1

Special Thanks

- Indiana Thespians
- Loos and Company
- Sapsis Rigging
- USITT

2

What We'll Cover

1. System components you see (and those you don't)
2. Procedures for using your counterweight system
3. Appropriate terminations (knots, wire rope clips and compression sleeves)
4. Working Loads, Design Factors and Hardware
5. Rigging Inspections
6. Appropriate PPE (hardhats, gloves, fall arrest)
7. Documentation
8. Student testing
9. ANSI Standards

3

As with everything in tech…

It is not just what you don't know,

It is what you don't know you don't know.

4

Types of Rigging Systems

You likely have one of six types of systems:

1. Single Purchase (1:1 Ratio of counterweight to load)
2. Double Purchase (2:1 Ratio of counterweight to load)
3. Motorized system where battens are raised and lowered by a motor.
4. A hybrid of 1 and 3
5. Dead Hung (nothing moves)
6. A hybrid of 1 and 5 (or maybe 3 and 5)

5

Motorized

- **Advantages**
- Systems are more compact than counterweight systems
- Reliance is more on machines rather than human strength and built in safety features
- Advanced automation systems reduce human error element from system operation.
- Less labor and time required for installations with "Packaged" hoist systems.
- Can be designed to needs of the user.

- **Disadvantages**
- More expensive than traditional systems (20—30k)
- Reliance on computers and electronics
- Machines have less ability to "sense" irregularities in a system than humans.
- A well-maintained manual counterweight system can likely last decades. Motorized, by one rigger's estimate, perhaps 15 years.

6

System Components

Rope Lock (positioning device, can hold 50 lbs. out of balance)

Counterweight Arbor

7

System Components

Head Block

Loft Block w/Idler

8

System Components

Floor Block/Tensioner

Spreader Plates w/ Locking Collars

9

System Components

Lift Lines

Purchase/Hand Lines

10

System Components

Trim Chain

Locking Rail/Index Strip

11

Procedure for Running a Line Set (Bringing batten in)

1. Make sure stage area is clear
2. Check hand lines below and above the arbor for excess tension
3. Make call "heads up on deck, _____coming in"
4. Wait for response "Thank you"
5. Open rope lock and bring batten in.
6. If you have a motorized system, you still need to make the calls.

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Procedure for Running a Line Set (taking batten out)

1. Make sure stage area is clear
2. Check hand lines below and above the arbor for excess tension
3. Make call "heads up on deck, _____going out"
4. Wait for response "Thank you"
5. Open rope lock and take batten out.

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Procedure for Loading an Arbor

(with a loading bridge/batten loaded first)

1. Make sure stage area is clear below loading bridge
2. Clarify how much weight is to be added or removed "add 80 lbs. over pipe weight"
3. Loader: "Clear the rail, loading weight"
   Operator: "Rail is clear, load weight"
   Loader: "Finished loading, check for balance"
   Operator: "Checking balance. Thank you."

4. If there is no loading bridge, you will either need to load the arbor incrementally or use a block and fall or a capstan winch to regain a mechanical advantage.

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Loading the Arbor (or batten)

- General note, when loading battens or arbors, make certain that they are in their full out or in position. Failing to do so can result in the system shifting unexpectedly.

15

General Guidelines for Loading an arbor when dealing with soft goods.

- **If you have a loading bridge**:
- 1. Attach load to batten. Most of the weight is resting on the deck, make provision for holding the batten down as counterweight is added
- 2. Load counterweight arbor.
- 3. Since much of the weight is still on the deck, you are in an arbor heavy situation. Hold the batten down.
- 4. Slowly raise the batten to test for balance, keeping it under control at all times. The weight ratio will get better as the batten rises but initially it will act like a runaway so have help at the fly rail. You may opt to use a bull line.
- 4. Add or subtract weight as needed for final balancing. (Glerum, *Stage Rigging Handbook*)

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General Guidelines for Unloading an arbor or objects on a batten.

- **If you have a loading bridge:**
- 1. Unload weight from the arbor first.
- 2. Remove weight from batten.
- (Glerum, *Stage Rigging Handbook*)

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General Guidelines for Loading an arbor or hanging objects on a batten.

- **If you do not have a loading bridge:**
- 1. Put a small amount of weight on the arbor-enough so the operator can can safely raise the arbor to a height where the batten can be reached.
- 2. Add part of the load to the batten, overloading the batten slightly.
- 3. Lower the arbor so more weight can be added. This procedure is followed back and forth until both the arbor and the batten are fully loaded and balanced. The rail operator needs to be strong and in good physical condition for this to work. (Glerum, *Stage Rigging Handbook*)

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General Guidelines for Unloading an arbor or objects on a batten.

- **If you do not have a loading bridge:**
- For unloading, the procedure is reversed. Do not remove all the load or counterweight at one time. This could result in a runaway set. (Glerum, *Stage Rigging Handbook*)

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Odds and Ends

1. Your line sets will never be in perfect balance. To that end, always be heavier on the arbor side. A batten heavy imbalance can result in injury to the actors.
2. Be certain that your rail is labeled indicating what each line set does (2nd Leg), arbor height and capacity, pipe weight.
3. Display safety signage
4. Stack counterweight in a cross hatched fashion and no higher than three bricks and never above the toe rail.

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What Things Weigh

21

Weights of Common Objects

- 1-1/2" Schedule 40 Pipe: 2.72 lb/Ft
- Source 4 PAR: 7.5 lbs.*
- Source 4 ERS: 14 lbs.*
- Selecon Rama Fresnel: 12 lbs.*
- Drapes: depends on the fabric, fullness and size. Ask your draper
- *Info found on fixture data sheet.
- 1x4: .64 lbs./ft.
- 2x4: 1.28 lbs./ft.
- Luaun: 1/" x 4' x8': 17.5 lbs.
- (wood and drapes are also influenced by the amount of moisture absorbed by the material)
- Side note: an excellent reason to ask that your theatre be air conditioned during the summer. Drapes get heavier when humidity is factored in.

22

How Much Will a Batten Hold?

- Depends on arbor capacity
- Depends on system components and their ratings.

- **Never exceed arbor capacity:** The manufacturer can help you or you can measure your arbors and then determine the types and weights of your counterweight.
- For a rough estimate (next page)

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Arbor Capacity

Approximate Load Capacities of Clancy Arbors
(Using Steel Counterweights)

	4" Wide Weights		6" Wide Weights	
Arbor Length	LB	KG	LB	KG
4 ft.	504	229	782	355
5 ft.	672	305	1,043	473
6 ft.	841	381	1,303	591
7 ft.	1,009	458	1,564	709
8 ft.	1,177	534	1,825	828
9 ft.	1,345	610	2,086	946
10 ft.	1,514	687	2,346	1,064
11 ft.	1,682	763	2,607	1,183
12 ft.	1,850	839	2,868	1,301
13 ft.	2,018	915	3,129	1,419

Please note, these are for J.R. Clancy arbors.

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Sometimes, we need to hang something besides a light or a drop.

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Types of Loads

- Point Load: A load exerting force at a single connection point (chain hoist, lights)
- Uniformly Distributed Load: A load spread evenly across a pipe or truss (drops)
- Static Load: A load that remains constant over time (a hanging scenic element)
- Dynamic Load: A load that changes over time (aerial effects)
- Shock Load: An instant load (runaway)

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Working Loads and Design Factors

1. Working load for rope, wire rope, or chain is determined by the manufacturer and will be printed on the spool or package.
2. The working load indicates the maximum amount of weight that can be suspended as a static load.
3. However, the design factor will be used to further clarify the maximum amount of weight that can be held.
4. Minimum design factors used in the entertainment industry are:

Static Wire Rope and Hardware	5:1
Running-wire rope	8:1
Fiber rope/Live Load	10:1

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Termination Efficiency

Wire Rope Clips (forged, not malleable)

1/8” 80%

Swaged Compression Sleeves (always copper for rigging)

Swaged 95-100%

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Wire Rope

Typically, we use 7 x 19 Galvanized Aircraft Cable (GAC). ¼" GAC is rated at 7000lbs.

Breaking Strength for 1/8" GAC is 2000lbs.

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Working Loads and Design Factors

Calculating the design factor:

1. 1/8" Galvanized Aircraft Cable (GAC) has a catalogue breaking strength of 2000 lbs.
2. Using wire rope clips gives us an 80% efficiency and a de-rated breaking strength of 1600 lbs. The allowable static load with a 5:1 design factor is 320 lbs. The allowable running load (at 8:1) is 200 lbs.

   2000 x 0.8 = 1600 lbs.
   1600/5 = 320 lbs. (5:1 DF)
   1600/8 = 200 lbs. (8:1 DF)
   1600/10 = 160 lbs. (10:1 DF)

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Working Loads and Design Factors

Our procedure for determining appropriate rope, hardware and terminations…

1. How much does the object weigh?
2. How will it be terminated?
3. Will it move?
4. We will also factor in (by increasing the design factor) the unforeseen forces hidden in the *factor of ignorance;* this includes fatigue and shock loading.

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Terminations

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Wire Rope Clips

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Wire Rope Clips

Forged

- Cost more but come with lot # and manufacturer information.
- **What you should use**

Malleable

- Typically purchased from Lowes, Home Depot, etc.
- **What you probably use (and shouldn't).**

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Wire Rope Clips

Recommended Method of Application of Cable Clips

1. Turn back the specified amount of rope from the thimble. Apply the first clip one base width from the dead end of the wire rope. Place the U-bolt over the dead end; the live end rests in the clip saddle. Tighten the nuts evenly to the recommended torque.

2. Apply the next clip as near the loop as possible. Turn on nuts firm, but do not tighten.

3. Space additional clips, if required, equally between the first two. Turn on nuts, take up any rope slack, and tighten all nuts evenly to the recommended torque.

4. Apply the initial load and retighten the nuts to recommended torque. The rope will stretch and shrink in diameter when loads are applied. Inspect the clips periodically and retighten.

Recommended torque values are based on the threads being clean, dry and free of lubrication.

IMPORTANT: Failure to make termination in accordance with instructions, or failure to check the recommended torque periodically and retighten, will cause a reduction in the efficiency ratings of the clips.

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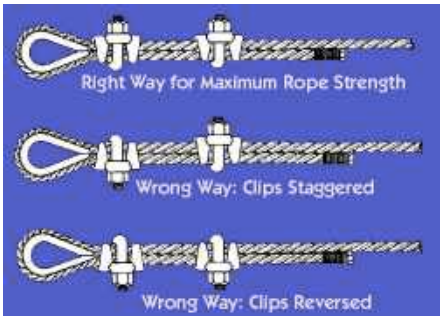
Wire Rope Clips



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Wire Rope Clips

Cable Size In Inches	Minimum Number of Clips	Amount of Rope Turnback/Inches	Torque in Ft. Lbs
1/8	2	3"	4.5
3/16	2	3"	7.5
1/4	2	4 3/4"	15
5/16	2	5 1/4"	30
3/8	2	6"	45
7/16	2	7"	65
1/2	3	11 1/2"	65

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Swaged Fittings

When applying multiple swages to a sleeve it is best to start at one end of the sleeve and work toward the other end, swaging in sequence until the proper number of swages are applied. Or you may start in the middle of the sleeve and go to either end completing the required number of swages. Do not swage the sleeve once on each end and then complete swages in the middle of the sleeve, as the copper material will not flow properly during expansion and will not allow the "lengthening" of the sleeve. DO NOT USE ALUMINUM OVALS FOR RIGGING. See next slide

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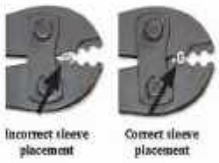
Swaged Fittings



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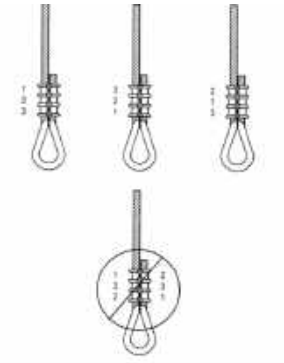
Swaged Fittings Crimp Sequence



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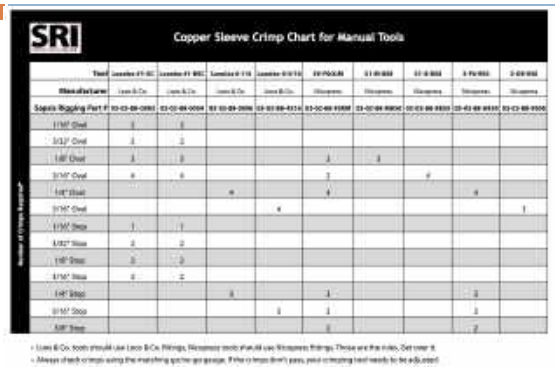
Swaged Fittings Number of Crimps



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Swaged Fittings Go-No Go Gauge

The swaged fitting should then be checked with the gauge. It should fit into the designated slot. If not, re-crimp. If it fails again, you must start over

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Rigging Inspections

ANSI E1.47 (Recommended Guidelines for Entertainment Rigging System Inspections)

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ANSI E1.47

According to the standard, rigging inspections are to be performed annually.

Inspections come in two forms:

Level 1 (performed annually) is a basic inspection looking at system components, functionality and noting any obvious issues.

Level 2 (performed every five years) is a thorough inspection of all system components.

If your rigging includes motorized components, they should receive a level 2 inspection annually.

If you don't know the date of you last inspection, you should have a level 2.

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What Will the Inspector Look For?

- Overstressed Components
- Impact Loading
- Fatigue
- Loose or missing Hardware
- Defective Hardware
- Corrosion
- Incorrectly Installed Hardware
- Wrong Hardware for the Job
- Organic Degradation

- Help the inspector by scheduling during a down time in the theatre
- Clear the stage area
- Stack counterweight correctly
- Take down scenery
- Don't clean too much as they may be looking for metal shavings and other signs of fatigue and wear.

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What Should I Expect? Cost?

- A written report (typically within two weeks)
- Images of problem areas, an explanation of the problems and potential fixes.
- The rigging inspector may work for a company that can do the repairs but you are not obligated to use them.

- Cost will be influenced by the size of your theatre and complexity of your systems
- There will be a charge for travel and usually a per diem.
- Our inspection last year ran about $2000 and we have 17 linesets

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What Can I Do?

How do I know if something is wrong?

A rigging system is like a vehicle. If it looks, sounds, feels or smells wrong, there is probably something wrong.

Just like vehicles and other machinery, rigging needs to be inspected and maintained.

How do I know if something is wrong?

Unusual noises

Physically difficult to move

Metal shavings or other visual abnormalities

Gifts from the hardware fairy

Any other signs of potential damage or friction.

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What Can I Do?--2

- Every time you use your rigging system, be attuned to the system's characteristics.
- Test fly every line set or running line that is used in a show before the house opens.
- Ensure that every line set operates as it should and is consistent with the previous performance.

- Investigate every strange noise, feel, smell or visual element to determine the cause and to see is a repair is needed.
- No performance is as important as the safety of the performers, crew and audience.
- If you can't find the problem or can't fix it, take the line set out of service.
- Keep detailed records of issues, this will help you to better monitor areas of concern. (Log Book)

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Special Assistance with Inspections

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Special Assistance with Inspections

Applications for the next funding cycle are due November 15, 2017. Previous applications not yet funded will be retained & automatically considered in the next cycle.

The RSI is open to all secondary schools nationwide. Once a school's application is approved, they choose from a list of participating ETCP certified rigging inspectors in their area. USITT pays the inspector directly for the inspection and four to six hours of safety training for faculty and student stage crew. The only cost to schools may be the inspector's travel and housing -- if necessary -- and any special equipment such as a lift to access the system.

USITT has a national network of inspectors, so many schools find their cost is ZERO. The school gets a detailed status report on their rigging -- what's working properly and what potential safety problems can be prevented with routine care. Free safety training for up to eight staff & students helps ensure safe operation of a complex system. Thanks to our sponsors & donors, we can promote safe stages for students at little or no cost to schools!

http://www.usitt.org/rsi/

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Documentation

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Documentation

Documentation of system including:

1. Issues noted and dated
2. Repairs (dated) with paperwork
3. Inspections (including inspection report)
4. Typically, this will be a log book of some sort.
5. Be certain that all information is shared with administration. Conversations one on one and by email. (keep hard copies and in the case of conversations, send a memo.)

Documentation of student competencies:

1. Dates of training
2. Nature of training (syllabus/lesson plan)
3. Written Testing
4. Practical Testing
5. Criteria for passing grade

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Student Documentation

A standard form

Student Skill Documentation

Name_____ Year_____

The following is a record of skills attainment for the above named student. In each instance, the student has passed a both written (100%) and practical examination.

Skill	Date	Student/Teacher Signature
Counterweight Rigging		
Screw Gun		
Miter Saw		
Circular Saw		
Jig Saw		
Table Saw		
Panel Saw		
Fall Arrest		

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Documentation (line set signage)

- Arbor capacity
- Arbor height
- Pipe weight (batten weight)

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Training for Teachers

JAY O. GLERUM RIGGING MASTERCLASS

The Masterclasses honor the memory of one of our industry's great advocates for safety and training, Jay O. Glerum. Taught annually beginning in 2016, these masterclasses will have three tracks of learning, entry level, intermediate and advanced. The advanced track will be taught for ETCP renewal credit and include training on the latest innovations in rigging as well as advanced safety such as life rescue and other topics. The entry track is geared towards students and educators and includes both counterweight and automated rigging safety and operations. The intermediate level expands on the entry level training.

http://www.usitt.org/glerummasterclass/

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Termination Efficiency

Knots:

Bowline 60%

Clove Hitch 75%

Figure 8 64%

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Knots

Bowline

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Knots

Clove Hitch

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Student Testing

Written

1. Parts of system
2. Procedures
3. Functions

A 1:1 weight ratio is a reasonable description of a____system.

A. Double Purchase C. Manual Purchase
B. Single Purchase D. Counterweight

_____Spreader plates must be placed no more than every____inches on the counterweights.

A. 10 C. 30
B. 24 D. 40

_____Excess tension on the handline below the arbor/ropelock indicates that the set is____heavy.

A. Arbor C. Set
B. Pipe D. Not

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Student Testing

Practical

1. Use of line set
2. Proper communication
3. Procedures

Specific Tasks

1. Loading and unloading arbor
2. Bringing in batten
3. Taking out batten
4. Determining weight

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Hanging Drops/Drapes

Whether drapes or drops, hang from the Center Line

out to SL/SR

simultaneously. Typically tie every other tie line, pulling the drop to L or R and then tie remaining lines.

When removing, untie lines from outsides to center. Keep the back of drop on the floor.

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Hanging Drops/Drapes

Please note, when hanging drops/drapes, the bulk of the weight will be on the stage deck creating a potentially out of balance situation in relationship to the weight of the arbor and the batten.

Depending on the weight of the drape or drop, when it moves on or off the deck, there will be an imbalance. Plan accordingly.

62

Snub Knot

Snubbing can be used to temporarily secure an out-of-weight line-set until the weight can be adjusted. One end of the "snub line" is secured to the rail with a fixed eye knot, such as a bowline. The other end of the line is snubbed to the operating line. This Snub knot is one of several that can be used for the purpose.

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Hardware

64

Hanging Hardwre

- Rules
- Opt for steel over aluminum
- Choose hardware with the manufacturers name on it
- Understand breaking strength, working load limit and design factors
- Use only rated hardware, designed for lifting

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Hardware/Ratings

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Hardware

- Screw Pin Shackle
- Only use forged with WLL and manufacturers name listed
- May be used in this position, upside down as long as it is on the long axis. Never load across the short axis.
- Load only one component on the pin.

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Hardware

- Turnbuckle
- Only use forged with WLL and manufacturers name listed
- Load only one component on the pin.

68

Hardware

- Turnbuckle
- Only use forged with WLL and manufacturers name listed
- Load only one component on the pin.

69

Hardware

- Pear Ring
- Must have manufacturers name listed
- Must be intended for overhead lifting

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Hardware **NOPE**

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OSHA and ANSI Standards

- Occupational Safety and Health Administration (Construction and General Industry)
- American National Standards Institute

E1.4 Counterweight Rigging

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A Culture of Safety

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Safety

- Process and Protocol (the clear and consistent methods of doing our work)
- Proper and Consistent Communication
- Awareness of surroundings and the actions of others
- Training and enforcement of both site protection and personal protective equipment is required
- Standardized communication protocol on which everyone is trained is crucial, so there is an awareness and consitency in commands for procedures such as loading weight, etc.
- It is important to communicate not only the locations you are working overhead, but also indicate what tools and objects you are using.]When working below, it is important to avoid becoming immune to calls from above. Listening and repeating back is as important as the calls.

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Safety

- Weight loading/moving line sets: important to have consistent dialogue so if someone cannot hear well with chaos on stage, they still know what is being stated.
- Key phrases: "HEADS", "RUNAWAY"
- Good communication protocols for headsets: no chatter and always on headset
- Non-verbal communication: flashlights, cue lights, warning lights. Hand signals. Dead-man switch, other contact switches and indicator lights.

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Safety

- Personal Protective Equipment (PPE)
- Hard Hats
- Hearing Protection
- Eye Protection
- Proper Footwear
- Fall Protection
- Hand Protection
- Protection of Others:
- Barriers
- Warning Signs
- Beacon Lights
- Awareness of Workers Through Proper Training
- Enforcement of Safety Policies (Proper Footwear, Hard Hats, etc.) in the work zone.

76

Training

JAY O. GLERUM RIGGING MASTERCLASS

The Masterclasses honor the memory of one of our industry's great advocates for safety and training, Jay O. Glerum. Taught annually beginning in 2016, these masterclasses will have two tracks of learning, advanced and entry level. The advanced track will be taught for ETCP renewal credit and include training on the latest innovations in rigging as well as advanced safety such as life rescue and other topics. The entry track is geared towards students and educators and includes both counterweight and automated rigging safety and operations.

http://www.usitt.org/glerummasterclass/

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OSHA

Personal Protective Equipment (PPE)

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What is PPE?

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes

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More…

- 1910.132(a)
- Application. Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.
-

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More…

- Employee-owned equipment. Where employees provide their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.

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Dana Taylor
www.techtheatre4teachers.com

- **Dana W. Taylor** served as director of Vocal Music and Technical Theatre instructor at Mt. Vernon Senior High School (Mt. Vernon, IN) for thirty years. Mr. Taylor holds a Bachelor of Music Education degree and a Master of Music degree in Choral Conducting, both from Indiana University (Bloomington, IN). As a writer in the area of entertainment technology, Mr. Taylor has contributed articles to *Projection Lights and Staging News, Dramatics Magazine* and *Teaching Theatre Journal* and *High School Today*. From 2006-2017, Mr. Taylor was Technical Editor of *Dramatics Magazine* and *Teaching Theatre Journal*. He is technical editor for the theatre textbook, *Basic Drama Projects* (9th Edition) and *Concert Lighting: The Art and Business of Entertainment Lighting* (4th Edition). Mr. Taylor is currently an adjunct theatre and music faculty member at the University of Evansville. From 2013-2019, he served as a Director for ESTA (Entertainment Services and Technology Association) and currently is Vice Commissioner for Education for the United States Institute for Theatre Technology (USITT). Mr. Taylor was named Technical Theatre Educator of the Year (2005) by *Stage Directions* magazine. In 2011 the Educational Theatre Association named Mr. Taylor as recipient of their Founders' Award for "significant contributions to theatre education in the United States". Also in 2011, the Arts Council of Southwestern Indiana designated Mr. Taylor as their "Artist of the Year". In 2014, Mr. Taylor received the Distinguished Achievement Award in Education by the United States Institute for Theatre Technology.

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Working Loads and Design Factors

Calculating the design factor:

1. Every known force should be added to the load (increased weight of curtains from moisture/humidity) and added force required to overcome the inertia of starting to move an object at rest.
2. Calculating *strength reduction factors*. Examples include the knot in a rope or the type of termination used on a wire rope. Because these factors are known, the strength of the hardware device should be derated before starting the equation. For example, wire rope clips are 80% efficient so multiply the breaking strength of the wire by 0.8 to determine the breaking strength after clips are applied.

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When Should I Have an Inspection?

- Annually
- Have work performed by a qualified outside party.
- If you are uncertain about when the system was last inspected, schedule one for the very near future.
- An inspection will at least establish a baseline for the current state of your system.
- Regular inspections based on use, by qualified personnel
- Keep detailed records of issues, this will help you to better monitor areas of concern.
- Proper maintenance and regular inspections can help mitigate larger risks that may grow exponentially if left unattended.

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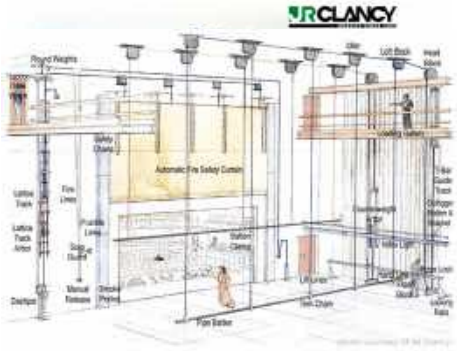
System Components



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Weight Distribution on Battens

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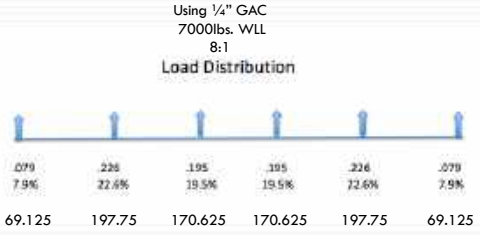
Weight Distribution on Battens

Using ¼" GAC
7000lbs. WLL
8:1
Load Distribution



69.125 197.75 170.625 170.625 197.75 69.125

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