



## FPST 2023 Industrial and Occupational Safety

Conveyors, Hoisting and Rigging

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## Objectives



- Describe types of hoisting and materials handling equipment
- Describe the four main causes of crane accidents
- Describe pre-use inspection criteria for hoisting and rigging equipment
- Understand safe lifting practices
- Describe how sling angles affect sling capacity

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## Conveyors



- Definition
  - ANSI/ASME B.20.1 (Safety Standards for Conveyors)
    - A horizontal, inclined, or vertical device for moving or transporting bulk material, packages, or objects, in a path predetermined by the design of the device, and having points of loading and discharge, fixed or selective.
- Types
  - Belt conveyors
  - Overhead conveyors
  - Screw conveyors
  - Gravity Conveyors

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## Belt Conveyors



- **Pulleys** are required to drive the belt, change direction of the belt, support the belt, and tighten the belt
- One side of every pulley is always an **in-running nip point**
- Defense against the hazard
  - Isolating the nip points
  - Installing guards
  - Installing emergency tripping devices

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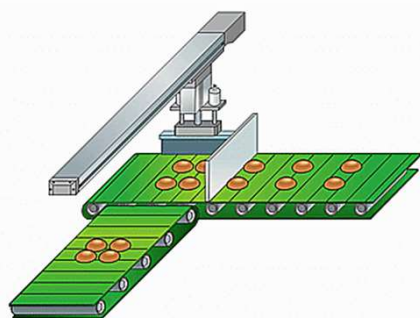
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<https://gfyat.com/discover/conveyor-belt-gifs>

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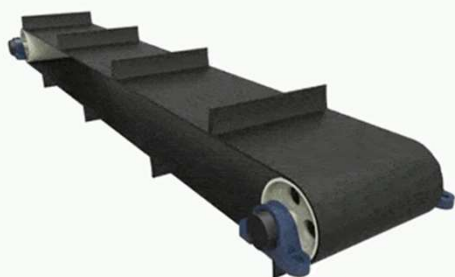
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<https://gfyat.com/discover/conveyor-belt-gifs>

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## Overhead Conveyors



- Designed for large appliance parts or vehicle assemblies
- Hooks attached to a moving chain support each item as it is moved
- Particularly suited for products that have delicate surfaces, and for paint spray or finishing operations
- Little contact between the conveyor and the product

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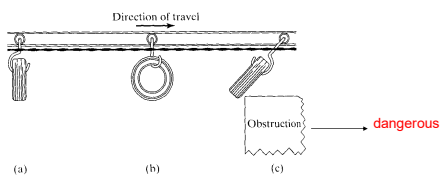
## Overhead Conveyors



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### Hazards

- Avoid many of the risks of belt conveyors
- Might drop conveyed materials
- Solution: place screens or shields under the conveyor, or design the safer orientation of the hook in specific plant



(a) (b) (c)

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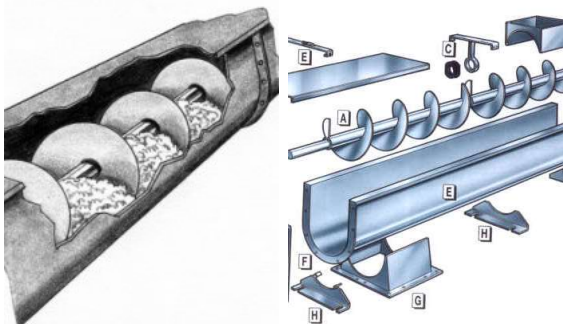
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## Screw Conveyors



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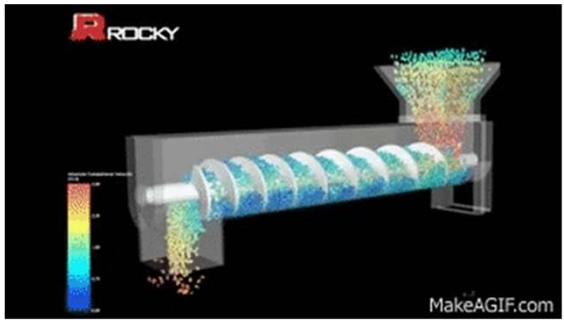
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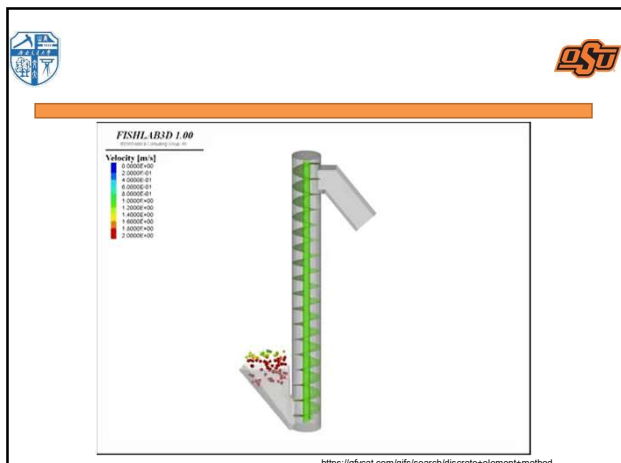
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## Screw Conveyors



- Screw conveyors can be very dangerous.
  - An ingoing nip point at the intake
  - Intake must be completely submerged in the material to be transported in order to operate at full capacity
  - The need for the worker to be fairly close to the screw conveyor for many applications in order to shovel or distribute material into the intake
- Solution
  - Box the intake area in a small screen enclosure that allows passage of the material, but keeps out fingers, hands, and feet

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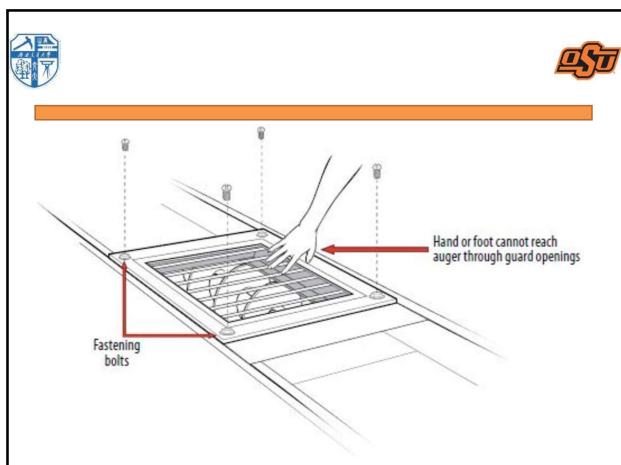
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## Gravity Conveyors



- Spiral Chute
  - Slope 18-30 degree
  - Fire hazards



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## Gravity Conveyors



- Roller
  - Angle of slope is much less (2-4%)
  - Material may run off the rollway



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## Operating Precautions



- In-running nip points, loose clothing can cause an irreversible process once the employee is caught
- Locate emergency stopping device not more than 75 ft. apart along walkways by the conveyor
- Interlocking devices
- Overload protection
- Before maintenance, they should lock out the main power control in the OFF position....referred to as?
  - Lockout

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## Cranes



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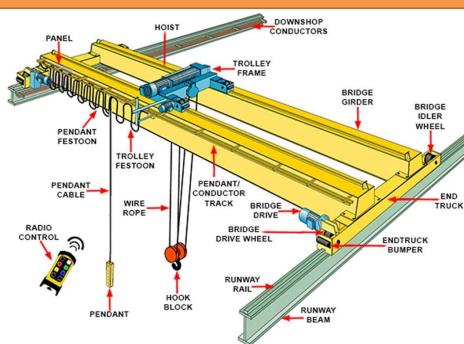
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## Overhead Crane



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## Mobile ("Truck") Crane



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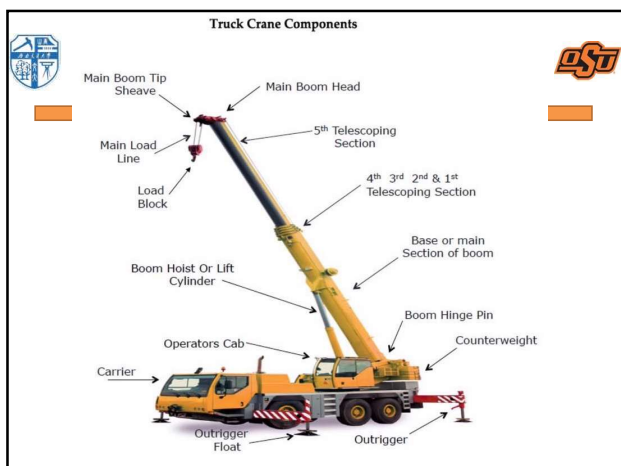
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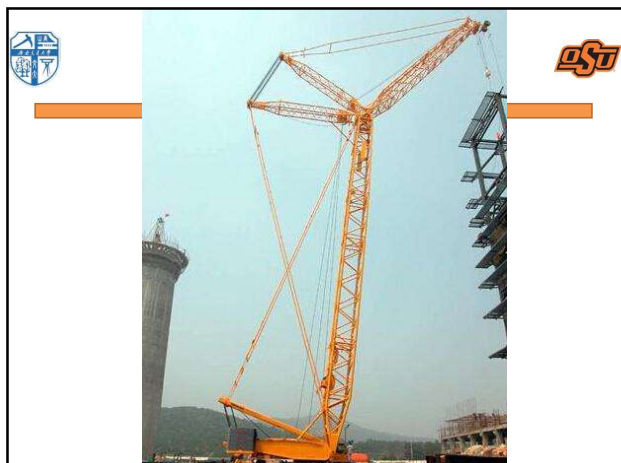
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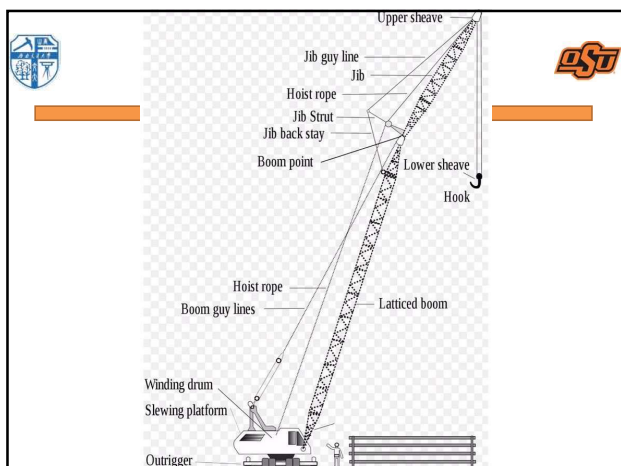
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Climbing Crane

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### Overhead Crane Gantry



- Have legs that support the bridge above the railway



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### Overhead Crane Cantilever gantry



- Have extensions on one or both ends of the bridge; these extensions extend the reach of the crane outside the area between the rails on which the crane travels



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### Semi-gantry





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## Crane Hazards



- Big Blue video
- Watch video:
  - Crane fails

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## Crane Hazards



- Overloading
  - The rated load should be marked on each side of crane
  - Uncertainties in the actual weight of the load
  - Dynamic loads during transport
  - Shock loads during lifting
- Solutions
  - Training of the workers to understand the risks and consequences of their actions
  - Study of accidents
- Wind
  - Automatic rail clamps are required for outdoor storage bridge cranes

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## Crane Hazards



- Two-blocking event
  - The wire rope of a crane or hoist has drawn the load hook or hook block up too far – to the point at which the load block makes contact with the boom point of the crane or other mechanical assembly for reeving the wire rope
  - Continued travel of the load block causes immediate severe tension stress on the wire rope
  - Has resulted in many fatalities

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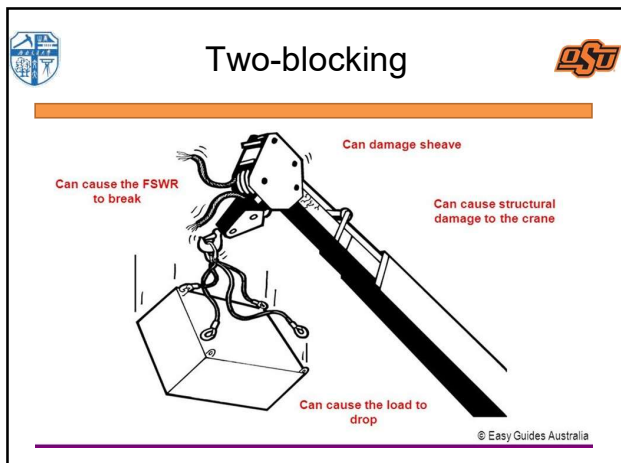
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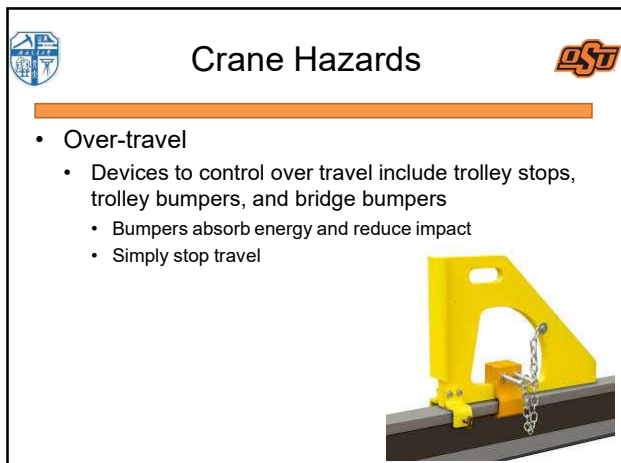
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## Crane Hazards



- Obstruction
  - Obstruction of the rail on which the bridge travels can cause catastrophic accident
  - Rail sweeps to eliminate the hazard



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## Crane Hazards



- Electric Shock
  - Shock from a shorted connection in a hanging control pendant box
  - The accidental contact of live, high-voltage overhead transmission lines
- Power Failure



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## Crane Operations



- Actual handling and moving of the loads conducted by skilled and knowledgeable crane operator and the workers
- Operator is the most important in preventing accidents
  - Overall control of the lift
  - Gives the go/no-go

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## Crane Inspections



- The standards specify the terms "frequent" or "periodic" for inspections
- The crane manufacturer is a good source for detailed guidance for the frequent inspections
  - A daily visual inspection of hoist chains
  - A monthly inspection with a signed report

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## Crane Hook Inspection



- Normal Service
  - Yearly
- Heavy Service
  - Semiannually
- Severe Service
  - Quarterly

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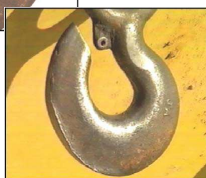
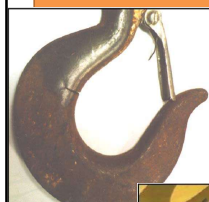
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## Load Hook Inspection



- Inspect for
  - Distortion of hook
  - No Bending
  - No Twisting
  - Increased throat opening
  - Wear
  - Cracks, Nicks, Gouges
  - Latch damage or malfunction
  - Hook attachment device

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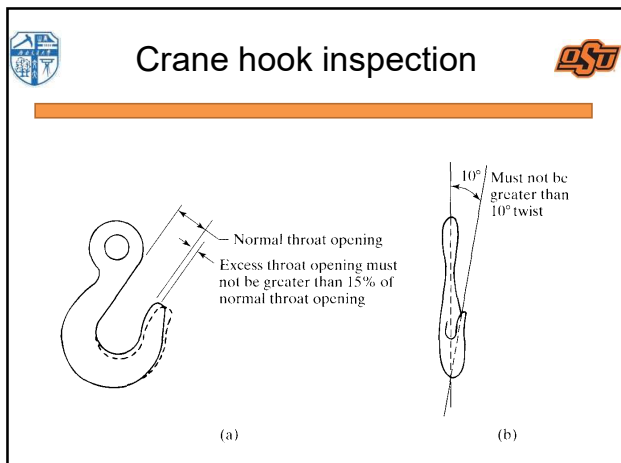
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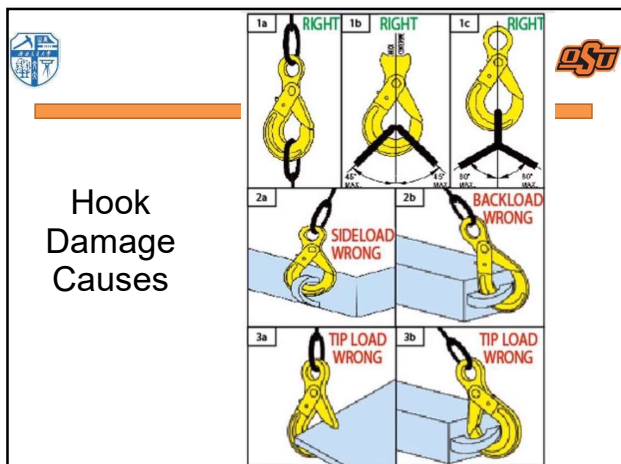
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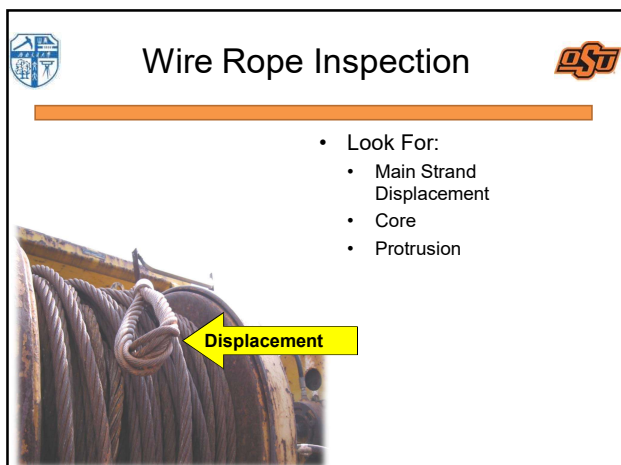
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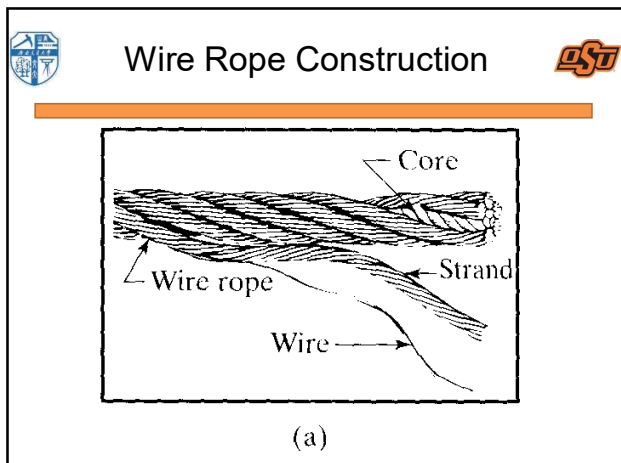
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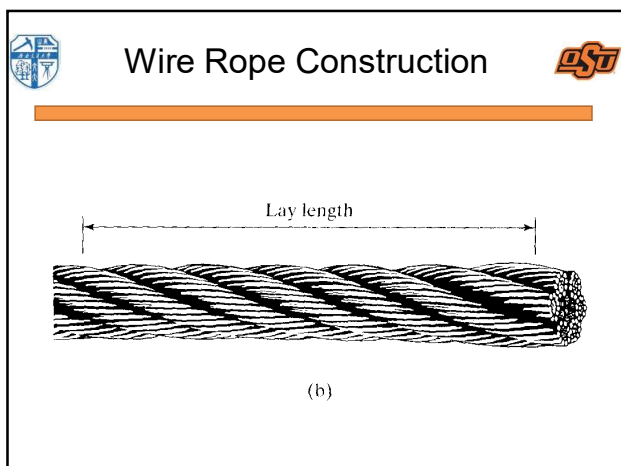
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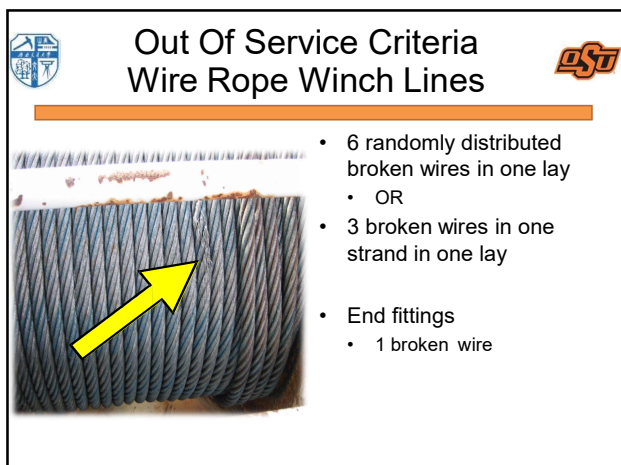
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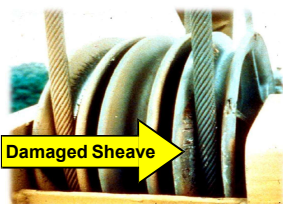
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## Sheave Inspection



- Pulley with a grooved wheel for holding a belt, wire rope, or rope
- The grooves must be smooth and free from surface defects which could cause rope damage



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## Major Causes of Crane Accidents



- Power-line Contact
- Overturns
- Falls (from crane)
- Mechanical failures



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## Planning Before Startup



- Level the crane
- Ensure support surface is firm and able to support the load
- Know the basic crane capacities, and limitations
- Know job site restrictions
- Make other personnel aware of hoisting activities
- Barricade areas within swing radius
- Ensure proper maintenance and inspections



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## Competent Person



- The competent person must inspect all machinery and equipment prior to each use, and during use, to make sure it is in safe operating condition



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## Spotter



- When hoisting loads in close proximity to energized lines, a spotter must be used
- Must not have other responsibilities
- Must have clear communication with the operator
- Must have a clear view

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## Load Charts



- Load charts and the operator's manual must be available in the cab at all times

ALLOWABLE LINE PULL									
2 PART LINE	3 PART LINE	4 PART LINE	5 PART LINE	6 PART LINE	7 PART LINE	8 PART LINE	9 PART LINE	10 PART LINE	11 PART LINE
1600 LBS	1200 LBS	900 LBS	720 LBS	576 LBS	461 LBS	369 LBS	295 LBS	236 LBS	189 LBS
1800 LBS	1350 LBS	1012 LBS	810 LBS	648 LBS	518 LBS	415 LBS	332 LBS	266 LBS	210 LBS
2000 LBS	1500 LBS	1125 LBS	900 LBS	720 LBS	576 LBS	461 LBS	369 LBS	295 LBS	236 LBS
2200 LBS	1650 LBS	1238 LBS	990 LBS	792 LBS	633 LBS	506 LBS	405 LBS	324 LBS	259 LBS
2400 LBS	1800 LBS	1350 LBS	1080 LBS	864 LBS	691 LBS	553 LBS	442 LBS	354 LBS	288 LBS
2600 LBS	1950 LBS	1463 LBS	1170 LBS	936 LBS	749 LBS	600 LBS	480 LBS	386 LBS	317 LBS
2800 LBS	2100 LBS	1575 LBS	1260 LBS	1008 LBS	807 LBS	648 LBS	518 LBS	415 LBS	332 LBS
3000 LBS	2250 LBS	1688 LBS	1350 LBS	1080 LBS	864 LBS	691 LBS	553 LBS	442 LBS	360 LBS
3200 LBS	2400 LBS	1800 LBS	1440 LBS	1152 LBS	922 LBS	736 LBS	588 LBS	470 LBS	388 LBS
3400 LBS	2550 LBS	1913 LBS	1530 LBS	1224 LBS	979 LBS	784 LBS	626 LBS	508 LBS	416 LBS
3600 LBS	2700 LBS	2025 LBS	1620 LBS	1296 LBS	1037 LBS	832 LBS	664 LBS	546 LBS	444 LBS
3800 LBS	2850 LBS	2138 LBS	1710 LBS	1368 LBS	1094 LBS	880 LBS	702 LBS	584 LBS	472 LBS
4000 LBS	3000 LBS	2250 LBS	1800 LBS	1440 LBS	1152 LBS	922 LBS	740 LBS	622 LBS	500 LBS
4200 LBS	3150 LBS	2363 LBS	1890 LBS	1512 LBS	1209 LBS	970 LBS	778 LBS	660 LBS	528 LBS
4400 LBS	3300 LBS	2475 LBS	1980 LBS	1584 LBS	1267 LBS	1018 LBS	816 LBS	698 LBS	556 LBS
4600 LBS	3450 LBS	2588 LBS	2070 LBS	1656 LBS	1324 LBS	1066 LBS	854 LBS	736 LBS	584 LBS
4800 LBS	3600 LBS	2700 LBS	2160 LBS	1728 LBS	1382 LBS	1114 LBS	892 LBS	774 LBS	612 LBS
5000 LBS	3750 LBS	2813 LBS	2250 LBS	1800 LBS	1439 LBS	1162 LBS	930 LBS	812 LBS	640 LBS
5200 LBS	3900 LBS	2925 LBS	2340 LBS	1872 LBS	1497 LBS	1210 LBS	968 LBS	850 LBS	668 LBS
5400 LBS	4050 LBS	3038 LBS	2430 LBS	1944 LBS	1554 LBS	1258 LBS	1006 LBS	888 LBS	696 LBS
5600 LBS	4200 LBS	3150 LBS	2520 LBS	2016 LBS	1612 LBS	1306 LBS	1044 LBS	926 LBS	724 LBS
5800 LBS	4350 LBS	3263 LBS	2610 LBS	2088 LBS	1669 LBS	1354 LBS	1082 LBS	964 LBS	752 LBS
6000 LBS	4500 LBS	3375 LBS	2700 LBS	2160 LBS	1727 LBS	1402 LBS	1120 LBS	1002 LBS	780 LBS
6200 LBS	4650 LBS	3488 LBS	2790 LBS	2232 LBS	1784 LBS	1450 LBS	1158 LBS	1040 LBS	808 LBS
6400 LBS	4800 LBS	3600 LBS	2880 LBS	2304 LBS	1842 LBS	1498 LBS	1196 LBS	1078 LBS	836 LBS
6600 LBS	4950 LBS	3713 LBS	2970 LBS	2376 LBS	1899 LBS	1546 LBS	1234 LBS	1116 LBS	864 LBS
6800 LBS	5100 LBS	3825 LBS	3060 LBS	2448 LBS	1957 LBS	1594 LBS	1272 LBS	1154 LBS	892 LBS
7000 LBS	5250 LBS	3938 LBS	3150 LBS	2520 LBS	2014 LBS	1642 LBS	1310 LBS	1192 LBS	920 LBS
7200 LBS	5400 LBS	4050 LBS	3240 LBS	2592 LBS	2072 LBS	1690 LBS	1348 LBS	1230 LBS	948 LBS
7400 LBS	5550 LBS	4163 LBS	3330 LBS	2664 LBS	2129 LBS	1738 LBS	1386 LBS	1268 LBS	976 LBS
7600 LBS	5700 LBS	4275 LBS	3420 LBS	2736 LBS	2187 LBS	1786 LBS	1424 LBS	1306 LBS	1004 LBS
7800 LBS	5850 LBS	4388 LBS	3510 LBS	2808 LBS	2244 LBS	1834 LBS	1462 LBS	1344 LBS	1032 LBS
8000 LBS	6000 LBS	4500 LBS	3600 LBS	2880 LBS	2302 LBS	1882 LBS	1500 LBS	1382 LBS	1060 LBS
8200 LBS	6150 LBS	4613 LBS	3690 LBS	2952 LBS	2359 LBS	1930 LBS	1538 LBS	1420 LBS	1088 LBS
8400 LBS	6300 LBS	4725 LBS	3780 LBS	3024 LBS	2417 LBS	1978 LBS	1576 LBS	1458 LBS	1116 LBS
8600 LBS	6450 LBS	4838 LBS	3870 LBS	3096 LBS	2474 LBS	2026 LBS	1614 LBS	1496 LBS	1144 LBS
8800 LBS	6600 LBS	4950 LBS	3960 LBS	3168 LBS	2532 LBS	2074 LBS	1652 LBS	1534 LBS	1172 LBS
9000 LBS	6750 LBS	5063 LBS	4050 LBS	3240 LBS	2589 LBS	2122 LBS	1690 LBS	1572 LBS	1200 LBS
9200 LBS	6900 LBS	5175 LBS	4140 LBS	3312 LBS	2647 LBS	2170 LBS	1728 LBS	1610 LBS	1228 LBS
9400 LBS	7050 LBS	5288 LBS	4230 LBS	3384 LBS	2704 LBS	2218 LBS	1766 LBS	1648 LBS	1256 LBS
9600 LBS	7200 LBS	5400 LBS	4320 LBS	3456 LBS	2762 LBS	2266 LBS	1804 LBS	1686 LBS	1284 LBS
9800 LBS	7350 LBS	5513 LBS	4410 LBS	3528 LBS	2819 LBS	2314 LBS	1842 LBS	1724 LBS	1312 LBS
10000 LBS	7500 LBS	5625 LBS	4500 LBS	3600 LBS	2877 LBS	2362 LBS	1880 LBS	1762 LBS	1340 LBS

**WARNING**

ANTI-TWO-BLOCK SYSTEM MUST BE IN GOOD OPERATING CONDITION BEFORE OPERATING CRANE. REFER TO OWNER'S MANUAL.

KEEP AT LEAST 3 WRAPS OF LOAD LINE ON DRUM AT ALL TIMES.

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











## Hand Signal Charts



- Hand signal charts
  - Posted on machine
  - Posted in vicinity

 <p><b>HOIST</b> With forearm vertical, fingers pointing up, thumb held in small horizontal circle.</p>	 <p><b>LOWER</b> With arm extended downward, hand open, fingers pointing down.</p>	 <p><b>USE MAIN HOIST</b> Forearm extended upward, hand open, fingers pointing up.</p>
 <p><b>USE WHIPLINE (Auxiliary Hoist)</b> Forearm extended horizontally, hand open, fingers pointing right.</p>	 <p><b>RAISE BOOM</b> Forearm extended horizontally, hand open, fingers pointing up.</p>	 <p><b>LOWER BOOM</b> Forearm extended horizontally, hand open, fingers pointing down.</p>
 <p><b>MOVE SLOWLY</b> Forearm extended horizontally, hand open, fingers pointing right.</p>	 <p><b>RAISE THE BOOM AND LOWER THE LOAD</b> Forearm extended horizontally, hand open, fingers pointing up.</p>	 <p><b>LOWER THE BOOM AND RAISE THE LOAD</b> Forearm extended horizontally, hand open, fingers pointing down.</p>

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## Hoists





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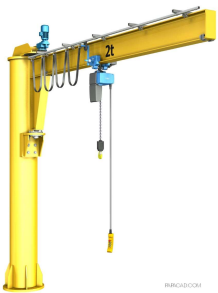
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## Jib Hoist





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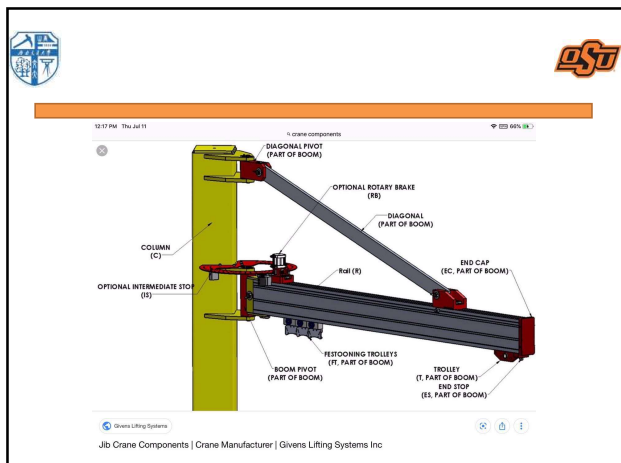
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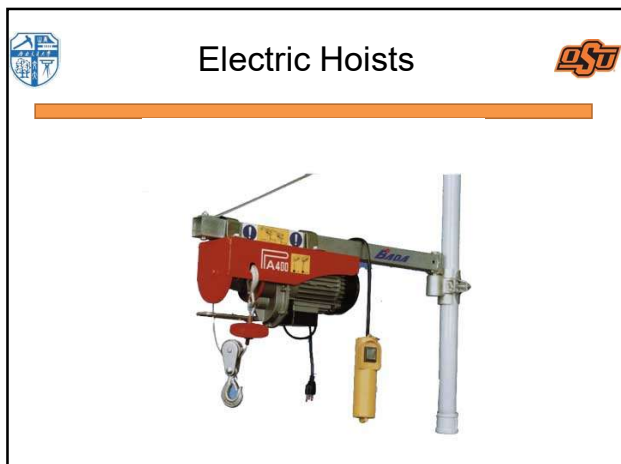
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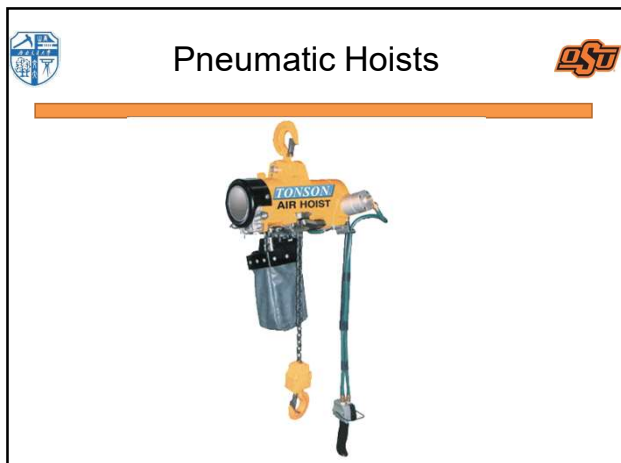
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## Hand-Operated Chain Hoists



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## ROPES, CHAINS, AND SLINGS

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## Fiber and Wire Rope Sling



- Slings are used to attach the load to the crane, or other lifting device and are constructed of
  - fiber line
  - wire rope
  - chain
- Slings come in a great many varieties
  - Fiber-line slings offer the advantage of flexibility and protection of finished material. But not as strong as wire-rope or chain slings.
  - Fiber-line slings are more likely to be damaged in the event of sharp edges on the material being hoisted than are wire-rope or chain slings.
- The proper application affects the stress on a sling and is greatly dependent on the way it is attached to the load

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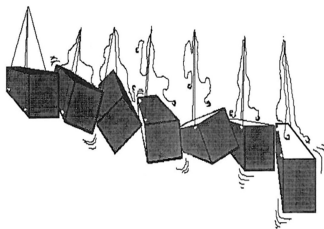
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## Causes of Rigging Failures



- Exceed rated capacity
- Improper hitch
- Center of gravity issues
- Shock load
- Damaged/Fatigued equipment
- Damaged during lift
- Home-made lift point failure



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## Fiber Rope



- Natural fibers
  - Manila and Sisal
- Synthetic fibers
  - Nylon, polyester, polyolefin rope



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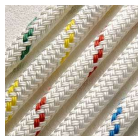
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## Working Load



- Linear density, tensile strength, working load



- Should the rope fail, it may recoil with considerable force, especially if the rope is made of nylon.

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## Fiber Rope Inspection



- Natural and synthetic fiber rope slings WILL be immediately removed from service if any of the following conditions are present:

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



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## Web Sling Inspection



- Synthetic web slings shall be removed from service if:

- Illegible Tag
- Burns
- Tears
- Cuts
- Punctures
- Broken/worn stitches



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## Inspection and Use



- If rope is being used under ordinary conditions, inspect it every 30 days.
- Do not drag rope.
- Avoid sharp bends.
- Splice lengths of rope that must be joined. Do not knot them.
- Do not allow wet rope to freeze.

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## Wire Rope



- The number of broken wires per lay is one of the principle bases for judging the condition of a rope.
  - ANSI standard
    - If there are more than 12 randomly distributed broken wires in a single strand in a single lay, there should be caused for questioning the continued use of the rope
- Corrosion is the principle cause of deterioration of wire rope used in wet mine shafts
- Clean wire rope monthly using mechanical methods
- Avoid reverse bending of wire rope over sheaves or drums

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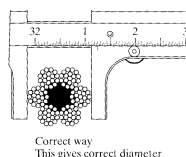
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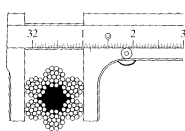
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## Measuring Wire Rope

Measure of rope condition is the amount of reduction of **rope diameter** below nominal.



Correct way  
This gives correct diameter



Incorrect way  
This does NOT give correct diameter

**Always read the widest diameter!**

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## Wire Rope Inspection



- Look for:
  - Excessive broken wires
  - Kinking
  - Bird Caging
  - Crushing
  - Deformation
  - Ten randomly distributed broken wires in one rope lay, or five broken wires in one strand in one rope lay

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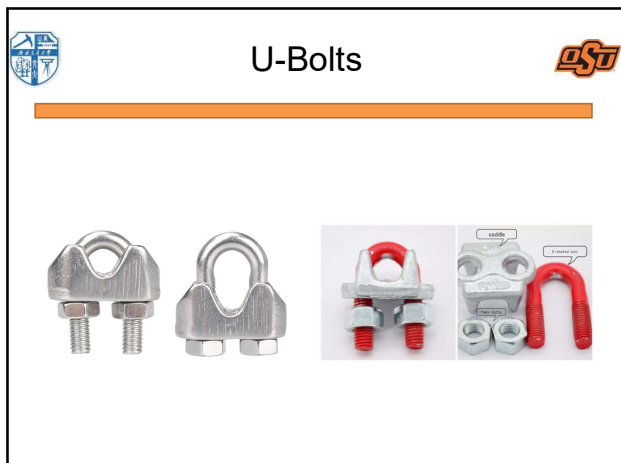
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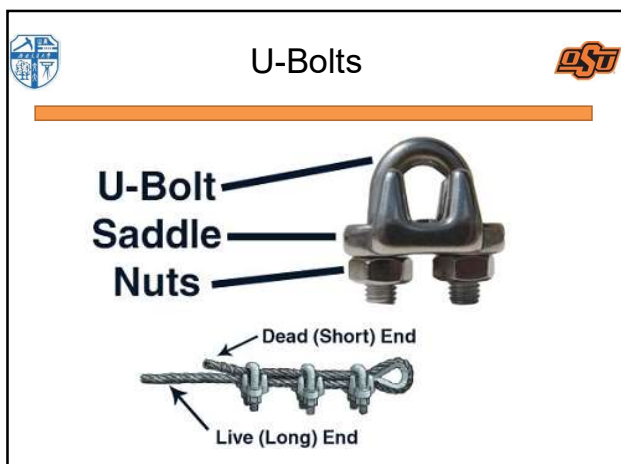
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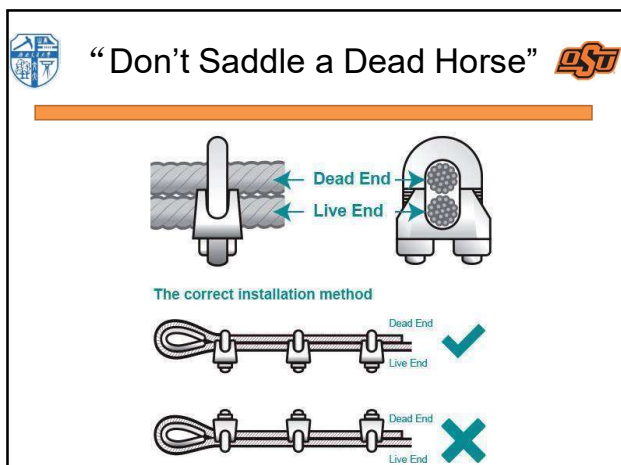
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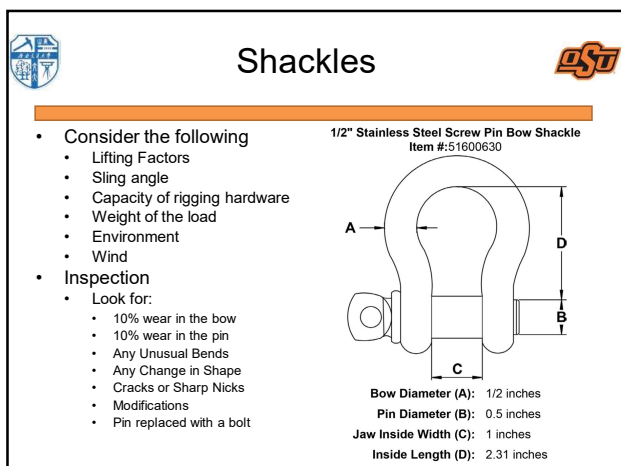
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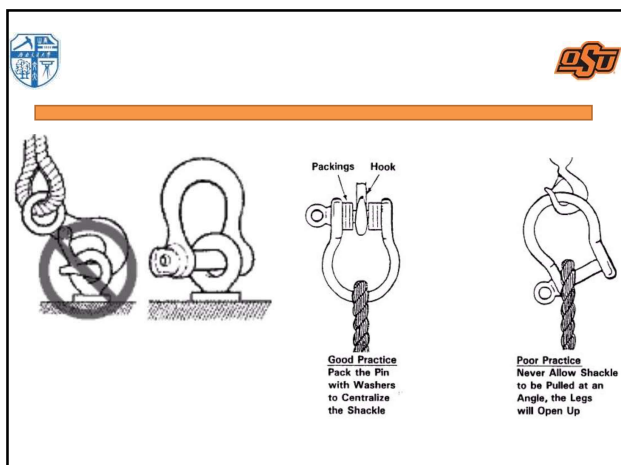
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## Alloy Steel Chain Slings



- Alloy steel has become the standard material for chain slings
  - very strong
  - very durable and capable of with standing the physical abuse that industrial slings routinely receive
- Never use "proof coil chain" for slings
  - has less carbon and is good service duty chain

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## Chain Slings



- A thorough periodic inspection of alloy steel chain slings in use shall be made once every 12 months
- The employer shall make and maintain records

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## Capacities



1/2-inch alloy steel chain	Capacity (lbs)
Single (at vertical)	11,250
Double (at 60° from horizontal)	19,500
Triple (at 60° from horizontal)	29,000
Quadruple (at 60° from horizontal)	29,000

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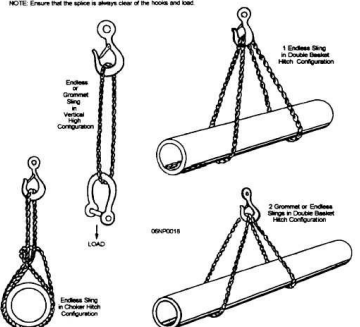


## Endless Slings



- Three methods of use
- Frequently, it is used as a choker hitch

NOTE: Ensure that the splice is always clear of the hooks and load.



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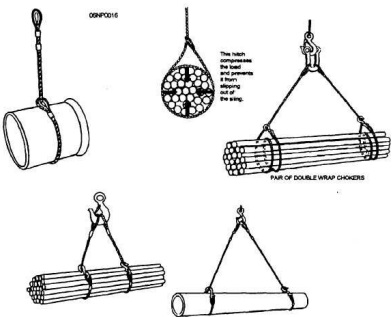
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## Single-leg slings





09HFD015

The hitch secures the load and prevents the sling from slipping out of the eye.

PAIR OF DOUBLE WRAP CHOKERS

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## Bridle Slings





- Use single-leg slings to make various types
  - 2-way
  - 4-way

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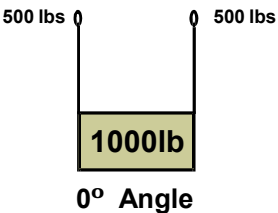




## Rigging Calculations



- Sling Angles
  - Two slings, each supporting the same uniformly distributed weight and having the same support angle results in an equal distribution of the load to each sling



500 lbs      500 lbs

1000lb

0° Angle

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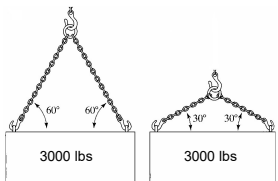
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## Sling Systems



- The objective is to use the sling system to lift a load weighing 3000 pounds two different ways. The rated capacity of a single sling is 2000 lbs.
- Question: Which rigging assembly is acceptable?



3000 lbs      3000 lbs

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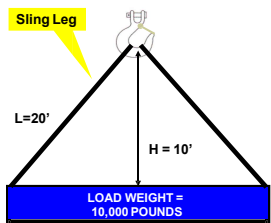
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Sling Leg

L=20'

H=10'

LOAD WEIGHT = 10,000 POUNDS

- Divide the sling length by the height from the load to the hook
- Sling Tension
  - $L/H \times \frac{1}{2} \text{ Load}$
- $20 \div 10 = 2$
- $2 \times \frac{1}{2} \text{ Weight} = 10,000$
- Each leg = 10,000 tension

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## Selection of Sling



- **Rated load**
- The **nature** of the item to be lifted
  - For example, nylon web slings are not permitted in the presence of acid or phenolic vapors; polyester/polypropylene web slings and web slings with aluminum fittings are not permitted in the case of caustic vapors
- Operation **temperature**
- Sling **cost**
- Environmental factors (e.g. sharp edges)

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## Inspections



- Each day before being used, the sling and all fastenings and attachments shall be inspected for damage or defects by a competent person designated by the employer
- Additional inspections shall be performed during sling use, where service conditions warrant
- Damaged or defective slings shall be immediately removed from service

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## Safe Rigging Practices



- Never exceed the rated capacity
- Never use a damaged sling
- Never shorten with knots, bolts, or other devices
- Always protect slings from sharp edges of the load
- Always keep hands and fingers clear of slings under tension

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# Collaborative Bachelor's Degree Program of Fire Protection and Safety Engineering Technology between Southwest Jiaotong University and Oklahoma State University, U.S.A.



Collaborative Bachelor's Degree Program of Fire Protection and Safety Engineering Technology between Southwest Jiaotong University and Oklahoma State University, U.S.A.



Take the time to Plan, Inspect,  
Check and Recheck

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