Rigging & Fall Arrest
Introduction

- Safety, safety, safety
- Respect
- Attention to detail

- Almost every event these days requires hanging scenery, sound, lighting and any other type of production equipment.
What is rigging?

- Rigging can be broken into six different problems.
  - Sling
  - Hitch
  - Hardware
  - Hang
  - Hoist
  - Fall Protection
Safety While Rigging

- Safety is key to successful rigging
- Using the correct tools is a must
- Know your limitations
- Know the space
- Equipment Inspections
- Design Safety Factor
Slings & Stuff
Sling Types

- Wire rope sling
- Chain sling
- Web sling
- Round sling
- Fiber rope sling
Wire Rope

Three Basic Parts

1. Wires
   1. Predominately made with high carbon steel
      1. Most wire ropes are uncoated or “bright”
      2. Wire ropes also be coated in Galvanized, zinc or tin coating.
   2. Other types include stainless steel, iron or bronze.

2. Strands
   1. Two or more wires wrapped around a core

3. Core
   1. Fiber or independent
   2. Core is used to support the outer strand
   3. If the core is not identical to the strands do not count the core when ordering wire rope.

PHOTO
Materials

- 2 main materials used
  - High Carbon Steel
    - Galvanized
  - Stainless Steel (weaker than high carbon)
- Different Grades of High Carbon Steel
  - Improved Plow Steel (IPS)
  - Extra Improved Plow Steel (XIP, ELP)
  - Extra Extra Improved Plow Steel (XXIP, EEIP)
Selection Criteria

- Abrasion Resistance
- Bending Fatigue
- Strength
- Price
Definitions

- **Nominal** = (breaking strength)
- **Breaking Strength** = 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
- **SWL** = Safe Working Load
- **Design Factor or 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: 4 to 1
- **D to d Ratio** = The D/d Ratio is the ratio of the diameter around which the sling is bent, divided by the body diameter of the sling.

**Example:** A 1/2" diameter wire rope is bent around a 10" diameter pipe; the D/d Ratio is 10" divided by 1/2" = D/d Ratio of 20:1
When a wire rope is bent around any sheave or other circular object there is a loss of strength due to this bending action. As the D/d ratio becomes smaller this loss of strength becomes greater and the rope becomes less efficient.
The type & size of wire rope determines the flexibility and abrasion resistance.

Understanding size
- Strand vs. wires (7X19, 6X19)

Wire Rope Core
- FC = Fiber Core
- IRWC = Independent Wire Rope Core

PHOTO
Aircraft Cable

- Most common in stage rigging
  - 1x9
    - (not flexible at all)
  - 7x7
    - Good for wire guided situations
    - Good on abrasion but not very flexible
    - Not as strong as 7x19, more airspace between strands.
  - 7x19
    - Most common
    - Very flexible

PHOTO
Ratings Chart

- 7x19 Aircraft Cable

<table>
<thead>
<tr>
<th>WIRE ROPE</th>
<th>Nominal Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8”</td>
<td>2,000lbs</td>
</tr>
<tr>
<td>1/4”</td>
<td>7,000lbs</td>
</tr>
<tr>
<td>3/8”</td>
<td>14,000lbs</td>
</tr>
<tr>
<td>1/2”</td>
<td>22,800lbs</td>
</tr>
</tbody>
</table>
Wire Rope Slings

- Soft Eye Sling do not use a thimble
- Use heavy pattern thimble for stage rigging.
- Sling body length = wire diameter x 10 due to flexibility of wire and premature failure.
- Bearing to Bearing length = overall length
- Lay = distance one strand needs to travel 360 deg.
# Wire Rope Slings

## Advantages
1. Easy to find
2. Good Strength
3. Light Weight
4. Easy to locate capacity
5. No tag required

## Disadvantages
1. Bad D to d
2. Does not grip
3. Not good on sharp edges.
Wire Rope Inspection

- Look for broken wires.
- Look for kinking and deformation.
- Look at eye for rope damage and wear.
- Look for corrosion and rust.
Synthetic Slings

- Spanset or Round Sling
  - Polyester fiber
  - Double or single jacket
  - Test for chemical reaction
  - D to d ratio is 1:1
  - Color of sling dictates strength
    - Purple = 2500 lbs. working load
    - Green = 5000 lbs. working load
  - If you choke a spanset you lose 20% of its strength.
  - Not fire proof
  - Good D to d ratio 1:1
Synthetic Slings

Advantages
1. Flexible
2. Mold to shape
3. Good D to d
4. Will not damage the load.
5. Light weight

Disadvantages
1. Subject to heat damage
2. Will stretch under load
3. Can tear or can be cut
4. Bad on sharp angles
5. Must have rating labels.
# Chain Slings

## Advantages
- Durable in almost all conditions
- Will shape to most loads
- Easy to adjust

## Disadvantages
- Difficult to inspect
- Heavy
- Can damage load
- Requires load rating
Chain Inspection

- Inspect for twisted or bent links
- Inspect for stretching, chain will squeeze together in the middle.
- Inspect for corrosion. Store in a dry place.
- Nicks or gouges.
- Use a wear Guage.
Types of Chain

- **Grade 80**
  - Grade 80 Chain is made from heat treated alloy steel and is specifically recommended for overhead lifting. Domestic.

- **Grade 30 Proof Coil**
  - Proof Coil Chain is made from low carbon steel and is an excellent general-purpose chain of standard commercial quality. Imported or Domestic. Do not use for overhead lifting.

- **STAC CHAIN (Special Theatrical Alloy Chain)**
  - W.L.L of 12,000 lbs.
  - Good for extending Bridles.
  - Usually comes in 3’ or 6’ pieces.
  - Never wrap around and i-beam
  - Accepts large shackles
  - 4:1 design factor
  - ½ “
  - Link.

- **CM Load Chain**
  - Available in ¼”, 5/16”
  - Hardened exterior.
  - Need to use grinder to cut exterior chain.
  - Cut with bolt cutters.
## Compare

### SLING TYPES

<table>
<thead>
<tr>
<th></th>
<th>Nylon Rope</th>
<th>Nylon Web</th>
<th>Polyester Roundsling</th>
<th>Grade 8 Chain</th>
<th>Wire Rope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Factor</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Durability</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Life</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
<td>Indefinite</td>
<td>Indefinite</td>
</tr>
<tr>
<td>Stretch at SWL</td>
<td>9%</td>
<td>6%</td>
<td>3%</td>
<td>?</td>
<td>1/2%</td>
</tr>
<tr>
<td>Handling Ease</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Size</td>
<td>1-1/2”</td>
<td>2” x ¼”</td>
<td>2” x 3/8”</td>
<td>1” x 2”</td>
<td>½” dia</td>
</tr>
<tr>
<td>Weight</td>
<td>6 lbs.</td>
<td>2 lbs.</td>
<td>1.25 lbs.</td>
<td>7 lbs.</td>
<td>4 lbs.</td>
</tr>
<tr>
<td>Cost</td>
<td>$61</td>
<td>$11</td>
<td>$25</td>
<td>$32</td>
<td>$11</td>
</tr>
</tbody>
</table>
Wire Size

BACK
7x19 Wire Rope

- 7 x 19 Flexible Preformed Galvanized and Stainless

7 x 19 (Flexible) small cord has seven strands of 19 wires each. It is stronger than the 7 x 7 construction and not as strong as the 1 x 19, but is the most flexible. Because of its fine wires, the best service is obtained with 7 x 19 where abrasion is not too severe. These fine wires make it the most flexible to withstand severe bending.
Wire Rope

Always measure the diameter of wire rope at its widest point.
STAC Chain

- CM Special Theatrical Alloy Chain (STAC) is used for theatrical rigging applications where bridle adjustability is required. Made from heat treated alloy steel to provide long life, each link is proof tested to assure weld and material integrity. The 4:1 design factor meets NACM/GR80 standards for strength. Pieces are tagged with grade, reach, size and working load limit for positive easy identification. The link accepts shackles up to 3/4" for versatility and adjustability.