposite.
2. The **relationship** between the direction strands lay in the rope and the direction wires lay in the strands. In a **regular** lay rope, wires lay opposite the direction of the strand. In a **lang** lay rope, wires lay in the SAME direction as strands.
3. The **length** along the rope which one strand uses to make one complete spiral around the rope core

Link is a single ring of a chain.

Master coupling link is an alloy steel welded coupling link used as an intermediate link to join alloy steel chain to master links.

Master link or **gathering ring** is a forged or welded steel link used to support all members (legs) of an alloy steel chain sling or wire rope sling.

Mechanical coupling link is a nonwelded, mechanically closed steel link used to attach master links, hooks, etc., to alloy steel chain.

Multiple Operation: When one of the above designs is covered with one or more layers of uniform sized wires in a different work operation. The second operation is necessary because the outer layers must have a different length of lay or direction of lay.

The grade of wire will affect such things as strength, resistance to wear, fatigue resistance, corrosion resistance, etc. The greatest portion of all wire rope is made from two grades of wire – *Improved Plow Steel* (IPS) and *Extra Improved Plow Steel* (XIP). Both are tough, strong, wear resistant carbon steel, with XIP providing about 15% greater tensile strength.

Sometimes wire is plated or galvanized before strands are formed, where special corrosion or wear characteristics are desired. Most wire is "Bright" – that is, without any surface coating or treatment.

Proof Test Load (Proof Load) The term "Proof Test" designates a quality control test applied to the product for the sole purpose of detecting defects in material or manufacture. The Proof Test Load (usually twice the Working Load Limit) is the load which the product withstood without deformation when new and under laboratory test conditions. A constantly increasing force is applied in direct line to the product at a uniform rate of speed on a standard pull testing machine. The Proof Test Load does not mean the Working Load Limit should ever be exceeded.

Rated capacity or **working load limit** is the maximum working load permitted by the provisions of this section.

Reach is the effective length of an alloy steel chain sling measured from the top bearing surface of the upper terminal component to the bottom bearing surface of the lower terminal component.

Rope: A number of strands helically laid around a core to form a rope.

Seale: Two layers of wires are formed around the center core wire, with the same number of wires in each layer. All wires in each layer are the same diameter, and the strand is designed so that the large outer wires rest in the valleys between the smaller inner wires.

Standard Rope Classifications
Most common wire rope constructions are grouped into four standard classifications, based on the number of strands and wires per strand. All ropes of the same size and wire grade in each classification have the same strength and weight ratings. Ropes within each classification may differ in working characteristics such as abrasion and fatigue resistance.

Classification	Wires per strand
6 x 7	7
6 x 19	16 through 26
6 x 37	27 through 49
8 x 19	16 through 26

Selvage edge is the finished edge of synthetic webbing designed to prevent unraveling.

Shock Load results from rapid change of movement, such as impacting, jerking, or swinging of a static load. Sudden release of tension is another form of shock loading. Shock loads are generally significantly greater than static loads. Any shock loading must be considered when selecting the item for use in a system. Avoid shock loads as they may exceed the Working Load Limit.

Single Layer: Single wire center with six wires of the same diameter around it. It is called a 7 wire (1-6) strand

Sling is an assembly which connects the load to the material handling equipment.

Sling-To-Load Angle is the horizontal angle formed between the sling leg and the "top" of the load.

Strand: A strand is a plurality of round or shaped wires helically laid around a center in one or more layers.

Vertical hitch is a method of supporting a load by a single, vertical part or leg of the sling.

Warrington: 2 layer construction with uniform sized wires in the inner layer, and two diameters of wire alternating large and small in the outer layer. The larger outer layer wires rest in the valleys, and the smaller ones on the crowns of the inner layer.

Wire the basic element of a wire rope is a single metallic wire it may be either round or shaped

Working Load Limit (WLL) is the maximum load which should ever be applied to the product, even when the product is new and when the load is uniformly applied - straight line pull only. Avoid side loading. All catalog ratings are based upon usual environmental conditions and consideration must be given to unusual conditions such as extreme high or low temperatures, chemical solutions or vapors, prolonged immersion in salt water, etc. Never exceed the Working Load Limits.

Safety Precautions

The operator must exercise intelligence, care, and common sense in the selection and use of slings. Slings must be selected in accordance with their intended use, based upon the size and type of load and the environmental conditions of the workplace. All slings must be visually inspected before use to ensure that there is no obvious damage.

A well-trained operator can prolong the service life of equipment and reduce costs by avoiding the potentially hazardous effects of overloading equipment, operating it at excessive speeds, taking up slack with a sudden jerk, and suddenly accelerating or decelerating equipment. The operator can look for causes and seek corrections whenever a danger exists. He or she should cooperate with co-workers and supervisors and become a leader in carrying out safety measures - not merely for the good of the equipment and the production schedule, but, more importantly, for the safety of everyone concerned

Storage

Usage

There are four primary factors to take into consideration when safely lifting a load. They are (1) the size, weight, and center of gravity of the load; (2) the number of legs and the angle the sling makes with the horizontal line; (3) the rated capacity of the sling; and (4) the history of the care and usage of the sling.

Size, Weight, and Center Gravity of the Load

Determining the weight of the load to be lifted, pulled, and/or stabilized is the most important step in rigging. The capacity of the sling must never be exceeded. After the weight of the load has been determined then the proper rigging equipment can be selected.

Properly rigging a load so that it is stable is a critical step. A stable load is one in which the center of gravity of the load is directly below or in line with the main hook. The center point of an object is that point at which the object will balance. The entire weight may be considered as concentrated at this point.

Number of Legs and Angle with the Horizontal:

As the angle formed by the sling leg and the horizontal line decreases, the rated capacity of the sling also decreases. In other words, the smaller the angle between the sling leg and the horizontal, the greater the stress on the sling leg and the smaller (lighter) the load the sling can safely support. Larger (heavier) loads can be safely moved if the weight of the load is distributed among more sling legs.

Rated Capacity of the Sling:

The rated capacity of a sling varies depending upon the type of sling, the size of the sling, and the type of hitch. Operators must know the capacity of the sling. Charts or tables that contain this information generally are available from sling manufacturers. The values

given are for new slings. Older slings must be used with additional caution. Under no circumstances shall a sling's rated capacity be exceeded.

History of Care and Usage
Mishandling and misuse of slings are the leading causes of accidents involving their use. The majority of injuries and accidents, however, can be avoided by becoming familiar with the essentials of proper sling care and usage.

Proper care and usage are essential for maximum service and safety. Slings must be protected from sharp bends and cutting edges by means of cover saddles, burlap padding, or wood blocking, as well as from unsafe lifting procedures such as overloading.

When selecting a sling to handle a load, always consider the sling-to-load angle and the tension that is applied to the sling, as a result of the angle. Slings with adequate work load limits to handle the "scale" weight of an object have catastrophically failed because of an inadequate consideration of the sling angle and the resultant tension. Sling failure results in injury, death and/or property damage. Please rig all loads, responsibly, by always considering the angle, the resultant tension, and the actual strength requirements of the sling.

Before making a lift, check to be certain that the sling is properly secured around the load and that the weight and balance of the load have been accurately determined. If the load is on the ground, do *not* allow the load to drag along the ground. This could damage the sling. If the load is already resting on the sling, ensure that there is no sling damage prior to making the lift.

Next, position the hook directly over the load and seat the sling squarely within the hook bowl. This gives the operator maximum lifting efficiency without bending the hook or overstressing the sling.

Wire rope slings are also subject to damage resulting from contact with sharp edges of the loads being lifted. These edges can be blocked or padded to minimize damage to the sling.

After the sling is properly attached to the load, there are a number of good lifting techniques that are common to all slings:

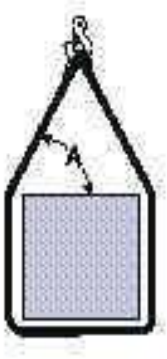
- Guard against shock loading by taking up the slack in the sling slowly. Apply power cautiously so as to prevent jerking at the beginning of the lift, and accelerate or decelerate slowly.
- Check the tension on the sling. Raise the load a few inches, stop, and check for proper balance and that all items are clear of the path of travel. Never allow anyone to ride on the hood or load.
- Keep all personnel clear while the load is being raised, moved, or lowered. Operators should watch the load at all times when it is in motion.

The sling-to-load angle is formed when slings are rigged in vertical or bridle configurations. As the value of the angle decreases, so does the actual work load limit of the sling. You can determine whether a sling will have adequate capacity to handle a given load weight.

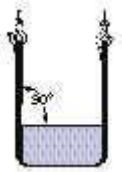
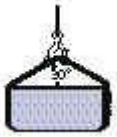
1) Calculate the sling-to-load angle
2) Determine the loss factor
3) Multiply the work load limit by the loss factor to determine the actual (reduced) sling work load limit.

As illustrated below increased load stress is magnified by any change from vertical toward horizontal lifting. The same stresses are imposed on sling legs when the legs are attached to the load at various angles.

The result is the actual and reduced work load limit. Sling angles of less than 45Þ should not be used.



ANGLE "A" DEGREES	LOSS FACTOR	ANGLE "A" DEGREES	LOSS FACTOR
90	1.000	55	.8192
85	.9962	50	.7660
80	.9848	45	.7071
75	.9659	40	.6428
70	.9397	35	.5736
65	.9063	30	.5000
60	.8660	25	.4226

A BASKET WORK LOAD LIMIT OF 10,000 LBS. CHANGES AS THE SLING-TO-LOAD ANGLE CHANGES: AT 90º-WORK LOAD LIMIT =10,000 LBS. AT 60º-WORK LOAD LIMIT = 8,660 LBS. AT 45º-WORK LOAD LIMIT = 7,071 LBS. AT 30º-WORK LOAD LIMIT = 5,000 LBS.				
SLING-TO-LOAD ANGLE (DEGREES)	**90º**	**60º**	**45º**	**30º**
WORK LOAD LIMIT X LOSS FACTOR	**10,000 LBS. X 1.000**	**10,000 LBS. X .866**	**10,000 LBS. X .7071**	**10,000 LBS. X .500**
ACTUAL SLING WORK LOAD LIMIT	**10,000 LBS.**	**8660 LBS.**	**7071 LBS.**	**5000 LBS**

Once the lift has been completed, clean the sling, check it for damage, and store it in a clean, dry and well ventilated location. It is best to hang it on a rack or wall. Remember that damaged slings cannot lift as much as new or well-cared for older slings. Safe and proper use and storage of slings will increase their service life.

RATED CAPACITY (WORKING LOAD LIMIT), FOR ALLOY STEEL CHAIN SLING; RATED CAPACITY (WORKING LOAD LIMIT), POUNDS

Chain Size, Inches	Single Branch Sling 90 Degree Loading	Double Sling			Triple & Quadruple Sling (3)		
		Vertical Angle (1)			Vertical Angle (1)		
		30 Degrees	45 Degrees	60 Degrees	30 Degrees	45 Degrees	60 Degrees
		Horizontal Angle (2)			Horizontal Angle (2)		
		60 Degrees	45 Degrees	30 Degrees	60 Degrees	45 Degrees	30 Degrees
1/4"	3,250	5,650	4,550	3,250	8,400	6,800	4,900
3/8"	6,600	11,400	9,300	6,600	17,000	14,000	9,900
1/2"	11,250	19,500	15,900	11,250	29,000	24,000	17,000
5/8"	16,500	28,500	23,300	16,500	43,000	35,000	24,500
3/4"	23,000	39,800	32,500	23,000	59,500	48,500	34,500
7/8"	28,750	49,800	40,600	28,750	74,500	61,000	43,000
1"	38,750	67,100	54,800	38,750	101,000	82,000	58,000
1 1/8"	44,500	77,000	63,000	44,500	115,500	94,500	66,500
1 1/4"	57,500	99,500	81,000	57,500	149,000	121,500	86,000
1 3/8"	67,000	116,000	94,000	67,000	174,000	141,000	100,500
1 1/2"	80,000	138,000	112,500	80,000	207,000	169,000	119,500
1 3/4"	100,000	172,000	140,000	100,000	258,000	210,000	150,000

(1) Rating of multileg slings adjusted for angle of loading measured as the included angle between the inclined leg and the vertical.
(2) Rating of multileg slings adjusted for angle of loading between the inclined leg and the horizontal plane of the load.
(3) Quadruple sling rating is same as triple sling because normal lifting practice may not distribute load uniformly to all 4 legs.

TABLE N-184-2

MINIMUM ALLOWABLE CHAIN SIZE AT ANY POINT OF LINK			
Chain Size, Inches	**Minimum Allowable Chain Size, Inches**	**Chain Size, Inches**	**Minimum Allowable Chain Size, Inches**
1/4"	13/64"	1"	13/16"
3/8"	19/64"	1 1/8"	29/32"
1/2"	25/64"	1 1/4"	1"
5/8"	31/64"	1 3/8"	1 3/32"
3/4"	19/32"	1 1/2"	1 3/16"
7\8"	45/64"	1 3/4"	1 13/32"

Summary

There are good practices to follow to protect you and all personnel working on the scene while using slings to move materials. First, learn as much as you can about the materials with which you will be working. Slings come in many different types, one of which is right for your purpose. Second, analyze the load to be moved - in terms of size, weight, shape, temperature, and sensitivity - then choose the sling which best meets those needs. Third, always inspect all the equipment before and after a move. Always be sure to give equipment whatever "in service" maintenance it may need. Fourth, use safe lifting practices. Use the proper lifting technique for the type of sling and the type of load

Chain Slings

Chains are commonly used because of their strength and ability to adapt to the shape of the load. Care should be taken, however, when using alloy chain slings because they are subject to damage by sudden shocks. Misuse of chain slings could damage the sling, resulting in sling failure and possible injury to an employee.

Chain slings are your best choice for lifting materials that are very hot. They can be heated to temperatures of up to 1000^{o}F; however, when alloy chain slings are consistently exposed to service temperatures in excess of 600^{o}F, operators must reduce the working load limits in accordance with the manufacturer's recommendations.

All sling types must be visually inspected prior to use. When inspecting alloy steel chain slings, pay special attention to any stretching, wear in excess of the allowances made by the manufacturer, and nicks and gouges. These are all indications that the sling may be unsafe and is to be removed from service.

Types of chain slings

In describing the type, the following symbols should be used. If attachments are other than standard, give detailed specifications.

First symbol (basic type):
S - Single chain sling.
C - Single choker chain sling with a standard end link on each end, no hooks.
D - Double branch chain sling.
T - Triple branch chain sling.
Q - Quadruple branch chain sling.

Second symbol (type of master link or end link):
0 - Oblong master link of standard dimensions.
P - Pear shaped master link (available on request, not a standard item).

Third symbol (type of hook):
S - Sling hook
G - Grab hook

F - Foundry hook
L - Latchlok

Sling tags are coded with numerals 1 through 4 to reflect number of branches in sling. Additional coding is defined as follows:
AS - Adjustable single
SB - Single basket
ES - Endless single
ED - Endless double
SAL - Single adjustable
DAL - Double adjustable loop
AD - Adjustable double

DB - Double basket

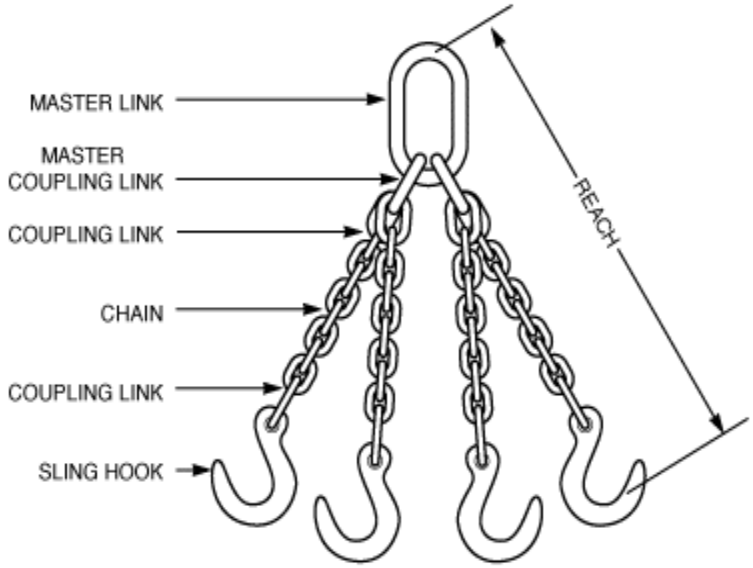


FIG. N-184-3 MAJOR COMPONENTS OF A QUADRUPLE SLING

CO Oblong Link both ends

SOG Oblong Link Clevis Grab Hook

SOS Oblong Link Clevis Sling Hook

SGS Clevis Sling Hook Clevis Grab Hook

SSS Clevis Sling Hook both ends

SGG Clevis Grab Hook both ends

SOSSL Oblong Link Swivel Safety Latch Hook

SOCSL Oblong Link Clevis Safety Latch Hook

SSCSL Sling Hook Clevis Safety Latch Hook

SGCSL Clevis Grab Hook Safety Latch Hook

A-SOS-A
Oblong Eye Grab Clevis Hook

A-SOS-B
Link Hook Sling

Oblong Clevis Hook Clevis Hook

A-SOS-SC
Link Grab Shortening Clutch Sling

Oblong Clevis Hook Clevis Hook

A-SOCSL-B
Link Safety Latch Hook Sling

Oblong Clevis Hook Clevis Hook

A-SOCSL-SC
Link Safety Latch Hook Grab

Oblong Shortening Clutch Link Hook

A-SOSSL-B
Oblong Swivel Clevis Grab Hook Safety Link Hook

A-SOSSL-SC
Oblong Swivel Shortening Clutch Safety Link Hook

Materials:
Carbon Chain – The selection of the base steel is left to the judgment of the individual chain manufacturer provided the steel meets the following criteria: Carbon, 0.35% max; phosphorous, 0.040% max.; and Sulfur, 0.050% max.

Alloy Chain – The selection and amounts of the alloying elements in the steel are left to the judgment of the individual chain manufacturer provided the steel meets the following criteria: Carbon, 0.35% max.; phosphorous, .035%% max.; Sulfur, 0.040% max. Nickel must be present in an alloying amount (0.40% min.), and at least one of the following elements must be present in an alloying amount: Chromium (.40% min.) or Molybdenum (0.15% min).

Stainless Steel Chain – The material must be a 300 series austenitic stainless steel.
Welding Process – Steel chain shall be made by electric welding or gas welding process.

Alloy steel chains

Welded alloy steel chain slings shall have permanently affixed durable identification stating size, grade, rated capacity, and sling manufacturer.

Hooks, rings, oblong links, pear-shaped links, welded or mechanical coupling links, or other attachments, when used with alloy steel chains, shall have a rated capacity at least equal to that of the chain.

Job or shop hooks and links, or makeshift fasteners, formed from bolts, rods, etc., or other such attachments, shall not be used.

Rated capacity (working load limit) for alloy steel chain slings shall conform to the values shown in Table H-1.

Whenever wear at any point of any chain link exceeds that shown in Table H-2, the assembly shall be removed from service.

Inspections

In addition to the inspection required by other paragraphs of this section, a thorough periodic inspection of alloy steel chain slings in use shall be made on a regular basis, to be determined on the basis of (A) frequency of sling use; (B) severity of service conditions; (C) nature of lifts being made; and (D) experience gained on the service life of slings used in similar circumstances. Such inspections shall in no event be at intervals greater than once every 12 months.

The employer shall make and maintain a record of the most recent month in which each alloy steel chain sling was thoroughly inspected, and shall make such record available for examination.

Other grades of proof tested steel chain include Proof Coil, BBB Coil and Hi-Test Chain. These grades are not recommended for overhead lifting and therefore are not covered by this code Footnote (1) Rating of multileg slings adjusted for angle of loading measured as the included angle between the inclined leg and the vertical.

Rating of multileg slings adjusted for angle of loading between the inclined leg and the horizontal plane of the load.

TABLE H - 2. -- MAXIMUM ALLOWABLE WEAR AT ANY POINT OF LINK

Maximum Allowable Wear At Any Point of Link	
Chain Size (inches)	Maximum Allowable Wear (inches)
1/4	3/64”
3/8	5/64
1/2	7/64
5/8	9/64
3/4	5/32
7/8	11/64
1	3/16
1 1/8	7/32
1 1/4	1/4
1 3/8	9/32
1 1/2	5/16
1 3/4	11/32

Maintenance

Chain slings must be cleaned prior to each inspection, as dirt or oil may hide damage. The operator must be certain to inspect the total length of the sling, periodically looking for stretching, binding, wear, or nicks and gouges. If a sling has stretched so that it is now more than three percent longer than it was when new, it is unsafe and must be discarded.

Binding is the term used to describe the condition that exists when a sling has become deformed to the extent that its individual links cannot move within each other freely. It is also an indication that the sling is unsafe. Generally, wear occurs on the load-bearing inside ends of the links. Pushing links together so that the inside surface becomes clearly visible is the best way to check for this type of wear. Wear may also occur, however, on the outside of links when the chain is dragged along abrasive surfaces or pulled out from under heavy loads. Either type of wear weakens slings and makes accidents more likely.

Heavy nicks and/or gouges must be filed smooth, measured with calipers, then compared with the manufacturer's minimum allowable safe dimensions. When in doubt, or in borderline situations, do not use the sling. In addition, never attempt to repair the welded components on a sling. If the sling needs repair of this nature, the supervisor must be notified.

Chain Fittings

Eye Sling Hook

Clevis Sling Hook

Eye Grab Hook

Clevis Grab Hook

Foundry Hook

Shur-Loc Eye Hook

Quick Alloy Coupling Link

Master Link Sub Assembly

Synthetic Web Slings

Synthetic web slings offer a number of advantages for rigging purposes. The most commonly used synthetic web slings are made of nylon, dacron, and polyester. They have the following properties in common:

- Strength - can handle extremely heavy loads
- Convenience - can conform to any shape.
- Safety - will adjust to the load contour and hold it with a tight, non-slip grip.
- Load protection - will not mar, deface, or scratch highly polished or delicate surfaces.
- Long life - are unaffected by mildew, rot, or bacteria; resist some chemical action; and have excellent abrasion resistance.
- Economy - have low initial cost plus long service life.
- Shock absorbency - can absorb heavy shocks without damage.
- Temperature resistance - are unaffected by temperatures up to 180^{o}F.

Each synthetic material has its own unique properties. Nylon must be used wherever alkaline or greasy conditions exist. It is also preferable when neutral conditions prevail and when resistance to chemicals and solvents is important. Dacron must be used where high concentrations of acid solutions - such as sulfuric, hydrochloric, nitric, and formic acids - and where high-temperature bleach solutions are prevalent. (Nylon will deteriorate under these conditions.) Do not use dacron in alkaline conditions because it will deteriorate; use nylon or polypropylene instead. Polyester must be used where acids or bleaching agents are present and is also ideal for applications where a minimum of stretching is important.

WEB MATERIAL - SOFT AND FLEXIBLE Web Slings are made from nylon or polymer lifting yarn that is woven into various widths and thicknesses. A tough abrasion resistant jacket yarn surrounds the lifting yarn.

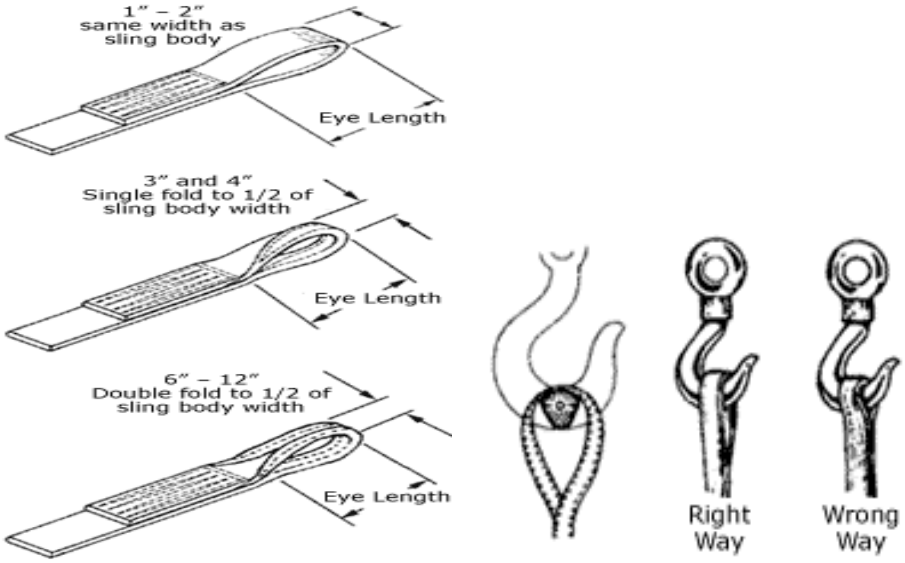
SHOCK ABSORPTION The stretching of web slings allows a cushion against sudden shock. When loaded at rated capacity, a nylon sling will stretch 6-8% and polyester 3-4% Slings return to normal length when not loaded.

Possible Defects. Synthetic web slings must be removed from service if any of the following defects exist:

- Acid or caustic burns,
- Melting or charring of any part of the surface,
- Snags, punctures, tears, or cuts,
- Broken or worn stitches,
- Wear or elongation exceeding the amount recommended by the manufacturer, or distortion of fittings.

RED WARNING CORE Red colored yarns under the jacket show when the jacket is worn or cut through and indicates that the sling should be taken out of service

Usage
A sling eye should always be 3x as long as the hook width or the pin diameter.
SLING STRENGTH OSHA standards demand that the rated capacity be noted on each sling. Check the capacity tables on this website to make sure of the strength of the sling you may need. Never exceed rated capacities of a web sling.



Type 1 : Triangle & Choker (TC) - Hardware on each end produces the most effective choker hitch. Can also be used in vertical and basket hitches.

Type 2 : Triangle & Triangle (TT) - Hardware on each end for use in basket or vertical hitch.

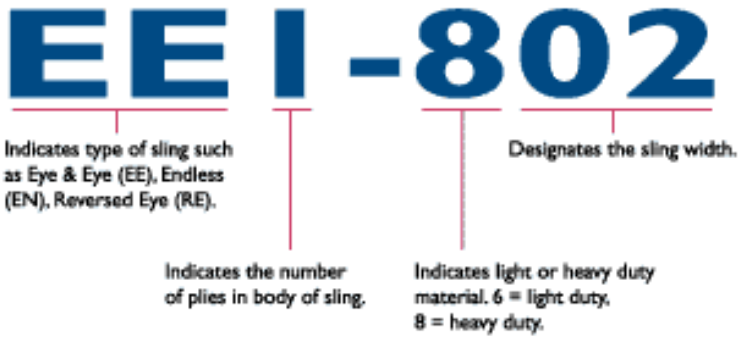
Type 3 : Flat Eye & Eye (EE) - Popular, versatile sling used in vertical, choker & basket hitches. Easy to remove from underneath loads.

Type 4 : Twisted Eye & Eye (EE) - Eyes turned at a right angle to sling body. Forms superior choker hitch & allows better fit on crane hook in basket hitch.

Type 5 : Endless (EE) - Economical & adaptable sling with no fixed wear points. Used in all hitches

Type 6 : Reversed Eye (RE) - Extremely strong & durable for continuous &/or abusive applications. Wear pads on both sides of body

The following system is used to identify different types of web slings:



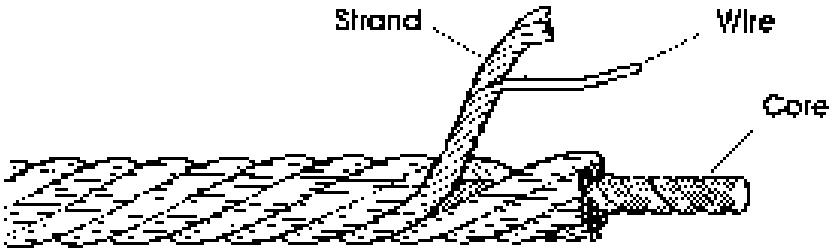
Therefore an EE1-802 is a heavy duty, 2" wide, single ply Eye & Eye sling. Relative to other types of slings, web slings are best in strength/weight ratio, poorest in abrasion and cut resistance, excellent with regard to flexibility and elongation, and poor in temperature extremes.

Maintenance

Fiber ropes and synthetic webs are generally discarded rather than serviced or repaired. Operators must always follow manufacturer's recommendations.

Wire Rope

A second type of sling is made of wire rope. Wire rope is composed of individual wires that have been twisted to form strands. The strands are then twisted to form a wire rope. When wire rope has a fiber core, it is usually more flexible but is less resistant to environmental damage. Conversely, a core that is made of a wire rope strand tends to have greater strength and is more resistant to heat damage.



The number of strands and the standard construction determine the classification of a rope. A strand consists of a "center" which supports a specified number of wires around it in one or more layers. The strands provide all the tensile strength of a fiber core rope and 92 ½ % of the strength of a IWRC six strand rope.

Physical characteristics, such as fatigue resistance and the ability to resist abrasion are directly affected by the design of the strands. In most strands with two or more layers of wires the inner layers support the outer layers in such a manner that all wires may slide and adjust freely when the strand flexes.

Generally a strand made up of a small number of large wires will be more abrasion resistant and less fatigue resistant than a strand of the same size made up of many smaller wires.

Wire Rope Life. Many operating conditions affect wire rope life. They are bending, stresses, loading conditions, speed of load application (jerking), abrasion, corrosion, sling design, materials handled, environmental conditions, and history of previous usage.

In addition to the above operating conditions, the weight, size, and shape of the loads to be handled also affect the service life of a wire rope sling. Flexibility is also a factor. Generally, more flexible ropes are selected when smaller radius bending is required. Less flexible ropes should be used when the rope must move through or over abrasive materials.

Wire Rope Sling Inspection. Wire rope slings must be visually inspected before each use. The operator should check the twists or lay of the sling. **If ten randomly distributed wires in one lay are broken, or five wires in one strand of a rope lay are damaged, the sling must not be used.** It is not sufficient, however, to check only the condition of the wire rope. End fittings and other components should also be inspected for any damage that could make the sling unsafe.

To ensure safe sling usage between scheduled inspections, all workers must participate in a safety awareness program. Each operator must keep a close watch on those slings he or she is using. If any accident involving the movement of materials occurs, the operator must immediately shut down the equipment and report the accident to a supervisor. The cause of the accident must be determined and corrected before resuming operations.

Field Lubrication. Although every rope sling is lubricated during manufacture, to lengthen its useful service life it must also be lubricated "in the field." There is no set rule on how much or how often this should be done. It depends on the conditions under which the sling is used. The heavier the loads, the greater the number of bends, or the more adverse the conditions under which the sling operates, the more frequently lubrication will be required.

Storage. Wire rope slings should be stored in a well ventilated, dry building or shed. Never store them on the ground or allow them to be continuously exposed to the elements because this will make them vulnerable to corrosion and rust. And, if it is necessary to store wire rope slings outside, make sure that they are set off the ground and protected.

Note: Using the sling several times a week, even at a light load, is a good practice. Records show that slings that are used frequently or continuously give useful service far longer than those that are idle.

Discarding Slings. Wire rope slings can provide a margin of safety by showing early signs of failure. Factors requiring that a wire sling be discarded include the following:

- severe corrosion,
- Localized wear (shiny worn spots) on the outside,
- A one-third reduction in outer wire diameter,
- Damage or displacement of end fittings - hooks, rings, links, or collars - by overload or misapplication,
- Distortion, kinking, bird caging, or other evidence of damage to the wire rope structure, or Excessive broken wires

When to retire wire slings

March 18, 1994

Mr. Michael G. Wyckoff
United Technologies--USBI
Chief, Operations Engineering
Mechanical Section, Mail Code USB-OE
P.O. Box 21212
Kennedy Space Center, Florida 32815

Dear Mr. Wyckoff:

Thank you for your inquiry of January 4, requesting clarification of the Occupational Safety and Health Administration (OSHA) standards at 29 CFR 1910.184(f)(5) which gives removal from service criteria for wire rope slings. We apologize for the delay in response.

The OSHA standards at 29 CFR 1910.184(f)(5)(i) and 29 CFR 1910.184(f)(5)(ii) require wire rope slings to be removed from service immediately when the following conditions are found:

(i) Ten randomly distributed broken wires in one rope lay, or five broken wires in one strand in one rope lay.

(ii) Wear and scraping of one-third the original diameter of outside individual wires.

Compliance with 29 CFR 1910.184(f)(5)(i) is determined by inspection of the rope sling.

The following method may be used to determine whether the wire rope sling must be removed from service as required by 29 CFR 1910.184(f)(5)(ii). The outside individual wires are not separated from the wire rope to make them available for measuring. To measure the wear or scraping of one-third the original diameter must be measured with a micrometer at the worn or scraped area and compared to the original diameter of whole wire rope. If the difference of this measurement is equal to, or more than, one-third the original diameter of an individual outside wire, the wire rope sling must be removed from service.

OSHA will allow a wire rope to be left in service with respect to a pass/fail gage measurement if the difference between the original diameter of the whole wire rope and a pass/fail gage OD **failed** measurement is less than one-third the original diameter of the outside individual wire.

Slings and all fastenings and attachments must be inspected for damage or defects each day before being used by a competent person designated by employer. Where service

conditions warrant, additional inspections must be performed during sling use. Damaged or defective slings must be immediately removed from service.

We appreciate your interest in employee safety and health. If we can be or further assistance, please do not hesitate to contact us.

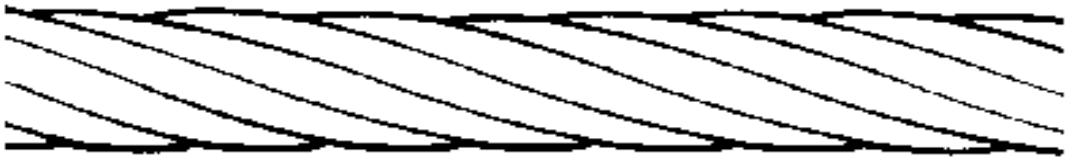
Sincerely,
H. Berrien Zettler, Director
Directorate of Compliance programs

Rope Lay

Wire rope may be further defined by the "lay." The lay of a wire rope can mean any of three things:

1. One complete wrap of a strand around the core*:* One rope lay is one complete wrap of a strand around the core. See figure below.

2. The direction the strands are wound around the core: Wire rope is referred to as right lay or left lay. A right lay rope is one in which the strands are wound in a right-hand direction like a conventional screw thread (see figure below). A left lay rope is just the opposite.



Right Lay

3. The direction the wires are wound in the strands in relation to the direction of the strands around the core*:* In regular lay rope, the wires in the strands are laid in one direction while the strands in the rope are laid in the opposite direction. In lang lay rope, the wires are twisted in the same direction as the strands.

Right Lay, Regular Lay

Right Lay, Lang Lay

Left Lay, Regular Lay

Left Lay, Lang Lay

In regular lay ropes, the wires in the strands are laid in one direction, while the strands in the rope are laid in the opposite direction. The result is that the wire crown runs approximately parallel to the longitudinal axis of the rope. These ropes have good resistance to kinking and twisting and are easy to handle. They are also able to withstand considerable crushing and distortion due to the short length of exposed wires. This type of rope has the widest range of applications.

Lang lay (where the wires are twisted in the same direction as the strands) is recommended for many excavating, construction, and mining applications, including draglines, hoist lines, dredgelines, and other similar lines.

Lang lay ropes are more flexible and have greater wearing surface per wire than regular lay ropes. In addition, since the outside wires in lang lay ropes lie at an angle to the rope axis, internal stress due to bending over sheaves and drums is reduced causing lang lay ropes to be more resistant to bending fatigue.

A left lay rope is one in which the strands form a left-hand helix similar to the threads of a left-hand screw thread. Left lay rope has its greatest usage in oil fields on rod and tubing lines, blast hole rigs, and spudders where rotation of right lay would loosen couplings. The rotation of a left lay rope tightens a standard coupling.

Wire Rope Sling Selection

When selecting a wire rope sling to give the best service, there are four characteristics to consider: strength, ability to bend without distortion, ability to withstand abrasive wear, and ability to withstand abuse.

1. Strength - The strength of a wire rope is a function of its size, grade, and construction. It must be sufficient to accommodate the maximum load that will be applied. The maximum load limit is determined by means of an appropriate multiplier. This multiplier is the number by which the ultimate strength of a wire rope is divided to determine the working load limit. Thus a wire rope sling with a strength of 10,000 pounds and a total working load of 2,000 pounds has a design factor (multiplier) of 5. New wire rope slings have a design factor of 5, and 10 when it is used to carry personnel
2. . As a sling suffers from the rigors of continued service, however, both the design factor and the sling's ultimate strength are proportionately reduced. If a sling is loaded beyond its ultimate strength, it will fail. For this reason, older slings must be more rigorously inspected to ensure that rope conditions adversely affecting the strength of the sling are considered in determining whether or not a wire rope sling should be allowed to continue in service.

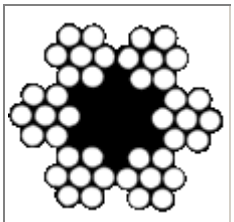
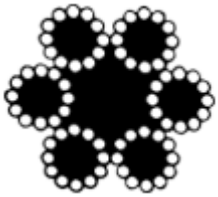
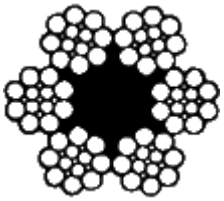
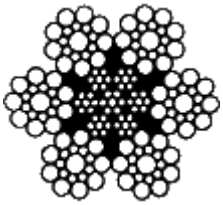
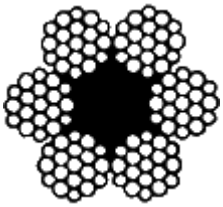
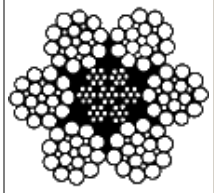
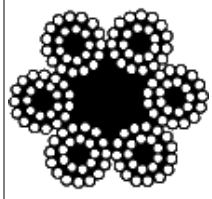
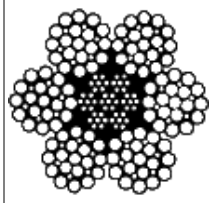
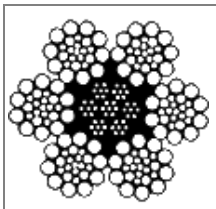
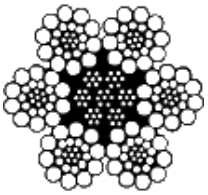
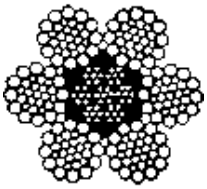
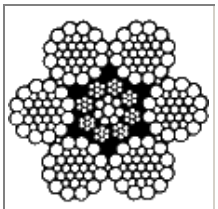
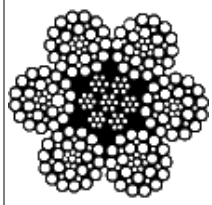
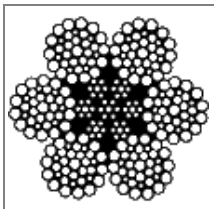
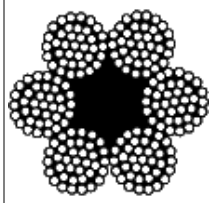
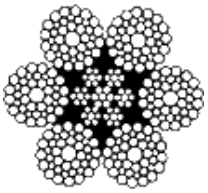
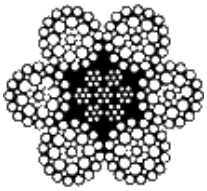
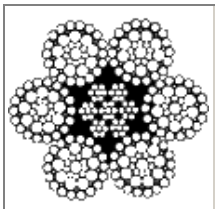
3. Fatigue - A wire rope must have the ability to withstand repeated bending without the failure of the wires from fatigue. Fatigue failure of the wires in a wire rope is the result of the development of small cracks under repeated applications of bending loads. It occurs when ropes make small radius bends. The best means of preventing fatigue failure of wire rope slings is to use blocking or padding to increase the radius of the bend.

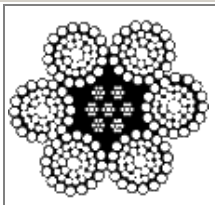
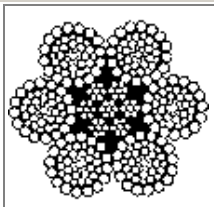
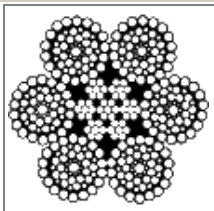
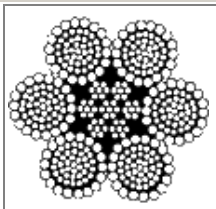
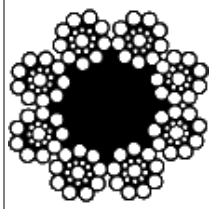
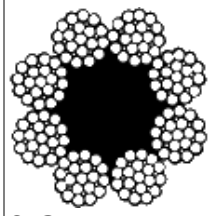
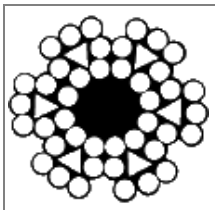
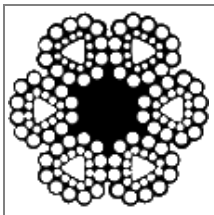
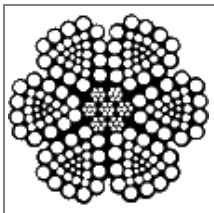
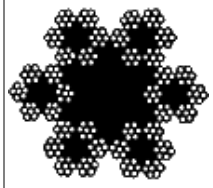
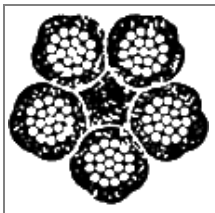
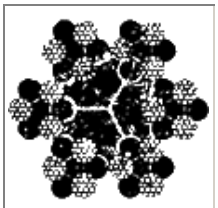
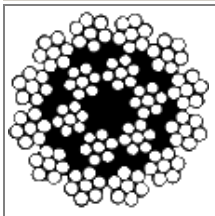
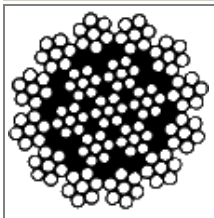
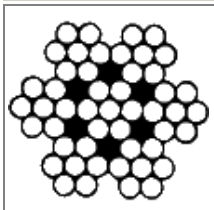
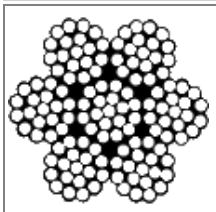
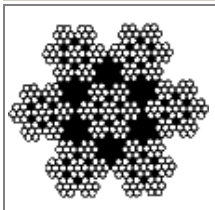
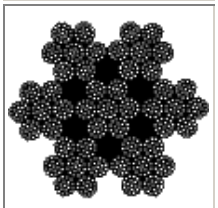
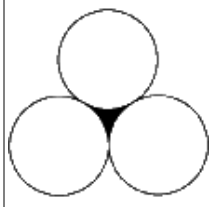
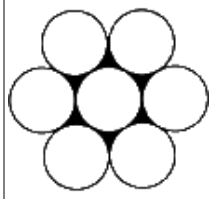
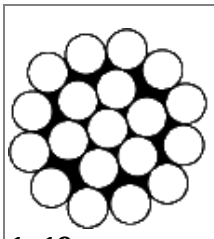
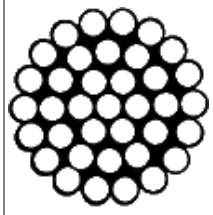
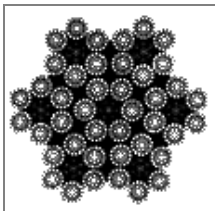
4. Abrasive Wear - The ability of a wire rope to withstand abrasion is determined by the size, number of wires, and construction of the rope. Smaller wires bend more readily and therefore offer greater flexibility but are less able to withstand abrasive wear. Conversely, the larger wires of less flexible ropes are better able to withstand abrasion than smaller wires of the more flexible ropes.

Abuse - All other factors being equal, misuse or abuse of wire rope will cause a wire rope sling to become unsafe long before any other factor. Abusing a wire rope sling can cause serious structural damage to the wire rope, such as kinking or bird caging which reduces the strength of the wire rope. (In bird caging, the wire rope strands are forcibly untwisted and become spread outward.) Therefore, in order to prolong the life of the sling and protect the lives of employees, the manufacturer's suggestion for safe and proper use of wire rope slings must be strictly adhered to.

Wire Rope Fatigue Failure

Wire Rope "Bird Cage"

 **6x7** Poly Core	 **6x12** Marine Rope	 **6x17** Filler Wire	 **6x19** Seale	 **6x19** Warrington	 **6x21** Filler Wire
 **6x24** Mooring Line	 **6x25** Filler Wire	 **6x26** Warrington-Seale	 **6x27*** Seale	 **6x31*** Filler Wire	 **6x21** Warrington-Seale
 **6x36** Filler Wire	 **6x36** Warrington-Seale	 **6x37*** Warrington	 **6x41** Warrington-Seale	 **6x41*** Seale-Filler Wire	 **6x46** Seale-Filler Wire

 **6x49*** Filler Wire-Seale	 **6x49** Warrington-Seale	 **6x55*** Seale-Warrington	 **6x61*** Filler Wire-Seale	 **8x19*** Seale	 **8x25** Filler Wire
 **6x8** **Style D** Flattened Strand	 **6x25** **Style B** Flattened Strand	 **6x30** **Style G** Flattened Strand	 **6x42** Tiller Rope	 **5x19*** Marine Clad Rope	 **6x3x19** Spring Lay Rope
 **18x7** Non-Rotating	 **19x7** Non-Rotating	 **7x7** Aircraft Cable	 **7x19** Aircraft Cable	 **7x7x7** Cable-Laid	 **7x7x19** Cable-Laid
 **1x3** Strand	 **1x7** Strand	 **1x19** Strand	 **1x37** Strand	 **7x6x41** IWRC Cable-Laid	* Not readily available any longer.

Maintenance

Wire rope slings, like chain slings, must be cleaned prior to each inspection because they are also subject to damage hidden by dirt or oil. In addition, they must be lubricated according to manufacturer's instructions. Lubrication prevents or reduces corrosion and wear due to friction and abrasion. Before applying any lubricant, however, the sling user should make certain that the sling is dry. Applying lubricant to a wet or damp sling traps moisture against the metal and hastens corrosion.

Corrosion deteriorates wire rope. It may be indicated by pitting, but it is sometimes hard to detect. Therefore, if a wire rope sling shows any sign of significant deterioration, that sling must be removed until it can be examined by a person who is qualified to determine the extent of the damage.

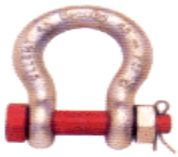
By following the above guidelines to proper sling use and maintenance, and by the avoidance of kinking, it is possible to greatly extend a wire rope sling's useful service life.

Wire Rope Fittings

Screw Pin Anchor Shackle

Screw Pin Chain Shackle

Bolt Type Anchor Shackle



Eye Hoist Hook

Swivel Hook

Sliding Choker Hook

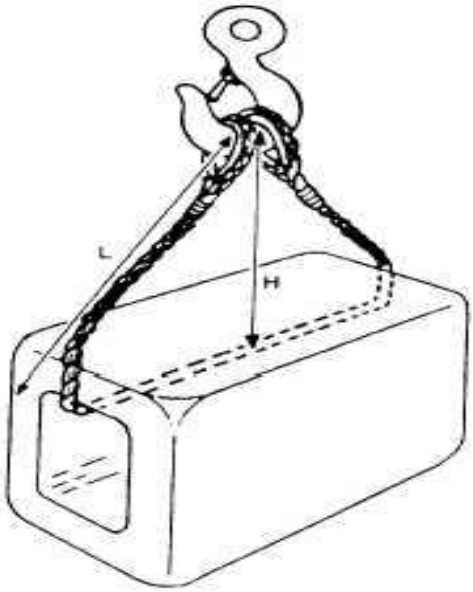
Oblong Master Link

Pear Link

Jaw End Swivel

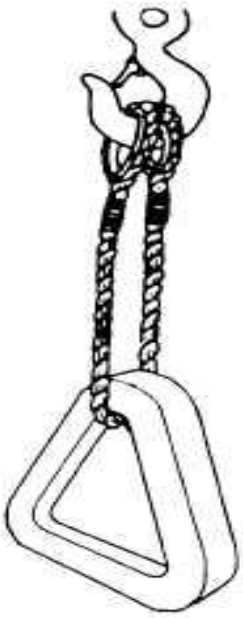
Regular Eye Bolt

Shoulder Eye Bolt



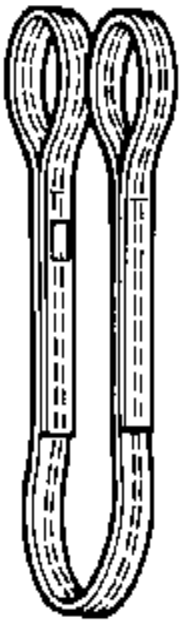
INCLINED LEGS

SWL = SWL
(OF SINGLE-VERTICAL HITCH)
$\times \frac{H}{L} \times 2$

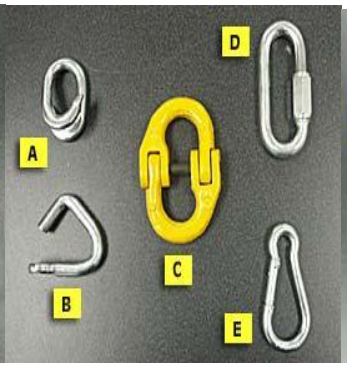


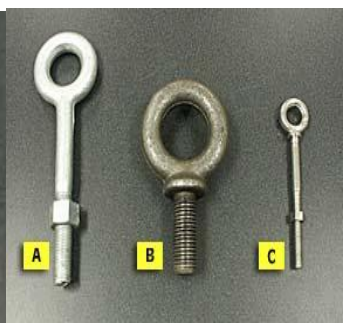
VERTICAL LEGS

SWL = SWL
(OF SINGLE-VERTICAL HITCH)
x 2



Rigging Hardware





WORK LOAD LIMIT
Never exceed the Work Load Limit (WLL) Rated Capacity. The Work Load Limit is the maximum load which should ever be applied to the product, even when the product is new and when the load is uniformly applied – straight line pull only. Avoid side loading. All web-site catalog ratings are based upon usual environmental conditions, and consideration must be given to unusual conditions such as extreme high or low temperatures, chemical solutions or vapors, prolonged immersion in salt water, etc. Such conditions or high-risk applications may necessitate reducing the Work Load Limit. Work Load Limit will not apply if product has been welded or otherwise modified.

Matching of Components
Components must match. Make certain that components such as hooks, links or shackles, etc. used with wire rope (or chain or cordage) are of suitable material and strength to provide adequate safety protection. Attachments must be properly installed and must have a Work Load Limit at least equal to the product with which they are used.