

ADVANCED RIGGING PRINCIPLES

Hoisting Applications Using Synthetic Rope



U.S. Department of Labor - OSHA

Susan Harwood Grant

SH-05018-SH8

Acknowledgement

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Advanced Rigging Principles

Course Organization

The training is organized into six sections. The following sections and topics are covered in this training:

- Section 1: Introduction to NATE and OSHA
- Section 2: State of the Industry
- Section 3: Primary Regulations, Codes, Standards, and Policies
- Section 4: Synthetic Rope
- Section 5: Rigging Forces and Lift Systems
- Section 6: Hoisting Operations, Execution and Communication



Turning Point Technology

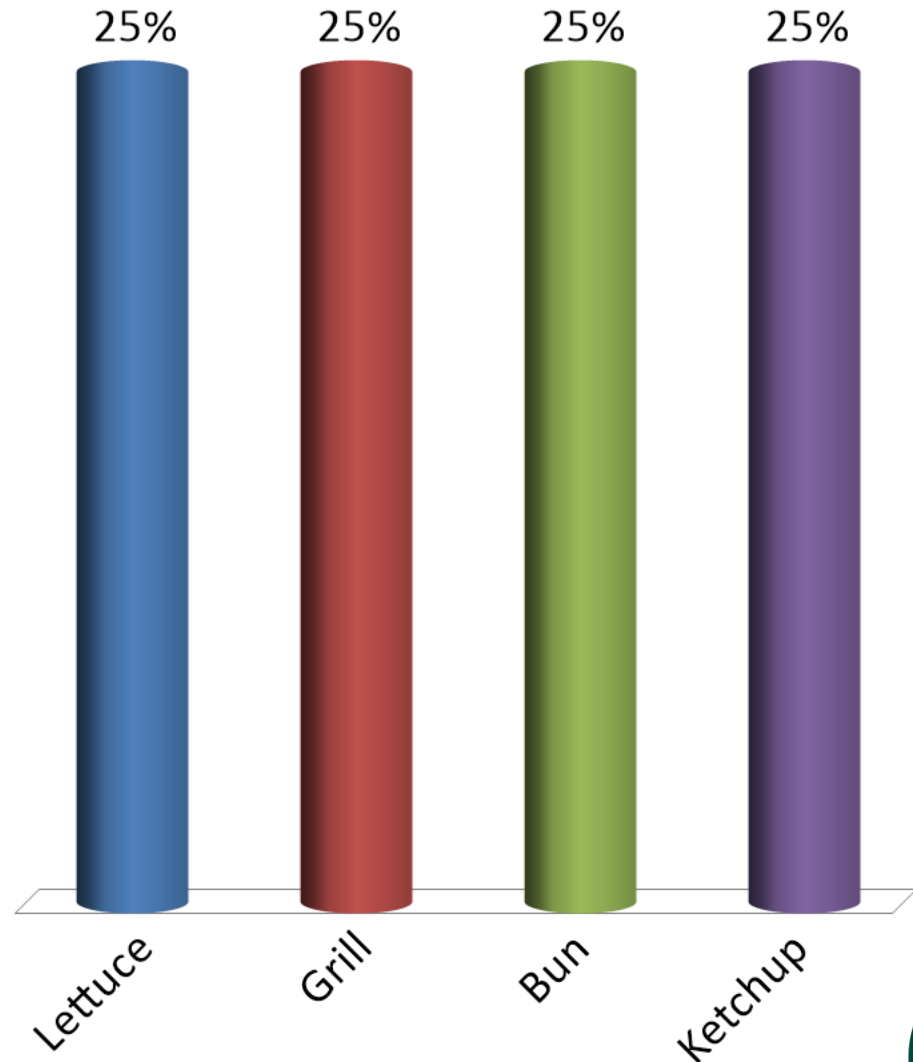
In this training you will utilize **Turning Point interactive response software.**

You will be asked questions and receive real-time feedback with handheld mobile devices. Results are instantly displayed on the screen and collected in detailed reports to ensure all participants are accounted for.



Pancake : Griddle :: Hamburger : ?

- A. Lettuce
- B. Grill
- C. Bun
- D. Ketchup



What is your age?

A. 18-24

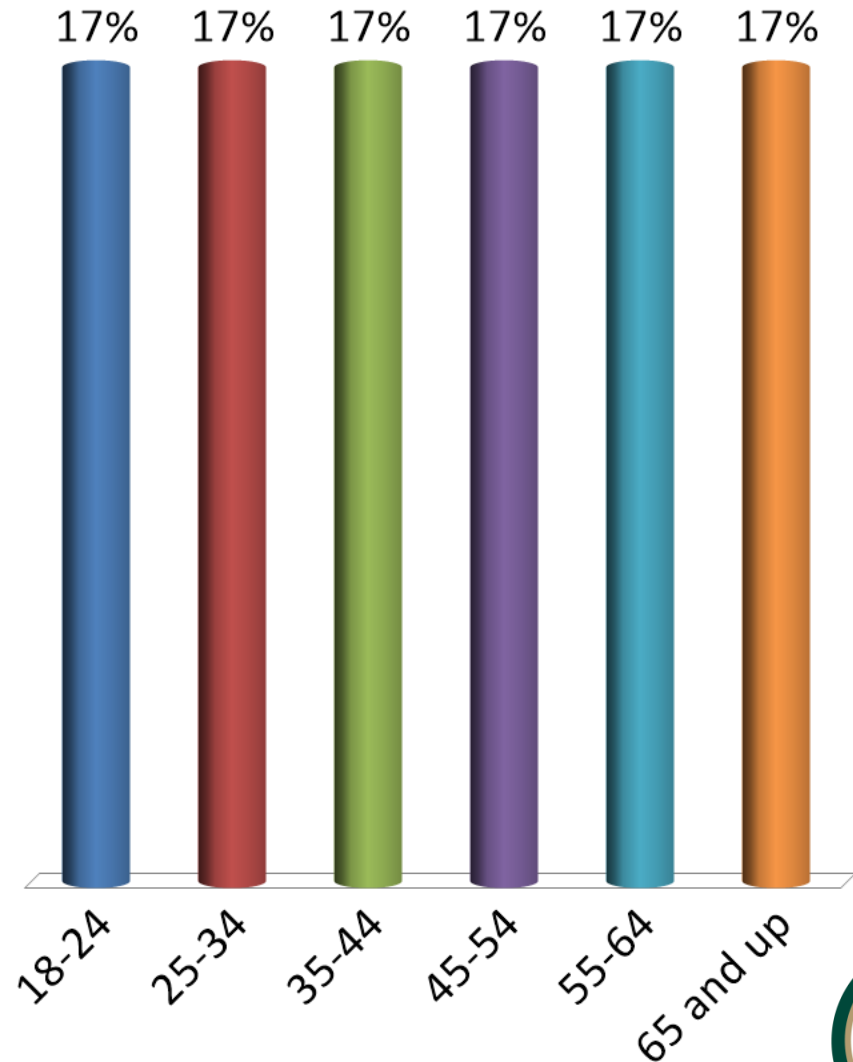
B. 25-34

C. 35-44

D. 45-54

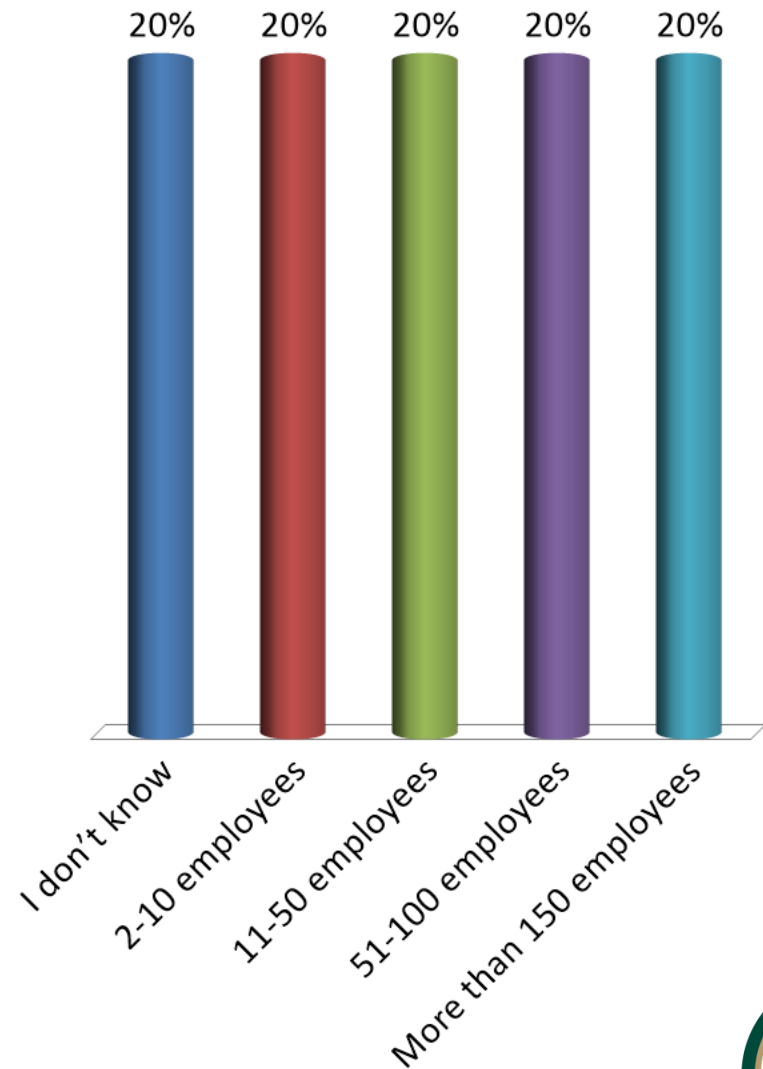
E. 55-64

F. 65 and up



What is the size of your employer?

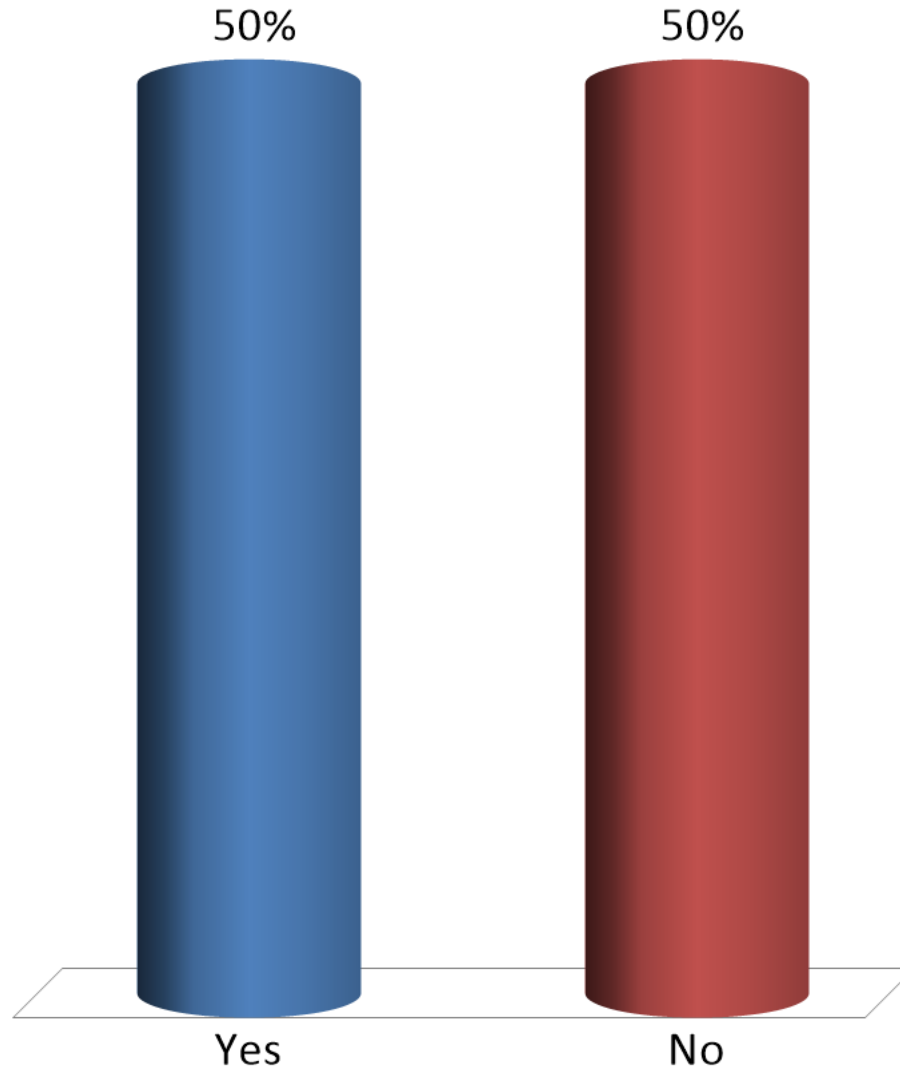
- A. I don't know
- B. 2-10 employees
- C. 11-50 employees
- D. 51-100 employees
- E. More than 150 employees



Does your company directly perform on-site construction?

A. Yes

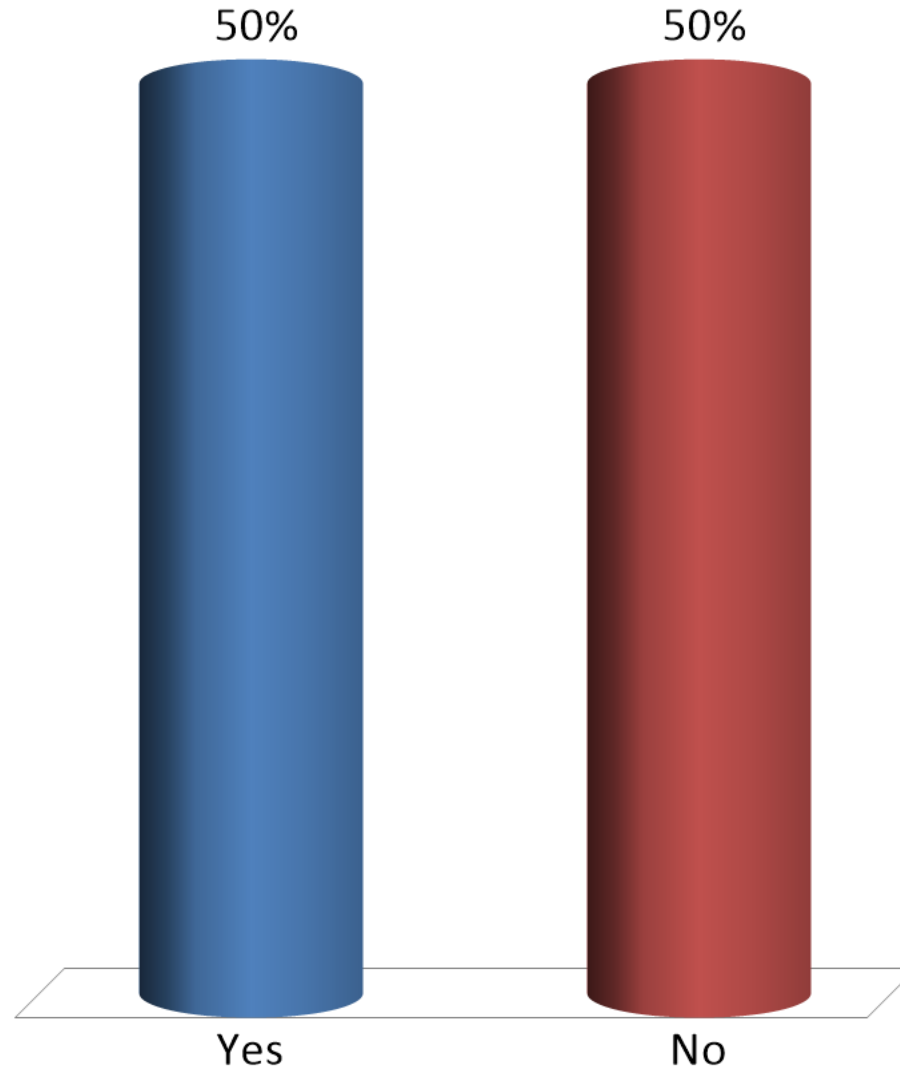
B. No



Do you create rigging plans?

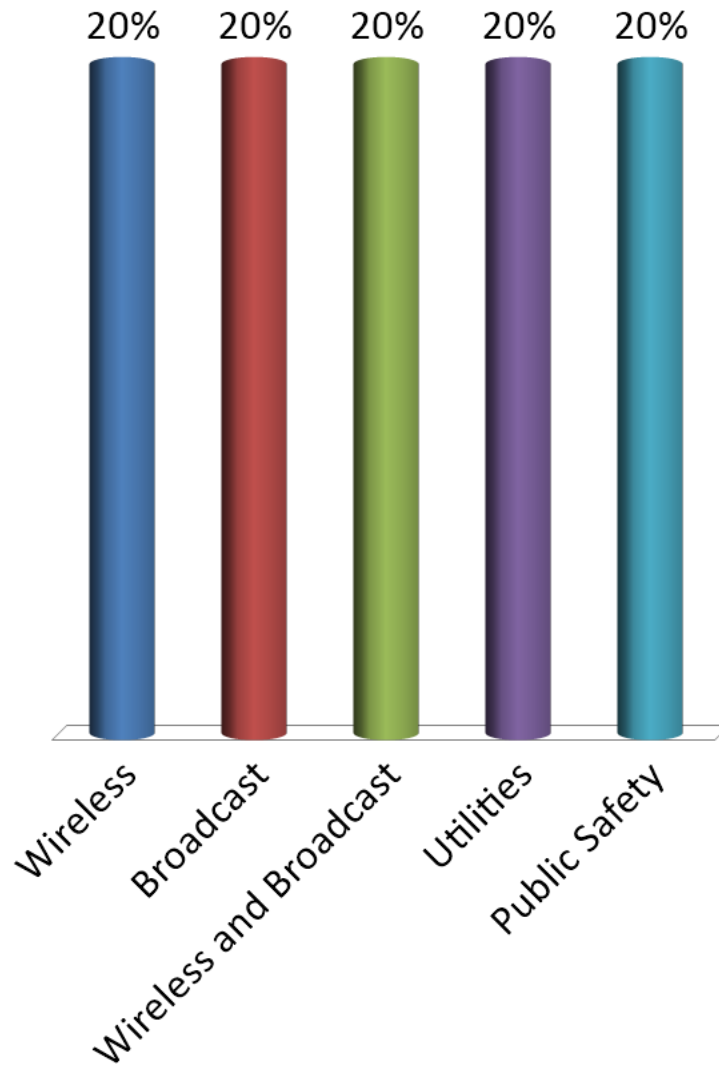
A. Yes

B. No



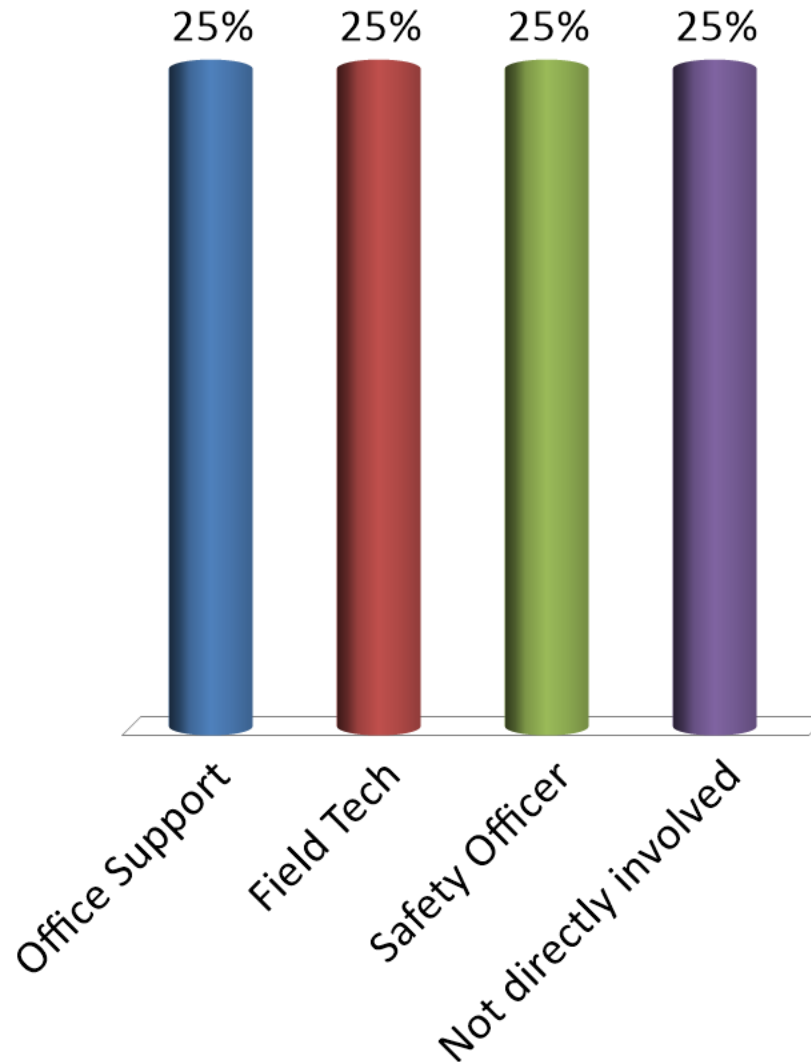
What primary sector do you service?

- A. Wireless
- B. Broadcast
- C. Wireless and Broadcast
- D. Utilities
- E. Public Safety



What is your primary responsibility for construction activities?

- A. Office Support
- B. Field Tech
- C. Safety Officer
- D. Not directly involved



Section 1

Introduction to NATE and OSHA



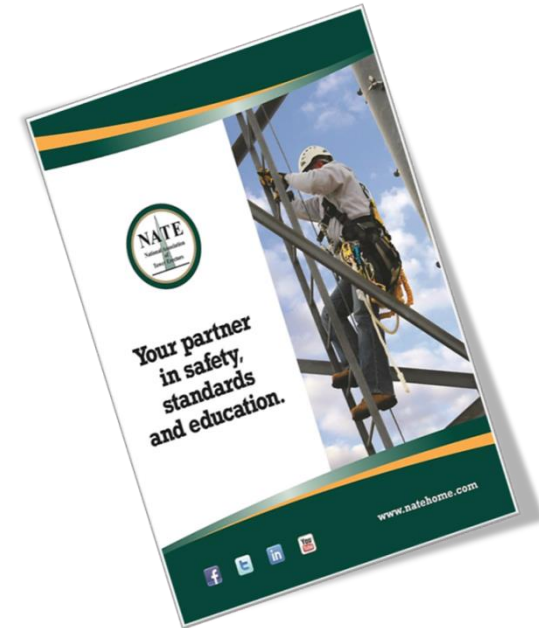
Topics

- Introduction to NATE and OSHA
- Importance of NATE and OSHA
- Responsibilities of the employer under OSHA
- Employee rights under OSHA



About NATE

- Global Leader in Industry Safety and Best Practices for 23 Years
- Voice of Tower Construction, Service and Maintenance Industry
- Diverse Membership make-up consisting of over 815 member companies



About OSHA

On December 29, 1970, President Nixon signed the **Occupational Safety and Health Act of 1970 (OSH Act) into law**. The OSH Act created the **Occupational Safety and Health Administration (OSHA)** to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.



What Does OSHA Do?

- Works with employers and employees to reduce workplace hazards through partnerships and alliances;
- Introduces new or improves upon existing safety and health programs;
- Utilizes consensus standards through an agreement with ANSI;
- Educates on safety and health rules that are designed to protect workers;
- Enforces the rules through inspection and citations;
- Monitors job-related injuries and illnesses through electronic records and reporting; and
- Conducts a variety of inspections to include: accidents, fatalities, complaints and programmed inspections.



Workers Have the Right To:

- Safe and healthful working conditions;
- File a confidential complaint with OSHA to have their workplace inspected;
- Review records of work-related injuries and illnesses;
- Receive training regarding the OSHA standards that apply to their workplace;
- Report any injury or illness without retaliation or discrimination;
- Obtain copies of test results done to find hazards in the workplace; and
- Obtain copies of their medical records.

Source: OSHA 3021-09R 2011, www.osha.gov/workers.html



Employers Must:

- Provide a workplace free from recognized hazards and comply with standards, rules and regulations issued under the OSHA Act;
- Eliminate or reduce hazards by making feasible changes in working conditions;
- Not discriminate against employees who exercise their rights under the Act;
- Inform employees of hazards through training, labels, alarms, etc.;
- Train employees in a language/vocabulary employees can understand; and
- Keep accurate records of work-related injuries and illnesses.



OSHA Whistleblower Protection

- Visit www.osha.gov/workers.html or call **800-321-OSHA**.
- Be prepared to provide specific details regarding your company and the type of hazard or discrimination being reported.
- Keep a confidential record of all details.
- Once a complaint is filed or reported, an investigation is normally warranted (see criteria on website).



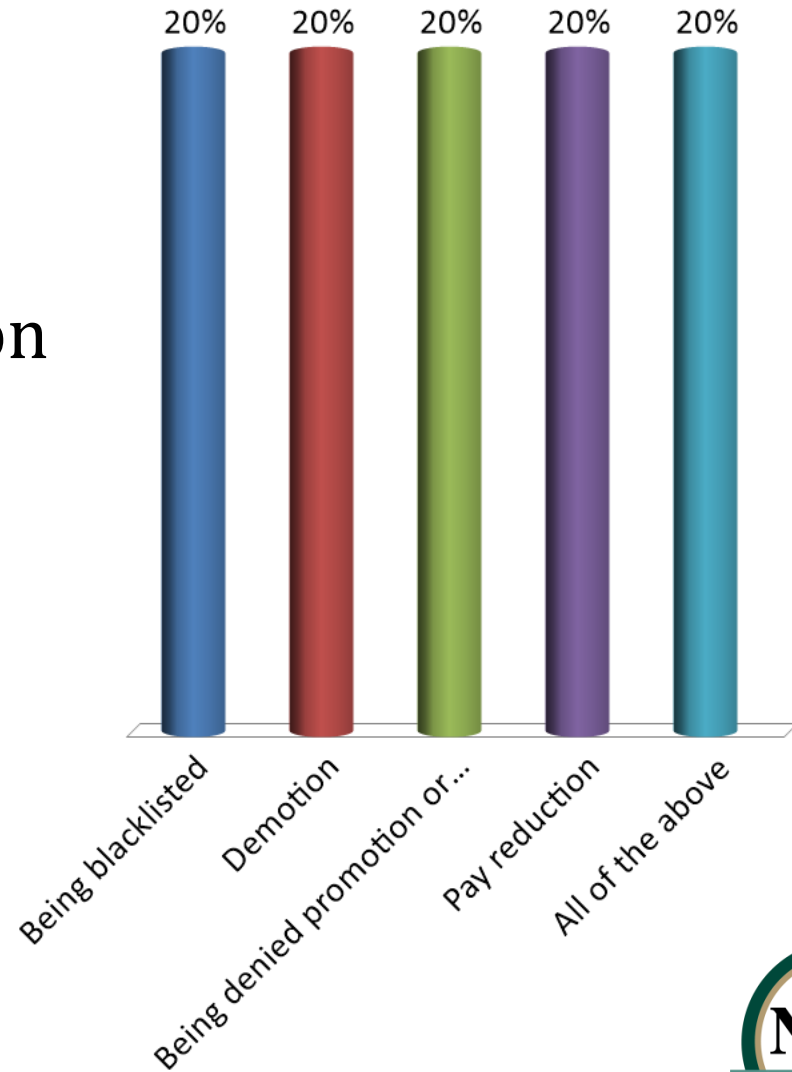
SECTION 1

REVIEW QUESTIONS



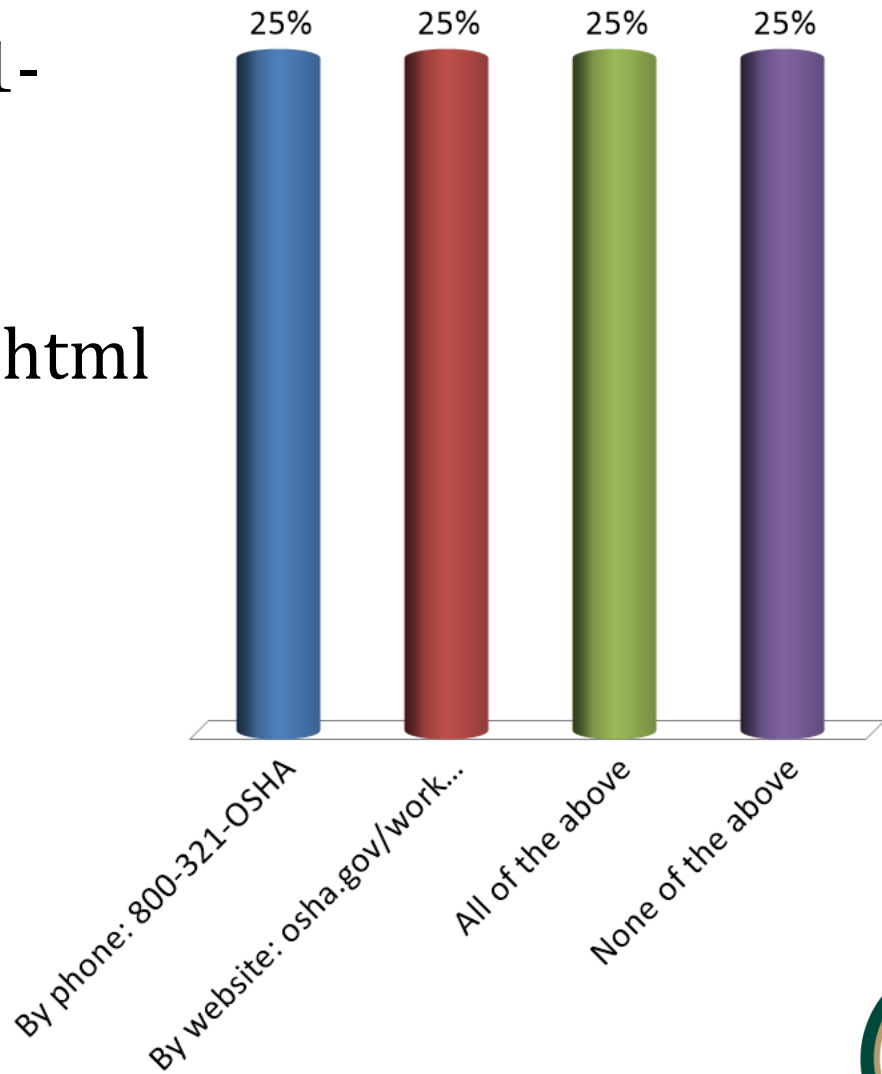
What OSHA whistleblower statutes are designed to provide employees the freedom to report violations and protect employees from the following acts of retribution?

- A. Being blacklisted
- B. Demotion
- C. Being denied promotion or overtime
- D. Pay reduction
- E. All of the above



Employees can report hazards and violations to OSHA through which mediums?

- A. By phone: 800-321-OSHA
- B. By website: osha.gov/workers.html
- C. All of the above
- D. None of the above



Section 2

State of the Industry



Topics

- Industry Statistics
- Incident Review
- Rigging Failures and Near Misses



Perspective Industry Fatality Statistics

Year	Fatalities
2003	15
2004	11
2005	7
2006	19
2007	11
2008	12
2009	5
2010	7
2011	7
2012	1
2013	14
2014	10
2015	4
2016	7
2017	8
2018	5
Total Fatalities	143



CTIA – The Wireless Association

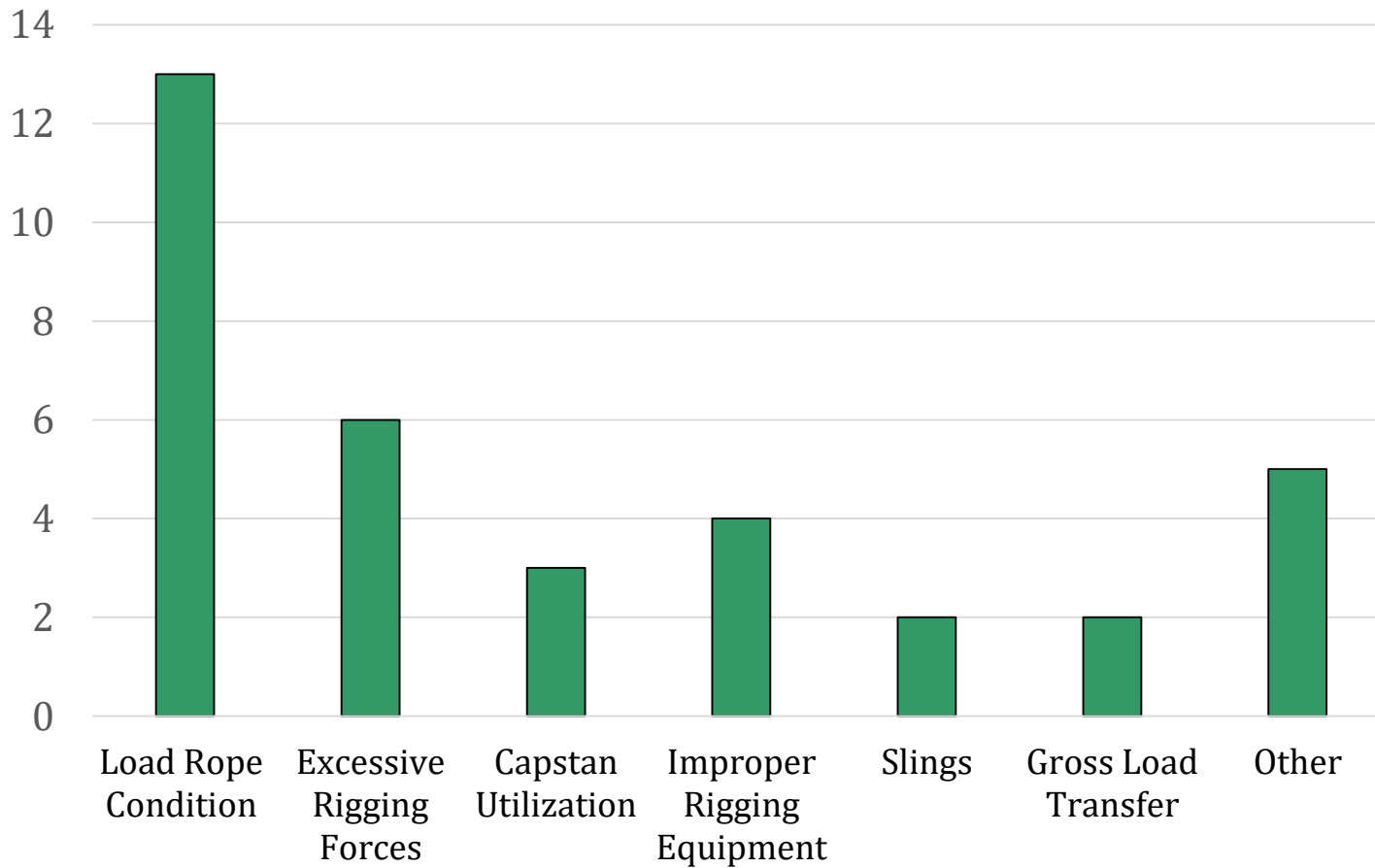
2018 Wireless Snapshot

- Over **15 trillion MB** carried over U.S. wireless networks last year, which is another annual record.
- A record **323,448 cell sites** were in operation at the end of 2017.
- CTIA indicates that today's **average download speed of 22.69 Mbps** is a **60% increase** from 2014.

Source: 2018 CTIA State of Wireless Report: https://api.ctia.org/wp-content/uploads/2018/07/CTIA_State-of-Wireless-2018_0710.pdf

Trends and Statistics

Reported Rigging Incidents - Technical Root Cause



**Sample of 35
Reported
Rigging
Incidents**
2016 - 11
2017 - 12
2018 - 13



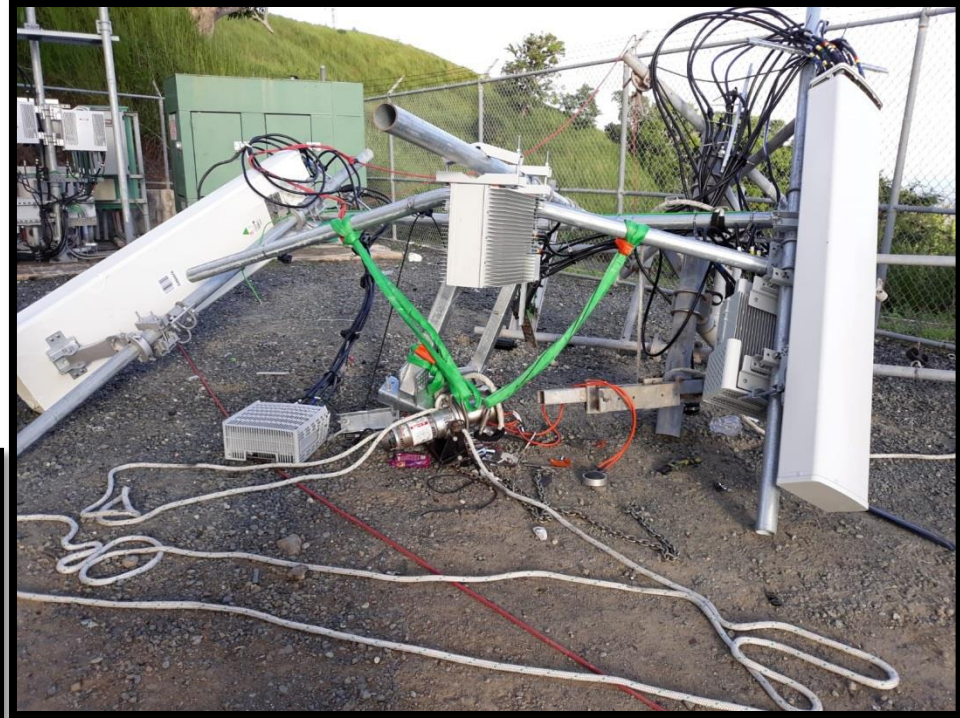
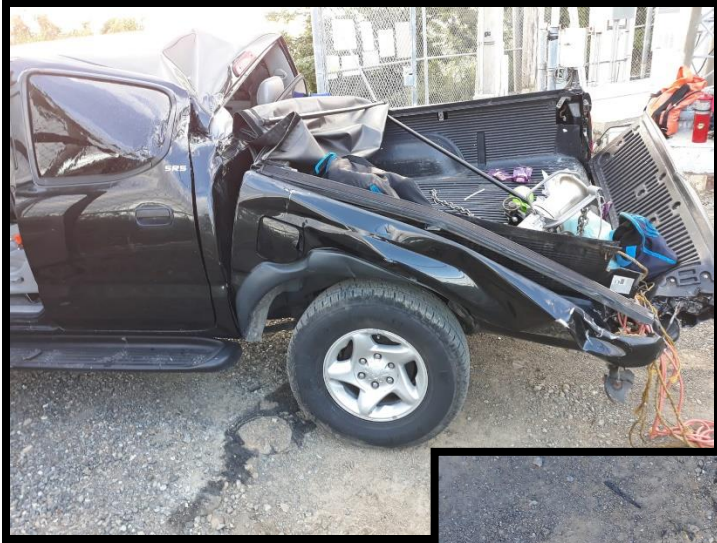
Incident #1



Incident #2



Incident #3



Incident #4

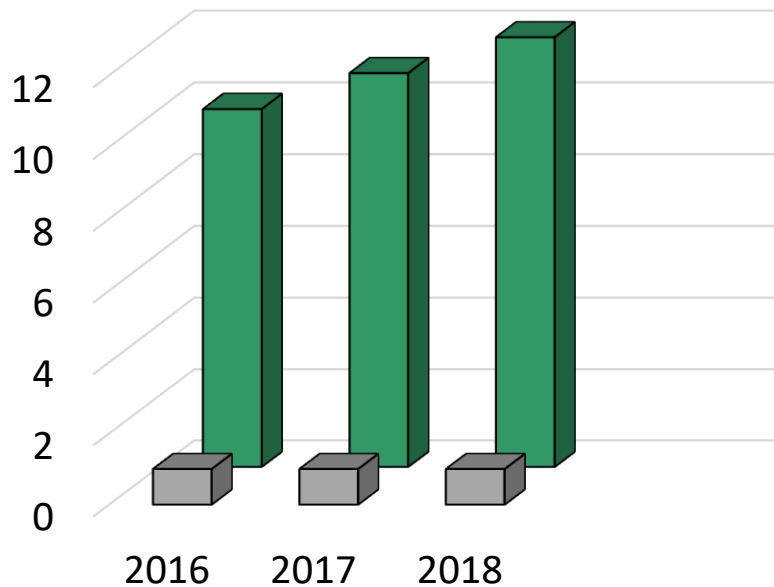


Incident #5



Trends and Statistics

Reported Rigging Incidents Per SOW



- Tower Modification Construction
- Antenna & Line Construction

Sample of 35 Reported Rigging Incidents

	L&A	Structural Mods
2016	10	1
2017	11	1
2018	12	1



Trends and Statistics

Antenna & Line Construction:

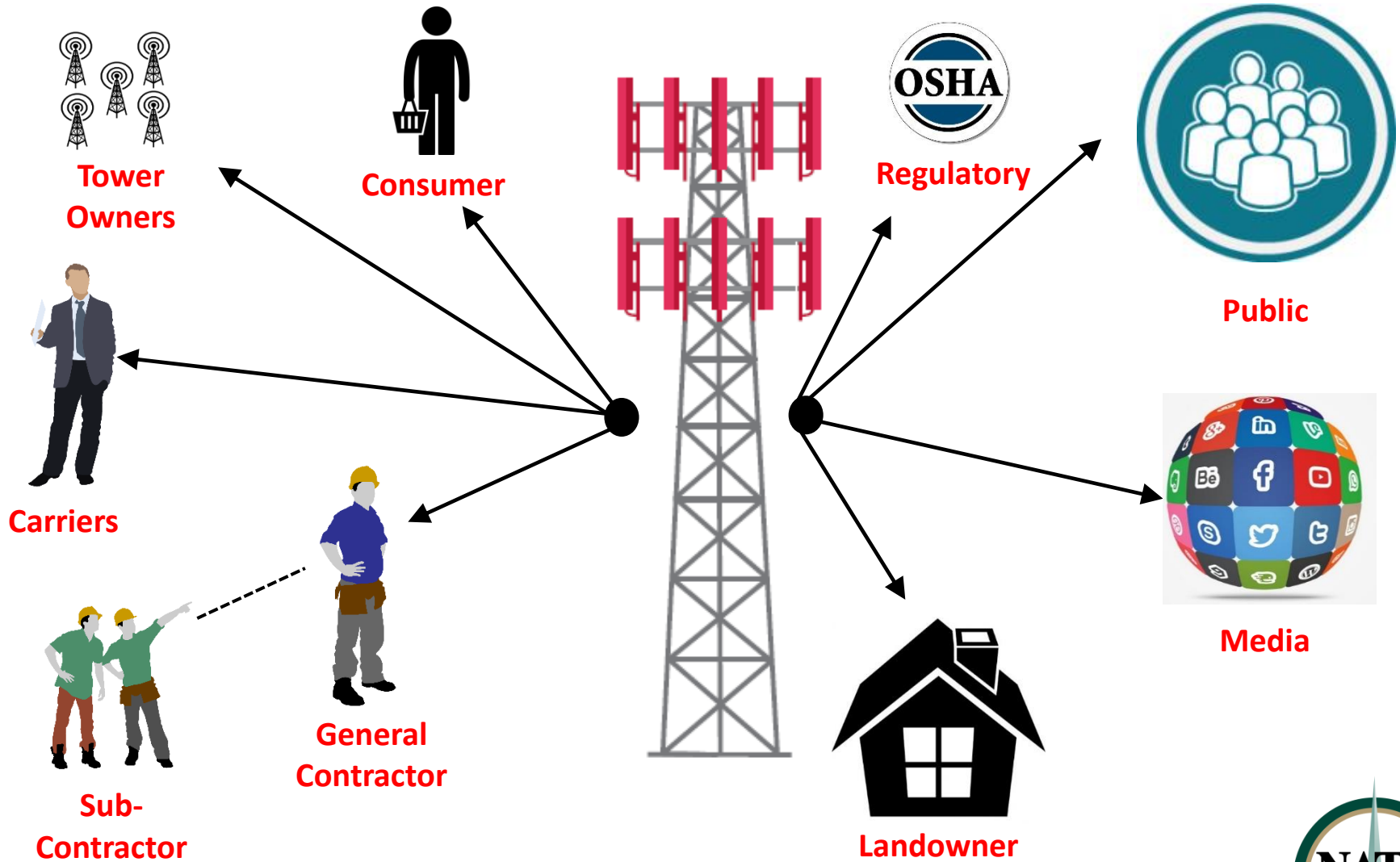
- Approximately 25,000 jobs were sampled for incidents each year
- 12 reported L&A Incidents for 2018 sample
- **Reported rigging incidents rates
1 out of 2,083 jobs**

Tower Modification Construction:

- Approximately 2,500 jobs were sampled for incidents each year
- 1 reported Structural Modification Incident for 2018 sample
- **Reported rigging incidents rates
1 out of 2,500 jobs**



Impacts to the Industry



Section 3

Primary Regulations, Codes, Standards and Policies



Topics

- Primary Regulations, Codes, Standards and Policies
- Telecommunications Industry Standards
- Roles and Responsibilities
- A10.48 Construction Classes
- Communications



Regulations, Codes, Standards and Policies

- **Federal Regulations** for General Industry and Construction establish laws set forth by the DOL and represent minimum requirements which must be satisfied to safeguard employee health, safety and welfare.
- **State Regulations** may build on Federal Regulations to establish more stringent requirements, but may not set forth requirements below those established at a Federal level.
- **Building Codes** adopted and enforced by one or more government entity and contain collection of evolving standards by direct or indirect reference.
- **ANSI Standards** represent voluntary guidelines to a given trade or industry developed by a consensus of committee members representing private stakeholders, trade organizations, and professional societies in compliance with the ANSI rules.
- **Consensus Standards** represent voluntary guidelines to a given trade or industry developed by a consensus of committee members representing private stakeholders, trade organizations, and professional societies.
 - Consensus standards can be enforceable when referenced/recognized by Regulations or Codes
- **Owner/Company/Customer Policies**



Rigging Equipment Standards

- Standard Rigging Equipment Used For Lifting and Load Handling Purposes Shall be Specifically Certified for Such Applications in Accordance With Applicable ANSI/ASME B30 Standards

ASME B30.9: Slings

ASME B30.10: Hooks

ASME B30.26: Shackles, Links, Rings, Rigging Blocks, and Load Indicating Devices



Applicable ANSI Standards

- ANSI/ASSE A10.48 – Criteria for Safety Practices with the Construction, Demolition, Modification and Maintenance of communications structures.
- ANSI/TIA 222 – Structural Standard for Antenna Supporting Structures, Antennas and Small Wind Turbine Support Structures.
- ANSI/TIA 322 – Loading Analysis, and Design Criteria Related to the Installation, Alteration and Maintenance of Communication Structures.
- **Note:** ANSI/TIA-222-H directly references 322/A10.48 (i.e. 2018 IBC consequently indirectly ref 322/A10.48).



Rope Standards

- Cordage Institute CI 2001-04 – Fiber Rope Inspection and Retirement Criteria
- Cordage Institute is an international association of rope, twine, and related manufacturers, their suppliers, and affiliated industries.
- This is a consensus standard.



A10.48 Standard Climber Connection Video

<https://www.youtube.com/watch?v=33DZTeu8b58>



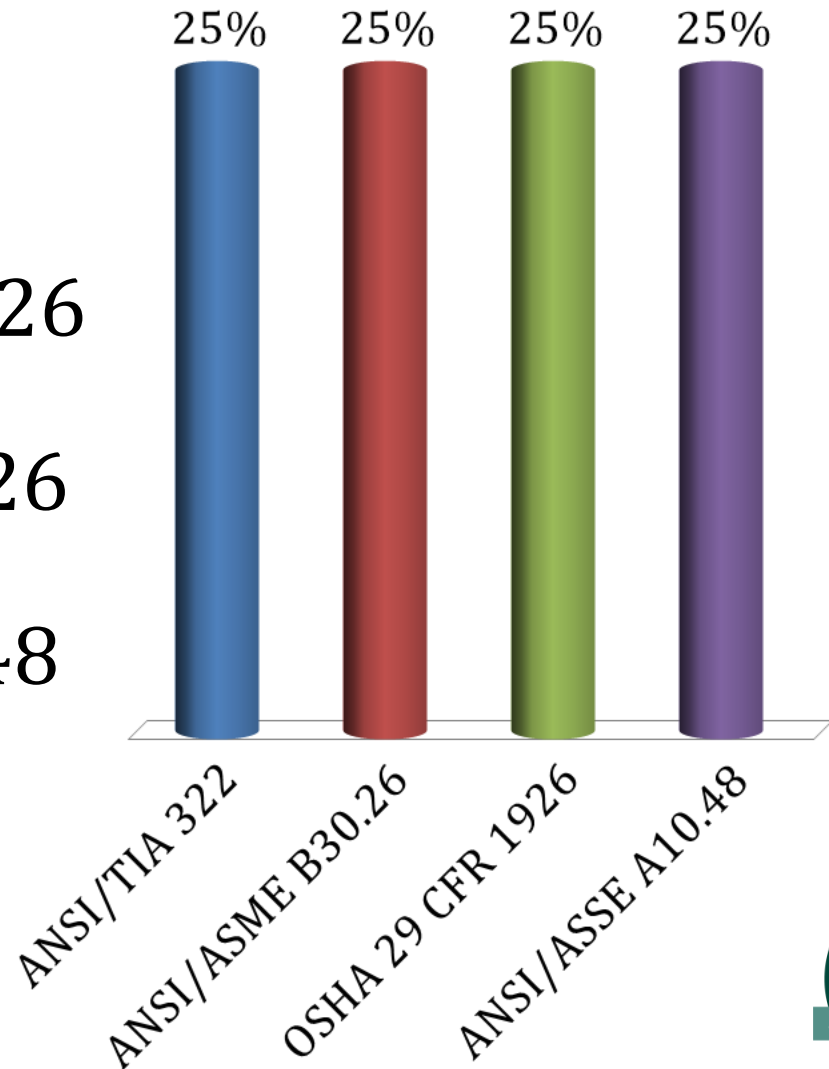
SECTION 3

REVIEW QUESTIONS

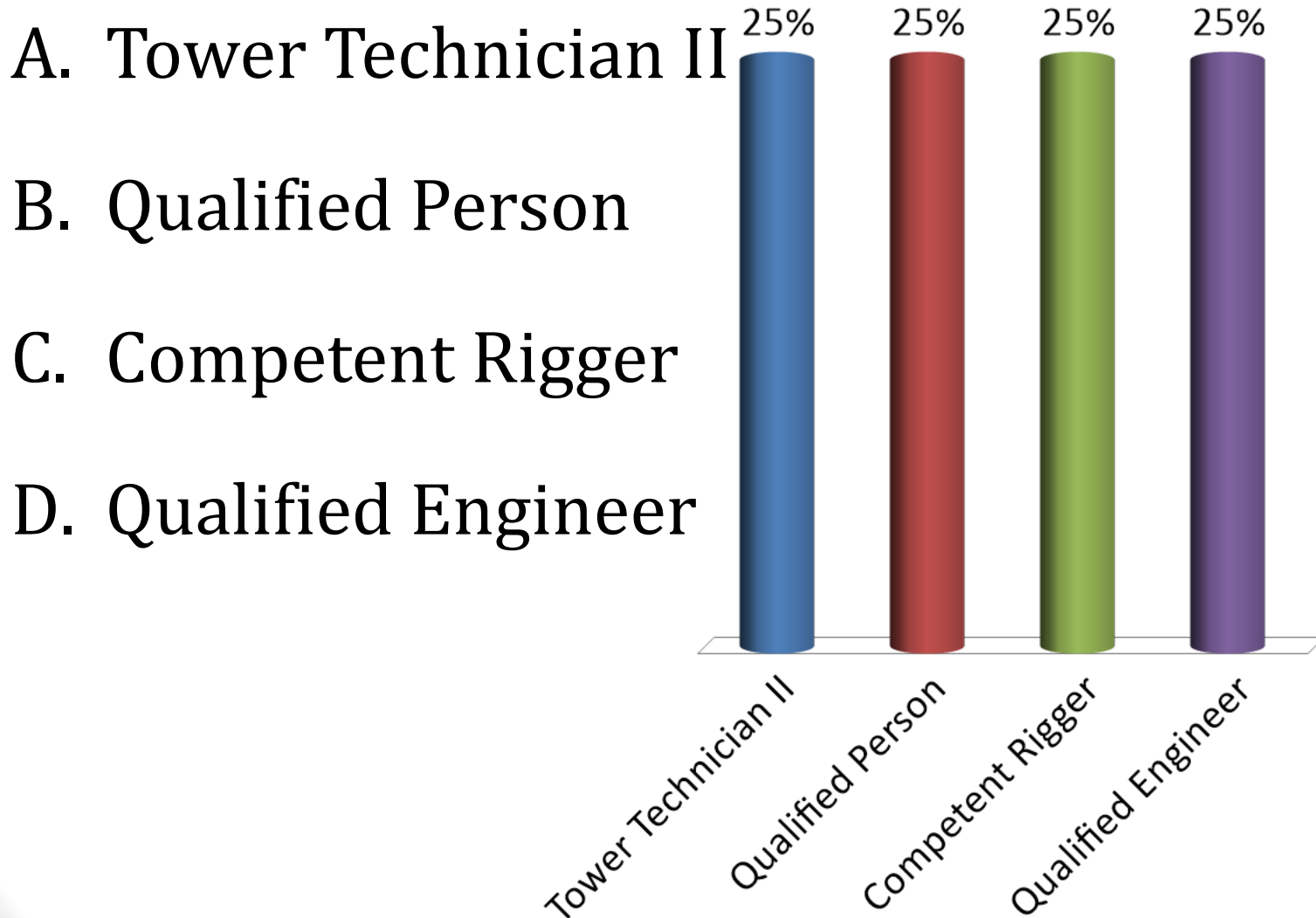


Which of the following is the most industry specific standard for safe work practices on a communication structure?

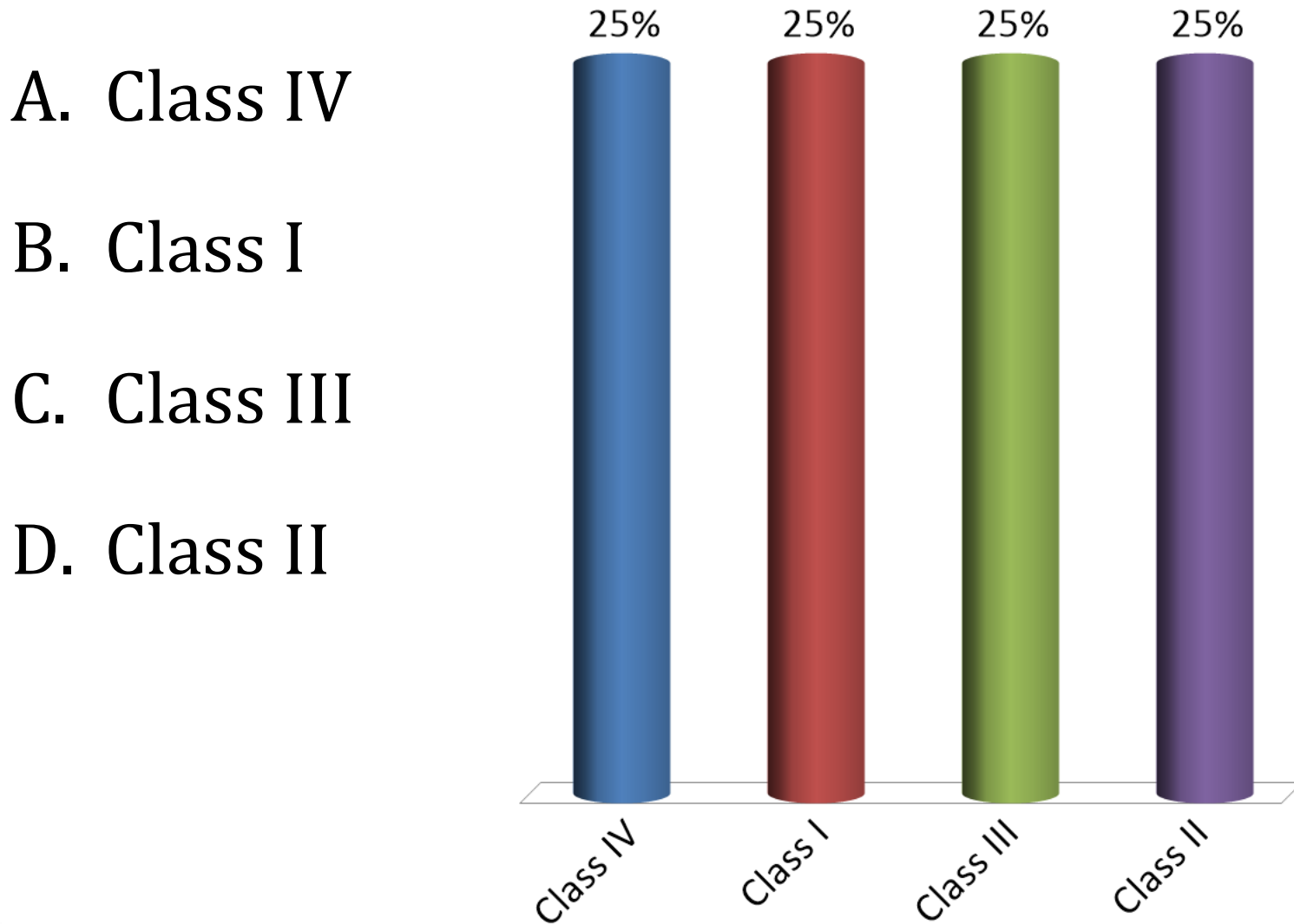
- A. ANSI/TIA 322
- B. ANSI/ASME B30.26
- C. OSHA 29 CFR 1926
- D. ANSI/ASSE A10.48



Who is responsible for the on-site execution of a rigging plan per ANSI A10.48?

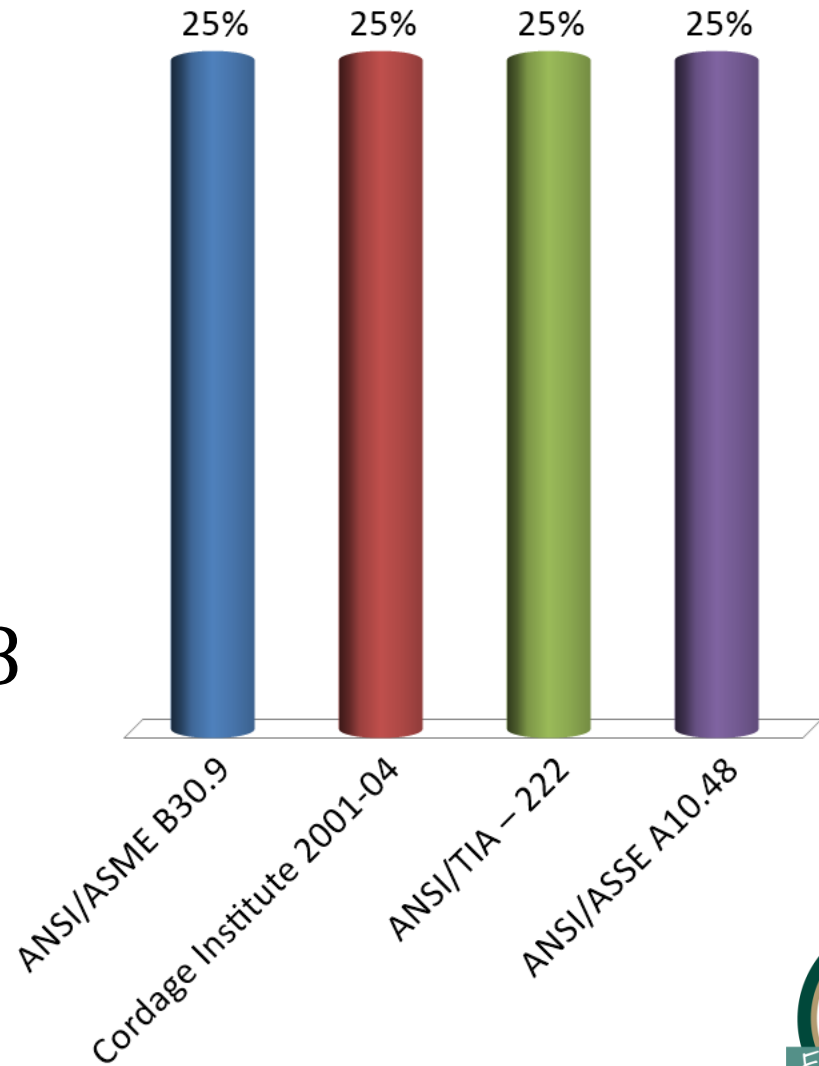


Which construction class always requires engagement of a qualified engineer?



Which standard contains inspection and retirement criteria for synthetic ropes?

- A. ANSI/ASME B30.9
- B. Cordage Institute 2001-04
- C. ANSI/TIA – 222
- D. ANSI/ASSE A10.48



Section 4

Synthetic Rope



Topics

Having knowledge of all equipment in your lifting plan is critical.

- Synthetic Rope
- Blocks, Slings, and Shackles
- Selection/Marking, Use, and Maintenance/Inspection
- System Compatibility



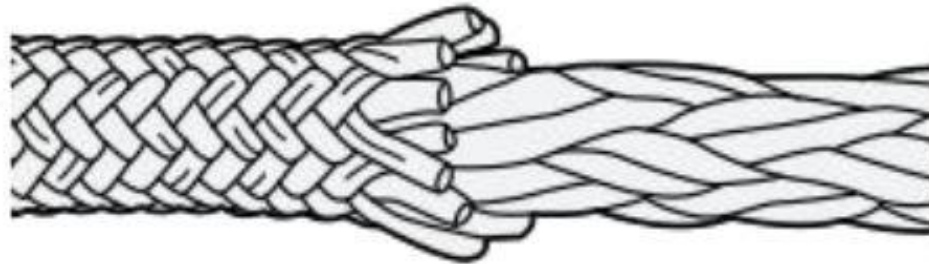
Kernmantle Rope

- Is ideal for use in rescue, lifelines, ascent/decent rope access work.
- Highest Strength/Weight Ratio.
- The most frequent kernmantle rope diameters used in telecom is 12mm (1/2").



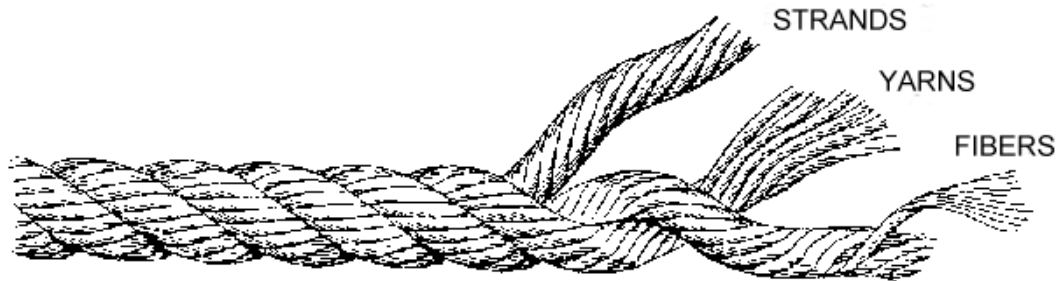
Double Braid Rope

- Most common type of rope used for hoisting is Double Braid.
- Double Braid is a braided core surrounded by a braided sheath.
- Both braids share the load equally.
- Ideal for load rope.



3 Strand Rope

- Most common type of rope used for chase rope.
- 5/8" is sometimes used as a backup lifeline.
- Remember that life safety ropes can never be used for material handling.
- Allows users to take their primary rope out of service for proper storage and inspection, and easily get back to operation.



Know Your Rope

- Knowing your rope specifications is critical.
 - Type of Rope
 - Rope Manufacturer
 - Date of Manufacturing
 - MBS
- Where can this information be found?



Terms for Rigging

- ABS Average Breaking Strength
- MBS Minimum Breaking Strength
- SWL Being Phased Out
- WLL Working Load Limit
 - The minimum breaking load of a component divided by an appropriate factor of safety giving a maximum load that can be lifted or be carried.
 - (WLL) For Ropes, is 10% of the (MBS) minimum breaking strength
- FS Factor of Safety
 - 10:1



Diameter & MBS

- Breaking Strength of Synthetic Rope must be known.
- Below is an example of one manufacturer's Double Braid.
- Each manufacturer's ratings are different, as different constructions and materials are used.

Example:



DIAMETER	STRENGTH
3/8" (10 mm)	MBS 5,000 lbs
1/2" (13 mm)	MBS 11,000 lbs
5/8" (16 mm)	MBS 17,000 lbs

Calculating WLL

Breaking Strength ÷ Factor of Safety

You have a ½” Double Braid Polyester rope that has a MBS of 11,000 pounds.

What is the WLL that can be safely lifted?



Calculating WLL

Breaking Strength ÷ **Factor of Safety**

You have a ½” Double Braid Polyester rope that has a MBS of 11,000 pounds.

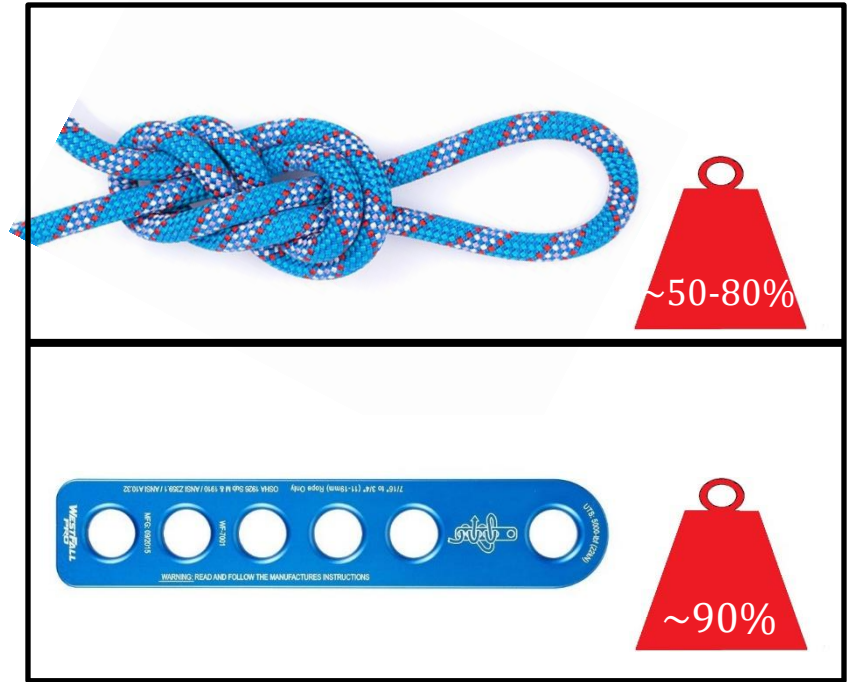
Answer: 11,000 (MBS) ÷ 10 = 1,100 lbs.



Knots & Terminations



~98%



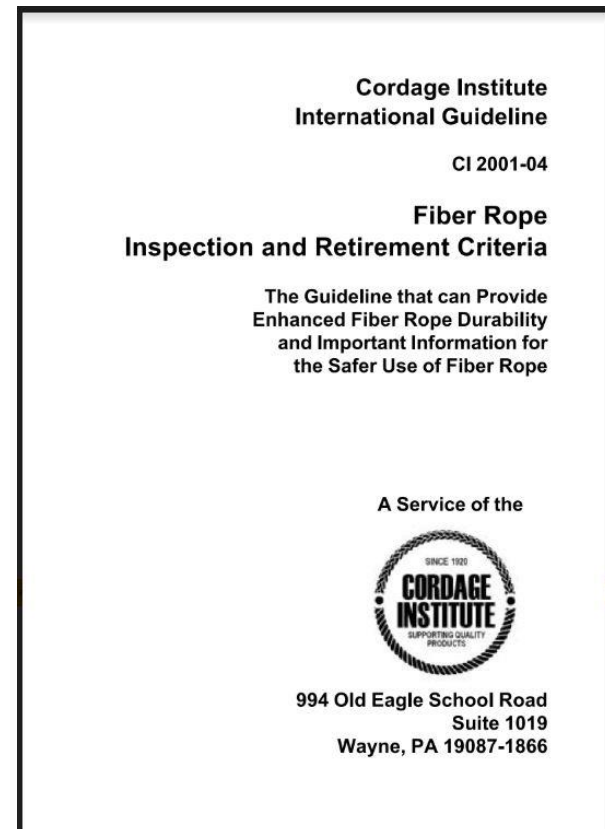
~50-80%



~90%

Cordage Institute

- Cordage Institute is an international association of rope manufacturers, nearly 100 years old, that creates uniform rope standards
- **CI 2001-04**
- **Fiber Rope Inspection & Retirement Criteria**



CI 2001-04 Guidelines

- Of particular interest to our industry is Section 4
- *Inspection & Retirement Programs*
- The following sections present the requirements for an effective inspection and retirement program.



CI 2001-04 Guidelines

- 4.1.1 The user is responsible to establish a program for inspection and retirement that considers conditions of use and degree of risk for the particular application.
- A program should include:
 - Assignment of supervisory responsibility. The user should assign an individual responsible for establishing the program, for training and qualifying inspectors and preserving records.
 - Written procedures
 - Training
 - Record keeping
 - Establishment of retirement criteria for each application.
 - Schedule for inspections.



CI 2001-04 Requirements

- 4.1.2 Ropes that secure or control valuable assets or whose failure would cause serious damage, pollution, or threat to life warrant more scrutiny than ropes in non-critical use. If a fiber rope is used in a highly demanding application, with potentially critical risks, the advice of a qualified person should be obtained when developing the specific inspection and retirement program.



CI 2001-04 Requirements

- 4.1.3 The user should continue to revise and refine the program based on experience.



Rope Inspection Log

- CI 2001-4.3
 - “An important tool for rope evaluation is a log. This will include data on the type of rope, time in service and description of intended use. The details of every inspection should be entered in the log as to date, location and conclusions. The log should include a regular inspection schedule.”

- CI 2001-5.1.1
 - During the inspection, identify the rope with a tag.
 - Shrink tube is an inexpensive solution.



Sample Rope Log

INSPECTION LOG

<i>MODEL:</i>			
<i>DATE OF MFG/SN:</i>			
<i>DATE PURCHASED:</i>		<i>DATE OF FIRST USE:</i>	

<i>INSPECTION DATE</i>	<i>INSPECTION ITEMS NOTED</i>	<i>ROPE INSPECTION</i>	<i>CONNECTOR INSPECTION</i>	<i>PASS/FAIL</i>
<i>Approved By:</i>				
<i>Approved By:</i>				
<i>Approved By:</i>				
<i>Approved By:</i>				
<i>Approved By:</i>				
<i>Approved By:</i>				



Rope Inspection

Section 6 outlines common causes of rope damage and describes their effects. These include:

- Excessive Tension / Shock Loading
- Cyclic Tension Wear
- Nicks, Cuts, and Abrasion Damage
- Pulled Strands and Yarns
- Flex Fatigue
- Knots
- Creep
- Sunlight Degradation
- Chemical and Heat Degradation
- Dirt and Grit



Rope Inspection

- Take note of factors such as load history, bending radius, abrasion, chemical exposure.
- Inspecting your rope should be a continuous process of observation, during, and after each use.
- Look and feel along every inch of rope length inspecting for cut strands, compression, pulled strands, melted or glazed fibers, discoloration, degradation, inconsistent diameter and abrasion.
- Signs of these may indicate possible loss of strength.



Rope Inspections

Can this rope be used safely?



Glossy/Glazed: Glossy or glazed areas in rope indicate that it has been exposed to heat damage or compression. Remove affected section. If not possible, retire rope.

Rope Inspections

Can this rope be used safely?

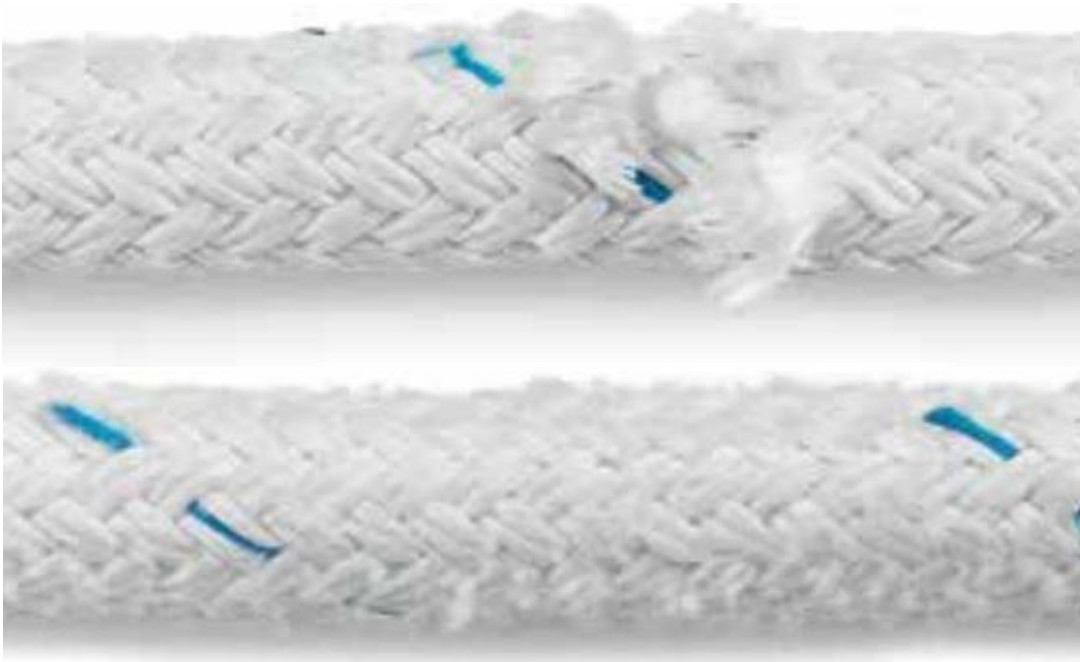


Inconsistent Diameter: Look for flat areas, bumps, or lumps in the rope. This can be a sign of core or internal damage from overloading or shock loads. Remove affected section. If not possible, retire rope.



Rope Inspections

Can this rope be used safely?



Wear: Any kind of burns, cuts, nicks, broken yarns, or excess wear (50% on double braid) on the sheath is also a sign that the rope needs to be removed from service.



Rope Inspections

Can this rope be used safely?



Discoloration: Ropes get dirty, but if the discoloration is from excess sun exposure or chemicals, the rope should be removed from service. Determining if discoloration is from dirt and grime or something more like sun exposure or chemicals is much easier if you regularly clean your rope.

Rope Care & Maintenance

Washing

- Dirt and grease causes internal fiber abrasion, and shortens its life. Wash by hand in a bath with non-bleaching, non-detergent soap.

Drying

- Dry your rope in a clean, dry area out of the sun.

Recording

- Record the cleaning in your rope log.



Rope Storage

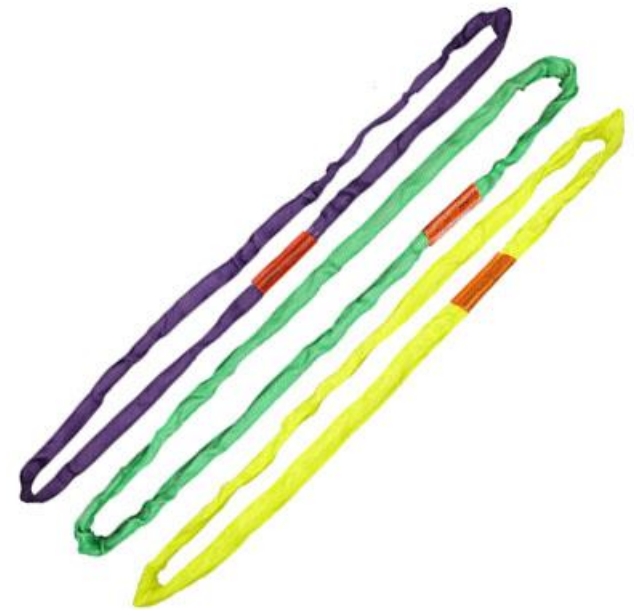
Storage

- Store your rope in a cool, clean, dark, dry environment.
- Excess humidity will damage your rope.



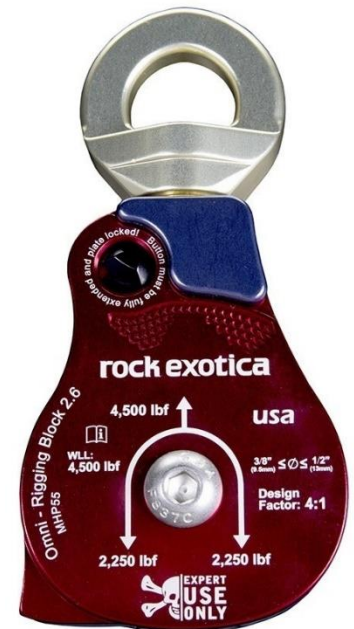
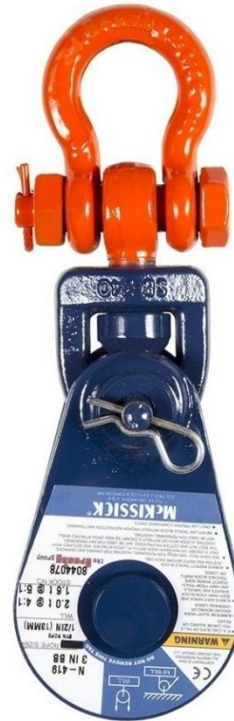
Other Components

ANSI B30 Compliant Blocks, Shackles, Slings



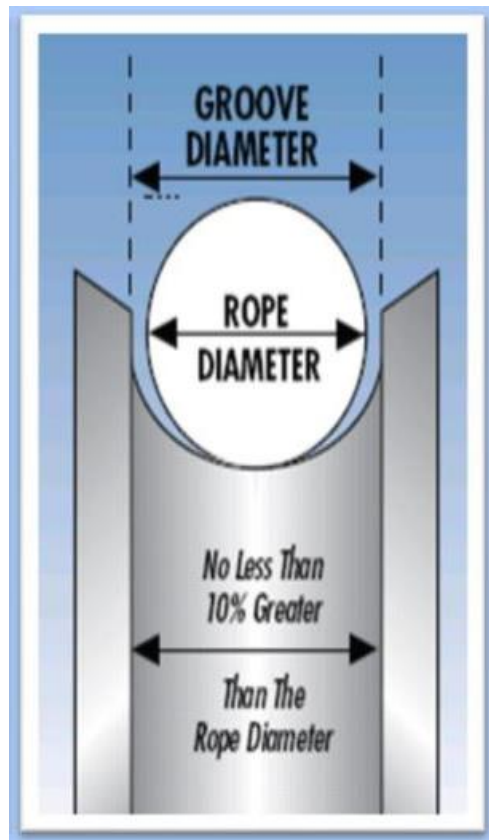
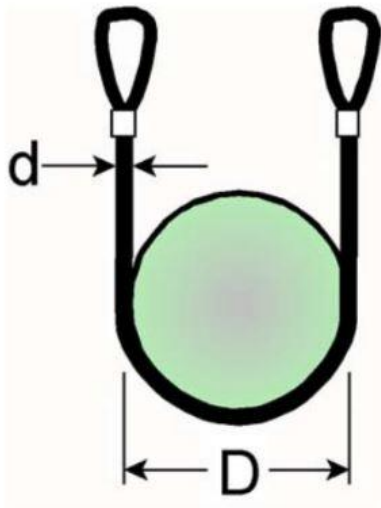
Blocks

- ASME B30.26
- Safety Factor SF 4:1
- Only use blocks designed to be used with synthetic rope.
- Blocks must have sufficient ductility to permanently deform before losing the ability to support the load.



Blocks

Block sheave and block groove must be compatible to rope size



DO NOT USE



Block Marking Requirements

- Blocks must have the following durable markings:
 - Name or trademark of manufacturer
 - Rated load (WLL)
 - Rope size capacity
- Identification must be maintained by the user so as to be legible throughout the life of the block.



Block Inspections

- Inspections should be performed by a designated person.
- Any perceived deficiencies must be examined by a qualified person to determine whether they constitute a hazard.
- A visual inspection shall be performed *each shift* before the block is used.
- Periodic inspection by a qualified person with a frequency not less than once per year, consult ASME B30.26-5.8.4 in order to determine the frequency necessary for your application.



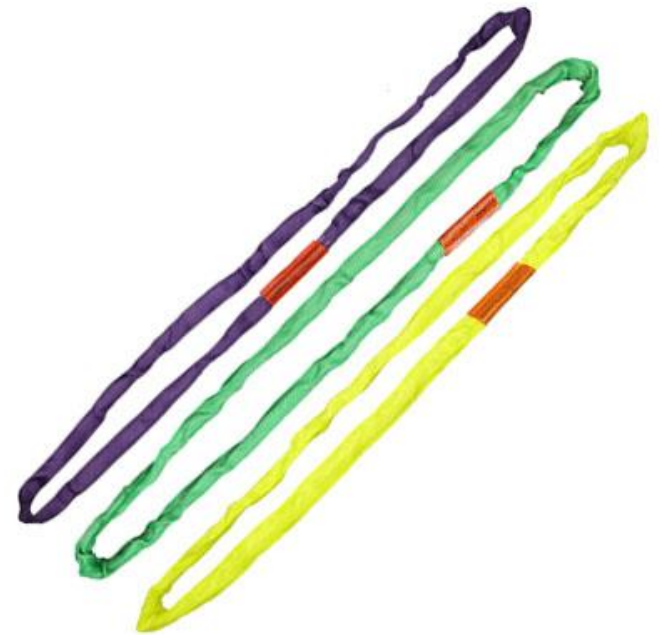
Block Retirement

- Rigging blocks shall be removed from service if conditions such as those included in, but not limited to, the list below are present:
 - Missing/illegible identification
 - Misalignment or wobble in sheaves
 - Excessive sheave groove wear
 - Loose more missing hardware
 - Indications of heat damage including weld patten or arc strikes
 - Excessive pitting or corrosion
 - Bent, cracked, twisted, distorted, stretched, elongated, or broken load bearing components
 - A 10% reduction in catalog dimension at any point
 - Evidence of unauthorized modifications
 - Visible damage that cause doubt as to the continued use of the block



Sling Marking Requirements

- Per ASME B30.9, each synthetic web sling shall have:
- Tag must be present
- Tag must identify
 - Manufacturer
 - Chocked, vertical and basket configuration
 - Sling Material
 - Date
 - Serial Number



ASME B30.9 Sling Inspections



CHEMICAL DAMAGE



HEAT DAMAGE



HOLES, CUTS, TEARS



BROKEN/WORN STITCHES



WEAR/ABRASION



KNOTS



UV DAMAGE



DAMAGED FITTINGS

Sling Inspections

Can these slings be used safely?



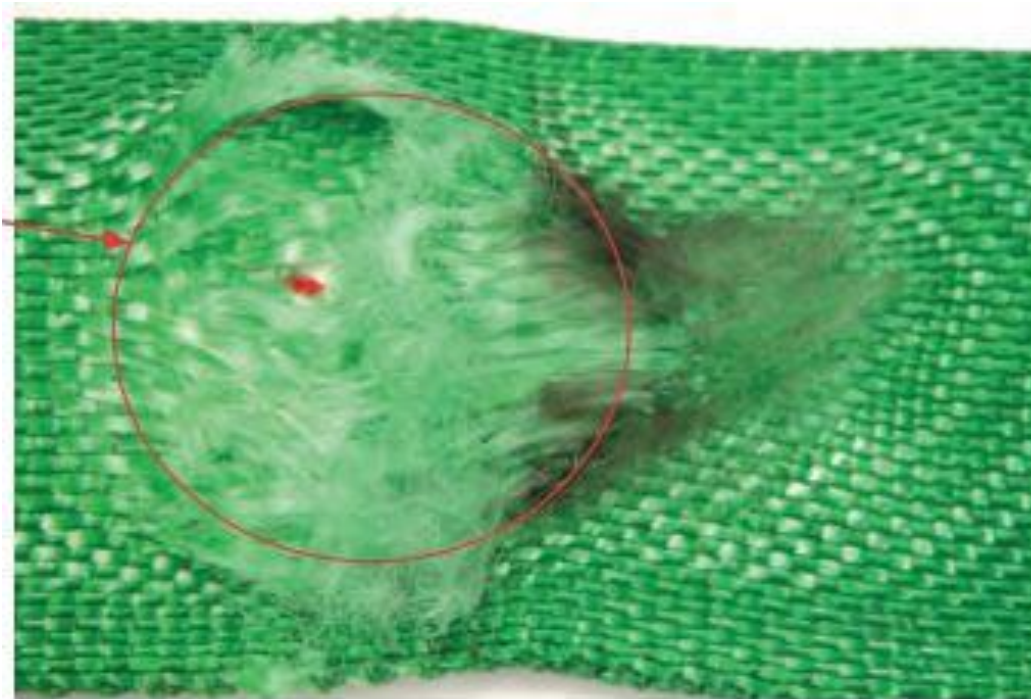
Sling Inspections

Can these slings be used safely?



Sling Inspections

Can these slings be used safely?



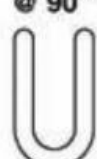
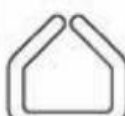


Inspection Requirements

- Three types of inspection:
 - Initial Inspection- when you first receive it
 - Frequent Inspection- each time used, prior to use and prior to change in application
 - Periodic / Annual inspection
- Inspect it by pulling the sling through your hand and looking for visible signs.
- If you feel something, or see something that causes doubt, **REMOVE FROM SERVICE.**



Endless Synthetic Sling Chart

Part No.	Color	Rated Capacity (lbs.)*				Minimum Length (ft.)	Approximate Measurements			
		Vertical	Choker	Basket @ 90°	Basket @ 45°		Weight (lbs. / ft.)	Body Dia. Relaxed (in.)	(W) Width at Load (in.)	Minimum Hardware Dia. ** (in.)
EN30	Purple					1 1/2	.2	5/8	1	7/16
EN60	Green					1 1/2	.3	7/8	1 3/8	5/8
EN90	Yellow					3	.5	1 1/8	1 3/4	3/4
EN120	Tan					3	.6	1 1/8	1 7/8	7/8
EN150	Red					3	.8	1 3/8	2	1
EN180	White					3	.9	1 3/8	2 1/8	1 1/8
EN240	Blue					3	1.3	1 3/4	2 5/8	1 3/16
EN360	Grey					3	1.7	2 1/4	3 1/4	1 1/2
EN600	Brown					8	2.8	2 3/4	4	2
EN800	Olive					8	3.4	3 1/8	4 5/8	2 1/8
EN1000	Black					8	4.3	3 5/8	5 1/4	2 1/2

The outer jacket of the sling is for protection of the material that is actually providing the sling's capacity



Shackle Marking Requirements

Per ASME B30.26, each shackle shall have:

- Safety Factor SF 5:1
- Shackle must have sufficient ductility to permanently deform before losing the ability to support the load
 - Markings on shackle body
 - Name or trademark of manufacturer
 - Rated load
 - Size
- Marking on Shackle Pin
 - Name or trademark of manufacturer
 - Grade, material type, or load rating



Shackle Inspections

- Inspections should be performed by a designated person.
- Any perceived deficiencies must be examined by a qualified person to determine whether they constitute a hazard.
- A visual inspection shall be performed *each shift* before the shackle is used.
- Periodic inspection by a qualified person with a frequency not less than once per year, consult ASME B30.26-1.8.4 in order to determine the frequency necessary for your application.



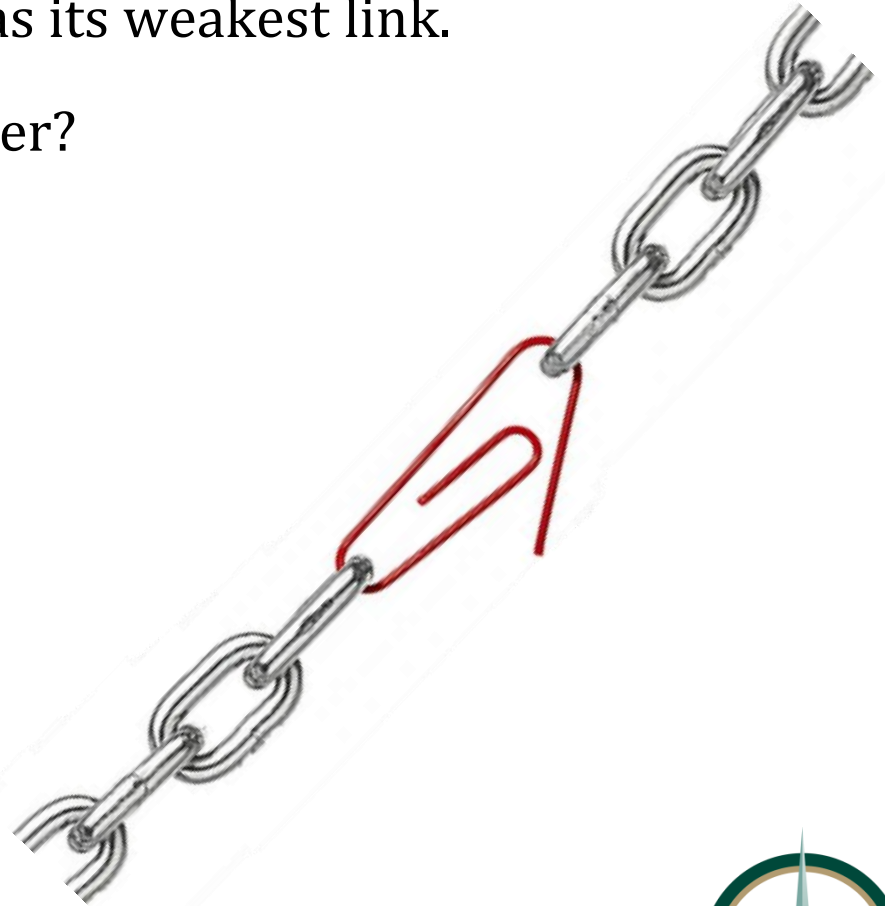
Shackle Retirement

- Shackles shall be removed from service if conditions such as those included in, but not limited to, the list below are present:
 - Missing/illegible identification
 - Indications of heat damage, including weld splatter
 - Excessive pitting or corrosion
 - Bent, twisted, distorted, stretched, elongated, cracked or broken load bearing components
 - Excessive nicks or gouges
 - A 10% reduction in catalog dimension at any point
 - Incomplete pin engagement
 - Excessive thread damage
 - Evidence of modification
 - Visible damage that cause doubt as to the continued use of the shackle



System Compatibility

- Your system is only as strong as its weakest link.
- What parts you need to consider?
 - Rope Size/Manufacturer
 - Rope Termination
 - Rope Care/Maintenance
 - Block for proper use
 - Block Size & Construction
 - Appropriate Slings & Shackles
 - Etc.



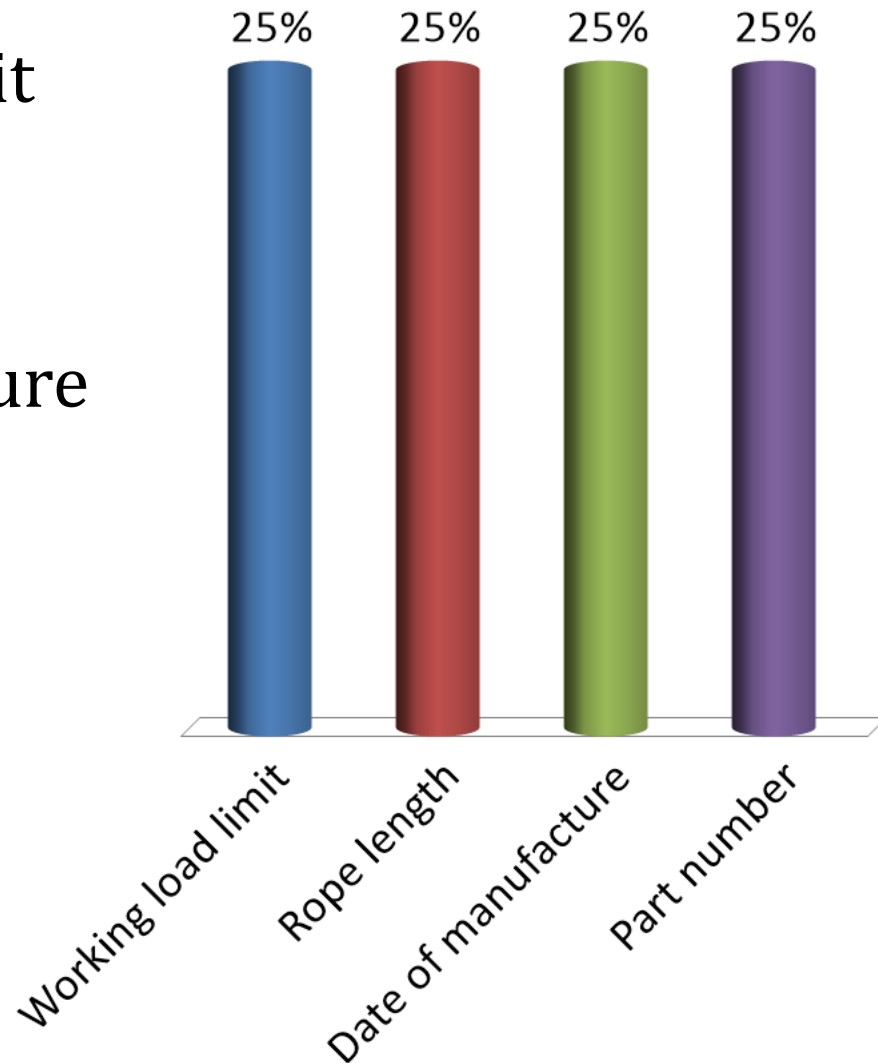
SECTION 4

REVIEW QUESTIONS



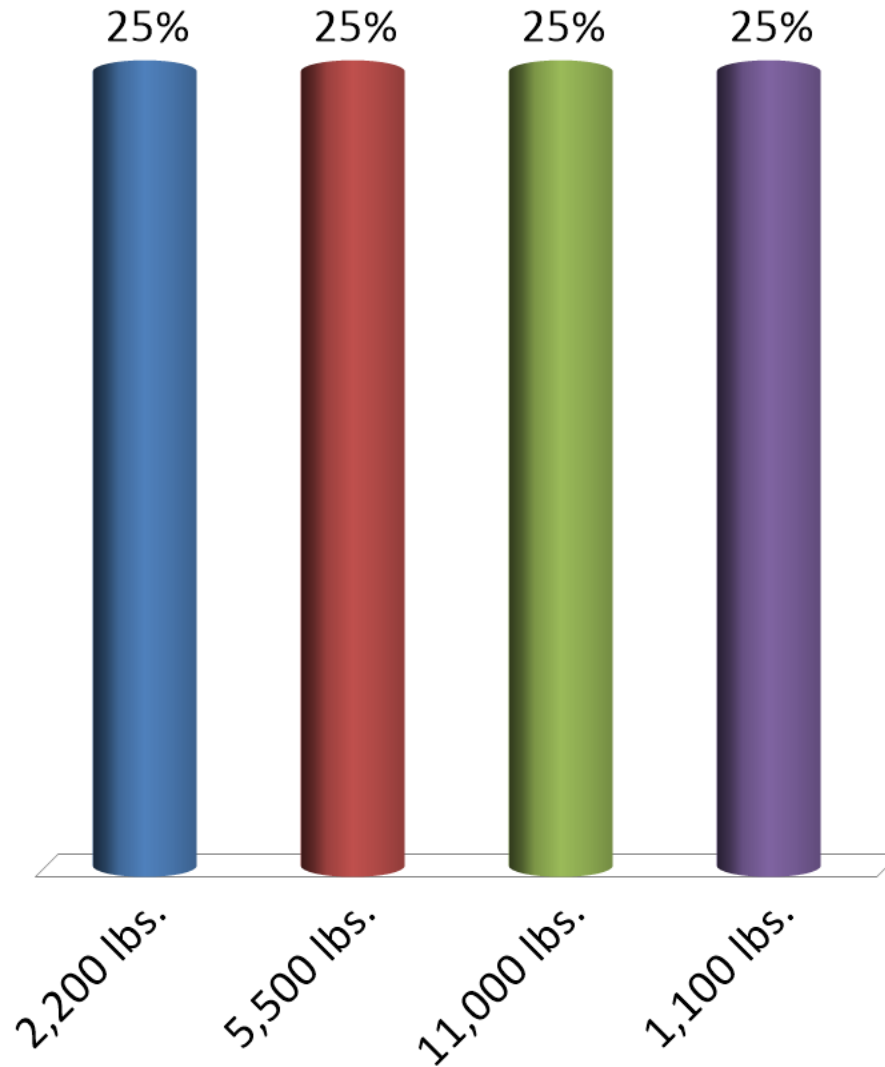
What information must be durably marked on the rigging block?

- A. Working load limit
- B. Rope length
- C. Date of manufacture
- D. Part number



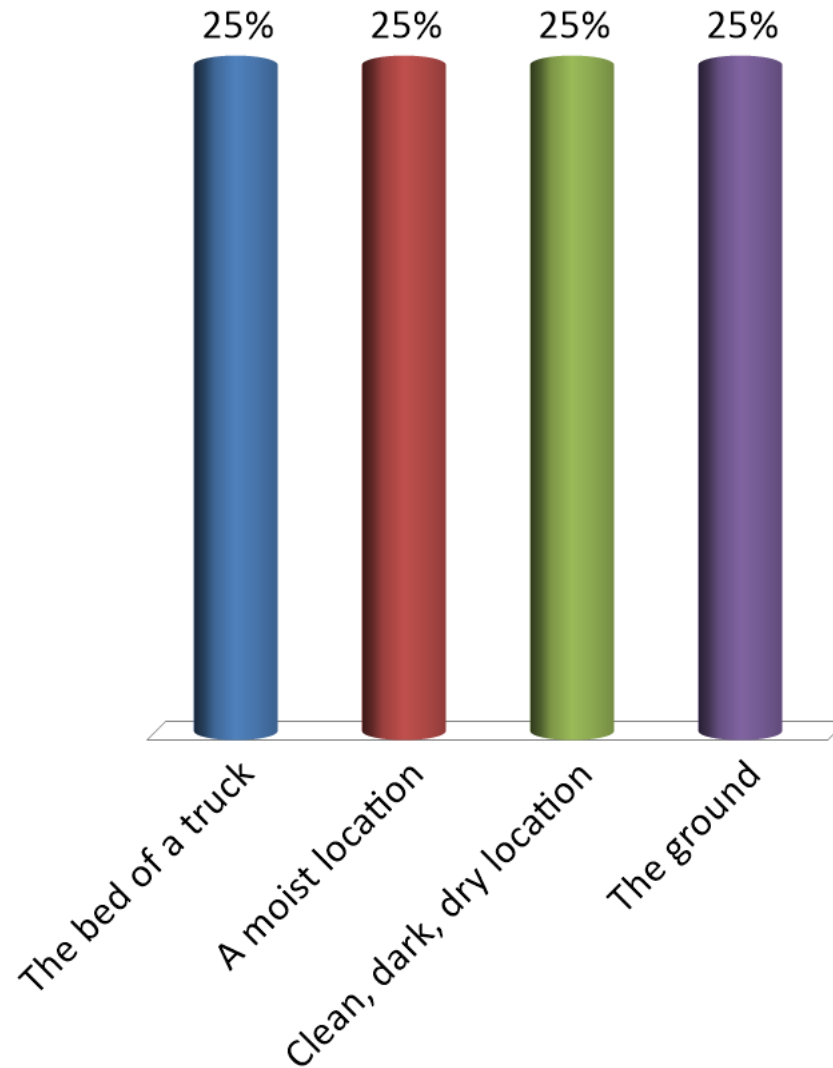
What is the WLL of a synthetic rope with a MBS of 11,000 lbs.?

- A. 2,200 lbs.
- B. 5,500 lbs.
- C. 11,000 lbs.
- D. 1,100 lbs.



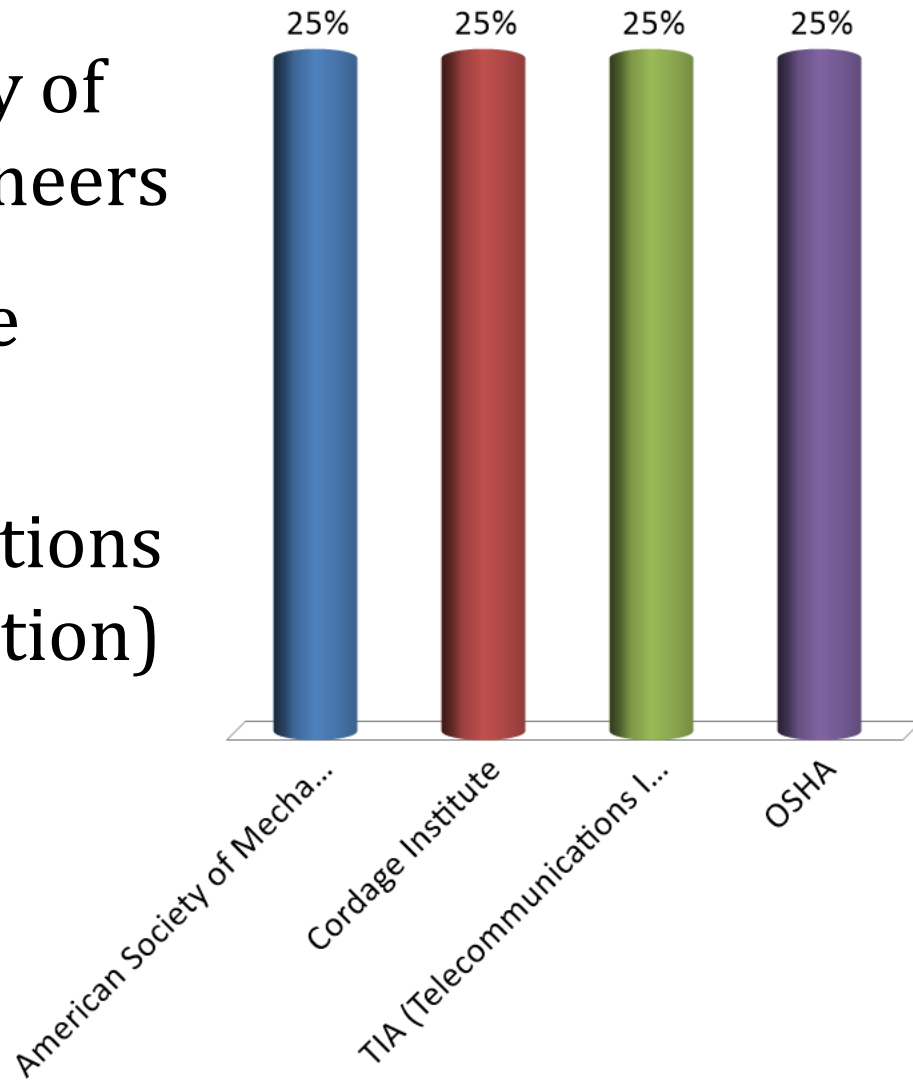
The best place to store rope not in use is?

- A. The bed of a truck
- B. A moist location
- C. Clean, dark, dry location
- D. The ground



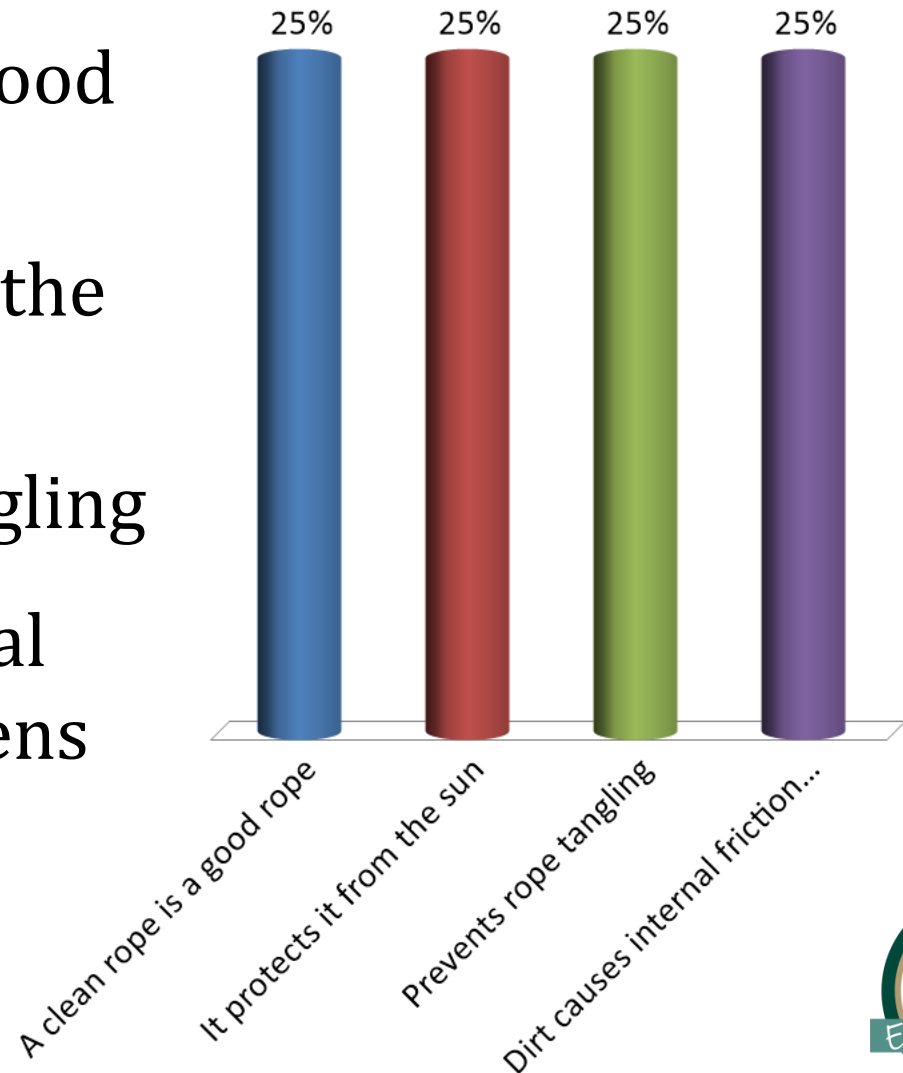
The standards group which has developed a standard for the inspection and retirement of rope is?

- A. American Society of Mechanical Engineers
- B. Cordage Institute
- C. TIA
(Telecommunications Industry Association)
- D. OSHA



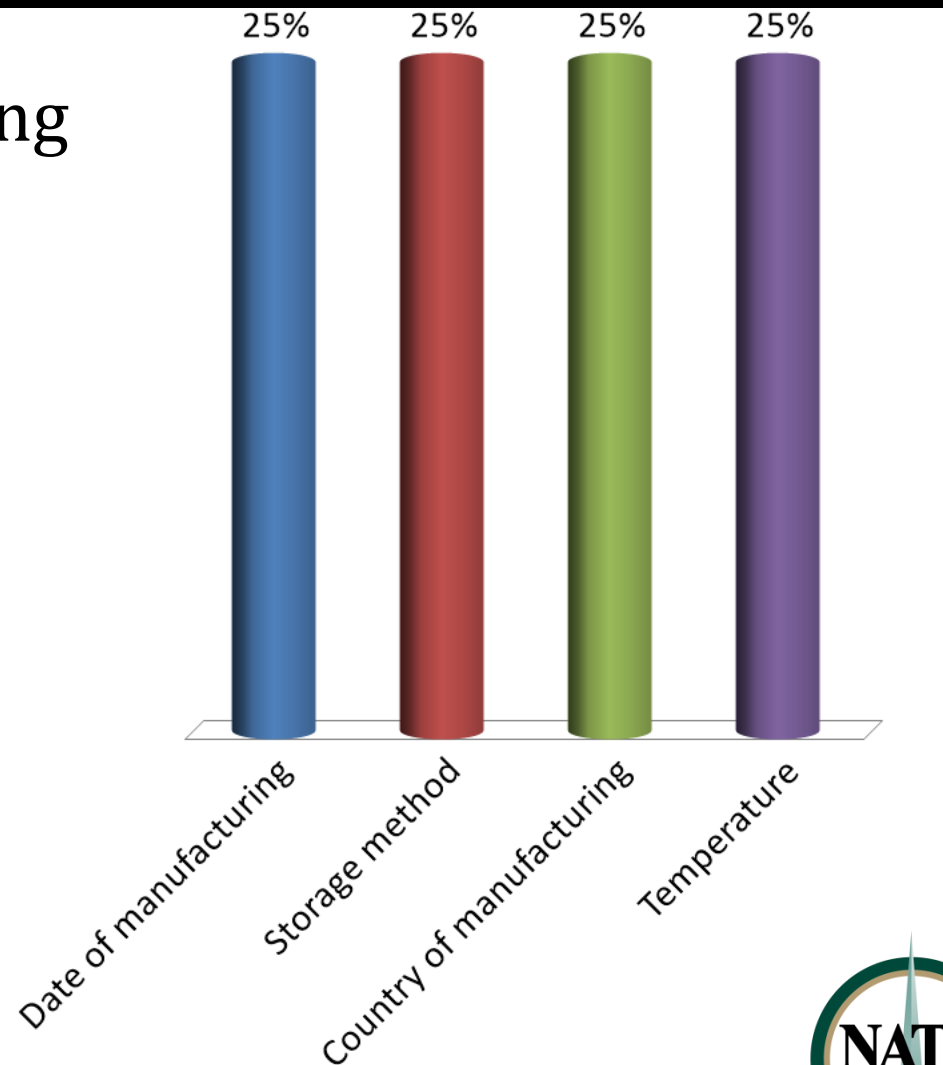
It is important to regularly clean your rope because?

- A. A clean rope is a good rope
- B. It protects it from the sun
- C. Prevents rope tangling
- D. Dirt causes internal friction and weakens rope



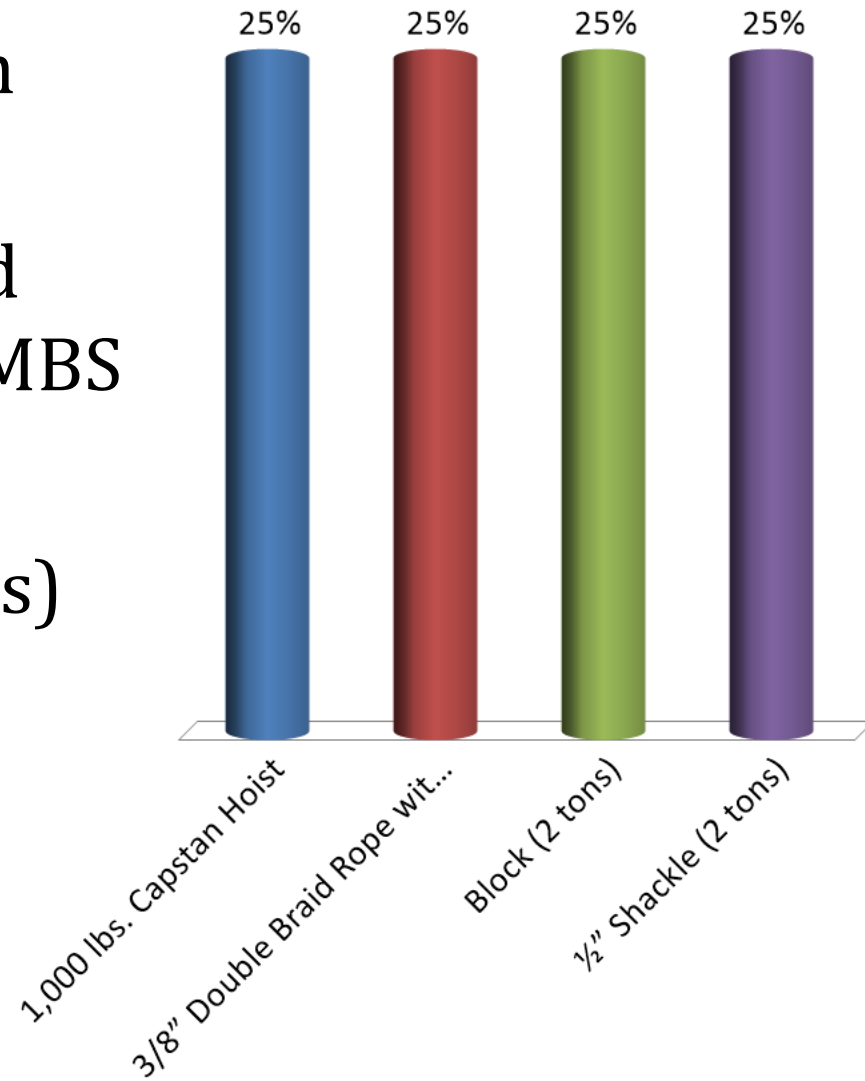
What information should be included in a rope inspection log?

- A. Date of manufacturing
- B. Storage method
- C. Country of manufacturing
- D. Temperature



What is the weakest link in this hoisting system?

- A. 1,000 lbs. Capstan Hoist
- B. 3/8" Double Braid Rope with 5,000 MBS
- C. Block (2 tons)
- D. 1/2" Shackle (2 tons)



Section 5

Rigging Forces and Lift Systems



Topics

- Typical Lift Configurations
- Sling Forces
- Block Forces
- Line Forces
- Worked Examples



Calculation Notes

- Calculated rigging forces provided in this presentation are intended for synthetic rope hoisting operations using typical 1,000 lbs. Capstan hoists.
- Calculations are based upon the following assumptions:
 - Block and Sling Forces assume constant line tension through the system (no friction and no reduction for fall line weight)
 - Line pull demands seen at hoist include compensation for fall line weight and friction in the reeved sheave assemblies

NOTE: Additional considerations may be required for more complex lifting systems including, but not limited to, line parts of 3 or more, 3 or more reeved sheaves, and/or gin pole applications.



Typical Lift Configurations

- Four Standard Lifting Block Arrangements:
 - 1) Top Block Only With Straight Tag
 - 2) Top And Heel Blocks With Straight Tag
 - 3) Integrated Trolley (aka Self-Trolley)
 - 4) Dedicated Trolley



Typical Lift Configurations

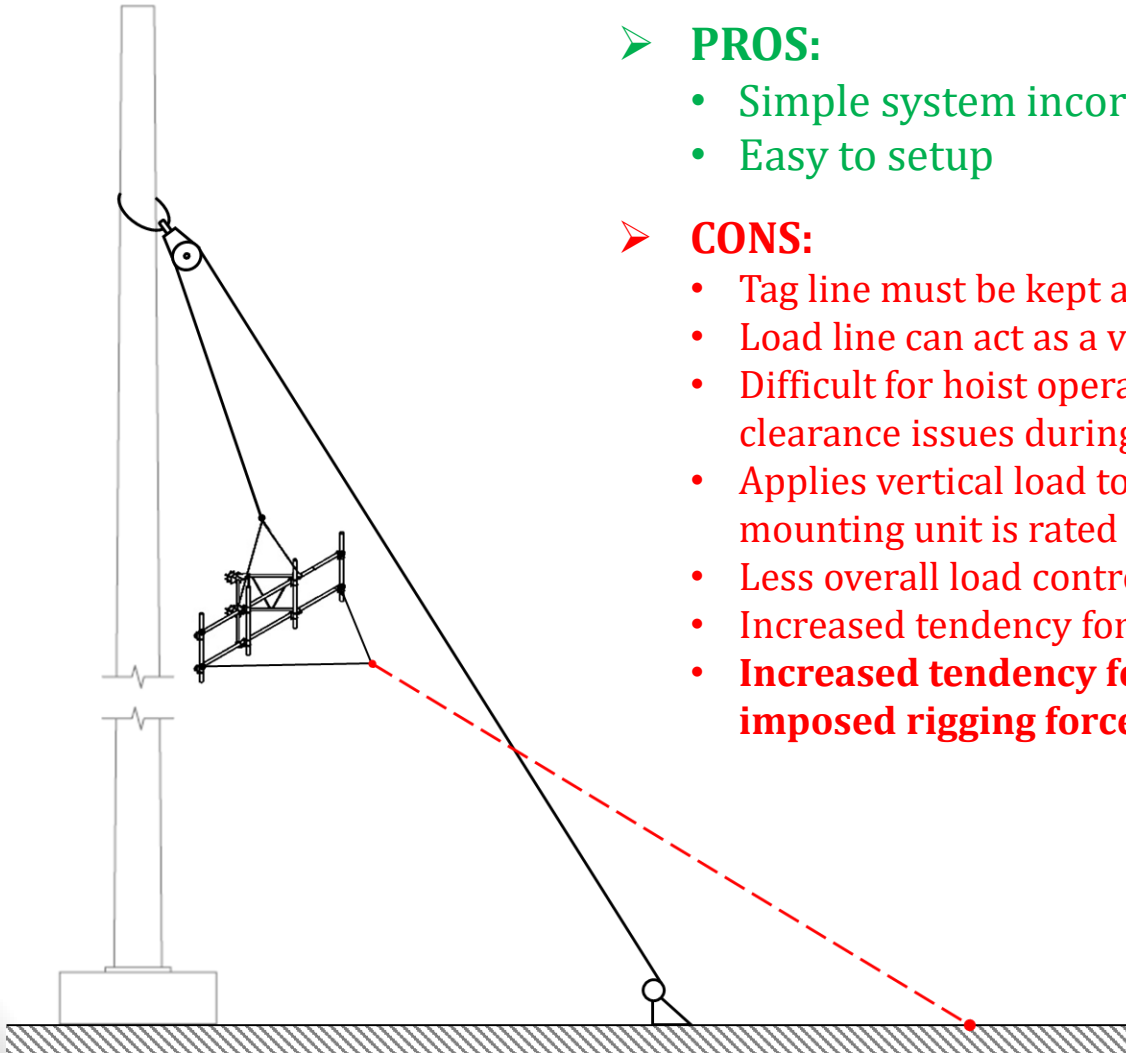
Straight Tag With Top Block Only:

➤ PROS:

- Simple system incorporating only one block
- Easy to setup

➤ CONS:

- Tag line must be kept away from load line
- Load line can act as a visual obstruction
- Difficult for hoist operator to visually identify clearance issues during hoisting
- Applies vertical load to hoisting unit (must ensure mounting unit is rated for vertical loading)
- Less overall load control
- Increased tendency for shock/impact loads
- **Increased tendency for developing high imposed rigging forces due to tag forces**



Typical Lift Configurations

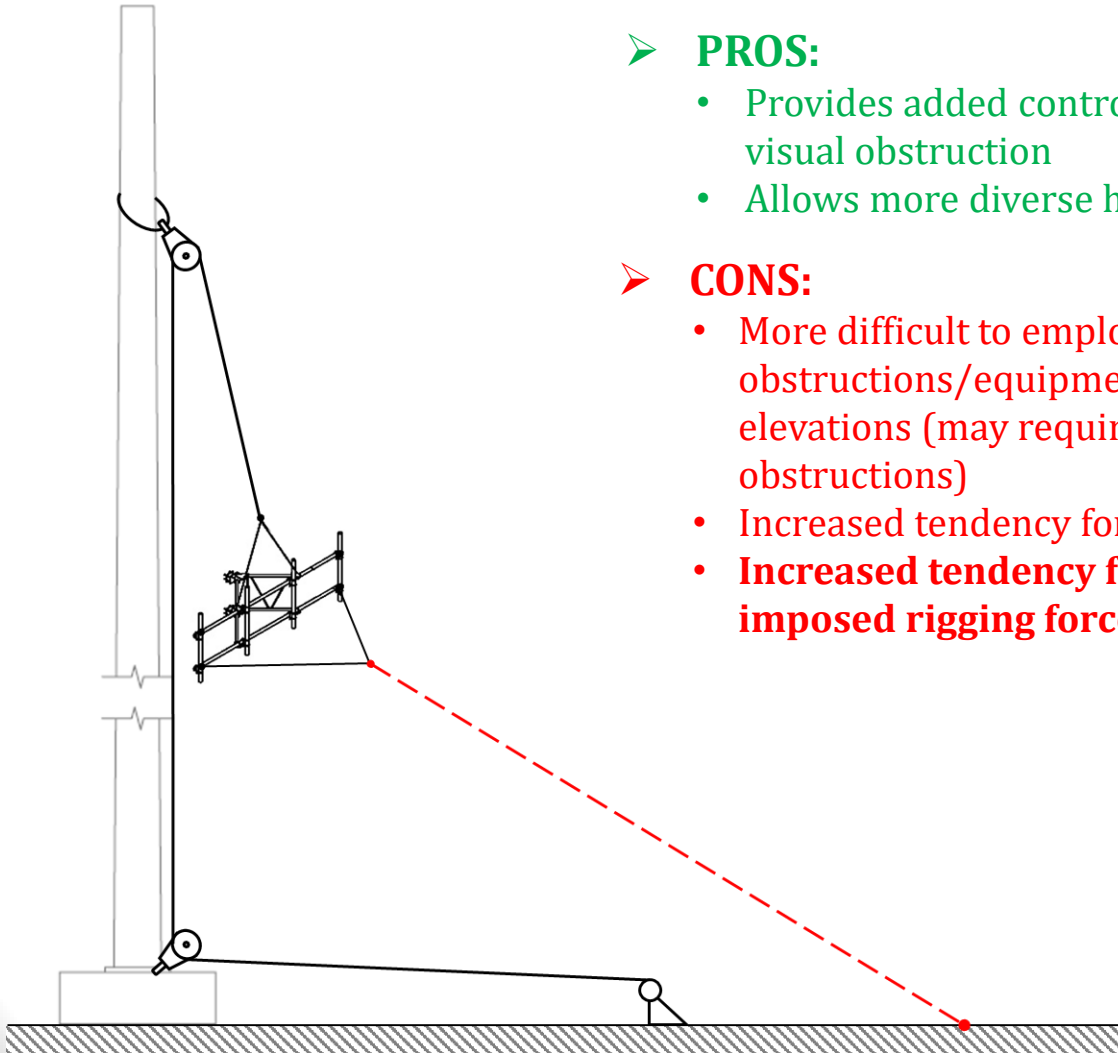
Straight Tag With Top and Heel Blocks:

➤ PROS:

- Provides added control to lead line and removes visual obstruction
- Allows more diverse hoist setup options

➤ CONS:

- More difficult to employ on towers with multiple obstructions/equipment below working elevations (may require reeving through obstructions)
- Increased tendency for shock/impact loads
- **Increased tendency for developing high imposed rigging forces due to tag forces**



Typical Lift Configurations

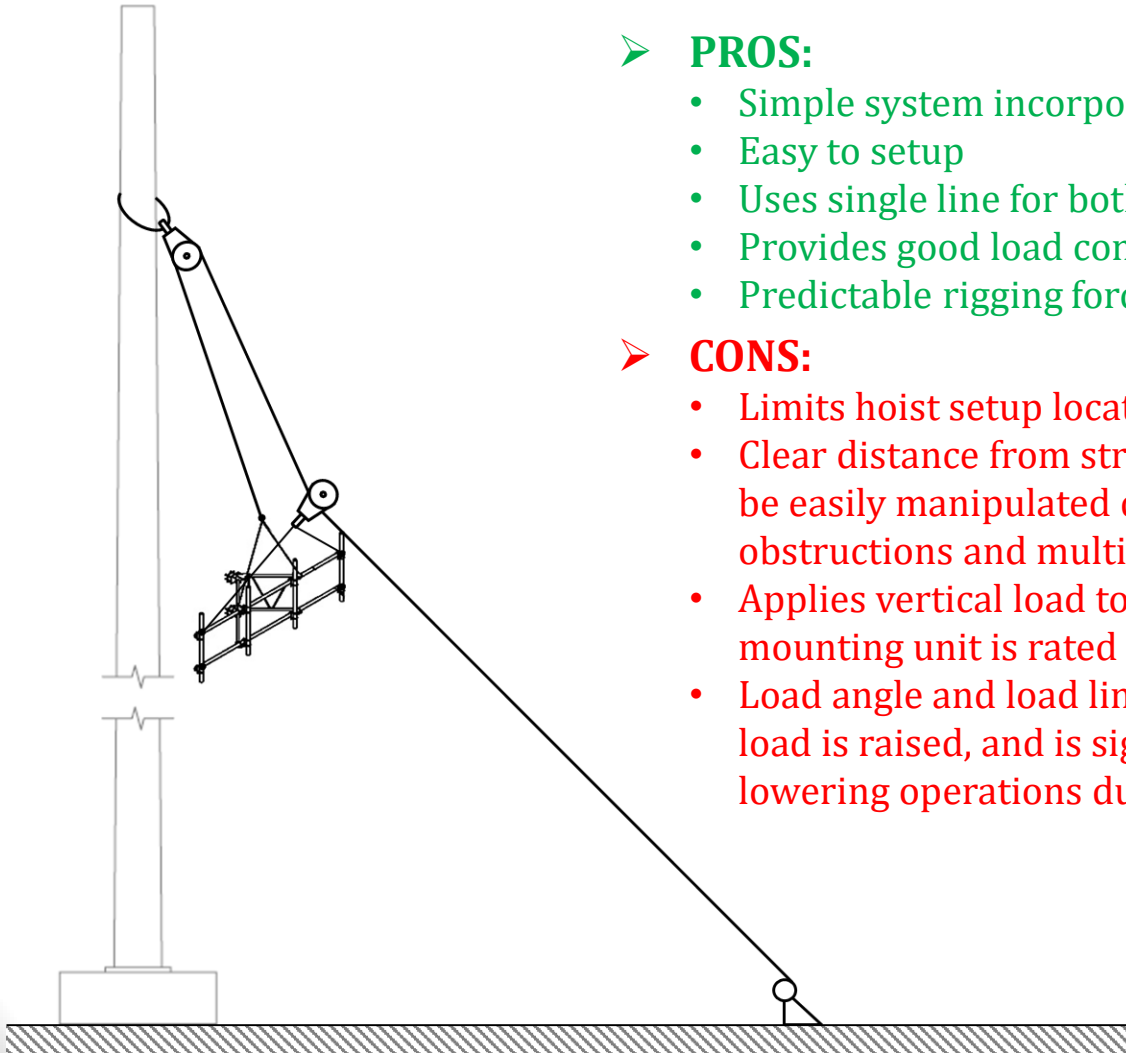
Integrated Trolley (aka Self-Trolley):

➤ PROS:

- Simple system incorporating only one block
- Easy to setup
- Uses single line for both lifting and control
- Provides good load control
- Predictable rigging forces in load line

➤ CONS:

- Limits hoist setup locations
- Clear distance from structure/obstructions cannot be easily manipulated during lift (issue for obstructions and multiple work elevations)
- Applies vertical load to hoisting unit (must ensure mounting unit is rated for vertical loading)
- Load angle and load line clear distance reduces as load is raised, and is significantly less during lowering operations due to sheave friction



Typical Lift Configurations

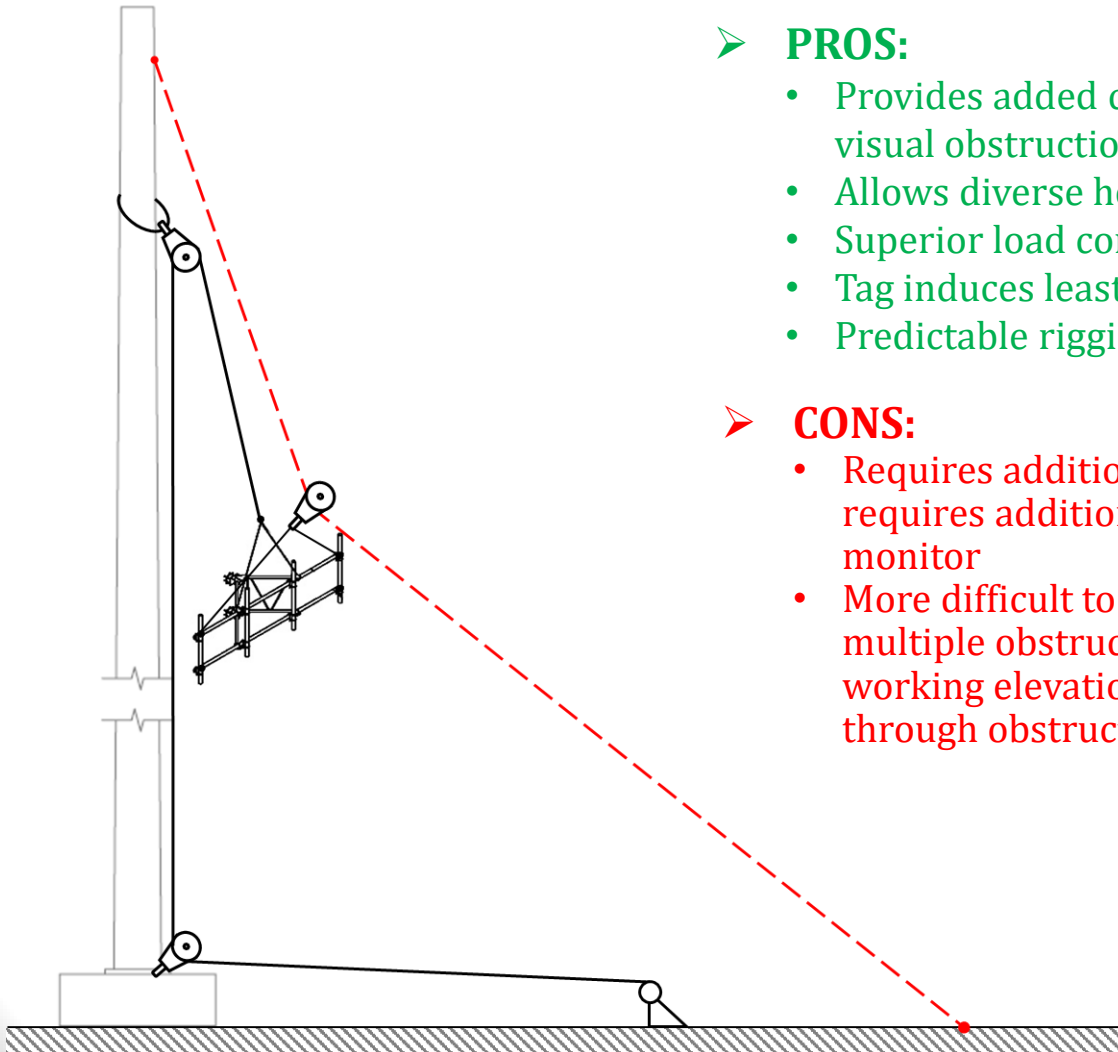
Dedicated Trolley:

➤ PROS:

- Provides added control to lead line and removes visual obstruction
- Allows diverse hoist setup options
- Superior load control
- Tag induces least force onto load
- Predictable rigging forces in load line

➤ CONS:

- Requires additional rigging attachments which requires additional crew members to properly monitor
- More difficult to employ on towers with multiple obstructions/equipment below working elevations (may require reeving through obstructions)



Sling Forces

To determine Sling Force, must know:

- 1) Applied Load
- 2) Sling Hitch Configuration
- 3) Sling Angle

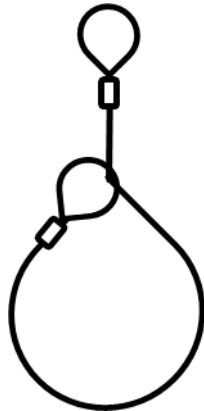


Sling Forces

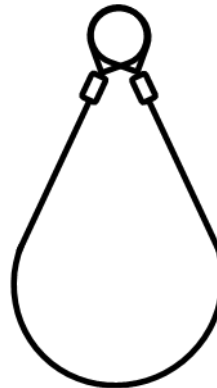
Types of Hitches:



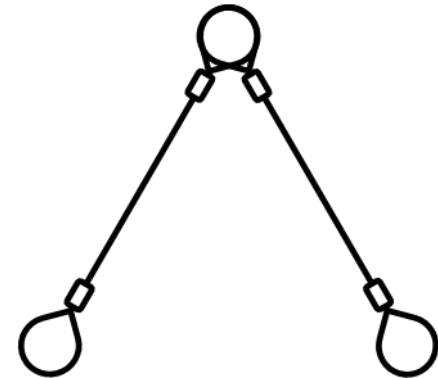
Vertical Hitch



Choker Hitch



Basket Hitch

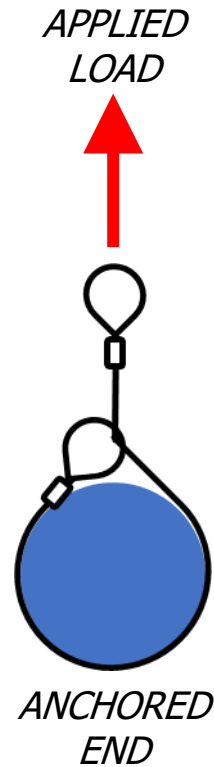
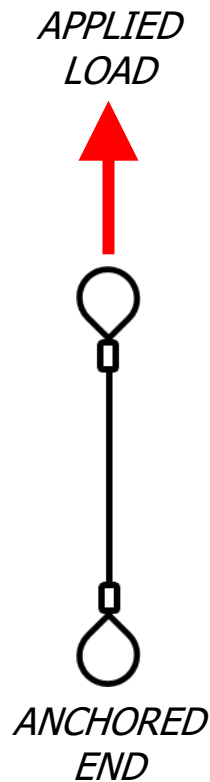


Bridle Hitch
Multiple Slings

Sling Forces

Vertical and Choker Hitches:

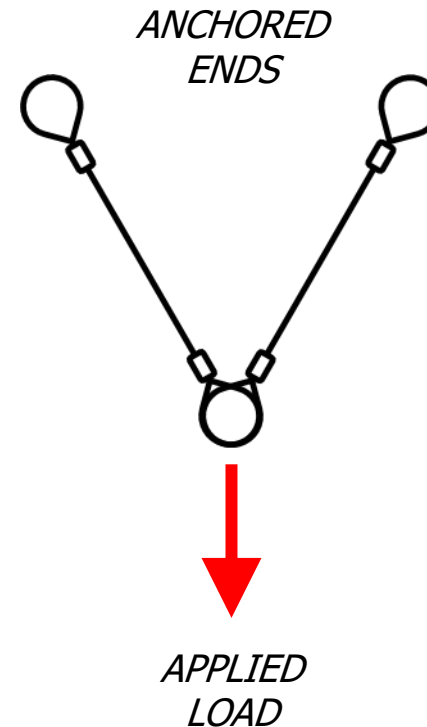
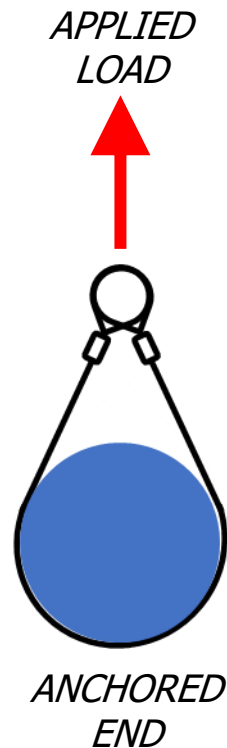
Sling Leg Force = Applied Load



Sling Forces

Symmetrically Loaded Basket Hitches & 2-Leg Bridle Hitches:

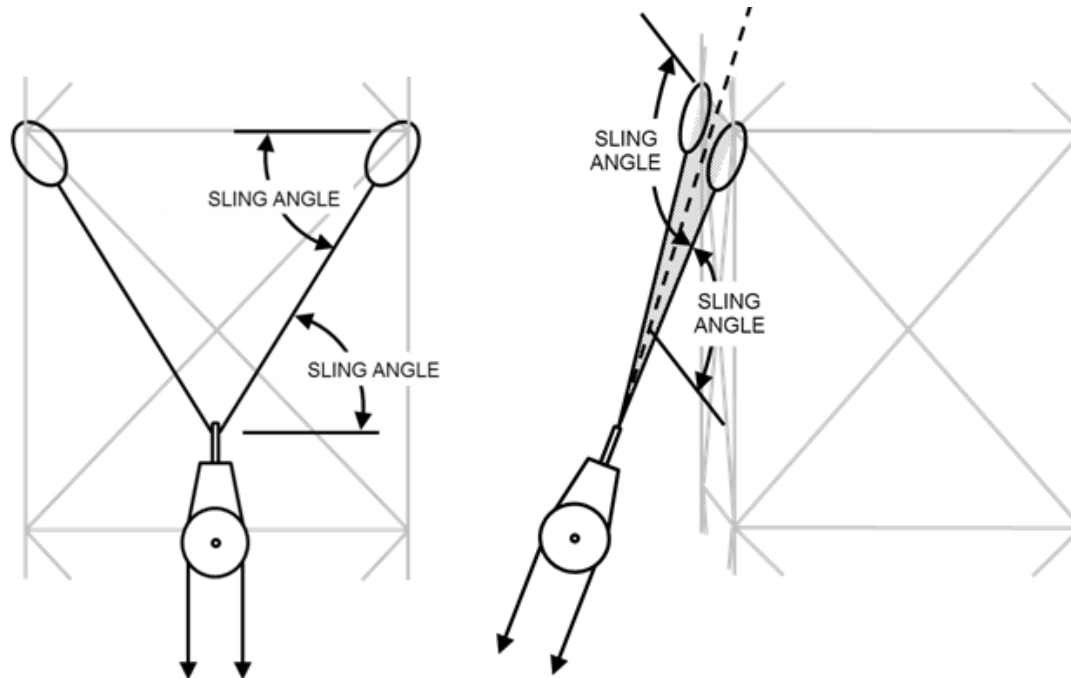
$$\text{Sling Leg Force} = \left(\frac{\text{Applied Load}}{2} \right) \times \text{Angle Factor}$$



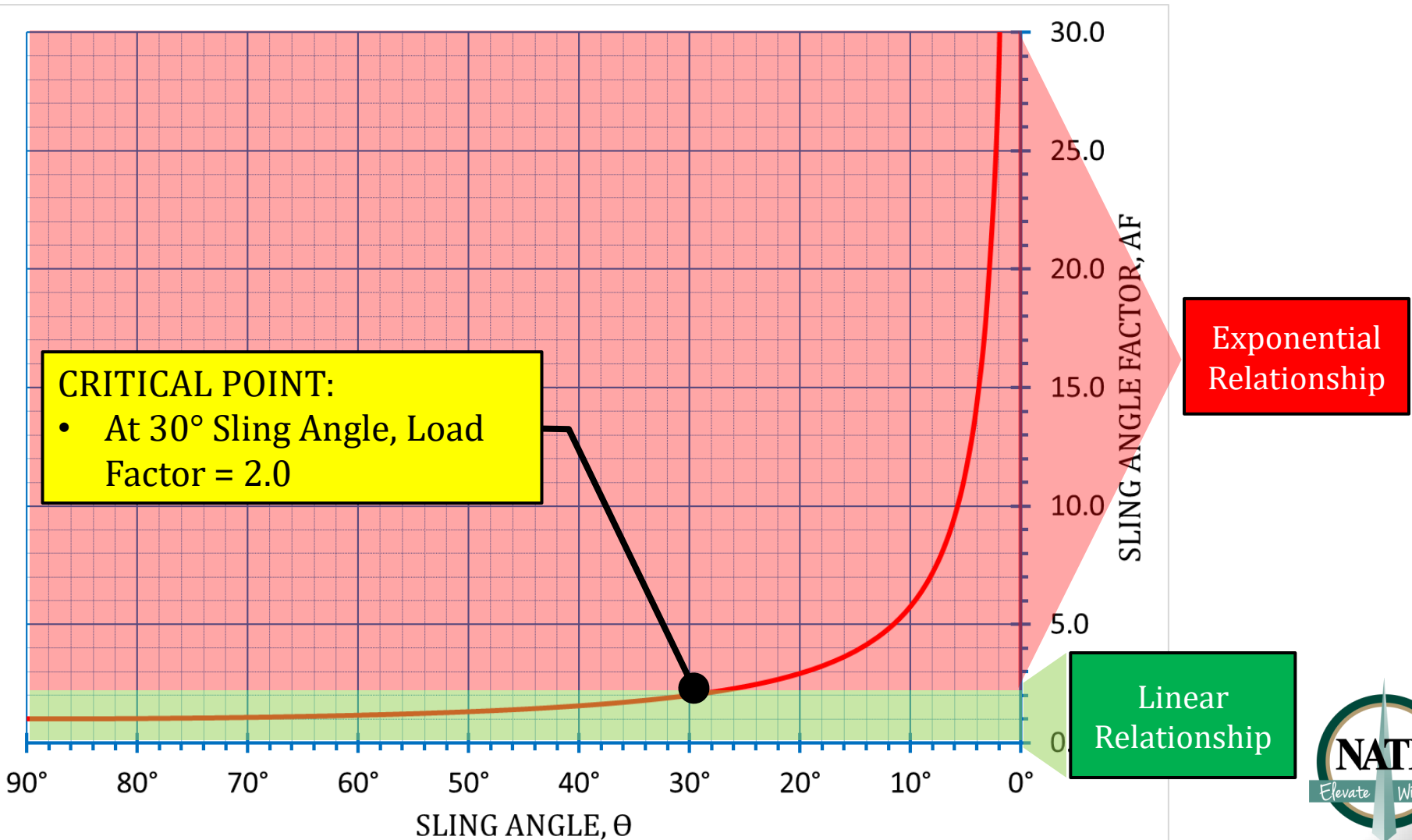
Sling Forces

Sling Angle:

- *Acute angle between sling leg and the plane perpendicular to the direction of the applied load*
- *For lifting applications, angle measured from horizontal to sling leg while accounting for incline in the rendered plane*



Sling Forces



Sling Forces

Sling Angle Factors:

SLING ANGLE, θ	ANGLE FACTOR AF	SLING ANGLE, θ	ANGLE FACTOR AF
90°	1.000	55°	1.221
85°	1.004	50°	1.305
80°	1.015	45°	1.414
75°	1.035	40°	1.556
70°	1.064	35°	1.743
65°	1.103	30°	2.000
60°	1.155	DO NOT SET BELOW 30°	

Critical Angles To Remember:

- 1) **60°**: Recommended Min Angle per ANSI/ASSE A10.48
- 2) **45°**: Min Angle per ANSI/ASSE A10.48 ~ Below 45° Requires Special Approval
- 3) **30°**: Min Angle per ASME B30.9 ~ Below 30° Requires Special Attention



Block Forces

To determine Block Force, must know:

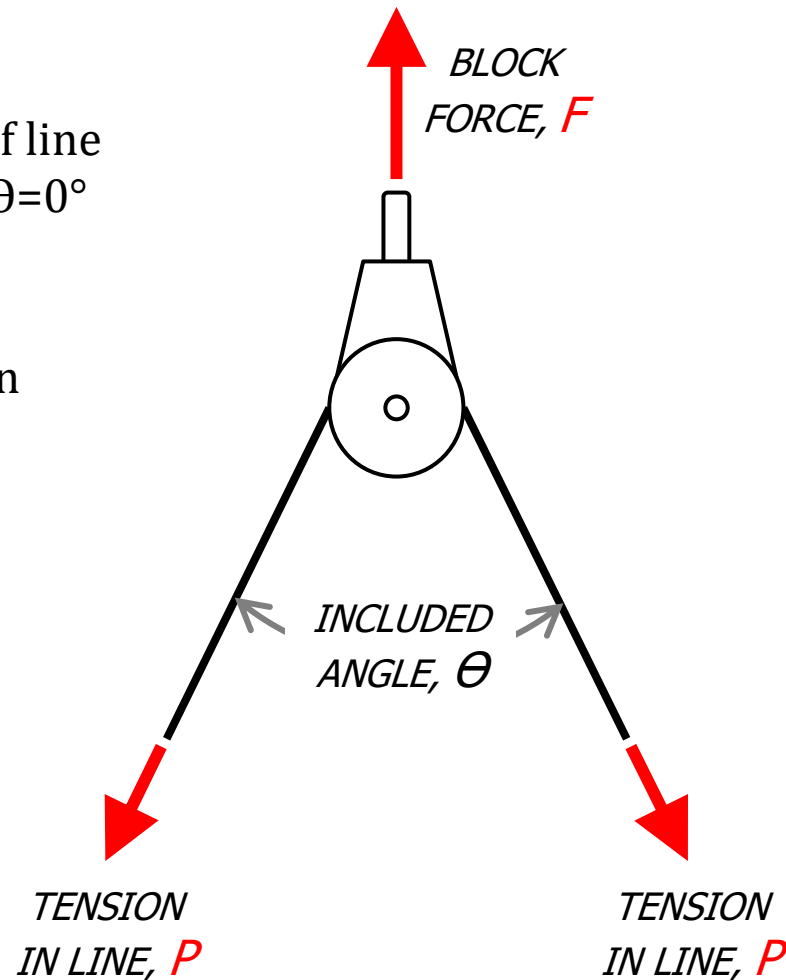
- 1) Line Tension
- 2) Block Included Angle



Block Forces

Block Force = Line Tension \times Angle Factor

- Included Angle, θ :
 - Angle formed between legs of line
e.g. Straight vertical lift $\sim \theta=0^\circ$
- Angle Factor, AF:
 - Multiplication factor based on Included Angle



Block Forces

INCLUDED ANGLE, θ	ANGLE FACTOR AF	INCLUDED ANGLE, θ	ANGLE FACTOR AF	INCLUDED ANGLE, θ	ANGLE FACTOR AF	INCLUDED ANGLE, θ	ANGLE FACTOR AF
0°	2.000	45°	1.848	90°	1.414	135°	0.765
5°	1.998	50°	1.813	95°	1.351	140°	0.684
10°	1.992	55°	1.774	100°	1.286	145°	0.601
15°	1.983	60°	1.732	105°	1.218	150°	0.518
20°	1.970	65°	1.687	110°	1.147	155°	0.433
25°	1.953	70°	1.638	115°	1.075	160°	0.347
30°	1.932	75°	1.587	120°	1.000	165°	0.261
35°	1.907	80°	1.532	125°	0.923	170°	0.174
40°	1.879	85°	1.475	130°	0.845	175°	0.087

Two Key Standard Angle Factors To Remember:

- 1) **Top Block Angle Factor:** During lift and setting the load, $\theta_{\min} = 0^\circ \rightarrow AF \sim 2.0$
- 2) **Heel Block Angle Factor:** θ typically ranges from $85^\circ - 95^\circ \rightarrow AF \sim 1.5$

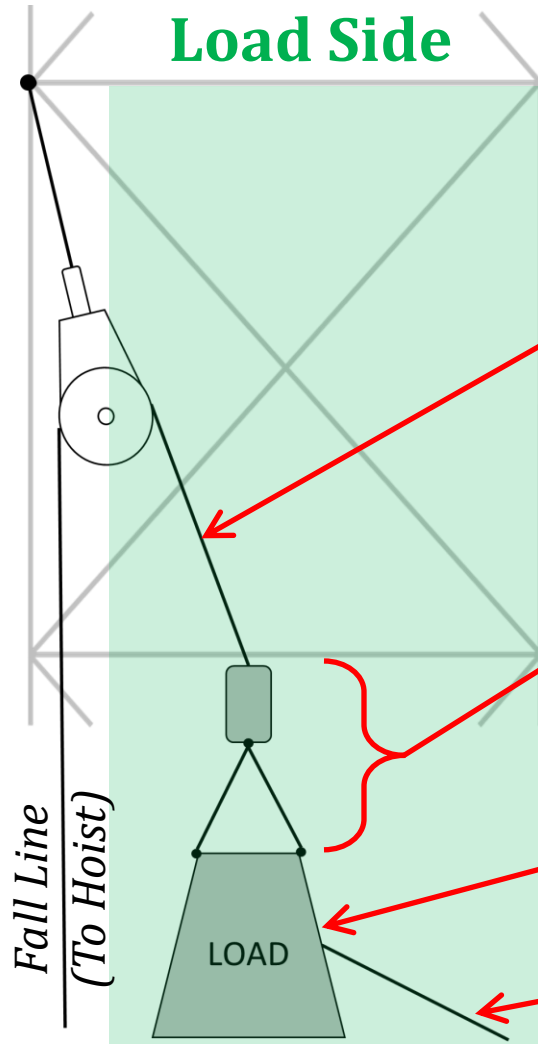


Line Forces

- To determine Line Forces, must know:
 - 1) Gross load weight
 - 2) Tag method
 - 3) Number of line parts
 - 4) Sheave frictional resistance
 - 5) Load position and tag angles



Line Forces



Gross Load, WT:

$WT = \text{Lifted Load} + \text{Rigging Weight on Load Side}$

Load Line Weight

- Do not need to include fall line weight to hoist

Rigging Weight

- Overhaul ball/weight, slings, shackles, etc.

Load Weight

Tag Line Weight

- Only include for Straight Tag configurations

Line Forces

Tag Method:

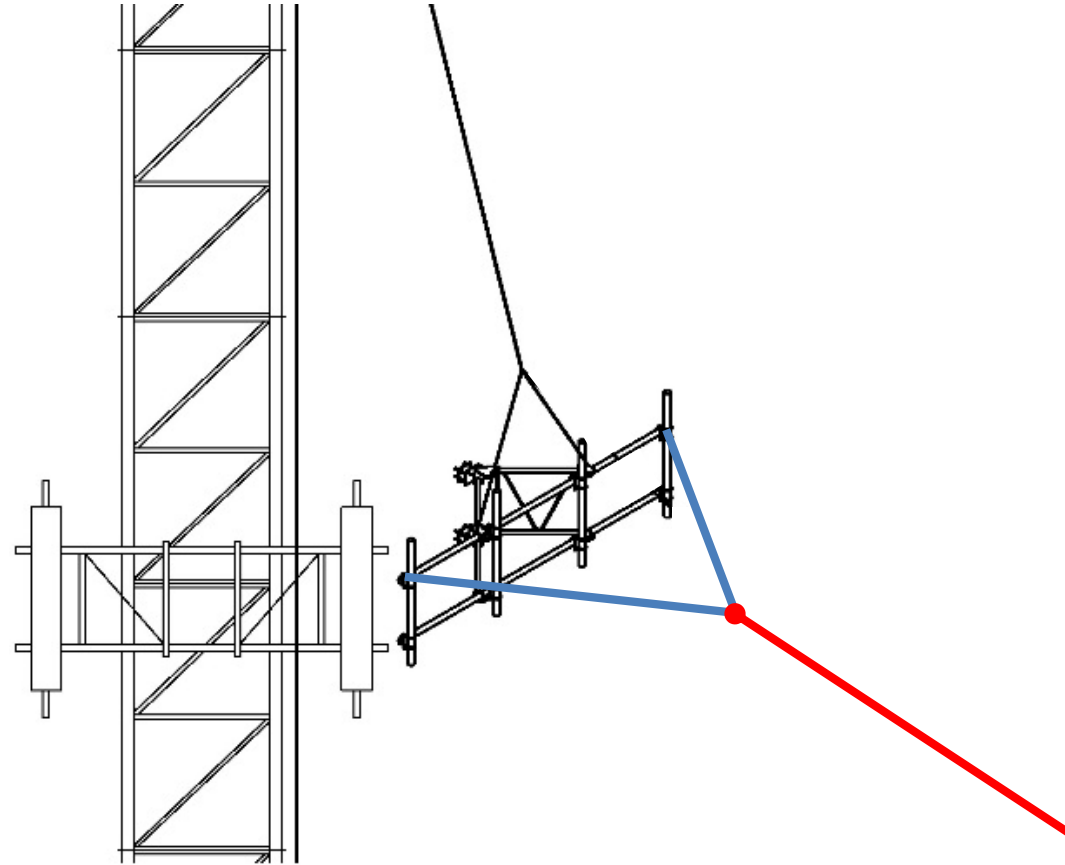
- Straight Tag
- Trolley Tag
 - Integrated Trolley (aka Self-Trolley)
 - Dedicated Trolley



Line Forces

Straight Tag:

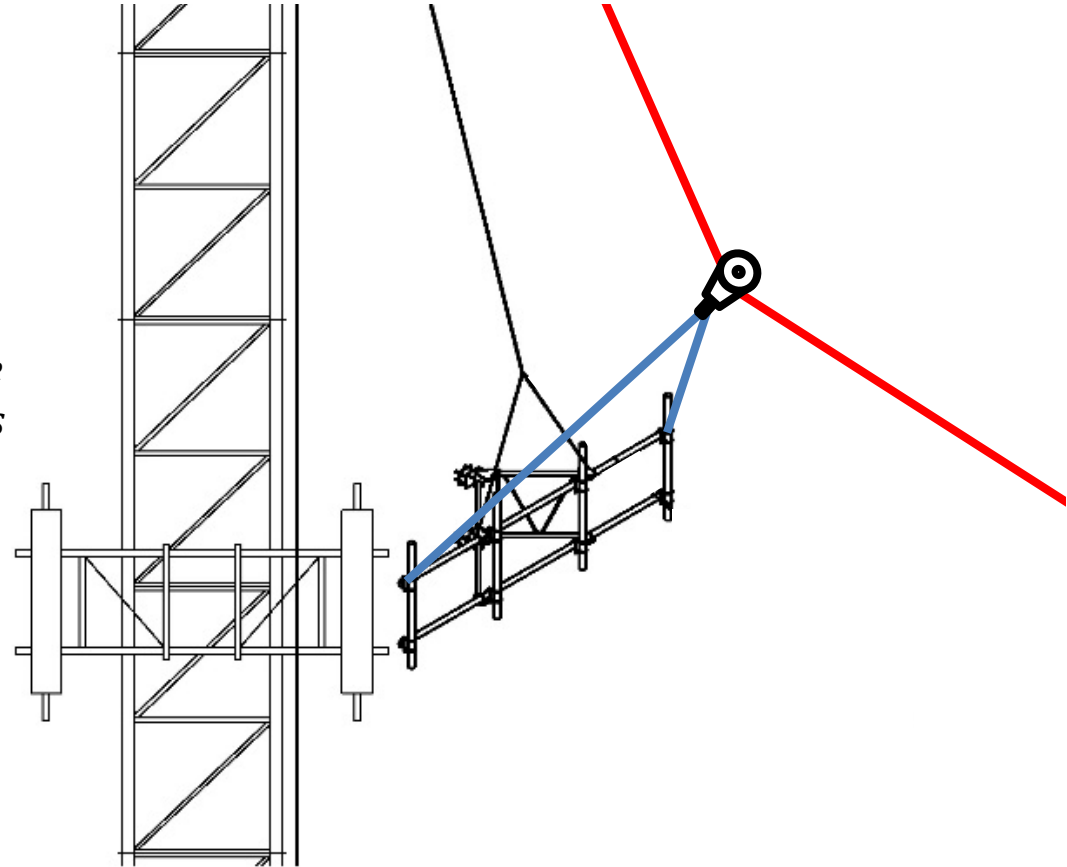
- Tag Line force is directly transferred into the Load Line
- Increased tendency for developing excessive forces in the Load Line
- Increased tendency for shock/impact loading
- Provides simple means for controlling the load with minimal attachments



Line Forces

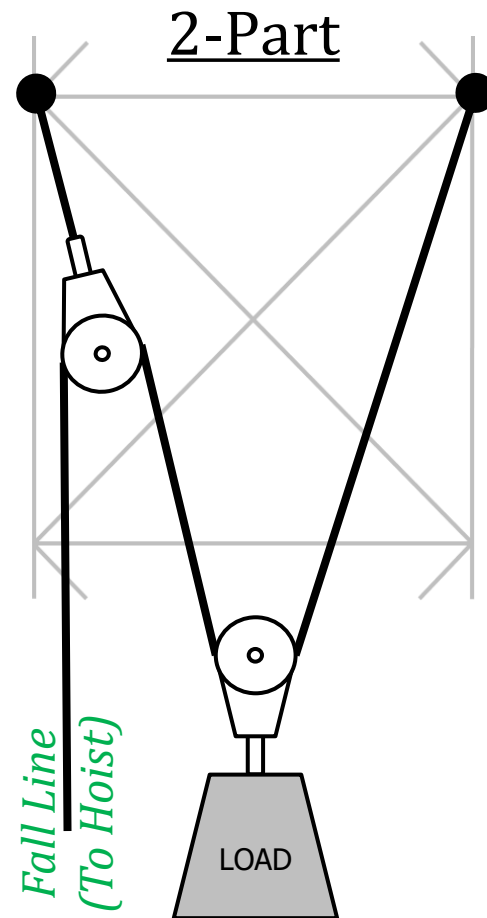
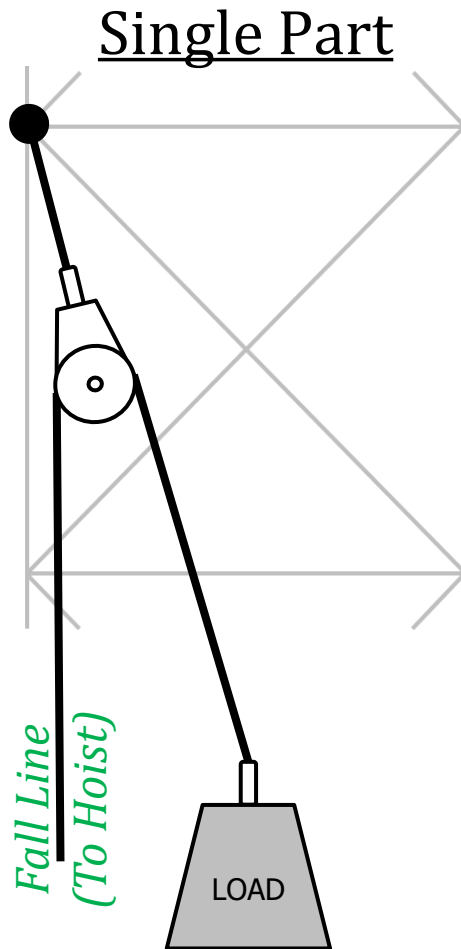
Trolley Tag:

- Tag Line force is **NOT** transferred into the Load Line
 - *During active lifting, the tag line actually relieves force from the load line; however, the Load Line ultimately supports the full Gross Load during the initial lift and final landing*
- Predictable Load Line force
- Provides superior load control
 - *More so for Dedicated Trolley Configurations*
- Requires additional attachments which must be monitored during hoisting operations



Line Forces

Number of Line Parts:



Line Forces

Line Parting Principles:

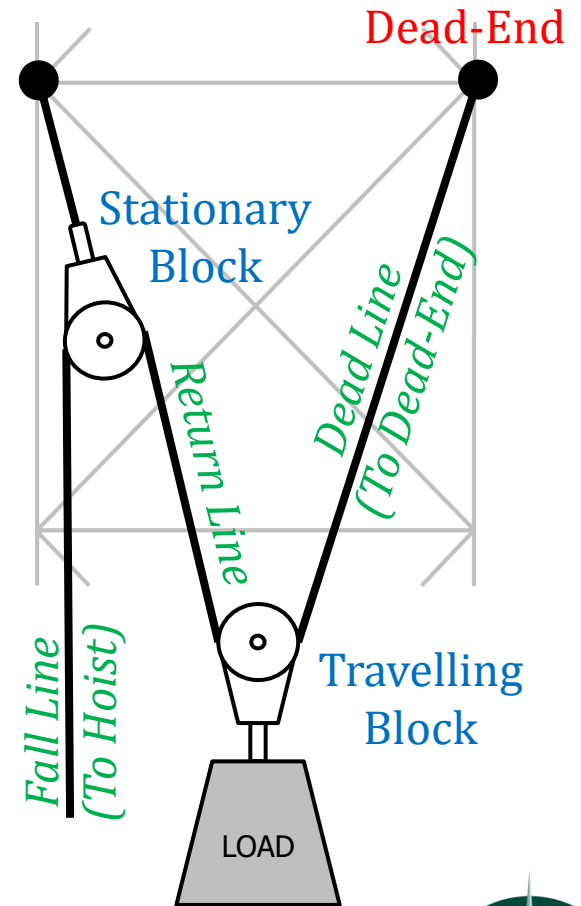
- Multi-parting the line provides a mechanical advantage for hoisting operations
 - 2-parting the line is most common for hoisting applications with synthetic rope
- Results in loss of load travel speed
- Increases frictional resistance of the hoisting system
- Important to consider attachment anchorage location for dead-end
 - If attached to rigging block becket, the additional line tension must be added to the resulting block force



Line Forces

Line Parting Principles:

- 2-Part Hoisting Configuration
 - Provides up to a 2:1 mechanical advantage not accounting for block angles and friction
 - Actual mechanical advantage typically ranges from around 1.5-1.9:1 for most common configurations
- System Components:
 - Blocks
 - Dead-End
 - Parts of Line



Line Forces

Mechanical Advantage for Typical 2-Part Arrangements:

- Must account for bearing type and total reeved sheaves in the system
- Losses attributed to sheave friction results in less mechanical advantage

TOTAL NO REEVED SHEAVES, S	2-PART MECHANICAL ADVANTAGE		
	STD PLAIN BEARINGS (K=1.09)	STD BRONZE BUSHINGS (K=1.045)	STD ROLLER BEARINGS (K=1.02)
2	1.759	1.873	1.942
3	1.614	1.792	1.903
4	1.481	1.715	1.866
5	1.358	1.641	1.830
6	1.246	1.570	1.794

Table based on common Bearing Constants, K, as specified

NOTE:

- 1) Typical 2-Part arrangement with top and heel blocks will have a minimum of 3 reeved sheaves ~ heel block, top block, and travelling block.
- 2) Each additional diverter/fairlead must be considered, and ultimately decreases the systems mechanical efficiency.



Line Forces

Sheave Frictional Resistance:

TOTAL NO REEVED SHEAVES, S	SHEAVE FRICTION FACTOR, SFF											
	NO OF LINE PARTS, N											
	1-Part			2-Part			3-Part			4-Part		
	PB	BB	SRB	PB	BB	SRB	PB	BB	SRB	PB	BB	SRB
1	1.090	1.045	1.020	-	-	-	-	-	-	-	-	-
2	1.188	1.092	1.040	1.137	1.068	1.030	-	-	-	-	-	-
3	1.295	1.141	1.061	1.239	1.116	1.051	1.185	1.091	1.040	-	-	-
4	1.412	1.193	1.082	1.351	1.166	1.072	1.292	1.140	1.061	1.235	1.115	1.050
5	1.539	1.246	1.104	1.472	1.219	1.093	1.408	1.192	1.082	1.346	1.165	1.072
6	1.677	1.302	1.126	1.605	1.274	1.115	1.535	1.245	1.104	1.467	1.218	1.093
7	1.828	1.361	1.149	1.749	1.331	1.137	1.673	1.301	1.126	1.599	1.272	1.115
8	1.993	1.422	1.172	1.907	1.391	1.160	1.824	1.360	1.149	1.743	1.330	1.137
9	2.172	1.486	1.195	2.078	1.453	1.183	1.988	1.421	1.172	1.900	1.389	1.160
10	2.367	1.553	1.219	2.265	1.519	1.207	2.167	1.485	1.195	2.071	1.452	1.183

Table based on bearing constants, K, of: Plain Bearings, PB=1.09 | Bronze Bushings, BB=1.045 | Steel Roller Bearings, SRB=1.02



Line Forces

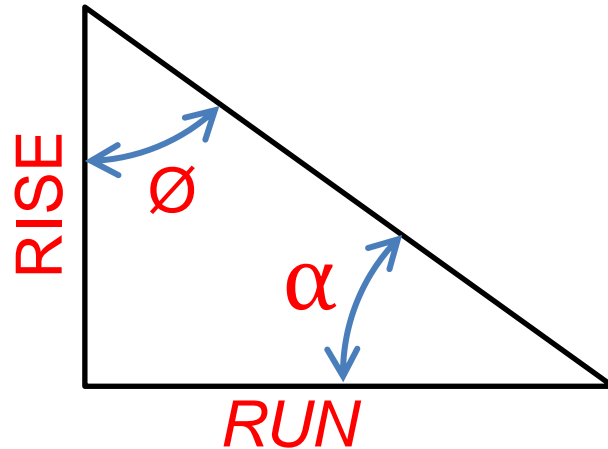
Load Position and Tag Angles:

- Angles and resulting line forces **CHANGE** throughout the various stages of the lift based on the tag force applied to create the horizontal clear distance needed to keep the load a safe distance from the structure and other obstructions.
- Must consider **ENTIRE** lifting operation from ground level to uppermost position to properly assess the maximum line forces created in the Load Line and Tag Line.



Line Forces

Load Position and Tag Angles:



RISE
RUN

Ex. For a top block rigged at 250 feet with the load positioned at 50 feet from the tower base, the $\frac{RISE}{RUN}$ would equal $\frac{250}{50}$ or 5.0, which equates to Load Position Angle, θ , of between 11° - 12°

θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)
90°	---	0°	75°	0.27	15°	60°	0.58	30°	45°	1.00	45°	30°	1.73	60°	15°	3.73	75°
89°	0.02	1°	74°	0.29	16°	59°	0.60	31°	44°	1.04	46°	29°	1.80	61°	14°	4.01	76°
88°	0.03	2°	73°	0.31	17°	58°	0.62	32°	43°	1.07	47°	28°	1.88	62°	13°	4.33	77°
87°	0.05	3°	72°	0.32	18°	57°	0.65	33°	42°	1.11	48°	27°	1.96	63°	12°	4.70	78°
86°	0.07	4°	71°	0.34	19°	56°	0.67	34°	41°	1.15	49°	26°	2.05	64°	11°	5.14	79°
85°	0.09	5°	70°	0.36	20°	55°	0.70	35°	40°	1.19	50°	25°	2.14	65°	10°	5.67	80°
84°	0.11	6°	69°	0.38	21°	54°	0.73	36°	39°	1.23	51°	24°	2.25	66°	9°	6.31	81°
83°	0.12	7°	68°	0.40	22°	53°	0.75	37°	38°	1.28	52°	23°	2.36	67°	8°	7.12	82°
82°	0.14	8°	67°	0.42	23°	52°	0.78	38°	37°	1.33	53°	22°	2.48	68°	7°	8.14	83°
81°	0.16	9°	66°	0.45	24°	51°	0.81	39°	36°	1.38	54°	21°	2.61	69°	6°	9.51	84°
80°	0.18	10°	65°	0.47	25°	50°	0.84	40°	35°	1.43	55°	20°	2.75	70°	5°	11.43	85°
79°	0.19	11°	64°	0.49	26°	49°	0.87	41°	34°	1.48	56°	19°	2.90	71°	4°	14.30	86°
78°	0.21	12°	63°	0.51	27°	48°	0.90	42°	33°	1.54	57°	18°	3.08	72°	3°	19.08	87°
77°	0.23	13°	62°	0.53	28°	47°	0.93	43°	32°	1.60	58°	17°	3.27	73°	2°	28.64	88°
76°	0.25	14°	61°	0.55	29°	46°	0.97	44°	31°	1.66	59°	16°	3.49	74°	1°	57.29	89°



Line Forces

- At minimum, resulting angles must be considered at the following lift positions:
 - 1) Ground Level
 - 2) Any Obstruction(s)
 - 3) Uppermost Lift Position
- For most operations, it is best practice to base your line force calculations using the Maximum Load Position Angle and Maximum Tag Angle.



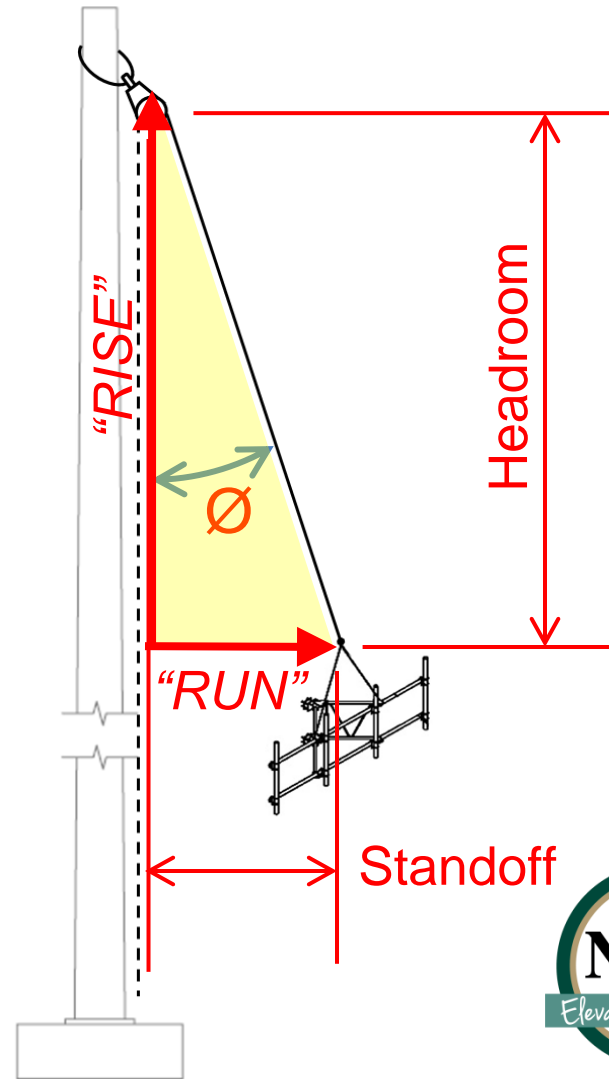
Line Forces

Load Position Angle, \emptyset :

- *Angle between true vertical and the rendered Load Line*
- *Best practice is to limit to 5° or less*
- *Once you exceed 10° on Straight Tag configurations, Load Line force can become excessive*

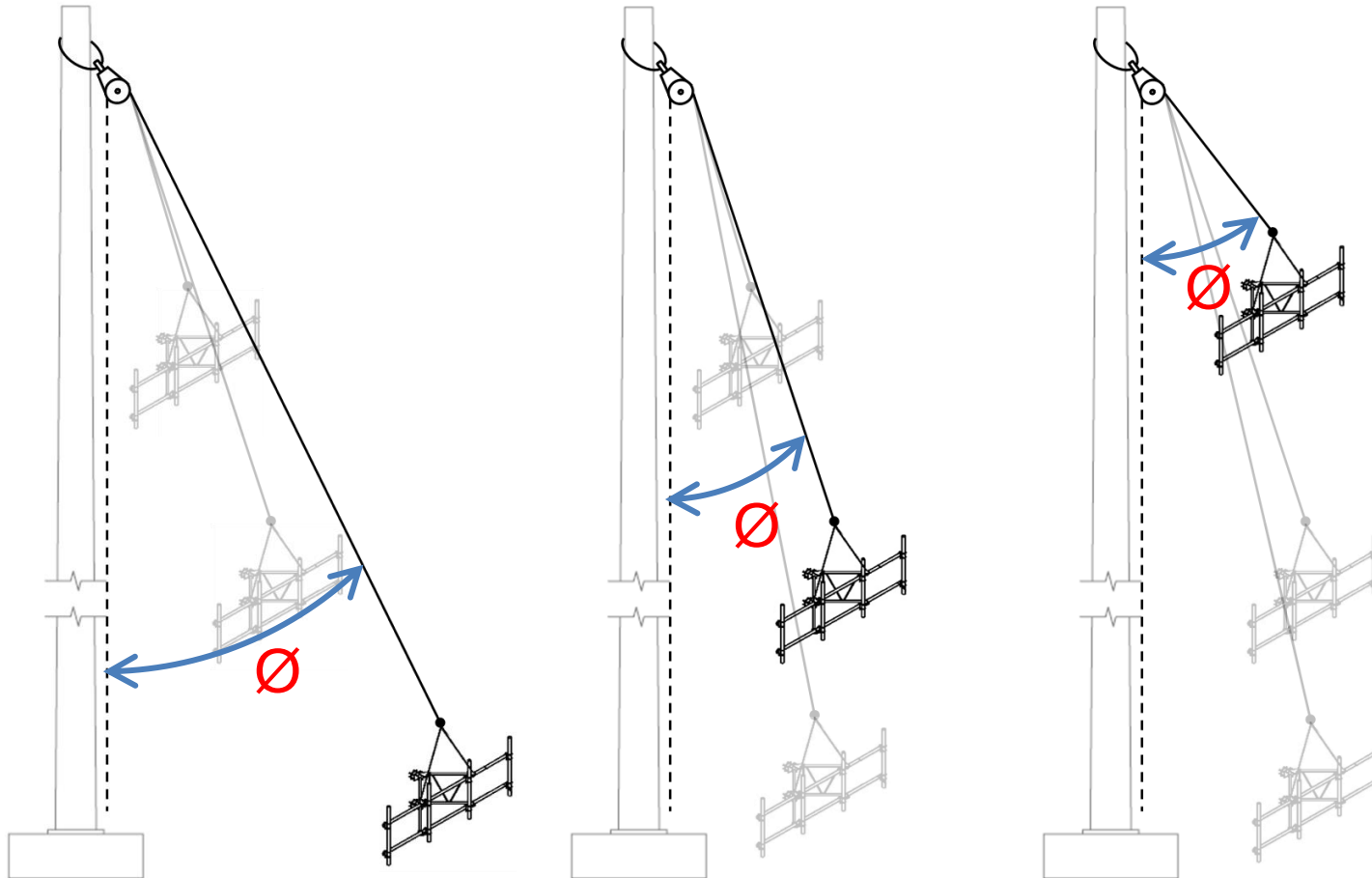
NOTE:

- *Standoff distance at 5° equals a RISE/RUN ratio of **11.4***
- *Standoff distance at 10° equals a RISE/RUN ratio of **5.7***



Line Forces

Always Determine **Maximum** Load Position Angle, \emptyset :



At Ground Level

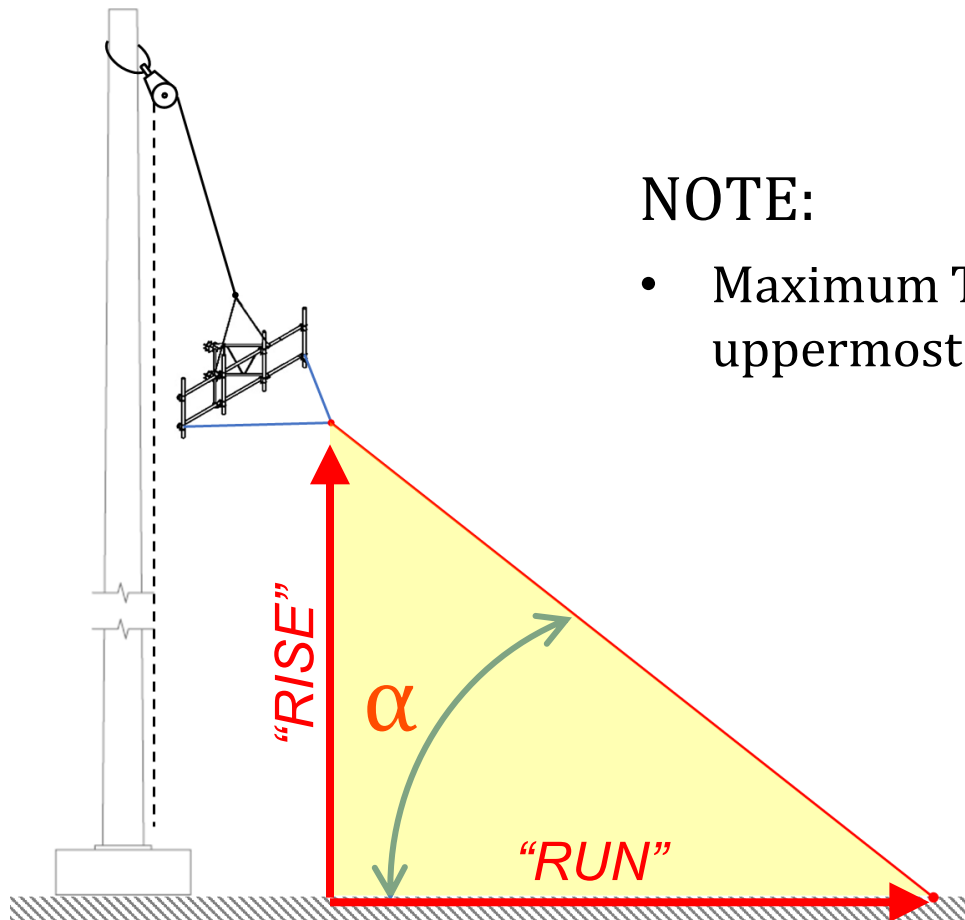
At Tower Obstruction

At Top Position

Line Forces

Tag Angle for Straight Tag Configurations, α :

- *Angle between horizontal and the rendered Tag Line*



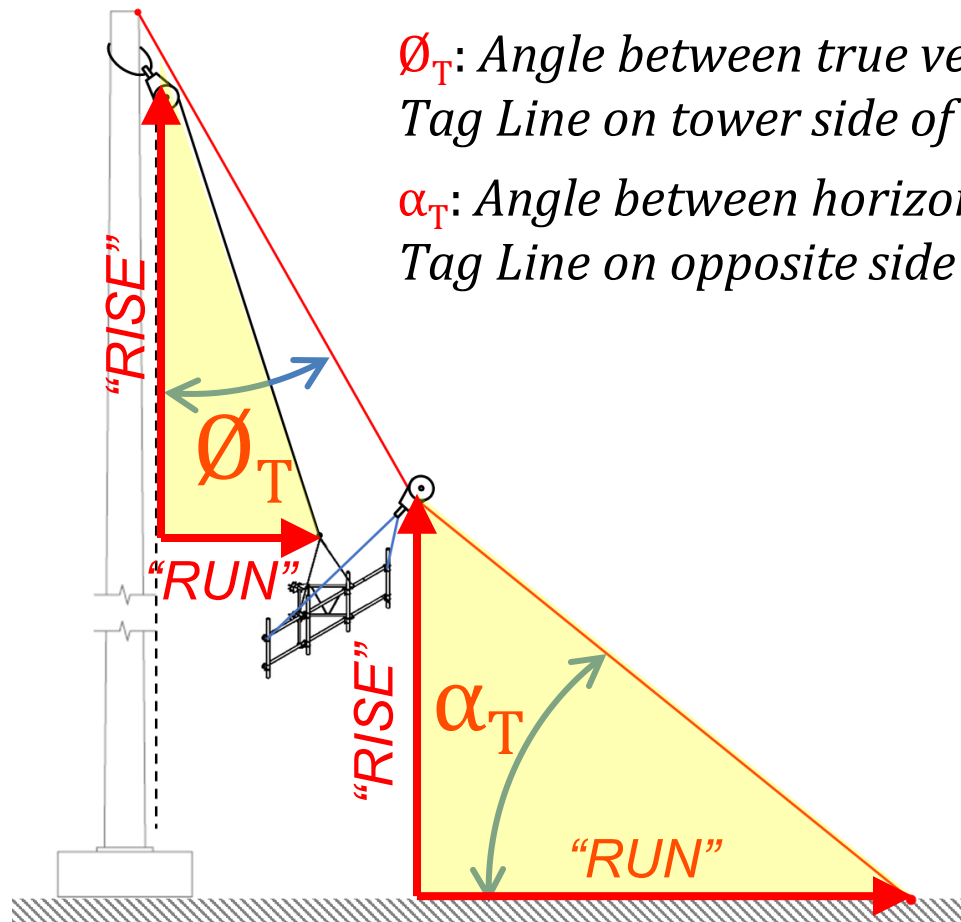
NOTE:

- Maximum Tag Angle occurs at uppermost position of lift

Line Forces

Tag Angles for Dedicated Trolley Configurations, θ_T & α_T :

- *Must identify BOTH angles to determine resulting Tag Line Force*



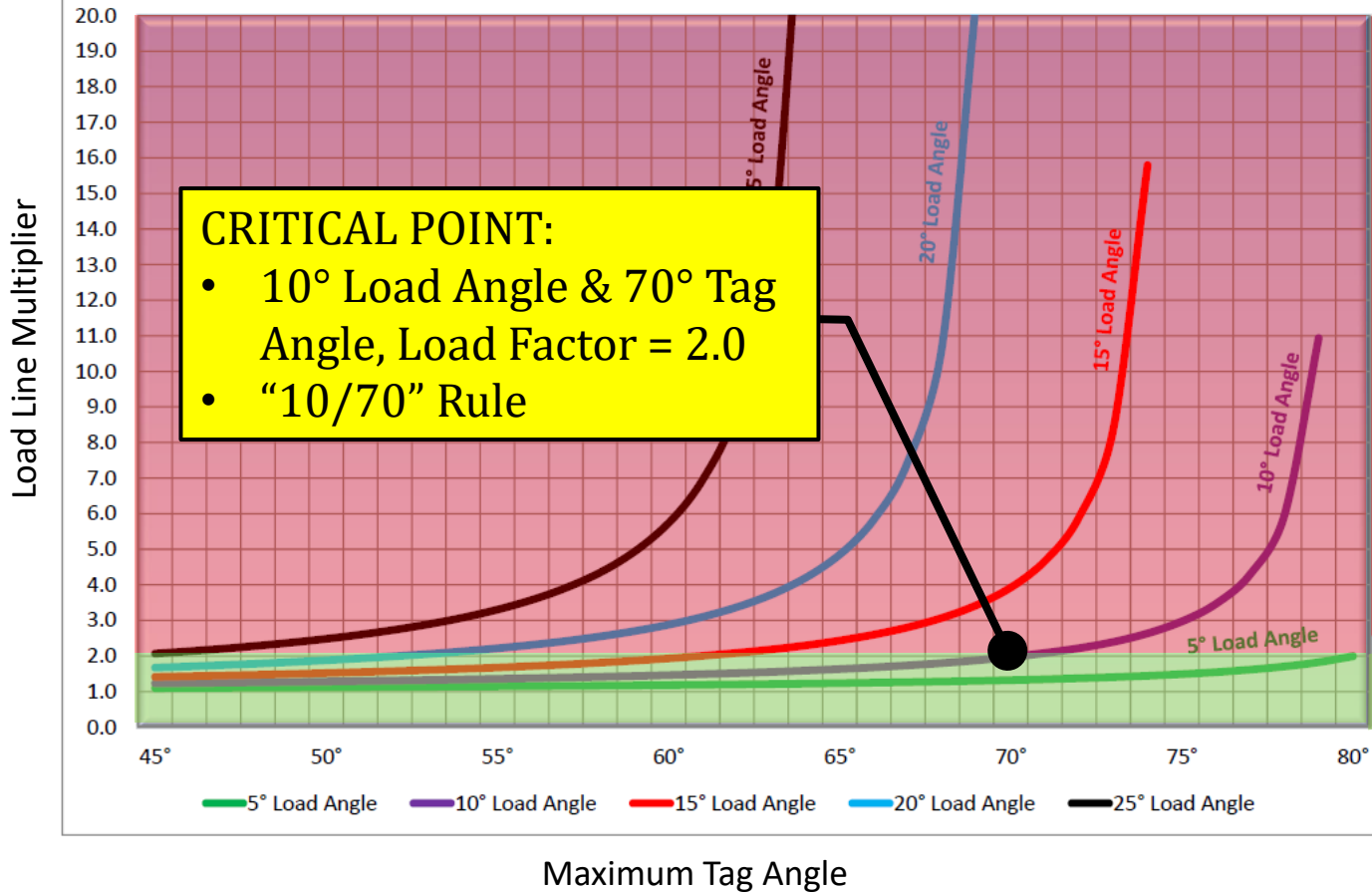
θ_T : Angle between true vertical and the rendered Tag Line on tower side of trolley block

α_T : Angle between horizontal and the rendered Tag Line on opposite side of trolley block

Line Forces

Load Line Multipliers - Straight Tag

$$\text{Line Force} = \text{Multiplier} \times \text{Gross Load}$$



CRITICAL POINT:

- 10° Load Angle & 70° Tag Angle, Load Factor = 2.0
- “10/70” Rule

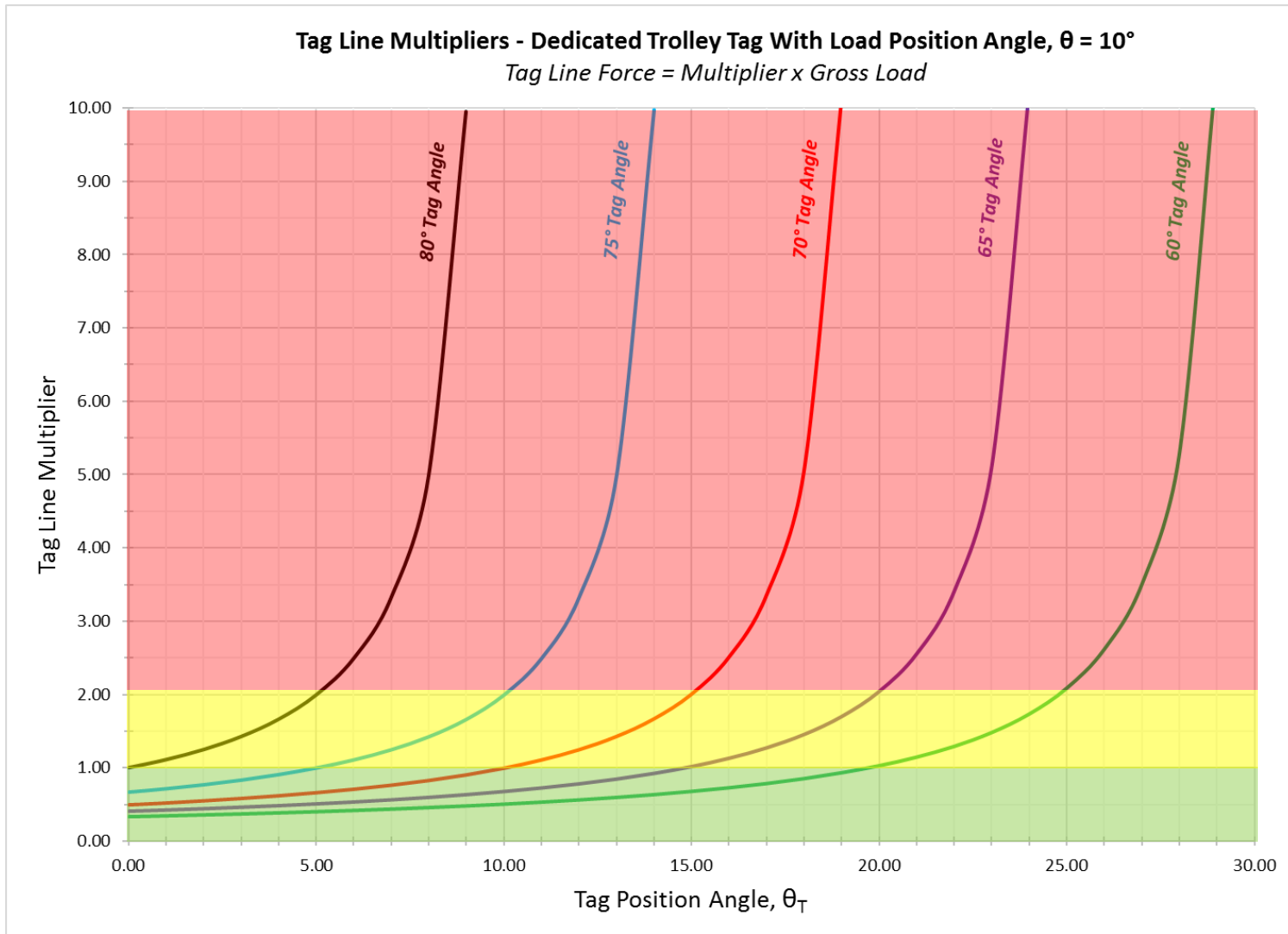
Exponential Relationship

Linear Relationship



Line Forces

Tag Line Multipliers - Dedicated Trolley Tag With Load Position Angle, $\theta = 10^\circ$
Tag Line Force = Multiplier x Gross Load



Line Forces

Line Forces at Load:

$$\text{Load Line Force at Load, } P = \left(\frac{WT \times PM}{N_P} \right)$$

$$\text{Tag Line Force at Load, } T = \left(\frac{WT \times TM}{N_T} \right)$$

Where:

P = Load Line Force at Load

T = Tag Line Force at Load

WT = Gross Load Weight

PM = Load Line Multiplier (Refer to Handbook)

***NOTE:** For Trolley Tag Arrangements, Set $PM = \underline{1.0}$ for Uppermost Position

TM = Tag Line Multiplier (Refer to Handbook)

N_P = Number of Line Parts in Load Line

N_T = Number of Line Parts in Tag Line



Line Forces

Load Line Pull at Hoist:

$$\text{Load Line Pull at Hoist, } P_H = (P - FLW) \times SFF \times AM$$

Where:

P_H = Load Line Pull at Hoist

P = Load Line Force at Load

FLW = Fall Line Weight

SFF = Sheave Friction Factor

AM = Additional Multipliers (i.e. Additional Angle/Safety Factors, Etc.)



Line Forces

Trolley Block Force:

Max Trolley Block Force $\cong T \times 1.5$; *Conservative Estimate*



Trolley Block

Where:

T = Tag Line Force at Load

(or Load Line Force at Load, P , for Integrated Trolley Systems)

Worked Examples

- *Refer to the loose Straight Tag Example and forms provided in your Handbook*
- *Turn to Page 110 of your Handbook to locate the Tables we'll be using for this example*



Straight Tag Example

➤ Refer to Loose Handouts in the back of your Handbook for the STRAIGHT TAG EXAMPLE:

STRAIGHT TAG EXAMPLE.

For the straight tag lifting arrangement shown below, determine the maximum rigging forces in the following:

Load Line Force at Load: _____

Tag Line Force at Load: _____

Load Line Force at Hoist: _____

Top Block Force: _____

Heel Block Force: _____

Top Block Sling Leg Force: _____

Heel Block Sling Leg Force: _____

WEIGHTS:
 Boom Mount: 400 lbs
 Load Line: 0.14 lbs/ft
 Tag Line: 0.14 lbs/ft (145 ft Total Length)
 Rigging/Misc: 25 lbs

TOP BLOCK AT
 Sling Type: S
 Sling Angle: _____

HEEL BLOCK
 Sling Type: S
 Block Use: _____
 *plain B

Lifted Load Rigging Forces					
Project Info					
Project No.	Revision No.	Project No.	Revision No.	Project No.	Revision No.
Rigging Plan Class: <input type="checkbox"/> Class I <input type="checkbox"/> Class II <input type="checkbox"/> Class III <input type="checkbox"/> Class IV					
Load Weight: Actual	Est	Load Line Weight: Actual	Est	Tag Line Weight: Actual	Est
Rigging Weight: <input type="checkbox"/>	<input type="checkbox"/>	Overhaul Ball Weight: <input type="checkbox"/>	<input type="checkbox"/>	Misc Weight: <input type="checkbox"/>	<input type="checkbox"/>
GROSS LOAD, WT:		FALL LINE WEIGHT, FLW:		Maximum Load Elevation:	
Tag Method: <input type="checkbox"/> Straight Tag <input type="checkbox"/> Integrated Trolley (Self-Trolley) <input type="checkbox"/> Dedicated Trolley <input type="checkbox"/> Special			Tag Distance:		
Max Load Position Angle, θ :			Max Tag Angle, $4/\theta_2$:		
_____round up to nearest degree			_____round up to nearest 5 deg increment		
*Load line position angles, θ , exceeding 10 degrees and/or tag angles, θ_2 , exceeding 70 degrees in straight tag configurations are not recommended and generally considered "Special" where additional engineering involvement may be required to assess resulting rigging forces.					
Max Tag Position Angle for Dedicated Trolley Arrangements, θ_2 :					
_____round up to nearest degree					
LINE FORCES AT LOAD					
Max Load Line Multiplier, PM:		Number of Parts of Load Line, N_L :		Load Line Force, $P = (WT \times PM) \div N_L$:	
Max Tag Line Multiplier, TM:		Number of Parts of Tag Line, N_T :		Tag Line Force, $T = (WT \times TM) \div N_T$:	
LOAD LINE FORCE AT HOIST					
Sheave Friction Factor, SFF:		Additional Multipliers, AM:		Line Pull at Hoist, $P_H = (P - FLW) \times SFF \times AM$:	
RIGGING BLOCK FORCES					
Block Configuration:		Top Block Elevation:		Heel Block Elevation:	
<input type="checkbox"/> Top and Heel Blocks <input type="checkbox"/> Top Block Only		Top Block Angle Factor, AF_{TB} :		Top Block Force, $F_{TB} = P \times AF_{TB}$:	
Min Top Block Included Angle:		Heel Block Angle Factor, AF_{HB} :		Heel Block Force, $F_{HB} = P \times AF_{HB}$:	
Min Heel Block Included Angle:		Trolley Block Angle Factor, AF_{TB} :		Trolley Block Force, $F_{TB} = T \times AF_{TB}$:	
Min Trolley Block Included Angle:		Trolley Block Force, F_{TB} :			
SLING FORCES					
Top Block Sling Hitch Type: <input type="checkbox"/> Vertical <input type="checkbox"/> Choker <input type="checkbox"/> Basket <input type="checkbox"/> 2-Leg Bridle <input type="checkbox"/> Special					
Number of Sling Legs, N_{SL} :		_____ "1" for typical vertical or choker hitches, or "2" for typical basket or 2-leg bridle hitches			
Sling Angle (for Basket/Bridle Hitches):		Sling Angle Factor, AF_{SL} :		Sling Leg Force, $F_{SL} = (F_{TB} \times AF_{SL}) \div N_{SL}$:	
Heel Block Sling Hitch Type: <input type="checkbox"/> Vertical <input type="checkbox"/> Choker <input type="checkbox"/> Basket <input type="checkbox"/> 2-Leg Bridle <input type="checkbox"/> Special					
Number of Sling Legs, N_{SH} :		_____ "1" for typical vertical or choker hitches, or "2" for typical basket or 2-leg bridle hitches			
Sling Angle (for Basket/Bridle Hitches):		Sling Angle Factor, AF_{SH} :		Sling Leg Force, $F_{SH} = (F_{HB} \times AF_{SH}) \div N_{SH}$:	
Trolley Block Sling Hitch Type: <input type="checkbox"/> Vertical <input type="checkbox"/> Choker <input type="checkbox"/> Basket <input type="checkbox"/> 2-Leg Bridle <input type="checkbox"/> Special					
Number of Sling Legs, N_{ST} :		_____ "1" for typical vertical or choker hitches, or "2" for typical basket or 2-leg bridle hitches			
Sling Angle (for Basket/Bridle Hitches):		Sling Angle Factor, AF_{ST} :		Sling Leg Force, $F_{ST} = (F_{TB} \times AF_{ST}) \div N_{ST}$:	

Lifted Load Rigging Forces					
Rigging Plan Class: <input type="checkbox"/> Class I <input type="checkbox"/> Class II <input type="checkbox"/> Class III <input type="checkbox"/> Class IV					
Description					
A to Load Headroom (Block):		At Ground Level		At Obstruction	
A to Load Standoff Distance (Run):		At Maximum Elevation		Other	
on Angle, θ (round up to nearest deg):					
Sent to Ground Tag Height (Block):					
Sent to Ground Tag Distance (Run):					
Round up to nearest 5 deg increment:					
TM:					
Multiplier, PM:		Multiplier, TM:			

Straight Tag Example

STRAIGHT TAG EXAMPLE.

For the straight tag lifting arrangement shown below, determine the maximum rigging forces in the following:

Load Line Force at Load: _____

Tag Line Force at Load: _____

Load Line Force at Hoist: _____

Top Block Force: _____

Heel Block Force: _____

Top Block Sling Leg Force: _____

Heel Block Sling Leg Force: _____



Straight Tag Example

STEP 1) Determine the Gross Load Weight

WEIGHTS:

Boom Mount: 400 lbs

Load Line: 0.14 lbs/ft

Tag Line: 0.14 lbs/ft (145 ft Total Length)

Rigging/Misc: 25 lbs



Straight Tag Example

STEP 1) Determine the Gross Load Weight

Load Info	Load Weight:	Actual	Est	Load Line Weight:	Actual	Est	Tag Line Weight:	Actual	Est
	<u>400 lbs</u>	<input type="checkbox"/>	<input type="checkbox"/>	<u>20 lbs</u>	<input type="checkbox"/>	<input type="checkbox"/>	<u>20 lbs</u>	<input type="checkbox"/>	<input type="checkbox"/>
	Rigging Weight:			Overhaul Ball Weight:			Misc Weight:		
	<u>25 lbs</u>	<input type="checkbox"/>	<input type="checkbox"/>	<u>0</u>	<input type="checkbox"/>	<input type="checkbox"/>	<u>0</u>	<input type="checkbox"/>	<input type="checkbox"/>
GROSS LOAD, WT:				FALL LINE WEIGHT, FLW:			Maximum Load Elevation:		
<u>465 lbs</u>				<u>20 lbs</u>			<u>130 ft</u>		

Load Line Weight:

145 ft x 0.14 plf = Approx. 20 lbs

Tag Line Weight:

145 ft x 0.14 plf = Approx. 20 lbs

GROSS LOAD WEIGHT:

400 + 20 + 20 + 25 = 465 lbs

Fall Line Weight, FLW:

145 ft x 0.14 plf = Approx. 20 lbs

WEIGHTS:

Boom Mount: 400 lbs

Load Line: 0.14 lbs/ft

Tag Line: 0.14 lbs/ft (145 ft Total Length)

Rigging/Misc: 25 lbs



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Lifted Load Rigging Forces

Project Info: _____
Rigging Plan Class: Class I Class II Class III Class IV

Description	Straight Tag Angles			
	At Ground Level	At Obstruction	At Maximum Elevation	Other
A) Top Block to Load Headroom (Rise):				
B) Top Block to Load Standoff distance (Run):				
C) Tag Attachment to Ground Tag Height (Rise):				
D) Tag Attachment to Ground Tag Distance (Run):				
Load Position Angle, θ (round up to nearest deg):				
Tag Angle, α (round up to nearest 5 deg increment):				
Load Line Multiplier, PM:				
Tag Line Multiplier, TM:				
Maximum Load Line Multiplier, PLM:				
Maximum Tag Line Multiplier, TLM:				

Straight Tag Example

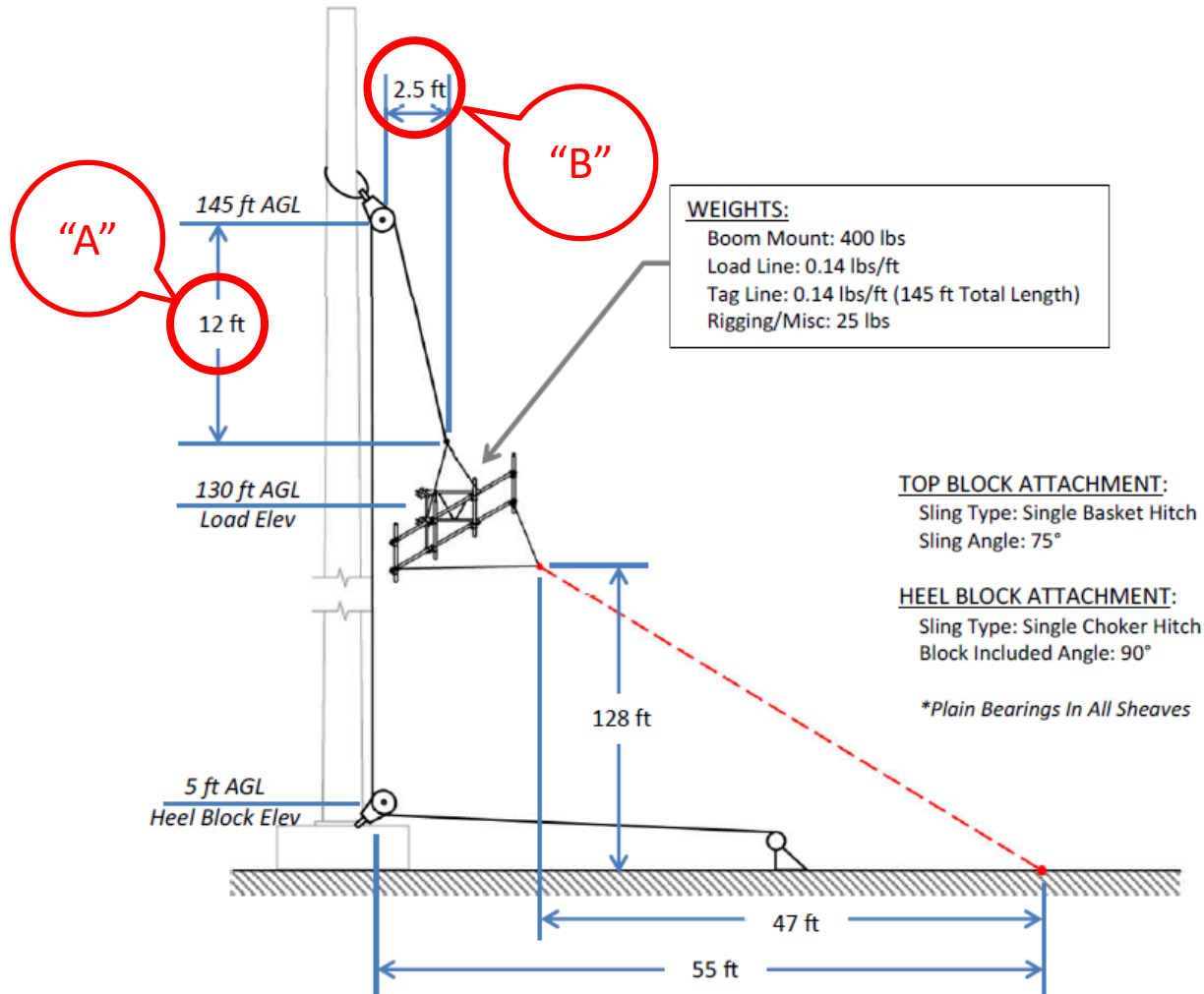
STEP 2) Determine the Maximum Load Position and Tag Angles

Straight Tag Angles				
Description	At Ground Level	At Obstruction	At Maximum Elevation	Other
A) Top Block to Load Headroom (Rise):				
B) Top Block to Load Standoff Distance (Run):				
Rise/Run:				
Load Position Angle, θ (round up to nearest deg):				
C) Tag Attachment to Ground Tag Height (Rise):				
D) Tag Attachment to Ground Tag Distance (Run):				
Rise/Run:				
Tag Angle, α (round up to nearest 5 deg increment):				
Load Line Multiplier, PM:				
Tag Line Multiplier, TM:				
Maximum Load Line Multiplier, PM:				
Maximum Tag Line Multiplier, TM:				



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Straight Tag Angles				
Description	At Ground Level	At Obstruction	At Maximum Elevation	Other
A) Top Block to Load Headroom (Rise):			12 ft	
B) Top Block to Load Standoff Distance (Run):			2.5 ft	
Rise/Run:			4.80	
Load Position Angle, θ (round up to nearest deg):				
C) Tag Attachment to Ground Tag Height (Rise):				
D) Tag Attachment to Ground Tag Distance (Run):				
Rise/Run:				
Tag Angle, α (round up to nearest 5 deg increment):				
Load Line Multiplier, PM:				
Tag Line Multiplier, TM:				
Maximum Load Line Multiplier, PM:				
Maximum Tag Line Multiplier, TM:				

$$\frac{RISE}{RUN} = \frac{12}{2.5} = 4.80$$



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Table A4. Rise-to-Run Angle Conversion

θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)
90°	---	0°	60°	0.58	30°	30°	1.73	60°
89°	0.02	1°	59°	0.60	31°	29°	1.80	61°
88°	0.03	2°	58°	0.62	32°	28°	1.88	62°
87°	0.05	3°	57°	0.65	33°	27°	1.96	63°
86°	0.07	4°	56°	0.67	34°	26°	2.05	64°
85°	0.09	5°	55°	0.70	35°	25°	2.14	65°
84°	0.11	6°	54°	0.73	36°	24°	2.25	66°
83°	0.12	7°	53°	0.75	37°	23°	2.36	67°
82°	0.14	8°	52°	0.78	38°	22°	2.48	68°
81°	0.16	9°	51°	0.81	39°	21°	2.61	69°
80°	0.18	10°	50°	0.84	40°	20°	2.75	70°
79°	0.19	11°	49°	0.87	41°	19°	2.90	71°
78°	0.21	12°	48°	0.90	42°	18°	3.08	72°
77°	0.23	13°	47°	0.93	43°	17°	3.27	73°
76°	0.25	14°	46°	0.97	44°	16°	3.49	74°
75°	0.27	15°	45°	1.00	45°	15°	3.73	75°
74°	0.29	16°	44°	1.04	46°	14°	4.01	76°
73°	0.31	17°	43°	1.07	47°	13°	4.33	77°
72°	0.32	18°	42°	1.11	48°	12°	4.70	78°
71°	0.34	19°	41°	1.15	49°	11°	5.14	79°
70°	0.36	20°	40°	1.19	50°	10°	5.67	80°
69°	0.38	21°	39°	1.23	51°	9°	6.31	81°
68°	0.40	22°	38°	1.28	52°	8°	7.12	82°

$$\frac{RISE}{RUN} = \frac{12}{2.5} = 4.80 \sim \text{Results in Load Position Angle of } 12^\circ$$

63°	0.51	27°	33°	1.54	57°	3°	19.08	87°
62°	0.53	28°	32°	1.60	58°	2°	28.64	88°
61°	0.55	29°	31°	1.66	59°	1°	57.29	89°



Straight Tag Example

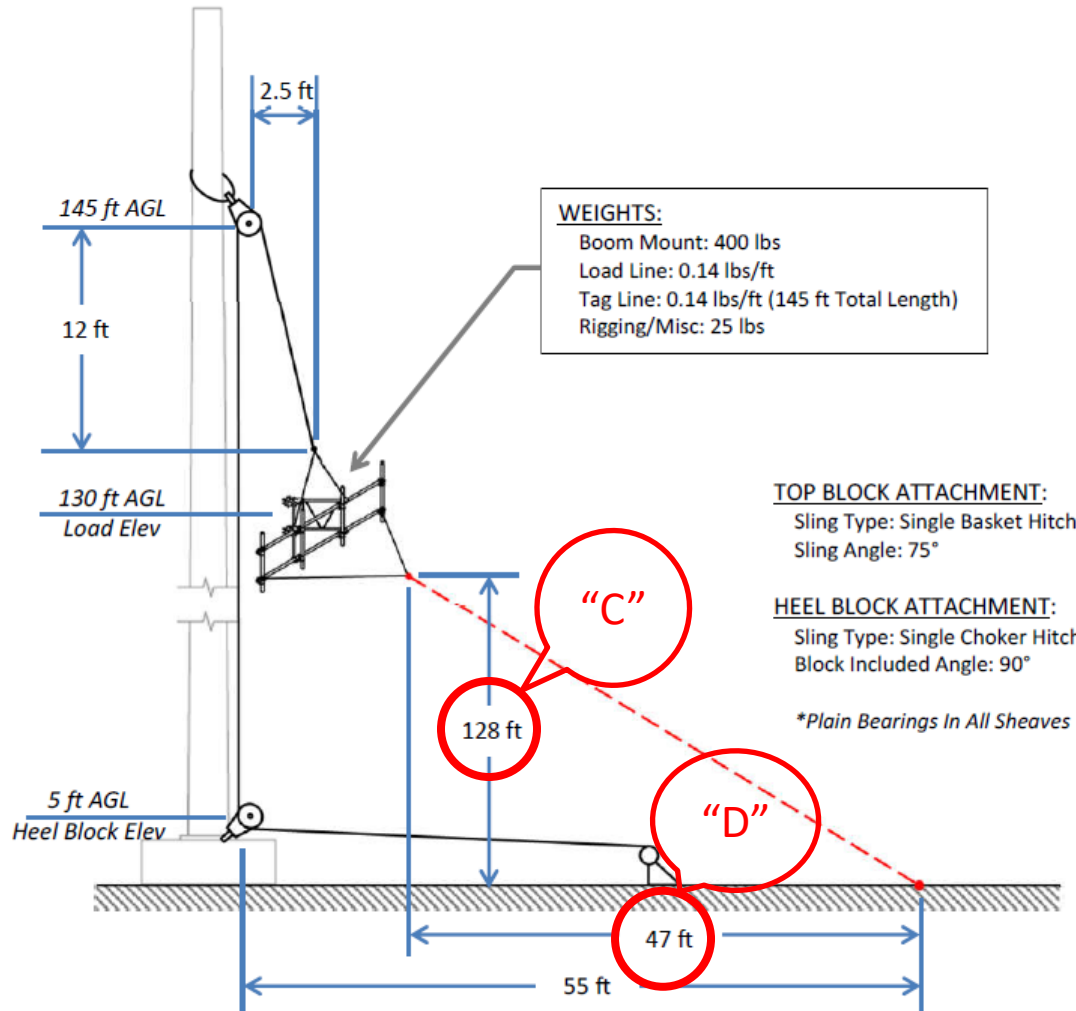
STEP 2) Determine the Maximum Load Position and Tag Angles

Straight Tag Angles				
Description	At Ground Level	At Obstruction	At Maximum Elevation	Other
A) Top Block to Load Headroom (Rise):			12 ft	
B) Top Block to Load Standoff Distance (Run):			2.5 ft	
Rise/Run:			4.80	
Load Position Angle, θ (round up to nearest deg):			12	
C) Tag Attachment to Ground Tag Height (Rise):				
D) Tag Attachment to Ground Tag Distance (Run):				
Rise/Run:				
Tag Angle, α (round up to nearest 5 deg increment):				
Load Line Multiplier, PM:				
Tag Line Multiplier, TM:				
Maximum Load Line Multiplier, PM:				
Maximum Tag Line Multiplier, TM:				



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Straight Tag Angles				
Description	At Ground Level	At Obstruction	At Maximum Elevation	Other
A) Top Block to Load Headroom (Rise):			12 ft	
B) Top Block to Load Standoff Distance (Run):			2.5 ft	
Rise/Run:			4.80	
Load Position Angle, θ (round up to nearest deg):			12	
C) Tag Attachment to Ground Tag Height (Rise):			128 ft	
D) Tag Attachment to Ground Tag Distance (Run):			47 ft	
Rise/Run:			2.72	
Tag Angle, α (round up to nearest 5 deg increment):				
Load Line Multiplier, PM:				
Tag Line Multiplier, TM:				
Maximum Load Line Multiplier, PM:				
Maximum Tag Line Multiplier, TM:				

$$\frac{RISE}{RUN} = \frac{128}{47} = 2.72$$



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Table A4. Rise-to-Run Angle Conversion

θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)	θ (deg)	RISE RUN	α (deg)
90°	---	0°	60°	0.58	30°	30°	1.73	60°
89°	0.02	1°	59°	0.60	31°	29°	1.80	61°
88°	0.03	2°	58°	0.62	32°	28°	1.88	62°
87°	0.05	3°	57°	0.65	33°	27°	1.96	63°
86°	0.07	4°	56°	0.67	34°	26°	2.05	64°
85°	0.09	5°	55°	0.70	35°	25°	2.14	65°
84°	0.11	6°	54°	0.73	36°	24°	2.25	66°
83°	0.12	7°	53°	0.75	37°	23°	2.36	67°
82°	0.14	8°	52°	0.78	38°	22°	2.48	68°
81°	0.16	9°	51°	0.81	39°	21°	2.61	69°
80°	0.18	10°	50°	0.84	40°	20°	2.75	70°
79°	0.19	11°	49°	0.87	41°	19°	2.90	71°
78°	0.21	12°	48°	0.90	42°	18°	3.08	72°
77°	0.23	13°	47°	0.93	43°	17°	3.27	73°
76°	0.25	14°	46°	0.97	44°	16°	3.49	74°
75°	0.27	15°	45°	1.00	45°	15°	3.73	75°
74°	0.29	16°	44°	1.04	46°	14°	4.01	76°
73°	0.31	17°	43°	1.07	47°	13°	4.33	77°
72°	0.32	18°	42°	1.11	48°	12°	4.70	78°
71°	0.34	19°	41°	1.15	49°	11°	5.14	79°
70°	0.36	20°	40°	1.19	50°	10°	5.67	80°
69°	0.38	21°	39°	1.23	51°	9°	6.31	81°
68°	0.40	22°	38°	1.28	52°	8°	7.12	82°

$$\frac{RISE}{RUN} = \frac{128}{47} = 2.72 \sim \text{Results in Tag Angle of } 70^\circ$$



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Straight Tag Angles				
Description	At Ground Level	At Obstruction	At Maximum Elevation	Other
A) Top Block to Load Headroom (Rise):			12 ft	
B) Top Block to Load Standoff Distance (Run):			2.5 ft	
Rise/Run:			4.80	
Load Position Angle, θ (round up to nearest deg):			12	
C) Tag Attachment to Ground Tag Height (Rise):			128 ft	
D) Tag Attachment to Ground Tag Distance (Run):			47 ft	
Rise/Run:			2.72	
Tag Angle, α (round up to nearest 5 deg increment):			70	
Load Line Multiplier, PM:				
Tag Line Multiplier, TM:				
Maximum Load Line Multiplier, PM:				
Maximum Tag Line Multiplier, TM:				



Straight Tag Example

STEP 3) Determine the Corresponding Load and Tag Line Multipliers

Tag Method & Lift Angles	Tag Method:	Tag Distance:
	<input checked="" type="checkbox"/> Straight Tag <input type="checkbox"/> Integrated Trolley (Self-Trolley) <input type="checkbox"/> Dedicated Trolley <input type="checkbox"/> Special	<u>55 ft</u>
	†Max Load Position Angle, θ : <u>12 deg</u> ;round up to nearest degree	†Max Tag Angle, α/α_T : <u>70 deg</u> ;round up to nearest 5 deg increment
	†Load line position angles, θ , exceeding 10 degrees and/or tag angles, α , exceeding 70 degrees in straight tag configurations are not recommended and generally considered "special" where additional engineering involvement may be required to assess resulting rigging forces.	
	Max Tag Position Angle for Dedicated Trolley Arrangements, θ_T : <u>N/A</u> ;round up to nearest degree	



Straight Tag Example

STEP 3) Determine the Corresponding Load and Tag Line Multipliers

Table A5. Load and Tag Line Multipliers for Straight Tag Lift Arrangements

LOAD POS. ANGLE, θ	LINE MULT.	TAG ANGLE, α													
		See Note 1						See Note 2		See Note 3					
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	
See Note 1	1°	PM	1.003	1.007	1.010	1.015	1.018	1.021	1.026	1.031	1.039	1.051	1.070	1.110	1.249
		TM	0.018	0.019	0.020	0.023	0.025	0.028	0.031	0.036	0.043	0.054	0.072	0.112	0.250
	2°	PM	1.007								1.082	1.107	1.151	1.248	1.665
		TM	0.036								0.089	0.113	0.155	0.251	0.667
	3°	PM	1.011								1.128	1.170	1.245	1.425	2.497
	TM	0.054								0.140	0.179	0.252	0.429	1.500	
	4°	PM	1.015							1.179	1.241	1.356	1.661	4.994	
	TM	0.072								0.195	0.253	0.366	0.667	3.997	
	5°	PM	1.020							1.236	1.321	1.490	1.992	-	
	TM	0.090								0.255	0.337	0.502	1.000	-	
See Note 2	6°	PM	1.024							1.298	1.414	1.654	2.489	-	
		TM	0.109							0.321	0.432	0.668	1.498	-	
	7°	PM	1.030							1.368	1.520	1.860	3.318	-	
		TM	0.127							0.394	0.542	0.876	2.329	-	
	8°	PM	1.035							1.445	1.645	2.124	4.976	-	
		TM	0.146							0.476	0.669	1.142	3.988	-	
	9°	PM	1.042							1.533	1.792	2.476	9.950	-	
		TM	0.165	0.179	0.201	0.238	0.266	0.304	0.357	0.437	0.568	0.820	1.497	8.963	-
	10°	PM	1.048	1.085	1.131	1.192	1.233	1.286	1.357	1.462	1.633	1.970	2.970	-	-
		TM	0.185	0.201	0.227	0.270	0.303	0.347	0.411	0.508	0.671	1.000	1.992	-	-
	11°	PM	1.055	1.096	1.147	1.217	1.265	1.326	1.410	1.536	1.747	2.186	3.710	-	-
	TM	0.204	0.223	0.253	0.303	0.341	0.394	0.469	0.586	0.789	1.200	2.735	-	-	
	12°	PM	1.062	1.108	1.165	1.244	1.298	1.369	1.468	1.618	1.879	2.458	4.945	-	-
	TM	0.224	0.245	0.280	0.338	0.382	0.443	0.532	0.673	0.924	1.494	3.973	-	-	
	13°	PM	1.070	1.120	1.184	1.273	1.334	1.416	1.531	1.710	2.033	2.806	7.416	-	-
	TM	0.244	0.268	0.308	0.374	0.425	0.495	0.600	0.769	1.082	1.846	6.446	-	-	

2.458

1.494



Straight Tag Example

STEP 3) Determine the Corresponding Load and Tag Line Multipliers

Straight Tag Angles				
Description	At Ground Level	At Obstruction	At Maximum Elevation	Other
A) Top Block to Load Headroom (Rise):			12 ft	
B) Top Block to Load Standoff Distance (Run):			2.5 ft	
Rise/Run:			4.80	
Load Position Angle, θ (round up to nearest deg):			12	
C) Tag Attachment to Ground Tag Height (Rise):			128 ft	
D) Tag Attachment to Ground Tag Distance (Run):			47 ft	
Rise/Run:			2.72	
Tag Angle, α (round up to nearest 5 deg increment):			70	
Load Line Multiplier, PM:			2.458	
Tag Line Multiplier, TM:			1.494	
Maximum Load Line Multiplier, PM: 2.458				
Maximum Tag Line Multiplier, TM: 1.494				



Straight Tag Example

STEP 4) Determine the Load and Tag Line Forces

LINE FORCES AT LOAD		
Max Load Line Multiplier, PM : <u>2.458</u>	Number of Parts of Load Line, N_p : <u>1</u>	Load Line Force, P = (WT x PM) ÷ N _p : <u>1,143 lbs</u>
Max Tag Line Multiplier, TM : <u>1.494</u>	Number of Parts of Tag Line, N_T : <u>1</u>	Tag Line Force, T = (WT x TM) ÷ N _T : <u>695 lbs</u>

Load Line Force, P:

$$P = (WT \times PM) \div N_p = (465 \times 2.458) \div 1 = \underline{1,143 \text{ lbs}}$$

Tag Line Force, T:

$$T = (WT \times TM) \div N_T = (465 \times 1.494) \div 1 = \underline{695 \text{ lbs}}$$



Straight Tag Example

STEP 4) Determine the Load and Tag Line Forces

Table A3. Sheave Friction Factors

TOTAL NO REEVED SHEAVES, S	SHEAVE FRICTION FACTOR, SFF											
	NO OF LINE PARTS, N											
	1-Part			2-Part			3-Part			4-Part		
	PB	BB	SRB	PB	BB	SRB	PB	BB	SRB	PB	BB	SRB
1	1.090	1.045	1.020	-	-	-	-	-	-	-	-	-
2	1.188	1.092	1.040	1.137	1.068	1.030	-	-	-	-	-	-
3	1.295	1.141	1.061	1.239	1.116	1.051	1.185	1.091	1.040	-	-	-
4	1.412	1.193	1.082	1.351	1.166	1.072	1.292	1.140	1.061	1.235	1.115	1.050
5	1.539	1.246	1.104	1.472	1.219	1.093	1.408	1.192	1.082	1.346	1.165	1.072
6	1.677	1.302	1.126	1.605	1.274	1.115	1.535	1.245	1.104	1.467	1.218	1.093
7	1.828	1.361	1.149	1.749	1.331	1.137	1.673	1.301	1.126	1.599	1.272	1.115
8	1.993	1.422	1.172	1.907	1.391	1.160	1.824	1.360	1.149	1.743	1.330	1.137
9	2.172	1.486	1.195	2.078	1.453	1.183	1.988	1.421	1.172	1.900	1.389	1.160
10	2.367	1.553	1.219	2.265	1.519	1.207	2.167	1.485	1.195	2.071	1.452	1.183

Load Line Configuration → 1-Part

Example States Plain Bearings in all Sheaves

Total Number of Reeved Sheaves = 2

Sheave Friction Factor, SFF = 1.188

EXAMPLE

TOP BLOCK ATTACHMENT:

Sling Type: Single Basket Hitch
Sling Angle: 75°

HEEL BLOCK ATTACHMENT:

Sling Type: Single Choker Hitch
Block Included Angle: 90°

*Plain Bearings In All Sheaves



Straight Tag Example

STEP 4) Determine the Load and Tag Line Forces

LOAD LINE FORCE AT HOIST		
Sheave Friction Factor, SFF:	Additional Multipliers, AM:	Line Pull at Hoist, $P_H = (P - FLW) \times SFF \times AM$:
1.188	N/A	1,334 lbs

Line Pull at Hoist, P_H :

$$P_H = (P - FLW) \times SFF \times AM = (1143 - 20) \times 1.188 = \underline{\underline{1,334 \text{ lbs}}}$$



Straight Tag Example

STEP 5) Determine the Block Forces

Table A2. Block Angle Factors

INCLUDED ANGLE, θ	ANGLE FACTOR, AF	INCLUDED ANGLE, θ	ANGLE FACTOR, AF	INCLUDED ANGLE, θ	ANGLE FACTOR, AF	INCLUDED ANGLE, θ	ANGLE FACTOR, AF
0°	2.000	45°	1.848	90°	1.414	135°	0.765
5°	1.998	50°	1.813	95°	1.351	140°	0.684
10°	1.992	55°	1.774	100°	1.286	145°	0.601
15°	1.983	60°	1.732	105°	1.218	150°	0.518
20°	1.970	65°	1.687	110°	1.147	155°	0.433
25°	1.953	70°	1.638	115°	1.075	160°	0.347
30°	1.932	75°	1.587	120°	1.000	165°	0.261
35°	1.907	80°	1.532	125°	0.923	170°	0.174
40°	1.879	85°	1.475	130°	0.845	175°	0.087

Top Block Min Included Angle = 0° when setting load

Top Block Angle Factor, AF = 2.000

Heel Block Min Included Angle = 90°

Heel Block Angle Factor, AF = 1.414

EXAMPLE

TOP BLOCK ATTACHMENT:

Sling Type: Single Basket Hitch
Sling Angle: 75°

HEEL BLOCK ATTACHMENT:

Sling Type: Single Choker Hitch
Block Included Angle: 90°

*Plain Bearings In All Sheaves



Straight Tag Example

STEP 5) Determine the Block Forces

RIGGING BLOCK FORCES		
Block Configuration: <input checked="" type="checkbox"/> Top and Heel Blocks <input type="checkbox"/> Top Block Only	Top Block Elevation: <u>145 ft</u>	Heel Block Elevation: <u>5 ft</u>
Min Top Block Included Angle: <u>0° (When Setting Load)</u>	Top Block Angle Factor, AF_{TB} : <u>2.000</u>	Top Block Force, $F_{TB} = P \times AF_{TB}$: <u>2,286 lbs</u>
Min Heel Block Included Angle: <u>90°</u>	Heel Block Angle Factor, AF_{HB} : <u>1.414</u>	Heel Block Force, $F_{HB} = P \times AF_{HB}$: <u>1,616 lbs</u>
Min Trolley Block Included Angle: <u>N/A</u>	Trolley Block Angle Factor, AF_{TRB} : <u>N/A</u>	Trolley Block Force, $F_{TRB} = T \times AF_{TRB}$: <u>N/A</u>

Top Block Force, F_{TB} :

$$F_{TB} = P \times AF_{TB} = 1143 \times 2.000 = \underline{2,286 \text{ lbs}}$$

Heel Block Force, F_{HB} :

$$F_{HB} = P \times AF_{HB} = 1143 \times 1.414 = \underline{1,616 \text{ lbs}}$$



Straight Tag Example

STEP 6) Determine the Sling Forces

Table A1. Sling Angle Factors

SLING ANGLE, θ	ANGLE FACTOR AF	SLING ANGLE, θ	ANGLE FACTOR AF
90°	1.000	55°	1.221
85°	1.004	50°	1.305
80°	1.015	45°	1.414
75°	1.035	40°	1.556
70°	1.064	35°	1.743
65°	1.103	30°	2.000
60°	1.155	† DO NOT SET BELOW 30°	

† Sling angles below 30° require approval from the sling manufacturer or a qualified person.

Top Block Sling → Single Basket Hitch With Sling Angle of 75°

Top Block Sling Angle Factor, AF = 1.035

Heel Block Sling → Single Choker Hitch (Sling Angle of 90°)

Heel Block Angle Factor, AF = 1.000

EXAMPLE

TOP BLOCK ATTACHMENT:

Sling Type: Single Basket Hitch
Sling Angle: 75°

HEEL BLOCK ATTACHMENT:

Sling Type: Single Choker Hitch
Block Included Angle: 90°

*Plain Bearings In All Sheaves



Straight Tag Example

STEP 6) Determine the Sling Forces

SLING FORCES		
Top Block Sling Hitch Type:	<input type="checkbox"/> Vertical <input type="checkbox"/> Choker <input checked="" type="checkbox"/> Basket <input type="checkbox"/> 2-Leg Bridle <input type="checkbox"/> Special	
Number of Sling Legs, N_{STB} :	_____ 2 _____ ; "1" for typical vertical or choker hitches, or "2" for typical basket or 2-leg bridle hitches	
Sling Angle (for Basket/Bridle Hitches):	Sling Angle Factor, AF_{STB} :	Sling Leg Force, $F_{SLTB} = (F_{TB} \times AF_{STB}) \div N_{STB}$:
_____ 75° _____	_____ 1.035 _____	_____ 1,183 lbs _____
Heel Block Sling Hitch Type:	<input type="checkbox"/> Vertical <input checked="" type="checkbox"/> Choker <input type="checkbox"/> Basket <input type="checkbox"/> 2-Leg Bridle <input type="checkbox"/> Special	
Number of Sling Legs, N_{SHB} :	_____ 1 _____ ; "1" for typical vertical or choker hitches, or "2" for typical basket or 2-leg bridle hitches	
Sling Angle (for Basket/Bridle Hitches):	Sling Angle Factor, AF_{SHB} :	Sling Leg Force, $F_{SLHB} = (F_{HB} \times AF_{SHB}) \div N_{SHB}$:
_____ 90° _____	_____ 1.000 _____	_____ 1,616 lbs _____

Top Block Sling Leg Force, F_{SLTB} :

$$F_{SLTB} = (F_{TB} \times AF_{STB}) \div N_{STB} = (2286 \times 1.035) \div 2 = \underline{\underline{1,183 \text{ lbs}}}$$

Heel Block Sling Leg Force, F_{SLHB} :

$$F_{SLHB} = (F_{HB} \times AF_{SHB}) \div N_{SHB} = (1616 \times 1.000) \div 1 = \underline{\underline{1,616 \text{ lbs}}}$$



Straight Tag Example

STRAIGHT TAG EXAMPLE.

For the straight tag lifting arrangement shown below, determine the maximum rigging forces in the following:

Load Line Force at Load: 1,143 lbs

Tag Line Force at Load: 695 lbs

Load Line Force at Hoist: 1,334 lbs

Top Block Force: 2,286 lbs

Heel Block Force: 1,616 lbs

Top Block Sling Leg Force: 1,183 lbs

Heel Block Sling Leg Force: 1,616 lbs

Remember where we started:

WEIGHTS:

Boom Mount: 400 lbs

Load Line: 0.14 lbs/ft

Tag Line: 0.14 lbs/ft (145 ft Total Length)

Rigging/Misc: 25 lbs



Straight Tag Video



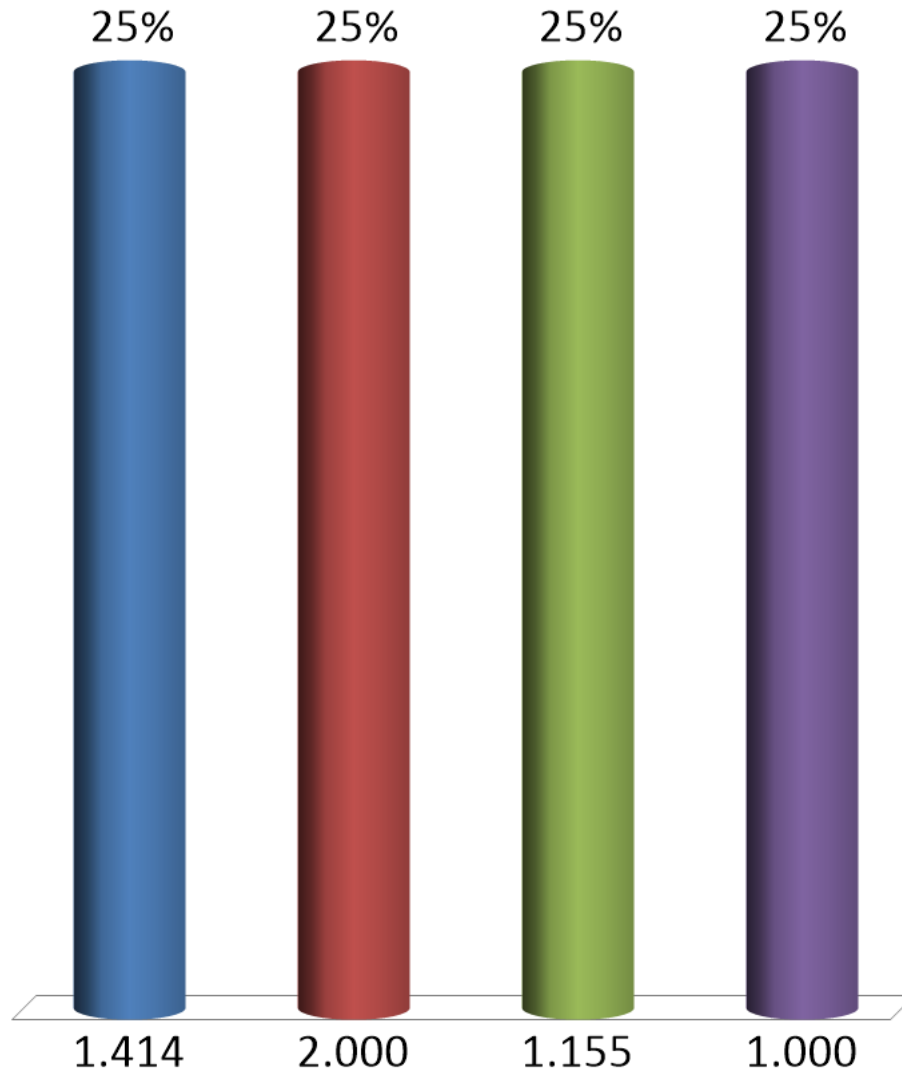
SECTION 5

REVIEW QUESTIONS



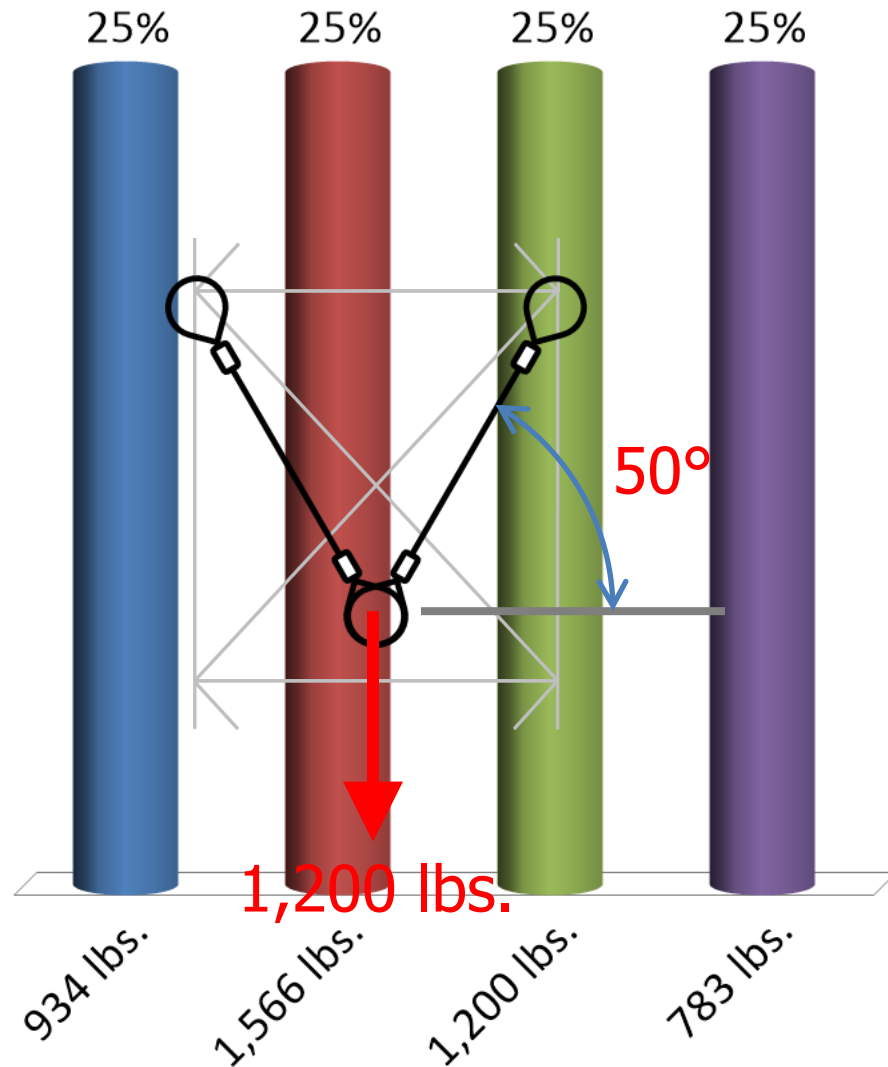
What is the angle factor for a sling set at 60 degrees?

- A. 1.414
- B. 2.000
- C. 1.155
- D. 1.000



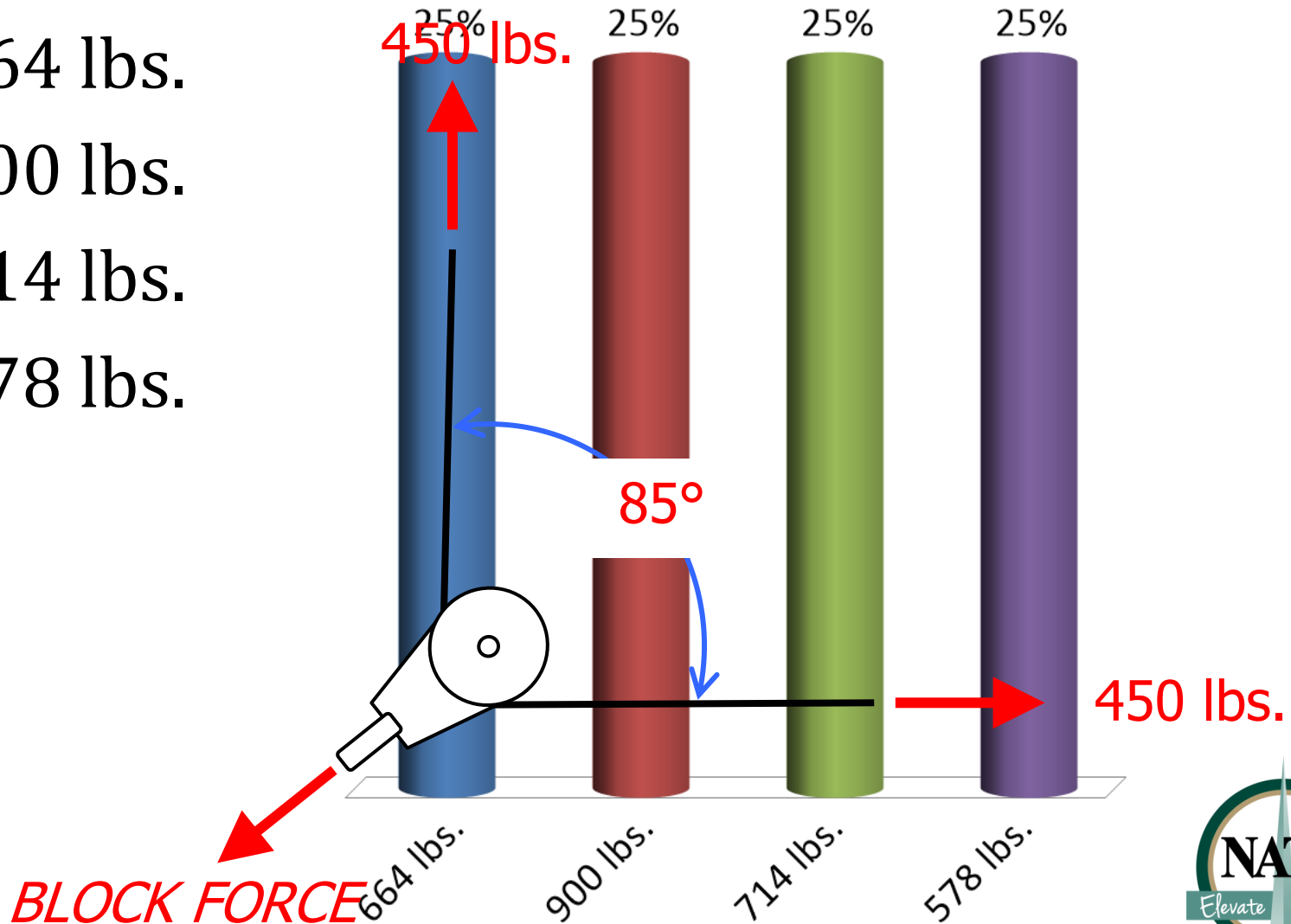
What is the sling force leg for the straight vertical bridle hitch configuration shown below?

- A. 934 lbs.
- B. 1,566 lbs.
- C. 1,200 lbs.
- D. 783 lbs.



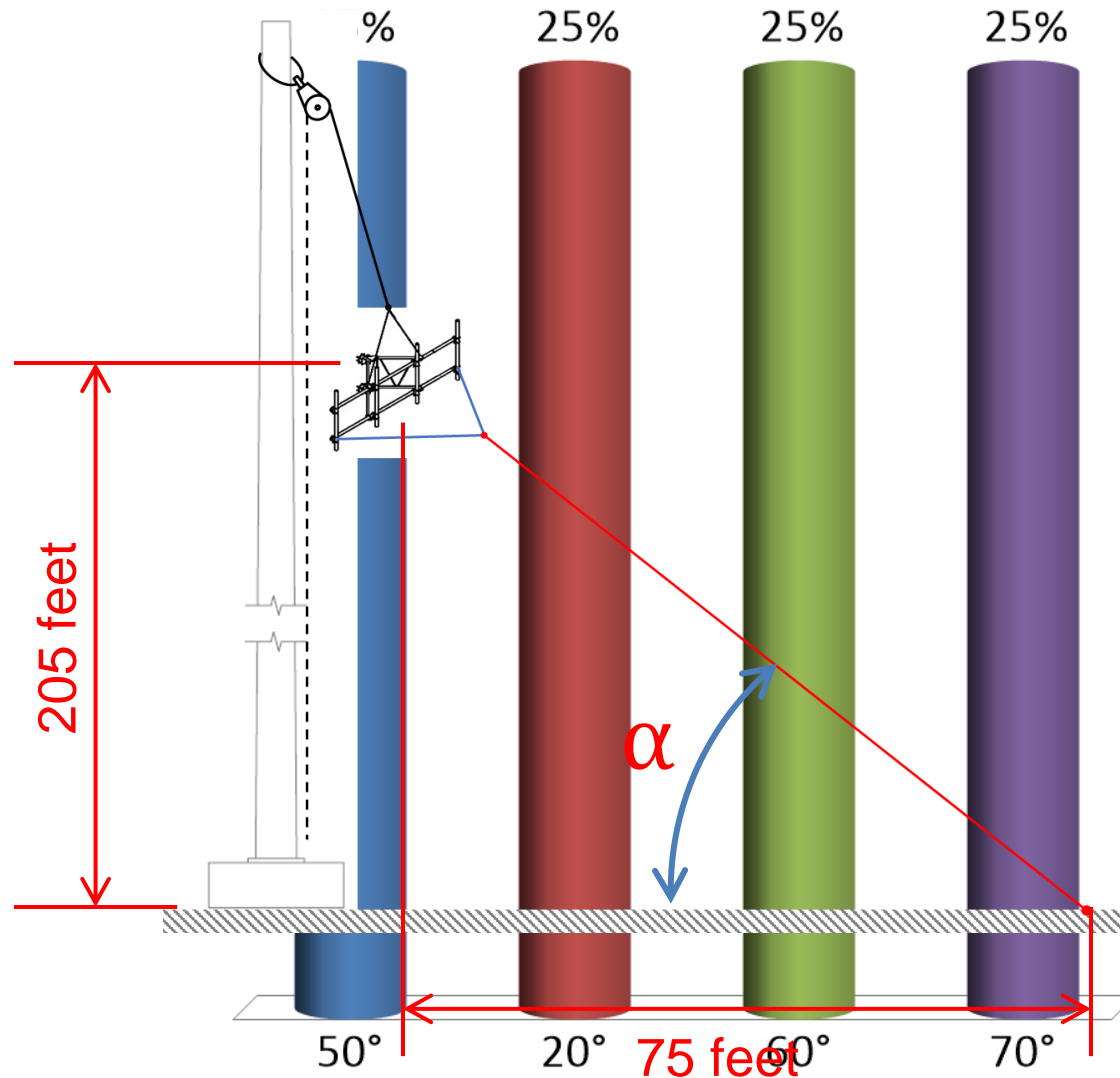
What is the heel block force for the configuration shown below with a hoist line pull of 450 lbs.?

- A. 664 lbs.
- B. 900 lbs.
- C. 714 lbs.
- D. 578 lbs.



For a load set at 205 feet with the tag positioned at 75 feet away, what is the approximate tag angle when the load is set?

- A. 50°
- B. 20°
- C. 60°
- D. 70°



Section 6

Hoisting Operations, Execution and Communication



Topics

- Hoisting
 - Capstan Hoist
 - Anchorage
 - Testing, Monitoring, Controls
- Communication
 - Planned vs. Changed Condition



Hoist

➤ Capstan Hoist

- Generally used for moderate lifting and tag applications
- Most units are rated from 1,000 to 3,000 lbs. WLL
- Requires trained operator
- Daily inspection prior to use
- Always follow guidelines of operator's manual

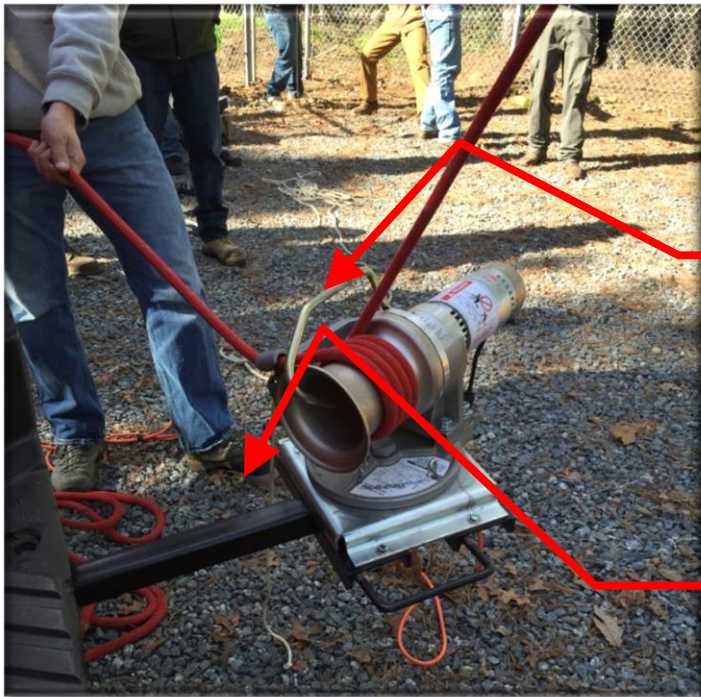


Capstan Hoist



NOT ALLOWED FOR PERSONNEL LIFTING

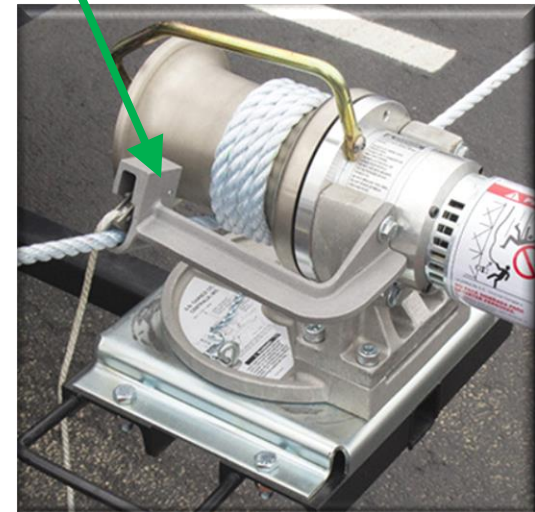
Must be equipped with Deadman Switch and Safety Bar



Rope Hook
(Required)

Foot Control
(Required)

Rope Lock
(Best Practice)



Hoist Anchorages



What makes up the hoist anchorage in this example?

How can we verify it?



Anchorage Verification



Engineered method incorporates a minimum factor of safety (FOS) of 2.0 for the WLL of all anchorage components. Method also assumes a maximum coefficient of friction of 0.20.

Proof load method of 1.5 times the maximum anticipated hoist load.



Field Verification Methods

- Proof Loading and Load Testing
- All field testing should be done in controlled conditions
- Monitoring devices help eliminate unknowns during testing

Did you know, that during load testing the FOS for synthetic rope may be reduced to 7.0?

Example:

Typical Use: 11,000 lbs. [MBS] \div 10.0 = 1,100 lbs. WLL

Testing Only: 11,000 lbs. [MBS] \div 7.0 = 1,570 lbs. WLL



Proof Loading

- Confirms Capabilities
- Typically involves loading some component beyond 100% of the anticipated load during planned operations.
 - Does not mean beyond 100% WLL for components!
- Ex. Hoist anchorage proof loading = $1.5 \times$ Load line force applied to anchorage.
- Used when circumstances or variables may not be predictable.



Load Testing

- Confirms operation
- Representative of actual conditions of load during planned operations:
 - 100% of gross load
 - Model load position(s) that result in maximum anticipated lifting system forces
 - Required when utilizing a Capstan hoist per A10.48
- Monitoring for deflections, anchorage and capstan control, line rendering.



Load Testing

- More generally a load test shall include:
 - Raise and lower a load to verify moving parts functionality;
 - Verify deflections under load are within allowances;
 - Once load has been lowered inspect all components and anchorage for proper arrangement and working condition; and
 - Verify supporting structure or individual structure members do not have unacceptable twist, rotation or deflection.



**We've covered a lot of details
and concepts, how do you
ensure all the requirements are
met on the job?**

**We put the information in the
Rigging Plan**



What's the purpose of the Rigging Plan?

To communicate intent based on the expectations of scope, methods and job characteristics



The Plan

- Planned condition
 - What content should be in the plan?
 - Determine the lift path: structure, obstructions, equipment placement, component placement, anchorage
 - Components/Equipment being used in the system
 - Expected lifting system and system forces
 - Who's doing what



**How many of you are
reviewing/using the planned
rigging plan?**



Inspect your Expectations

- Pre-rigged conditions
- Rigged condition not under load
- Proof Loading
- Load Test
 - Operational test rigged condition under load



**What happens when you can't
follow the plan Rigging Plan?**

You change it!



Changing the Plan

- When do you change the plan?
 - Changed condition
- What are some examples of changes that warrant additional communications/approvals?
- Who needs to be involved in the approval and why?



**How many of you have
encountered changed
conditions requiring you to
modify the rigging plan?**



Do you feel you have a better grasp on what goes into the plan and the steps you can take to accommodate changed conditions?



**How do you typically learn
about industry standards?**



SECTION 6

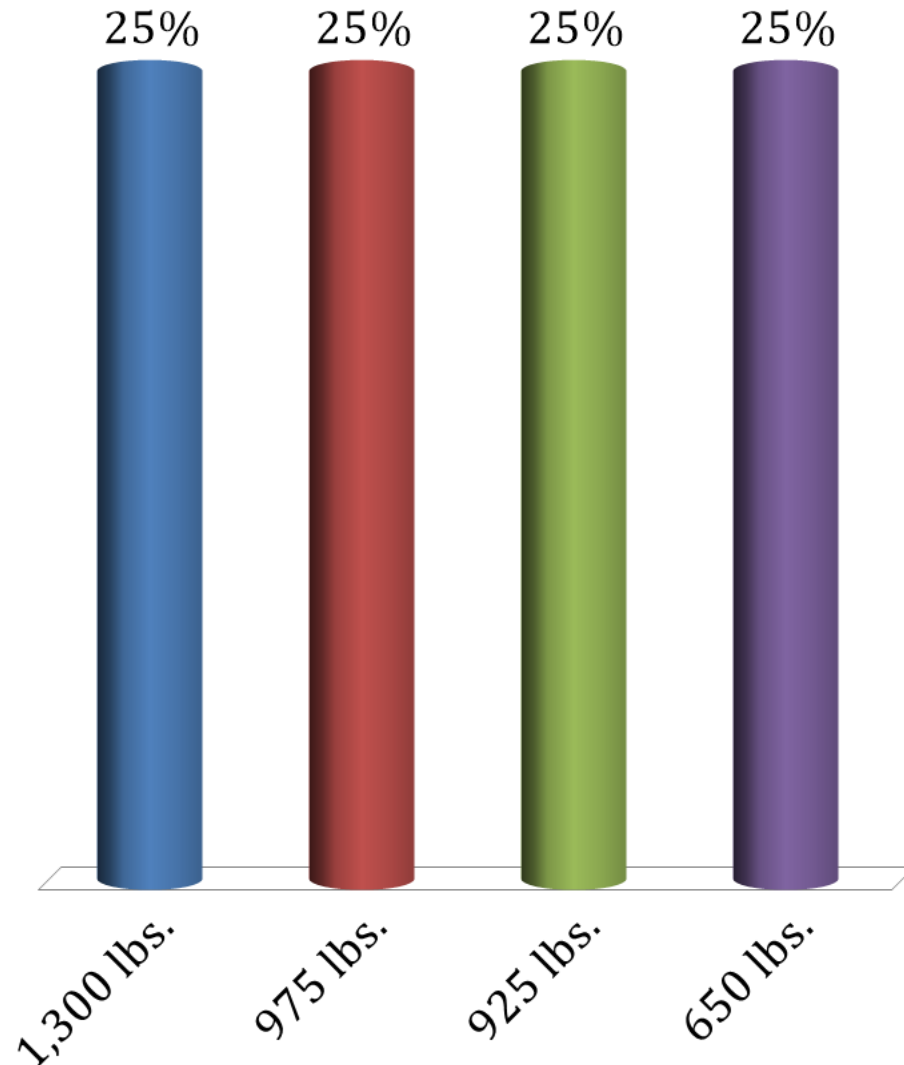
REVIEW QUESTIONS



What force should be applied to the hoist anchorage to proof load it?

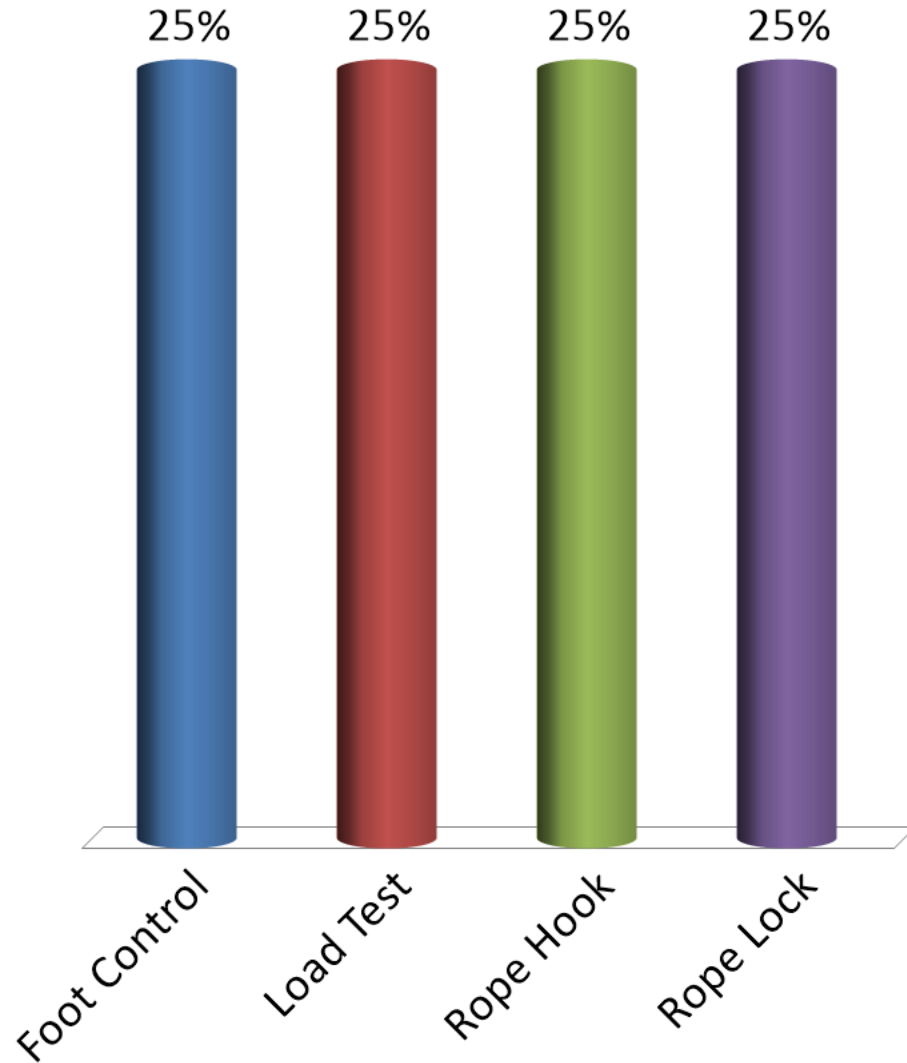
The load line force for the system is calculated to be 650 lbs.

- A. 1,300 lbs.
- B. 975 lbs.
- C. 925 lbs.
- D. 650 lbs.

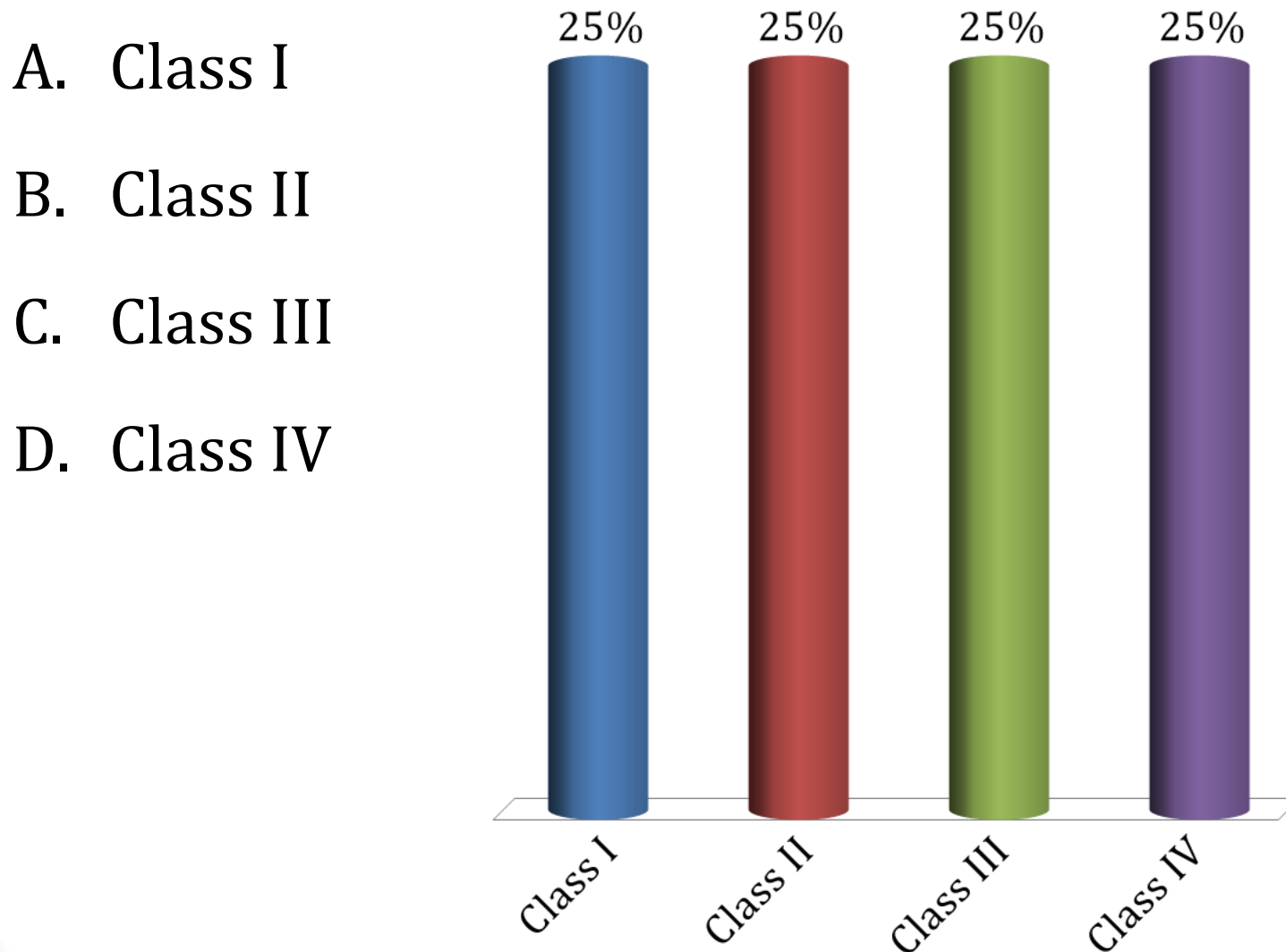


Which of the following is not required for Capstan Hoist Operation?

- A. Foot Control
- B. Load Test
- C. Rope Hook
- D. Rope Lock



Rigging to mount using a redirect block with a tower mounted crown. What rigging class would this be?



A. Class I

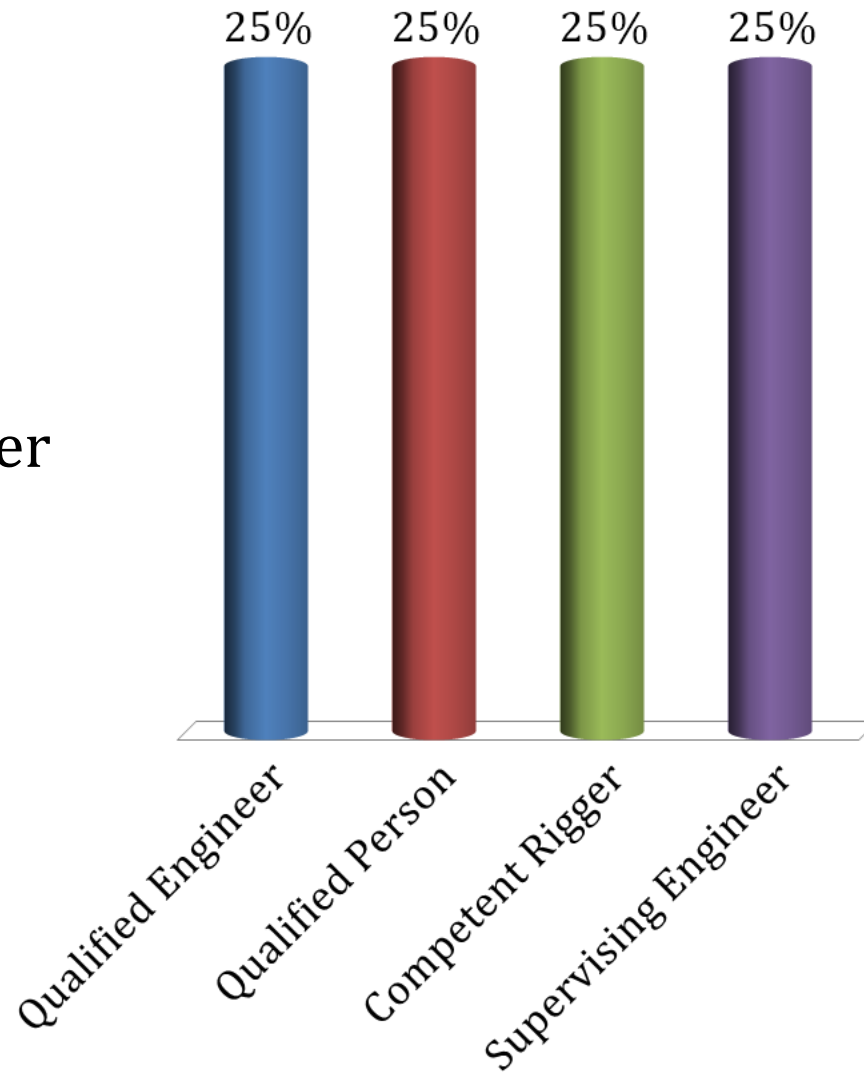
B. Class II

C. Class III

D. Class IV

When a rigging plan moves from Class II to a Class III plan, which role at a minimum must now be involved?

- A. Qualified Engineer
- B. Qualified Person
- C. Competent Rigger
- D. Supervising Engineer

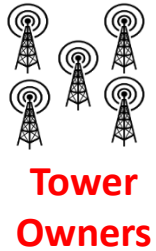


Who may be affected by the means and methods of a rigging plan and need to be included in communication regarding a change to the plan?

- A. All of the Below
- B. Competent Rigger
- C. General Contractor
- D. Carrier
- E. Tower Owner
- F. Landowner
- G. Public



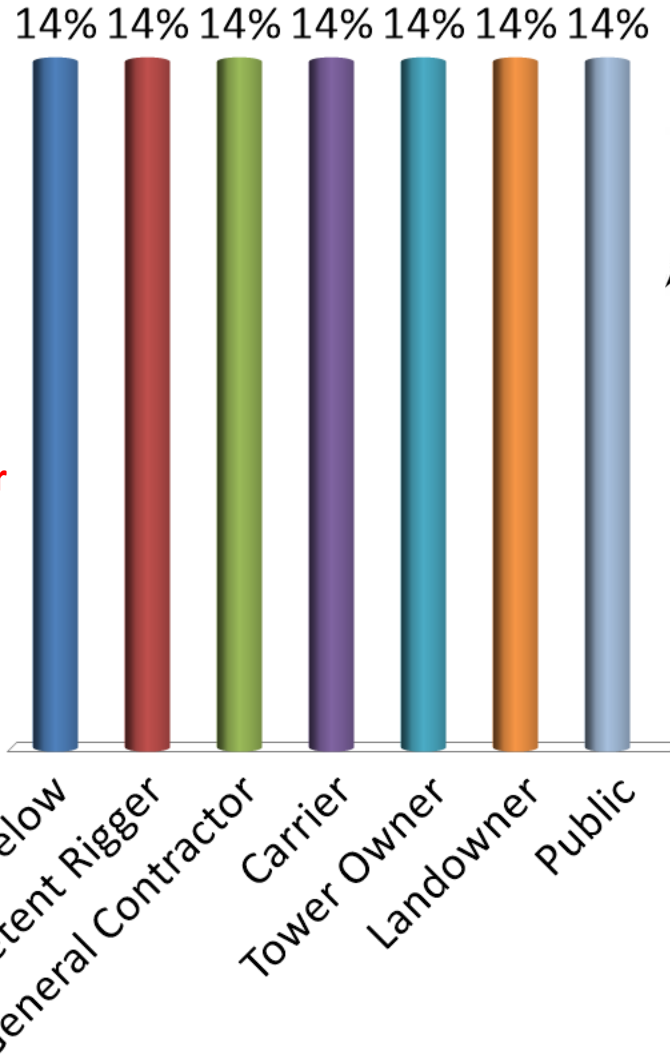
Public



Tower Owners



General Contractor



Landowner



Carriers



Thank You!

