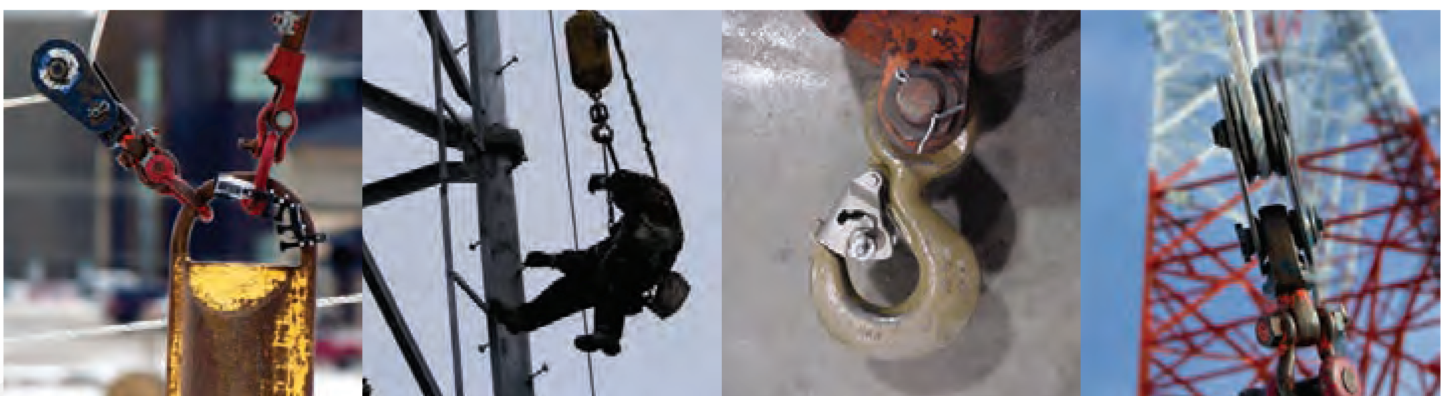
ADVANCED RIGGING PRINCIPLES TRAINING COURSE

Instructor's Manual

Susan Harwood Grant #SH-05018-SH8



NATE Elevate Wireless®

NATE WIN® WIRELESS INDUSTRY NETWORK

Introduction

Disclaimer

This material was produced under a 2018 Susan Harwood Training Grant (SH-05018-SH8) from the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor. It does not necessarily reflect the views or policies of the U.S. Department of Labor, nor does the mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.

Notes for Instructors

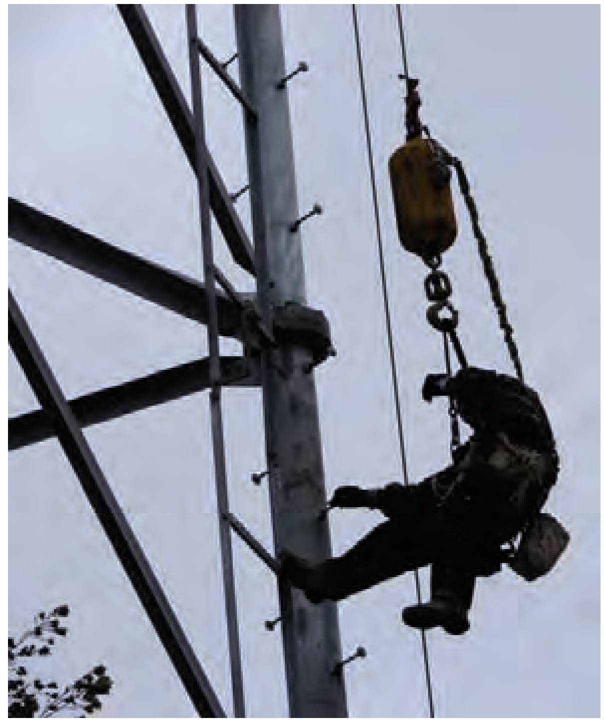
This industry-specific Advanced Rigging Principles curriculum will be tailored specifically to the communication tower industry and include detailed instruction on advanced industry rigging principles workers need to know such as synthetic rope, rope inspection, rigging forces and lift systems, and communication and execution of hoisting operations per the ANSI/ASSE 10.48 Standard. The course will also include information regarding employee and employer rights and responsibilities under the OSH Act of 1970, whistleblower complaint procedures and protection provisions.

What you will need to conduct this training

1. Turning Point Technology Remote Responders
2. Laptop Computer
3. Power Point Projector
4. Projector Screen
5. Advanced Rigging Principles Training Course Student Workbooks
6. Advanced Rigging Principles Training Course Level 2 Evaluation Forms
7. Advanced Rigging Principles Training Course Course Certificates

Level 1 Evaluation Methodology – Turning Point Technology

In this class students will utilize Turning Point interactive response software. This interactive software is presented at the end of each section to determine if they have learned the information presented.



Turning Point is very simple to use. You will present students with either a multiple choice, or true or false question. You will visibly see the question on the overhead. You will read the question to the students, (as you may have some students that have difficulties reading), and the possible correct answer. Using a transponder, that will be provided to them before class starts, they will choose what they believe to be the correct answer. Once everyone in the class answers, you will close the voting and the correct answer will appear on the overhead along with the number of correct and incorrect answers. This will help your student in the learning process as you will receive instant feedback on their knowledge of the subject matter.

Student answers are automatically collected in detailed reports to ensure all participants are counted.

Instructor's Manual

Videos

The training course curriculum includes several videos that will supplement the instructional material contained in the training PowerPoint presentation. The two videos that will be showcased as part of the training course include the A10.48 Standard NATE Climber Connection Volume 2 video and the Straight Tag Video. The videos, which are embedded directly into Section 3 and Section 5 of the Advanced Rigging Principles Training Course PowerPoint, will provide another effective medium for instructors to reinforce the objectives of the course.

Course Objectives

- Enhance knowledge of OSHA and NATE
- Apply knowledge gained from failures and near misses
- Enhance awareness of primary regulations, codes, standards and policies pertinent to rigging as a part of construction or maintenance on communication structures
- Enhance awareness of synthetic rope including the use, compatibility, inspection, maintenance, and retirement as part of a rigging system
- Enhanc awareness of rigging forces developed in typical lifting systems
- Advance awareness of the proper execution of the construction plan, compliant with the regulations, codes, standards and policies

Course Organization

The training course is organized into six sections. Each section varies in length by section. It is paramount that the instructors dictate the pace of the training and allocate the specified time for each section referenced below. Instructors also need to make sure a 45 minute break is scheduled for lunch and three 15 minute breaks are included throughout the training day. The following sections and topics are covered in this training:

- Section 1:
  Introduction to NATE and OSHA (20 minutes)
- Section 2:
  State of the Industry (20 minutes)
- Section 3:
  Primary Regulations, Codes, Standards, and Policies (25 minutes)
- Section 4:
  Synthetic Rope (70 minutes)
- Section 5:
  Rigging Forces and Lift Systems (165 minutes)
- Section 6: Hoisting Operations, Execution and Communciation (60 minutes)

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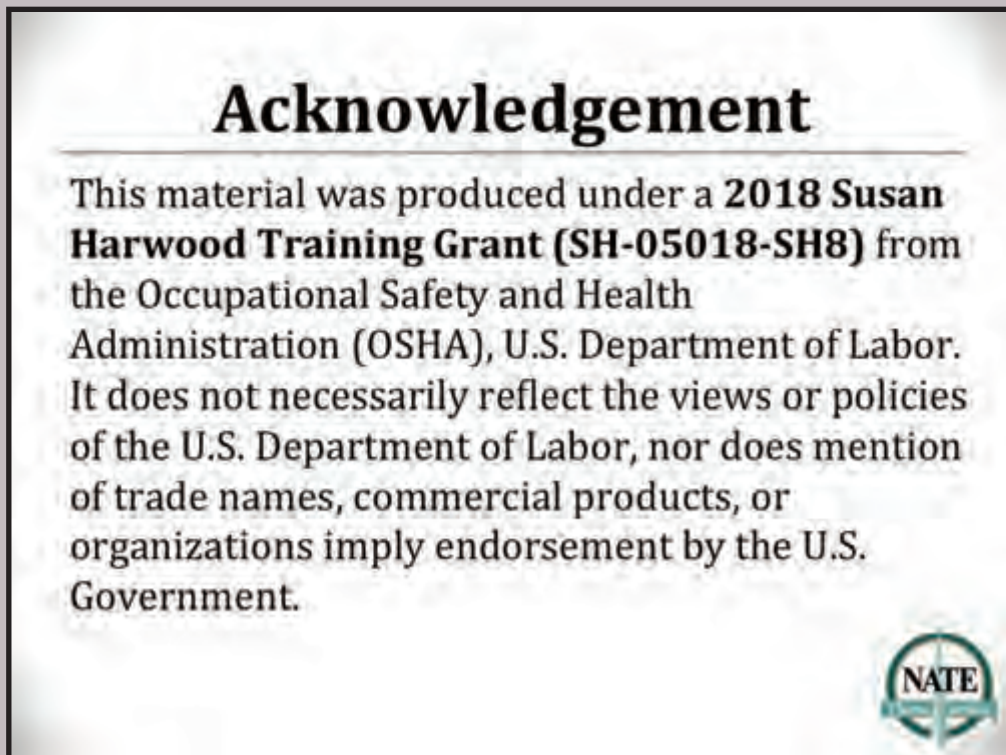
(Plan on 20 minutes for Intro and Section 1 — 9:00 - 9:20)



Instructor:

Acknowledge that funding for the development of this training and delivery of the training was provided by the Department of Labor through a Susan Harwood Grant.

Advanced Rigging Principles Course Organization

The following sections and topics are covered in this course:

- 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

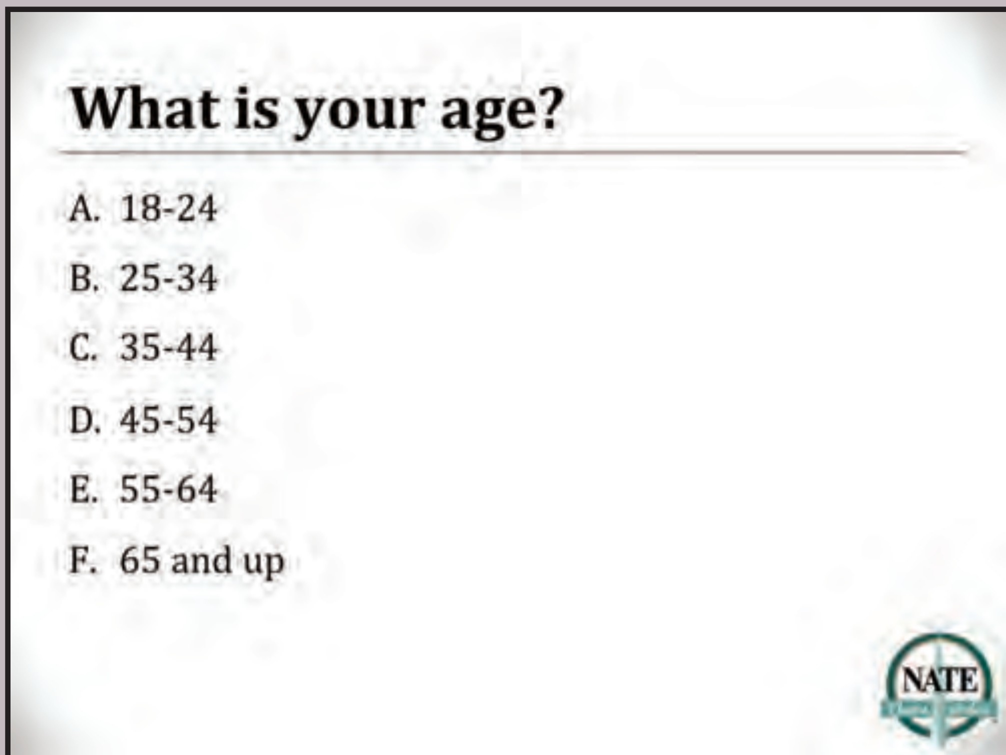
NATE

In this class students will utilize Turning Point interactive response software. This interactive software is presented at the end of each section to determine if they have learned the information presented.

Turning Point is very simple to use. You will present students with either a multiple choice, or true or false question. You will visibly see the question on the overhead. You will read the question to the students, (as you may have some students that have difficulties reading), and the possible correct answer. Using a transponder, that will be provided to them before class starts, they will choose what they believe to be the correct answer.

Once everyone in the class answers, you will close the voting and the correct answer will appear on the overhead along with the number of correct and incorrect answers. This will help your student in the learning process as you will receive instant feedback on their knowledge of the subject matter.


Pancake : Griddle :: Hamburger : ?
A. Lettuce
B. Grill
C. Bun
D. Ketchup
NATE

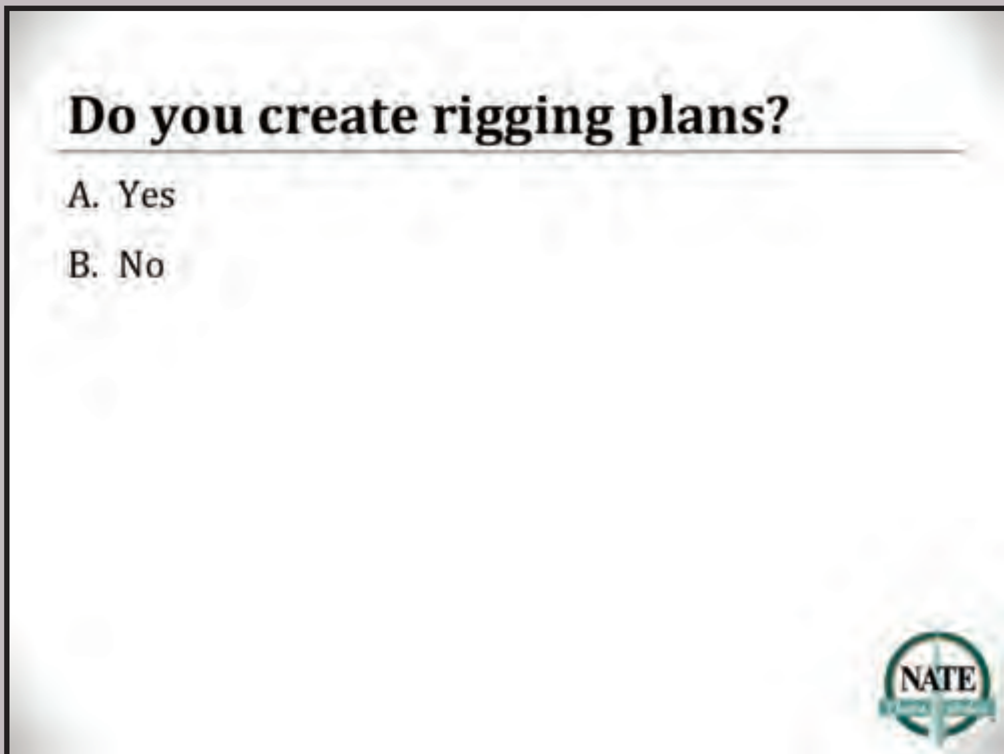

What is your age?
A. 18-24
B. 25-34
C. 35-44
D. 45-54
E. 55-64
F. 65 and up
NATE

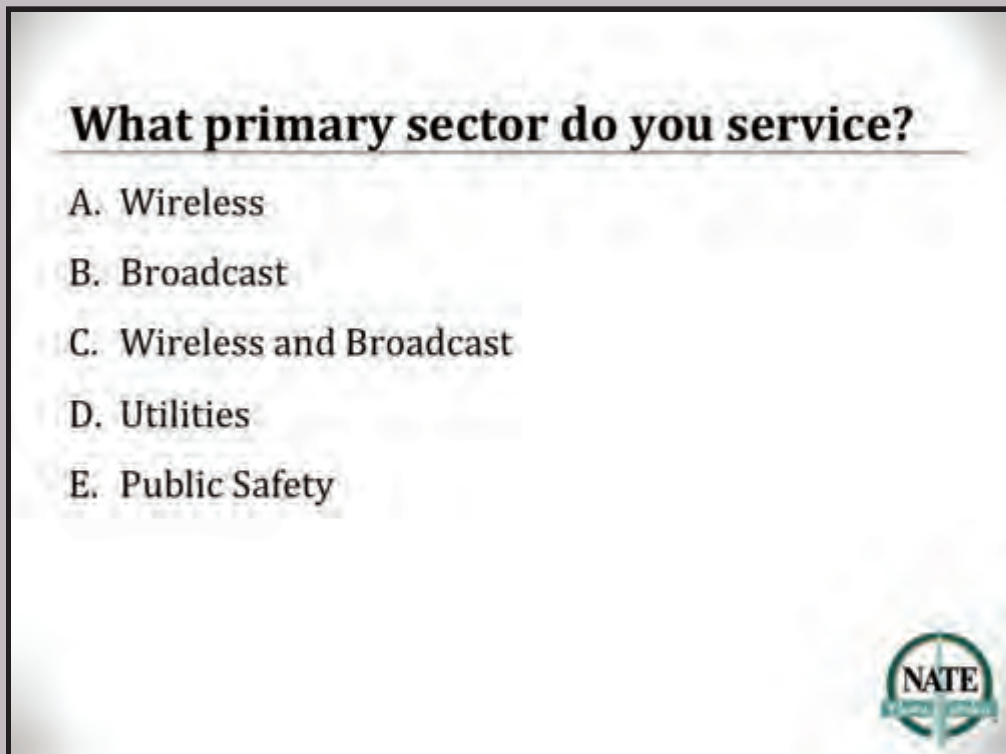

What is the size of your employer?
A. I don't know
B. 2-10 employees
C. 11- 50 employees
D. 51 - 100 employees
E. More than 150 employees
NATE

Does your company directly perform on-site construction?

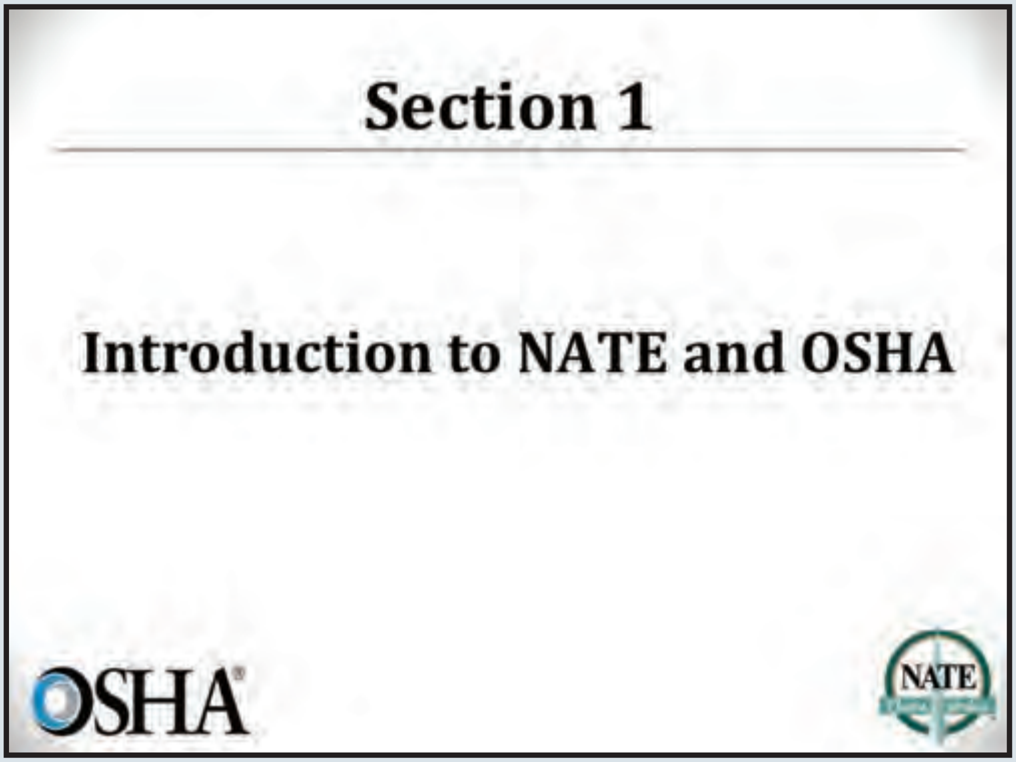
A. Yes

B. No


Do you create rigging plans?
A. Yes
B. No
NATE


What primary sector do you service?
A. Wireless
B. Broadcast
C. Wireless and Broadcast
D. Utilities
E. Public Safety
NATE


What is your primary responsibility for construction activities?
A. Office support
B. Field tech
C. Safety officer
D. Not directly involved
NATE



(Plan on 20 minutes for Intro and Section 1 — 9:00 - 9:20)

Topics

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

NATE

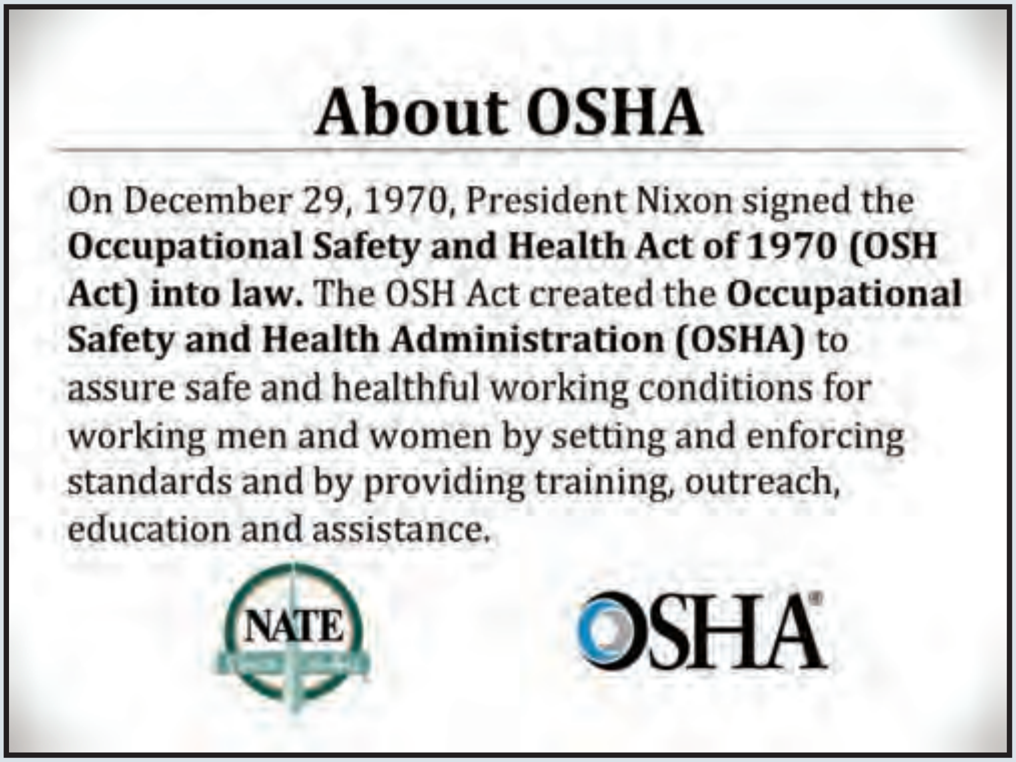
Instructor:

Talk about the vital role NATE plays in the wireless and broadcast infrastructure industries.

Share their personal connection to NATE and how they have worked with NATE through the years.

Mission Statement:

- Pursue, formulate and adhere to uniform standards of safety for tower personnel.
- Educate the general public, applicable government agencies and clients on continued progress toward safer standards within the industry.
- Keep all members informed of issues relevant to the industry.
- Provide a unified voice for tower erection, service and maintenance companies.
- Facilitate effective safety training for the industry.

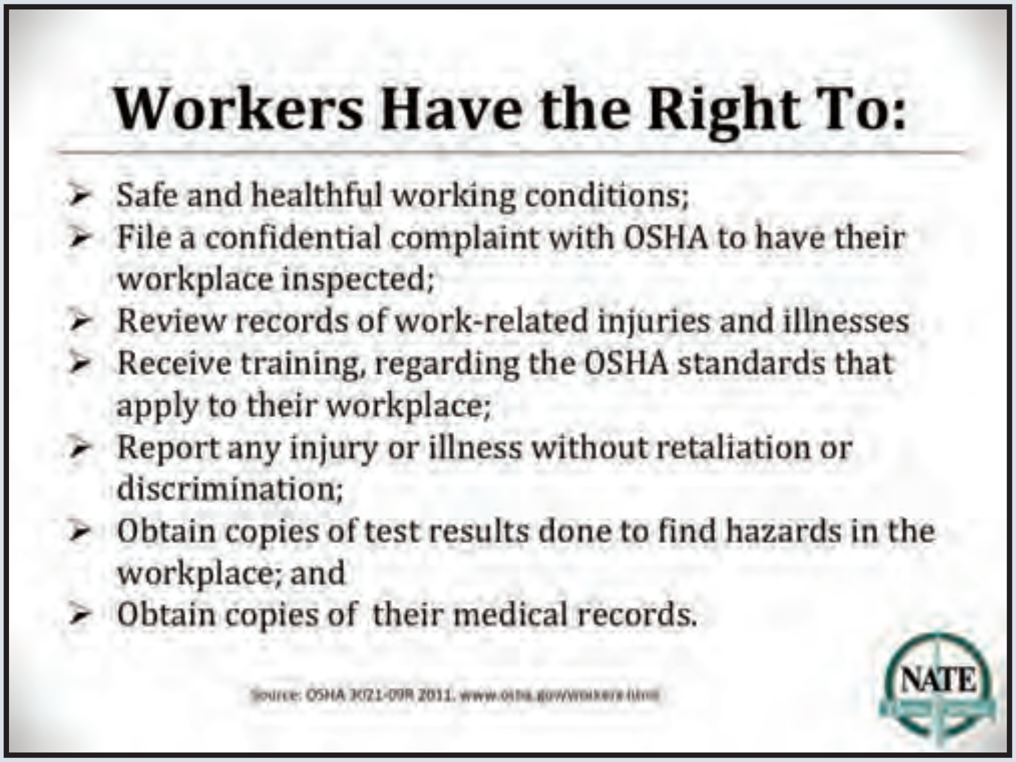


Instructor:

Talk about OSHA being established during Nixon Administration after Congress passed the OSH Act.

Instructor:

Note that OSHA (the Occupational Safety and Health Administration) is a regulatory agency of the federal government that has been established to ensure that the Law is adhered to by regulating employers. This is accomplished by developing standards consistent with the law, educating employers and employees and enforcing the standards on employers.



Instructor:

Describe this protection in simple terms or by example. This provision advocates for workers who report complaints which provide a hazard in the environment in which they work. The protection protects them from each of the bulleted points.

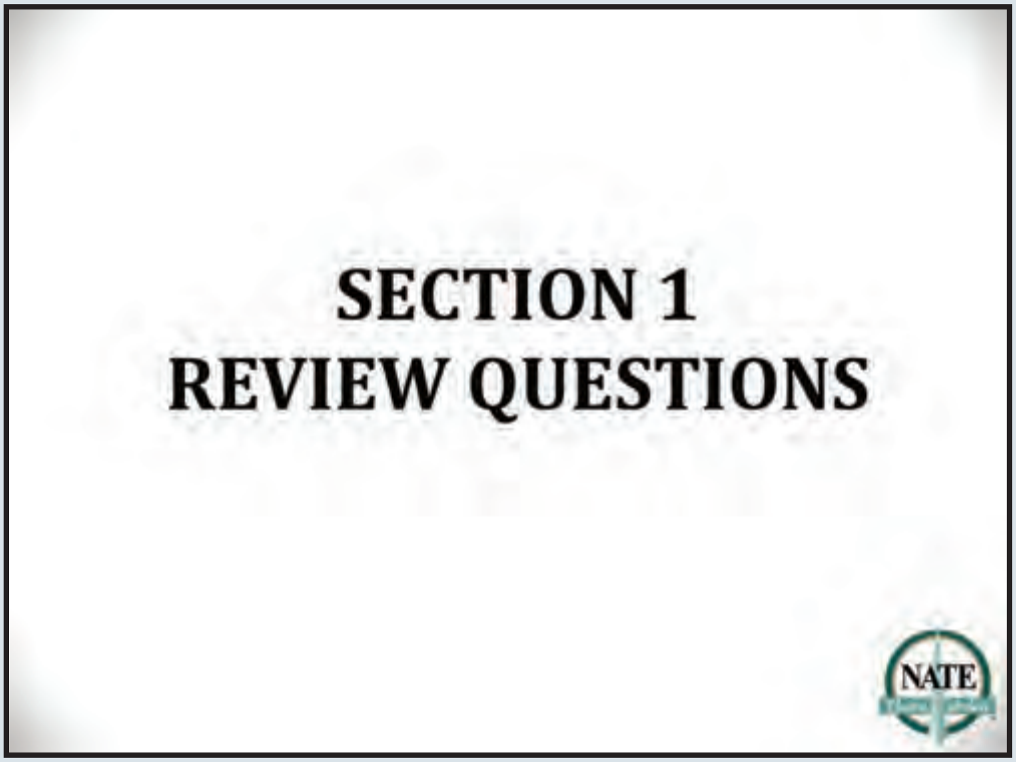
Instructor:

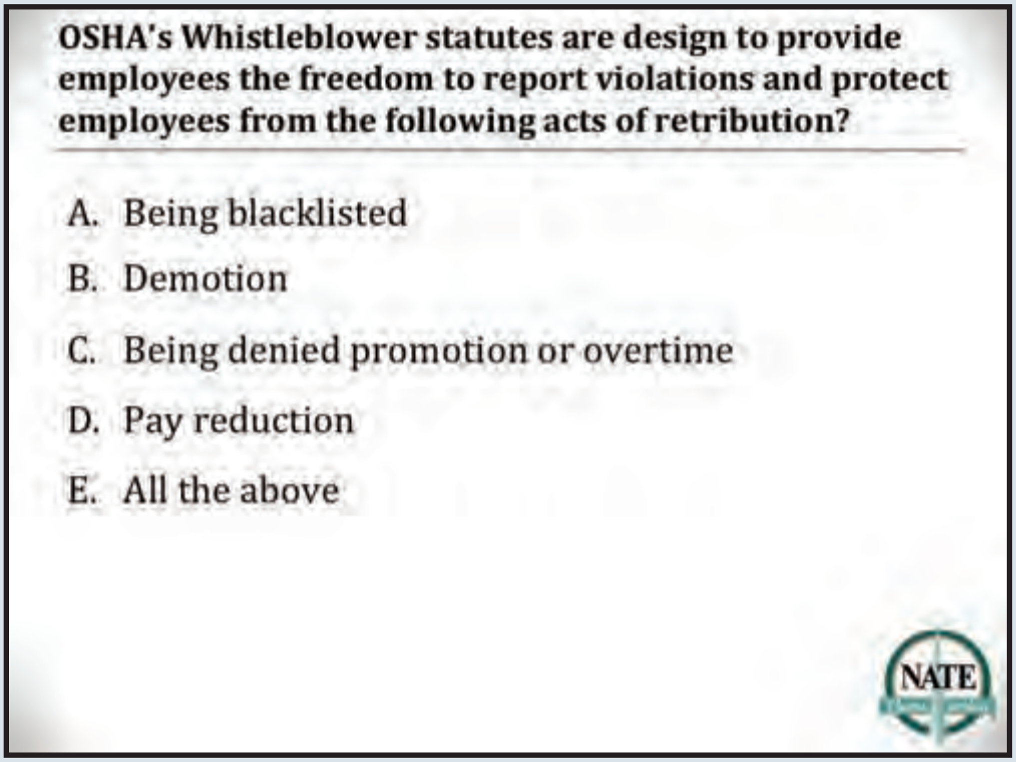
Point out the responsibilities employers have to protect their employees.

Instructor:

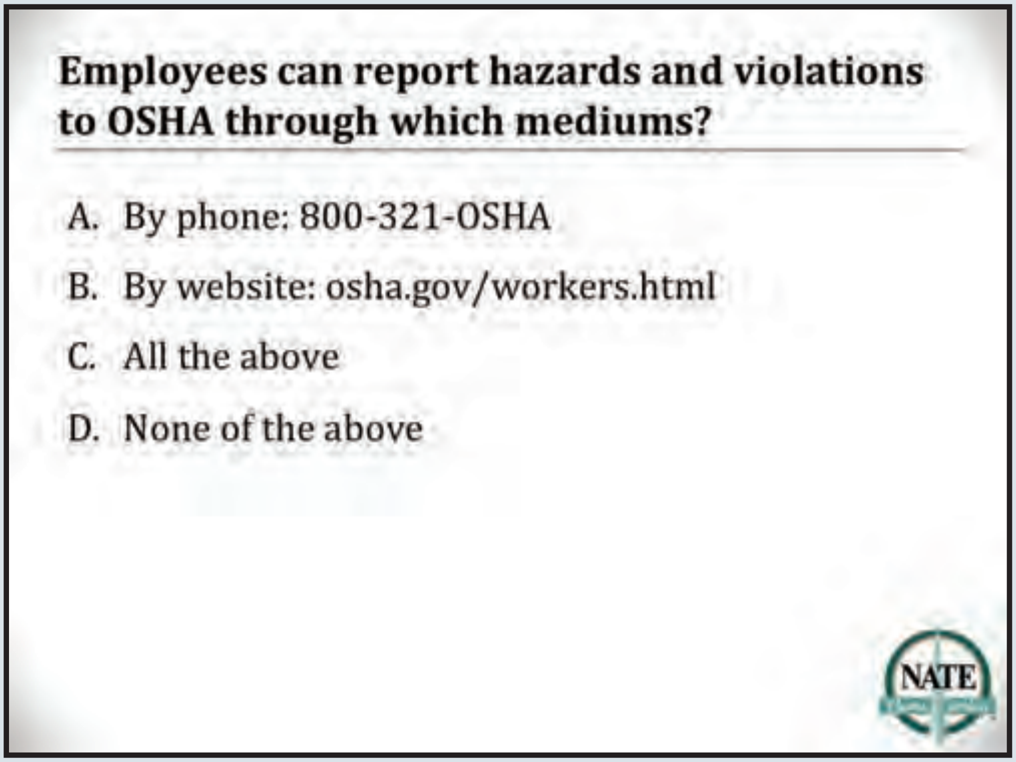
Can outline the Whistleblower Protection protocol for employees to follow with OSHA. The website and phone number should be emphasized on this slide to educate workers on how to report this information.

- Being fired or laid off
- Being blacklisted
- Demotion
- Being denied promotion or overtime
- Pay reduction
- Reassignment
- Benefits denial

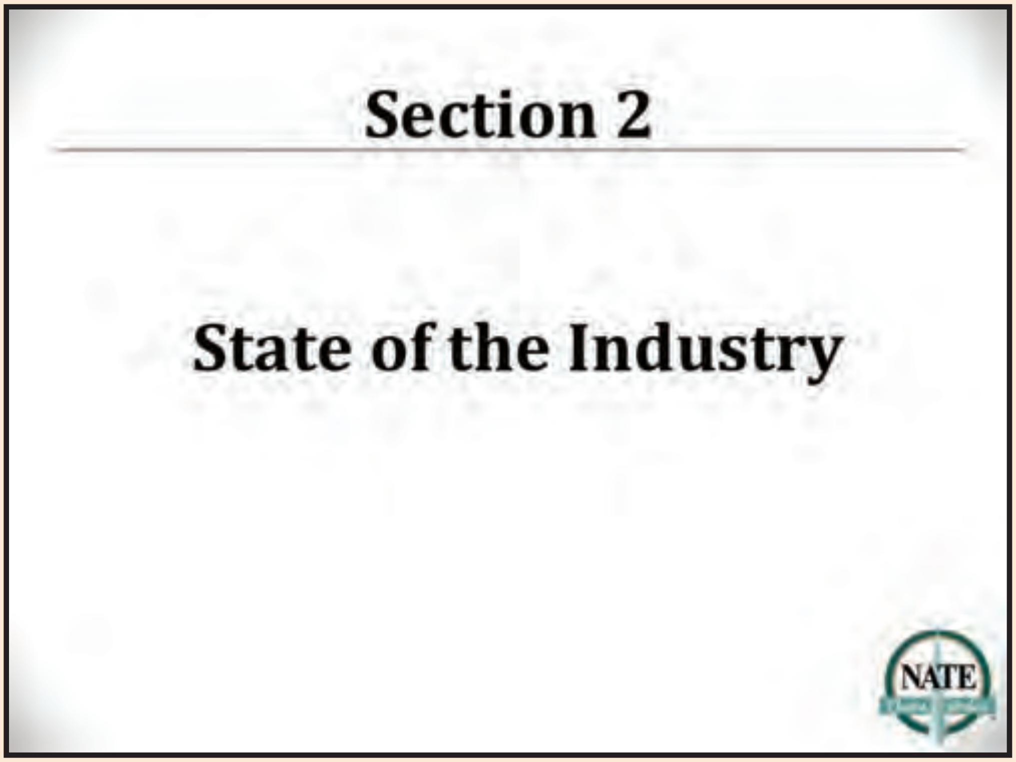

SECTION 1
REVIEW QUESTIONS
NATE



Answer: E (All of the Above)



Answer: C (All of the Above)

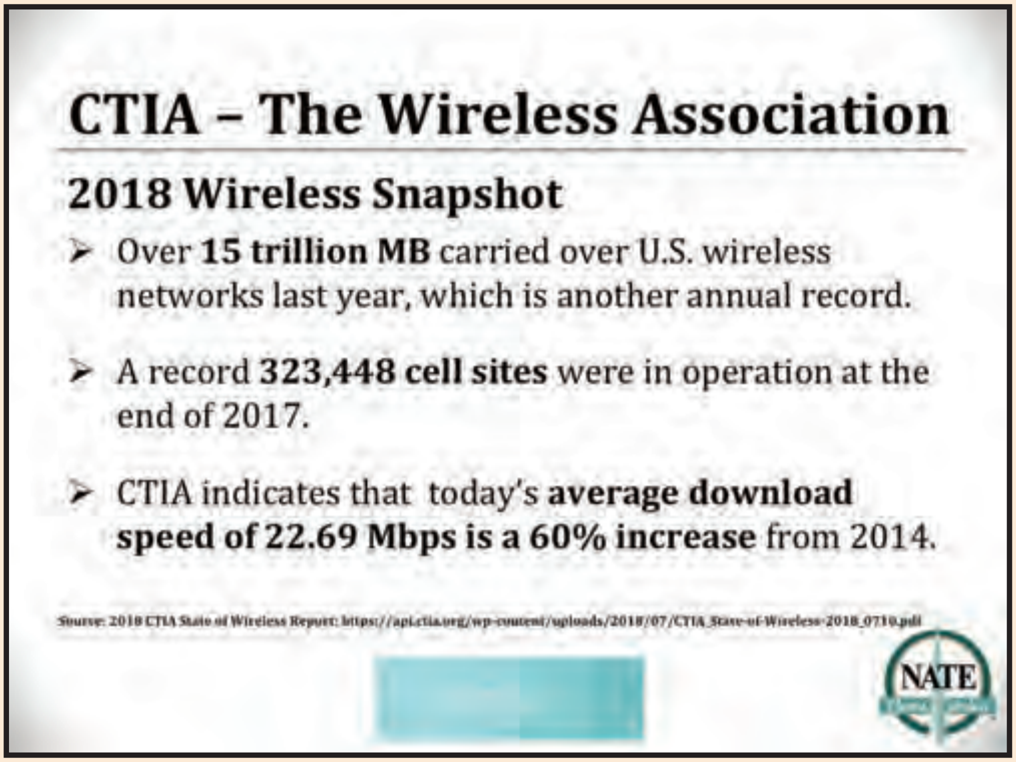


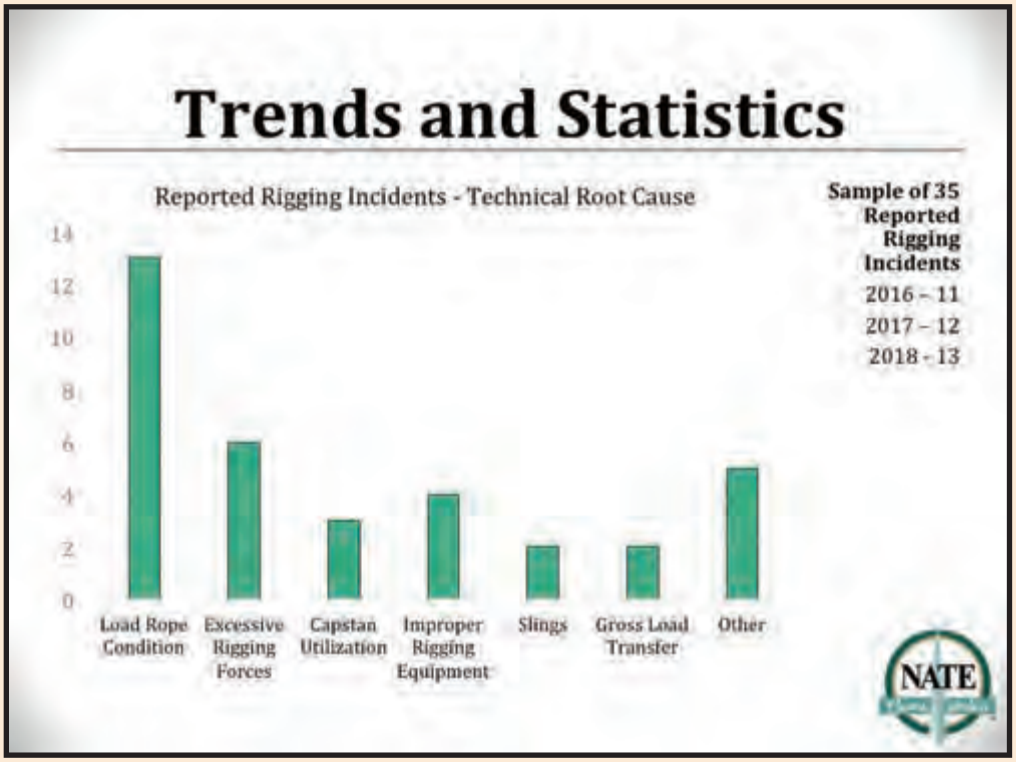
(Plan on 20 minutes for Section 2 — 9:20 - 9:40)


Topics
Industry Statistics
Incident Review
Rigging Failures and Near Misses
NATE

Perspective Industry Fatality Statistics

Year	Fatalities
2003	15
2004	11
2005	7
2006	19
2007	11
[illegible]	12
[illegible]	5
[illegible]	7
[illegible]	7
[illegible]	1
[illegible]	14
[illegible]	10
[illegible]	4
[illegible]	7
[illegible]	8
[illegible]	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
NATE



Instructor:

Load Rope Condition
- Synthetic rope
- Improper inspection/removal criteria
- Poor rope storage/maintenance techniques

Excessive Rigging Force
- Tagging Forces
- Staging Area Selection (tag/hoist locations impacted rigging forces)
- Load Manipulation

Capstan Utilization
- Removing wraps while load is suspended
- Rope Hook not installed

Improper Rigging Equipment
- Non-compliant with industry standards
- Home made equipment
- PPE utilized as rigging equipment
- Non compatible equipment – D:d ratios not met

Other
- Crane Operation
- Material handling
- Load Inspection Prior to rigging activity

Instructor:

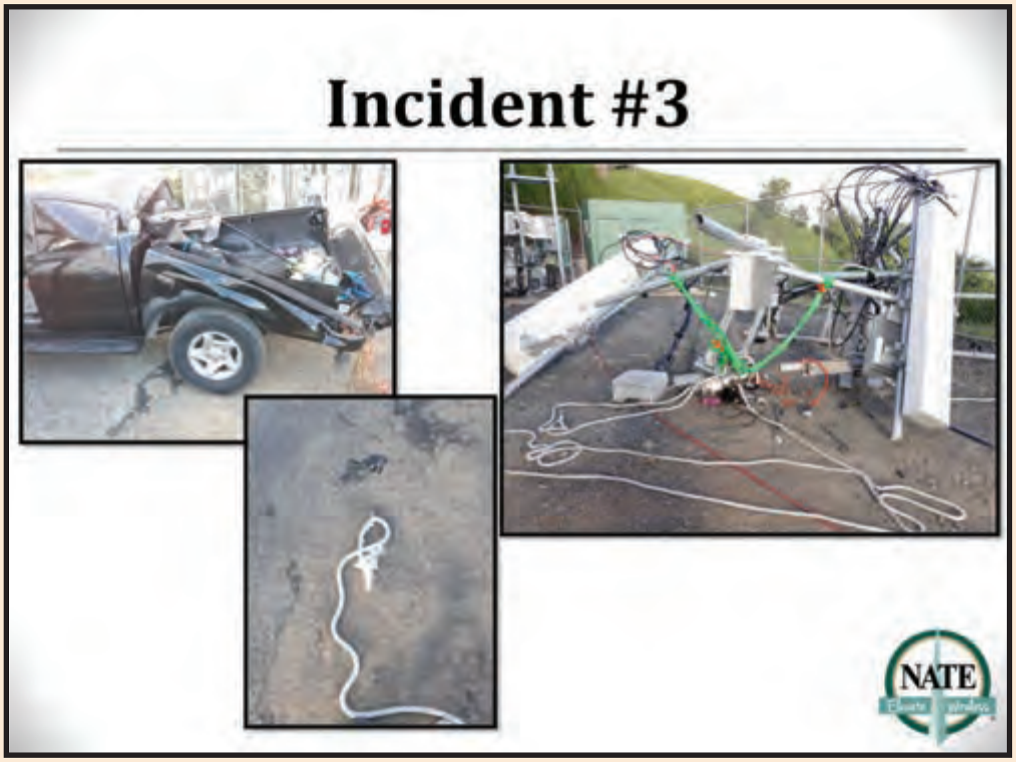
Description: On March 1st, 2018, at approximately 10:33 AM, GC was on site performing an antenna and line installation for a carrier. During hoisting activities, the load rope failed causing the load weighing approximately 1100 lbs. to fall approximately 245 feet. GC was utilizing synthetic ropes, a capstan hoist, and one snatch block for hoisting applications. Fortunately there were no documented injuries however there was damage to the carrier equipment, mount and compound fence.

Root Causes: A. Improper reduction of the load rope's WLL when using a knot. B. Rope Failure due to condition.

Instructor:

Description: On 8/23/18 at approximately 12:03 PM, the GC on site for a carrier antenna and line installation called to report a boom fell from approximately 98 Feet. This occurred while performing Class III Rigging. The GC was attempting to raise a boom for the carrier. While the lift was occurring, the load rope snapped and the Carrier Boom fell, struck an un-related carrier Boom at 90' Feet and then fell to the ground below. Nobody was injured, however, the foreman reported the un-related carrier Boom was damaged and they were unsure as to whether or not it was in danger of falling or the extent of the damage to the boom.

Root Causes: A. Load rope condition B. Inadequate Rope Inspection and Retirement Protocols C. Incompatible Rigging Equipment Utilized D. Discrepancies between construction planning and implementation.



Instructor:

Description: On October 31st, 2018 a GC was performing antenna and line construction for a carrier. While hoisting a load of approximately 840 lbs. to the 200 ft. elevation the load rope broke. The load fell the ground and landed on a pickup truck within the compound. One individual sustained minor injuries and the carrier's sector was offline as a result of this subject incident. There was no recorded damage to the property or the structure.

Root Causes:

Discrepancies between construction planning and implementation,

A. Significant increase in gross lifted load,
B. Excessive tagging and load manipulation forces,
C. Improper rigging equipment utilized,
D. Rope failed due to excessive tag forces,
E. Rigging planning and execution was not performed properly.

Commentary: The tag method was attached to both a 3,000-lb. capstan hoist mounted to the hitch of the truck and had two individuals applying tag forces in addition to the 3,000-lb. hoist. The tag force capabilities exceeded 3,000 lbs., which results in a load line force potential of over 5,000 lbs. and a potential resultant force on the structure of 10,000 lbs.

Instructor:

Description: On 10/23/18 at approximately 9:40 AM, the GC on site for a carrier line and antenna installation called to report a top block failure while the load was at approximately 60 feet. The load of approximately 220 lb. fell to the ground and landed outside of the compound. This occurred while executing the Class I Rigging Plan. The GC was attempting to raise two antennas to the beta sector for a carrier located at 98'. The carrier equipment dropped was damaged as a result of this subject incident. There were no reported injuries, damage to the structure, or damage to the site compound.

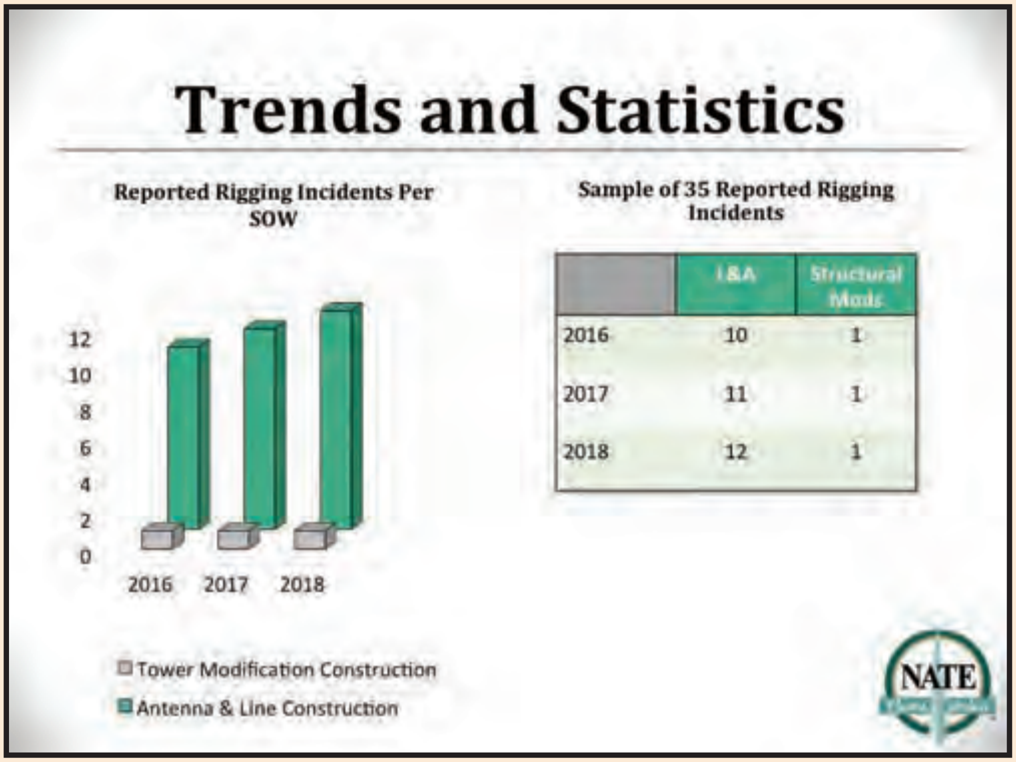
Root Causes:
A. Non-Compliant Rigging Equipment Utilized,
B. Discrepancies Between Construction Planning and Implementation.

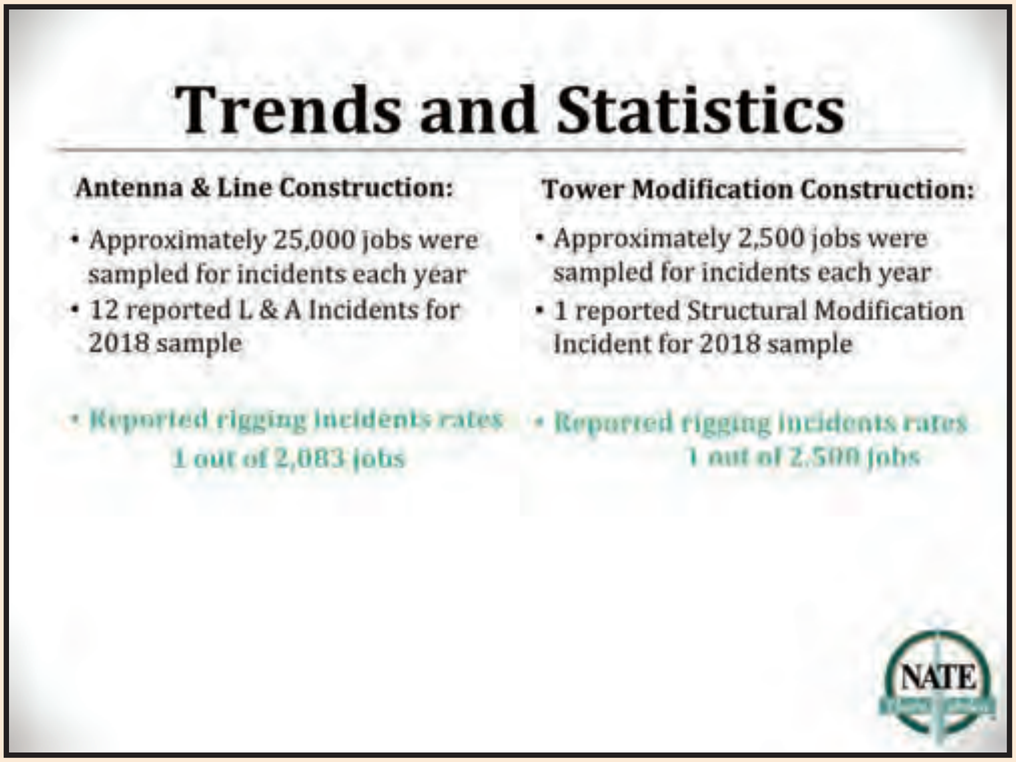
Instructor:

Description: At approximately 3:30 PM EST on 04/18/2018 while performing antenna and line construction for a carrier, GC was hoisting loads to the 279' centerline on the structure. During the hoisting activity for leg B, the Capstan Swivel Bracket failed. As a result the load of approximately 1,360 lbs. was dropped approximately 200' and landed on the another carrier's shelter East of leg B and the capstan hoist was propelled across the compound. There were no documented injuries, another carrier was temporarily taken out of service, the dropped carrier equipment was damaged beyond repair, and there were instances of damage to structure.

Root Causes:

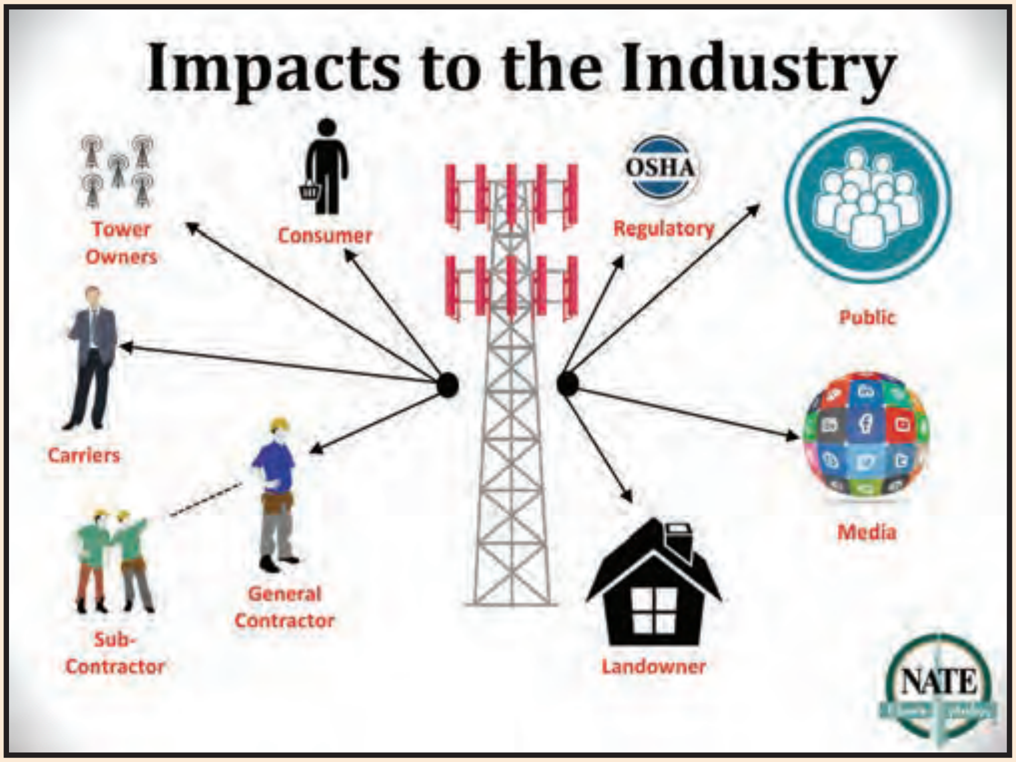
A. Capstan Swivel Bracket failed due to excessive loading.,
B. Inadequate rigging inspection,
C. Rigging equipment selection/rigging force validation,
D. Discrepancies between construction planning and implementation.


Trends and Statistics
Reported Rigging Incidents Per SOW
12
10
8
6
4
2
0
2016
2017
2018
Tower Modification Construction
Antenna & Line Construction
Sample of 35 Reported Rigging Incidents
I&A
Structural Mods
2016 10 1
2017 11 1
2018 12 1
NATE



Instructor:

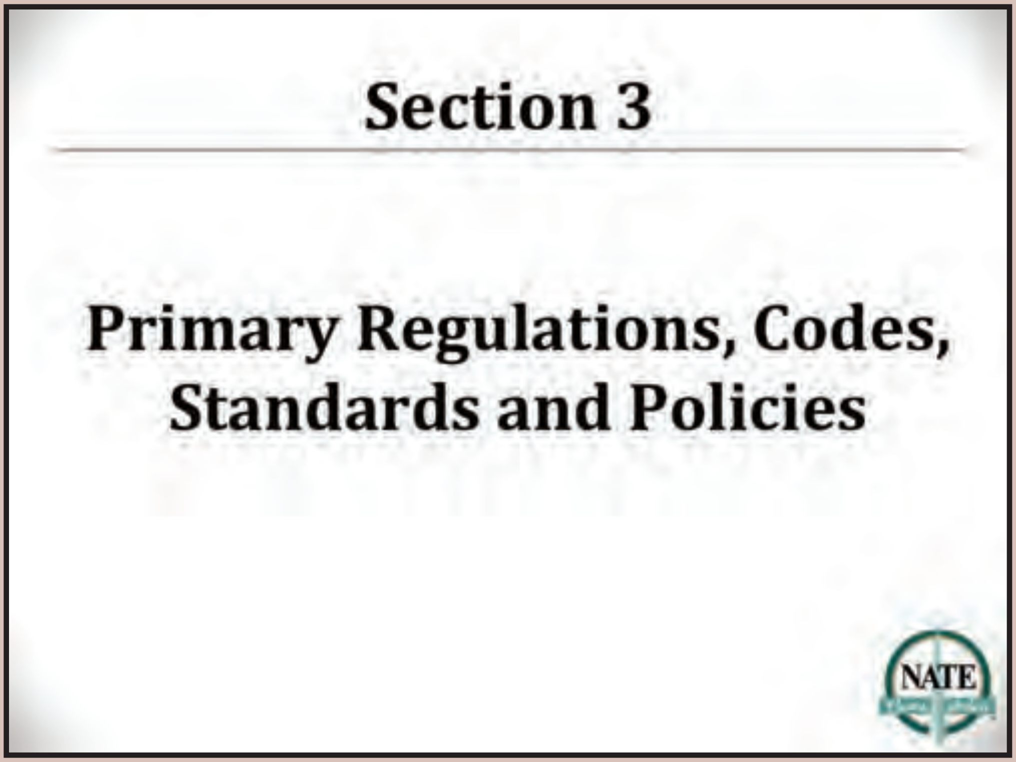
The number of jobs sampled in L&A vs. tower modification is representative of the spread for the work being performed.



Instructor:

Although incident rate per a job may seem low, it only takes one incident to bruise tarnish reputation.

1. Customer/Carrier – The customer wants a quiet and enjoyable ride. When their service is lost due to an incident caused by human error they are not happy. There is also the potential that the equipment on the tower provides emergency/safety services. When these instances happen the customer could lose faith and confidence in the owner and/or the contractor hired to perform the work and it may take tremendous efforts to mend that relationship.
2. Contractor and Subs – If the contractor is at fault, the reputation of that contractor is extremely affected. There is a risk that they could lose the opportunity to do business for that customer or even in the industry as a whole. Aside from future work, there's also the possibility of paying for fines and losses – cost of construction, cost of materials, cost of service outage, etc.
3. Landowner – property damage, the use of the property – for instance if a business is located on or near the property they may lose functionality in the midst of an incident and its investigation. This could absolutely effect the future relationships with landowners.
4. Tower Owners - Reputation. Time, effort, money, & resources to resolve the immediate issue. Potential revenue loss depending on the severity of the issue, if incident ruins a structure, there's possibility that that revenue source no long exists at that site. Potential for new standards, procedures, safety requirements, etc.
5. Public/OSHA – incidents give a black eye to the industry – being a tower climber is one of the most dangerous jobs in the world. The more and more incidents happen OSHA may continue to tighten their view on our industry.



(Plan on 25 minutes for Section 3 — 9:40 - 10:05 — 15 minute break after Section 3)

Topics

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

NATE

Federal Regulations

The United States Department of Labor, (DOL) is a cabinet-level department of the US federal government responsible for occupational safety and health. The purpose of the Department of Labor is to foster, promote, and develop the wellbeing of wage earners of the United States; improve working conditions; advance opportunities for profitable employment; and assure work-related benefits and rights.

In carrying out this mission, the DOL administers and enforces more than 180 federal laws and thousands of federal regulations representing minimum requirements, which must be satisfied to safeguard wage earners health, safety and welfare.

State Regulations

OSHA covers most private sector employers and workers in all 50 states, the District of Columbia, and other United Safes jurisdictions – either directly through OSHA or through an OSHA – approved State Plan. State Plans are OSHA – approved job safety and health programs operated by individual states rather than federal OSHA.

State – run safety and health programs must be at least as effective as the federal OSHA program. There are roughly 22 states and/or territories that have approved State Plans.

Some State Plans are more stringent than federal regulations. It is important to know if the state you or your employer is working in has a State Plan and to verify you are in compliance with that States regulations. If you have questions about State Plans contact OSHA for more information at www.osha.gov.

Building Codes

adopted and enforced by one or more government entity and contain collection of evolving standards by direct or indirect reference

Consensus Standards

A consensus standard is a standard developed through the cooperation of all parties who have an interest in participating in the development and/or use of the standards. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution. These standards are voluntary guidelines to be followed. Voluntary standards are standards established generally by private-sector bodies and that are available for use by any person or organization, private or government. The term includes what are commonly referred to as “industry standards” as well as “consensus standards”. A voluntary standard may become mandatory as a result of its use, reference, or adoption by a regulatory authority, or when invoked in contracts, purchase orders, or other commercial instruments.

Owner/Customer Policies

Voluntary standards and/or “other” policies and procedures may become mandatory when invoked in contracts, purchase orders, or other commercial instruments.

Instructor:

ASME American Society of Mechanical Engineers.

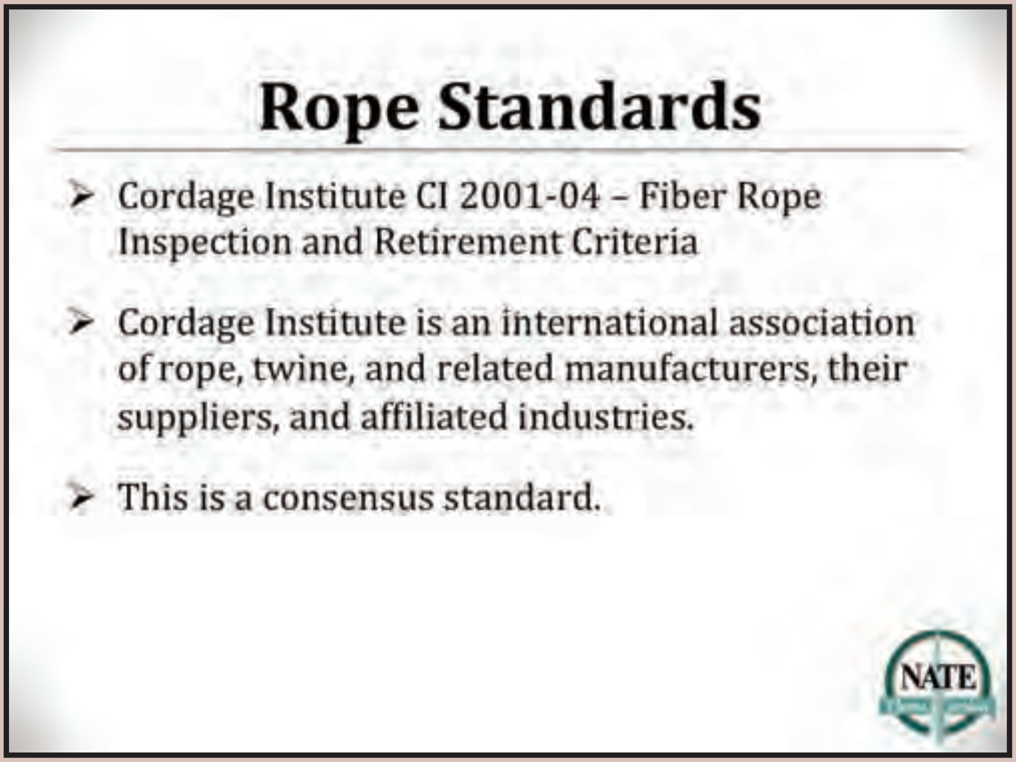
Instructor:

ANSI – American National Standards Institute

ASSE – American Society of Safety Engineers. NOTE the name has been changed to ASSP American Society of Safety Professionals. Reference is to the ASSE as the standard used is the ANSI/ASSE A10.48.

TIA – Telecommunications Industry Association

IBC – International Building Code

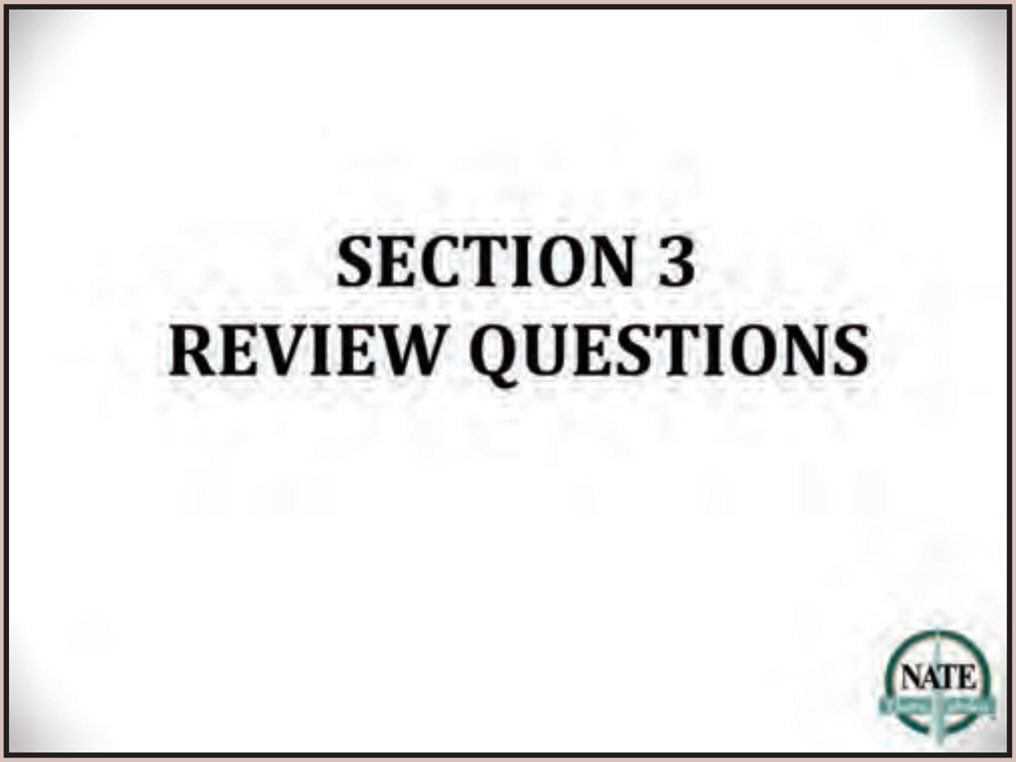


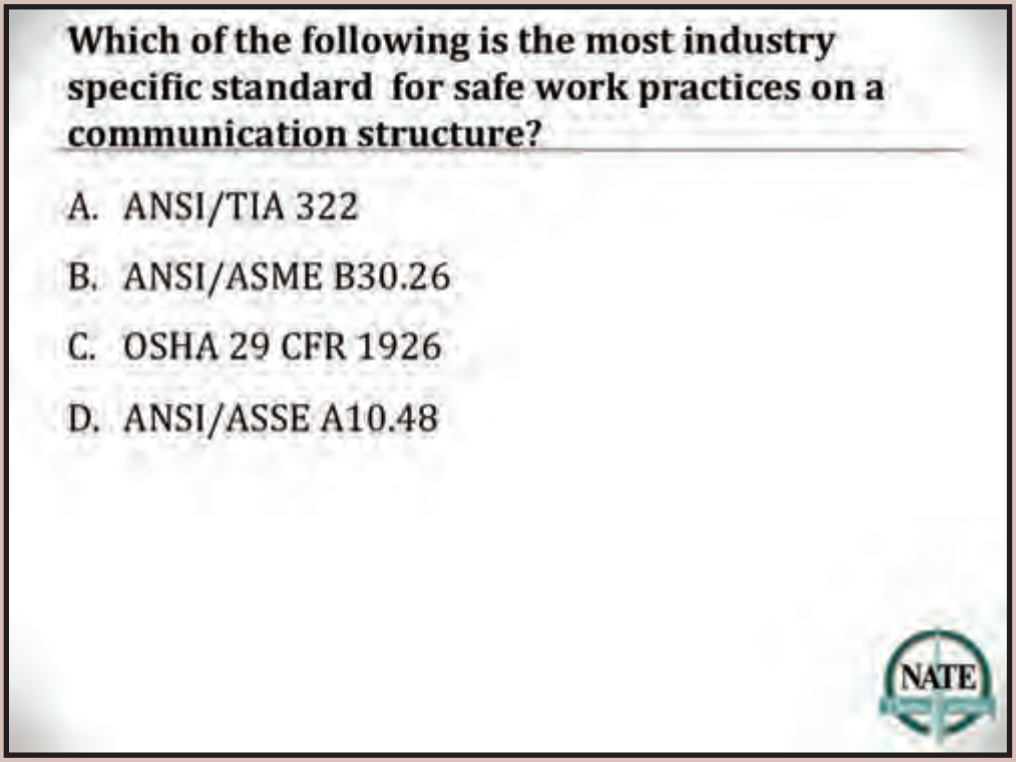
Instructor:

This is a voluntary standard that provides information used by the manufactures and end users of Fiber rope. In the absence of Regulations, ANSI standards this is an sound reference for use, care and retirement of rope.

* *Cordage Institute CI 2001-2004 – Fiber Rope Inspection and Retirement Criteria is located in the Appendix section for reference. Cordage Institute has provided permission for the document to be used as a part of this training tool.*

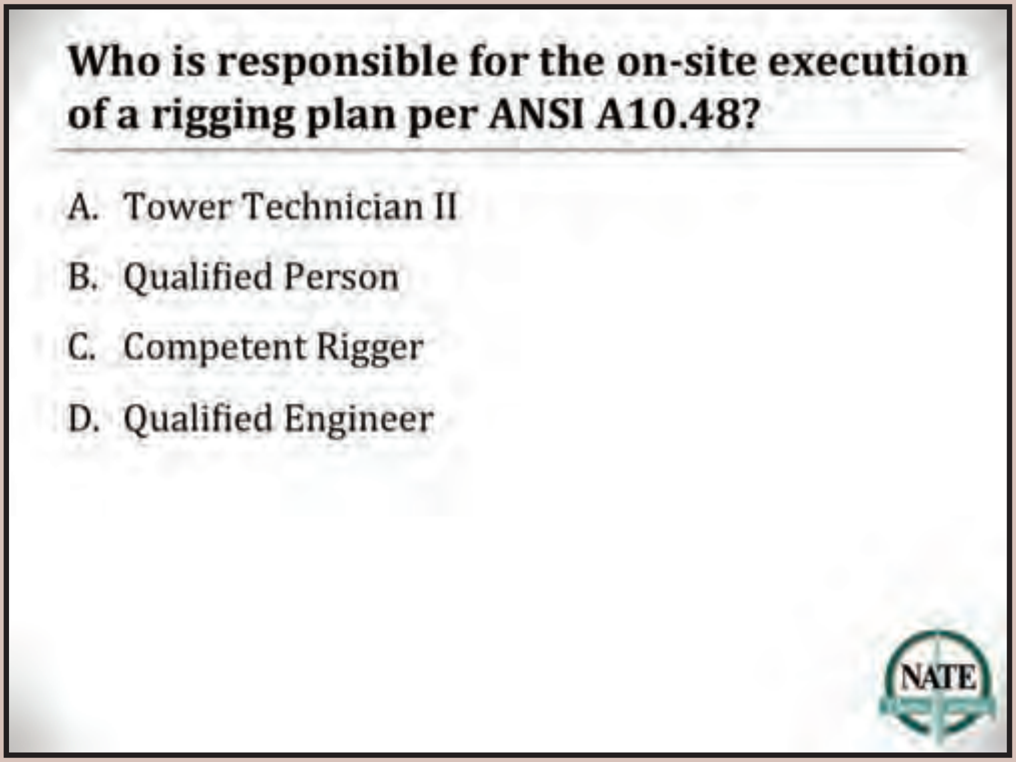

A10.48 Standard
Climber Connection Video
NATE


SECTION 3
REVIEW QUESTIONS
NATE



Answer: D (ANSI/ASSE A10.48)

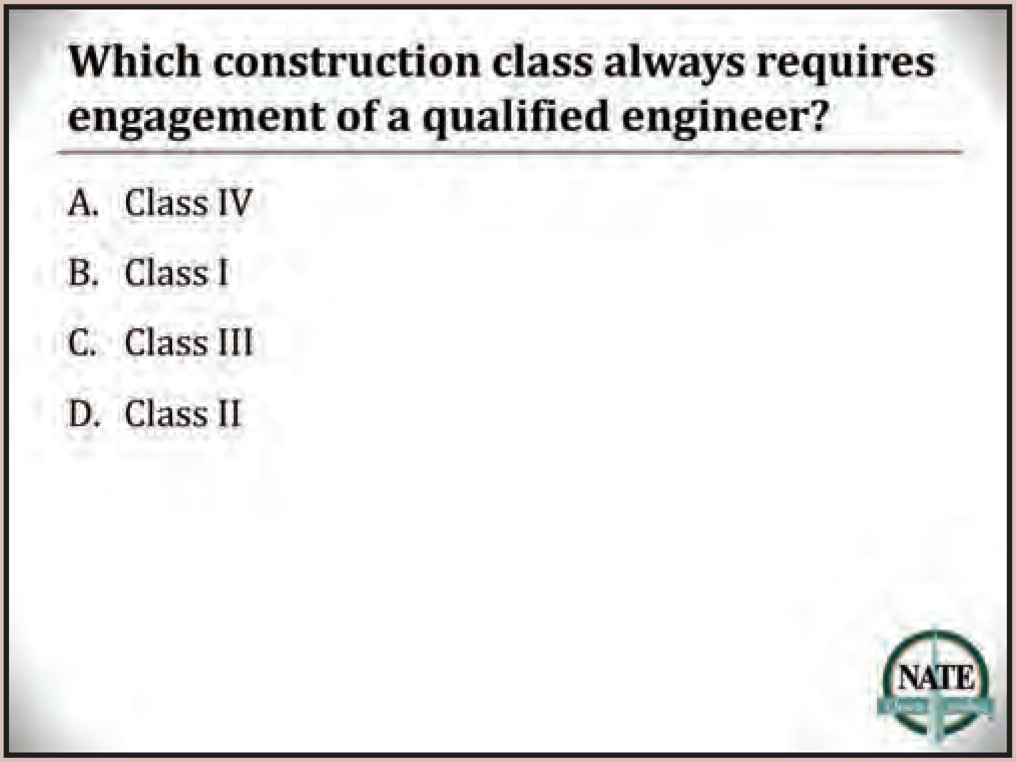
The means and methods are governed by ANSI/ASSE A10.48. This standard works hand in hand with the ANSI/TIA 322 and when necessary engineers will use the 322 to provide a review of a rigging plan created via the requirements of the 10.48.



Answer: C (Competent Rigger)

While it is the competent rigger it is possible that the qualified person may assist or that the qualified person may also be the competent rigger.

The qualified engineer is only responsible for the review of the rigging plan. It would require a supervising engineer for them to have any execution responsibilities on site. Please see ANSI/ASSE A10.48 and ANSI/TIA 322 for more information about a qualified engineer and a supervising engineer.

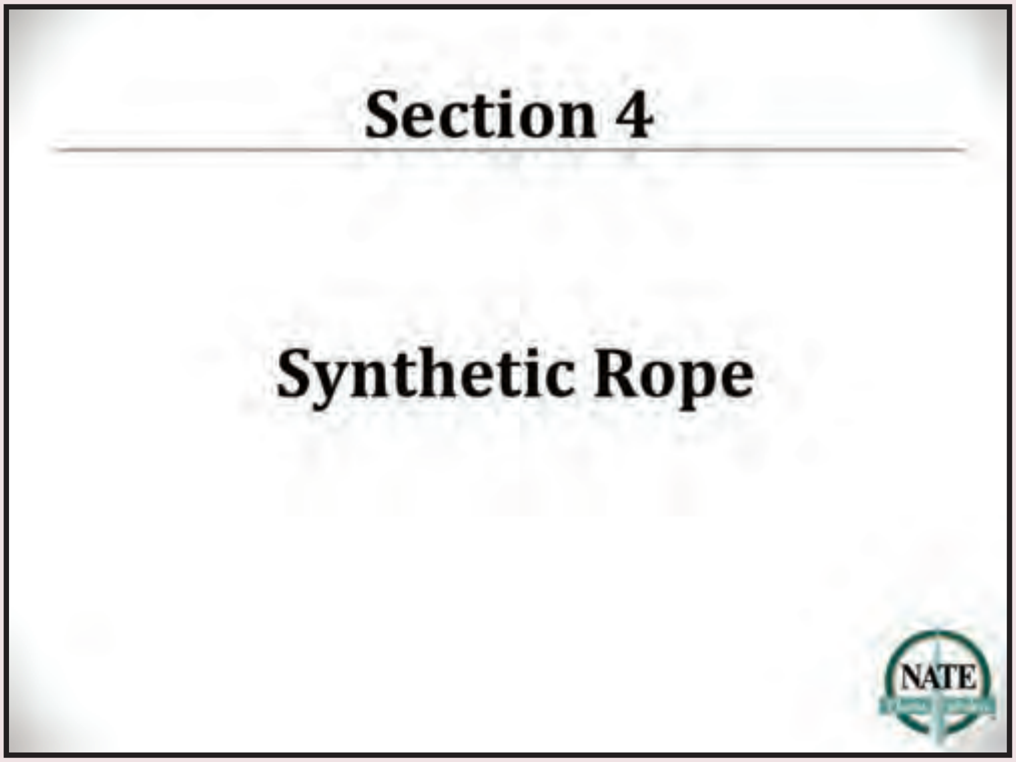


Answer: A (Class IV)

While class IV determined by the requirements of the ANSI/ASSE A10.48 always requires a qualified engineer it is possible that a qualified person may elect input from a qualified engineer for any rigging plan class.

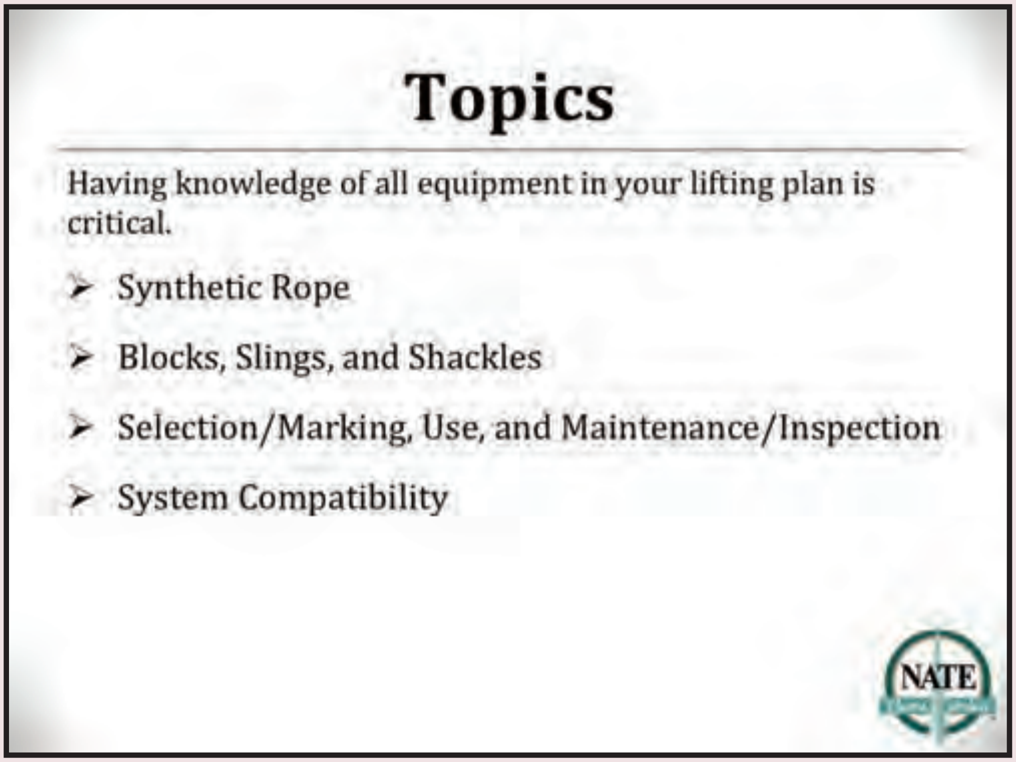
Answer: B (Cordage Institute 2001-04)

This consensus standard provides information complied by the manufacturers of rope. It is specific to the rope manufacturers industry and they are as a consensus body seeking to provide accurate data based on: Manufacture, use, care, documentation and retirement of rope.



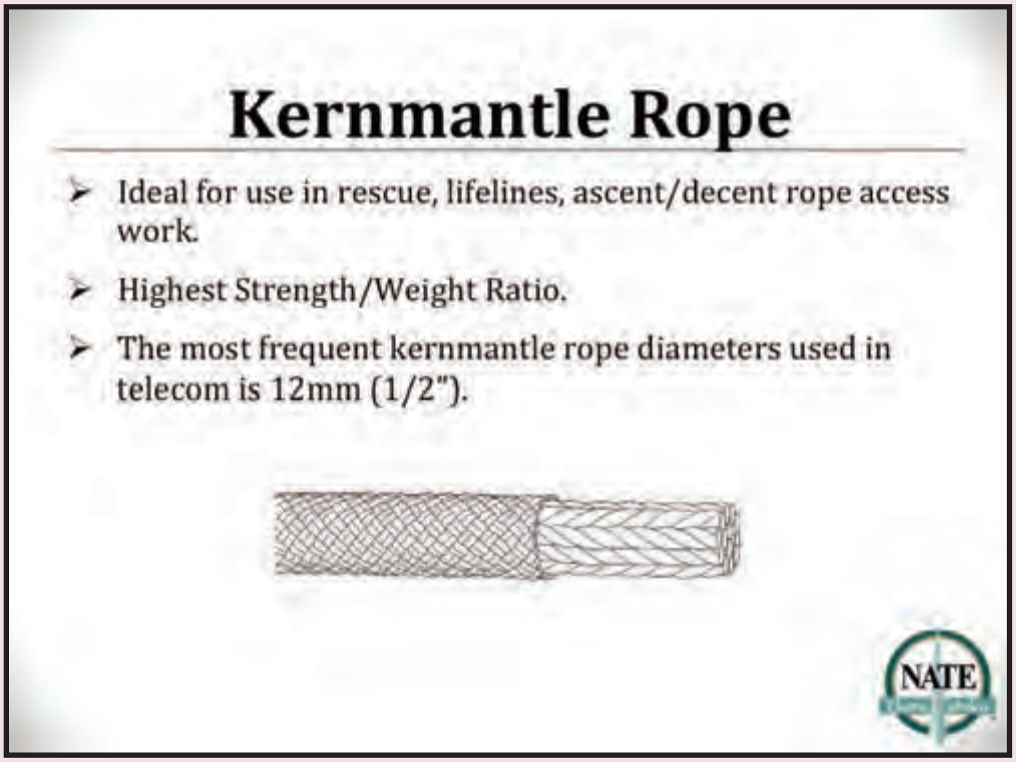
(15 minute break — 10:05 - 10:20)

(Plan on 70 minutes for Section 4 — 10:20 - 11:30 — 45 minute lunch break after Section 4)



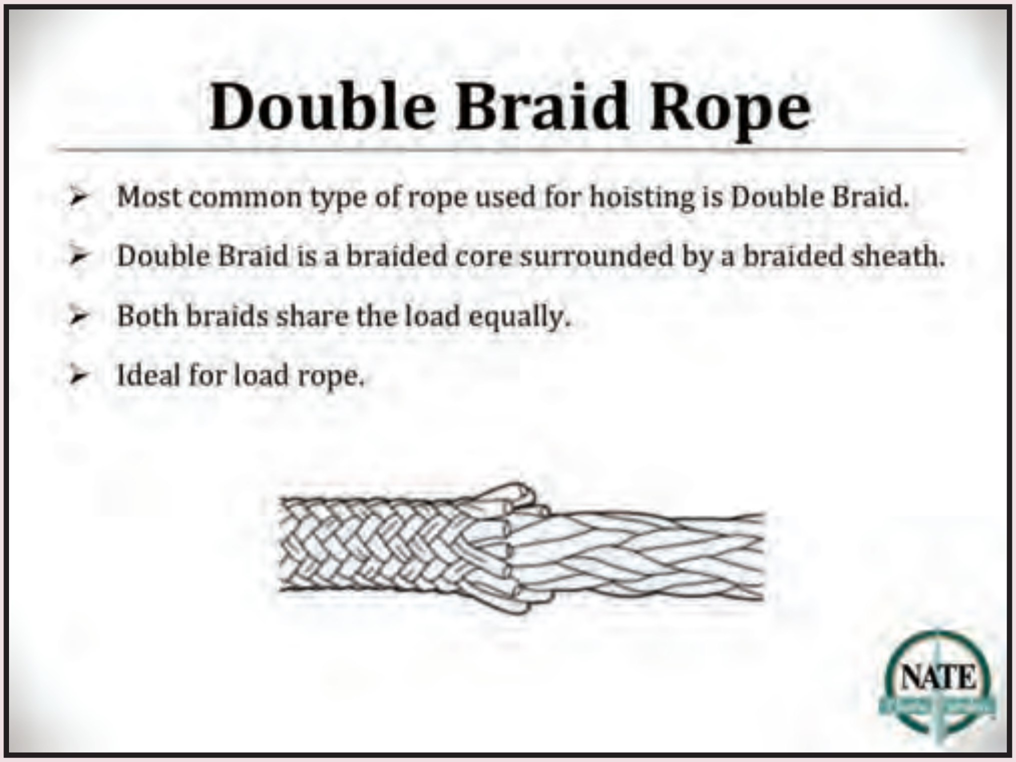
Instructor:

We are primarily focusing on rope, blocks, slings, and shackles in this presentation.



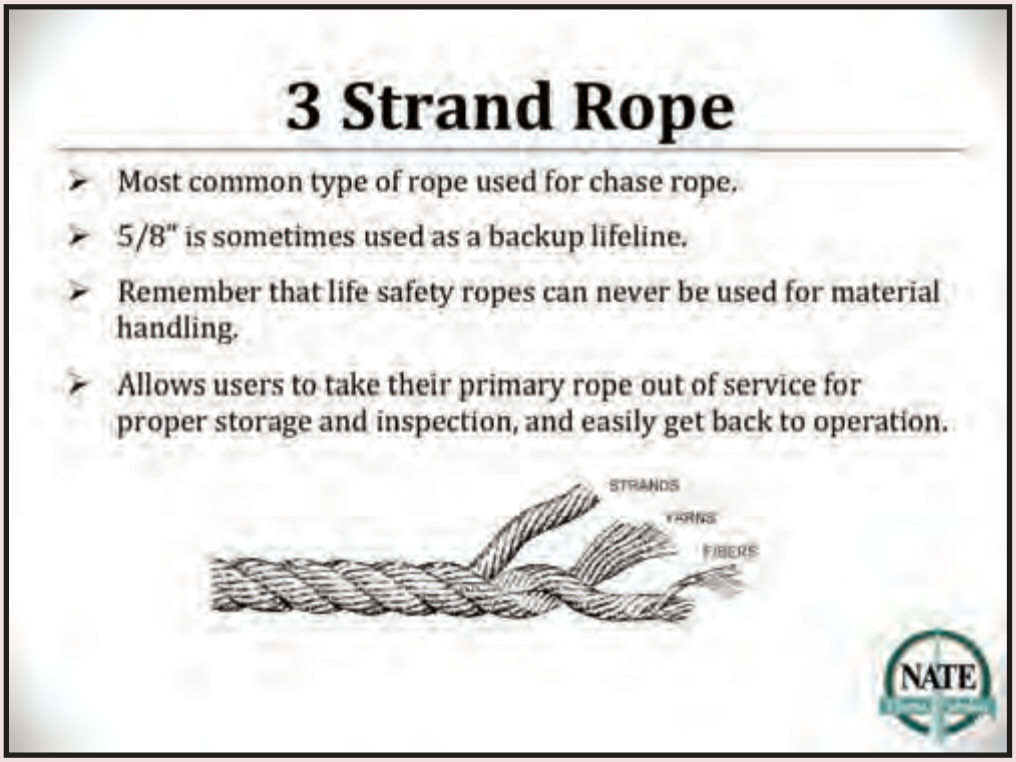
Instructor:

- Kernmantle rope consists of parallel fibers (the kern) surrounded by a tightly braided sheath (the mantle).
- With this tight braid, the core fibers provide the majority of the rope's strength.
- Kernmantle rope is frequently split into two categories: static and dynamic.
- As the names imply, the amount of stretch which the rope sees when put under load are the defining characteristic.
- For professional applications, static kernmantle is preferred. The low-stretch characteristics diminish concerns with fall arrest systems deploying and decrease the risks associated with fall clearance. The most frequent kernmantle rope diameters purchased is 12.5-13mm (~½").



Instructor:

- Most common type of rope used with a capstan as a load line is Double Braid
- Double braid is a braided core surrounded by a braided sheath
- 50% rope strength on inside core, 50% rope strength on outside core
- Flexible, and less likely to tangle
- Double braid flattens ever so slightly- more than a kernmantle or twisted braid, but significantly less than a hollow braid. This helps improve grip on the drum of a capstan hoist without flattening to the extent of causing excessive inefficiency when passing through the sheave of a block or pulley.
- These characteristics make it ideal for a load rope



Instructor:

- Three-strand twisted ropes have long been a staple in American at-height industry.
- Twisted ropes are built by first twisting multiple fibers together (synthetic or natural fiber) and forming a single strand.
- From that point three strands are laid together to create a three strand rope.
- This is the most common rope construction for general purpose use.
- The tightly-twisted fibers feeding the twisted braid ensure a low amount of stretch under load.
- That said, this approach does lead to a sacrifice in breaking strength.
- To achieve higher MBS strengths, a large rope is required than alternative rope products.
- Great application as a chase rope, allowing you to take your primary ropes out of service while away from the job site.

Instructor:

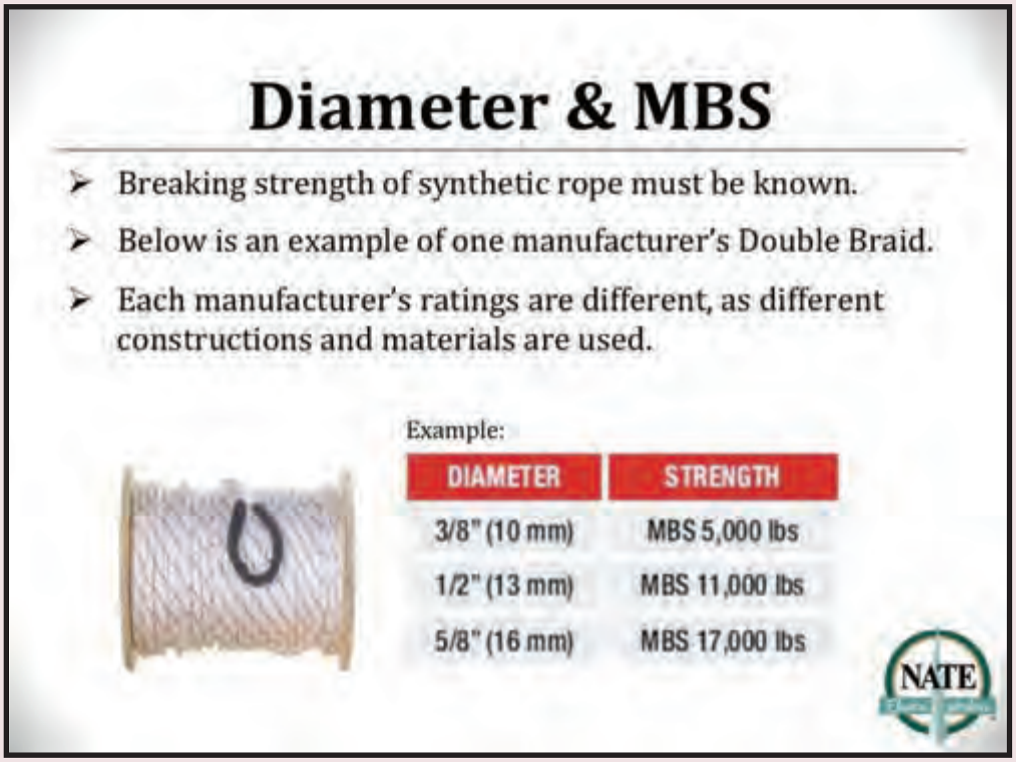
It is critical that all rope users know the strength of the rope.

Check the owner's manual.

These manuals also typically include:
1. Use, Care, and Inspection Instructions,
2. Retirement Criteria,
3. Strength Charts,
4. Rope Log to document inspections.

Instructor:

- It is important for everyone to know rigging acronyms, and their meaning.
- SWL- Safe Working Load and WWL are the same. SWL is being phased out, because of the legal significance placed on the word 'safe'.
- The default safety factor is 10:1, meaning that the maximum load to which a synthetic rope can be subjected is one-tenth (10%) of the manufacturer's documented minimum breaking strength (MBS).
- It is worth noting that the 10:1 safety factor accounts for strength reductions associated with knotting/termination and losses in strength and efficiency as the rope passes through sheaves. This helps to explain why the safety factor exceeds the more common 5:1 factor found regularly in ASME B30 for other rigging components.

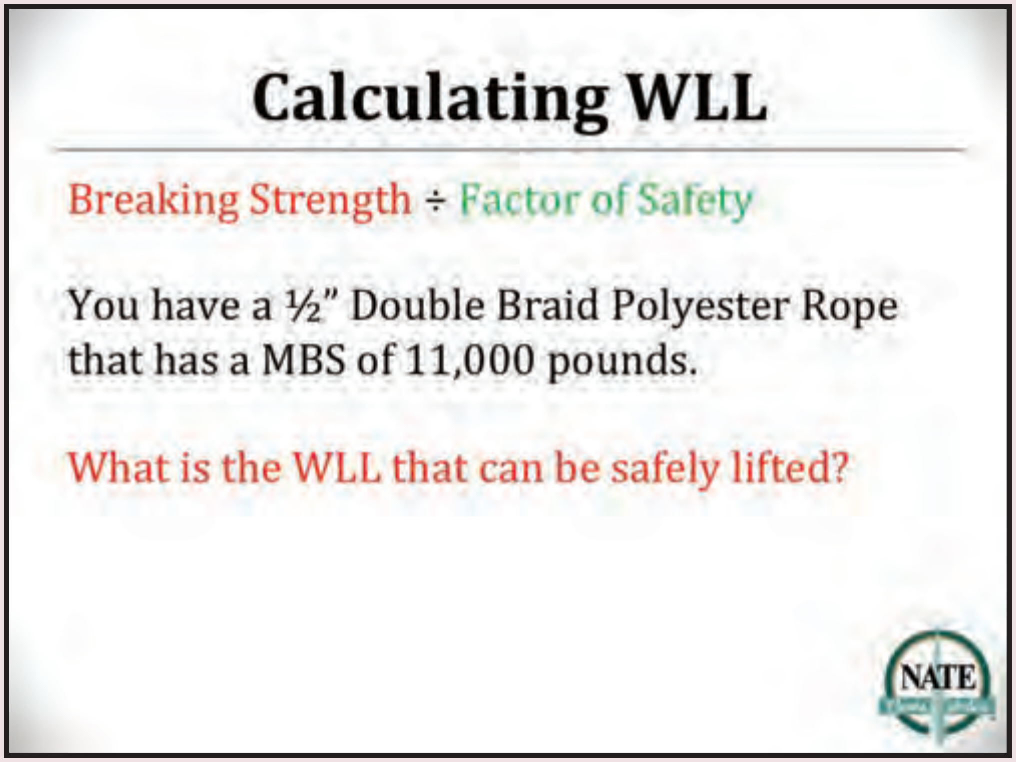


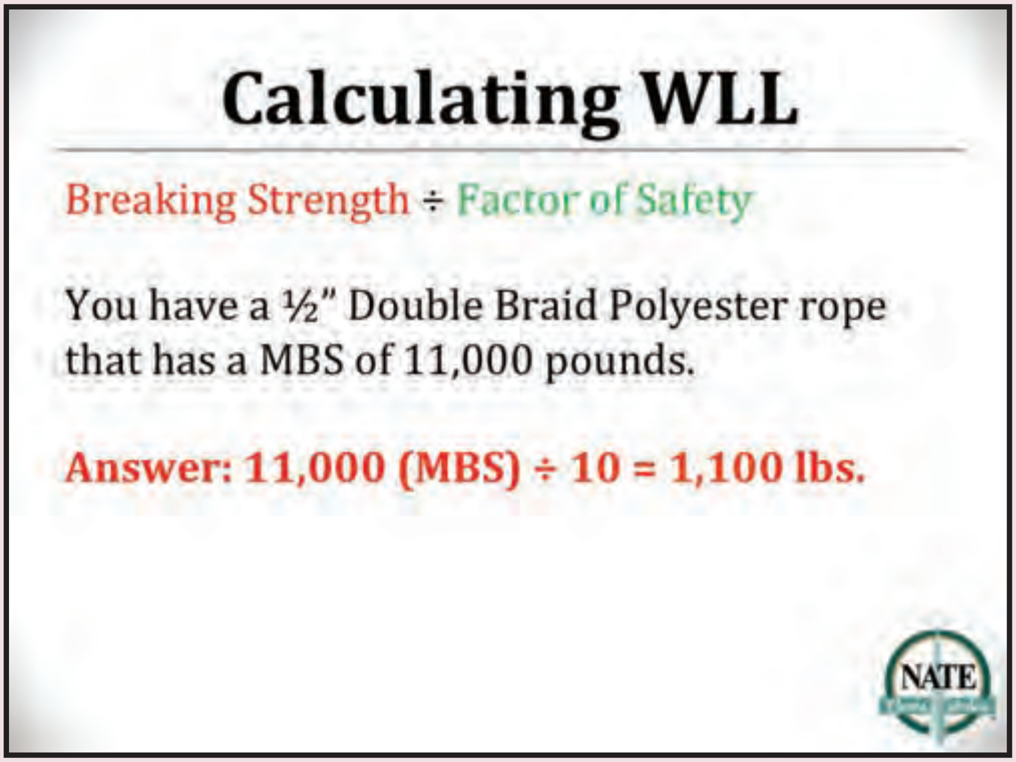
Instructor:

If you are using a 1,000 pound capstan hoist, could a 3/8" rope be used?- No- does not maintain a 10 to 1.

Similarly, the 5/8" rope would be fine; however, it would not give the user any additional capacity, as the winch would be the limiting factor.

What is the SWL or WLL of ½" rope which has these specs? Answer: 1,100 lbs.

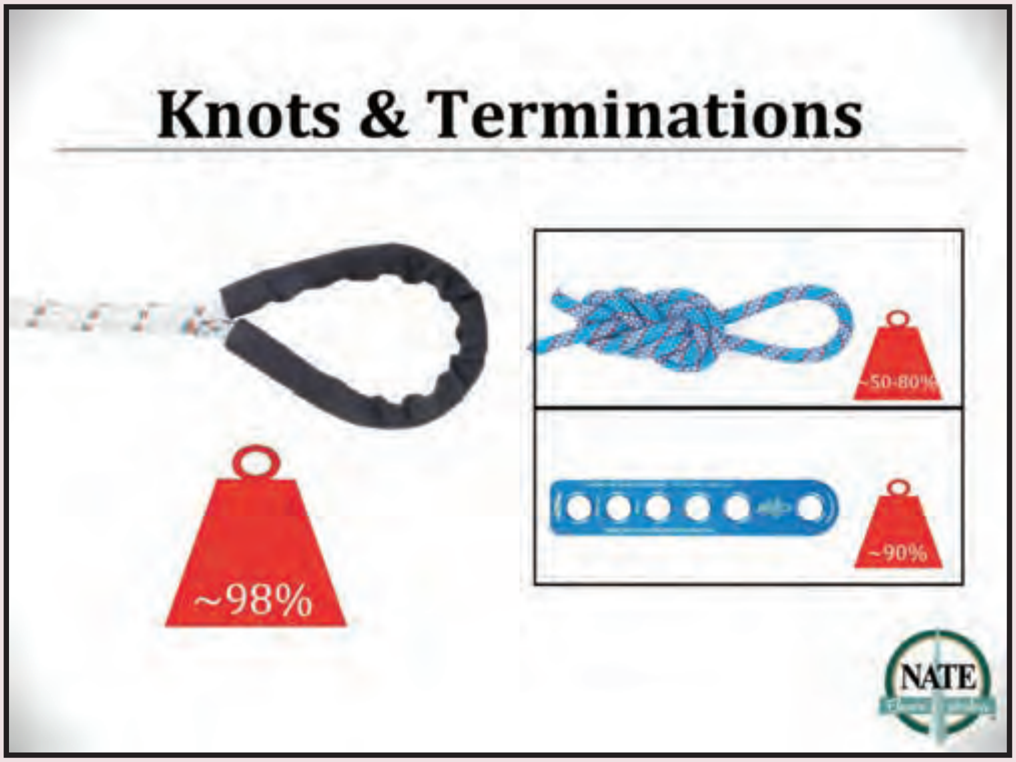

Calculating WLL
Breaking Strength ÷ Factor of Safety
You have a ½" Double Braid Polyester Rope that has a MBS of 11,000 pounds.
What is the WLL that can be safely lifted?
NATE



Instructor:

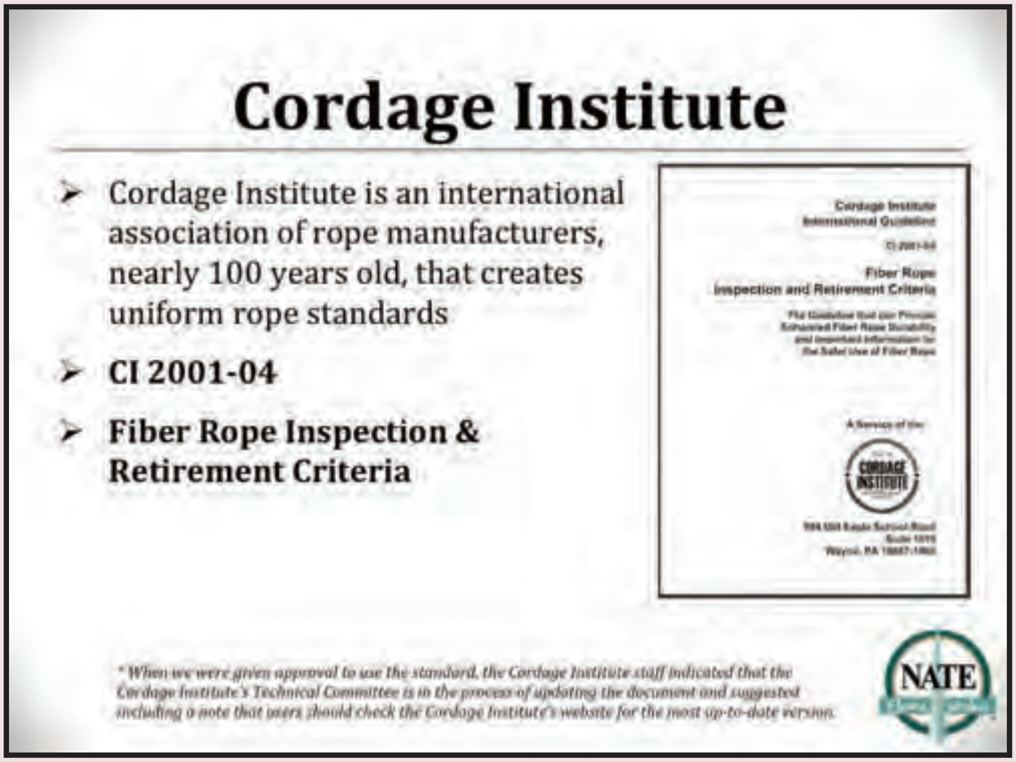
Answer: 770 Lbs.

For Ropes, is 10% of the (MBS) minimum breaking strength, 10:1 Factor of Safety.



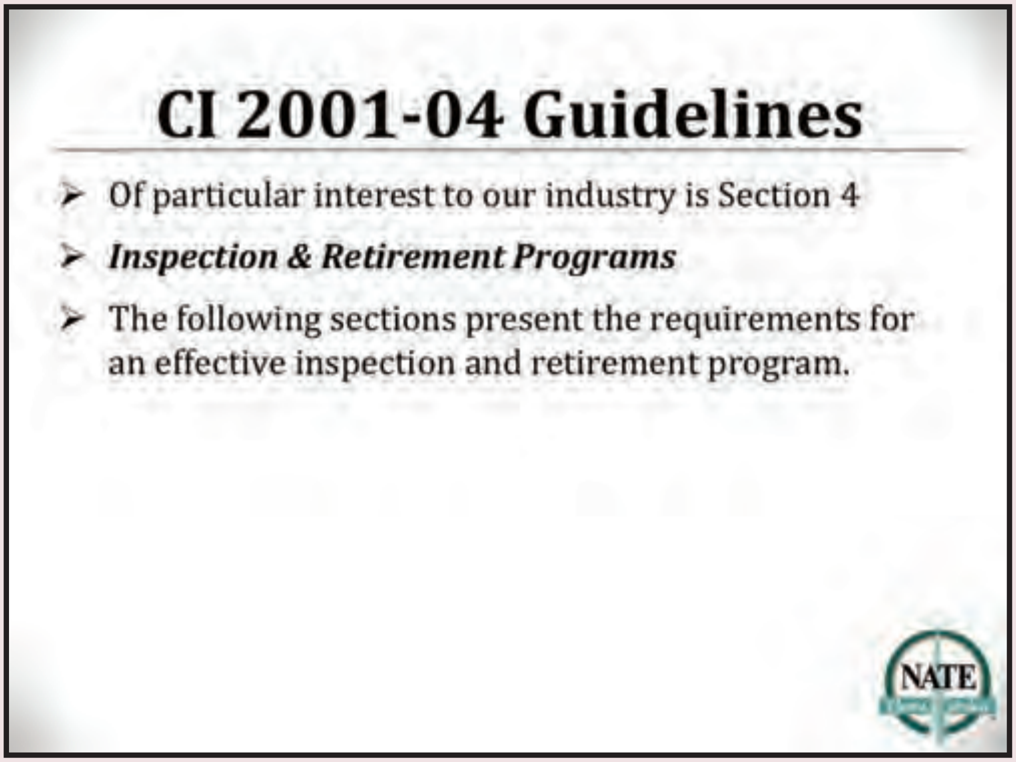
Instructor:

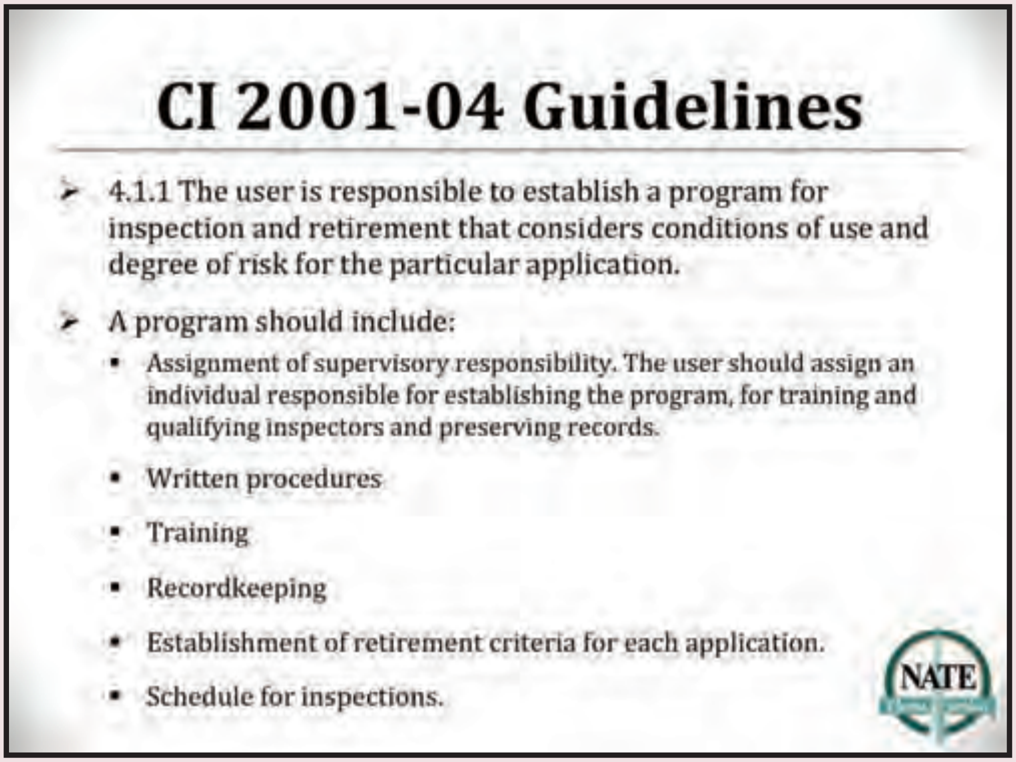
- Factory terminations are the best, normally maintain ~98% of the ropes capacity.
- Knots may reduce rope capacity by ~50%.
- The additional friction and twisting at the point of the knot reduce the MBS of the rope.
- The decrease in strength can be irreversible, depending on the stress applied to the twisted fibers. This provides even more reason for a thorough inspection of your ropes before each use.
- Ropes terminated with a Termination Plate de-rates capacity by 10-15%.

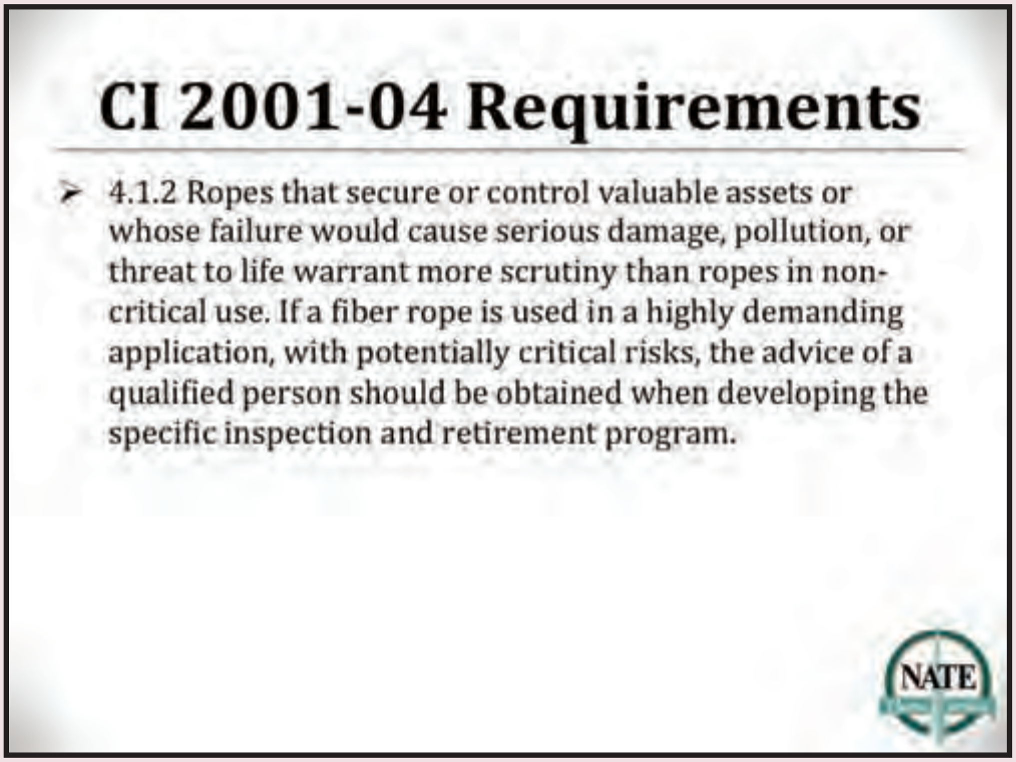


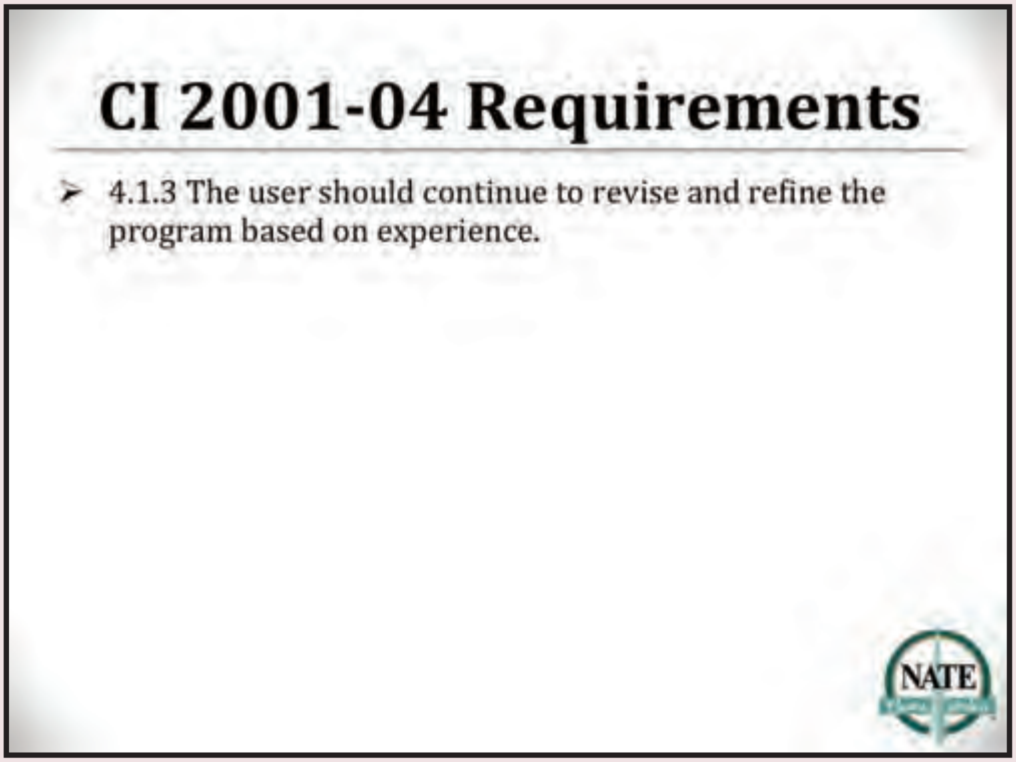
Instructor:

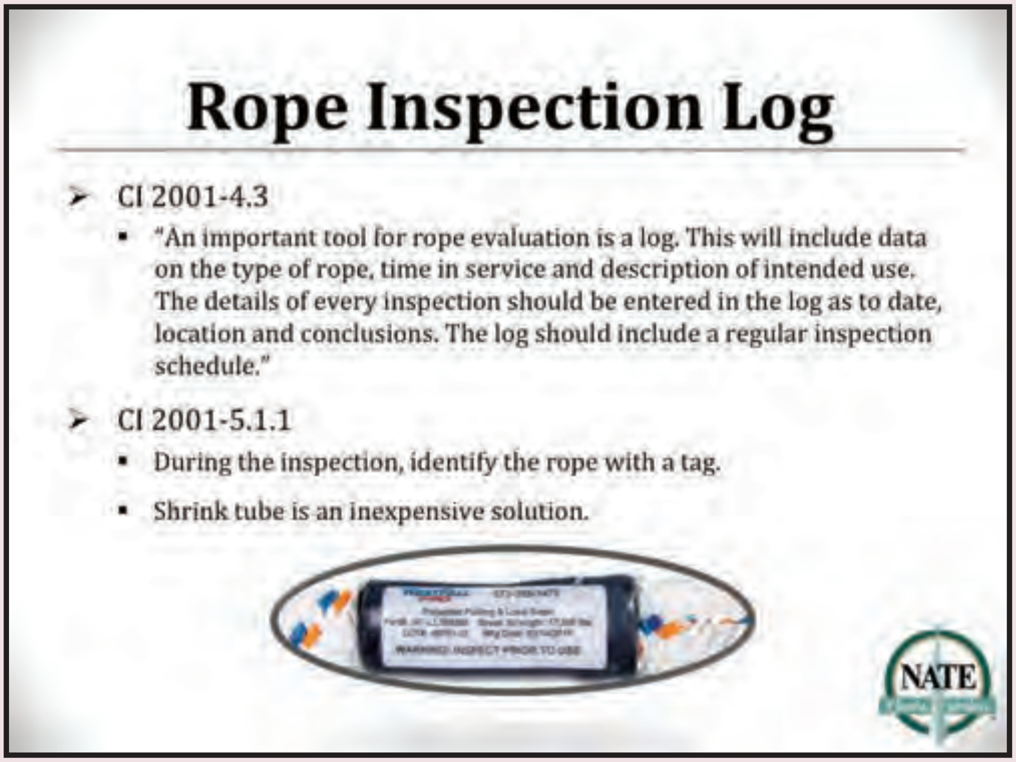
** CI 2001-04 Fiber Rope Inspection & Retirement Criteria located in Appendix for reference.*


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.
NATE


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
Recordkeeping
Establishment of retirement criteria for each application.
Schedule for inspections.
NATE


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.
NATE

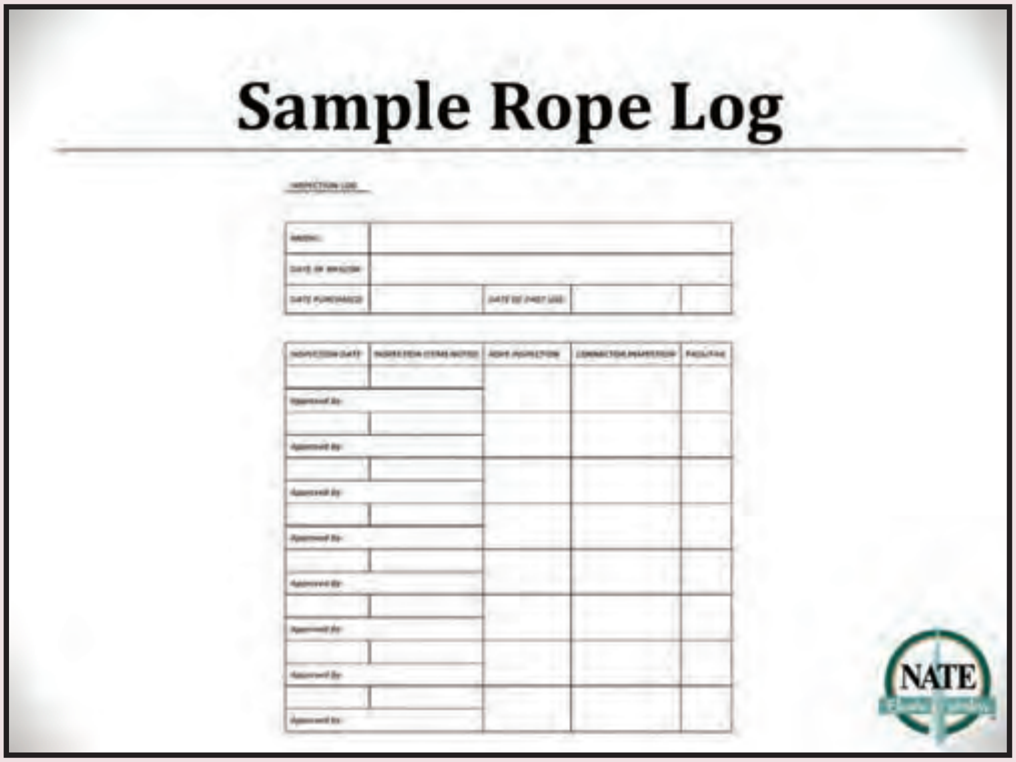

CI 2001-04 Requirements
➢ 4.1.3 The user should continue to revise and refine the program based on experience.



Instructor:

You can't keep and inspection log if you don't have a system to identify your ropes. Therefore, rope tags are an important part of your inspection program.

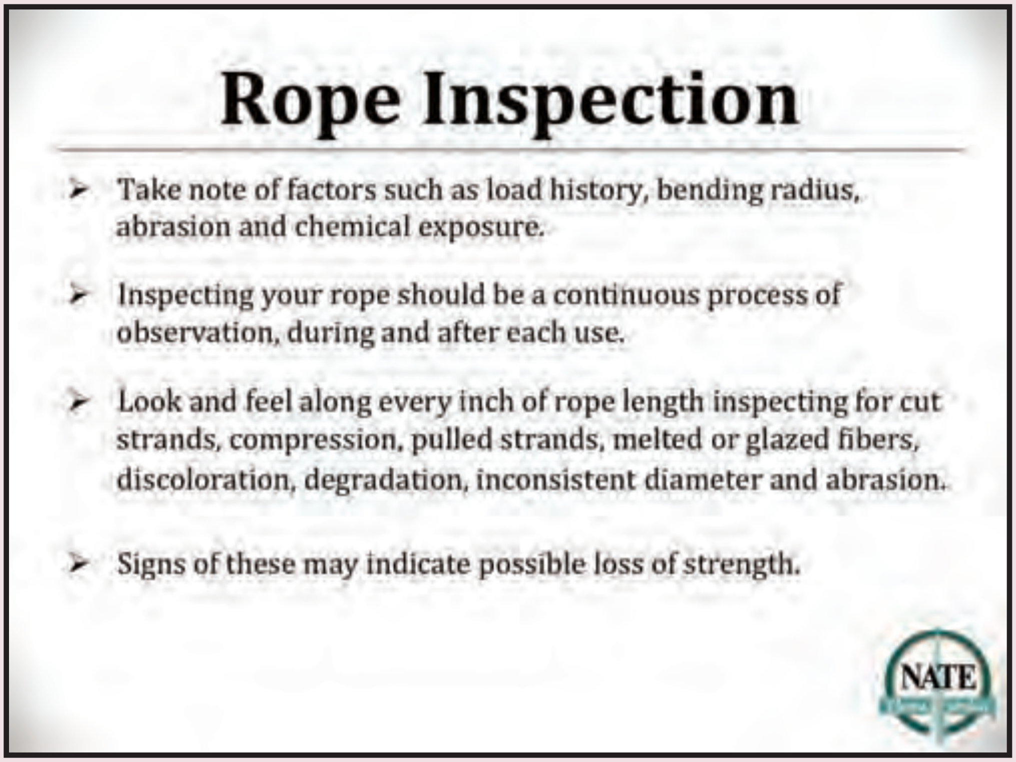
Ropes can be purchased from the factory with a tag, or shrink tube can be used to create your own labeling system.



Instructor:

Pictured is a sample inspection log. Point out to students the importance of capturing the model number, date of manufacturing, assign a unique serial number, date of purchase, and date of use. This aids in knowing the rope so that the proper of use of the rope can be maintained.


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
NATE



Instructor:

You can't keep and inspection log if you don't have a system to identify your ropes. Therefore, rope tags are an important part of your inspection program.

Ropes can be purchased from the factory with a tag, or shrink tube can be used to create your own labeling system.

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.

NATE

Rope Inspections

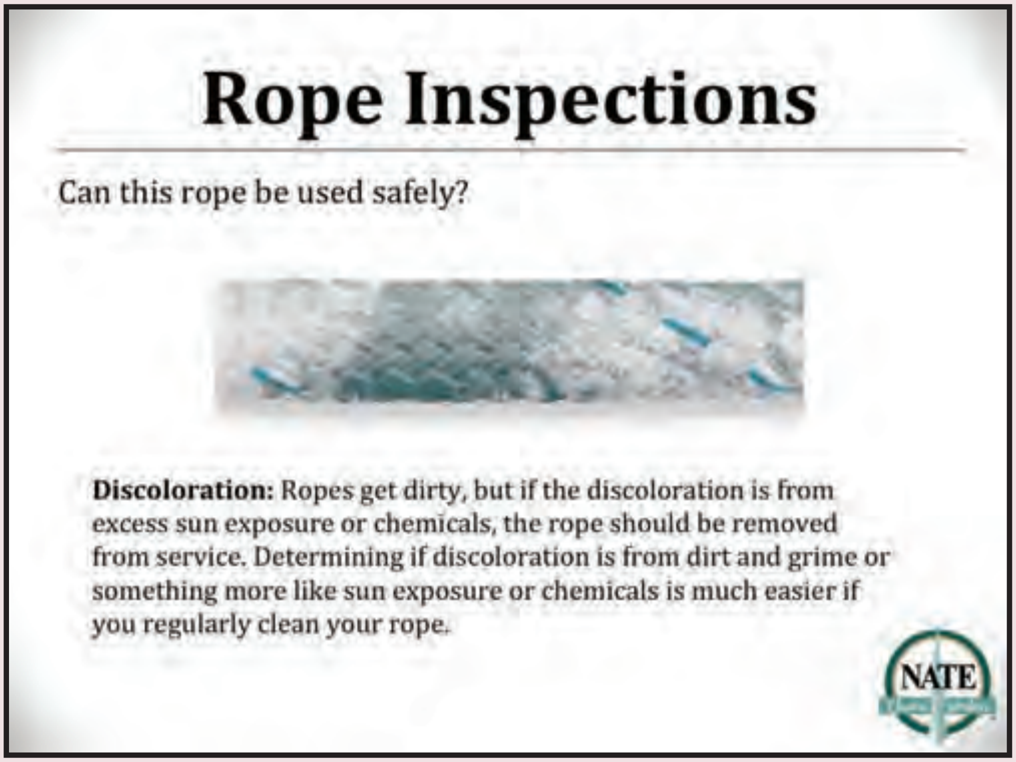
Can this rope be used safely?

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

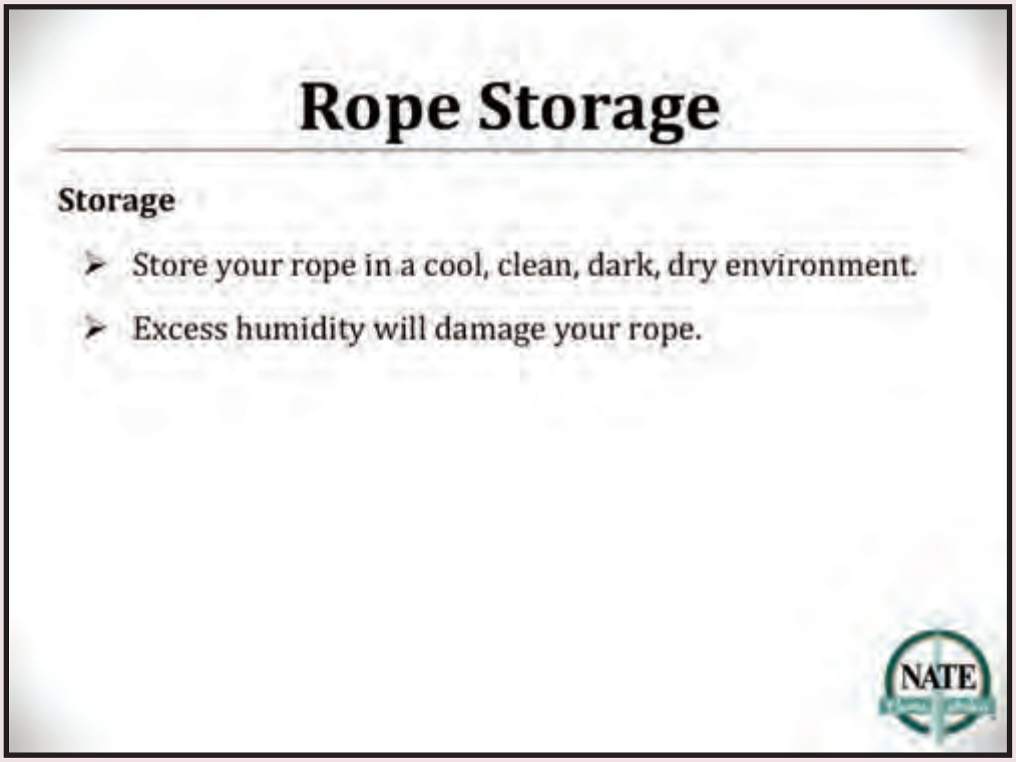
Can this rope be used safely?

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.
NATE

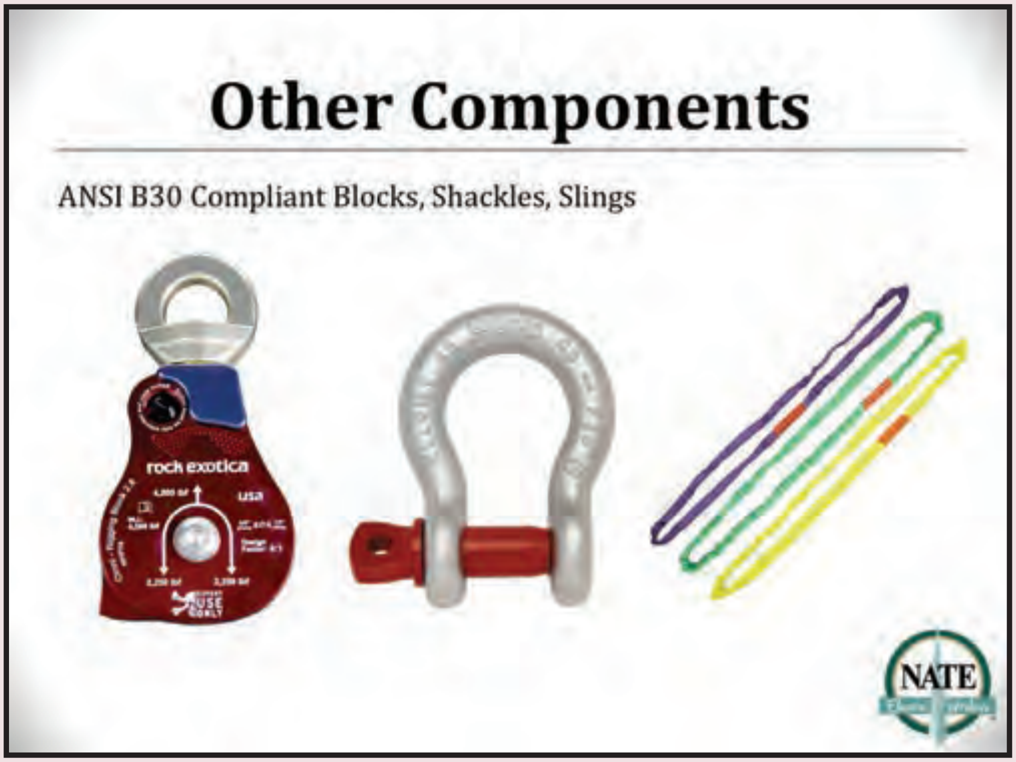
Instructor:

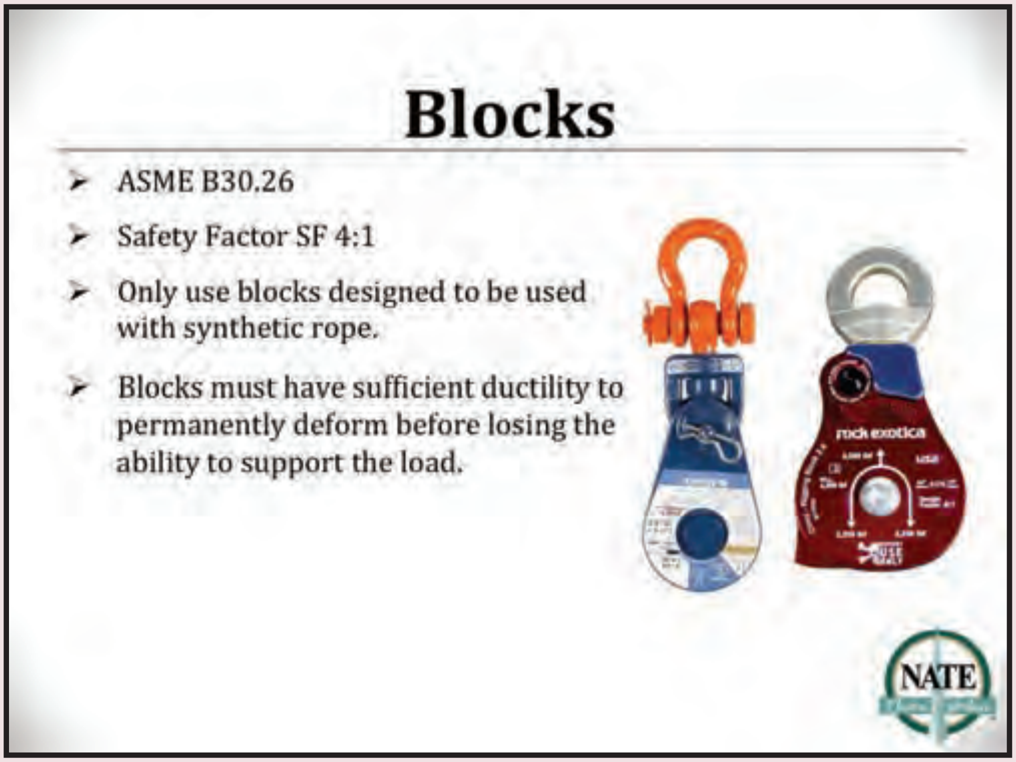
- Take care of your rope.
- Proper use, care, and storage of your rope prolongs its use.
- Don’t let your rope touch the ground.



Instructor:

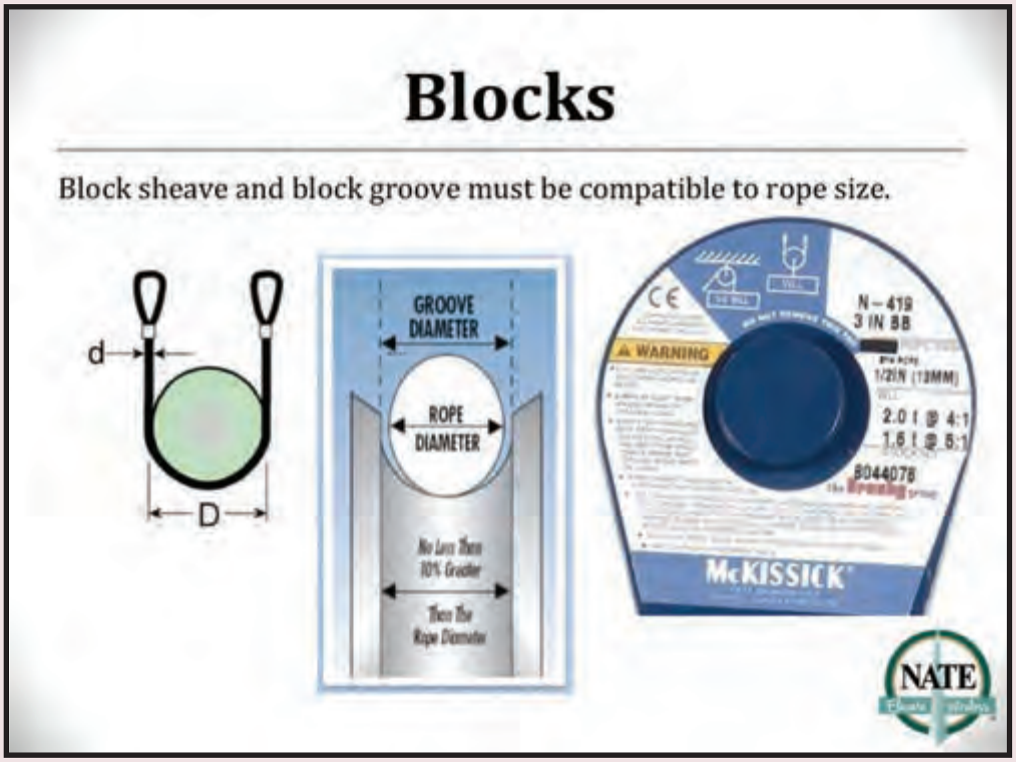
- Ropes should be stored away from dirt, moisture, and sunlight.
- Introducing excessive sediment into your ropes imparts additional friction points which speed up fiber degradation and can contribute to strength reduction.
- Excessive moisture can result in mold.
- The risk of this varies by textile, but avoidance is a best practice unless the rope was intended for extended use in wet environments.
- UV rays degrade fiber strength over time. Storing your ropes out of the sun will extend their lifetime.


Other Components
ANSI B30 Compliant Blocks, Shackles, Slings
rock exotica
usa
NATE



Instructor:

ASME B30, Chapter 26 defines standards for Shackles, Turnbuckles, U-bolts, and Blocks.



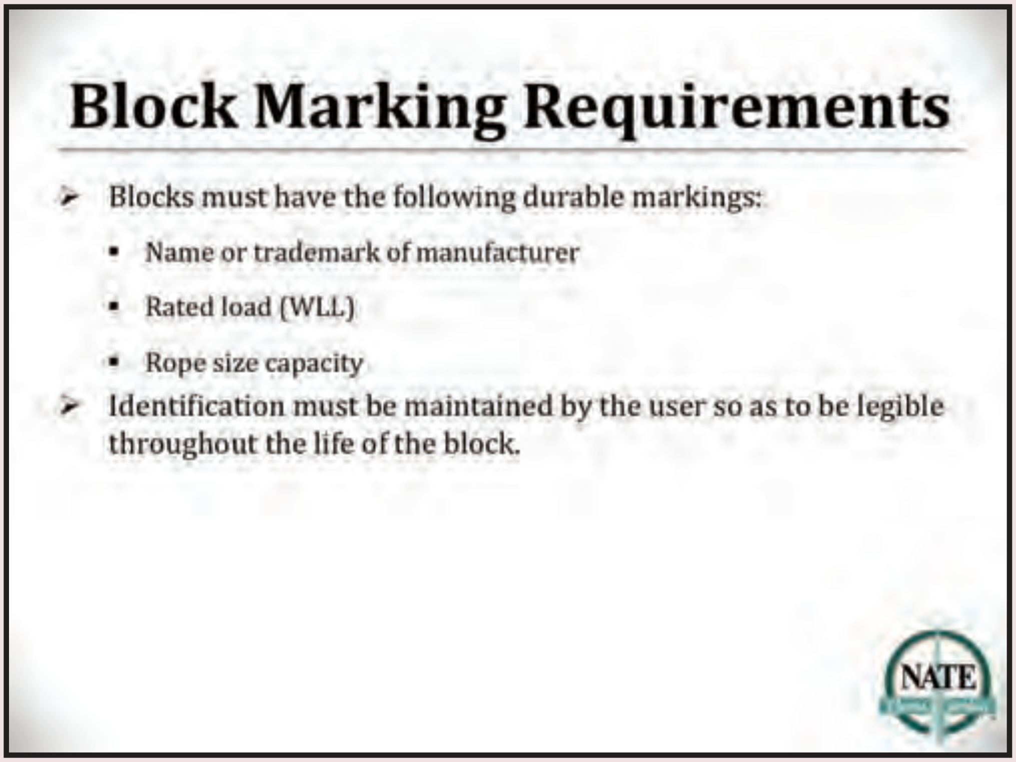
Instructor:

- The diameter of the sheave effects the WLL of the rope.
- The A10.48 requirement for double braid and kernmantle rope is 6:1, while the requirement for three-strand ropes is 10:1.
- The measure used to evaluate compatibility is the diameter:diameter (D:d) ratio.
- It is important to note that this is not a comparison between the inner diameter of the sheave and the diameter of the rope.
- The ratio is based on the measurement from center of synthetic rope to center of synthetic rope when dropping from a 90 degree angle over the sheave.
- A synthetic rope block/pulley which is compliant with the ASME B30.26 standard is required to visibly display rope diameter capacity as pictured above.
- Sheaves which have roller bearings, and are sealed, are the best. Don't require greasing, lower friction.
- Block groove should be designed for use with rope, and not be less than 10% greater than the rope diameter. Improper groove profiles will damage your rope.

Instructor:

Do not use any of the following-

- Handline blocks are not ASME B30 compliant, and are not to be used when lifting loads with a capstan.
- Import blocks that are designed to be used with wire rope, not synthetic rope.
- Any block that does not meet ASME B30 marking requirements.



Instructor:

In addition to the above, when using synthetic rope, it is important to only use blocks designed for synthetic rope. Blocks that are designed for synthetic rope will clearly say this on the label.

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 patter 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

NATE

Instructor:

Prior to each rigging application, ensure that the sling matches your lifting requirements by double checking the strength in the applicable configuration.

Instructor:

Users must carefully read the manufacturer's recommendations for use, care, and inspection.

Remove from service if any of the following are visible

1. A rated capacity tag is missing or illegible,
2. Exposure of red core warning yarn (for slings with red core yarn),
3. Broken or worn threads in the stitch patterns,
4. Knots in any part of the sling,
5. Chemical or heat damage,
6. Holes, cuts, or tears are present,
7. Any other visible damage which causes doubt as to the sling strength.

Instructor:

Illegible or Missing Tags – The information provided by the sling tag is important for knowing what sling to use and how it will function.

WHAT TO LOOK FOR: If you cannot find or read all of the information on a sling tag, the sling shall be taken out of service.

TO PREVENT: Never set loads down on top of slings or pull slings from beneath loads if there is any resistance. Load edges should never contact sling tags during the lift. Avoid paint or chemical contact with tags.

Instructor:

Knots compromise the strength of all slings by not allowing all fibers to contribute to the lift as designed.

WHAT TO LOOK FOR: Knots are rather obvious problems as shown here.

TO PREVENT: Never tie knots in slings and never use slings that are knotted.

Instructor:

Abrasion exposing internal core yarns.

WHAT TO LOOK FOR: Areas of the sling that look and feel fuzzy indicate that the fibers have been broken by being subject to contact and movement against a rough surface. Affected areas are usually discolored.

TO PREVENT: Never drag slings along the ground. Never pull slings from under loads that are resting on the sling. Use wear pads between slings and rough surface loads.


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.
NATE

Endless Synthetic Sling Chart

Part No.	Color	Rated Capacity (lbs.)* Vertical	Choker	Basket @ 90°	Basket @ 45°	Minimum Length (ft.)	Approximate Measurements Weight (lbs. / ft.)	Body Dia. Relaxed (in.)	(W) Width at Load (in.)	Minimum Hardware Dia. ** (in.)
EN30	Purple	2,600	2,100	5,200	3,600	1 1/2	.2	5/8	1	7/16
EN60	Green	5,300	4,200	10,600	7,400	1 1/2	.3	7/8	1 3/8	5/8
EN90	Yellow	8,400	6,700	16,800	11,800	3	.5	1 1/8	1 3/4	3/4
EN120	Tan	10,600	8,500	21,200	14,000	3	.6	1 1/8	1 7/8	7/8
EN150	Red	13,200	10,600	26,400	18,000	3	.8	1 3/8	2	1
EN180	White	16,800	13,400	33,600	23,000	3	.9	1 3/8	2 1/8	1 1/8
EN240	Blue	21,200	17,000	42,400	29,000	3	1.3	1 3/4	2 5/8	1 3/16
EN360	Grey	31,000	24,800	62,000	43,000	3	1.7	2 1/4	3 1/4	1 1/2
EN600	Brown	53,000	42,400	106,000	74,000	6	2.8	2 3/4	4	2
EN800	Olive	66,000	52,800	132,000	93,000	6	3.4	3 1/8	4 5/8	2 1/8
EN1000	Black	90,000	72,000	180,000	127,000	6	4.3	3 5/8	5 1/4	2 1/2

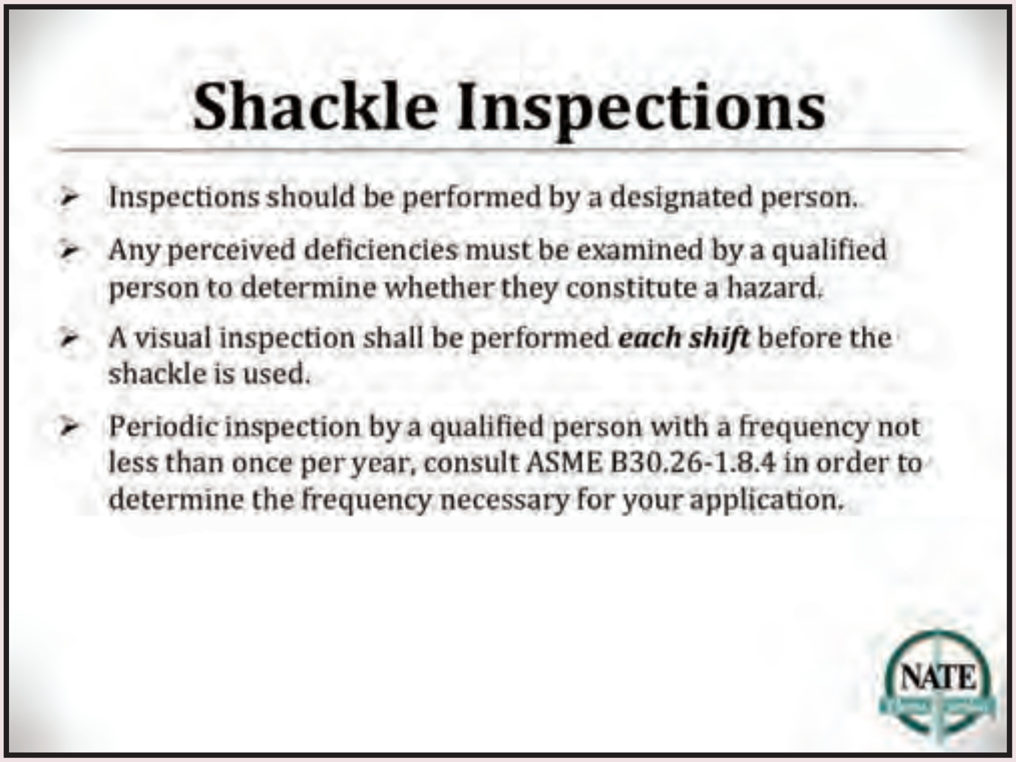
The outer jacket of the sling is for protection of the material that is actually providing the sling's capacity.

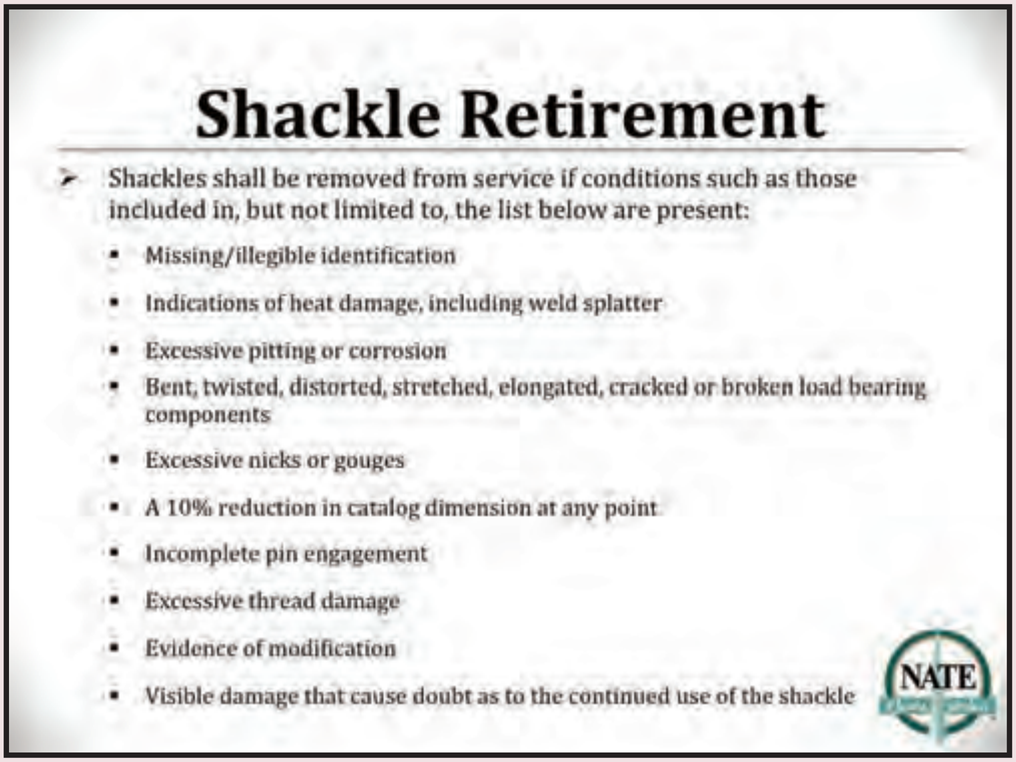
NATE

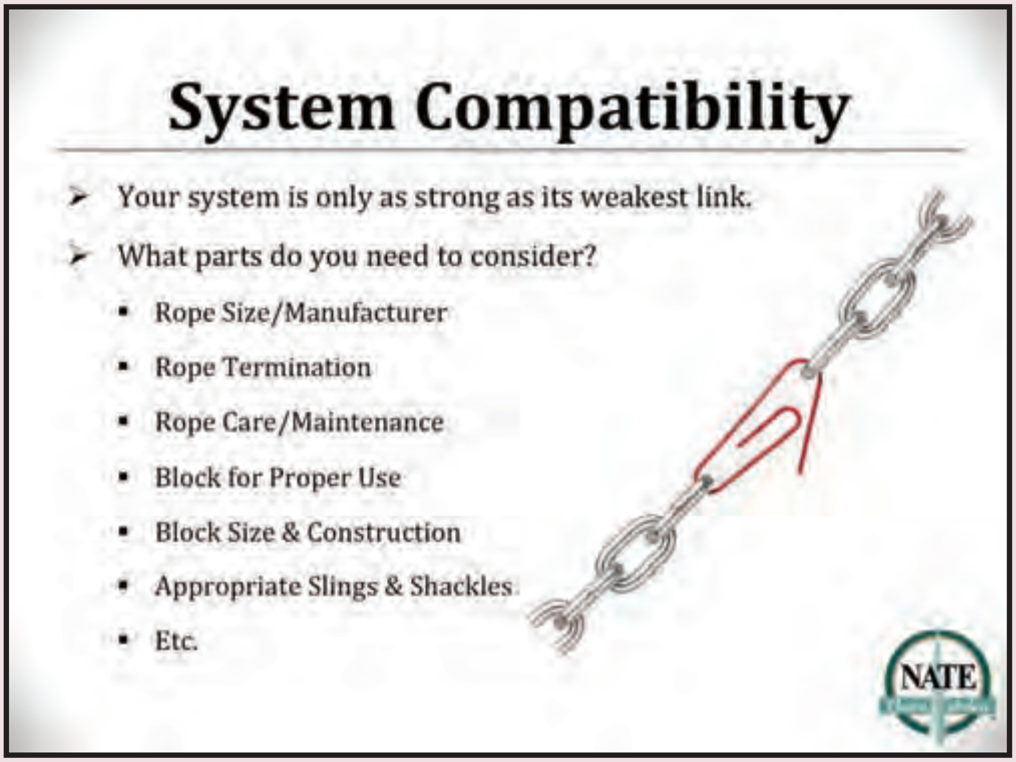
Shackle Marking Requirements

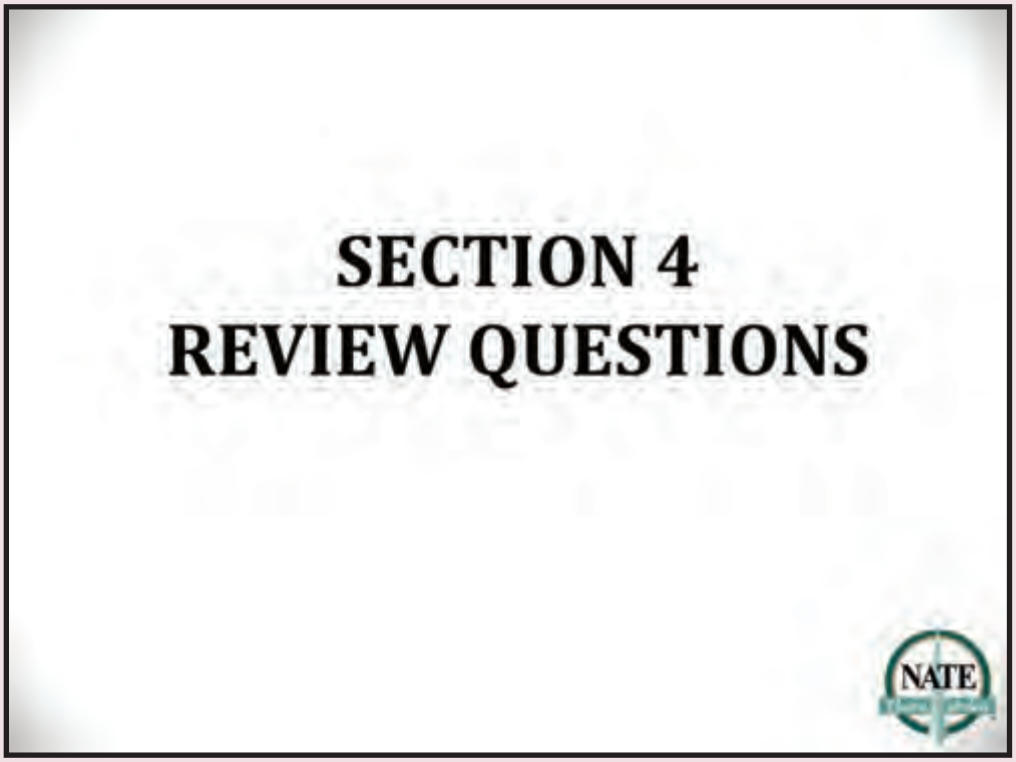
Per ASME B30.26, each shackle shall have:

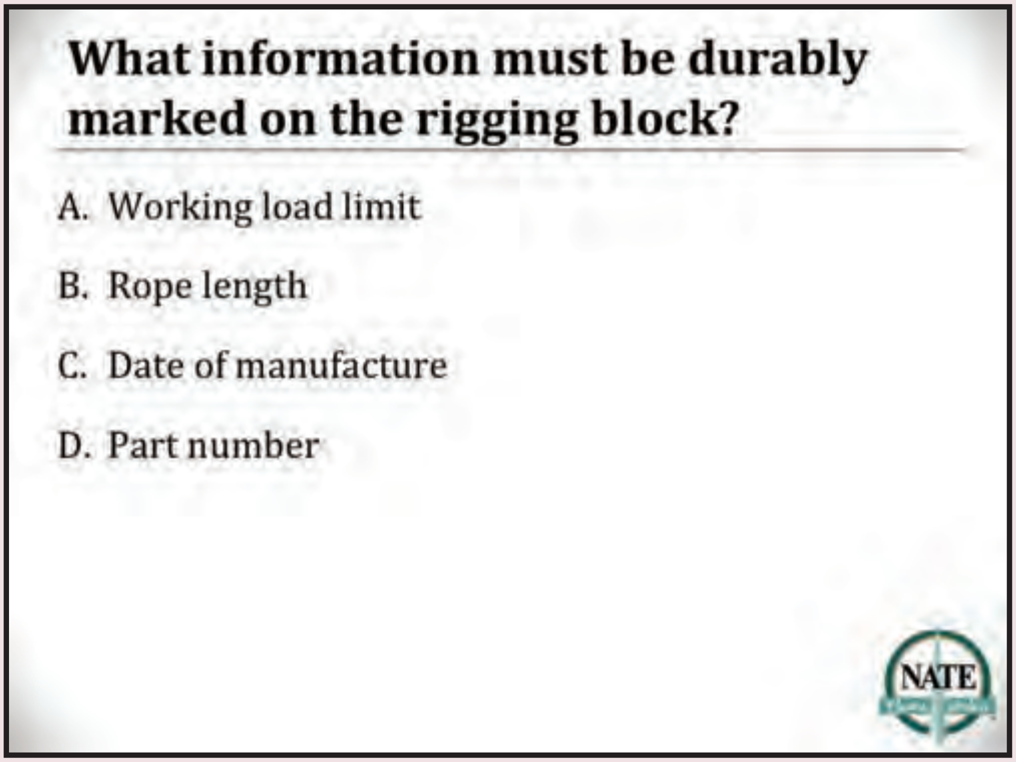
- Safety Factor SF 5:1
- Shackle must have sufficient ductility to permanently deform before losing the ability to support the load
  - Markings on shackle body
  - Name or trademark of manufacturer
  - Rated load
  - Size
- Marking on Shackle Pin
  - Name or trademark of manufacturer
  - Grade, material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


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
NATE


System Compatibility
Your system is only as strong as its weakest link.
What parts do 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
NATE



Answer: A (Working load limit)

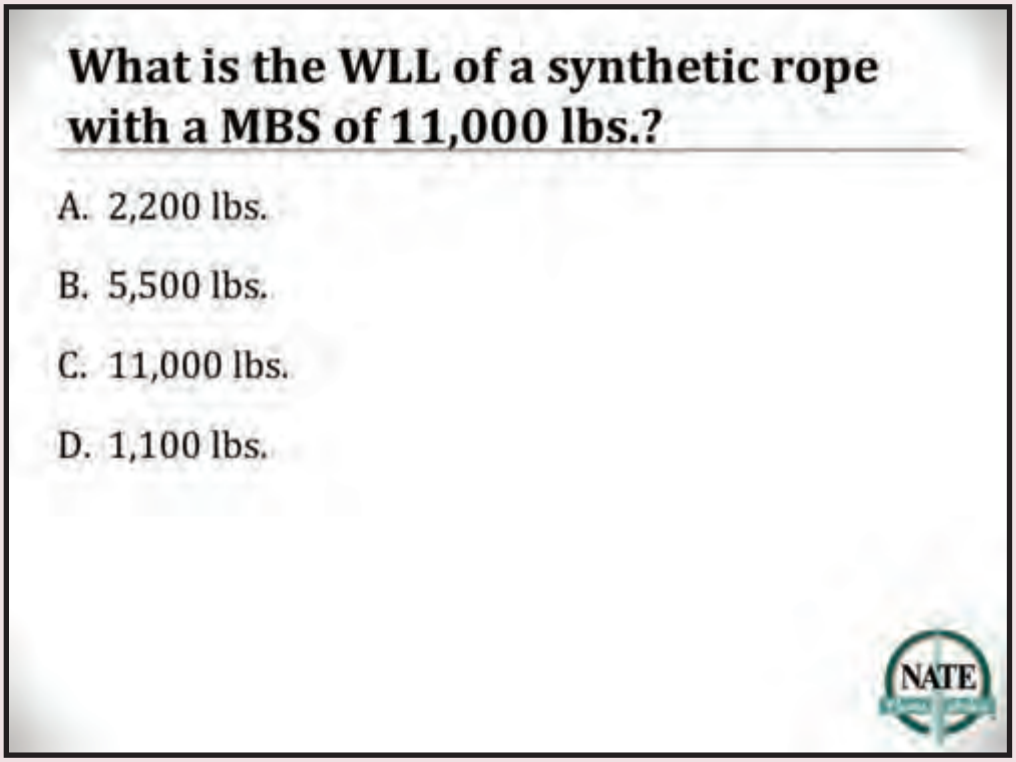
ASME B30.26 requires the following markings:

*Name or trademark of manufacturer

*Rated load

*Rope size capacity

Also, Identification must be maintained by the user so as to be legible throughout the life of the block.

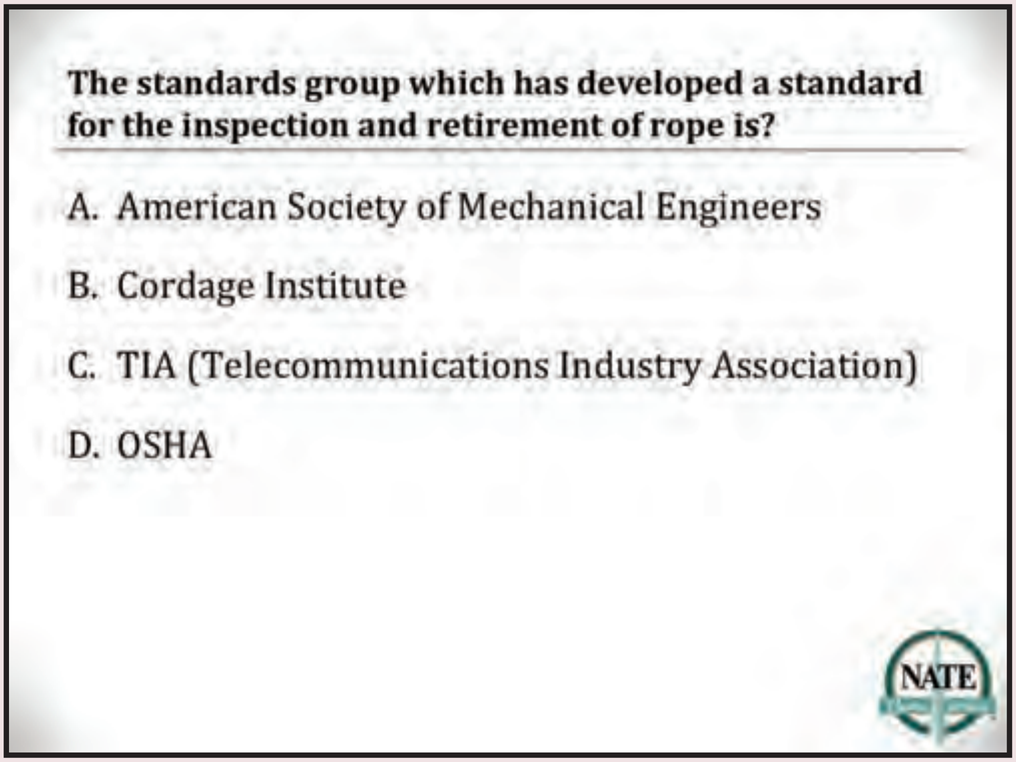


Answer: D (1,100 lbs.)

(WLL) For Ropes, is 10% of the (MBS) minimum breaking strength

ANSWER: C (Clean, dark, dry location)

Proper storage of your rope is critical for its continued lifespan. Store your rope in a cool, clean, dark, dry environment. Excess humidity will damage your rope.



ANSWER: B (Cordage Institute)

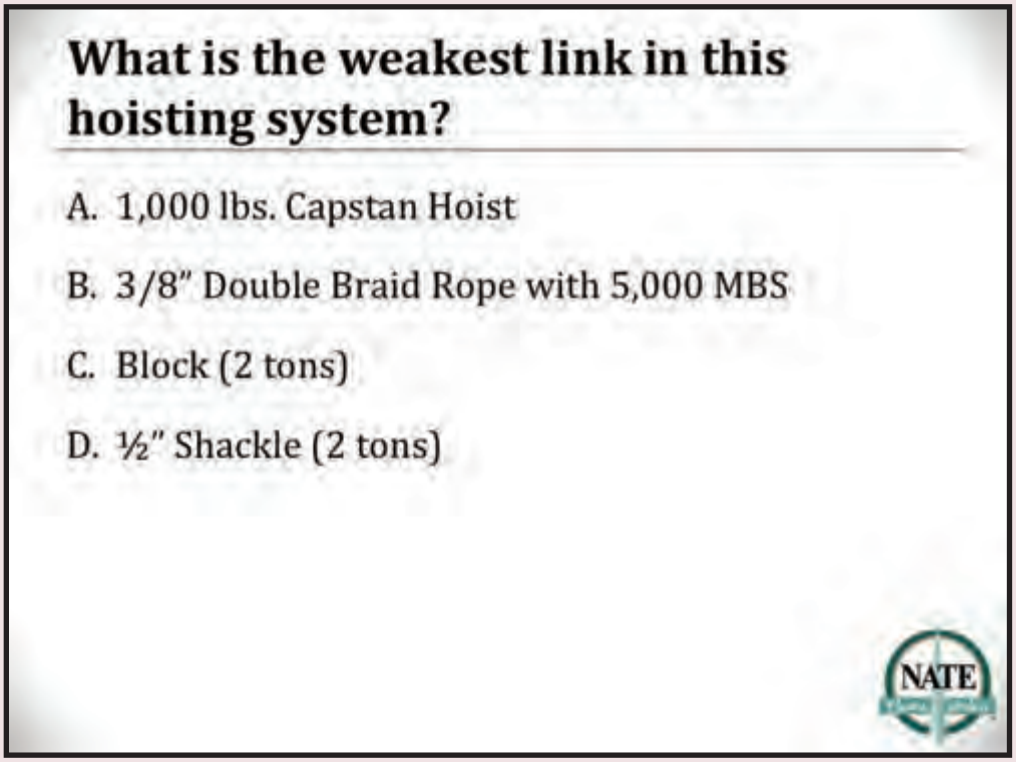
The Cordage Institute is an international association of rope manufacturers, nearly 100 years old, that creates uniform rope standards.

Answer: D (Dirt causes internal friction and weakens rope)

Keep your ropes clean, and free from debris.

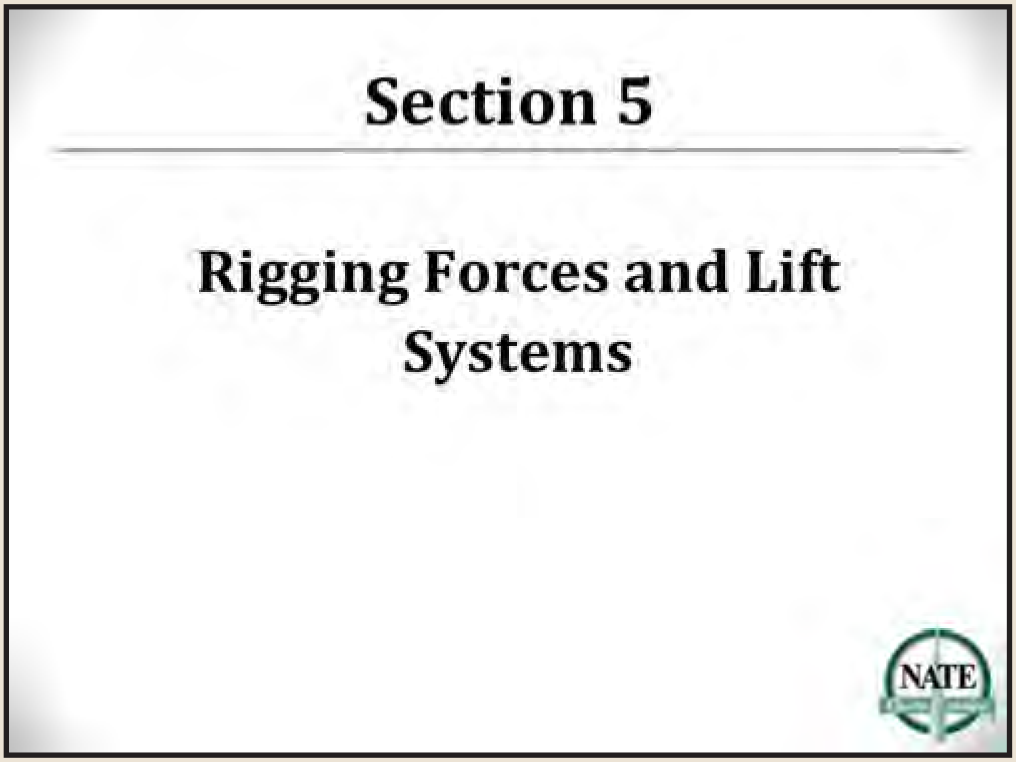
Answer: A (Date of Manufacturing)

It's important to capture the following on a rope log: the model number, date of manufacturing, assign a unique serial number, date of purchase, and date of use. This aids in knowing the rope so that the proper of use of the rope can be maintained. Refer to the sample rope log.



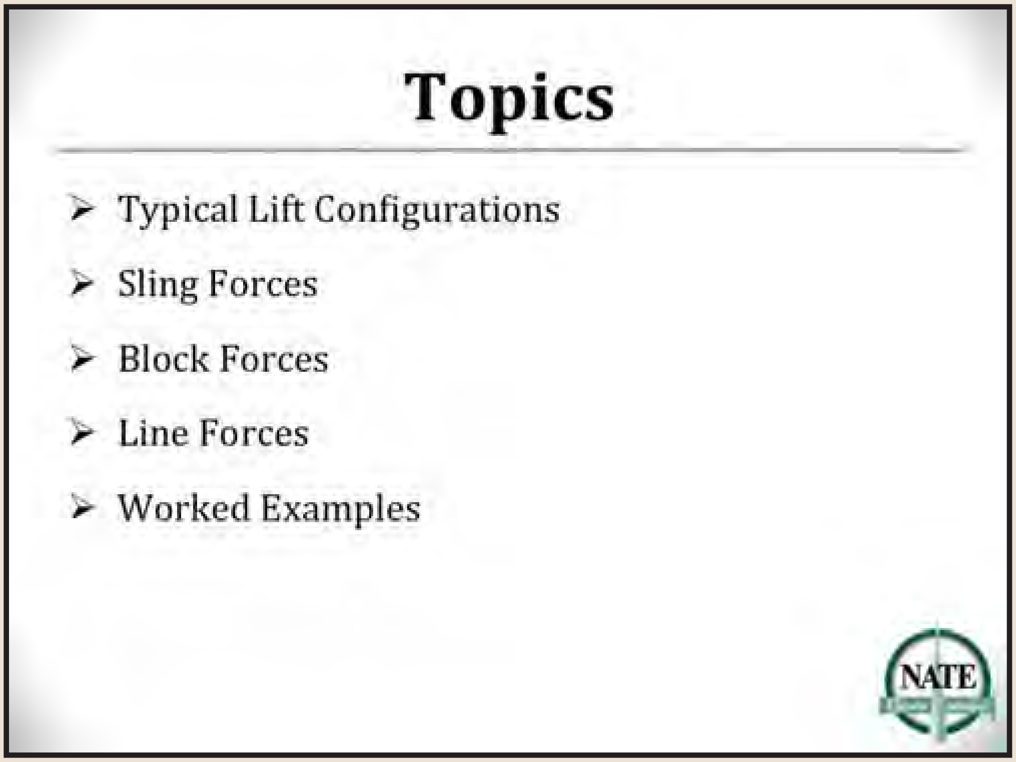
Answer: B (3/8" Double Braid Rope with 5,000 MBS)

Your system is only as strong as its weakest link. A 3/8" rope with a 5,000 MBS would have a WLL of 500 lbs.



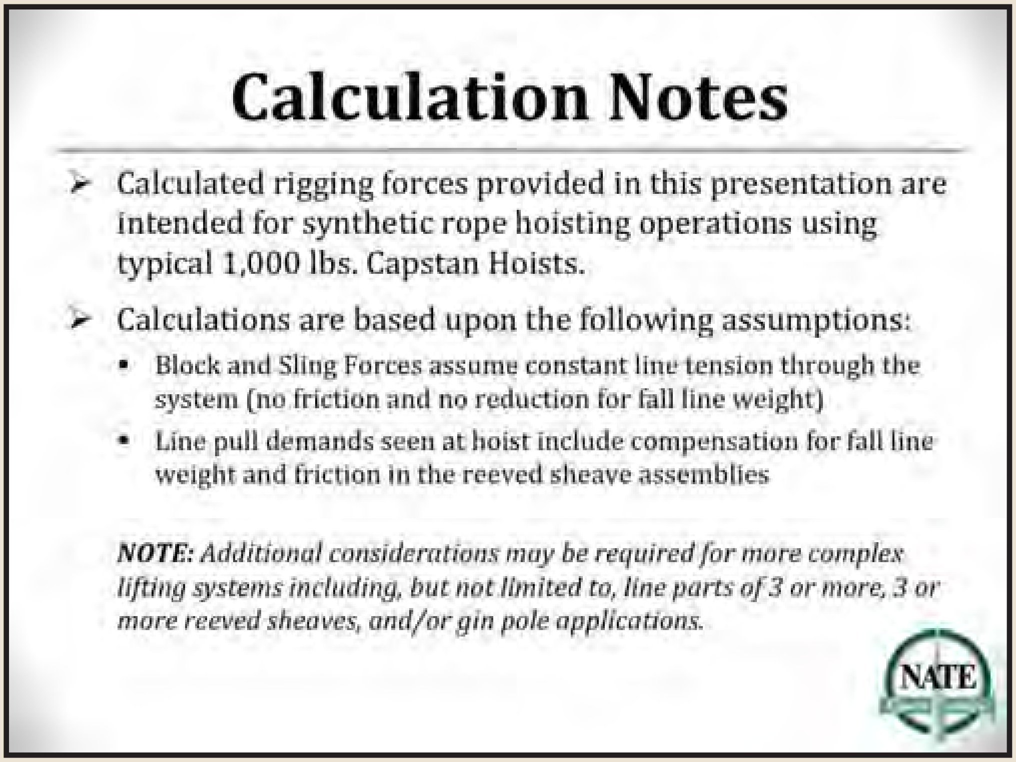
(45 minute lunch break — 11:30 - 12:15)

(Plan on 2 hours and 45 minutes (165 minutes) — 12:15 - 3:00 — 15 minute break after Section 5)



Instructor:

- Emphasize this section covers how rigging forces are developed and transferred between components of the rigging system.
  - This section does NOT address the strength or applicable work load limits of the individual rigging components.
  - For strength considerations, refer to the 2018 Rigger Awareness Training.

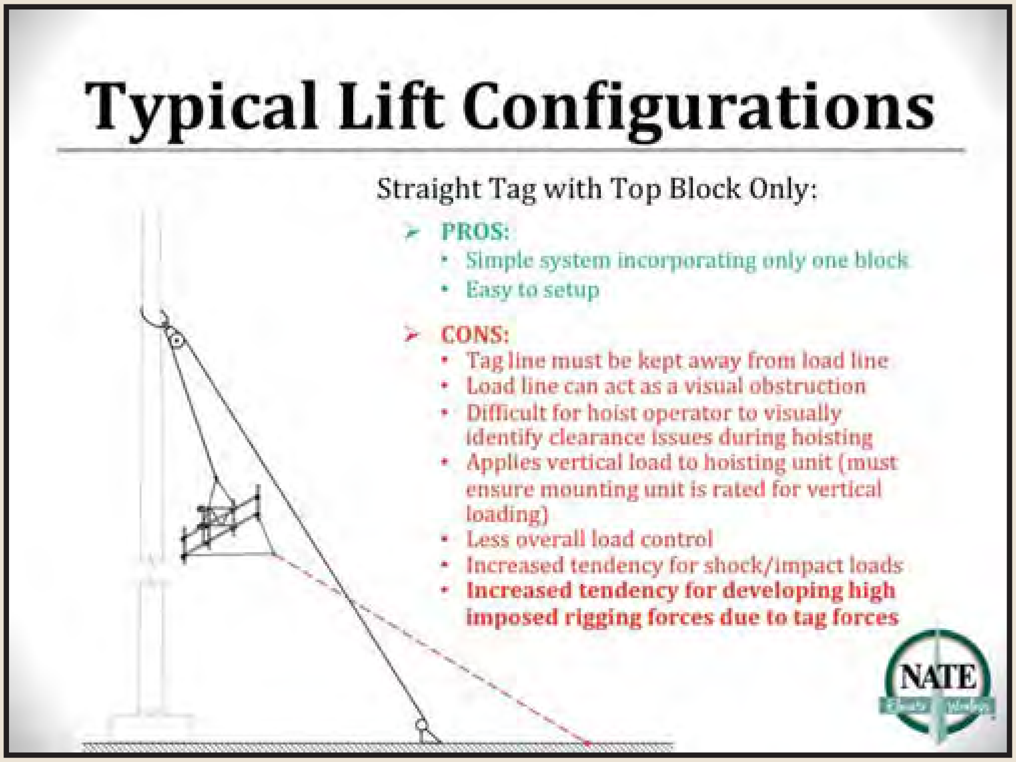


Instructor:

- Emphasize calculations presented in this section are intended for lightweight lifting applications using synthetic rope with 1,000 lbs. capstan hoists.
- Consult with a Qualified Person if you are unsure if a certain lifting arrangement requires additional considerations.

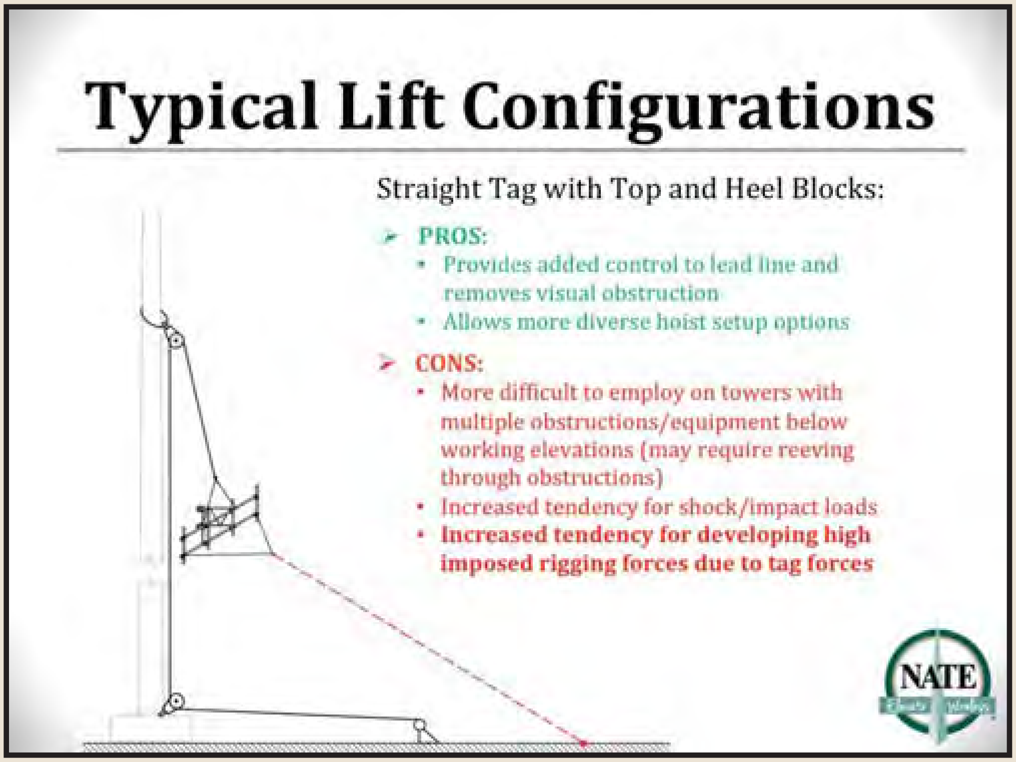
Instructor:

- Refer back to 2018 Rigger Awareness Training for further information regarding these lifting configurations.
- This training only introduces the basic rigging arrangements for these systems in order to identify the methods for evaluating the resulting rigging forces.



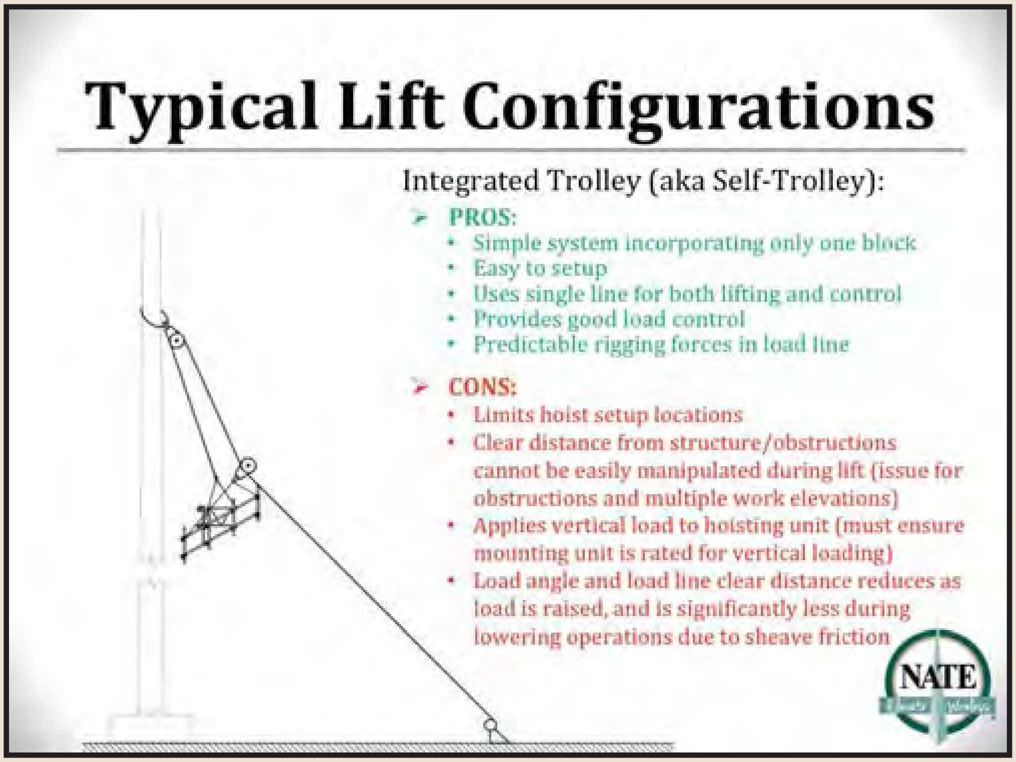
Instructor:

Identify general pro's and con's for this lifting system and discuss as a group potential scenarios where this would be a good choice or poor choice for the lifting system.



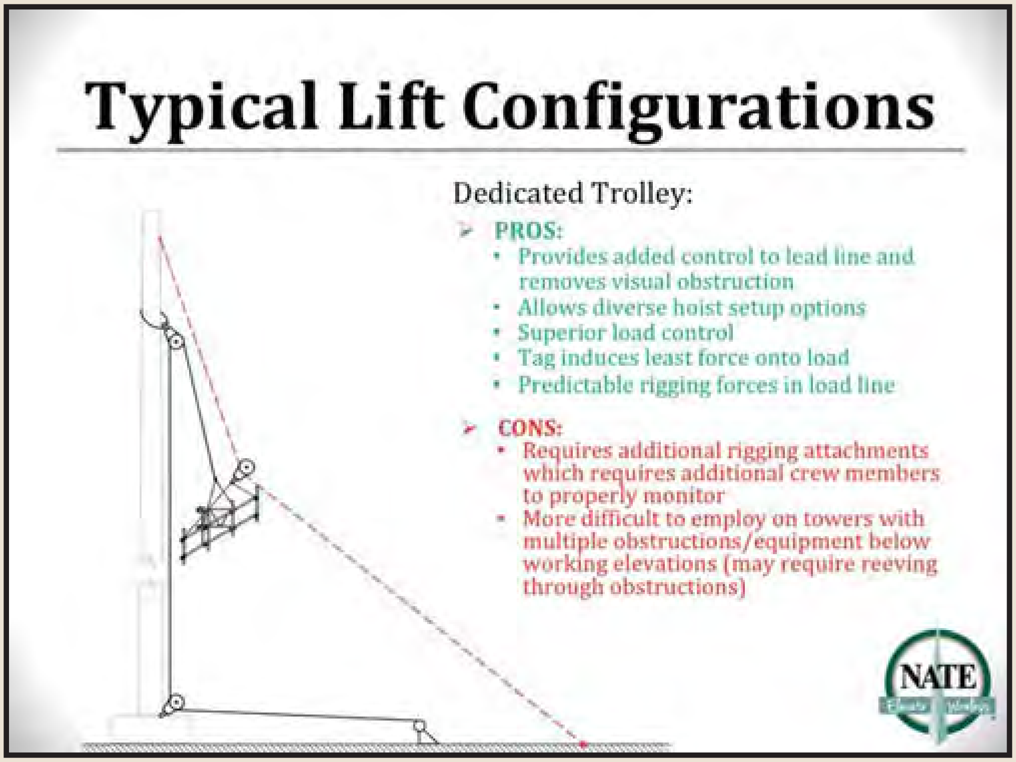
Instructor:

Identify general pro's and con's for this lifting system and discuss as a group potential scenarios where this would be a good choice or poor choice for the lifting system.



Instructor:

Identify general pro's and con's for this lifting system and discuss as a group potential scenarios where this would be a good choice or poor choice for the lifting system.



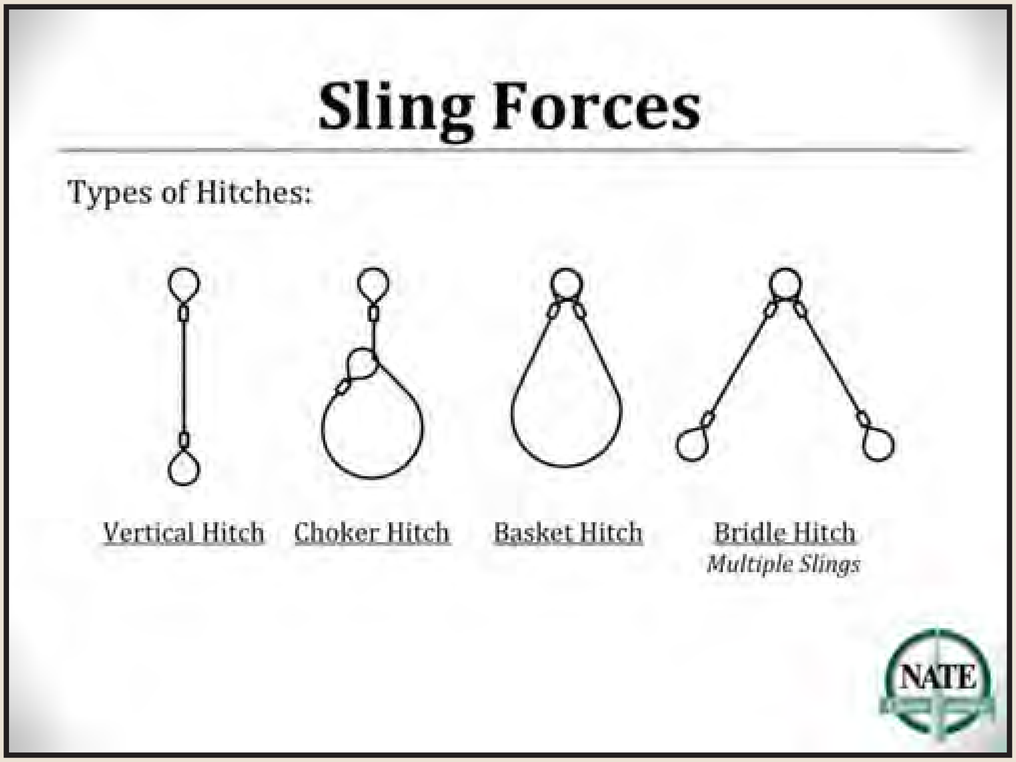
Instructor:

Identify general pro's and con's for this lifting system and discuss as a group potential scenarios where this would be a good choice or poor choice for the lifting system.

Instructor:

For typical hoisting scenarios, slings are utilized for attaching the rigging blocks to the supporting structure or anchorage point (e.g. rigging lugs at tower base).

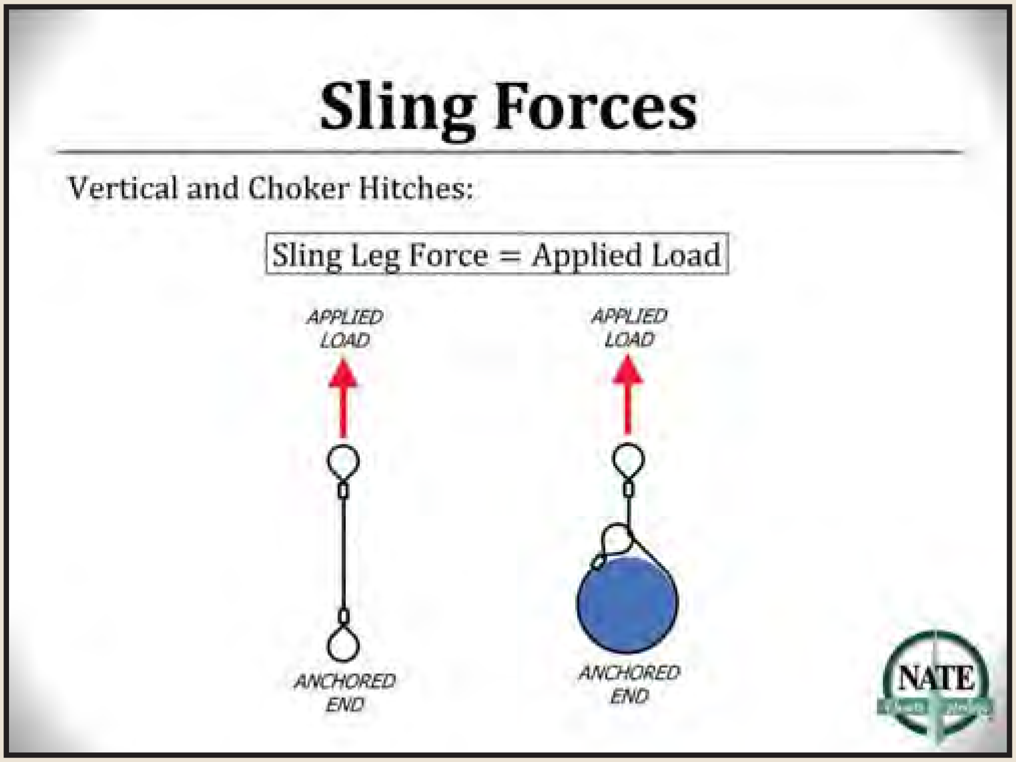
For block attachments, the applied load will equal the Block Force which will be covered later in this presentation.



Instructor:

Vertical, choker, and basket hitches consist of a single sling configured as shown.

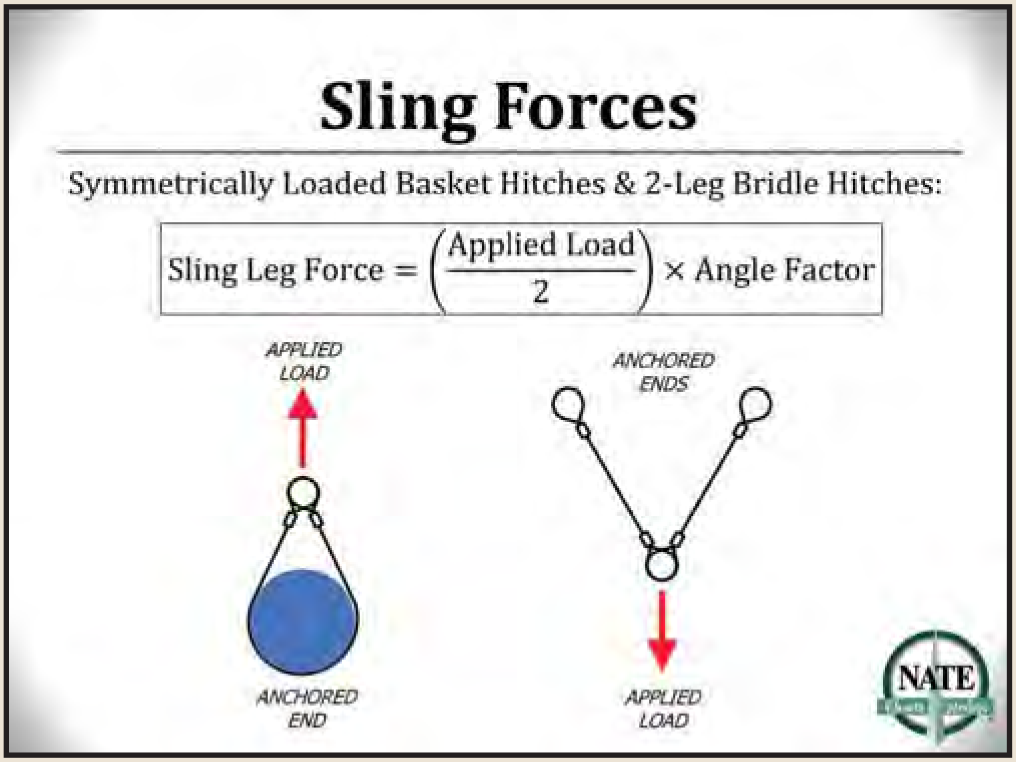
Bridle hitches utilizes two or more slings with the individual slings configured in either vertical, choker, or basket hitch arrangements.



Instructor:

Direct force transfer from loaded end of sling to anchored end of sling.

NOTE: The sling force should NOT be confused with sling strength. The sling's strength is reduced for choker hitches due to the sharp bend at the choked point.

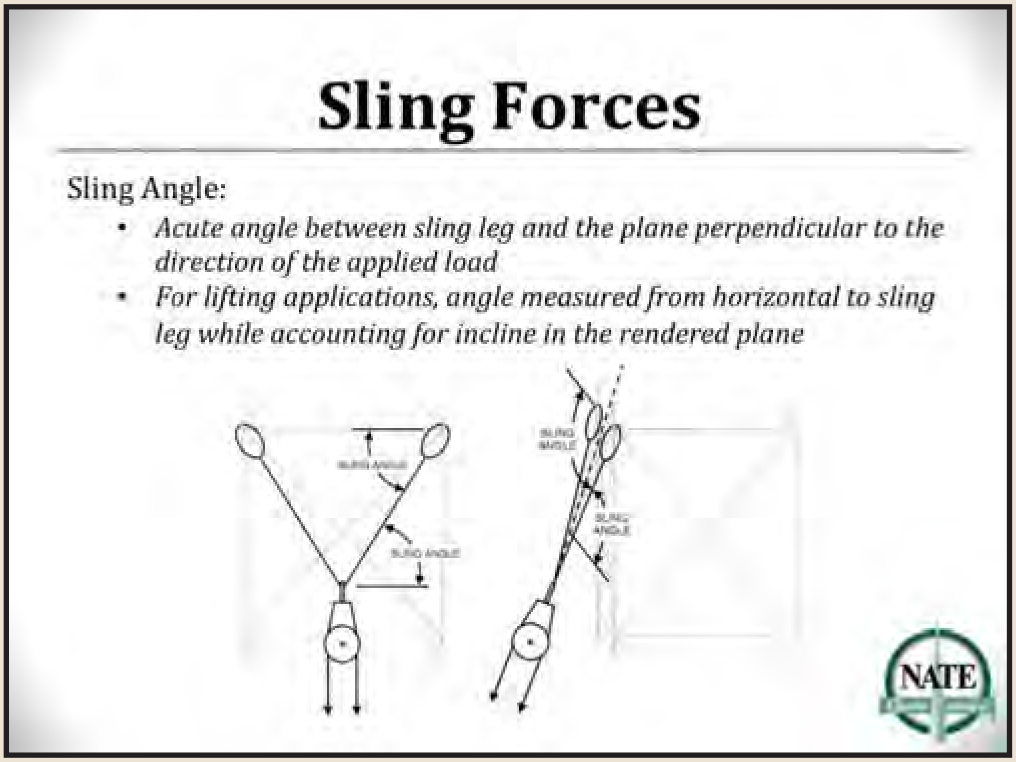


Instructor:

Note, this presentation is focused on normal hoisting operations, and the equation given only covers symmetrically loaded 2-leg bridle hitches (asymmetrically loaded bridles and bridles with 3 or more legs are not covered).

Applied load is shared between the two sling legs formed around the wrap.

For symmetrical basket hitch wrapped around a single member (e.g. tower leg or monopole shaft), the force transferred from loaded ends of the sling eyes to anchored end still equals the applied load as the resulting force components acting perpendicular to the applied load cancel.



Instructor:

- For lifting applications, the sling angle is measured from horizontal to the sling leg while accounting for incline in the rendered plane.
- Can measure from either horizontal DOWN to sling leg, or from horizontal UP to sling leg ~ congruent angles.

Instructor:

Relationship between sling angle and resulting sling force transitions from linear to exponential at 30°. This inflection point results in an Angle Factor of 2.0.

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

Instructor:

Standard references:

- ANSI/ASSE A10.48, Section 13.5.2, recommends a sling angle of 60 degrees as the goal, with 45 degrees representing the minimum where special attention is required.
- ASME B30.9, Section 9-1.10.1 (i) sets the minimum sling angle at 30°. Below 30° requires approval from the sling manufacturer or a qualified person.

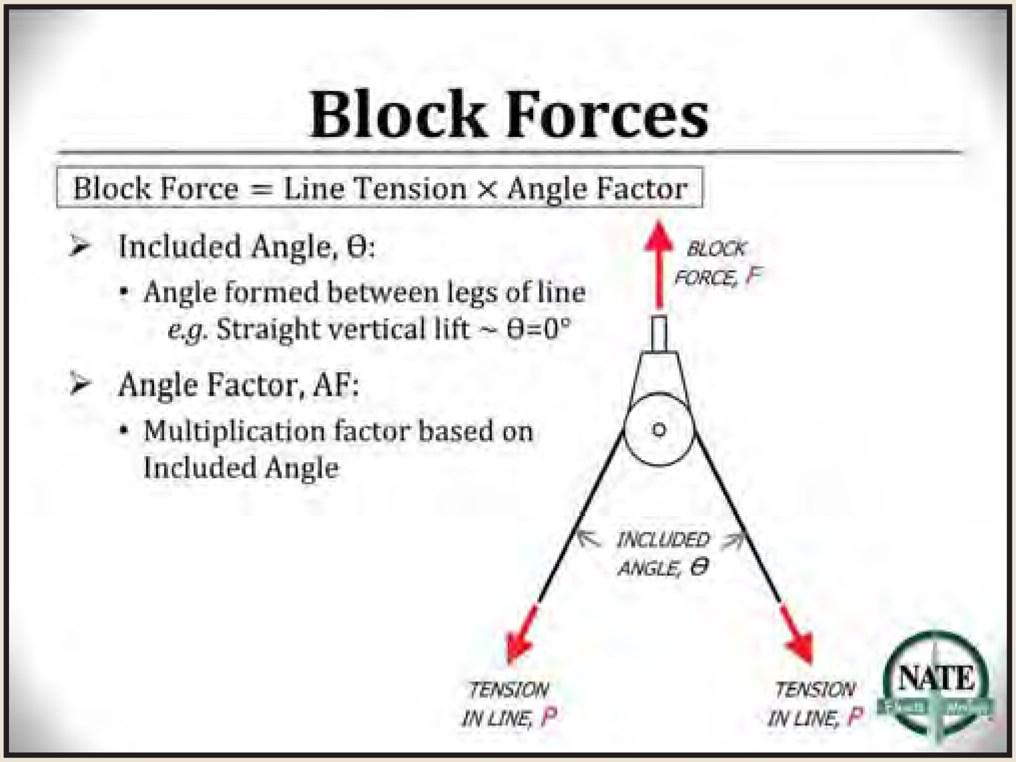
Recall previous slide depicting inflection point at 30° ~ this corresponds at the minimum angle setting under B30.9 without special review/approval.

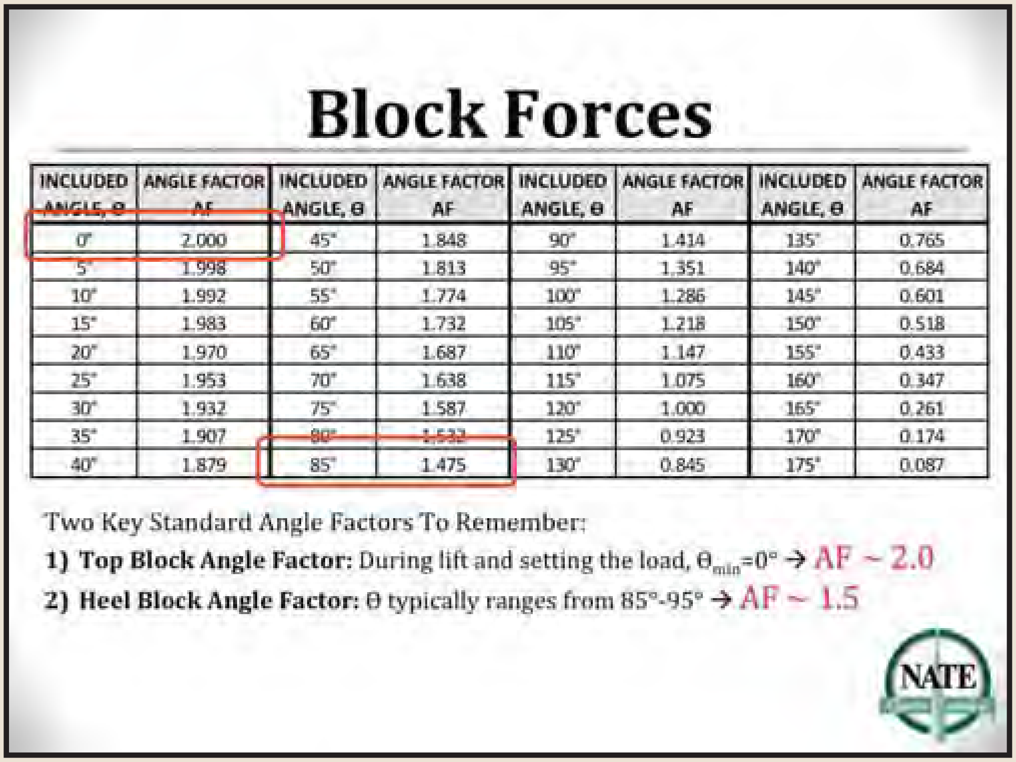
Note, while steeper sling angles reduce the force carried by the sling legs, they also result in less lateral stability for lifted loads. In general, sling angles should be set at 75° down to 45° to provide the greatest combination of strength and stability.

Instructor:

Rigging blocks used in a lifting system are generally categorized as a top/crown block, heel/base block, or diverter/fairlead block.

The forces developed on each type of block are calculated in the same manner.


Block Forces
Block Force = Line Tension × Angle Factor
➢ Included Angle, Θ:
• Angle formed between legs of line
e.g. Straight vertical lift ~ Θ=0°
➢ Angle Factor, AF:
• Multiplication factor based on Included Angle
BLOCK FORCE, F
INCLUDED ANGLE, Θ
TENSION IN LINE, P
TENSION IN LINE, P
NATE



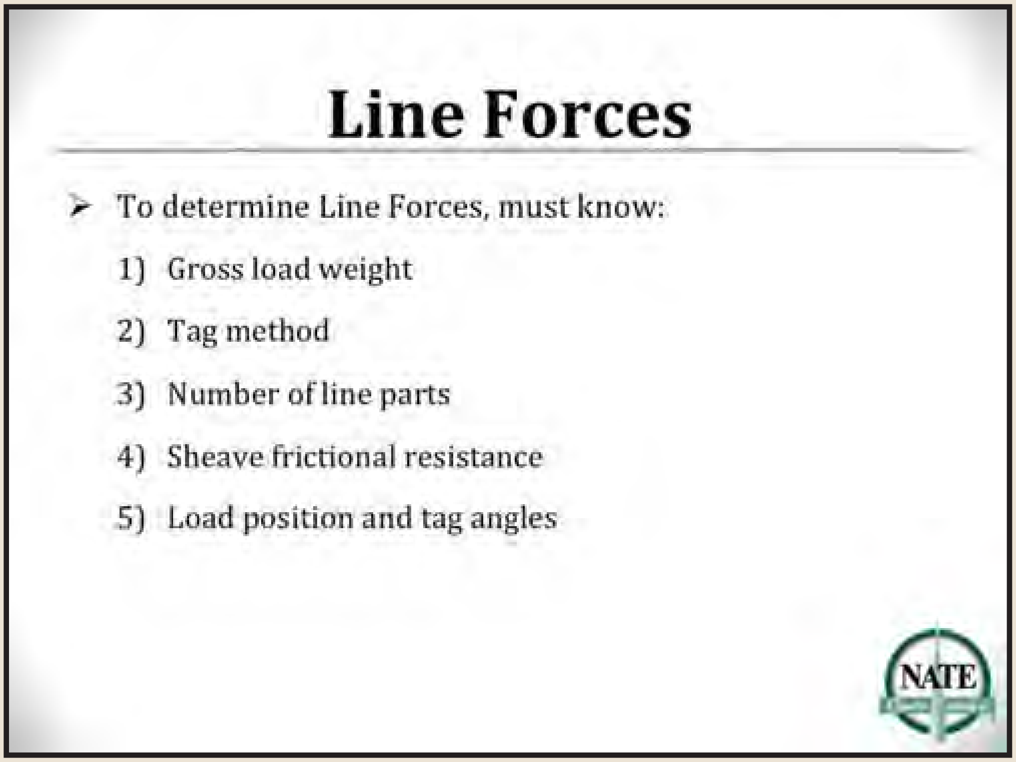
Block Forces

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:

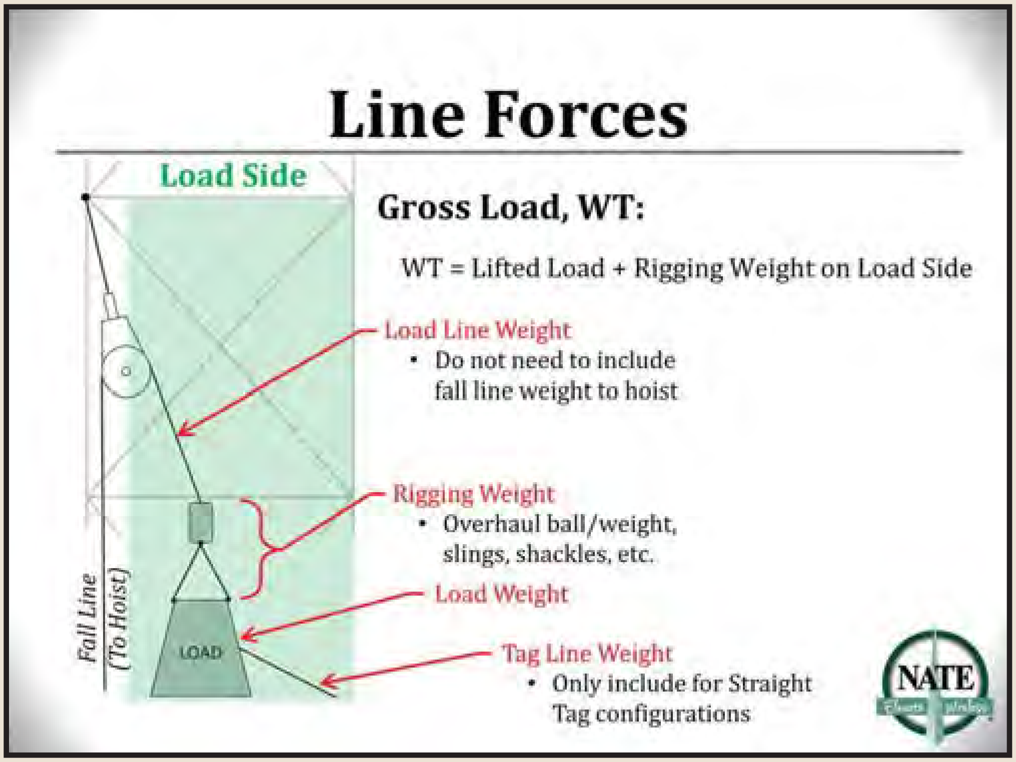
1) **Top Block Angle Factor:** During lift and setting the load, $\theta_{min}=0°$ → AF ~ 2.0

2) **Heel Block Angle Factor:** θ typically ranges from 85°-95° → AF ~ 1.5



Instructor:

Determining line forces is not necessary complicated, but it does require several more variables to be established

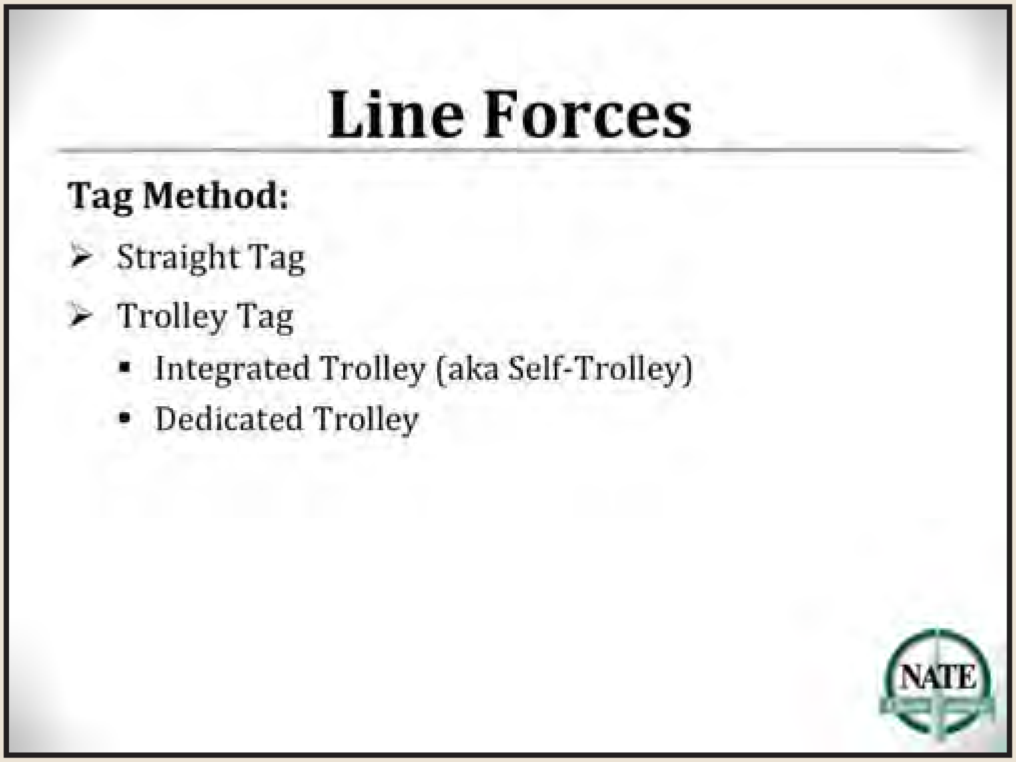


Instructor:

Extremely important to define the total Gross Load weight.

The Gross Load weight is one factor used to define the Minimum Construction Classification when evaluating lifts utilizing rigging systems attached to the structure (ref A10.48, Sec 4.8).

All rigging force calculations presented in this training along with those contained in the A10.48 are based on the Gross Load weight (ref A10.48, App A-13(f)).



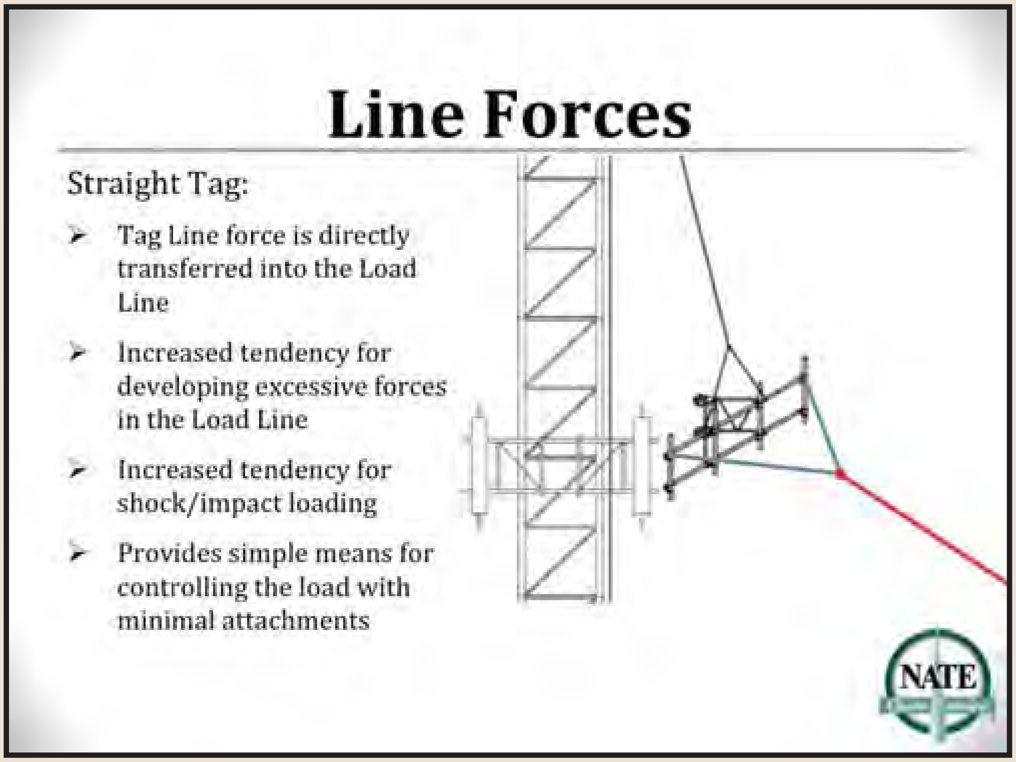
Instructor:

Straight Tag:

- Tag line is directly attached to load resulting in direct transfer of tag line force to load line.
- For a 1-part configuration, the resulting load line force will ALWAYS exceed the lifted Gross Load, and increases exponentially once the load position and tag angles exceed 10° and 70° respectively ~ this relationship is covered further in the presentation.

Trolley Tag:

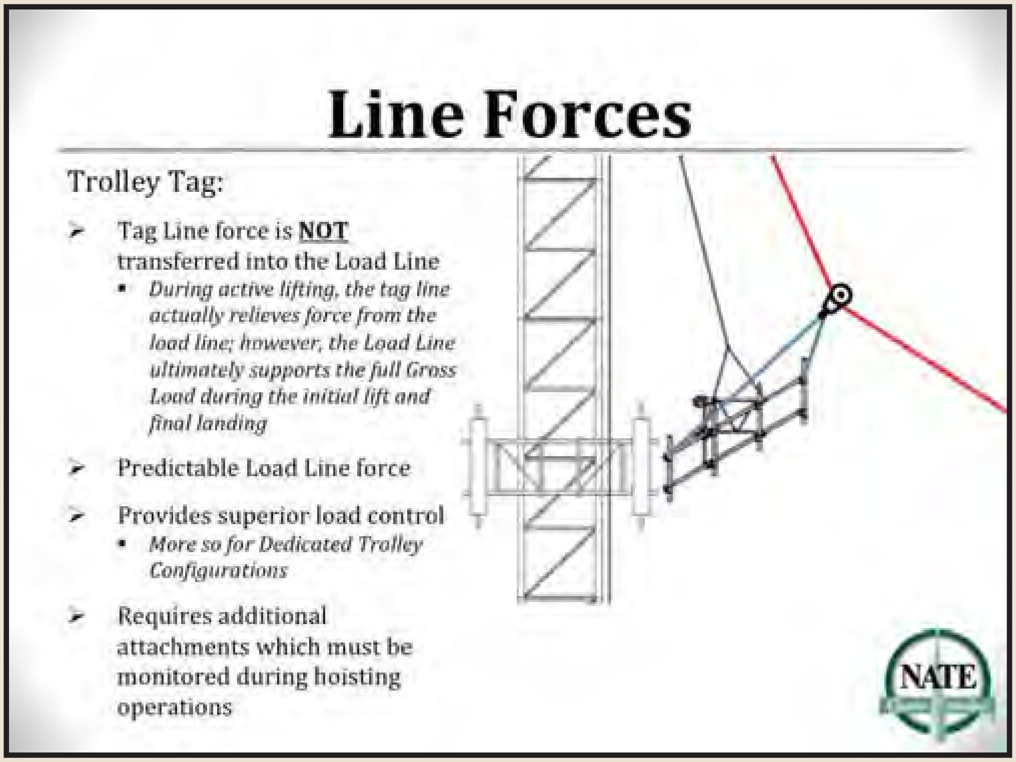
- Incorporates a traveling trolley block which guides the hoisted load along the path of the trolley line.
- Both types of trolley arrangements are covered further in this section.



Instructor:

Tag line is directly attached to the load resulting in direct transfer of tag line force to load line.

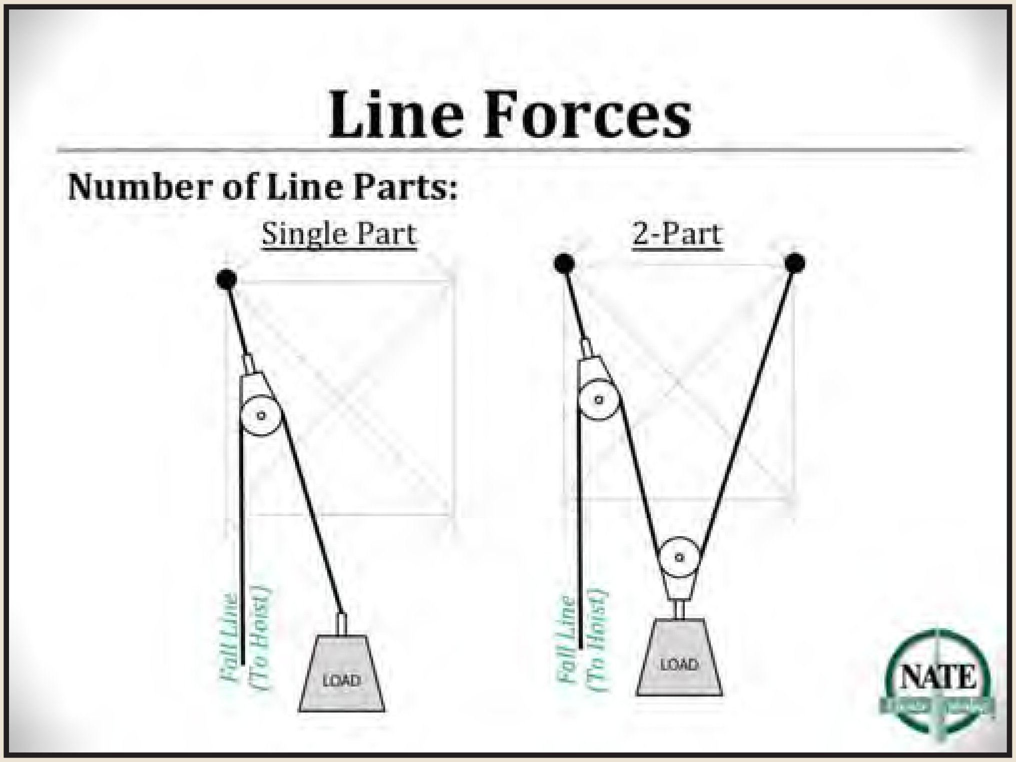
For a 1-part configuration, the resulting load line force will ***always*** exceed the lifted Gross Load, and increases exponentially once the load position and tag angles exceed 10° and 70° respectively ~ this relationship is covered further in the presentation.



Instructor:

Incorporates a traveling trolley block which guides the hoisted load along the path of the trolley line.

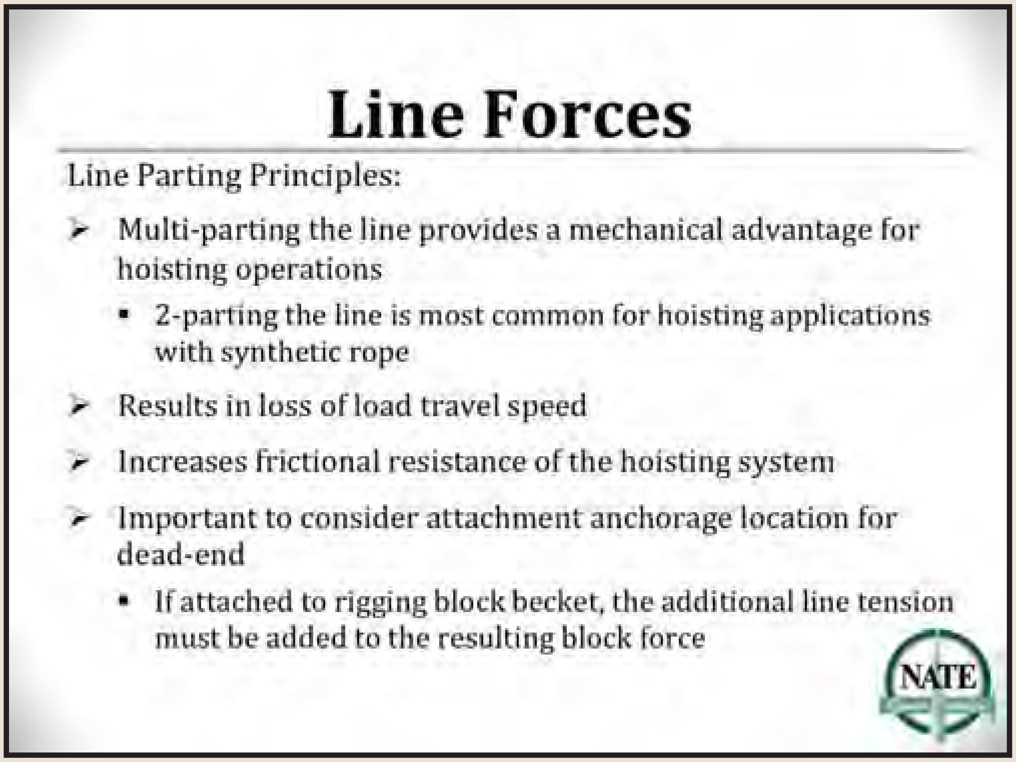
Both types of trolley arrangements (integrated and dedicated) are covered further in this section.



Instructor:

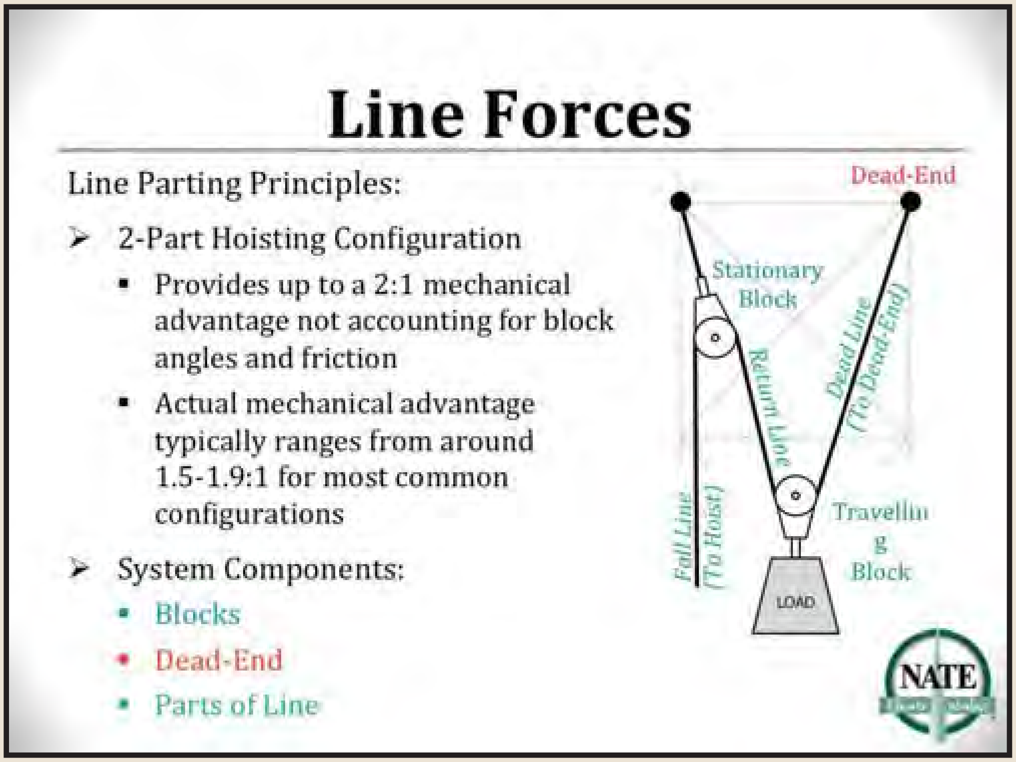
This training will only cover single and 2-part configurations which are most prominent in hoisting applications using synthetic rope.

In addition, the training will focus on 2-part configurations where the dead-end is attached away from the top block as most common rigging blocks used for lifting in this industry are not fitted with a becket lug and attaching away from the block helps reduce the applied force at the block's rigging attachment.



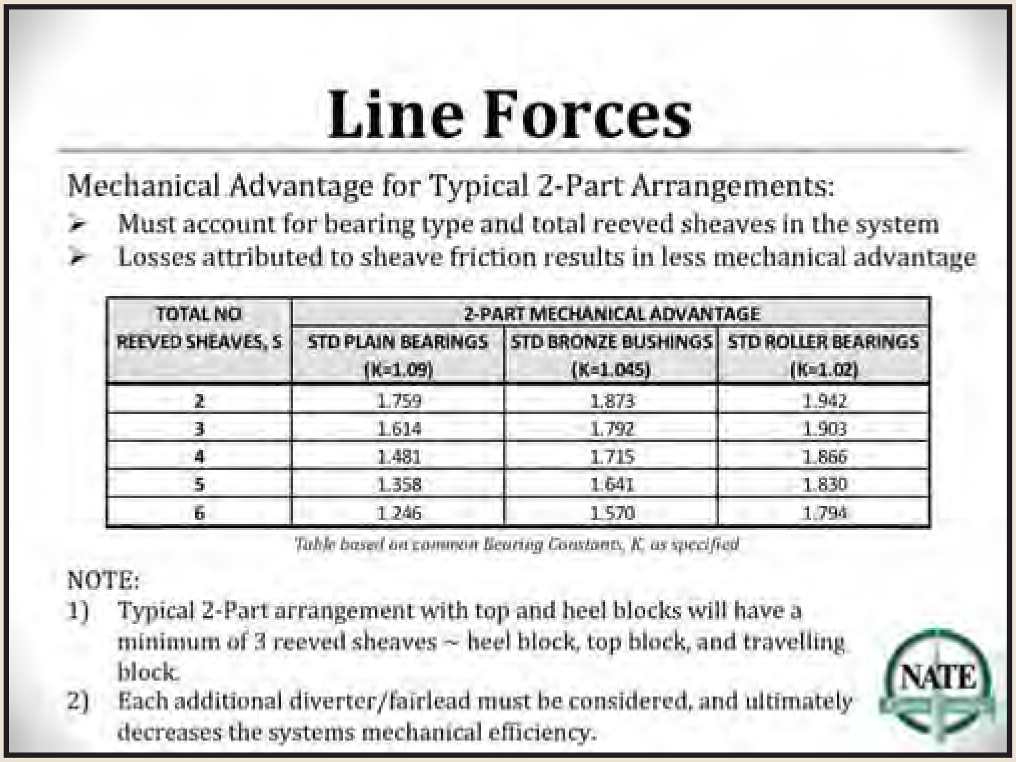
Instructor:

- As number of line parts increase, so does the overall complexity of the lifting system which adds additional attachments that must be monitored/controlled to prevent fouling of the line and proper rendering of the rigging components.
- Slower load travel speeds adds additional control.
- Primary frictional resistance is attributed to sheave bearings.



Instructor:

- Note, this presentation is intended for typical hoisting operations using synthetic rope and therefor only covers typical 2-part configurations with the dead-end anchored away from the top rigging block.
  - Again, if dead-end is attached back to a becket on the top block, the additional line tension must be added to the resulting block force.
- 2:1 mechanical advantage ~ can theoretically lift up to 2 times the line pull tension.
  - Mechanical advantage losses attributed to traveling block included angle and frictional resistance from sheave bearings.
- Multi-part hoisting configurations will always utilize a traveling block that moves/travels as load is hoisted.
- Re-emphasize importance of selecting proper anchor attachment location for both the Stationary Block and Dead-End.



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

Instructor:

- Using standard plain bearings and adding diverter/fairlead blocks ultimately results in greater frictional resistance in the lifting system thus reducing the mechanical advantage.
- Note, use of diverter/fairlead blocks many times greatly improves the overall line control as well as directing the line away from obstructions and towards the work location required.
    - Simply remember to account for the added friction when used ~ covered further in the next slides

Line Forces

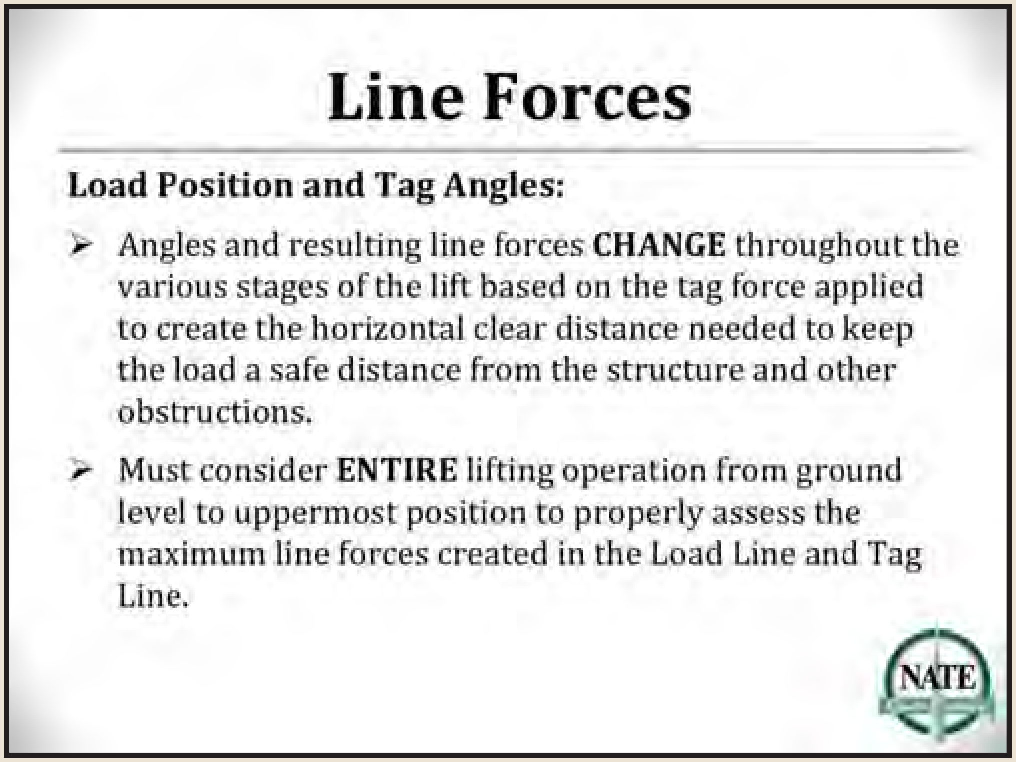
Sheave Frictional Resistance:

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

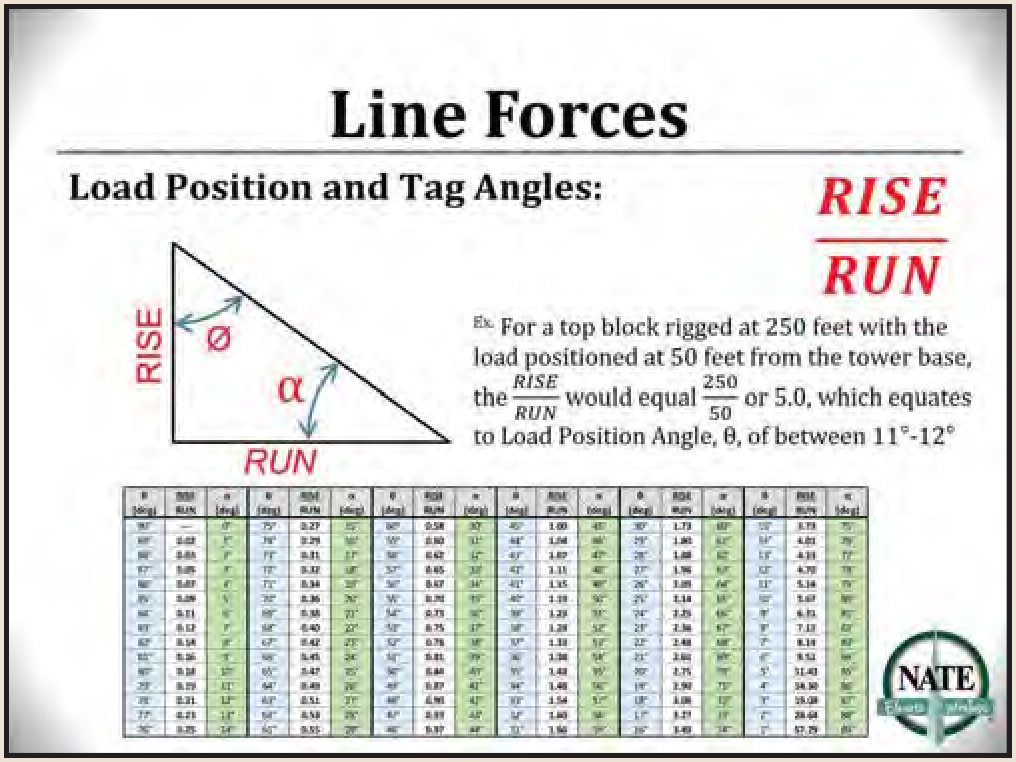
Instructor:

The frictional resistance attributed to the sheave bearings is a function of the number of line parts, total number of reeved blocks, and sheave bearing constant.



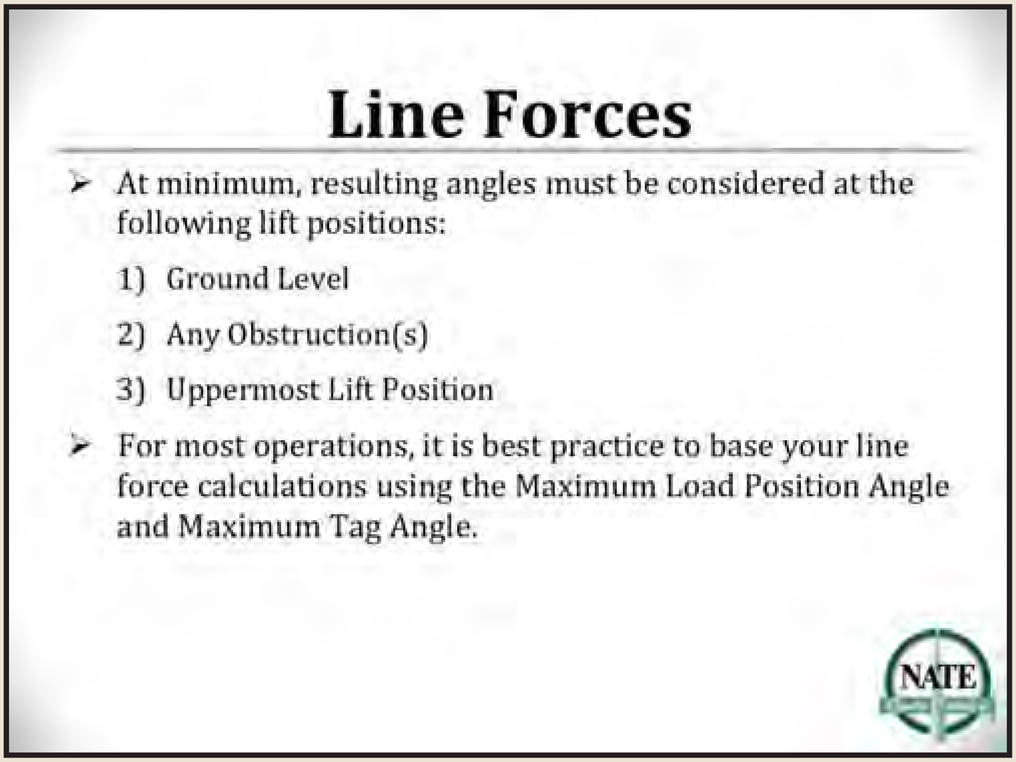
Instructor:

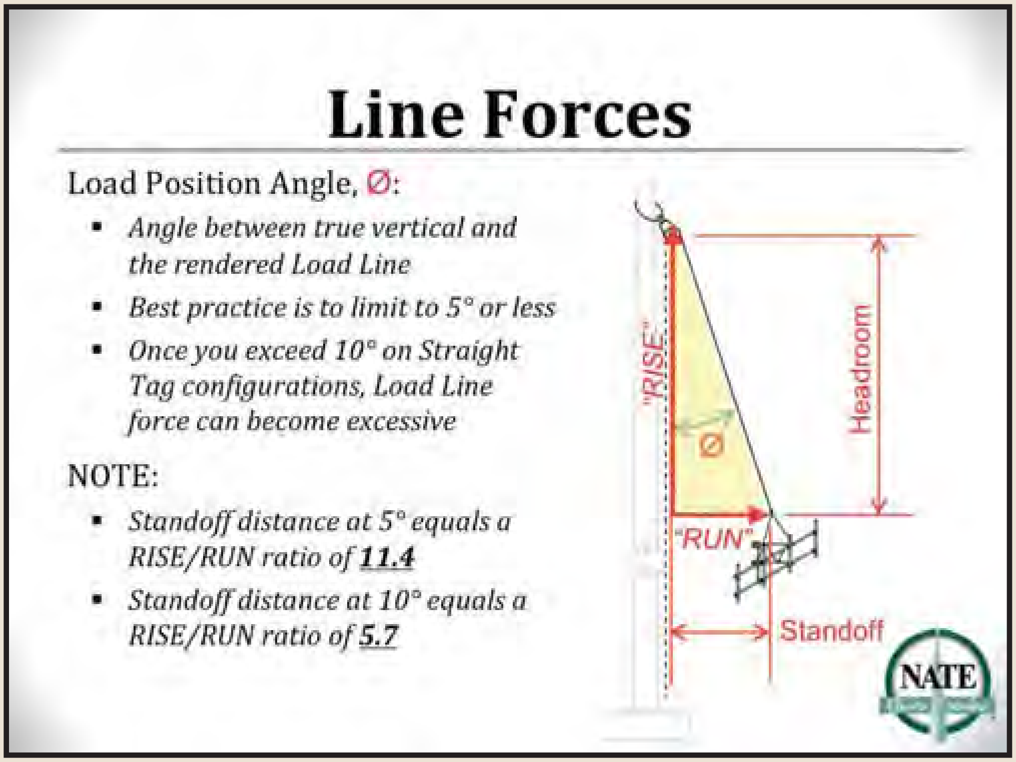
- Angles and resulting forces imposed through the rigging and back to the supporting structure **CHANGE** as loads are hoisted.
- Must review the **ENTIRE** lift to properly determine the maximum forces developed.



Instructor:

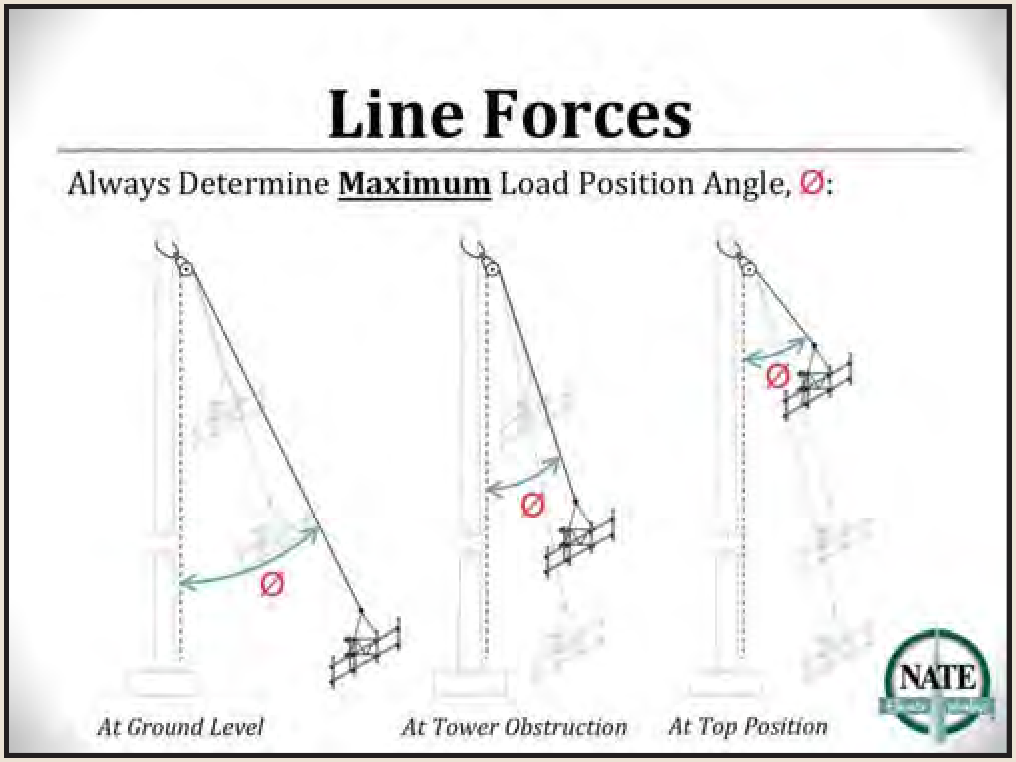
- Page 100 of the student workbook provides a full copy of the table shown which can be used to quickly convert the ratio of **RISE OVER RUN** to the corresponding angles used for determining critical load and tag angles.
- Once you know your setup distances, this table can be used to easily assess the resulting angles relative to either the horizontal or vertical axis.


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.
NATE



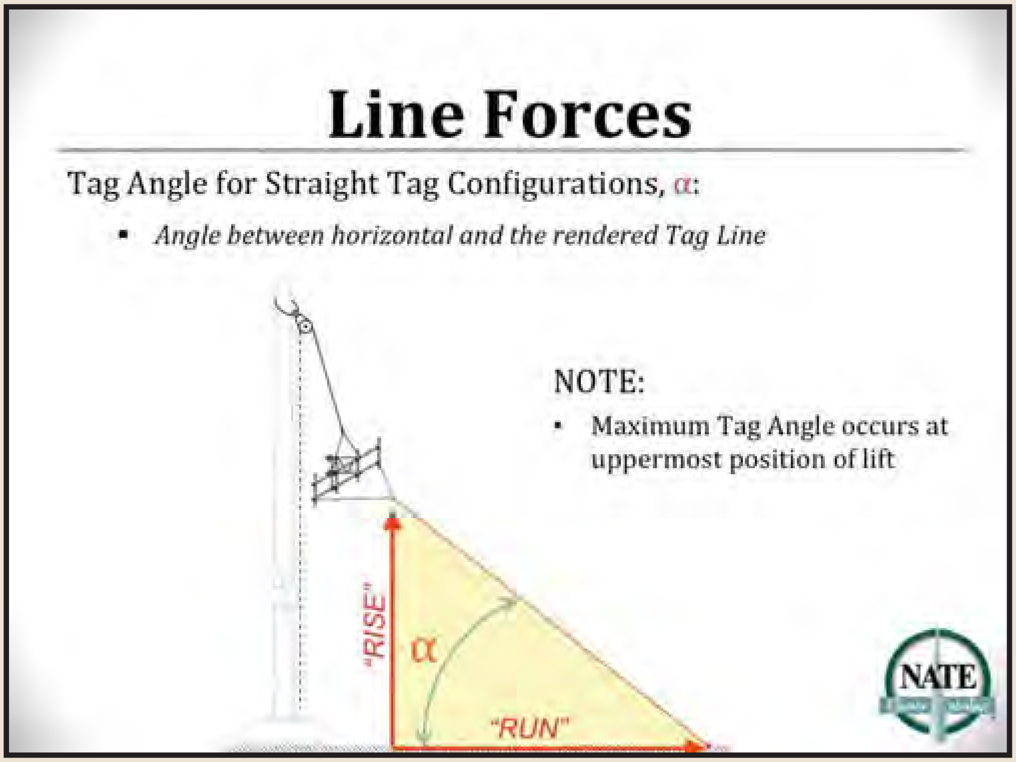
Instructor:

Angle assumes straight line ~ do not adjust for sag in the line.



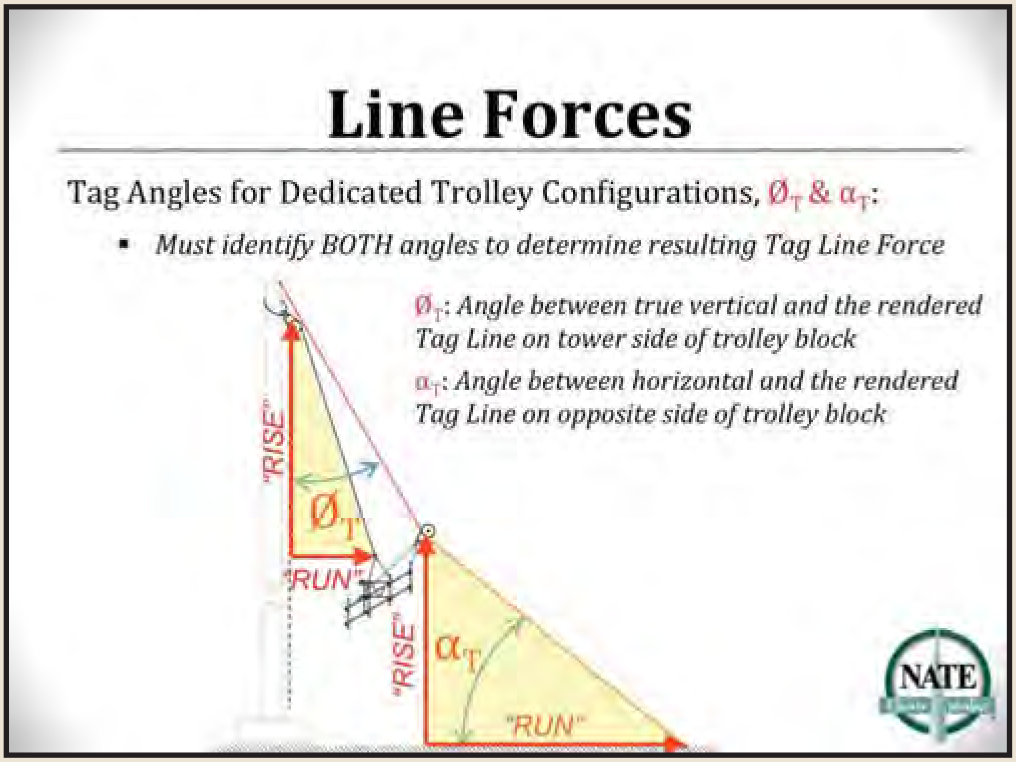
Instructor:

- Max angle usually occurs at one of the critical positions shown above.
  - **At Top Position:** Generally occurs when load has to be manipulated away from the tower to place the load at elevation or to remove a load which is stood off the structure.
  - **At Tower Obstruction:** Generally occurs when load has to clear a tower mounted appurtenance or component such as another carrier's array, a platform level, or a torque arm.
  - **At Ground Level:** Generally occurs work area near the tower base is obstructed with common obstacles such as transmitter buildings, transmission line bridges, fences, etc.



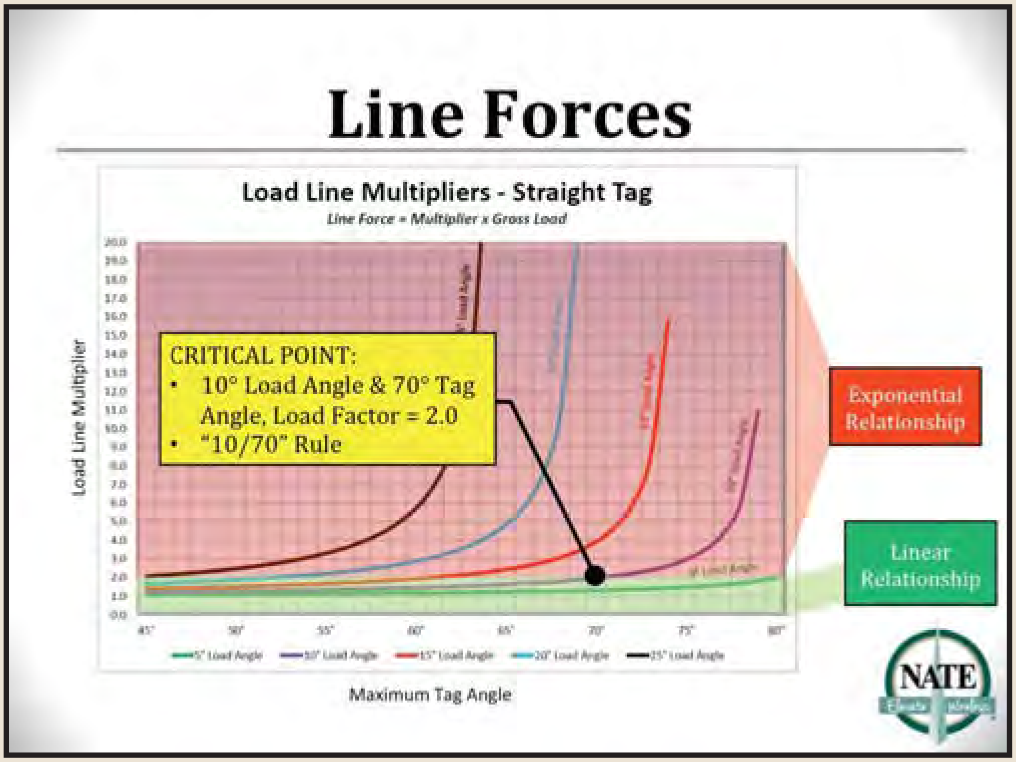
Instructor:

Angles assumes straight line ~ do not adjust for sag in the line.



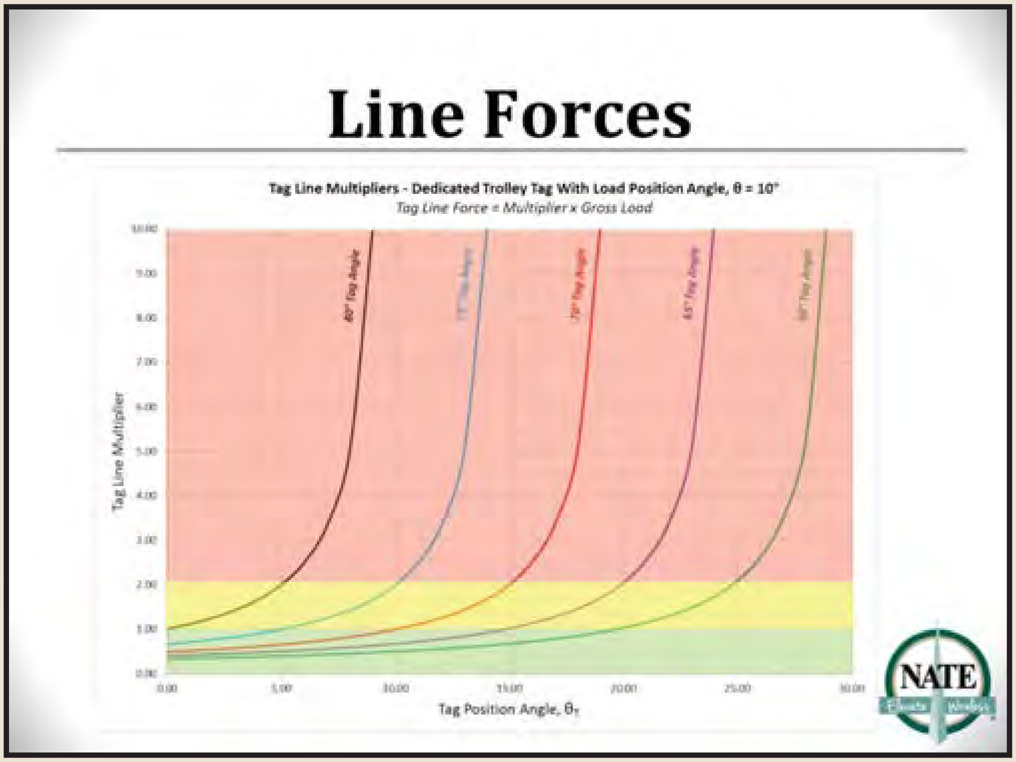
Instructor:

- Angles assumes straight line ~ do not adjust for sag in the line.
- Note, for integrated trolley systems the load line also serves as the control/tag line.



Instructor:

- The chart depicted represents the Load Line Multipliers for Straight Tag Configurations staged Load Position Angles of 5°, 10°, 15°, 20° and 25° with varying Tag Angles shown on the horizontal axis and the corresponding Load Line Multiplier given on the vertical axis.
- Relationship between load and tag angles and resulting load force transitions from linear to exponential at 10°/70°. This inflection point results in an Line Multiplier Factor of 2.0.
    - – Note direct relationship between critical inflection point occurring at a 30° angle for slings.
- Remember the "10/70 Rule" when utilizing Straight Tag Configurations. When exceeded, consult a qualified person.



Instructor:

- The chart depicted represents the Tag Line Multipliers for a Dedicated Trolley Tag Configuration with a Load Position Angle of 10° and staged Tag Angles of 60°, 65°, 70°, 75° and 80° with varying Tag Position Angles shown on the horizontal axis and the corresponding Tag Line Multiplier given on the vertical axis.
- Note the critical inflection points in force escalation occurring at multipliers of 1.0, and then the sharp rise at 2.0.
- Refer to color coded Line Multiplier Table A6.10 on page 110 of the Student Workbook for comparison.

Line Forces

Line Forces at Load:

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

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

Where:

P = Load Line Force at Load

T = Tag Line Force at Load

WT = Gross Load Weight

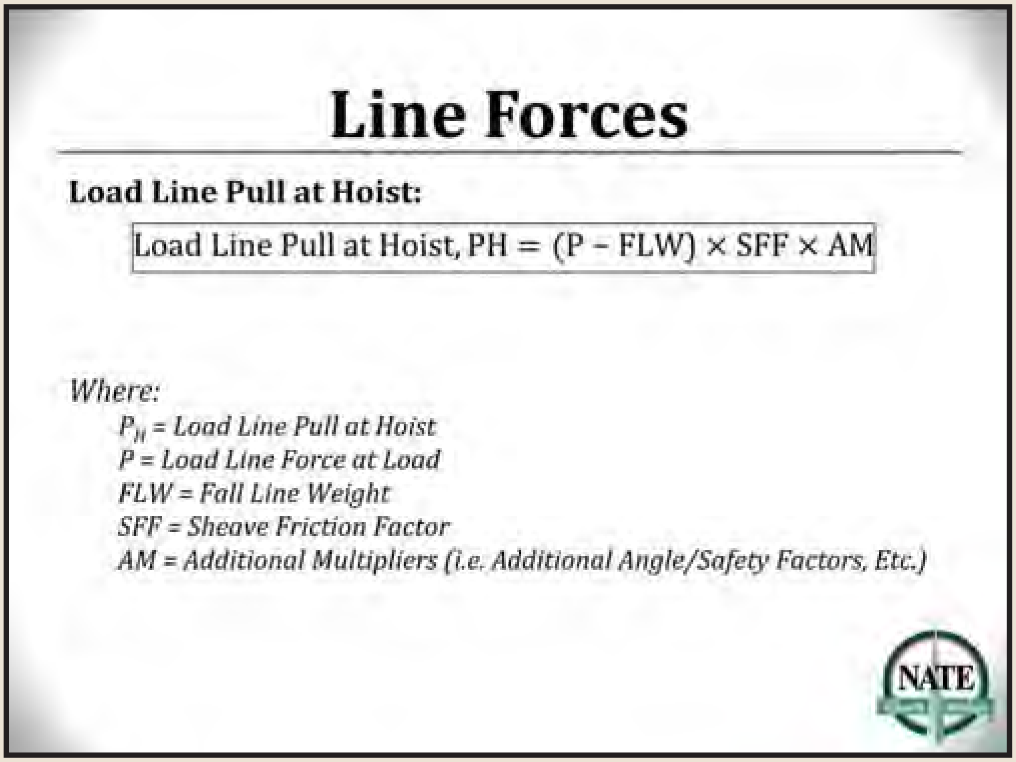
PM = Load Line Multiplier (Refer to Handbook)

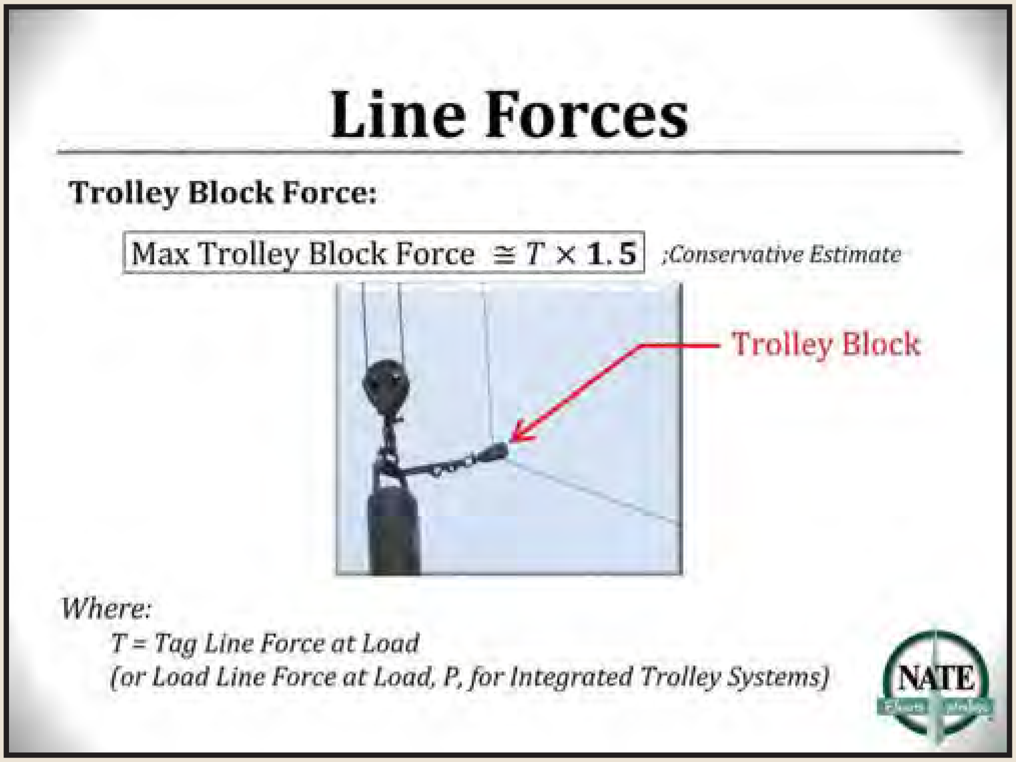
*****NOTE:*** *For Trolley Tag Arrangements, Set PM=****<u>1.0</u>*** *for Uppermost Position*

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:
Load Line Pull at Hoist, PH = (P – FLW) × SFF × 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.)
NATE



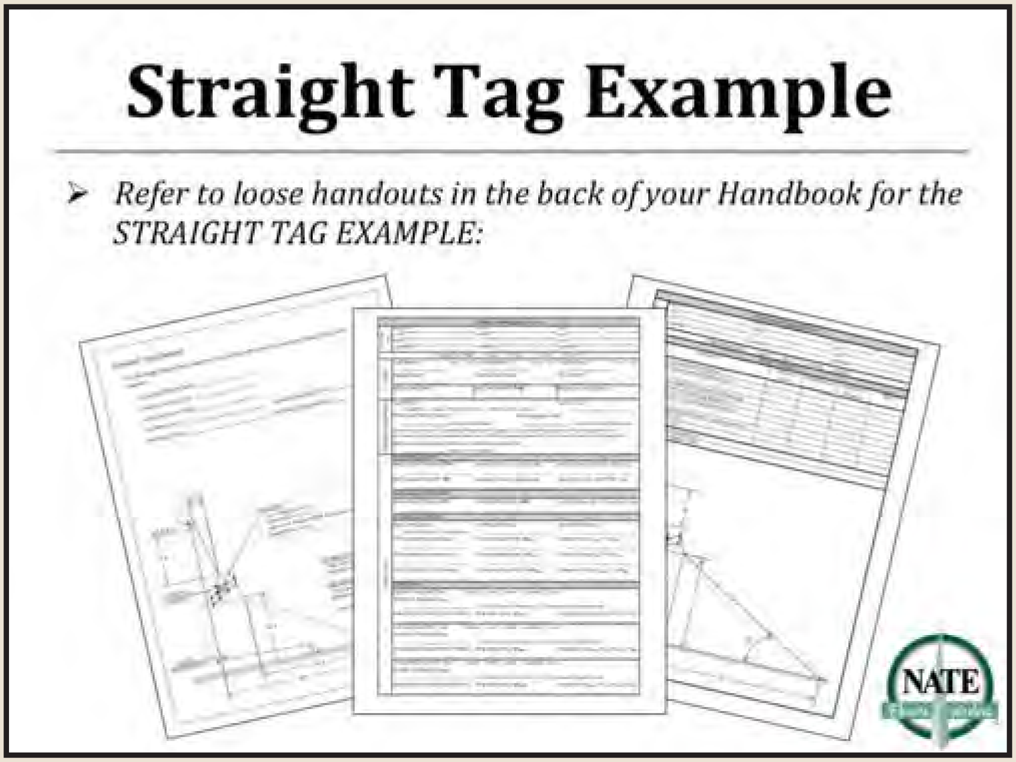
Instructor:

- Remember, for both trolley systems, you also need to determine the resulting force in the traveling trolley block attachment.
- Use the Load Line Force, P, in place of the Tag Line Force, T, for Integrated Trolley Systems.
- This provides a conservative estimate and is based upon a minimum block included angle of slightly less than 85° ~ refer back to Block Angle Factors.
    - Corresponds to the load at ground level.
    - Conservative because max tag force is almost always seen when load is well above grade (i.e. included angle well above 90°), and the only time the included angle would go below 85° is if the hoisting unit was located well ABOVE the load (e.g. hoist located atop a hill.)

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*

NATE



Instructor:

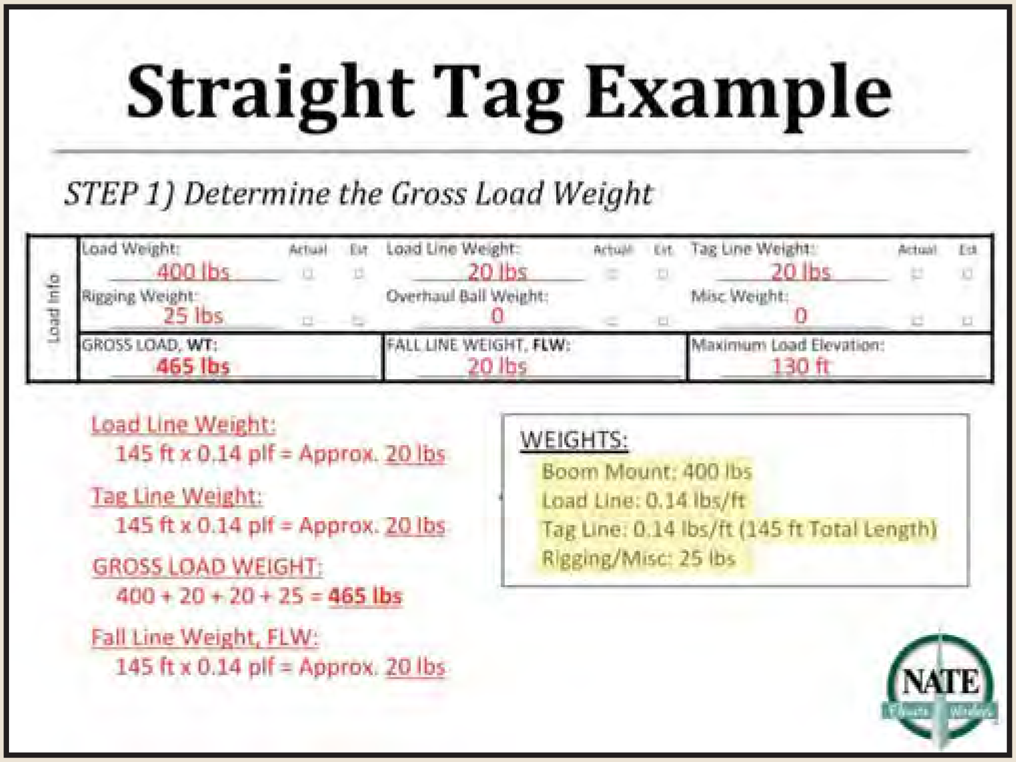
- Take time to introduce each page of the 3 page loose handout that will be used for working the Straight Tag Example problem
    - NOTE: A Dedicated Trolley Example problem is also provided; however, due to time constraints we will not be able to work this together, but can be used for future reference purposes.
- Page 1 provides the STRAIGHT TAG EXAMPLE problem that will be worked
- Page 2 titled “Lifted Load Rigging Forces” provides the organized from we’ll be filling out together to determine the applicable rigging forces in the lines, blocks, and slings
- Page 3 provides the critical distances needed to determine the resulting load position and tag angles

Instructor:

- For this example, we will determine the Load and Tag Line Forces, Block Forces, and Sling Forces
- Please turn to page 110 of your Handbook to locate the Tables we'll be using for this example

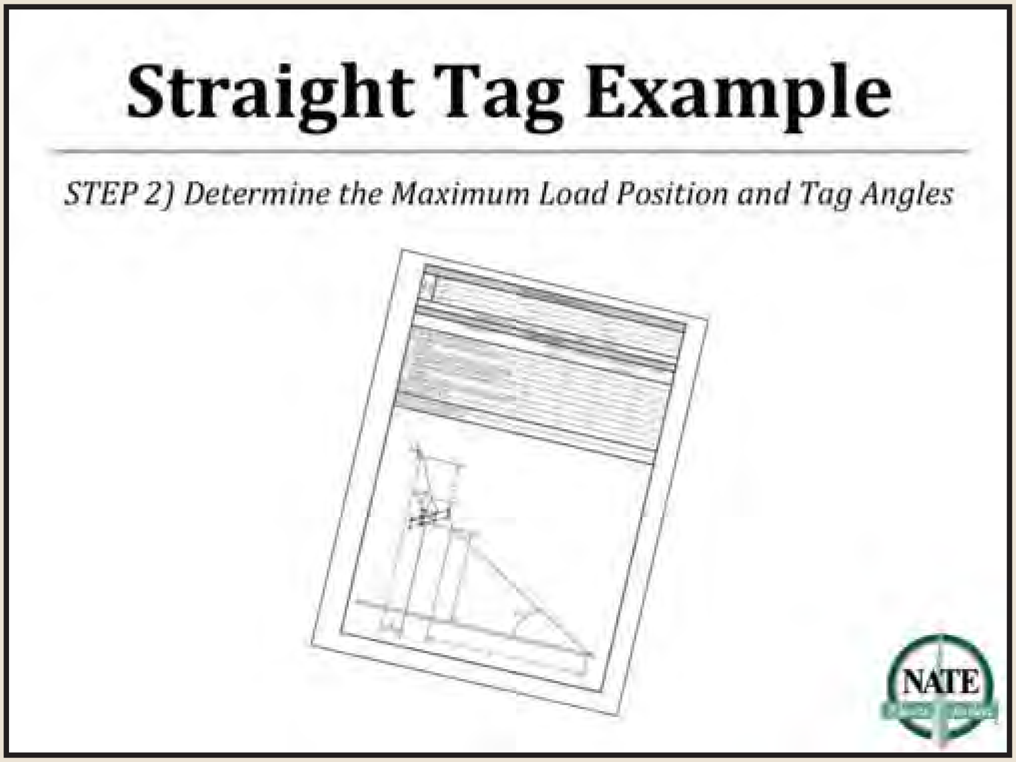
Instructor:

- Start by establishing the total Gross Load Weight



Instructor:

• Step through weights for the example



Instructor:

- Refer to the last page in your loose handout for the Load Position and Tag Angle form
- Please note, this form is simply being used to highlight the critical distances needed to identify the corresponding Load Position and Tag Angles

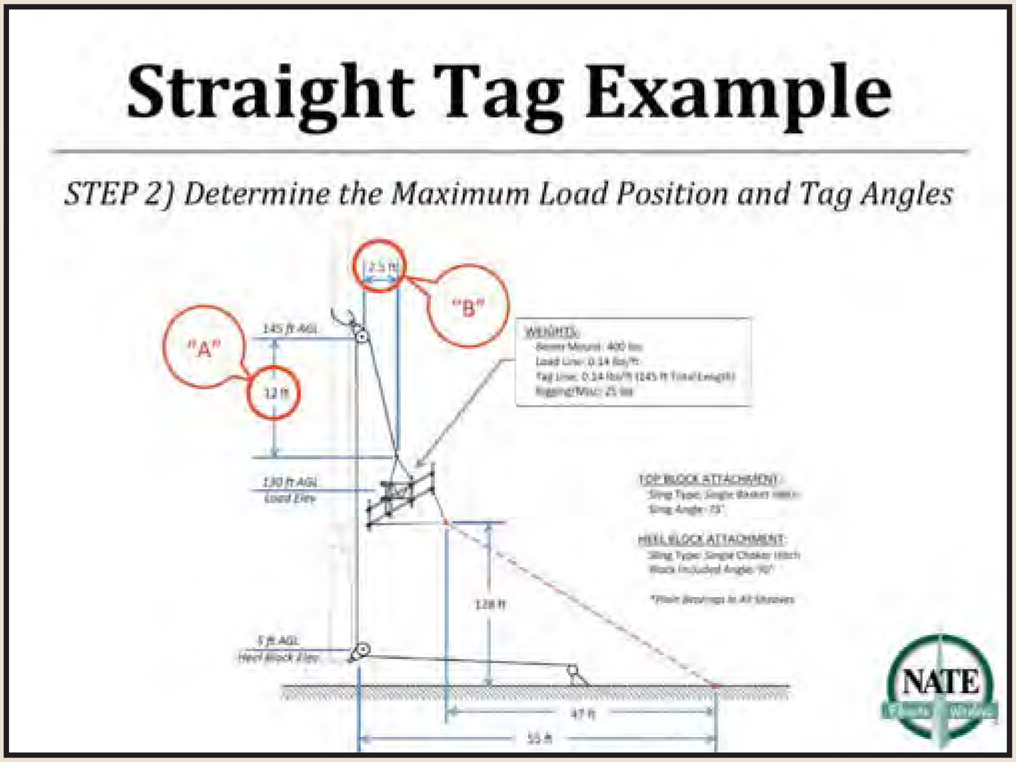
Straight Tag Example

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):				
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:				

Instructor:

- We'll start with identifying distances "A" and "B" to determine the Load Position Angle



Instructor:

- Distance "A" = Top Block to Load Headroom (Rise) = 12 ft
- Distance "B" = Top Block to Load Standoff Distance (Run) = 2.5 ft

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:				

$RISE/RUN = 12/2.5 = 4.80$

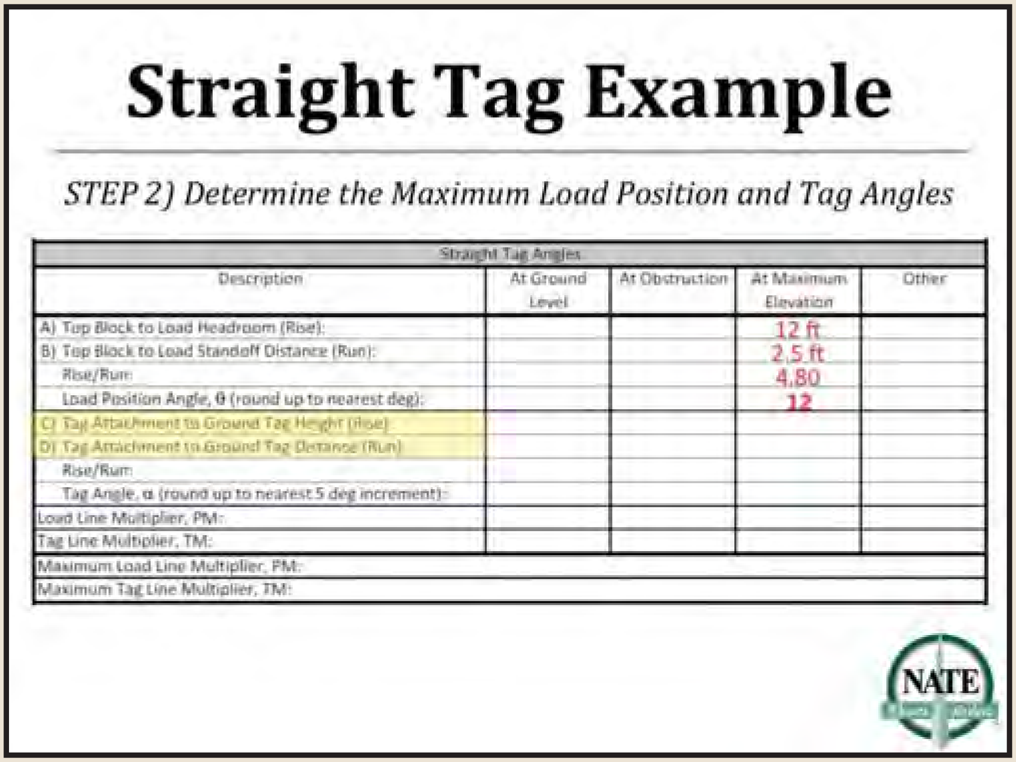
NATE

Instructor:

- The corresponding RISE/RUN ratio equals 4.80

Instructor:

- Using Table A4 from you Handbook on page 112, we can now determine the resulting Load Position Angle as measured from the True Vertical Axis ~ Remember to round up to the nearest 1 degree increment
- RISE/RUN Ratio of 4.80 therefore rounds up to a 12 deg Load Position Angle

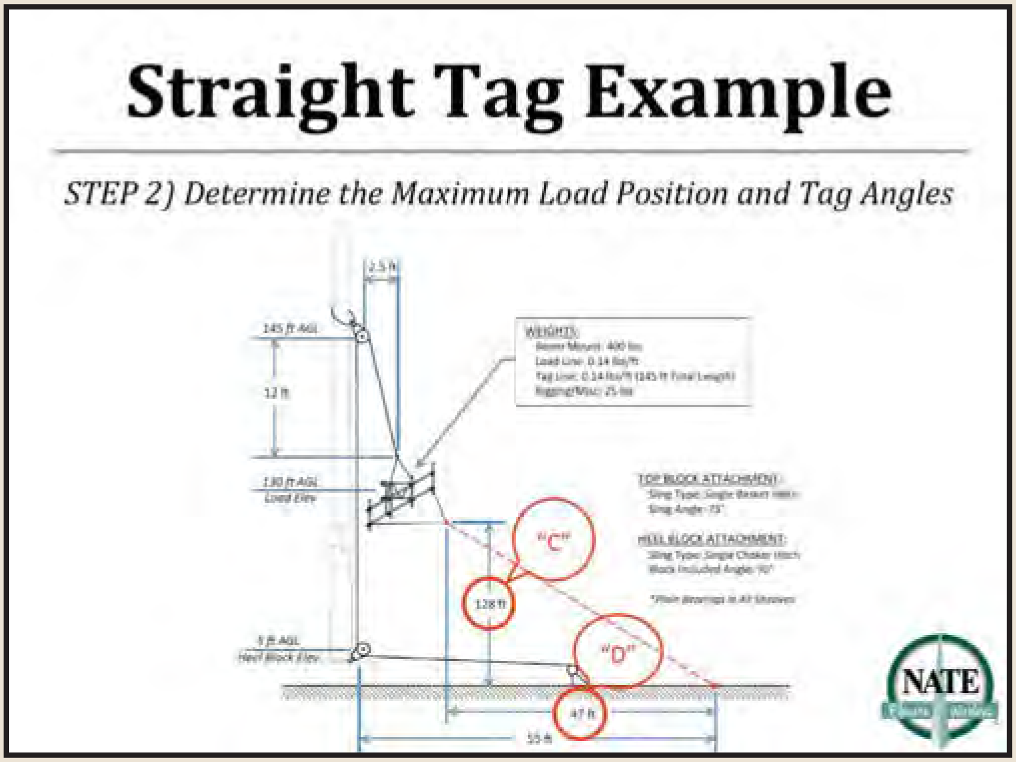

Straight Tag Example

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:				

Instructor:

• Next we'll determine the Tag Angle by defining distances "C" and "D"



Instructor:

- Distance “C” = Tag Attachment to Ground Tag Height (Rise) = 128 ft
- Distance “D” = Tag Attachment to Ground Tag Distance (Run) = 47 ft

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:				

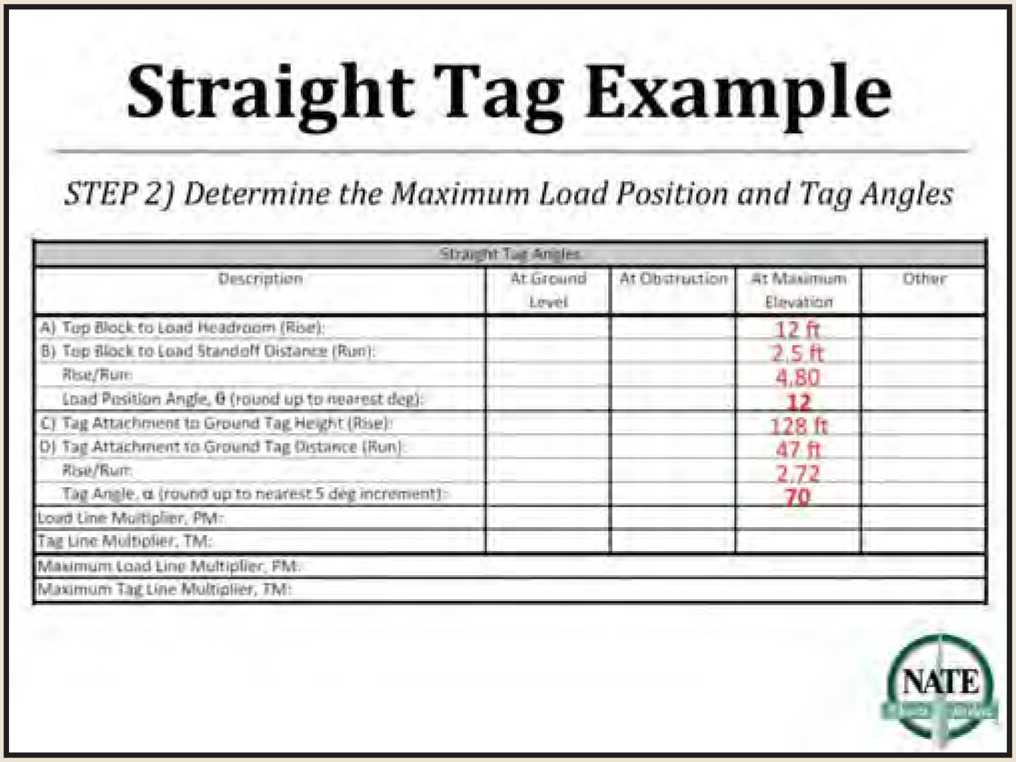
$RISE/RUN = 128/47 = 2.72$

Instructor:

- The corresponding RISE/RUN ratio equals 2.72

Instructor:

- Again using Table A4 from you Handbook on page 112, we can now determine the resulting Tag Angle as measured from the Horizontal Axis ~ Remember to round up to the nearest 5 degree increment
- RISE/RUN Ratio of 2.72 therefore rounds up to a 70 deg Load Position Angle



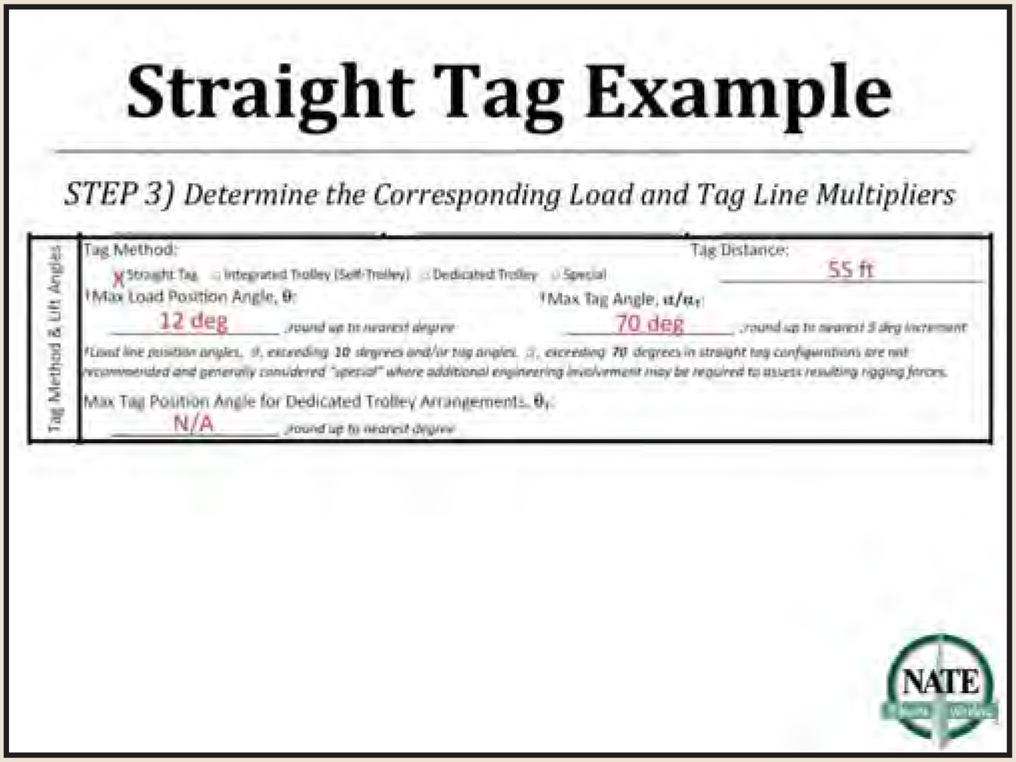
Straight Tag Example

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, FM:				
Maximum Tag Line Multiplier, TM:				

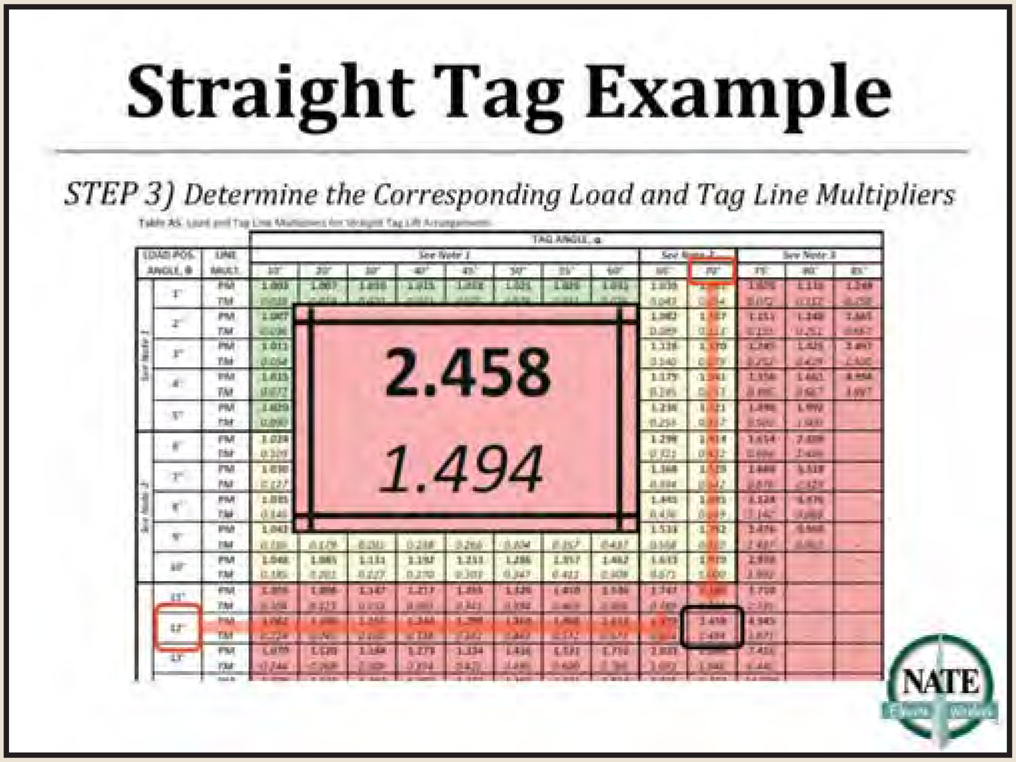
Instructor:

- With the Load Position and Tag Angles now established, we can move to the next step of determining the applicable Load Line and Tag Line Multipliers



Instructor:

- Now we can continue to fill out page 2 in your loose handout packet to calculate the Lines Forces



Instructor:

- Refer to Table A5 on page 113 of your Handbook for the Load and Tag Line Multipliers for Straight Tag Lift Arrangements
- Lining up the 12 deg Load Position Angle with the 70 deg Tag Angle provides the "PM" and "TM" Multipliers of 2.458 and 1.494 respectively

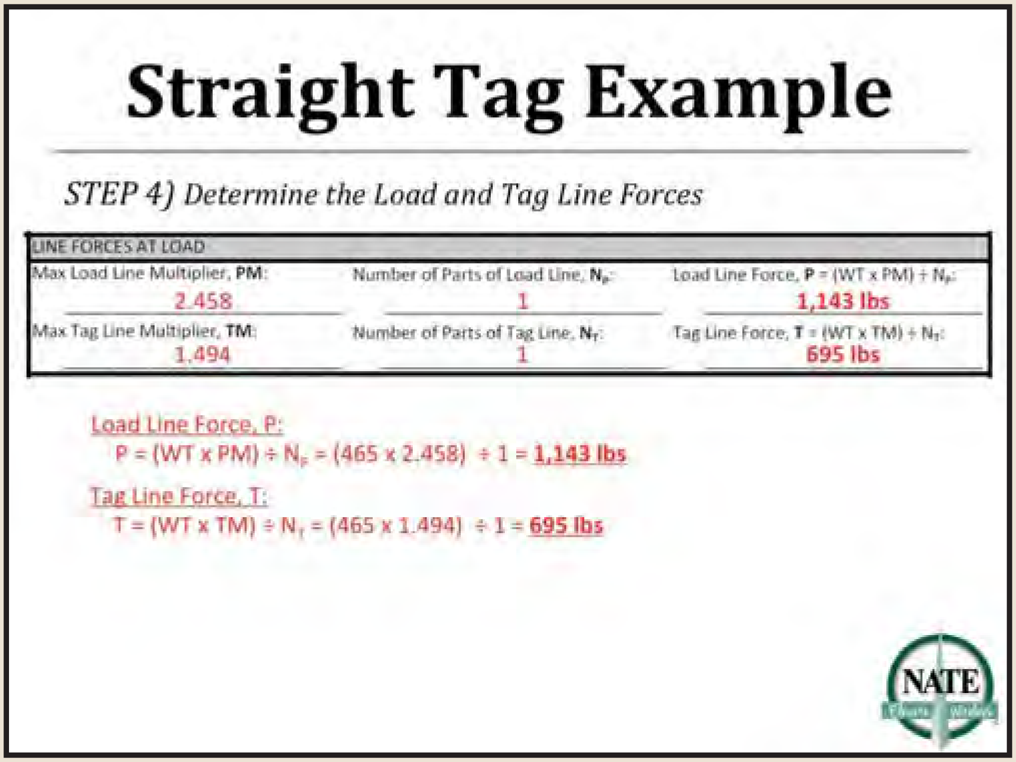
Straight Tag Example

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				

Instructor:

- Please note, for this example we are only focusing on the load at its maximum elevation.
- To fully assess, we would always want to ensure the Line Multipliers for the load at ground elevation and at any obstructions do not govern. In general, we simply want to define where the Maximum Load Position Angle is formed to ensure we are properly assessing the maximum line forces developed in the lift.



Instructor:

- The Line Forces at the Load are then calculated using the Line Multipliers multiplied by the Gross Load Weight and divided by the number of parts in the lines. For this example we're assuming standard single part load and tag line arrangements.

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°

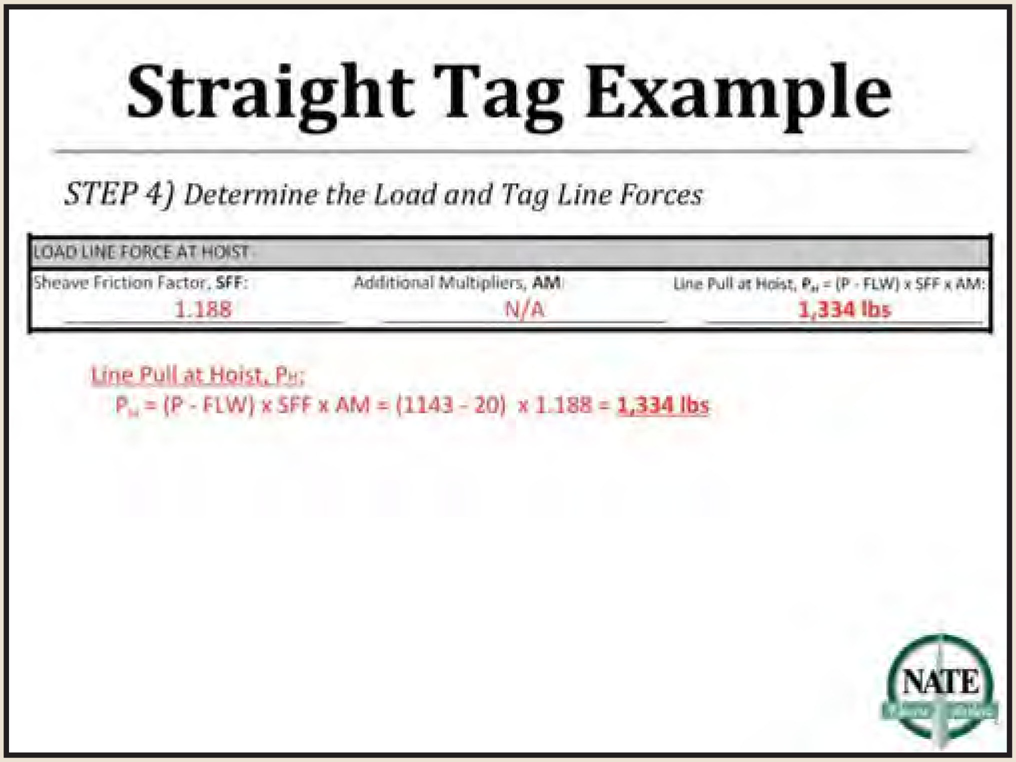
HEEL BLOCK ATTACHMENT:
Sling Type: Single Choker Hitch
Block Included Angle: 90°

*Plain Bearings in All Sheaves

NATE

Instructor:

- To determine the acting Load Line Force at the Hoist, we must account for the frictional resistance in the block sheaves using Table A3 on page 111 of your Handbook
- The Load Line is configured in a 1-Part
- For this example we have specified Plain Bearings in all sheaves.
- And we are reeved through a total of 2 Sheaves (i.e. top and heel blocks)
- The corresponding Sheave Friction Factor (SFF) is then determined to be **1.188**



Instructor:

- The Load Line Force at the Hoist then equals the Line Force at the Load (P) minus the Fall Line Weight (FLW) multiplied by the Sheave Friction Factor (SFF) and any additional multipliers that may apply (AM). For this example, we'll assume only the sheave frictional resistance applies. Examples of other multipliers includes steel on steel contact when jumping gin poles.

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**

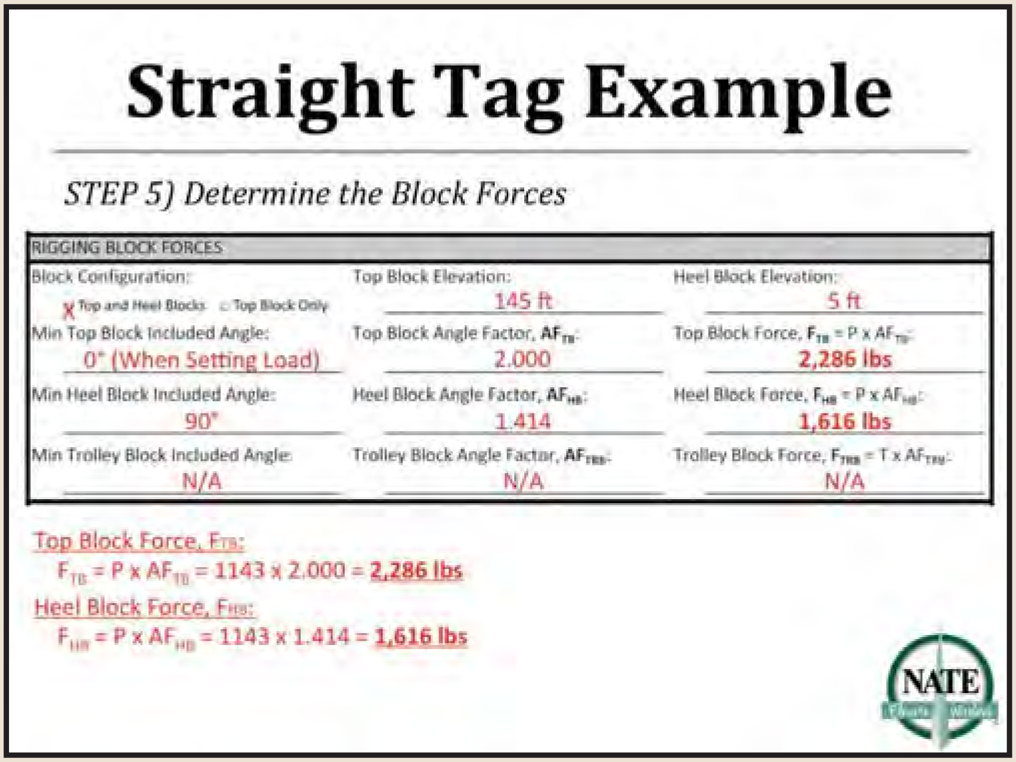
Heel Block Min Included Angle = 90°
Heel Block Angle Factor, AF = **1.414**

EXAMPLE
TOP BLOCK ATTACHMENT:
Sling Type: Single Basket Hitch
Sling Angle: 75°
HEEL BLOCK ATTACHMENT:
Sling Type: Single Choker Hitch
Block Included Angle: 90°

NATE

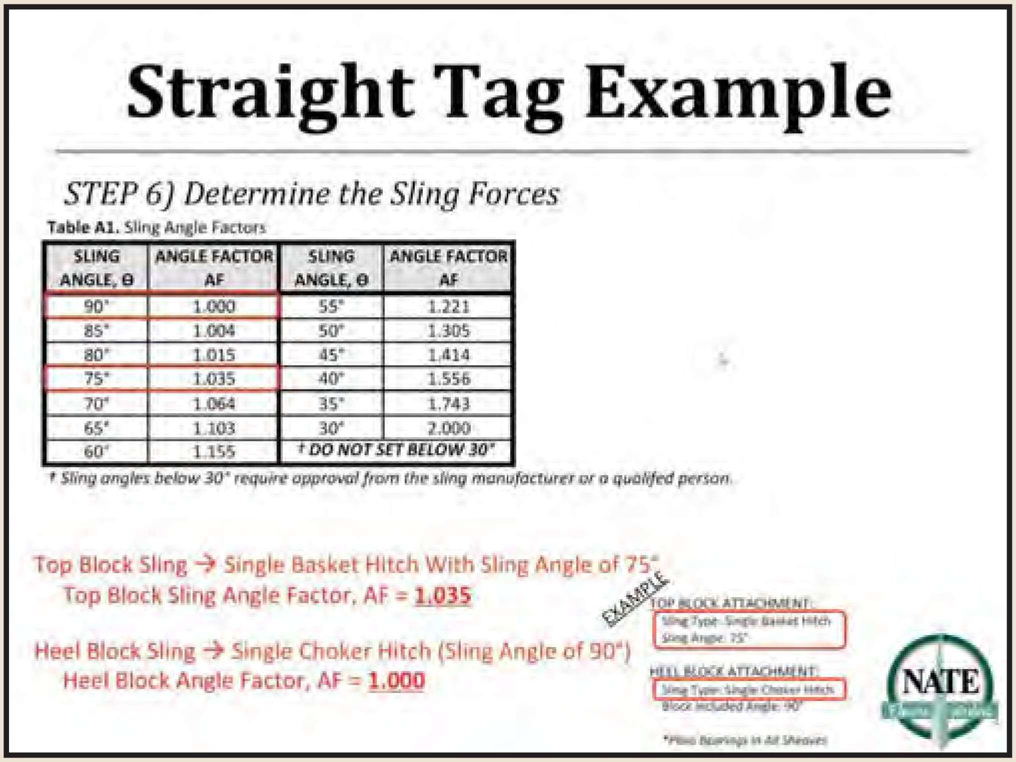
Instructor:

- Now that we have the line forces calculated, we can use Table A2 on page 111 to determine the Block Angle Factors



Instructor:

- We can now use the Block Angle Factors determined from Table A2 to calculate the resulting Block Forces in the Top and Heel Blocks



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°	

Instructor:

- Finally, we can continue to trace the rigging forces from the Lines, through the Blocks, and into the Slings attached to the supporting structure
- The first step will be to determine Sling Angle Factors using Table A1 on page 110 of your Handbooks

Instructor:

- We can now use the Sling Angle Factors determined from Table A1 to calculate the resulting Sling Leg Forces at the Top and Heel Block Attachments

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

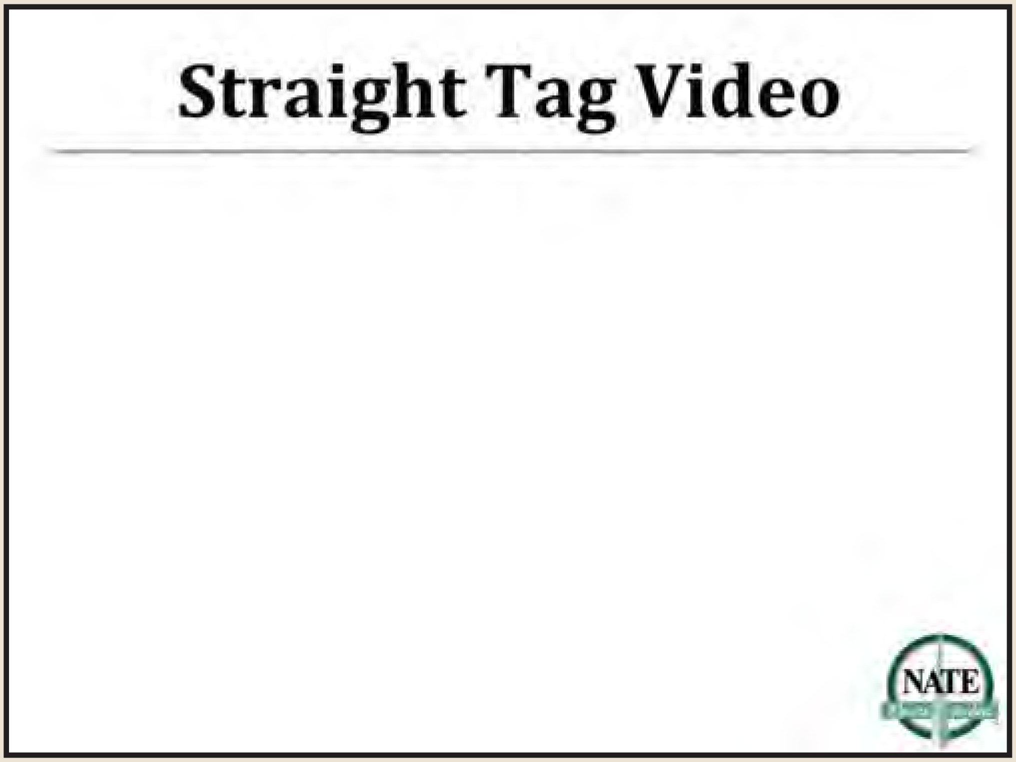
Remember where we started:

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

NATE

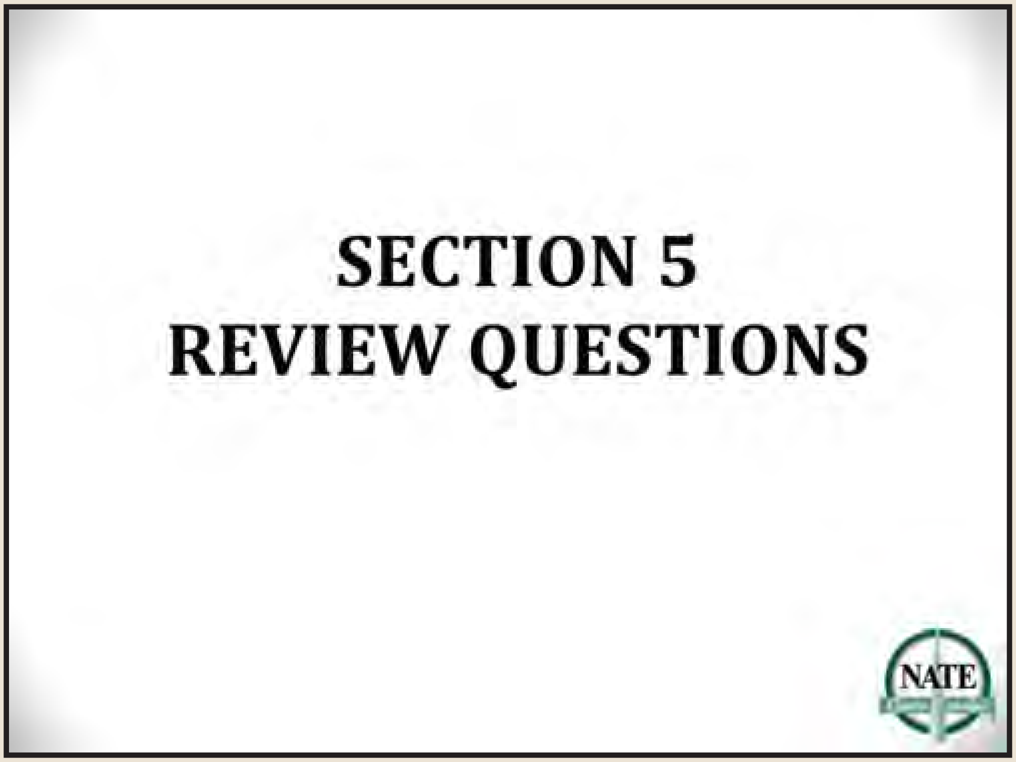
Instructor:

- We now have all force demands acting from the Lines, through the Blocks, and into the individual Slings attached to the supporting structure
- Please pause and take time to emphasize how these forces relate to the original 400 lbs boom mount being hoisted. This example which again assumed 12 ft of headroom with only a 2.5 ft load standoff distance resulted in a Load Position Angle of 12° and Tag Angle of 70° (Exceeds the critical 10/70 Rule where forces can increase exponentially). This has in turn developed Load Line and Hoist Pull force demands well above 1,000 lbs which would overcome most typical hoist and line WLL ratings.



Instructor:

Play video ~ roughly 10min long


SECTION 5
REVIEW QUESTIONS
NATE

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

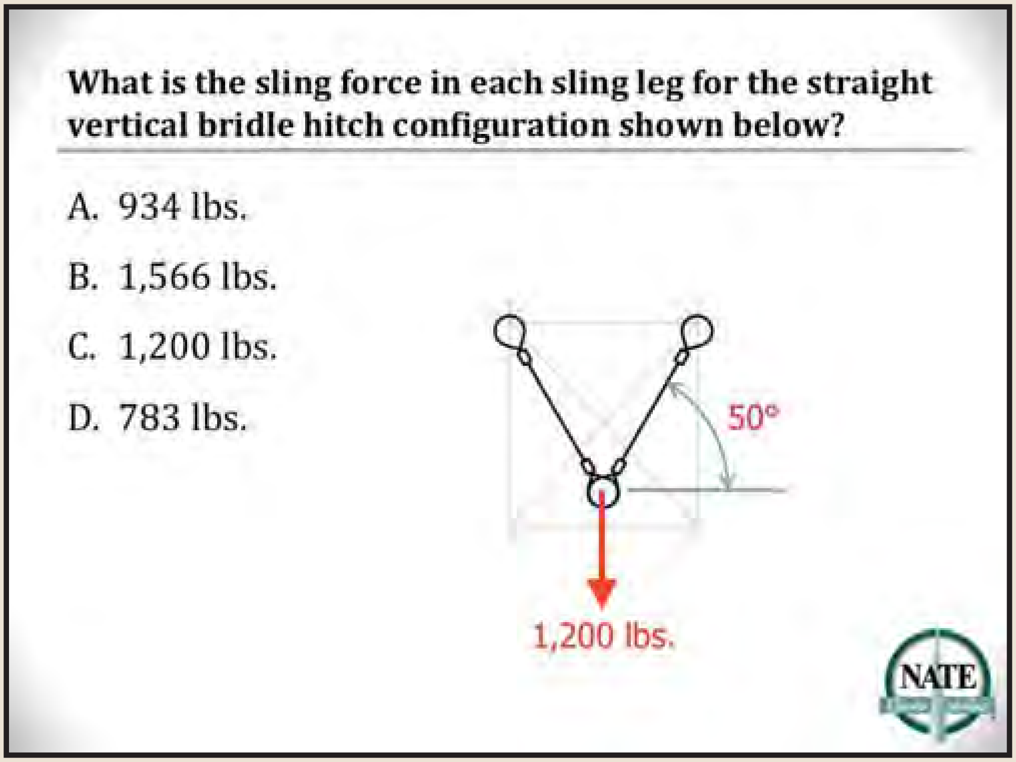
A. 1.414

B. 2.000

C. 1.155

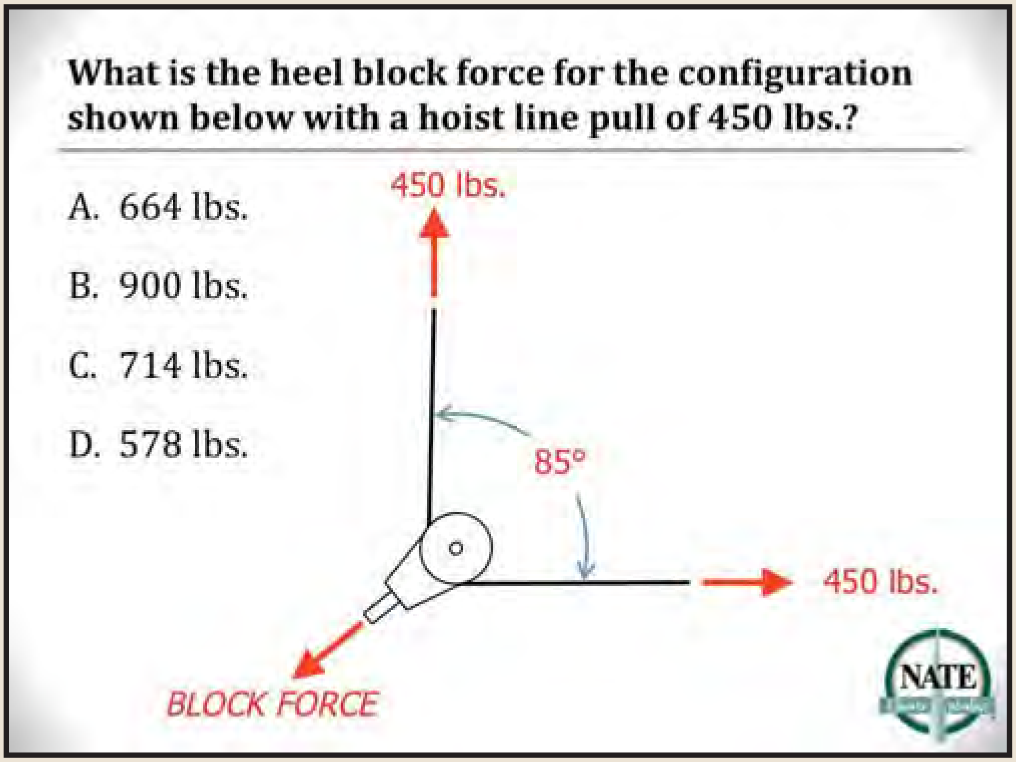
D. 1.000

ANSWER: C (1.155)



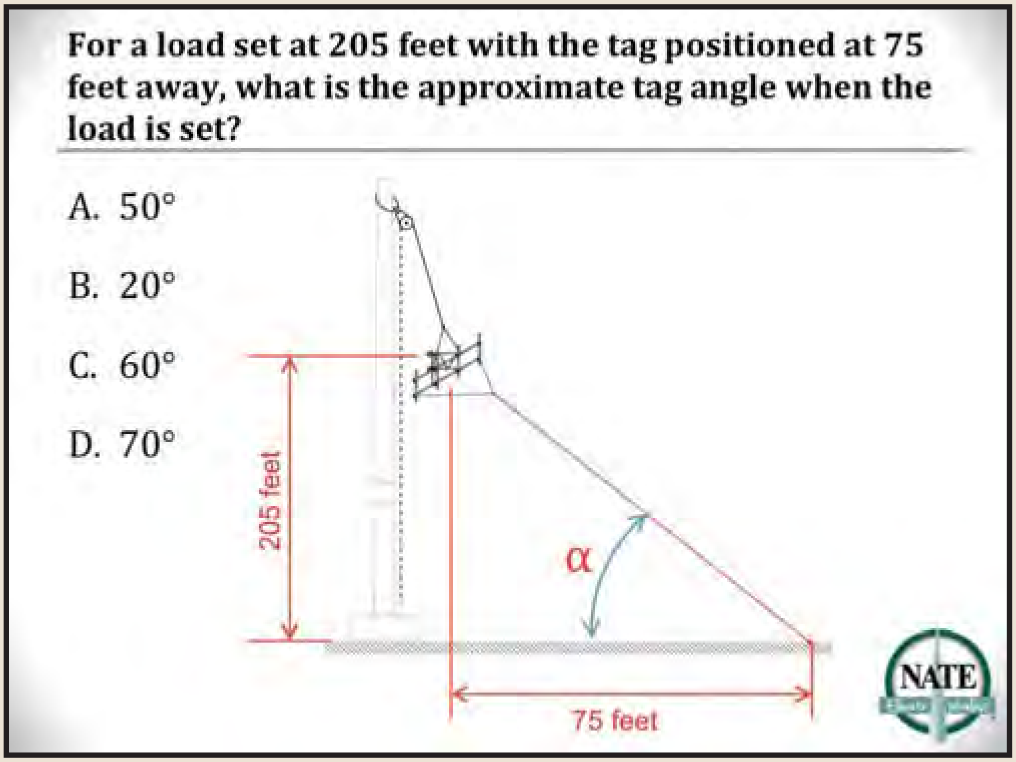
ANSWER: D (783 lbs.)

(1200)/2 x 1.305 = 783



ANSWER: A (664 lbs.)

450 x 1.475 = 664



ANSWER: D (70°)

(Rise/Run) = (205/75) = 2.73 ~ Approx. 70°

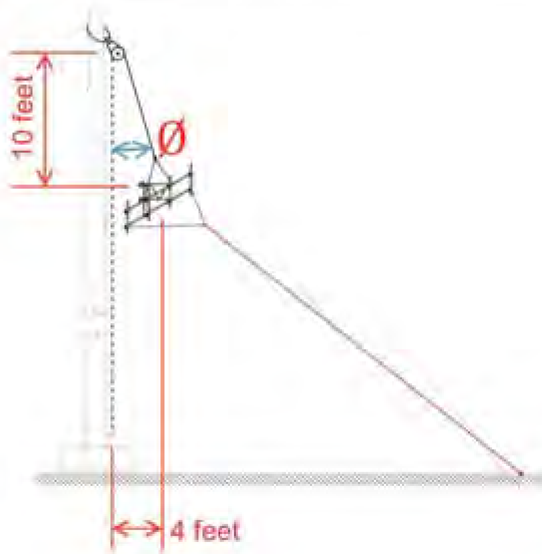
For a load located 10 feet below the top block and tagged out 4 feet, what is the approximate load position angle, Ø?

A. 22°

B. 8°

C. 14°

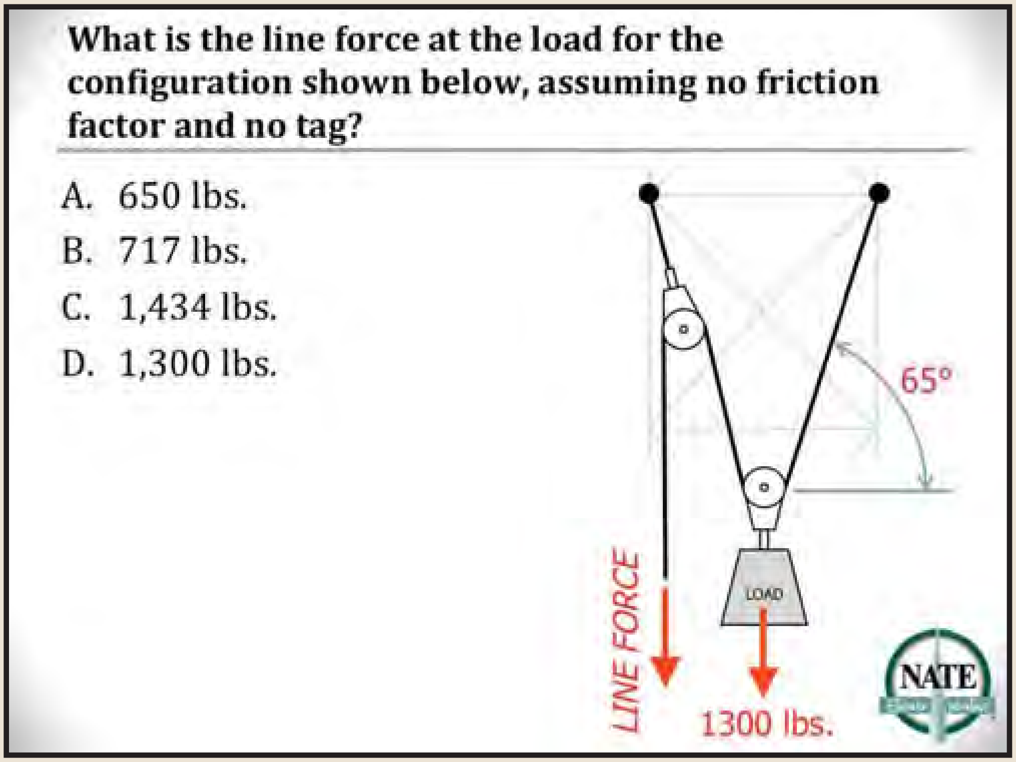
D. 68°



ANSWER: A (22°)

(RISE/RUN) = (10/4) = 2.5 ~ Approx. 22°

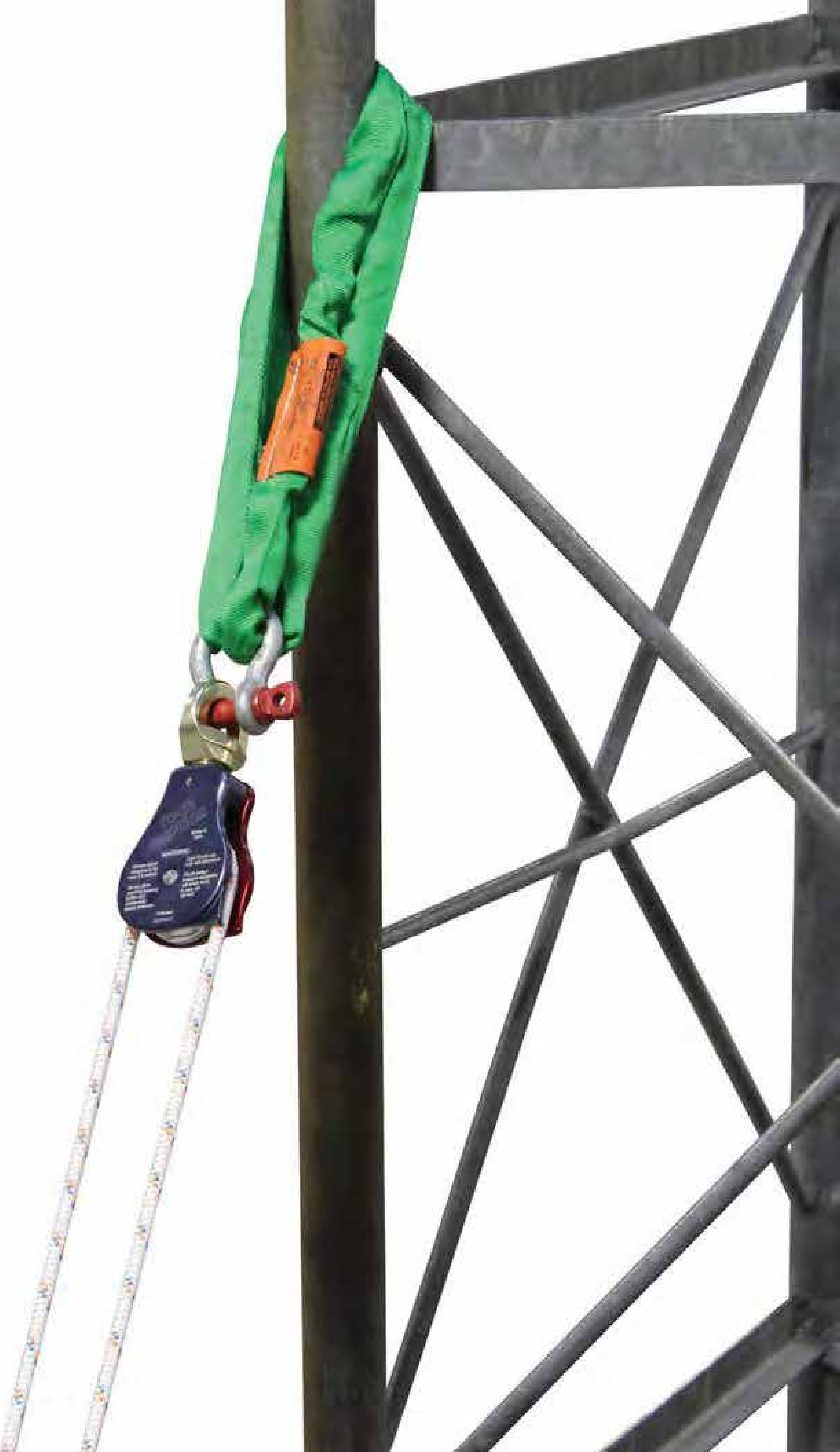
- Discuss the potential concerns with the Load Position Angle ~ far exceeds 10° where resulting line forces can quickly far exceed the Gross Load Weight.

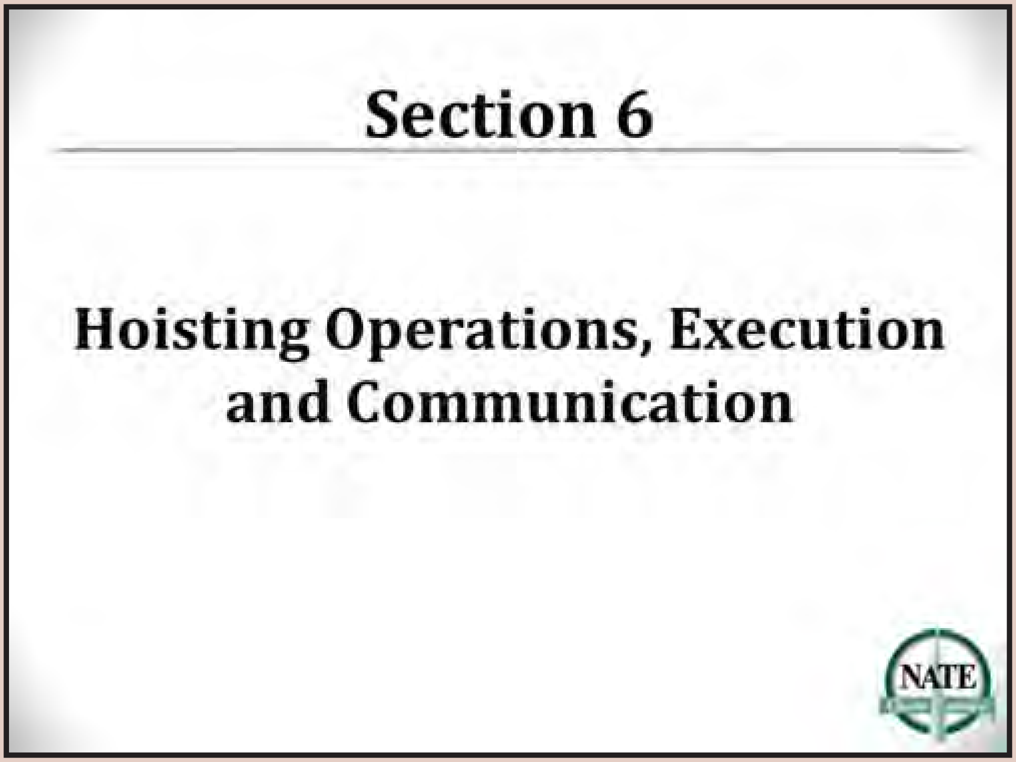


ANSWER: B (717 lbs.)

2-Part configuration with line legs at the top attachments set to a 65° angle from the horizontal

(Gross Load/Number of Line Parts) x Angle Factor = (1300/2) x 1.103 = 717





(15 minute break — 3:00 - 3:15)

(Plan on 60 minutes for Section 6 — 3:15 - 4:15)

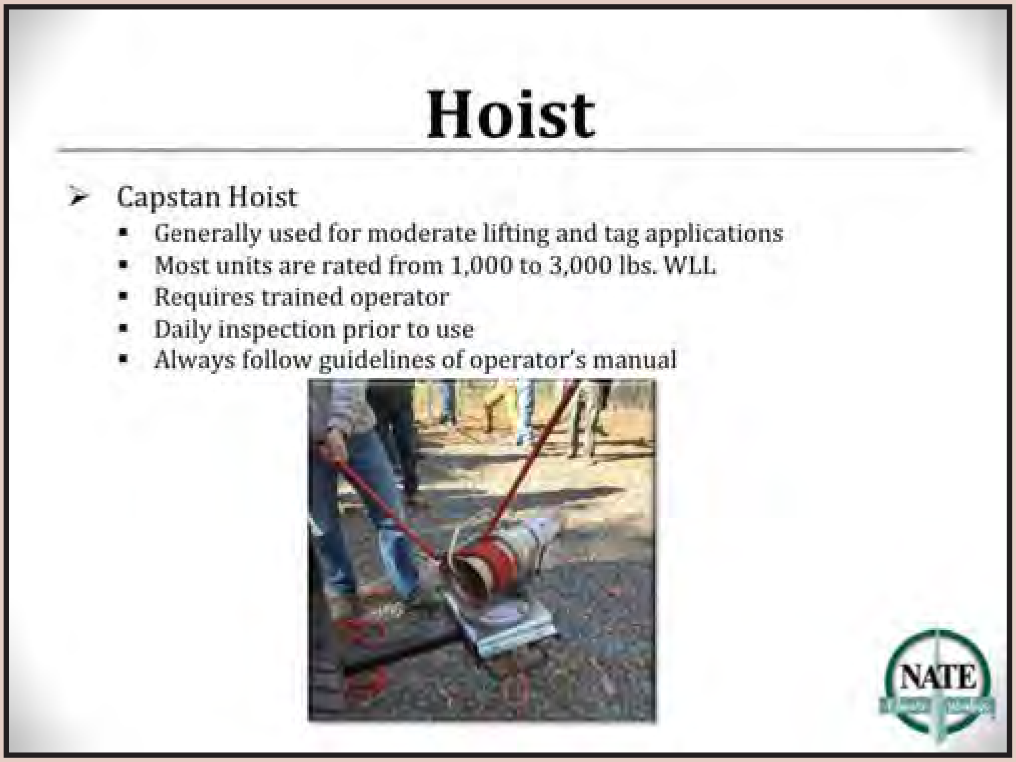
6

Instructor:

This section will cover the most common hoisting mechanism utilized with synthetic rope.

Will review what makes up an anchorage; and what sort of tests can be done in the field to verify the operations of the planned lifting system

We'll then pull it all together with a review of how effective communication can be used to modify a plan.



Instructor:

Read Slide.

Capstan Hoists are used for synthetic rope applications.

Always follow manufacturer's instructions for assembly, inspection, maintenance, and operation.

Next we'll look at some features of the hoist, requirements, and limitations.

Instructor:

Restrictions:

- A Capstan hoist must never be used for personnel lifting.
- No rope splices are allowed to come into contact with the drum.

Requirements:

- Safety Bar – a safety bar is required and prevents the rope from slipping from the drum.
- Deadman Switch – a deadman switch is required for operational control of the capstan.

Best Practices:

- Rope Grab – this feature allows for a means of tying off the load at any point during operation. If no rope grab is being used an alternate method to tie off the load should be included in the plan.
- Rope Collection – Use a bucket or a bin to store the fall line. This helps to prevent the rope from coming into contact with dirt or contaminates that will add wear and tear to the rope.
- Load line should always be positioned toward the drive unit for best control and to prevent fouling.
- Operator is responsible for the load during operations, clear line of sight to the load itself should be maintained.
  - Use of hand signals or alternate communication methods should be determined prior to performing work

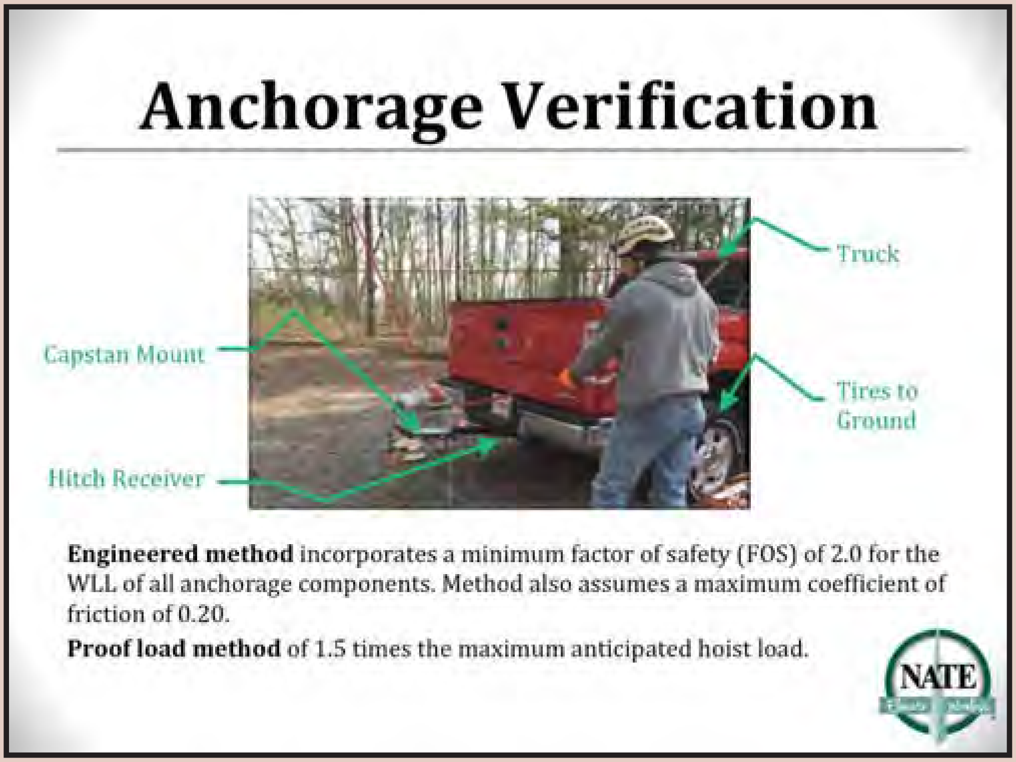
Hoist Anchorages

What makes up the hoist anchorage in this example?

How can we verify it?

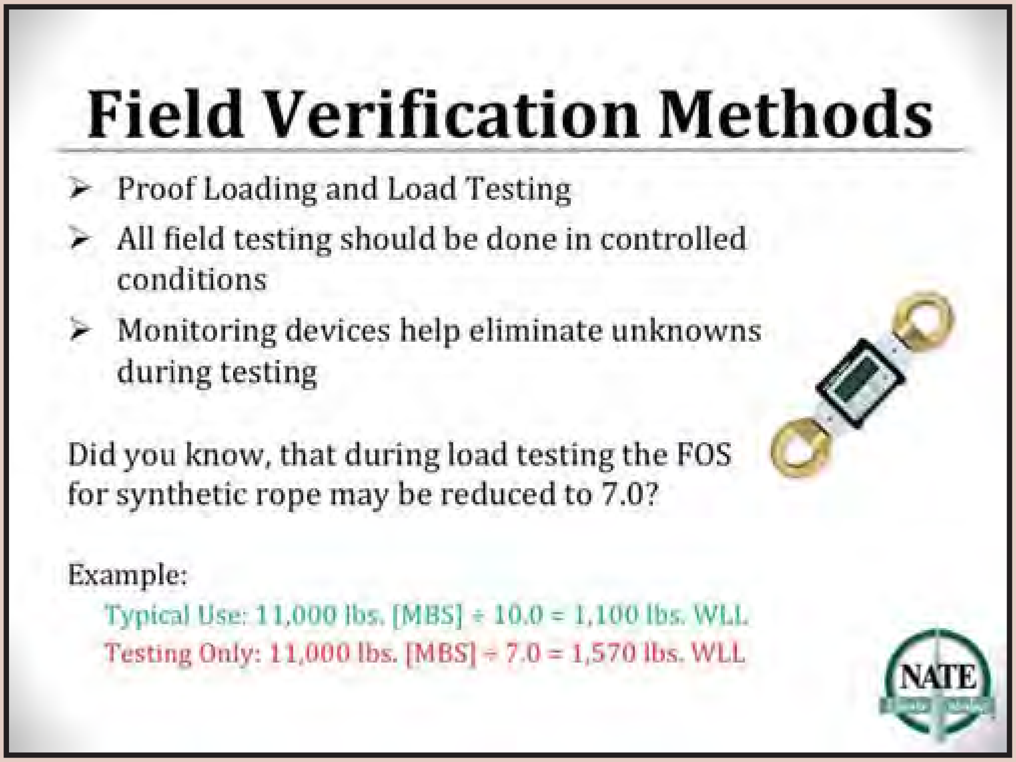
Instructor:

- Ask Question on Slide and get feedback from audience.
- Answer: The hoist anchorage is everything that resists the loading on the capstan from Twisting, Sliding and Sliding Resistance.
- This includes:
    - Review load path in Capstan
        - capstan / capstan mount / receiver hitch / truck / truck contact with ground
- Ask How can we verify the anchorage?
- Answer: Two Methods, details on next slide



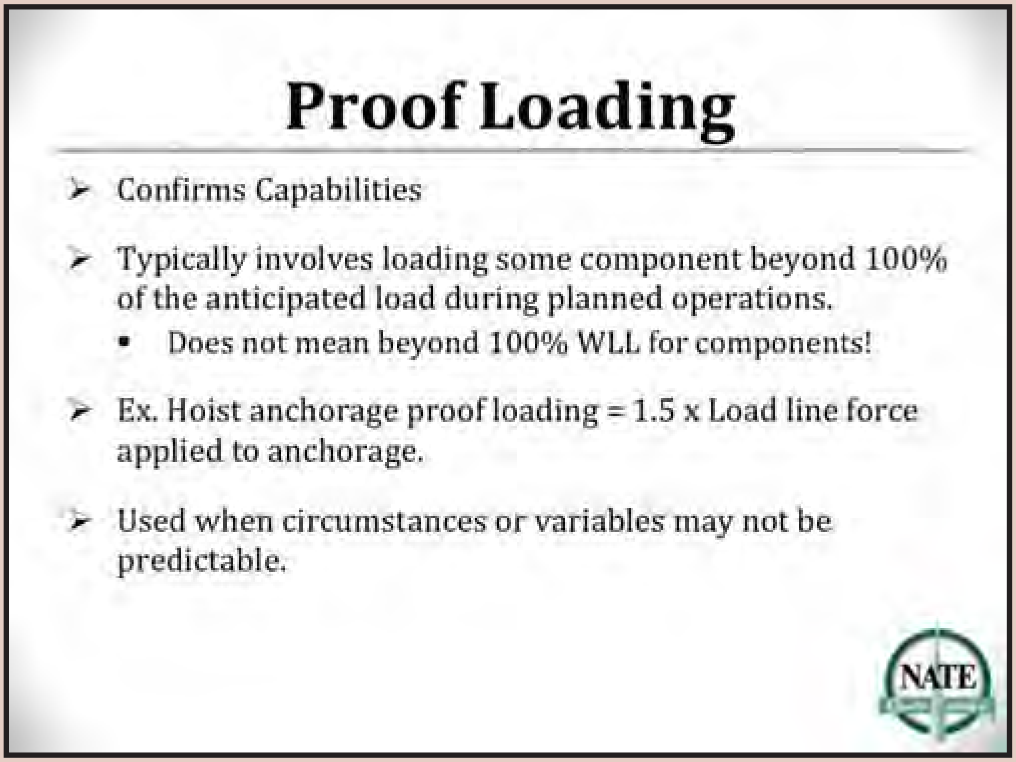
Instructor:

- Identify and review the Anchorage items: Capstan Mount, Hitch Receiver, Truck and Contact to Ground (Tires).
- The Engineered method utilizes calculations based upon anticipated load, a minimum factor of safety and some baseline assumptions.
- The proof load method utilizes a larger than anticipated force against the system in a controlled setting to provide an inspection point for part of the system.
- Some Key points about the Capstan Mount to keep in mind as part of the Hoist Anchorage.
    - Hitch Mount must be approved by the hoist manufacturer or designed by an engineer. “Homemade” mounts without documented engineer’s review/rating shall not be used.
    - Must be assembled and installed per design and direction of manufacturer.
    - Some hitch mounts may not be rated for forces in the vertical direction, in these cases inclusion of a heel block to the lifting system may be required.
- *Identify Section 8.17 in A10.48 as reference for additional information.*



Instructor:

- Proof Loading and Load Testing are two methods of field testing to make confirmations about the lifting system.
- In either test scenario, the work shall be done in controlled conditions similar to those expected during construction activity operations:
  - – Ex. Calm wind,
  - – Loads shall not exceed the WLL of any rigging component.
- Devices such as load cells and transits, can aid with providing measured confirmations for load forces and deflections that the system is supporting. When using a load cell in a lifting system ensure that manufacture's guideline for use are followed and that like any other component forces are kept within it's WLL.
- Read the Did you know question? Ask if anyone knows why you may need to do this?
- Answer – Oftentimes synthetic rope may be the controlling component in your rigging system for a planned lift, meaning it has the lowest WLL. In the setting of a controlled case like load testing you may need to increase the forces within the lifting system to validate other components. This reduction to the synthetic rope FOS facilitates these field testing needs.
- **REMINDER – The FOS determination is also subject to the condition and inspection of the rope itself.**
- Next we'll look at the differences between Proof load testing and Load testing.



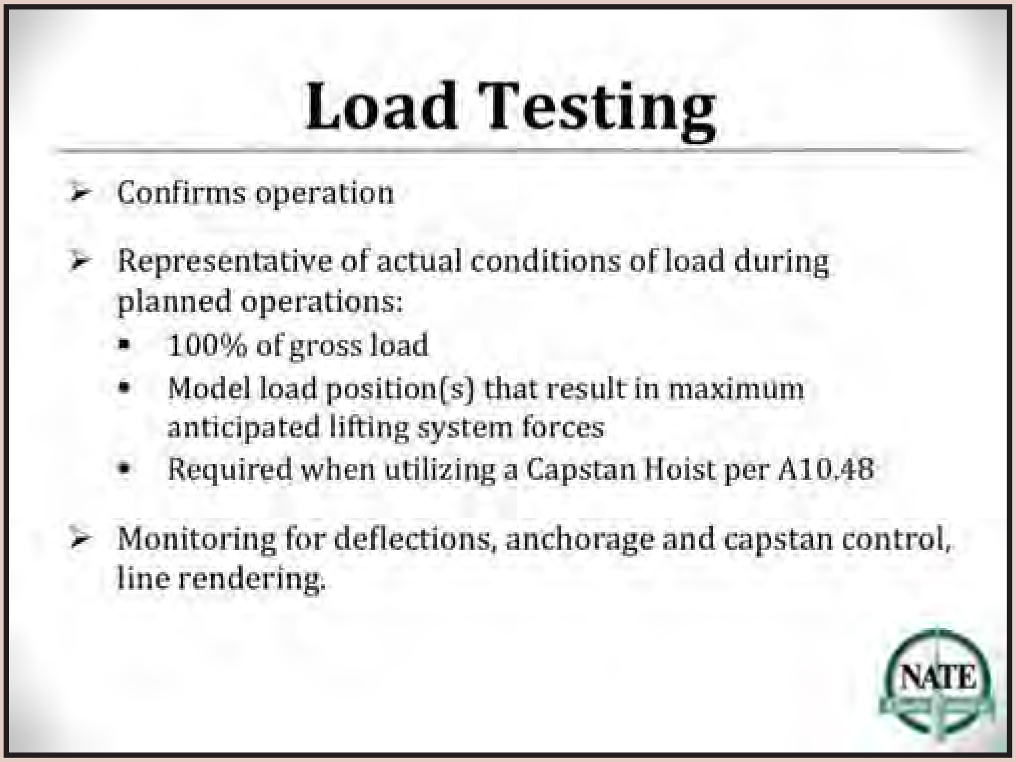
Instructor:

Proof Loading is utilized to confirm the capability of some component of the system or the system it self.

Read Slide.

Proof Loading is considered a best practice, particularly in the cases of hoist anchorages. Example, Capstan with hitch mount; vehicle parked on uneven ground, or varying ground conditions, dirt, sand, asphalt.

Proof Loading should always be performed under the expected site conditions for the planned lift.

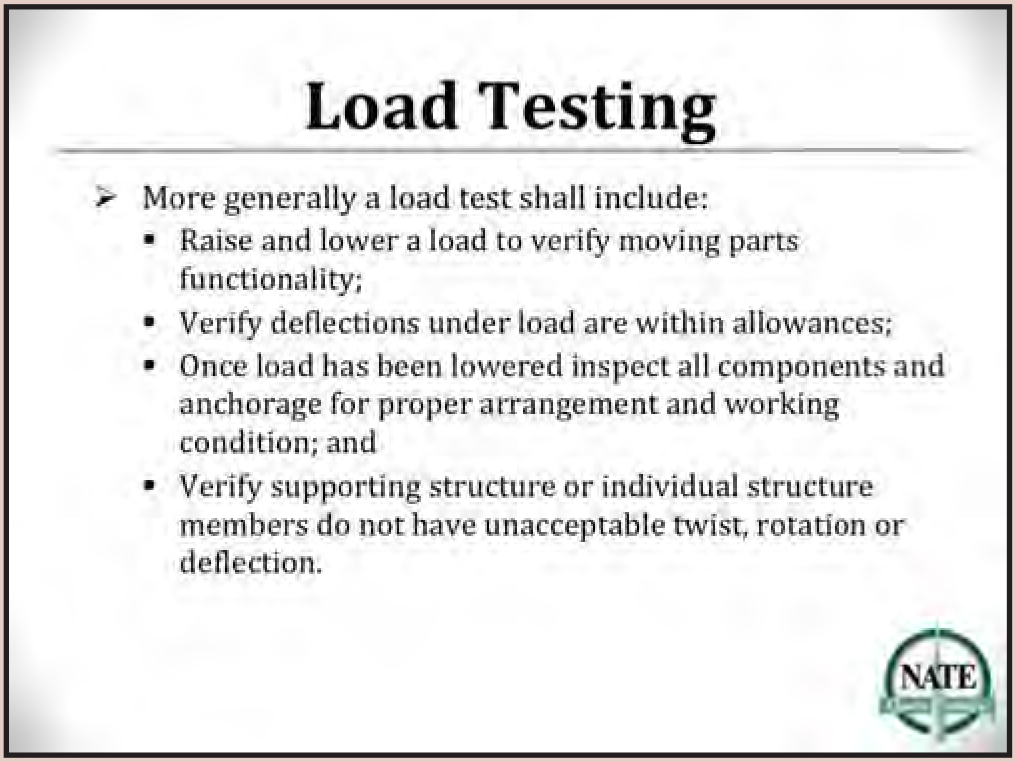


Instructor:

Read Slide.

Summarize intent:

The load test is a best practice requirement, where everything comes together. This is the best opportunity to validate the system prior to executing the work at height.



Instructor:

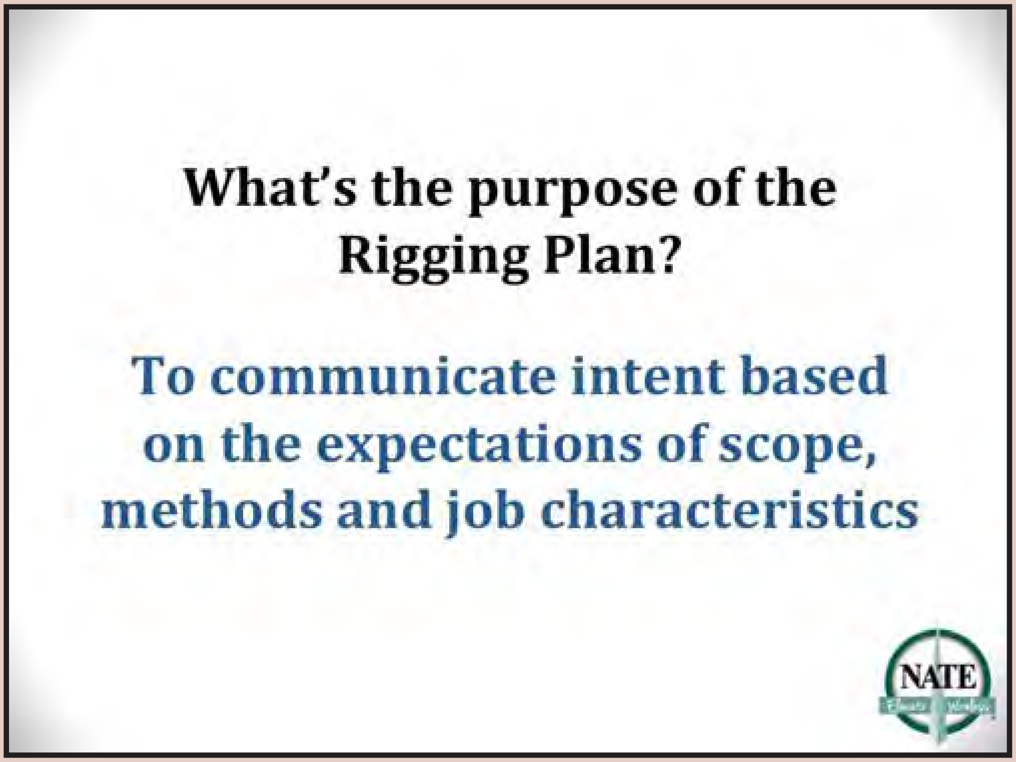
Regardless of lifting system type these are guidelines for a complete Load Test

Read Slide.

Open discussion question.

Click for Answer:

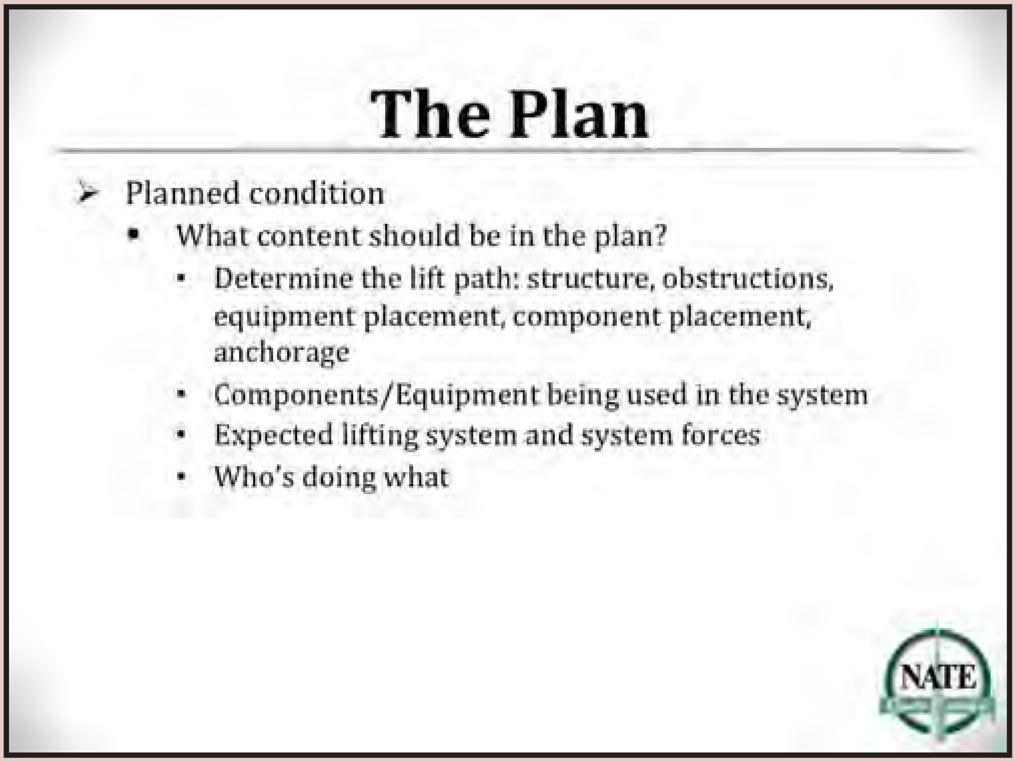
We put the information in the Rigging Plan



Open discussion question.

Click for Answer:

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



Instructor:

Planned Condition

Review summary of items that are required information for the rigging plan.

ASK –

How are your plans currently being put together?

Does the crew lead do it? The CM? Some office staff member?

Is that okay?

Who all reviews a plan as it is being put together?

What's the importance of identifying the Who's doing What in the field?

– Because the Competent Rigger **OWNS** the plan.

Yes, it is okay if the plan is produced using multiple resources; but a CRITICAL component to the communication is that the Competent Rigger not only understands the plan, but endorses the plan, will follow the plan, and has the competency, which means training and experience, to use the means and methods the plan calls for.

Open discussion question.

Probe familiarity with plans and processes used to generate plans.

Ask how roles and responsibilities are covered.

Ask who owns the plan at the time showing up on site.

Instructor:

A rigging plan should improve project efficiency by helping you to Inspect what you Expect.

The working and access areas.

The lifting system used and component placement.

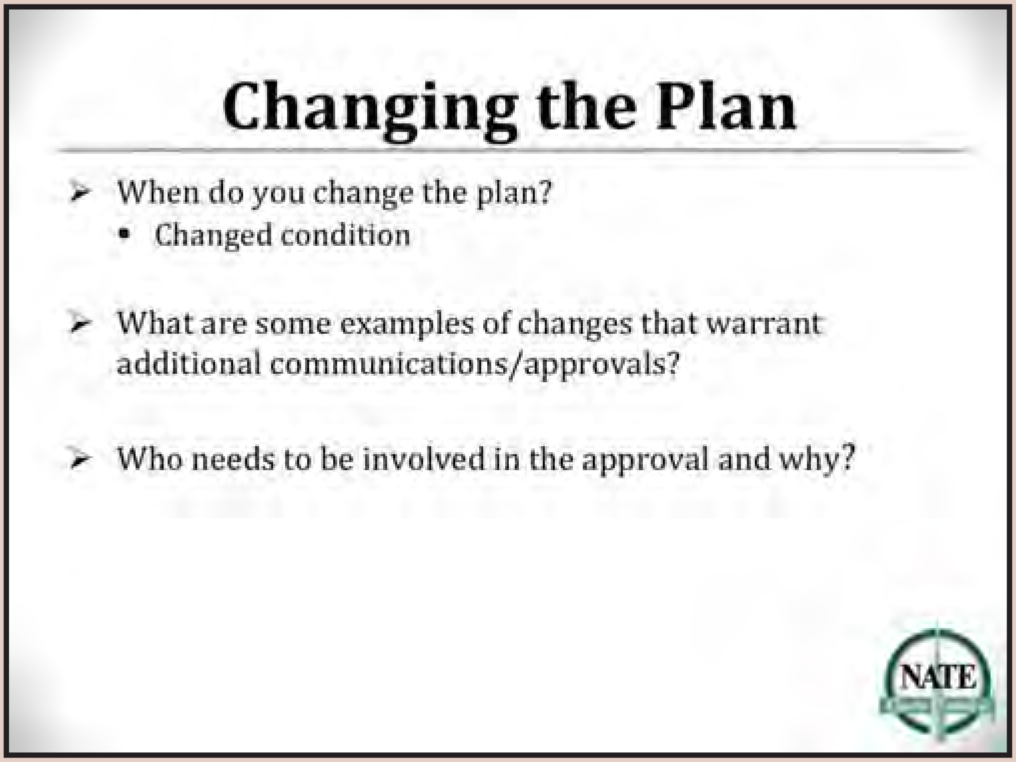
Expected rigging forces and component needs.

Operation testing.

Open discussion question.

Click for Answer:

Meaning the Stakeholders collaborate on viable solutions and document the updates.



Instructor:

Changed Condition Examples:

• Planned load path unachievable:

  – Appurtenances on the tower that were not known about, need to change tag-out, need to change crown block placement.

  – Hoist and Anchorage can't go in planned location; new ground equipment, sloping terrain, LL access restrictions.

Examples of primary changes

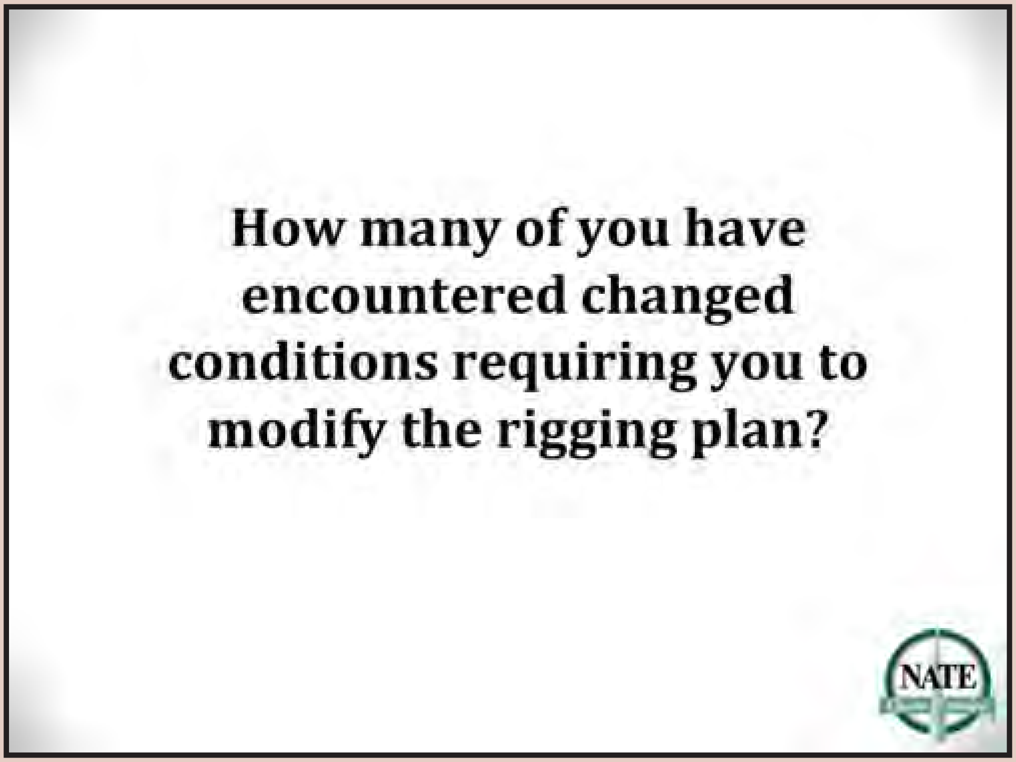
• Lifting Configuration Change – Forces change.

• Change in classification – minimum responsibility, may need to engage additional personnel e.g. Qualified Person or Engineer.

• New / Additional components – redirect block.

• Change in Gross Load – Verification of forces and components.

Who is involved:
All Stakeholders that may be affected by the change in means, methods or sequence: Competent Rigger, Qualified Person (if app), Qualified Engineer (if app).

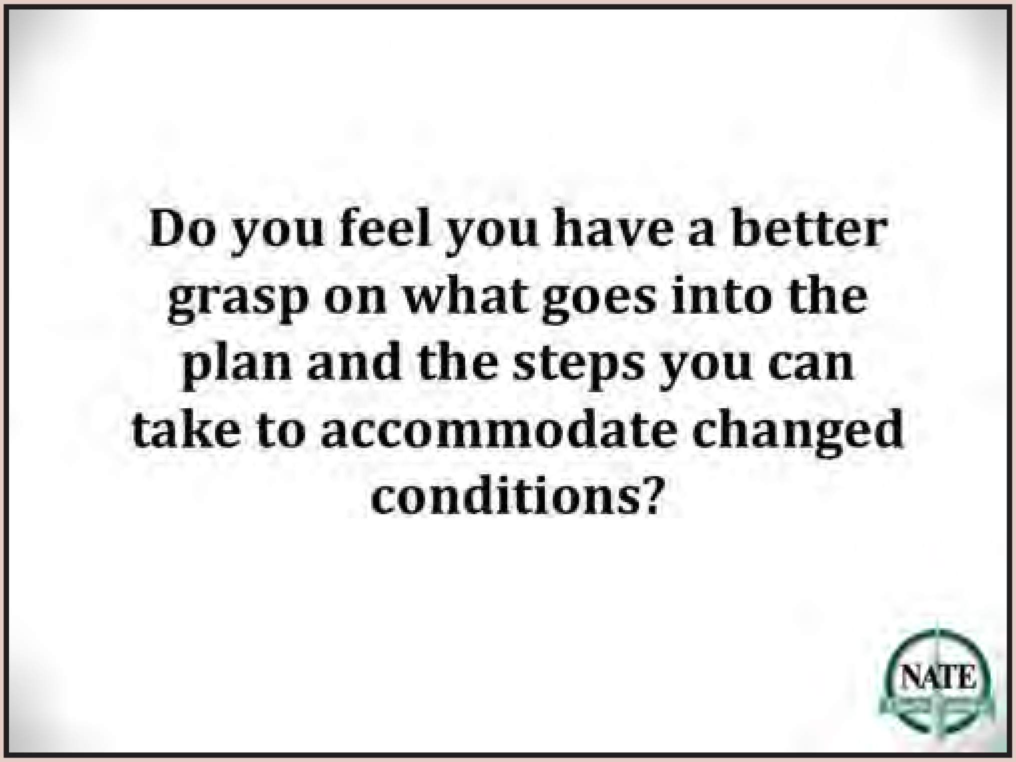


Instructor:

Follow on Questions:

Q: What was the process you used?

Q: Who all did you communicate with?



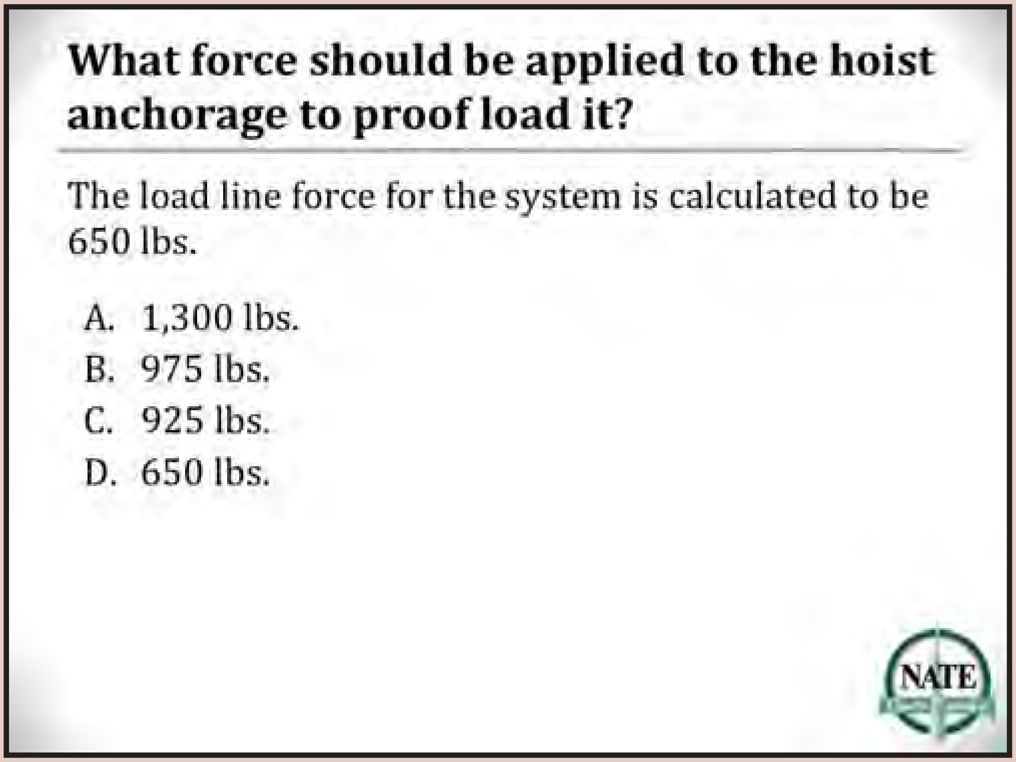
Instructor:

Probe for opportunity to address any open questions.

Instructor:

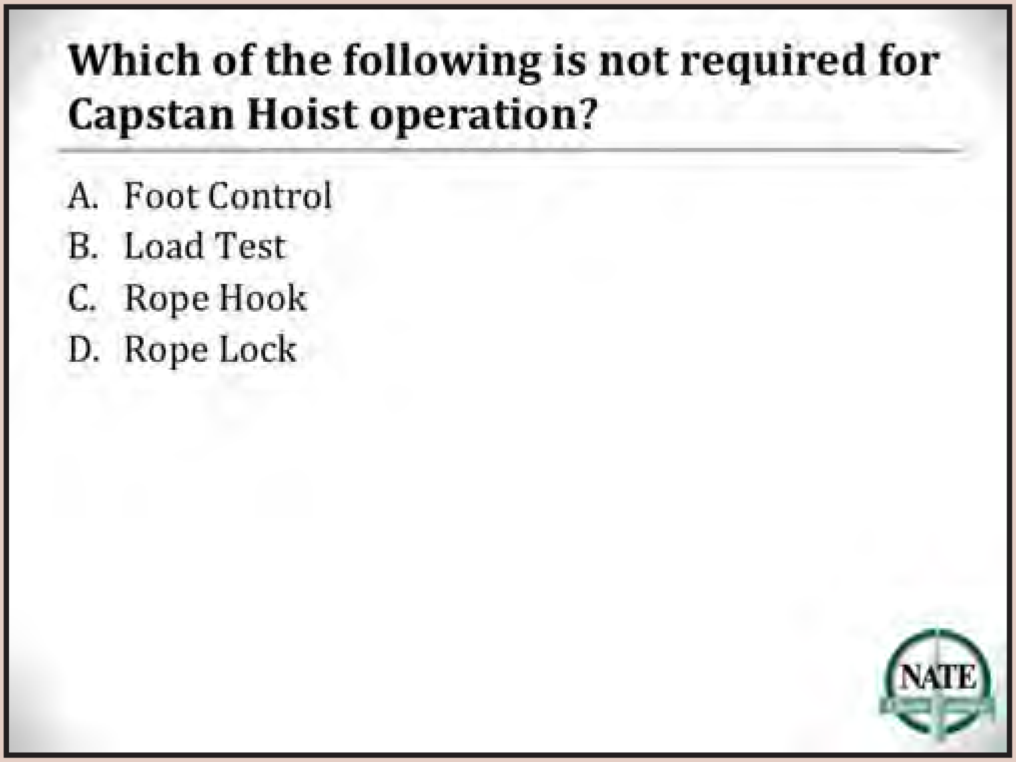
Ask what communication paths lead to audience learning about A10.48 Standard? Industry Organization participation? NATE, State Wireless Associations? Customers, Competitors, etc.? Encourage awareness and participation.

SECTION 6
REVIEW QUESTIONS



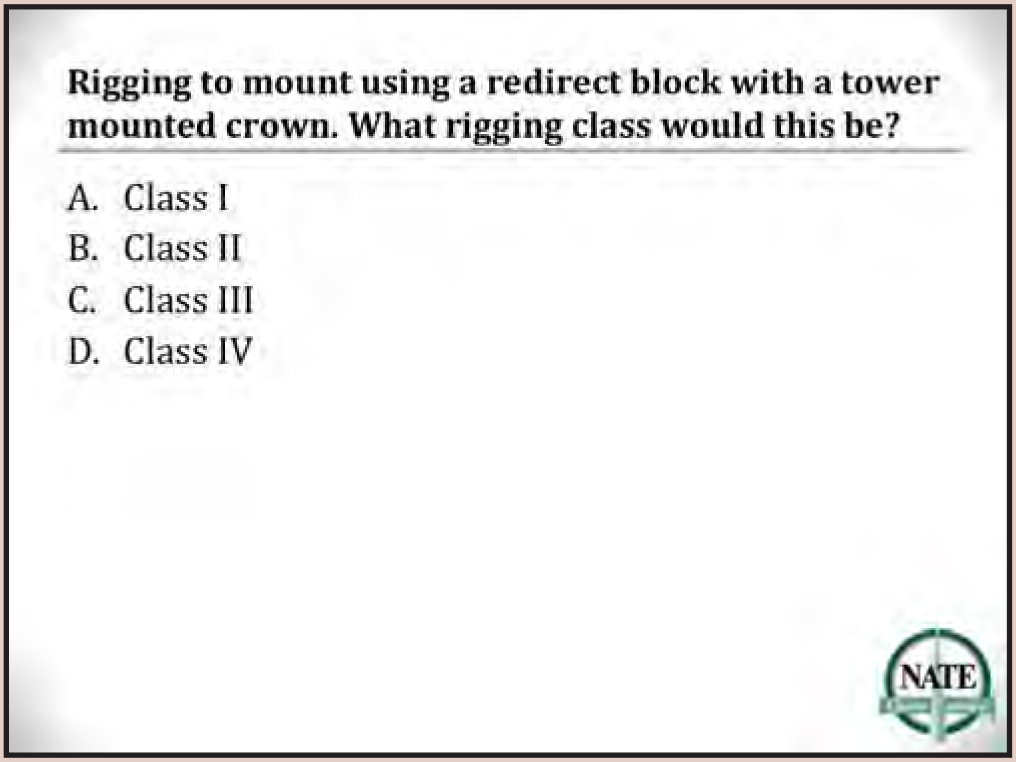
Answer: B (975 lbs.)

Hoist Anchorage utilizes a proof load of 1.5 x force on hoist. 1.5 x 650 = 975 lbs.



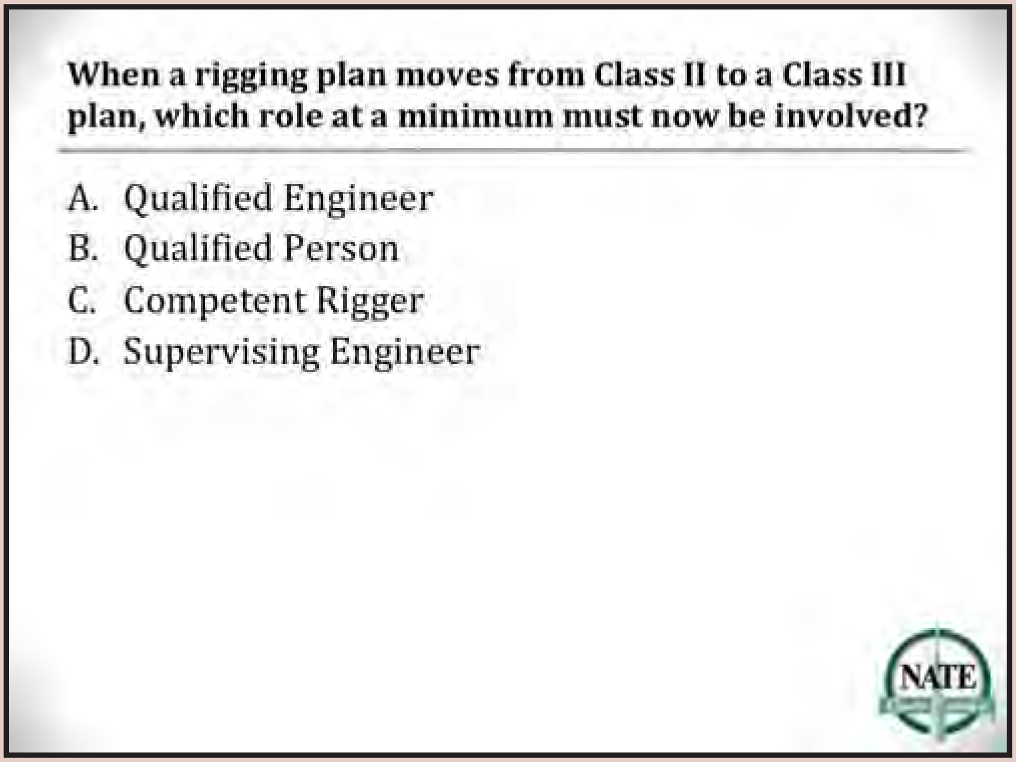
Answer: D (Rope Lock) is not required, but is considered best practice.

Reminder – when a Rope Lock isn't used, there still needs to be an effective means to suspend and support a load.



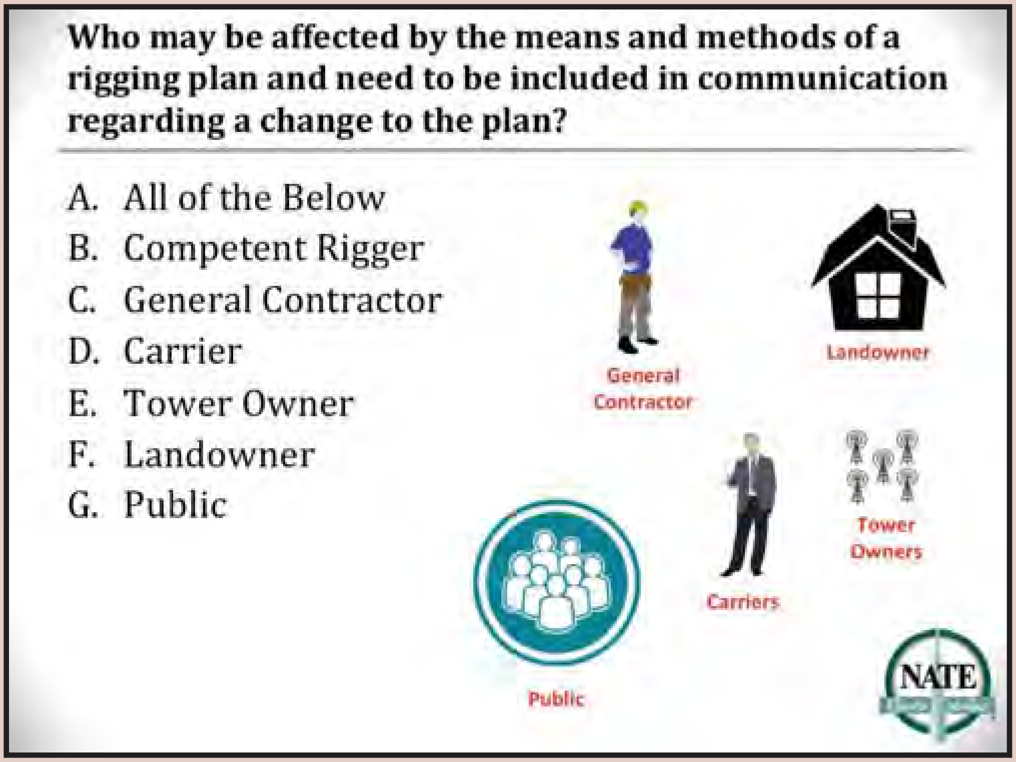
Answer: D (Class IV)

Class IV Rigging Plan would be required. The classification system based on gross lifted load when the lifting system is connected to the supporting structure. Utilizing an appurtenance such as a mount for part of the rigging system requires that the mount be analyzed to carry the forces applied during the operational condition.



Answer: B (Qualified Person)

Class III plans require as the minimum level of responsibility a Competent Rigger and Qualified Person. A Class II plan requires a Competent Rigger at a minimum so the new role required in Class III is the Qualified Person. Additionally, the Qualified Person and Competent Rigger may be the same individual, but capable of serving the needs of both roles. Ref A10.48 Section 4.8.3



Answer: A (All of the Below)

It's important to remember that the means and methods while controlled by the Competent Rigger and General Contractor, have the ability to affect the property of others. All effected stakeholders or those authorized to represent those interests should be engaged for the sake of successful completion of the scope of work.


Thank You!
NATE

APPENDIX

REFERENCES

ANSI/ASSE A10.4, Personnel Hoists and Employee Elevators

ANSI/ASSE A10.5, Material Hoists

ANSI/ASSE A10.6, Safety Requirements for Demolition Operations

ANSI/ASSE A10.28, Work Platforms Suspended from Cranes or Derricks

ANSI/ASSE A10.32, Personal Fall Protection Systems for Construction and Demolition Operations

ANSI/ASSE A10.33, Safety and Health Program Requirements for Multi-Employer Projects

ANSI/ASSE A10.34, Protection of the Public on or Adjacent to Construction Sites

ANSI/ASSE A10.42, Safety Requirements for Rigging Qualifications and Responsibilities

ANSI/ASSE A10.44, Control of Energy Sources (Lockout/Tagout) for Construction & Demolition Operations

ANSI/ASSE A10.48, Criteria for Safety Practices with the Construction, Demolition, Modification and Maintenance of Communication Structures

ANSI/ASME B30.7, Winches

ANSI/ASME B30.9, Slings

ANSI/ASME B30.21, Lever Hoists

ANSI/ASME B30.23, Personnel Lifting Systems

ANSI/ASME B30.26, Rigging Hardware

ANSI/IEEE C95.1, Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic and Electromagnetic Fields, 0 Hz to 300 GHz

ANSI/TIA-222-G, Structural Standard for Supporting Structures and Antennas

ANSI/TIA-222-H, Structural Standard for Antenna Supporting Structures, Antennas and Small Wind Turbine Support Structures

ANSI/TIA-322, Loading Criteria, Analysis, and Design Related to the Installation, Alteration and Maintenance of Communication Structures

ANSI/ASSE Z490.1, Criteria for Accepted Practices in Safety, Health and Environmental Training

ANSI/ASSE Z359.2, Minimum Requirements for a Comprehensive Managed Fall Protection Program

AWS D1.1/D1.1M, Structural Welding Code-Steel

Cordage Institute International Guideline - CI 2001-2004: Fiber Rope Inspection and Retirement Criteria

Federal Aviation Administration, Rotorcraft External-Load Operations, Part 133

Federal Communications Commission (FCC), OET Bulletin 65

Institute of Electrical and Electronic Engineers (IEEE) C95.1, Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

NFPA 10, Standard for Portable Fire Extinguishers

“NATE Training Guidelines for Working on Communication and Similar Structures with a Gin Pole and Associated Equipment” Copyright 2013

National Association of Tower Erectors (NATE), Tower Climber Fall Protection Training Standard, Third Edition Revised 2013

National Association of Tower Erectors (NATE), Resource Reference for RF Awareness

National Association of Tower Erectors (NATE), Base Mounted Hoist Mechanism Design and Use Standard for Lifting Personnel While Working on Telecommunication Structures, (10/23/03)

OSHA 29 CFR 1910, Occupational Safety and Health Standards

OSHA 29 CFR 1926, Safety and Health Regulations for Construction

OSHA Construction Safety and Health Outreach Program U.S. Department of Labor May 1996

OSHA Demolition Factsheet

OSHA Directive CPL 02-01-056 7-17-14 Inspection Procedures for Accessing Communication Towers by Hoist

U.S. Department of Labor Division of Occupational Safety and Health (OSHA)

REFERENCES

Current OSHA WEBSITE specific to telecommunications structures: https://
www.google.com/search?q=osha+telecommunications+website&rlz=1C1CHBD_
enUS818US818&oq=OSHA&aqs=chrome.3.69i57j69i60j69i59j35i39j0l2.3848j0j4&sourceid=chrome&ie=UTF-8

Reference page for NATE climber connection videos and Planning Advisory Notices: https://natehome.com/

Note: ASSE had a name change to ASSP during 2018. The American Society of Safety Engineers officially changed their name to the American society of Safety Professionals during June of 2018. This name change did not impact the ANSI (American National Standards Institute) accreditation. The change was intended to ensure that the organization stays at the forefront of workplace safety advancements.

The documents are supported by ASSP but are listed in this reference as ASSE to ensure access to the proper documents until the updates to the various standards occurs.

Lifted Load Rigging Forces

Project Info				
	Rigging Plan No:	Revision No:	Project No:	Date:
	Customer:	Site Address:	Latitude:	
	Site Name:		Longitude:	
	Competent Rigger:	Qualified Person:	Qualified Engineer:	

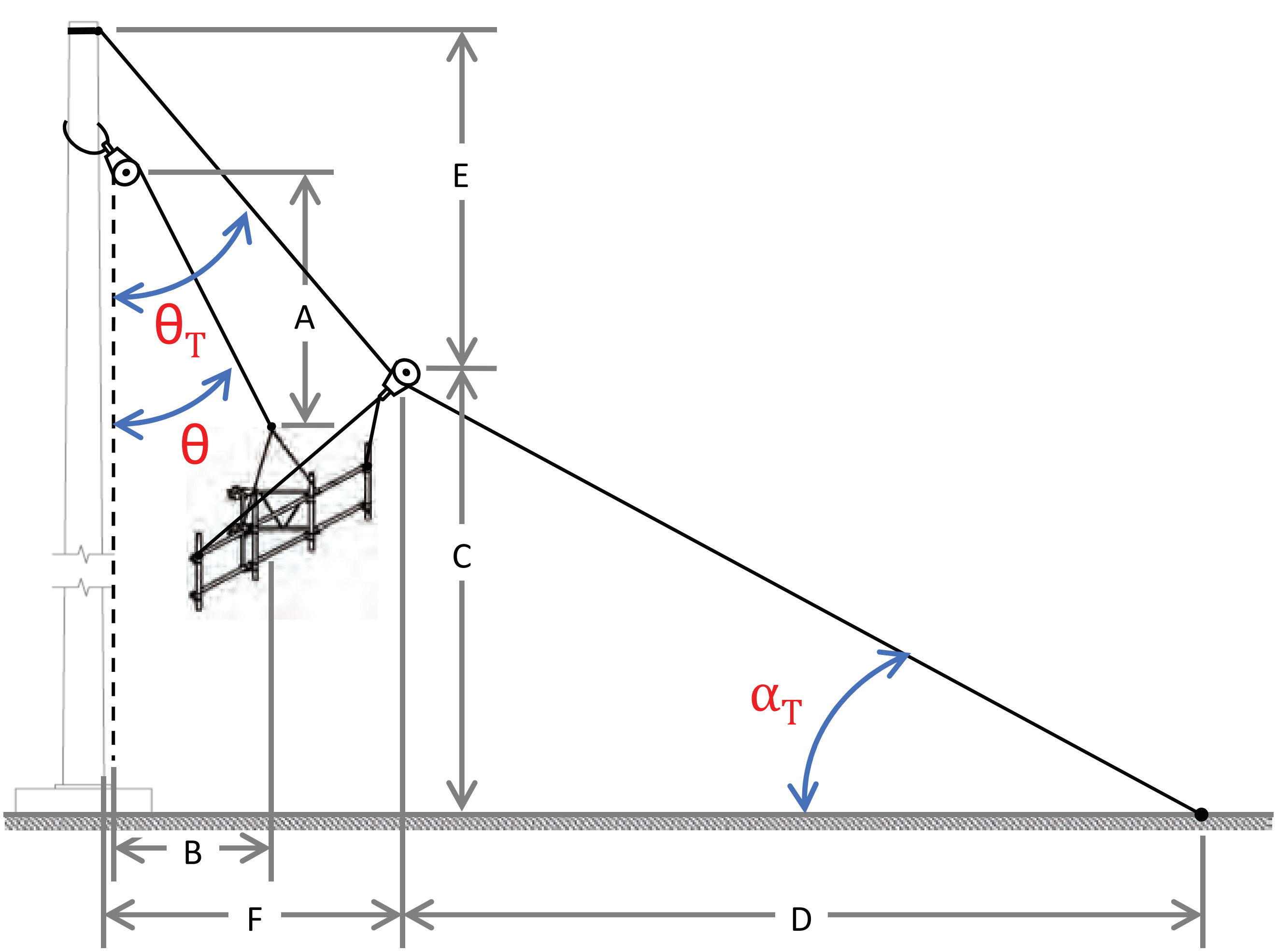
Rigging Plan Class: ☐ Class I ☐ Class II ☐ Class III ☐ Class IV

Dedicated Trolley 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 degree):				
C) Trolley Block to Ground Tag Height (Rise):				
D) Trolley Block to Ground Tag Distance (Run):				
Rise/Run:				
Tag Angle, α_T (round up to nearest 5 deg increment):				
E) Trolley Block to Top Tag Attachment Height (Rise):				
F) Trolley Block to Top Tag Attachment Distance (Run):				
Rise/Run:				
Tag Position Angle, θ_T (round up to nearest degree):				
Load Line Multiplier, PM:				
Tag Line Multiplier, TM:				

Maximum Load Line Multiplier, PM:

Maximum Tag Line Multiplier, TM:



Lifted Load Rigging Forces

Project Info

Rigging Plan No: ____ Revision No: ____ Project No: ____ Date: ____

Customer: ____ Site Address: ____ Latitude: ____

Site Name: ____ Longitude: ____

Competent Rigger: ____ Qualified Person: ____ Qualified Engineer: ____

Rigging Plan Class: □ Class I □ Class II □ Class III □ Class IV

Load Info

Load Weight:	Actual	Est	Load Line Weight:	Actual	Est	Tag Line Weight:	Actual	Est
____	□	□	____	□	□	____	□	□
Rigging Weight:			Overhaul Ball Weight:			Misc Weight:		
____	□	□	____	□	□	____	□	□

GROSS LOAD, **WT:** ____ FALL LINE WEIGHT, **FLW:** ____ Maximum Load Elevation: ____

Tag Method & Lift Angles

Tag Method: Tag Distance: ____

□ Straight Tag □ Integrated Trolley (Self-Trolley) □ Dedicated Trolley □ Special

†Max Load Position Angle, θ: ____ *;round up to nearest degree*

†Max Tag Angle, α/α_T: ____ *;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:

____ *;round up to nearest degree*

Rigging Forces

LINE FORCES AT LOAD

Max Load Line Multiplier, **PM**: ____

Number of Parts of Load Line, N_P: ____

Load Line Force, $P = (WT \times PM) \div N_P$: ____

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 and Heel Blocks □ Top Block Only

Top Block Elevation: ____

Heel Block Elevation: ____

Min Top Block Included Angle: ____

Top Block Angle Factor, AF_{TB}: ____

Top Block Force, $F_{TB} = P \times AF_{TB}$: ____

Min Heel Block Included Angle: ____

Heel Block Angle Factor, AF_{HB}: ____

Heel Block Force, $F_{HB} = P \times AF_{HB}$: ____

Min Trolley Block Included Angle: ____

Trolley Block Angle Factor, AF_{TRB}: ____

Trolley Block Force, $F_{TRB} = T \times AF_{TRB}$: ____

SLING FORCES

Top Block Sling Hitch Type: □ Vertical □ Choker □ Basket □ 2-Leg Bridle □ Special

Number of Sling Legs, N_{STB}:

____ ;"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, $F_{SLTB} = (F_{TB} \times AF_{STB}) \div N_{STB}$: ____

Heel Block Sling Hitch Type: □ Vertical □ Choker □ Basket □ 2-Leg Bridle □ Special

Number of Sling Legs, N_{SHB}:

____ ;"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, $F_{SLHB} = (F_{HB} \times AF_{SHB}) \div N_{SHB}$: ____

Trolley Block Sling Hitch Type: □ Vertical □ Choker □ Basket □ 2-Leg Bridle □ Special

Number of Sling Legs, N_{STRB}:

____ ;"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_{STRB}: ____

Sling Leg Force, $F_{SLTRB} = (F_{TRB} \times AF_{STRB}) \div N_{STRB}$: ____

Lifted Load Rigging Forces

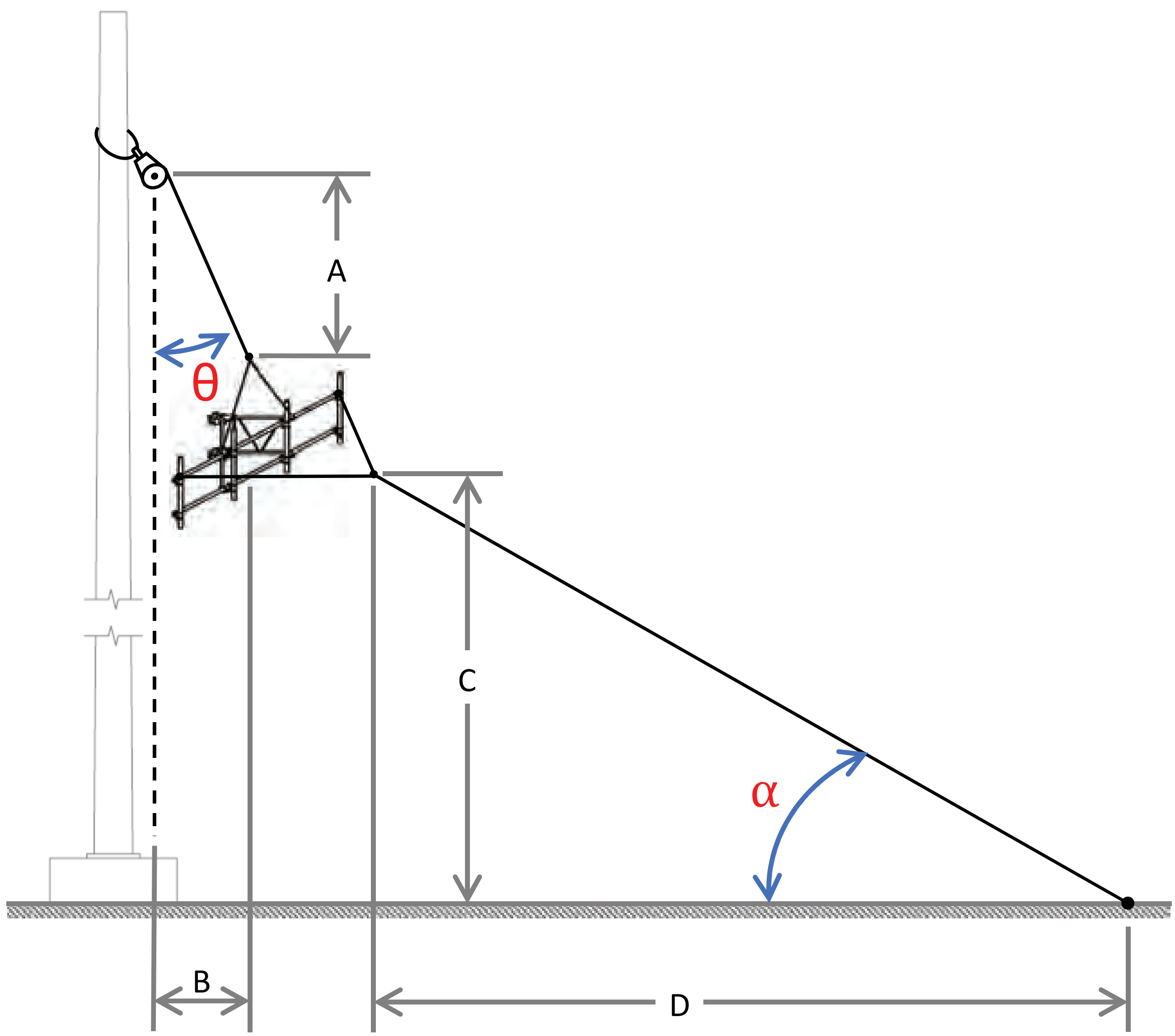
Project Info				
Rigging Plan No:	Revision No:	Project No:	Date:
Customer:	Site Address:	Latitude:	
Site Name:		Longitude:	
Competent Rigger:	Qualified Person:	Qualified Engineer:	

Rigging Plan Class: ☐ Class I ☐ Class II ☐ Class III ☐ Class IV

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:	



Sling Angle Factors

Figure A1. Sling Hitch Types

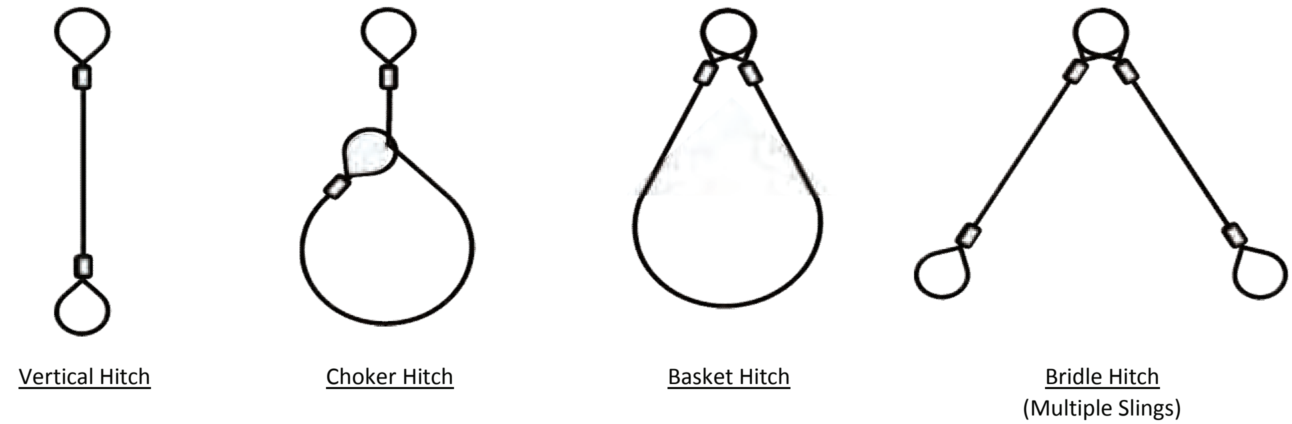
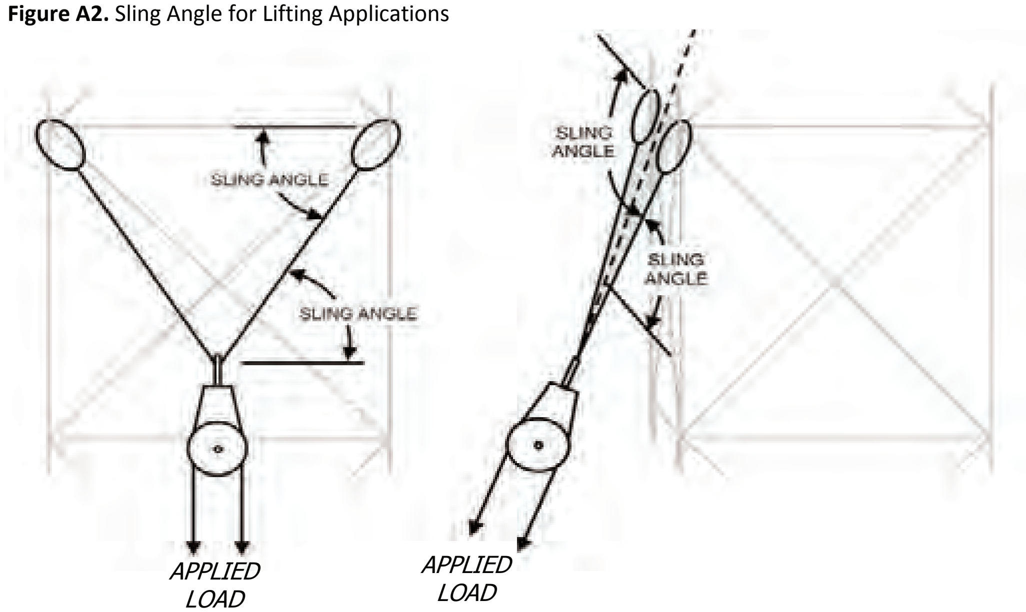


Figure A2. Sling Angle for Lifting Applications



DEFINITION:

Sling Angle: The acute angle between the sling leg and the plane perpendicular to the direction of the applied load. For lifting applications, the angle measured from the horizontal to the sling leg while accounting for incline in the rendered plane.

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 qualifed person.

NOTE: For additional information on sling definitions, selection, use, and maintenance refer to the sling manufacturer's guidlelines and ASME B30.9, Slings.

Block Angle Factors

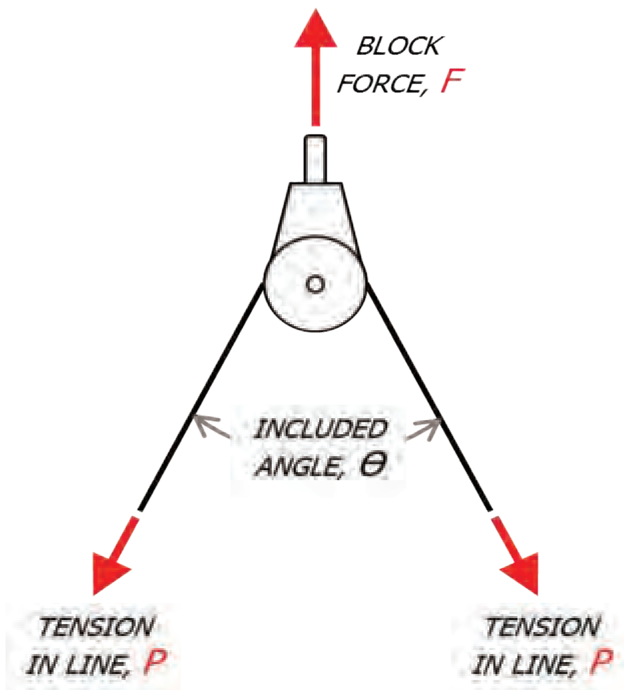


Table A2. Block Angle Factors

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

NOTE: For additional information on rigging block definitions, selection, use, and maintenance refer to the block manufacturer's guidlelines and ASME B30.26, Rigging Hardware.

Sheave Friction Factors

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

NOTES:

1) Table based on bearing constants, K, of: Plain Bearings, PB=1.09 l Bronze Bushings, BB=1.045 l Steel Roller Bearings, SRB=1.02
2) Reference sheave manufacturer for other applicable bearing constants.

Rise/Run Angle Conversion

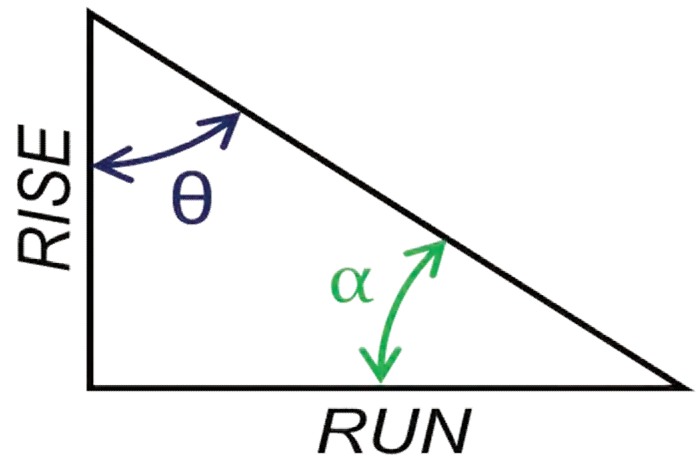


Table A4. Rise-to-Run Angle Conversion

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°
67°	**0.42**	23°	37°	**1.33**	53°	7°	**8.14**	83°
66°	**0.45**	24°	36°	**1.38**	54°	6°	**9.51**	84°
65°	**0.47**	25°	35°	**1.43**	55°	5°	**11.43**	85°
64°	**0.49**	26°	34°	**1.48**	56°	4°	**14.30**	86°
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°

Load and Tag Line Multipliers for Straight Tag Lift Arrangements

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**	**1.013**	**1.021**	**1.031**	**1.037**	**1.044**	**1.053**	**1.065**	**1.082**	**1.107**	**1.151**	**1.248**	**1.665**
		TM	*0.036*	*0.038*	*0.041*	*0.047*	*0.051*	*0.057*	*0.064*	*0.074*	*0.089*	*0.113*	*0.155*	*0.251*	*0.667*
	3°	PM	**1.011**	**1.021**	**1.033**	**1.047**	**1.057**	**1.068**	**1.082**	**1.101**	**1.128**	**1.170**	**1.245**	**1.425**	**2.497**
		TM	*0.054*	*0.057*	*0.062*	*0.072*	*0.078*	*0.087*	*0.099*	*0.115*	*0.140*	*0.179*	*0.252*	*0.429*	*1.500*
	4°	PM	**1.015**	**1.029**	**1.045**	**1.065**	**1.078**	**1.094**	**1.114**	**1.141**	**1.179**	**1.241**	**1.356**	**1.661**	**4.994**
		TM	*0.072*	*0.076*	*0.084*	*0.097*	*0.106*	*0.119*	*0.135*	*0.159*	*0.195*	*0.253*	*0.366*	*0.667*	*3.997*
	5°	PM	**1.020**	**1.037**	**1.057**	**1.083**	**1.100**	**1.121**	**1.147**	**1.183**	**1.236**	**1.321**	**1.490**	**1.992**	-
		TM	*0.090*	*0.096*	*0.106*	*0.123*	*0.136*	*0.152*	*0.174*	*0.206*	*0.255*	*0.337*	*0.502*	*1.000*	-
See Note 2	6°	PM	**1.024**	**1.046**	**1.070**	**1.103**	**1.124**	**1.149**	**1.183**	**1.229**	**1.298**	**1.414**	**1.654**	**2.489**	-
		TM	*0.109*	*0.116*	*0.129*	*0.150*	*0.166*	*0.187*	*0.216*	*0.257*	*0.321*	*0.432*	*0.668*	*1.498*	-
	7°	PM	**1.030**	**1.055**	**1.084**	**1.123**	**1.149**	**1.180**	**1.222**	**1.280**	**1.368**	**1.520**	**1.860**	**3.318**	-
		TM	*0.127*	*0.137*	*0.153*	*0.179*	*0.198*	*0.224*	*0.260*	*0.312*	*0.394*	*0.542*	*0.876*	*2.329*	-
	8°	PM	**1.035**	**1.064**	**1.099**	**1.145**	**1.175**	**1.213**	**1.263**	**1.335**	**1.445**	**1.645**	**2.124**	**4.976**	-
		TM	*0.146*	*0.158*	*0.177*	*0.208*	*0.231*	*0.263*	*0.307*	*0.372*	*0.476*	*0.669*	*1.142*	*3.988*	-
	9°	PM	**1.042**	**1.074**	**1.114**	**1.168**	**1.203**	**1.248**	**1.308**	**1.395**	**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*	-	-
See Note 3	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*	*1.220*	*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*	-	-
	14°	PM	**1.078**	**1.133**	**1.204**	**1.303**	**1.373**	**1.466**	**1.601**	**1.814**	**2.215**	**3.272**	**14.830**	-	-
		TM	*0.265*	*0.292*	*0.336*	*0.412*	*0.470*	*0.552*	*0.675*	*0.878*	*1.268*	*2.314*	*13.862*	-	-
	15°	PM	**1.087**	**1.147**	**1.225**	**1.336**	**1.414**	**1.521**	**1.677**	**1.932**	**2.434**	**3.924**	-	-	-
		TM	*0.286*	*0.316*	*0.366*	*0.451*	*0.518*	*0.612*	*0.757*	*1.000*	*1.490*	*2.970*	-	-	-
	16°	PM	**1.096**	**1.162**	**1.247**	**1.370**	**1.459**	**1.580**	**1.762**	**2.067**	**2.702**	**4.903**	-	-	-
		TM	*0.307*	*0.341*	*0.397*	*0.493*	*0.569*	*0.678*	*0.847*	*1.139*	*1.762*	*3.951*	-	-	-
	17°	PM	**1.105**	**1.177**	**1.270**	**1.407**	**1.506**	**1.645**	**1.856**	**2.223**	**3.037**	**6.535**	-	-	-
		TM	*0.328*	*0.366*	*0.429*	*0.537*	*0.623*	*0.748*	*0.946*	*1.300*	*2.101*	*5.586*	-	-	-
	18°	PM	**1.115**	**1.192**	**1.294**	**1.446**	**1.558**	**1.716**	**1.962**	**2.405**	**3.468**	**9.800**	-	-	-
		TM	*0.350*	*0.392*	*0.462*	*0.583*	*0.681*	*0.825*	*1.057*	*1.486*	*2.536*	*8.854*	-	-	-
	19°	PM	**1.126**	**1.209**	**1.320**	**1.487**	**1.613**	**1.794**	**2.081**	**2.620**	**4.043**	**19.597**	-	-	-
		TM	*0.372*	*0.419*	*0.496*	*0.632*	*0.743*	*0.908*	*1.181*	*1.706*	*3.115*	*18.655*	-	-	-
	20°	PM	**1.137**	**1.227**	**1.347**	**1.532**	**1.673**	**1.879**	**2.216**	**2.879**	**4.849**	-	-	-	-
		TM	*0.395*	*0.446*	*0.532*	*0.684*	*0.809*	*1.000*	*1.321*	*1.970*	*3.924*	-	-	-	-
	21°	PM	**1.149**	**1.245**	**1.376**	**1.580**	**1.738**	**1.974**	**2.371**	**3.196**	**6.058**	-	-	-	-
		TM	*0.418*	*0.475*	*0.569*	*0.739*	*0.881*	*1.101*	*1.481*	*2.291*	*5.137*	-	-	-	-
	22°	PM	**1.161**	**1.264**	**1.407**	**1.632**	**1.810**	**2.080**	**2.550**	**3.593**	**8.075**	-	-	-	-
		TM	*0.442*	*0.504*	*0.608*	*0.798*	*0.959*	*1.212*	*1.665*	*2.692*	*7.158*	-	-	-	-
	23°	PM	**1.174**	**1.285**	**1.439**	**1.687**	**1.888**	**2.199**	**2.759**	**4.103**	**12.110**	-	-	-	-
		TM	*0.466*	*0.534*	*0.649*	*0.861*	*1.043*	*1.336*	*1.879*	*3.206*	*11.196*	-	-	-	-
	24°	PM	**1.188**	**1.306**	**1.473**	**1.747**	**1.973**	**2.332**	**3.006**	**4.783**	**24.215**	-	-	-	-
		TM	*0.491*	*0.565*	*0.692*	*0.928*	*1.135*	*1.476*	*2.132*	*3.891*	*23.305*	-	-	-	-
	25°	PM	**1.202**	**1.329**	**1.510**	**1.813**	**2.067**	**2.484**	**3.303**	**5.737**	-	-	-	-	-
		TM	*0.516*	*0.598*	*0.737*	*1.000*	*1.236*	*1.633*	*2.434*	*4.849*	-	-	-	-	-
	26°	PM	**1.217**	**1.353**	**1.549**	**1.883**	**2.172**	**2.657**	**3.667**	**7.168**	-	-	-	-	-
		TM	*0.542*	*0.631*	*0.784*	*1.078*	*1.346*	*1.812*	*2.802*	*6.284*	-	-	-	-	-
	27°	PM	**1.233**	**1.378**	**1.590**	**1.961**	**2.288**	**2.857**	**4.121**	**9.554**	-	-	-	-	-
		TM	*0.568*	*0.666*	*0.834*	*1.162*	*1.469*	*2.018*	*3.262*	*8.675*	-	-	-	-	-
	28°	PM	**1.250**	**1.404**	**1.634**	**2.045**	**2.419**	**3.092**	**4.706**	**14.327**	-	-	-	-	-
		TM	*0.596*	*0.702*	*0.886*	*1.253*	*1.606*	*2.258*	*3.852*	*13.452*	-	-	-	-	-
	29°	PM	**1.267**	**1.432**	**1.681**	**2.138**	**2.565**	**3.369**	**5.487**	**28.649**	-	-	-	-	-
		TM	*0.624*	*0.739*	*0.941*	*1.353*	*1.759*	*2.541*	*4.638*	*27.779*	-	-	-	-	-
	30°	PM	**1.286**	**1.462**	**1.732**	**2.240**	**2.732**	**3.702**	**6.581**	-	-	-	-	-	-
		TM	*0.653*	*0.778*	*1.000*	*1.462*	*1.932*	*2.879*	*5.737*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ load position angles less than 5° and tag angles less than 60°.
2) Caution should be excercised for lift operations involving load angles from 5°-10° or tag angles from 60°-70°.
3) All lift operations involving load angles exceeding 10° or tag angles exceeding 70° for straight tag applications should be considered "special lifts" due to the potential excessive line multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.1. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 1°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 1° TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.985**	**0.988**	**0.990**	**0.992**	**0.993**	**0.994**	**0.995**	**0.995**	**0.996**	**0.997**	**0.998**	**0.998**	**0.999**
	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	**0.985**	**0.988**	**0.990**	**0.992**	**0.993**	**0.993**	**0.994**	**0.995**	**0.996**	**0.997**	**0.998**	**0.998**	**0.999**
	TM	*0.018*	*0.019*	*0.021*	*0.024*	*0.026*	*0.029*	*0.032*	*0.037*	*0.045*	*0.057*	*0.078*	*0.126*	*0.334*
3°	PM	**0.985**	**0.987**	**0.990**	**0.992**	**0.992**	**0.993**	**0.994**	**0.995**	**0.996**	**0.997**	**0.997**	**0.998**	**0.999**
	TM	*0.018*	*0.019*	*0.021*	*0.024*	*0.026*	*0.029*	*0.033*	*0.039*	*0.047*	*0.060*	*0.084*	*0.144*	*0.501*
4°	PM	**0.985**	**0.987**	**0.989**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	**0.996**	**0.996**	**0.997**	**0.998**	**0.999**
	TM	*0.019*	*0.020*	*0.022*	*0.025*	*0.027*	*0.030*	*0.034*	*0.040*	*0.049*	*0.064*	*0.092*	*0.168*	*1.002*
5°	PM	**0.984**	**0.987**	**0.989**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	**0.995**	**0.996**	**0.997**	**0.998**	-
	TM	*0.019*	*0.020*	*0.022*	*0.025*	*0.028*	*0.031*	*0.036*	*0.042*	*0.052*	*0.068*	*0.101*	*0.201*	-
6°	PM	**0.984**	**0.987**	**0.989**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	**0.995**	**0.996**	**0.997**	**0.998**	-
	TM	*0.020*	*0.021*	*0.023*	*0.026*	*0.029*	*0.032*	*0.037*	*0.044*	*0.055*	*0.073*	*0.113*	*0.252*	-
7°	PM	**0.984**	**0.986**	**0.989**	**0.991**	**0.992**	**0.993**	**0.993**	**0.994**	**0.995**	**0.996**	**0.997**	**0.998**	-
	TM	*0.020*	*0.021*	*0.023*	*0.027*	*0.030*	*0.033*	*0.038*	*0.046*	*0.058*	*0.079*	*0.127*	*0.336*	-
8°	PM	**0.984**	**0.986**	**0.989**	**0.991**	**0.992**	**0.992**	**0.993**	**0.994**	**0.995**	**0.996**	**0.997**	**0.997**	-
	TM	*0.020*	*0.022*	*0.024*	*0.028*	*0.030*	*0.034*	*0.040*	*0.048*	*0.061*	*0.086*	*0.145*	*0.505*	-
9°	PM	**0.983**	**0.986**	**0.988**	**0.990**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	**0.996**	**0.996**	**0.997**	-
	TM	*0.021*	*0.022*	*0.024*	*0.028*	*0.031*	*0.036*	*0.042*	*0.050*	*0.065*	*0.094*	*0.170*	*1.011*	-
10°	PM	**0.983**	**0.986**	**0.988**	**0.990**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	**0.995**	**0.996**	-	-
	TM	*0.021*	*0.022*	*0.025*	*0.029*	*0.032*	*0.037*	*0.043*	*0.053*	*0.070*	*0.103*	*0.204*	-	-
11°	PM	**0.983**	**0.985**	**0.988**	**0.990**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	**0.995**	**0.996**	-	-
	TM	*0.022*	*0.023*	*0.026*	*0.030*	*0.033*	*0.038*	*0.045*	*0.056*	*0.075*	*0.115*	*0.256*	-	-
12°	PM	**0.982**	**0.985**	**0.988**	**0.990**	**0.991**	**0.992**	**0.993**	**0.993**	**0.994**	**0.995**	**0.996**	-	-
	TM	*0.022*	*0.023*	*0.026*	*0.031*	*0.035*	*0.040*	*0.047*	*0.059*	*0.081*	*0.130*	*0.341*	-	-
13°	PM	**0.982**	**0.985**	**0.987**	**0.990**	**0.991**	**0.992**	**0.992**	**0.993**	**0.994**	**0.995**	**0.996**	-	-
	TM	*0.023*	*0.024*	*0.027*	*0.032*	*0.036*	*0.041*	*0.050*	*0.063*	*0.088*	*0.148*	*0.513*	-	-
14°	PM	**0.982**	**0.985**	**0.987**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	**0.996**	-	-
	TM	*0.023*	*0.025*	*0.028*	*0.033*	*0.037*	*0.043*	*0.052*	*0.067*	*0.096*	*0.173*	*1.028*	-	-
15°	PM	**0.981**	**0.984**	**0.987**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	-	-	-
	TM	*0.024*	*0.025*	*0.028*	*0.034*	*0.039*	*0.045*	*0.055*	*0.072*	*0.106*	*0.209*	-	-	-
16°	PM	**0.981**	**0.984**	**0.987**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	**0.994**	**0.995**	-	-	-
	TM	*0.024*	*0.026*	*0.029*	*0.035*	*0.040*	*0.047*	*0.058*	*0.077*	*0.118*	*0.261*	-	-	-
17°	PM	**0.981**	**0.984**	**0.986**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	**0.993**	**0.994**	-	-	-
	TM	*0.025*	*0.027*	*0.030*	*0.036*	*0.042*	*0.049*	*0.062*	*0.083*	*0.133*	*0.350*	-	-	-
18°	PM	**0.980**	**0.984**	**0.986**	**0.989**	**0.990**	**0.991**	**0.992**	**0.992**	**0.993**	**0.994**	-	-	-
	TM	*0.025*	*0.027*	*0.031*	*0.038*	*0.043*	*0.052*	*0.065*	*0.091*	*0.153*	*0.526*	-	-	-
19°	PM	**0.980**	**0.983**	**0.986**	**0.988**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	**0.994**	-	-	-
	TM	*0.026*	*0.028*	*0.032*	*0.039*	*0.045*	*0.054*	*0.070*	*0.099*	*0.179*	*1.054*	-	-	-
20°	PM	**0.980**	**0.983**	**0.986**	**0.988**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	-	-	-	-
	TM	*0.027*	*0.029*	*0.033*	*0.041*	*0.047*	*0.057*	*0.075*	*0.110*	*0.215*	-	-	-	-
21°	PM	**0.979**	**0.983**	**0.985**	**0.988**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	-	-	-	-
	TM	*0.027*	*0.030*	*0.034*	*0.042*	*0.049*	*0.061*	*0.080*	*0.122*	*0.270*	-	-	-	-
22°	PM	**0.979**	**0.982**	**0.985**	**0.988**	**0.989**	**0.990**	**0.991**	**0.992**	**0.993**	-	-	-	-
	TM	*0.028*	*0.030*	*0.035*	*0.044*	*0.052*	*0.064*	*0.087*	*0.138*	*0.361*	-	-	-	-
23°	PM	**0.979**	**0.982**	**0.985**	**0.987**	**0.989**	**0.990**	**0.991**	**0.992**	**0.992**	-	-	-	-
	TM	*0.029*	*0.031*	*0.036*	*0.046*	*0.055*	*0.069*	*0.095*	*0.158*	*0.543*	-	-	-	-
24°	PM	**0.978**	**0.982**	**0.985**	**0.987**	**0.988**	**0.989**	**0.990**	**0.991**	**0.992**	-	-	-	-
	TM	*0.030*	*0.032*	*0.037*	*0.048*	*0.057*	*0.073*	*0.104*	*0.186*	*1.090*	-	-	-	-
25°	PM	**0.978**	**0.981**	**0.984**	**0.987**	**0.988**	**0.989**	**0.990**	**0.991**	-	-	-	-	-
	TM	*0.030*	*0.033*	*0.039*	*0.050*	*0.061*	*0.078*	*0.114*	*0.224*	-	-	-	-	-
26°	PM	**0.978**	**0.981**	**0.984**	**0.987**	**0.988**	**0.989**	**0.990**	**0.991**	-	-	-	-	-
	TM	*0.031*	*0.034*	*0.040*	*0.053*	*0.064*	*0.084*	*0.128*	*0.281*	-	-	-	-	-
27°	PM	**0.977**	**0.981**	**0.984**	**0.986**	**0.988**	**0.989**	**0.990**	**0.991**	-	-	-	-	-
	TM	*0.032*	*0.035*	*0.042*	*0.055*	*0.068*	*0.091*	*0.144*	*0.376*	-	-	-	-	-
28°	PM	**0.977**	**0.980**	**0.984**	**0.986**	**0.987**	**0.989**	**0.990**	**0.991**	-	-	-	-	-
	TM	*0.033*	*0.036*	*0.043*	*0.058*	*0.073*	*0.100*	*0.166*	*0.566*	-	-	-	-	-
29°	PM	**0.976**	**0.980**	**0.983**	**0.986**	**0.987**	**0.988**	**0.989**	**0.990**	-	-	-	-	-
	TM	*0.034*	*0.038*	*0.045*	*0.061*	*0.078*	*0.109*	*0.195*	*1.138*	-	-	-	-	-
30°	PM	**0.976**	**0.980**	**0.983**	**0.986**	**0.987**	**0.988**	**0.989**	-	-	-	-	-	-
	TM	*0.035*	*0.039*	*0.047*	*0.065*	*0.083*	*0.121*	*0.235*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.2. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 2°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 2°												
		TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.972	0.976	0.980	0.984	0.986	0.988	0.989	0.991	0.993	0.994	0.996	0.997	0.999
	TM	0.035	0.037	0.040	0.046	0.050	0.055	0.062	0.072	0.085	0.107	0.144	0.223	0.500
2°	PM	0.971	0.976	0.980	0.984	0.986	0.987	0.989	0.991	0.992	0.994	0.995	0.997	0.998
	TM	0.036	0.038	0.041	0.047	0.051	0.057	0.064	0.074	0.089	0.113	0.155	0.251	0.667
3°	PM	0.971	0.975	0.980	0.983	0.985	0.987	0.989	0.990	0.992	0.994	0.995	0.997	0.998
	TM	0.036	0.038	0.042	0.048	0.053	0.058	0.066	0.077	0.093	0.120	0.168	0.287	1.000
4°	PM	0.970	0.975	0.979	0.983	0.985	0.987	0.988	0.990	0.992	0.993	0.995	0.996	0.998
	TM	0.037	0.039	0.043	0.049	0.054	0.060	0.068	0.080	0.098	0.127	0.184	0.335	2.002
5°	PM	0.970	0.974	0.979	0.983	0.985	0.986	0.988	0.990	0.991	0.993	0.994	0.996	-
	TM	0.038	0.040	0.044	0.051	0.055	0.062	0.071	0.084	0.103	0.136	0.202	0.402	-
6°	PM	0.969	0.974	0.978	0.982	0.984	0.986	0.988	0.989	0.991	0.993	0.994	0.996	-
	TM	0.038	0.041	0.045	0.052	0.057	0.064	0.073	0.087	0.109	0.146	0.225	0.503	-
7°	PM	0.969	0.974	0.978	0.982	0.984	0.986	0.987	0.989	0.991	0.992	0.994	0.995	-
	TM	0.039	0.042	0.046	0.053	0.059	0.066	0.076	0.091	0.115	0.157	0.253	0.671	-
8°	PM	0.968	0.973	0.978	0.982	0.983	0.985	0.987	0.989	0.990	0.992	0.994	0.995	-
	TM	0.040	0.042	0.047	0.055	0.060	0.068	0.079	0.096	0.122	0.171	0.290	1.007	-
9°	PM	0.967	0.973	0.977	0.981	0.983	0.985	0.987	0.988	0.990	0.992	0.993	0.995	-
	TM	0.041	0.043	0.048	0.056	0.062	0.071	0.083	0.100	0.130	0.186	0.339	2.017	-
10°	PM	0.967	0.972	0.977	0.981	0.983	0.985	0.986	0.988	0.990	0.991	0.993	-	-
	TM	0.042	0.044	0.049	0.058	0.064	0.073	0.086	0.106	0.139	0.205	0.407	-	-
11°	PM	0.966	0.972	0.976	0.980	0.982	0.984	0.986	0.988	0.989	0.991	0.993	-	-
	TM	0.042	0.045	0.050	0.059	0.066	0.076	0.090	0.111	0.149	0.229	0.509	-	-
12°	PM	0.966	0.971	0.976	0.980	0.982	0.984	0.986	0.987	0.989	0.991	0.992	-	-
	TM	0.043	0.046	0.052	0.061	0.069	0.079	0.094	0.118	0.161	0.258	0.680	-	-
13°	PM	0.965	0.971	0.975	0.980	0.982	0.983	0.985	0.987	0.989	0.990	0.992	-	-
	TM	0.044	0.047	0.053	0.063	0.071	0.082	0.099	0.125	0.175	0.295	1.022	-	-
14°	PM	0.964	0.970	0.975	0.979	0.981	0.983	0.985	0.987	0.988	0.990	0.992	-	-
	TM	0.045	0.049	0.055	0.065	0.074	0.086	0.104	0.133	0.191	0.345	2.048	-	-
15°	PM	0.964	0.970	0.974	0.979	0.981	0.983	0.985	0.986	0.988	0.990	-	-	-
	TM	0.046	0.050	0.056	0.067	0.076	0.089	0.109	0.143	0.211	0.415	-	-	-
16°	PM	0.963	0.969	0.974	0.978	0.980	0.982	0.984	0.986	0.988	0.989	-	-	-
	TM	0.047	0.051	0.058	0.070	0.079	0.093	0.115	0.153	0.235	0.520	-	-	-
17°	PM	0.963	0.969	0.974	0.978	0.980	0.982	0.984	0.986	0.987	0.989	-	-	-
	TM	0.049	0.052	0.059	0.072	0.082	0.098	0.122	0.166	0.265	0.695	-	-	-
18°	PM	0.962	0.968	0.973	0.978	0.980	0.982	0.983	0.985	0.987	0.989	-	-	-
	TM	0.050	0.054	0.061	0.075	0.086	0.103	0.130	0.180	0.303	1.046	-	-	-
19°	PM	0.961	0.967	0.973	0.977	0.979	0.981	0.983	0.985	0.987	0.988	-	-	-
	TM	0.051	0.055	0.063	0.077	0.090	0.108	0.138	0.197	0.355	2.097	-	-	-
20°	PM	0.961	0.967	0.972	0.977	0.979	0.981	0.983	0.985	0.986	-	-	-	-
	TM	0.052	0.056	0.065	0.080	0.094	0.114	0.148	0.218	0.427	-	-	-	-
21°	PM	0.960	0.966	0.972	0.976	0.978	0.980	0.982	0.984	0.986	-	-	-	-
	TM	0.053	0.058	0.067	0.084	0.098	0.120	0.159	0.243	0.536	-	-	-	-
22°	PM	0.959	0.966	0.971	0.976	0.978	0.980	0.982	0.984	0.986	-	-	-	-
	TM	0.055	0.060	0.069	0.087	0.103	0.128	0.172	0.274	0.716	-	-	-	-
23°	PM	0.959	0.965	0.971	0.975	0.978	0.980	0.982	0.983	0.985	-	-	-	-
	TM	0.056	0.061	0.071	0.091	0.108	0.136	0.187	0.314	1.078	-	-	-	-
24°	PM	0.958	0.964	0.970	0.975	0.977	0.979	0.981	0.983	0.985	-	-	-	-
	TM	0.058	0.063	0.074	0.095	0.114	0.145	0.205	0.368	2.164	-	-	-	-
25°	PM	0.957	0.964	0.970	0.974	0.977	0.979	0.981	0.983	-	-	-	-	-
	TM	0.059	0.065	0.076	0.099	0.120	0.155	0.227	0.443	-	-	-	-	-
26°	PM	0.956	0.963	0.969	0.974	0.976	0.978	0.980	0.982	-	-	-	-	-
	TM	0.061	0.067	0.079	0.104	0.127	0.167	0.253	0.556	-	-	-	-	-
27°	PM	0.956	0.963	0.969	0.974	0.976	0.978	0.980	0.982	-	-	-	-	-
	TM	0.063	0.069	0.082	0.109	0.135	0.181	0.286	0.745	-	-	-	-	-
28°	PM	0.955	0.962	0.968	0.973	0.975	0.978	0.980	0.982	-	-	-	-	-
	TM	0.065	0.071	0.085	0.115	0.143	0.197	0.328	1.122	-	-	-	-	-
29°	PM	0.954	0.961	0.967	0.973	0.975	0.977	0.979	0.981	-	-	-	-	-
	TM	0.067	0.074	0.089	0.121	0.153	0.216	0.385	2.254	-	-	-	-	-
30°	PM	0.953	0.961	0.967	0.972	0.974	0.977	0.979	-	-	-	-	-	-
	TM	0.069	0.076	0.092	0.128	0.164	0.239	0.464	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.3. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 3°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 3°												
		TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.958**	**0.965**	**0.971**	**0.977**	**0.980**	**0.982**	**0.985**	**0.987**	**0.989**	**0.992**	**0.994**	**0.996**	**0.999**
	TM	*0.052*	*0.055*	*0.060*	*0.068*	*0.074*	*0.082*	*0.093*	*0.107*	*0.128*	*0.160*	*0.216*	*0.334*	*0.750*
2°	PM	**0.958**	**0.965**	**0.971**	**0.976**	**0.979**	**0.982**	**0.984**	**0.987**	**0.989**	**0.991**	**0.994**	**0.996**	**0.998**
	TM	*0.053*	*0.056*	*0.061*	*0.070*	*0.076*	*0.085*	*0.096*	*0.111*	*0.133*	*0.169*	*0.232*	*0.376*	*1.000*
3°	PM	**0.957**	**0.964**	**0.970**	**0.976**	**0.979**	**0.981**	**0.984**	**0.986**	**0.988**	**0.991**	**0.993**	**0.995**	**0.998**
	TM	*0.054*	*0.057*	*0.062*	*0.072*	*0.078*	*0.087*	*0.099*	*0.115*	*0.140*	*0.179*	*0.252*	*0.429*	*1.500*
4°	PM	**0.956**	**0.963**	**0.970**	**0.975**	**0.978**	**0.981**	**0.983**	**0.986**	**0.988**	**0.990**	**0.993**	**0.995**	**0.997**
	TM	*0.055*	*0.058*	*0.064*	*0.073*	*0.080*	*0.090*	*0.102*	*0.120*	*0.147*	*0.190*	*0.275*	*0.501*	*3.000*
5°	PM	**0.955**	**0.963**	**0.969**	**0.975**	**0.977**	**0.980**	**0.983**	**0.985**	**0.988**	**0.990**	**0.992**	**0.995**	-
	TM	*0.056*	*0.059*	*0.065*	*0.075*	*0.083*	*0.092*	*0.106*	*0.125*	*0.154*	*0.203*	*0.302*	*0.602*	-
6°	PM	**0.955**	**0.962**	**0.968**	**0.974**	**0.977**	**0.980**	**0.982**	**0.985**	**0.987**	**0.989**	**0.992**	**0.994**	-
	TM	*0.057*	*0.060*	*0.067*	*0.077*	*0.085*	*0.095*	*0.110*	*0.130*	*0.162*	*0.218*	*0.336*	*0.753*	-
7°	PM	**0.954**	**0.961**	**0.968**	**0.974**	**0.976**	**0.979**	**0.982**	**0.984**	**0.987**	**0.989**	**0.991**	**0.994**	-
	TM	*0.058*	*0.062*	*0.068*	*0.079*	*0.087*	*0.098*	*0.114*	*0.136*	*0.172*	*0.235*	*0.379*	*1.004*	-
8°	PM	**0.953**	**0.961**	**0.967**	**0.973**	**0.976**	**0.979**	**0.981**	**0.984**	**0.986**	**0.988**	**0.991**	**0.993**	-
	TM	*0.059*	*0.063*	*0.070*	*0.081*	*0.090*	*0.102*	*0.118*	*0.143*	*0.182*	*0.255*	*0.433*	*1.508*	-
9°	PM	**0.952**	**0.960**	**0.967**	**0.973**	**0.975**	**0.978**	**0.981**	**0.983**	**0.986**	**0.988**	**0.990**	**0.993**	-
	TM	*0.060*	*0.064*	*0.071*	*0.083*	*0.093*	*0.105*	*0.123*	*0.150*	*0.194*	*0.279*	*0.506*	*3.018*	-
10°	PM	**0.952**	**0.959**	**0.966**	**0.972**	**0.975**	**0.977**	**0.980**	**0.983**	**0.985**	**0.988**	**0.990**	-	-
	TM	*0.061*	*0.066*	*0.073*	*0.086*	*0.096*	*0.109*	*0.128*	*0.158*	*0.207*	*0.307*	*0.608*	-	-
11°	PM	**0.951**	**0.958**	**0.965**	**0.971**	**0.974**	**0.977**	**0.980**	**0.982**	**0.985**	**0.987**	**0.989**	-	-
	TM	*0.063*	*0.067*	*0.075*	*0.088*	*0.099*	*0.113*	*0.134*	*0.166*	*0.222*	*0.342*	*0.761*	-	-
12°	PM	**0.950**	**0.958**	**0.965**	**0.971**	**0.974**	**0.976**	**0.979**	**0.982**	**0.984**	**0.987**	**0.989**	-	-
	TM	*0.064*	*0.068*	*0.077*	*0.091*	*0.102*	*0.118*	*0.140*	*0.176*	*0.240*	*0.385*	*1.017*	-	-
13°	PM	**0.949**	**0.957**	**0.964**	**0.970**	**0.973**	**0.976**	**0.979**	**0.981**	**0.984**	**0.986**	**0.988**	-	-
	TM	*0.065*	*0.070*	*0.079*	*0.094*	*0.106*	*0.122*	*0.147*	*0.187*	*0.260*	*0.441*	*1.527*	-	-
14°	PM	**0.948**	**0.956**	**0.963**	**0.970**	**0.973**	**0.975**	**0.978**	**0.981**	**0.983**	**0.986**	**0.988**	-	-
	TM	*0.067*	*0.072*	*0.081*	*0.097*	*0.109*	*0.127*	*0.154*	*0.199*	*0.285*	*0.515*	*3.060*	-	-
15°	PM	**0.947**	**0.955**	**0.963**	**0.969**	**0.972**	**0.975**	**0.977**	**0.980**	**0.983**	**0.985**	-	-	-
	TM	*0.068*	*0.073*	*0.083*	*0.100*	*0.113*	*0.133*	*0.163*	*0.213*	*0.314*	*0.620*	-	-	-
16°	PM	**0.946**	**0.955**	**0.962**	**0.968**	**0.971**	**0.974**	**0.977**	**0.980**	**0.982**	**0.985**	-	-	-
	TM	*0.070*	*0.075*	*0.085*	*0.103*	*0.118*	*0.139*	*0.172*	*0.229*	*0.350*	*0.776*	-	-	-
17°	PM	**0.945**	**0.954**	**0.961**	**0.968**	**0.971**	**0.974**	**0.976**	**0.979**	**0.982**	**0.984**	-	-	-
	TM	*0.071*	*0.077*	*0.088*	*0.107*	*0.123*	*0.145*	*0.182*	*0.247*	*0.394*	*1.037*	-	-	-
18°	PM	**0.944**	**0.953**	**0.961**	**0.967**	**0.970**	**0.973**	**0.976**	**0.979**	**0.981**	**0.984**	-	-	-
	TM	*0.073*	*0.079*	*0.090*	*0.111*	*0.128*	*0.153*	*0.193*	*0.268*	*0.452*	*1.560*	-	-	-
19°	PM	**0.943**	**0.952**	**0.960**	**0.967**	**0.970**	**0.973**	**0.975**	**0.978**	**0.981**	**0.983**	-	-	-
	TM	*0.075*	*0.081*	*0.093*	*0.115*	*0.133*	*0.160*	*0.206*	*0.293*	*0.529*	*3.127*	-	-	-
20°	PM	**0.943**	**0.952**	**0.959**	**0.966**	**0.969**	**0.972**	**0.975**	**0.977**	**0.980**	-	-	-	-
	TM	*0.077*	*0.083*	*0.096*	*0.119*	*0.139*	*0.169*	*0.220*	*0.324*	*0.636*	-	-	-	-
21°	PM	**0.942**	**0.951**	**0.958**	**0.965**	**0.968**	**0.971**	**0.974**	**0.977**	**0.980**	-	-	-	-
	TM	*0.079*	*0.086*	*0.099*	*0.124*	*0.145*	*0.179*	*0.237*	*0.361*	*0.798*	-	-	-	-
22°	PM	**0.941**	**0.950**	**0.958**	**0.965**	**0.968**	**0.971**	**0.974**	**0.976**	**0.979**	-	-	-	-
	TM	*0.081*	*0.088*	*0.102*	*0.129*	*0.152*	*0.189*	*0.256*	*0.408*	*1.067*	-	-	-	-
23°	PM	**0.939**	**0.949**	**0.957**	**0.964**	**0.967**	**0.970**	**0.973**	**0.976**	**0.979**	-	-	-	-
	TM	*0.083*	*0.090*	*0.105*	*0.134*	*0.160*	*0.201*	*0.279*	*0.467*	*1.606*	-	-	-	-
24°	PM	**0.938**	**0.948**	**0.956**	**0.963**	**0.967**	**0.970**	**0.973**	**0.975**	**0.978**	-	-	-	-
	TM	*0.085*	*0.093*	*0.109*	*0.140*	*0.168*	*0.215*	*0.305*	*0.547*	*3.223*	-	-	-	-
25°	PM	**0.937**	**0.947**	**0.955**	**0.963**	**0.966**	**0.969**	**0.972**	**0.975**	-	-	-	-	-
	TM	*0.087*	*0.096*	*0.113*	*0.147*	*0.178*	*0.230*	*0.337*	*0.659*	-	-	-	-	-
26°	PM	**0.936**	**0.946**	**0.955**	**0.962**	**0.965**	**0.968**	**0.971**	**0.974**	-	-	-	-	-
	TM	*0.090*	*0.099*	*0.117*	*0.154*	*0.188*	*0.248*	*0.376*	*0.827*	-	-	-	-	-
27°	PM	**0.935**	**0.945**	**0.954**	**0.961**	**0.965**	**0.968**	**0.971**	**0.974**	-	-	-	-	-
	TM	*0.092*	*0.102*	*0.121*	*0.161*	*0.199*	*0.268*	*0.425*	*1.108*	-	-	-	-	-
28°	PM	**0.934**	**0.944**	**0.953**	**0.961**	**0.964**	**0.967**	**0.970**	**0.973**	-	-	-	-	-
	TM	*0.095*	*0.105*	*0.126*	*0.170*	*0.212*	*0.292*	*0.488*	*1.668*	-	-	-	-	-
29°	PM	**0.933**	**0.943**	**0.952**	**0.960**	**0.963**	**0.967**	**0.970**	**0.973**	-	-	-	-	-
	TM	*0.098*	*0.109*	*0.131*	*0.179*	*0.227*	*0.320*	*0.572*	*3.351*	-	-	-	-	-
30°	PM	**0.932**	**0.943**	**0.952**	**0.959**	**0.963**	**0.966**	**0.969**	-	-	-	-	-	-
	TM	*0.101*	*0.112*	*0.136*	*0.189*	*0.243*	*0.354*	*0.689*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.4. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 4°

		LOAD POSITION ANGLE, Θ = 4°												
TAG POS. ANGLE, θ_T	LINE MULT.	TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.946	0.955	0.963	0.970	0.974	0.977	0.980	0.983	0.987	0.990	0.993	0.996	0.999
	TM	0.068	0.072	0.079	0.090	0.098	0.109	0.123	0.142	0.170	0.213	0.287	0.445	1.000
2°	PM	0.945	0.954	0.962	0.969	0.973	0.976	0.980	0.983	0.986	0.989	0.992	0.995	0.998
	TM	0.069	0.074	0.081	0.092	0.101	0.112	0.127	0.147	0.177	0.225	0.309	0.500	1.332
3°	PM	0.944	0.953	0.961	0.969	0.972	0.976	0.979	0.982	0.985	0.988	0.991	0.995	0.998
	TM	0.071	0.075	0.082	0.095	0.104	0.115	0.131	0.153	0.186	0.238	0.335	0.572	1.998
4°	PM	0.943	0.952	0.960	0.968	0.971	0.975	0.978	0.981	0.985	0.988	0.991	0.994	0.997
	TM	0.072	0.076	0.084	0.097	0.106	0.119	0.135	0.159	0.195	0.253	0.366	0.667	3.997
5°	PM	0.942	0.951	0.960	0.967	0.971	0.974	0.978	0.981	0.984	0.987	0.990	0.993	-
	TM	0.073	0.078	0.086	0.099	0.109	0.122	0.140	0.166	0.205	0.270	0.402	0.801	-
6°	PM	0.941	0.951	0.959	0.967	0.970	0.974	0.977	0.980	0.983	0.987	0.990	0.993	-
	TM	0.075	0.079	0.088	0.102	0.112	0.126	0.145	0.173	0.216	0.290	0.447	1.002	-
7°	PM	0.940	0.950	0.958	0.966	0.969	0.973	0.976	0.980	0.983	0.986	0.989	0.992	-
	TM	0.076	0.081	0.090	0.105	0.116	0.130	0.151	0.181	0.228	0.312	0.504	1.337	-
8°	PM	0.939	0.949	0.957	0.965	0.969	0.972	0.976	0.979	0.982	0.985	0.988	0.991	-
	TM	0.077	0.083	0.092	0.107	0.119	0.135	0.157	0.189	0.242	0.339	0.576	2.006	-
9°	PM	0.938	0.948	0.956	0.964	0.968	0.971	0.975	0.978	0.981	0.985	0.988	0.991	-
	TM	0.079	0.084	0.094	0.110	0.123	0.139	0.163	0.199	0.257	0.370	0.673	4.015	-
10°	PM	0.937	0.947	0.956	0.964	0.967	0.971	0.974	0.978	0.981	0.984	0.987	-	-
	TM	0.081	0.086	0.096	0.113	0.126	0.144	0.170	0.209	0.275	0.408	0.808	-	-
11°	PM	0.936	0.946	0.955	0.963	0.967	0.970	0.974	0.977	0.980	0.983	0.987	-	-
	TM	0.082	0.088	0.099	0.117	0.131	0.150	0.177	0.220	0.295	0.454	1.012	-	-
12°	PM	0.935	0.945	0.954	0.962	0.966	0.969	0.973	0.976	0.980	0.983	0.986	-	-
	TM	0.084	0.090	0.101	0.120	0.135	0.155	0.186	0.233	0.318	0.511	1.351	-	-
13°	PM	0.934	0.944	0.953	0.961	0.965	0.969	0.972	0.976	0.979	0.982	0.985	-	-
	TM	0.086	0.092	0.104	0.124	0.140	0.162	0.195	0.247	0.345	0.585	2.029	-	-
14°	PM	0.933	0.943	0.952	0.960	0.964	0.968	0.971	0.975	0.978	0.981	0.985	-	-
	TM	0.088	0.094	0.106	0.128	0.145	0.168	0.204	0.264	0.378	0.684	4.065	-	-
15°	PM	0.931	0.942	0.951	0.960	0.964	0.967	0.971	0.974	0.978	0.981	-	-	-
	TM	0.089	0.097	0.109	0.132	0.150	0.176	0.215	0.282	0.416	0.822	-	-	-
16°	PM	0.930	0.941	0.951	0.959	0.963	0.967	0.970	0.974	0.977	0.980	-	-	-
	TM	0.091	0.099	0.112	0.136	0.156	0.184	0.227	0.303	0.464	1.030	-	-	-
17°	PM	0.929	0.940	0.950	0.958	0.962	0.966	0.969	0.973	0.976	0.980	-	-	-
	TM	0.094	0.101	0.115	0.141	0.162	0.192	0.240	0.327	0.523	1.376	-	-	-
18°	PM	0.928	0.939	0.949	0.957	0.961	0.965	0.969	0.972	0.976	0.979	-	-	-
	TM	0.096	0.104	0.119	0.146	0.168	0.202	0.255	0.355	0.599	2.069	-	-	-
19°	PM	0.927	0.938	0.948	0.956	0.960	0.964	0.968	0.971	0.975	0.978	-	-	-
	TM	0.098	0.107	0.122	0.151	0.176	0.212	0.272	0.389	0.701	4.148	-	-	-
20°	PM	0.925	0.937	0.947	0.956	0.960	0.964	0.967	0.971	0.974	-	-	-	-
	TM	0.100	0.109	0.126	0.157	0.183	0.223	0.291	0.429	0.843	-	-	-	-
21°	PM	0.924	0.936	0.946	0.955	0.959	0.963	0.967	0.970	0.974	-	-	-	-
	TM	0.103	0.112	0.130	0.163	0.192	0.236	0.313	0.478	1.057	-	-	-	-
22°	PM	0.923	0.935	0.945	0.954	0.958	0.962	0.966	0.969	0.973	-	-	-	-
	TM	0.105	0.115	0.134	0.170	0.201	0.250	0.339	0.539	1.413	-	-	-	-
23°	PM	0.921	0.934	0.944	0.953	0.957	0.961	0.965	0.969	0.972	-	-	-	-
	TM	0.108	0.119	0.139	0.177	0.211	0.266	0.368	0.618	2.127	-	-	-	-
24°	PM	0.920	0.933	0.943	0.952	0.956	0.960	0.964	0.968	0.971	-	-	-	-
	TM	0.111	0.122	0.143	0.185	0.222	0.284	0.403	0.724	4.267	-	-	-	-
25°	PM	0.919	0.931	0.942	0.951	0.956	0.960	0.964	0.967	-	-	-	-	-
	TM	0.114	0.126	0.148	0.193	0.234	0.304	0.445	0.872	-	-	-	-	-
26°	PM	0.917	0.930	0.941	0.951	0.955	0.959	0.963	0.967	-	-	-	-	-
	TM	0.117	0.129	0.154	0.202	0.248	0.327	0.497	1.094	-	-	-	-	-
27°	PM	0.916	0.929	0.940	0.950	0.954	0.958	0.962	0.966	-	-	-	-	-
	TM	0.120	0.133	0.159	0.212	0.263	0.354	0.561	1.464	-	-	-	-	-
28°	PM	0.914	0.928	0.939	0.949	0.953	0.957	0.961	0.965	-	-	-	-	-
	TM	0.124	0.138	0.165	0.223	0.280	0.385	0.644	2.205	-	-	-	-	-
29°	PM	0.913	0.927	0.938	0.948	0.952	0.956	0.960	0.964	-	-	-	-	-
	TM	0.127	0.142	0.172	0.235	0.299	0.422	0.755	4.428	-	-	-	-	-
30°	PM	0.911	0.925	0.937	0.947	0.951	0.956	0.960	-	-	-	-	-	-
	TM	0.131	0.147	0.179	0.248	0.320	0.467	0.910	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.5. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 5°

		LOAD POSITION ANGLE, Θ = 5°												
TAG POS.	**LINE**	**TAG ANGLE, α_T**												
ANGLE, θ_T	**MULT.**	**10°**	**20°**	**30°**	**40°**	**45°**	**50°**	**55°**	**60°**	**65°**	**70°**	**75°**	**80°**	**85°**
1°	**PM**	**0.934**	**0.945**	**0.955**	**0.964**	**0.968**	**0.972**	**0.976**	**0.980**	**0.984**	**0.988**	**0.992**	**0.995**	**0.999**
	TM	*0.084*	*0.089*	*0.098*	*0.112*	*0.122*	*0.135*	*0.153*	*0.177*	*0.212*	*0.265*	*0.358*	*0.555*	*1.249*
2°	**PM**	**0.933**	**0.944**	**0.954**	**0.963**	**0.967**	**0.971**	**0.975**	**0.979**	**0.983**	**0.987**	**0.991**	**0.995**	**0.998**
	TM	*0.086*	*0.091*	*0.100*	*0.115*	*0.125*	*0.139*	*0.158*	*0.184*	*0.221*	*0.280*	*0.386*	*0.625*	*1.665*
3°	**PM**	**0.932**	**0.943**	**0.953**	**0.962**	**0.966**	**0.970**	**0.974**	**0.978**	**0.982**	**0.986**	**0.990**	**0.994**	**0.998**
	TM	*0.087*	*0.093*	*0.102*	*0.117*	*0.129*	*0.143*	*0.163*	*0.190*	*0.231*	*0.297*	*0.418*	*0.714*	*2.497*
4°	**PM**	**0.931**	**0.942**	**0.952**	**0.961**	**0.965**	**0.970**	**0.974**	**0.978**	**0.982**	**0.985**	**0.989**	**0.993**	**0.997**
	TM	*0.089*	*0.094*	*0.104*	*0.120*	*0.132*	*0.147*	*0.168*	*0.198*	*0.242*	*0.315*	*0.456*	*0.833*	*4.994*
5°	**PM**	**0.929**	**0.941**	**0.951**	**0.960**	**0.964**	**0.969**	**0.973**	**0.977**	**0.981**	**0.985**	**0.989**	**0.992**	**-**
	TM	*0.090*	*0.096*	*0.106*	*0.123*	*0.136*	*0.152*	*0.174*	*0.206*	*0.255*	*0.337*	*0.502*	*1.000*	*-*
6°	**PM**	**0.928**	**0.940**	**0.950**	**0.959**	**0.964**	**0.968**	**0.972**	**0.976**	**0.980**	**0.984**	**0.988**	**0.992**	**-**
	TM	*0.092*	*0.098*	*0.109*	*0.126*	*0.139*	*0.157*	*0.181*	*0.215*	*0.269*	*0.361*	*0.558*	*1.250*	*-*
7°	**PM**	**0.927**	**0.939**	**0.949**	**0.958**	**0.963**	**0.967**	**0.971**	**0.975**	**0.979**	**0.983**	**0.987**	**0.991**	**-**
	TM	*0.094*	*0.100*	*0.111*	*0.130*	*0.143*	*0.162*	*0.187*	*0.225*	*0.284*	*0.389*	*0.628*	*1.668*	*-*
8°	**PM**	**0.926**	**0.937**	**0.948**	**0.957**	**0.962**	**0.966**	**0.970**	**0.974**	**0.978**	**0.982**	**0.986**	**0.990**	**-**
	TM	*0.095*	*0.102*	*0.114*	*0.133*	*0.148*	*0.167*	*0.195*	*0.235*	*0.301*	*0.422*	*0.718*	*2.503*	*-*
9°	**PM**	**0.924**	**0.936**	**0.947**	**0.956**	**0.961**	**0.965**	**0.970**	**0.974**	**0.978**	**0.982**	**0.985**	**0.989**	**-**
	TM	*0.097*	*0.104*	*0.116*	*0.137*	*0.152*	*0.173*	*0.203*	*0.247*	*0.320*	*0.461*	*0.839*	*5.009*	*-*
10°	**PM**	**0.923**	**0.935**	**0.946**	**0.956**	**0.960**	**0.964**	**0.969**	**0.973**	**0.977**	**0.981**	**0.985**	**-**	**-**
	TM	*0.099*	*0.106*	*0.119*	*0.141*	*0.157*	*0.179*	*0.211*	*0.260*	*0.342*	*0.508*	*1.008*	*-*	*-*
11°	**PM**	**0.922**	**0.934**	**0.945**	**0.955**	**0.959**	**0.964**	**0.968**	**0.972**	**0.976**	**0.980**	**0.984**	**-**	**-**
	TM	*0.101*	*0.109*	*0.122*	*0.145*	*0.162*	*0.186*	*0.220*	*0.274*	*0.367*	*0.565*	*1.261*	*-*	*-*
12°	**PM**	**0.920**	**0.933**	**0.944**	**0.954**	**0.958**	**0.963**	**0.967**	**0.971**	**0.975**	**0.979**	**0.983**	**-**	**-**
	TM	*0.103*	*0.111*	*0.125*	*0.149*	*0.167*	*0.193*	*0.230*	*0.290*	*0.396*	*0.636*	*1.683*	*-*	*-*
13°	**PM**	**0.919**	**0.932**	**0.943**	**0.953**	**0.957**	**0.962**	**0.966**	**0.970**	**0.974**	**0.978**	**0.982**	**-**	**-**
	TM	*0.105*	*0.114*	*0.128*	*0.153*	*0.173*	*0.201*	*0.242*	*0.307*	*0.430*	*0.728*	*2.528*	*-*	*-*
14°	**PM**	**0.918**	**0.931**	**0.942**	**0.952**	**0.956**	**0.961**	**0.965**	**0.970**	**0.974**	**0.978**	**0.982**	**-**	**-**
	TM	*0.108*	*0.116*	*0.132*	*0.158*	*0.179*	*0.209*	*0.254*	*0.327*	*0.470*	*0.851*	*5.063*	*-*	*-*
15°	**PM**	**0.916**	**0.929**	**0.941**	**0.951**	**0.956**	**0.960**	**0.964**	**0.969**	**0.973**	**0.977**	**-**	**-**	**-**
	TM	*0.110*	*0.119*	*0.135*	*0.163*	*0.186*	*0.218*	*0.267*	*0.350*	*0.518*	*1.023*	*-*	*-*	*-*
16°	**PM**	**0.915**	**0.928**	**0.940**	**0.950**	**0.955**	**0.959**	**0.964**	**0.968**	**0.972**	**0.976**	**-**	**-**	**-**
	TM	*0.112*	*0.122*	*0.139*	*0.169*	*0.193*	*0.228*	*0.282*	*0.376*	*0.576*	*1.282*	*-*	*-*	*-*
17°	**PM**	**0.913**	**0.927**	**0.939**	**0.949**	**0.954**	**0.958**	**0.963**	**0.967**	**0.971**	**0.975**	**-**	**-**	**-**
	TM	*0.115*	*0.125*	*0.143*	*0.175*	*0.200*	*0.238*	*0.298*	*0.406*	*0.650*	*1.712*	*-*	*-*	*-*
18°	**PM**	**0.912**	**0.926**	**0.937**	**0.948**	**0.953**	**0.957**	**0.962**	**0.966**	**0.970**	**0.974**	**-**	**-**	**-**
	TM	*0.118*	*0.128*	*0.147*	*0.181*	*0.209*	*0.250*	*0.317*	*0.441*	*0.744*	*2.573*	*-*	*-*	*-*
19°	**PM**	**0.911**	**0.924**	**0.936**	**0.947**	**0.952**	**0.956**	**0.961**	**0.965**	**0.970**	**0.974**	**-**	**-**	**-**
	TM	*0.120*	*0.131*	*0.151*	*0.187*	*0.217*	*0.263*	*0.338*	*0.482*	*0.871*	*5.158*	*-*	*-*	*-*
20°	**PM**	**0.909**	**0.923**	**0.935**	**0.946**	**0.951**	**0.956**	**0.960**	**0.964**	**0.969**	**-**	**-**	**-**	**-**
	TM	*0.123*	*0.135*	*0.156*	*0.194*	*0.227*	*0.277*	*0.361*	*0.532*	*1.048*	*-*	*-*	*-*	*-*
21°	**PM**	**0.908**	**0.922**	**0.934**	**0.945**	**0.950**	**0.955**	**0.959**	**0.964**	**0.968**	**-**	**-**	**-**	**-**
	TM	*0.126*	*0.138*	*0.160*	*0.202*	*0.237*	*0.293*	*0.388*	*0.593*	*1.313*	*-*	*-*	*-*	*-*
22°	**PM**	**0.906**	**0.920**	**0.933**	**0.944**	**0.949**	**0.954**	**0.958**	**0.963**	**0.967**	**-**	**-**	**-**	**-**
	TM	*0.129*	*0.142*	*0.165*	*0.210*	*0.249*	*0.310*	*0.420*	*0.669*	*1.755*	*-*	*-*	*-*	*-*
23°	**PM**	**0.904**	**0.919**	**0.932**	**0.943**	**0.948**	**0.953**	**0.957**	**0.962**	**0.966**	**-**	**-**	**-**	**-**
	TM	*0.133*	*0.146*	*0.171*	*0.219*	*0.261*	*0.329*	*0.456*	*0.767*	*2.641*	*-*	*-*	*-*	*-*
24°	**PM**	**0.903**	**0.918**	**0.931**	**0.942**	**0.947**	**0.952**	**0.956**	**0.961**	**0.965**	**-**	**-**	**-**	**-**
	TM	*0.136*	*0.150*	*0.177*	*0.228*	*0.275*	*0.351*	*0.500*	*0.898*	*5.298*	*-*	*-*	*-*	*-*
25°	**PM**	**0.901**	**0.916**	**0.929**	**0.941**	**0.946**	**0.951**	**0.956**	**0.960**	**-**	**-**	**-**	**-**	**-**
	TM	*0.140*	*0.154*	*0.183*	*0.239*	*0.290*	*0.376*	*0.552*	*1.081*	*-*	*-*	*-*	*-*	*-*
26°	**PM**	**0.899**	**0.915**	**0.928**	**0.940**	**0.945**	**0.950**	**0.955**	**0.959**	**-**	**-**	**-**	**-**	**-**
	TM	*0.143*	*0.159*	*0.189*	*0.250*	*0.306*	*0.405*	*0.615*	*1.357*	*-*	*-*	*-*	*-*	*-*
27°	**PM**	**0.898**	**0.913**	**0.927**	**0.939**	**0.944**	**0.949**	**0.954**	**0.958**	**-**	**-**	**-**	**-**	**-**
	TM	*0.147*	*0.164*	*0.196*	*0.262*	*0.325*	*0.438*	*0.695*	*1.815*	*-*	*-*	*-*	*-*	*-*
28°	**PM**	**0.896**	**0.912**	**0.926**	**0.937**	**0.943**	**0.948**	**0.953**	**0.957**	**-**	**-**	**-**	**-**	**-**
	TM	*0.152*	*0.169*	*0.203*	*0.275*	*0.346*	*0.477*	*0.798*	*2.733*	*-*	*-*	*-*	*-*	*-*
29°	**PM**	**0.894**	**0.911**	**0.924**	**0.936**	**0.942**	**0.947**	**0.952**	**0.956**	**-**	**-**	**-**	**-**	**-**
	TM	*0.156*	*0.174*	*0.211*	*0.290*	*0.369*	*0.522*	*0.935*	*5.488*	*-*	*-*	*-*	*-*	*-*
30°	**PM**	**0.892**	**0.909**	**0.923**	**0.935**	**0.941**	**0.946**	**0.951**	**-**	**-**	**-**	**-**	**-**	**-**
	TM	*0.160*	*0.180*	*0.220*	*0.306*	*0.396*	*0.577*	*1.126*	*-*	*-*	*-*	*-*	*-*	*-*

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.6. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 6°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 6° TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.923	0.935	0.947	0.958	0.963	0.967	0.972	0.977	0.982	0.986	0.991	0.995	1.000
	TM	0.100	0.106	0.117	0.134	0.146	0.162	0.183	0.212	0.253	0.318	0.429	0.666	1.500
2°	PM	0.921	0.934	0.946	0.956	0.962	0.967	0.971	0.976	0.981	0.985	0.990	0.995	0.999
	TM	0.101	0.108	0.119	0.137	0.150	0.166	0.188	0.219	0.264	0.335	0.462	0.749	1.998
3°	PM	0.920	0.933	0.945	0.955	0.961	0.966	0.970	0.975	0.980	0.984	0.989	0.994	0.998
	TM	0.103	0.110	0.121	0.140	0.153	0.171	0.195	0.228	0.277	0.355	0.501	0.856	2.996
4°	PM	0.919	0.932	0.944	0.954	0.960	0.965	0.969	0.974	0.979	0.984	0.988	0.993	0.997
	TM	0.105	0.112	0.124	0.143	0.157	0.176	0.201	0.237	0.290	0.378	0.546	0.999	5.991
5°	PM	0.917	0.930	0.942	0.953	0.959	0.964	0.968	0.973	0.978	0.983	0.987	0.992	-
	TM	0.107	0.114	0.126	0.147	0.162	0.181	0.208	0.246	0.305	0.403	0.601	1.199	-
6°	PM	0.916	0.929	0.941	0.952	0.958	0.963	0.967	0.972	0.977	0.982	0.986	0.991	-
	TM	0.109	0.116	0.129	0.150	0.166	0.187	0.216	0.257	0.321	0.432	0.668	1.498	-
7°	PM	0.914	0.928	0.940	0.951	0.956	0.962	0.967	0.971	0.976	0.981	0.985	0.990	-
	TM	0.111	0.119	0.132	0.154	0.171	0.193	0.224	0.269	0.339	0.466	0.752	1.998	-
8°	PM	0.913	0.927	0.939	0.950	0.955	0.961	0.966	0.970	0.975	0.980	0.984	0.989	-
	TM	0.113	0.121	0.135	0.158	0.176	0.199	0.232	0.281	0.360	0.505	0.860	2.999	-
9°	PM	0.911	0.925	0.938	0.949	0.954	0.960	0.965	0.969	0.974	0.979	0.984	0.988	-
	TM	0.115	0.123	0.138	0.163	0.181	0.206	0.242	0.295	0.383	0.551	1.004	6.000	-
10°	PM	0.910	0.924	0.937	0.948	0.953	0.959	0.964	0.968	0.973	0.978	0.983	-	-
	TM	0.117	0.126	0.141	0.167	0.187	0.214	0.252	0.310	0.409	0.607	1.206	-	-
11°	PM	0.908	0.923	0.935	0.947	0.952	0.958	0.963	0.967	0.972	0.977	0.982	-	-
	TM	0.120	0.129	0.145	0.172	0.193	0.221	0.263	0.327	0.438	0.675	1.509	-	-
12°	PM	0.907	0.921	0.934	0.946	0.951	0.956	0.962	0.967	0.971	0.976	0.981	-	-
	TM	0.122	0.132	0.148	0.177	0.199	0.230	0.275	0.346	0.473	0.761	2.014	-	-
13°	PM	0.905	0.920	0.933	0.945	0.950	0.955	0.961	0.966	0.970	0.975	0.980	-	-
	TM	0.125	0.135	0.152	0.182	0.206	0.239	0.288	0.367	0.513	0.871	3.024	-	-
14°	PM	0.904	0.919	0.932	0.944	0.949	0.954	0.960	0.965	0.969	0.974	0.979	-	-
	TM	0.127	0.138	0.156	0.188	0.213	0.249	0.302	0.391	0.561	1.017	6.056	-	-
15°	PM	0.902	0.917	0.930	0.942	0.948	0.953	0.959	0.964	0.968	0.973	-	-	-
	TM	0.130	0.141	0.160	0.194	0.221	0.260	0.318	0.418	0.618	1.223	-	-	-
16°	PM	0.900	0.916	0.929	0.941	0.947	0.952	0.958	0.963	0.967	0.972	-	-	-
	TM	0.133	0.144	0.165	0.201	0.229	0.271	0.336	0.448	0.688	1.531	-	-	-
17°	PM	0.899	0.914	0.928	0.940	0.946	0.951	0.956	0.962	0.967	0.971	-	-	-
	TM	0.136	0.148	0.169	0.207	0.238	0.284	0.356	0.484	0.776	2.045	-	-	-
18°	PM	0.897	0.913	0.927	0.939	0.945	0.950	0.955	0.961	0.966	0.970	-	-	-
	TM	0.139	0.151	0.174	0.215	0.248	0.298	0.377	0.526	0.888	3.073	-	-	-
19°	PM	0.895	0.911	0.925	0.938	0.944	0.949	0.954	0.960	0.965	0.969	-	-	-
	TM	0.142	0.155	0.179	0.223	0.258	0.313	0.402	0.575	1.039	6.159	-	-	-
20°	PM	0.894	0.910	0.924	0.937	0.942	0.948	0.953	0.959	0.964	-	-	-	-
	TM	0.145	0.159	0.184	0.231	0.270	0.329	0.430	0.634	1.250	-	-	-	-
21°	PM	0.892	0.908	0.923	0.935	0.941	0.947	0.952	0.958	0.963	-	-	-	-
	TM	0.149	0.163	0.190	0.240	0.282	0.348	0.463	0.707	1.566	-	-	-	-
22°	PM	0.890	0.907	0.921	0.934	0.940	0.946	0.951	0.956	0.962	-	-	-	-
	TM	0.152	0.168	0.196	0.249	0.296	0.369	0.500	0.797	2.093	-	-	-	-
23°	PM	0.888	0.905	0.920	0.933	0.939	0.945	0.950	0.955	0.961	-	-	-	-
	TM	0.156	0.172	0.202	0.260	0.310	0.392	0.543	0.914	3.149	-	-	-	-
24°	PM	0.886	0.904	0.919	0.932	0.938	0.944	0.949	0.954	0.960	-	-	-	-
	TM	0.160	0.177	0.209	0.271	0.326	0.418	0.595	1.070	6.315	-	-	-	-
25°	PM	0.884	0.902	0.917	0.930	0.937	0.942	0.948	0.953	-	-	-	-	-
	TM	0.164	0.182	0.216	0.283	0.344	0.447	0.656	1.288	-	-	-	-	-
26°	PM	0.882	0.900	0.916	0.929	0.935	0.941	0.947	0.952	-	-	-	-	-
	TM	0.169	0.188	0.224	0.296	0.364	0.481	0.732	1.615	-	-	-	-	-
27°	PM	0.880	0.899	0.914	0.928	0.934	0.940	0.946	0.951	-	-	-	-	-
	TM	0.173	0.193	0.232	0.311	0.386	0.520	0.827	2.161	-	-	-	-	-
28°	PM	0.878	0.897	0.913	0.927	0.933	0.939	0.945	0.950	-	-	-	-	-
	TM	0.178	0.199	0.241	0.327	0.410	0.566	0.949	3.253	-	-	-	-	-
29°	PM	0.876	0.895	0.911	0.925	0.932	0.938	0.944	0.949	-	-	-	-	-
	TM	0.183	0.206	0.250	0.344	0.438	0.620	1.111	6.531	-	-	-	-	-
30°	PM	0.874	0.894	0.910	0.924	0.930	0.937	0.942	-	-	-	-	-	-
	TM	0.189	0.212	0.260	0.363	0.470	0.686	1.339	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.7. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 7°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 7° TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.912	0.926	0.940	0.952	0.958	0.963	0.969	0.974	0.980	0.985	0.990	0.996	1.001
	TM	0.115	0.122	0.135	0.155	0.169	0.188	0.212	0.246	0.295	0.370	0.500	0.777	1.750
2°	PM	0.910	0.925	0.938	0.951	0.956	0.962	0.968	0.973	0.979	0.984	0.989	0.995	1.000
	TM	0.117	0.125	0.138	0.158	0.173	0.193	0.219	0.255	0.308	0.390	0.538	0.874	2.332
3°	PM	0.909	0.924	0.937	0.949	0.955	0.961	0.967	0.972	0.978	0.983	0.988	0.994	0.999
	TM	0.119	0.127	0.140	0.162	0.178	0.198	0.226	0.265	0.322	0.414	0.583	0.998	3.496
4°	PM	0.907	0.922	0.936	0.948	0.954	0.960	0.966	0.971	0.977	0.982	0.987	0.993	0.998
	TM	0.121	0.129	0.143	0.166	0.182	0.204	0.234	0.275	0.337	0.440	0.636	1.164	6.989
5°	PM	0.906	0.921	0.934	0.947	0.953	0.959	0.964	0.970	0.975	0.981	0.986	0.991	-
	TM	0.123	0.132	0.146	0.170	0.187	0.210	0.242	0.286	0.354	0.469	0.700	1.397	-
6°	PM	0.904	0.919	0.933	0.946	0.952	0.958	0.963	0.969	0.974	0.980	0.985	0.990	-
	TM	0.125	0.134	0.149	0.174	0.192	0.217	0.250	0.299	0.373	0.503	0.778	1.746	-
7°	PM	0.902	0.918	0.932	0.945	0.951	0.956	0.962	0.968	0.973	0.979	0.984	0.989	-
	TM	0.127	0.137	0.153	0.179	0.198	0.224	0.260	0.312	0.394	0.542	0.876	2.329	-
8°	PM	0.901	0.916	0.930	0.943	0.949	0.955	0.961	0.967	0.972	0.978	0.983	0.988	-
	TM	0.130	0.140	0.156	0.183	0.204	0.231	0.270	0.326	0.418	0.587	1.001	3.494	-
9°	PM	0.899	0.915	0.929	0.942	0.948	0.954	0.960	0.966	0.971	0.977	0.982	0.987	-
	TM	0.132	0.142	0.160	0.188	0.210	0.239	0.280	0.342	0.445	0.641	1.169	6.989	-
10°	PM	0.897	0.913	0.928	0.941	0.947	0.953	0.959	0.964	0.970	0.975	0.981	-	-
	TM	0.135	0.145	0.163	0.194	0.216	0.248	0.292	0.360	0.475	0.706	1.403	-	-
11°	PM	0.896	0.912	0.926	0.940	0.946	0.952	0.958	0.963	0.969	0.974	0.980	-	-
	TM	0.137	0.148	0.167	0.199	0.223	0.257	0.305	0.380	0.509	0.785	1.756	-	-
12°	PM	0.894	0.910	0.925	0.938	0.945	0.951	0.956	0.962	0.968	0.973	0.979	-	-
	TM	0.140	0.152	0.171	0.205	0.231	0.266	0.319	0.401	0.549	0.884	2.343	-	-
13°	PM	0.892	0.909	0.924	0.937	0.943	0.949	0.955	0.961	0.967	0.972	0.978	-	-
	TM	0.143	0.155	0.176	0.211	0.238	0.277	0.334	0.426	0.596	1.012	3.518	-	-
14°	PM	0.890	0.907	0.922	0.936	0.942	0.948	0.954	0.960	0.966	0.971	0.977	-	-
	TM	0.146	0.158	0.180	0.218	0.247	0.288	0.351	0.453	0.651	1.182	7.043	-	-
15°	PM	0.888	0.906	0.921	0.934	0.941	0.947	0.953	0.959	0.964	0.970	-	-	-
	TM	0.149	0.162	0.185	0.225	0.256	0.301	0.369	0.484	0.718	1.421	-	-	-
16°	PM	0.887	0.904	0.919	0.933	0.940	0.946	0.952	0.958	0.963	0.969	-	-	-
	TM	0.152	0.166	0.190	0.232	0.265	0.314	0.389	0.520	0.799	1.779	-	-	-
17°	PM	0.885	0.902	0.918	0.932	0.938	0.945	0.951	0.956	0.962	0.968	-	-	-
	TM	0.156	0.170	0.195	0.240	0.276	0.328	0.412	0.561	0.900	2.375	-	-	-
18°	PM	0.883	0.901	0.916	0.930	0.937	0.943	0.949	0.955	0.961	0.967	-	-	-
	TM	0.159	0.174	0.201	0.248	0.287	0.344	0.437	0.610	1.031	3.569	-	-	-
19°	PM	0.881	0.899	0.915	0.929	0.936	0.942	0.948	0.954	0.960	0.966	-	-	-
	TM	0.163	0.178	0.206	0.257	0.299	0.362	0.466	0.667	1.205	7.152	-	-	-
20°	PM	0.879	0.897	0.913	0.928	0.934	0.941	0.947	0.953	0.959	-	-	-	-
	TM	0.167	0.183	0.212	0.267	0.312	0.381	0.498	0.735	1.450	-	-	-	-
21°	PM	0.877	0.896	0.912	0.926	0.933	0.940	0.946	0.952	0.958	-	-	-	-
	TM	0.171	0.188	0.219	0.277	0.326	0.403	0.536	0.819	1.816	-	-	-	-
22°	PM	0.875	0.894	0.910	0.925	0.932	0.938	0.945	0.951	0.956	-	-	-	-
	TM	0.175	0.193	0.226	0.288	0.342	0.426	0.579	0.924	2.428	-	-	-	-
23°	PM	0.873	0.892	0.909	0.924	0.930	0.937	0.943	0.949	0.955	-	-	-	-
	TM	0.179	0.198	0.233	0.300	0.358	0.453	0.629	1.059	3.651	-	-	-	-
24°	PM	0.871	0.890	0.907	0.922	0.929	0.936	0.942	0.948	0.954	-	-	-	-
	TM	0.184	0.204	0.241	0.313	0.377	0.483	0.688	1.239	7.322	-	-	-	-
25°	PM	0.869	0.888	0.906	0.921	0.928	0.934	0.941	0.947	-	-	-	-	-
	TM	0.188	0.209	0.249	0.327	0.397	0.517	0.760	1.491	-	-	-	-	-
26°	PM	0.866	0.887	0.904	0.919	0.926	0.933	0.940	0.946	-	-	-	-	-
	TM	0.193	0.216	0.258	0.342	0.420	0.556	0.847	1.870	-	-	-	-	-
27°	PM	0.864	0.885	0.902	0.918	0.925	0.932	0.938	0.945	-	-	-	-	-
	TM	0.198	0.222	0.267	0.358	0.445	0.601	0.956	2.502	-	-	-	-	-
28°	PM	0.862	0.883	0.901	0.916	0.924	0.930	0.937	0.943	-	-	-	-	-
	TM	0.204	0.229	0.277	0.377	0.474	0.654	1.097	3.766	-	-	-	-	-
29°	PM	0.860	0.881	0.899	0.915	0.922	0.929	0.936	0.942	-	-	-	-	-
	TM	0.210	0.236	0.287	0.396	0.506	0.717	1.285	7.558	-	-	-	-	-
30°	PM	0.857	0.879	0.897	0.913	0.921	0.928	0.934	-	-	-	-	-	-
	TM	0.215	0.244	0.299	0.418	0.542	0.792	1.548	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.8. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 8°

		LOAD POSITION ANGLE, Θ = 8°												
TAG POS. ANGLE, θ_T	LINE MULT.	TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.902	0.918	0.933	0.946	0.953	0.959	0.966	0.972	0.978	0.984	0.990	0.996	1.002
	TM	0.130	0.139	0.153	0.176	0.192	0.214	0.242	0.280	0.336	0.422	0.571	0.888	2.002
2°	PM	0.900	0.916	0.931	0.945	0.952	0.958	0.964	0.971	0.977	0.983	0.989	0.995	1.001
	TM	0.132	0.141	0.156	0.180	0.197	0.219	0.249	0.290	0.351	0.445	0.615	0.998	2.667
3°	PM	0.898	0.915	0.930	0.944	0.950	0.957	0.963	0.969	0.976	0.982	0.988	0.994	1.000
	TM	0.134	0.143	0.159	0.184	0.202	0.226	0.257	0.301	0.367	0.472	0.666	1.140	3.997
4°	PM	0.896	0.913	0.928	0.942	0.949	0.956	0.962	0.968	0.974	0.981	0.987	0.993	0.999
	TM	0.136	0.146	0.162	0.188	0.207	0.232	0.266	0.313	0.384	0.501	0.726	1.330	7.989
5°	PM	0.895	0.912	0.927	0.941	0.948	0.954	0.961	0.967	0.973	0.979	0.985	0.991	-
	TM	0.139	0.149	0.166	0.193	0.213	0.239	0.275	0.326	0.404	0.535	0.799	1.595	-
6°	PM	0.893	0.910	0.925	0.940	0.946	0.953	0.959	0.966	0.972	0.978	0.984	0.990	-
	TM	0.141	0.152	0.169	0.198	0.219	0.246	0.285	0.340	0.425	0.573	0.888	1.994	-
7°	PM	0.891	0.908	0.924	0.938	0.945	0.952	0.958	0.964	0.971	0.977	0.983	0.989	-
	TM	0.144	0.155	0.173	0.203	0.225	0.254	0.295	0.355	0.449	0.618	0.999	2.658	-
8°	PM	0.889	0.907	0.922	0.937	0.944	0.950	0.957	0.963	0.969	0.976	0.982	0.988	-
	TM	0.146	0.158	0.177	0.208	0.231	0.263	0.307	0.372	0.476	0.669	1.142	3.988	-
9°	PM	0.887	0.905	0.921	0.935	0.942	0.949	0.956	0.962	0.968	0.974	0.981	0.987	-
	TM	0.149	0.161	0.181	0.214	0.238	0.272	0.319	0.390	0.506	0.731	1.333	7.977	-
10°	PM	0.885	0.903	0.919	0.934	0.941	0.948	0.954	0.961	0.967	0.973	0.979	-	-
	TM	0.152	0.164	0.185	0.219	0.245	0.281	0.332	0.410	0.541	0.804	1.600	-	-
11°	PM	0.883	0.902	0.918	0.933	0.940	0.946	0.953	0.959	0.966	0.972	0.978	-	-
	TM	0.155	0.168	0.189	0.226	0.253	0.291	0.346	0.432	0.580	0.895	2.002	-	-
12°	PM	0.882	0.900	0.916	0.931	0.938	0.945	0.952	0.958	0.964	0.971	0.977	-	-
	TM	0.158	0.171	0.194	0.232	0.262	0.302	0.362	0.457	0.625	1.007	2.671	-	-
13°	PM	0.880	0.898	0.915	0.930	0.937	0.944	0.950	0.957	0.963	0.969	0.976	-	-
	TM	0.161	0.175	0.199	0.239	0.270	0.314	0.379	0.484	0.678	1.153	4.009	-	-
14°	PM	0.878	0.896	0.913	0.928	0.935	0.942	0.949	0.956	0.962	0.968	0.974	-	-
	TM	0.164	0.179	0.204	0.246	0.280	0.327	0.398	0.515	0.741	1.346	8.026	-	-
15°	PM	0.876	0.895	0.912	0.927	0.934	0.941	0.948	0.954	0.961	0.967	-	-	-
	TM	0.168	0.183	0.209	0.254	0.290	0.341	0.419	0.551	0.816	1.617	-	-	-
16°	PM	0.873	0.893	0.910	0.925	0.933	0.940	0.946	0.953	0.959	0.966	-	-	-
	TM	0.171	0.187	0.214	0.263	0.301	0.356	0.442	0.591	0.908	2.025	-	-	-
17°	PM	0.871	0.891	0.908	0.924	0.931	0.938	0.945	0.952	0.958	0.964	-	-	-
	TM	0.175	0.192	0.220	0.271	0.312	0.373	0.468	0.638	1.024	2.704	-	-	-
18°	PM	0.869	0.889	0.907	0.922	0.930	0.937	0.944	0.950	0.957	0.963	-	-	-
	TM	0.179	0.196	0.227	0.281	0.325	0.391	0.496	0.693	1.172	4.062	-	-	-
19°	PM	0.867	0.887	0.905	0.921	0.928	0.935	0.942	0.949	0.956	0.962	-	-	-
	TM	0.183	0.201	0.233	0.291	0.339	0.410	0.529	0.757	1.370	8.137	-	-	-
20°	PM	0.865	0.885	0.903	0.919	0.927	0.934	0.941	0.948	0.954	-	-	-	-
	TM	0.187	0.206	0.240	0.302	0.353	0.432	0.566	0.835	1.648	-	-	-	-
21°	PM	0.863	0.883	0.902	0.918	0.925	0.933	0.940	0.946	0.953	-	-	-	-
	TM	0.192	0.212	0.247	0.313	0.369	0.456	0.608	0.930	2.064	-	-	-	-
22°	PM	0.860	0.882	0.900	0.916	0.924	0.931	0.938	0.945	0.952	-	-	-	-
	TM	0.196	0.217	0.255	0.326	0.387	0.483	0.656	1.049	2.759	-	-	-	-
23°	PM	0.858	0.880	0.898	0.915	0.922	0.930	0.937	0.944	0.950	-	-	-	-
	TM	0.201	0.223	0.263	0.339	0.406	0.513	0.713	1.202	4.148	-	-	-	-
24°	PM	0.856	0.878	0.896	0.913	0.921	0.928	0.935	0.942	0.949	-	-	-	-
	TM	0.206	0.229	0.272	0.354	0.427	0.547	0.780	1.406	8.317	-	-	-	-
25°	PM	0.854	0.876	0.895	0.912	0.919	0.927	0.934	0.941	-	-	-	-	-
	TM	0.211	0.236	0.281	0.369	0.450	0.586	0.861	1.692	-	-	-	-	-
26°	PM	0.851	0.873	0.893	0.910	0.918	0.925	0.933	0.940	-	-	-	-	-
	TM	0.217	0.242	0.291	0.386	0.475	0.630	0.960	2.122	-	-	-	-	-
27°	PM	0.849	0.871	0.891	0.908	0.916	0.924	0.931	0.938	-	-	-	-	-
	TM	0.223	0.250	0.301	0.405	0.504	0.681	1.084	2.838	-	-	-	-	-
28°	PM	0.846	0.869	0.889	0.907	0.915	0.922	0.930	0.937	-	-	-	-	-
	TM	0.229	0.257	0.312	0.425	0.536	0.741	1.243	4.271	-	-	-	-	-
29°	PM	0.844	0.867	0.887	0.905	0.913	0.921	0.928	0.935	-	-	-	-	-
	TM	0.235	0.265	0.324	0.448	0.572	0.811	1.455	8.570	-	-	-	-	-
30°	PM	0.841	0.865	0.885	0.903	0.912	0.919	0.927	-	-	-	-	-	-
	TM	0.241	0.274	0.337	0.473	0.613	0.896	1.753	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.9. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 9°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 9° TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	**PM**	**0.892**	**0.910**	**0.926**	**0.941**	**0.949**	**0.956**	**0.963**	**0.970**	**0.977**	**0.984**	**0.990**	**0.997**	**1.004**
	TM	*0.144*	*0.154*	*0.171*	*0.197*	*0.215*	*0.239*	*0.271*	*0.314*	*0.377*	*0.474*	*0.642*	*0.999*	*2.254*
2°	**PM**	**0.890**	**0.908**	**0.924**	**0.940**	**0.947**	**0.954**	**0.962**	**0.968**	**0.975**	**0.982**	**0.989**	**0.996**	**1.003**
	TM	*0.147*	*0.157*	*0.174*	*0.201*	*0.220*	*0.246*	*0.279*	*0.326*	*0.394*	*0.500*	*0.691*	*1.123*	*3.002*
3°	**PM**	**0.888**	**0.906**	**0.923**	**0.938**	**0.946**	**0.953**	**0.960**	**0.967**	**0.974**	**0.981**	**0.988**	**0.995**	**1.001**
	TM	*0.149*	*0.160*	*0.177*	*0.206*	*0.226*	*0.252*	*0.288*	*0.338*	*0.411*	*0.530*	*0.748*	*1.282*	*4.499*
4°	**PM**	**0.886**	**0.905**	**0.921**	**0.937**	**0.944**	**0.952**	**0.959**	**0.966**	**0.973**	**0.979**	**0.986**	**0.993**	**1.000**
	TM	*0.151*	*0.163*	*0.181*	*0.210*	*0.232*	*0.260*	*0.298*	*0.351*	*0.431*	*0.563*	*0.816*	*1.495*	*8.991*
5°	**PM**	**0.884**	**0.903**	**0.920**	**0.935**	**0.943**	**0.950**	**0.957**	**0.964**	**0.971**	**0.978**	**0.985**	**0.992**	**-**
	TM	*0.154*	*0.166*	*0.185*	*0.216*	*0.238*	*0.268*	*0.308*	*0.365*	*0.453*	*0.600*	*0.898*	*1.794*	*-*
6°	**PM**	**0.882**	**0.901**	**0.918**	**0.934**	**0.941**	**0.949**	**0.956**	**0.963**	**0.970**	**0.977**	**0.984**	**0.990**	**-**
	TM	*0.157*	*0.169*	*0.189*	*0.221*	*0.244*	*0.276*	*0.319*	*0.381*	*0.477*	*0.643*	*0.997*	*2.242*	*-*
7°	**PM**	**0.880**	**0.899**	**0.916**	**0.932**	**0.940**	**0.947**	**0.954**	**0.962**	**0.968**	**0.975**	**0.982**	**0.989**	**-**
	TM	*0.160*	*0.172*	*0.193*	*0.226*	*0.251*	*0.284*	*0.331*	*0.398*	*0.504*	*0.693*	*1.122*	*2.988*	*-*
8°	**PM**	**0.878**	**0.897**	**0.915**	**0.931**	**0.938**	**0.946**	**0.953**	**0.960**	**0.967**	**0.974**	**0.981**	**0.988**	**-**
	TM	*0.162*	*0.175*	*0.197*	*0.232*	*0.258*	*0.294*	*0.343*	*0.416*	*0.534*	*0.751*	*1.282*	*4.482*	*-*
9°	**PM**	**0.876**	**0.896**	**0.913**	**0.929**	**0.937**	**0.944**	**0.952**	**0.959**	**0.966**	**0.973**	**0.979**	**0.986**	**-**
	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**	**0.874**	**0.894**	**0.911**	**0.928**	**0.935**	**0.943**	**0.950**	**0.957**	**0.964**	**0.971**	**0.978**	**-**	**-**
	TM	*0.169*	*0.183*	*0.206*	*0.245*	*0.274*	*0.314*	*0.372*	*0.459*	*0.606*	*0.902*	*1.797*	*-*	*-*
11°	**PM**	**0.872**	**0.892**	**0.910**	**0.926**	**0.934**	**0.941**	**0.949**	**0.956**	**0.963**	**0.970**	**0.977**	**-**	**-**
	TM	*0.172*	*0.186*	*0.211*	*0.252*	*0.283*	*0.326*	*0.388*	*0.484*	*0.650*	*1.003*	*2.247*	*-*	*-*
12°	**PM**	**0.870**	**0.890**	**0.908**	**0.924**	**0.932**	**0.940**	**0.947**	**0.954**	**0.962**	**0.968**	**0.975**	**-**	**-**
	TM	*0.175*	*0.190*	*0.216*	*0.259*	*0.292*	*0.338*	*0.405*	*0.511*	*0.701*	*1.130*	*2.997*	*-*	*-*
13°	**PM**	**0.868**	**0.888**	**0.906**	**0.923**	**0.931**	**0.938**	**0.946**	**0.953**	**0.960**	**0.967**	**0.974**	**-**	**-**
	TM	*0.179*	*0.194*	*0.221*	*0.267*	*0.302*	*0.351*	*0.424*	*0.542*	*0.760*	*1.292*	*4.499*	*-*	*-*
14°	**PM**	**0.865**	**0.886**	**0.905**	**0.921**	**0.929**	**0.937**	**0.944**	**0.952**	**0.959**	**0.966**	**0.973**	**-**	**-**
	TM	*0.182*	*0.199*	*0.227*	*0.275*	*0.312*	*0.366*	*0.445*	*0.577*	*0.830*	*1.509*	*9.005*	*-*	*-*
15°	**PM**	**0.863**	**0.884**	**0.903**	**0.920**	**0.928**	**0.935**	**0.943**	**0.950**	**0.957**	**0.964**	**-**	**-**	**-**
	TM	*0.186*	*0.203*	*0.233*	*0.284*	*0.324*	*0.381*	*0.469*	*0.616*	*0.914*	*1.813*	*-*	*-*	*-*
16°	**PM**	**0.861**	**0.882**	**0.901**	**0.918**	**0.926**	**0.934**	**0.941**	**0.949**	**0.956**	**0.963**	**-**	**-**	**-**
	TM	*0.190*	*0.208*	*0.239*	*0.293*	*0.336*	*0.398*	*0.494*	*0.661*	*1.017*	*2.269*	*-*	*-*	*-*
17°	**PM**	**0.859**	**0.880**	**0.899**	**0.916**	**0.924**	**0.932**	**0.940**	**0.947**	**0.954**	**0.962**	**-**	**-**	**-**
	TM	*0.194*	*0.213*	*0.245*	*0.303*	*0.349*	*0.416*	*0.523*	*0.714*	*1.146*	*3.030*	*-*	*-*	*-*
18°	**PM**	**0.856**	**0.878**	**0.897**	**0.915**	**0.923**	**0.931**	**0.938**	**0.946**	**0.953**	**0.960**	**-**	**-**	**-**
	TM	*0.198*	*0.218*	*0.252*	*0.313*	*0.363*	*0.436*	*0.555*	*0.775*	*1.312*	*4.551*	*-*	*-*	*-*
19°	**PM**	**0.854**	**0.876**	**0.896**	**0.913**	**0.921**	**0.929**	**0.937**	**0.944**	**0.952**	**0.959**	**-**	**-**	**-**
	TM	*0.203*	*0.223*	*0.259*	*0.324*	*0.378*	*0.458*	*0.591*	*0.847*	*1.534*	*9.116*	*-*	*-*	*-*
20°	**PM**	**0.852**	**0.874**	**0.894**	**0.911**	**0.920**	**0.928**	**0.935**	**0.943**	**0.950**	**-**	**-**	**-**	**-**
	TM	*0.207*	*0.229*	*0.267*	*0.336*	*0.394*	*0.482*	*0.632*	*0.934*	*1.844*	*-*	*-*	*-*	*-*
21°	**PM**	**0.849**	**0.872**	**0.892**	**0.910**	**0.918**	**0.926**	**0.934**	**0.941**	**0.949**	**-**	**-**	**-**	**-**
	TM	*0.212*	*0.235*	*0.275*	*0.349*	*0.412*	*0.509*	*0.679*	*1.040*	*2.310*	*-*	*-*	*-*	*-*
22°	**PM**	**0.847**	**0.870**	**0.890**	**0.908**	**0.916**	**0.924**	**0.932**	**0.940**	**0.947**	**-**	**-**	**-**	**-**
	TM	*0.217*	*0.241*	*0.283*	*0.363*	*0.431*	*0.539*	*0.733*	*1.173*	*3.086*	*-*	*-*	*-*	*-*
23°	**PM**	**0.844**	**0.868**	**0.888**	**0.906**	**0.915**	**0.923**	**0.931**	**0.938**	**0.946**	**-**	**-**	**-**	**-**
	TM	*0.222*	*0.247*	*0.292*	*0.378*	*0.452*	*0.573*	*0.796*	*1.343*	*4.640*	*-*	*-*	*-*	*-*
24°	**PM**	**0.842**	**0.865**	**0.886**	**0.905**	**0.913**	**0.921**	**0.929**	**0.937**	**0.944**	**-**	**-**	**-**	**-**
	TM	*0.228*	*0.254*	*0.302*	*0.394*	*0.476*	*0.611*	*0.871*	*1.571*	*9.301*	*-*	*-*	*-*	*-*
25°	**PM**	**0.839**	**0.863**	**0.884**	**0.903**	**0.911**	**0.920**	**0.928**	**0.935**	**-**	**-**	**-**	**-**	**-**
	TM	*0.234*	*0.261*	*0.312*	*0.411*	*0.501*	*0.653*	*0.961*	*1.891*	*-*	*-*	*-*	*-*	*-*
26°	**PM**	**0.837**	**0.861**	**0.882**	**0.901**	**0.910**	**0.918**	**0.926**	**0.934**	**-**	**-**	**-**	**-**	**-**
	TM	*0.240*	*0.269*	*0.323*	*0.430*	*0.530*	*0.703*	*1.071*	*2.370*	*-*	*-*	*-*	*-*	*-*
27°	**PM**	**0.834**	**0.859**	**0.880**	**0.899**	**0.908**	**0.916**	**0.924**	**0.932**	**-**	**-**	**-**	**-**	**-**
	TM	*0.246*	*0.277*	*0.334*	*0.451*	*0.561*	*0.759*	*1.209*	*3.170*	*-*	*-*	*-*	*-*	*-*
28°	**PM**	**0.831**	**0.856**	**0.878**	**0.897**	**0.906**	**0.915**	**0.923**	**0.931**	**-**	**-**	**-**	**-**	**-**
	TM	*0.252*	*0.285*	*0.346*	*0.473*	*0.597*	*0.826*	*1.387*	*4.769*	*-*	*-*	*-*	*-*	*-*
29°	**PM**	**0.828**	**0.854**	**0.876**	**0.896**	**0.905**	**0.913**	**0.921**	**0.929**	**-**	**-**	**-**	**-**	**-**
	TM	*0.259*	*0.294*	*0.360*	*0.498*	*0.637*	*0.904*	*1.624*	*9.569*	*-*	*-*	*-*	*-*	*-*
30°	**PM**	**0.826**	**0.852**	**0.874**	**0.894**	**0.903**	**0.911**	**0.920**	**-**	**-**	**-**	**-**	**-**	**-**
	TM	*0.266*	*0.303*	*0.374*	*0.525*	*0.682*	*0.998*	*1.955*	*-*	*-*	*-*	*-*	*-*	*-*

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.10. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 10°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 10° TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.883**	**0.902**	**0.920**	**0.937**	**0.945**	**0.953**	**0.960**	**0.968**	**0.976**	**0.983**	**0.991**	**0.998**	**1.006**
	TM	*0.158*	*0.170*	*0.188*	*0.217*	*0.238*	*0.265*	*0.300*	*0.348*	*0.418*	*0.526*	*0.713*	*1.110*	*2.507*
2°	PM	**0.880**	**0.900**	**0.918**	**0.935**	**0.943**	**0.951**	**0.959**	**0.967**	**0.974**	**0.982**	**0.989**	**0.997**	**1.005**
	TM	*0.161*	*0.173*	*0.192*	*0.222*	*0.244*	*0.272*	*0.309*	*0.361*	*0.436*	*0.555*	*0.767*	*1.248*	*3.338*
3°	PM	**0.878**	**0.898**	**0.916**	**0.933**	**0.942**	**0.949**	**0.957**	**0.965**	**0.973**	**0.980**	**0.988**	**0.995**	**1.003**
	TM	*0.164*	*0.176*	*0.196*	*0.227*	*0.250*	*0.279*	*0.319*	*0.374*	*0.456*	*0.588*	*0.831*	*1.425*	*5.002*
4°	PM	**0.876**	**0.896**	**0.915**	**0.932**	**0.940**	**0.948**	**0.956**	**0.963**	**0.971**	**0.979**	**0.986**	**0.994**	**1.002**
	TM	*0.166*	*0.179*	*0.199*	*0.232*	*0.256*	*0.287*	*0.329*	*0.389*	*0.478*	*0.624*	*0.906*	*1.661*	*9.995*
5°	PM	**0.874**	**0.894**	**0.913**	**0.930**	**0.938**	**0.946**	**0.954**	**0.962**	**0.970**	**0.977**	**0.985**	**0.992**	**-**
	TM	*0.169*	*0.182*	*0.204*	*0.238*	*0.263*	*0.296*	*0.341*	*0.405*	*0.502*	*0.666*	*0.996*	*1.992*	*-*
6°	PM	**0.872**	**0.892**	**0.911**	**0.928**	**0.937**	**0.945**	**0.953**	**0.960**	**0.968**	**0.976**	**0.983**	**0.991**	**-**
	TM	*0.172*	*0.186*	*0.208*	*0.244*	*0.270*	*0.305*	*0.353*	*0.422*	*0.528*	*0.713*	*1.107*	*2.489*	*-*
7°	PM	**0.870**	**0.891**	**0.909**	**0.927**	**0.935**	**0.943**	**0.951**	**0.959**	**0.967**	**0.974**	**0.982**	**0.989**	**-**
	TM	*0.175*	*0.189*	*0.212*	*0.250*	*0.277*	*0.314*	*0.366*	*0.440*	*0.558*	*0.768*	*1.245*	*3.318*	*-*
8°	PM	**0.868**	**0.889**	**0.907**	**0.925**	**0.933**	**0.942**	**0.949**	**0.957**	**0.965**	**0.973**	**0.980**	**0.988**	**-**
	TM	*0.178*	*0.193*	*0.217*	*0.256*	*0.285*	*0.325*	*0.380*	*0.461*	*0.591*	*0.833*	*1.423*	*4.976*	*-*
9°	PM	**0.865**	**0.887**	**0.906**	**0.923**	**0.932**	**0.940**	**0.948**	**0.956**	**0.963**	**0.971**	**0.979**	**0.986**	**-**
	TM	*0.181*	*0.197*	*0.222*	*0.263*	*0.294*	*0.336*	*0.395*	*0.483*	*0.629*	*0.909*	*1.660*	*9.950*	*-*
10°	PM	**0.863**	**0.885**	**0.904**	**0.922**	**0.930**	**0.938**	**0.946**	**0.954**	**0.962**	**0.970**	**0.977**	**-**	**-**
	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	**0.861**	**0.883**	**0.902**	**0.920**	**0.928**	**0.937**	**0.945**	**0.953**	**0.960**	**0.968**	**0.976**	**-**	**-**
	TM	*0.188*	*0.205*	*0.232*	*0.278*	*0.312*	*0.360*	*0.429*	*0.535*	*0.719*	*1.112*	*2.491*	*-*	*-*
12°	PM	**0.859**	**0.880**	**0.900**	**0.918**	**0.927**	**0.935**	**0.943**	**0.951**	**0.959**	**0.967**	**0.974**	**-**	**-**
	TM	*0.192*	*0.209*	*0.238*	*0.286*	*0.322*	*0.373*	*0.448*	*0.565*	*0.775*	*1.252*	*3.323*	*-*	*-*
13°	PM	**0.856**	**0.878**	**0.898**	**0.916**	**0.925**	**0.933**	**0.942**	**0.949**	**0.957**	**0.965**	**0.973**	**-**	**-**
	TM	*0.196*	*0.213*	*0.243*	*0.294*	*0.333*	*0.388*	*0.469*	*0.599*	*0.841*	*1.431*	*4.987*	*-*	*-*
14°	PM	**0.854**	**0.876**	**0.896**	**0.915**	**0.923**	**0.932**	**0.940**	**0.948**	**0.956**	**0.963**	**0.971**	**-**	**-**
	TM	*0.200*	*0.218*	*0.249*	*0.303*	*0.345*	*0.404*	*0.492*	*0.638*	*0.918*	*1.671*	*9.980*	*-*	*-*
15°	PM	**0.852**	**0.874**	**0.894**	**0.913**	**0.922**	**0.930**	**0.938**	**0.946**	**0.954**	**0.962**	**-**	**-**	**-**
	TM	*0.204*	*0.223*	*0.256*	*0.313*	*0.357*	*0.421*	*0.518*	*0.681*	*1.012*	*2.008*	*-*	*-*	*-*
16°	PM	**0.849**	**0.872**	**0.892**	**0.911**	**0.920**	**0.928**	**0.937**	**0.945**	**0.953**	**0.960**	**-**	**-**	**-**
	TM	*0.208*	*0.228*	*0.263*	*0.323*	*0.370*	*0.439*	*0.546*	*0.731*	*1.125*	*2.512*	*-*	*-*	*-*
17°	PM	**0.847**	**0.870**	**0.891**	**0.909**	**0.918**	**0.927**	**0.935**	**0.943**	**0.951**	**0.959**	**-**	**-**	**-**
	TM	*0.212*	*0.233*	*0.270*	*0.333*	*0.384*	*0.459*	*0.577*	*0.789*	*1.268*	*3.354*	*-*	*-*	*-*
18°	PM	**0.844**	**0.868**	**0.889**	**0.907**	**0.916**	**0.925**	**0.933**	**0.942**	**0.949**	**0.957**	**-**	**-**	**-**
	TM	*0.217*	*0.239*	*0.277*	*0.345*	*0.400*	*0.481*	*0.613*	*0.856*	*1.451*	*5.037*	*-*	*-*	*-*
19°	PM	**0.842**	**0.865**	**0.887**	**0.906**	**0.915**	**0.923**	**0.932**	**0.940**	**0.948**	**0.956**	**-**	**-**	**-**
	TM	*0.222*	*0.245*	*0.285*	*0.357*	*0.416*	*0.505*	*0.652*	*0.936*	*1.696*	*10.088*	*-*	*-*	*-*
20°	PM	**0.839**	**0.863**	**0.885**	**0.904**	**0.913**	**0.922**	**0.930**	**0.938**	**0.946**	**-**	**-**	**-**	**-**
	TM	*0.227*	*0.251*	*0.293*	*0.370*	*0.434*	*0.532*	*0.697*	*1.031*	*2.039*	*-*	*-*	*-*	*-*
21°	PM	**0.836**	**0.861**	**0.883**	**0.902**	**0.911**	**0.920**	**0.928**	**0.937**	**0.945**	**-**	**-**	**-**	**-**
	TM	*0.232*	*0.257*	*0.302*	*0.384*	*0.454*	*0.562*	*0.749*	*1.148*	*2.553*	*-*	*-*	*-*	*-*
22°	PM	**0.834**	**0.859**	**0.880**	**0.900**	**0.909**	**0.918**	**0.927**	**0.935**	**0.943**	**-**	**-**	**-**	**-**
	TM	*0.237*	*0.264*	*0.311*	*0.399*	*0.475*	*0.595*	*0.809*	*1.295*	*3.411*	*-*	*-*	*-*	*-*
23°	PM	**0.831**	**0.856**	**0.878**	**0.898**	**0.907**	**0.916**	**0.925**	**0.933**	**0.942**	**-**	**-**	**-**	**-**
	TM	*0.243*	*0.271*	*0.321*	*0.416*	*0.498*	*0.631*	*0.878*	*1.483*	*5.127*	*-*	*-*	*-*	*-*
24°	PM	**0.828**	**0.854**	**0.876**	**0.896**	**0.906**	**0.915**	**0.923**	**0.932**	**0.940**	**-**	**-**	**-**	**-**
	TM	*0.249*	*0.278*	*0.331*	*0.433*	*0.524*	*0.673*	*0.961*	*1.735*	*10.277*	*-*	*-*	*-*	*-*
25°	PM	**0.826**	**0.852**	**0.874**	**0.894**	**0.904**	**0.913**	**0.922**	**0.930**	**-**	**-**	**-**	**-**	**-**
	TM	*0.255*	*0.286*	*0.342*	*0.452*	*0.552*	*0.720*	*1.060*	*2.087*	*-*	*-*	*-*	*-*	*-*
26°	PM	**0.823**	**0.849**	**0.872**	**0.892**	**0.902**	**0.911**	**0.920**	**0.928**	**-**	**-**	**-**	**-**	**-**
	TM	*0.261*	*0.294*	*0.354*	*0.473*	*0.583*	*0.774*	*1.181*	*2.616*	*-*	*-*	*-*	*-*	*-*
27°	PM	**0.820**	**0.847**	**0.870**	**0.891**	**0.900**	**0.909**	**0.918**	**0.927**	**-**	**-**	**-**	**-**	**-**
	TM	*0.268*	*0.303*	*0.367*	*0.496*	*0.618*	*0.836*	*1.333*	*3.498*	*-*	*-*	*-*	*-*	*-*
28°	PM	**0.817**	**0.844**	**0.868**	**0.889**	**0.898**	**0.907**	**0.916**	**0.925**	**-**	**-**	**-**	**-**	**-**
	TM	*0.275*	*0.312*	*0.380*	*0.520*	*0.656*	*0.909*	*1.529*	*5.262*	*-*	*-*	*-*	*-*	*-*
29°	PM	**0.814**	**0.842**	**0.865**	**0.887**	**0.896**	**0.906**	**0.915**	**0.923**	**-**	**-**	**-**	**-**	**-**
	TM	*0.283*	*0.321*	*0.394*	*0.547*	*0.700*	*0.996*	*1.789*	*10.555*	*-*	*-*	*-*	*-*	*-*
30°	PM	**0.811**	**0.839**	**0.863**	**0.885**	**0.894**	**0.904**	**0.913**	**-**	**-**	**-**	**-**	**-**	**-**
	TM	*0.291*	*0.331*	*0.410*	*0.577*	*0.750*	*1.099*	*2.154*	*-*	*-*	*-*	*-*	*-*	*-*

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.11. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 11°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 11° TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	**PM**	**0.874**	**0.895**	**0.914**	**0.932**	**0.941**	**0.950**	**0.958**	**0.967**	**0.975**	**0.983**	**0.992**	**1.000**	**1.008**
	TM	*0.172*	*0.185*	*0.206*	*0.238*	*0.260*	*0.290*	*0.329*	*0.382*	*0.459*	*0.578*	*0.784*	*1.222*	*2.761*
2°	**PM**	**0.871**	**0.893**	**0.912**	**0.931**	**0.939**	**0.948**	**0.957**	**0.965**	**0.973**	**0.982**	**0.990**	**0.998**	**1.007**
	TM	*0.175*	*0.188*	*0.209*	*0.243*	*0.267*	*0.298*	*0.339*	*0.396*	*0.479*	*0.610*	*0.844*	*1.373*	*3.676*
3°	**PM**	**0.869**	**0.891**	**0.910**	**0.929**	**0.938**	**0.946**	**0.955**	**0.963**	**0.972**	**0.980**	**0.988**	**0.997**	**1.005**
	TM	*0.178*	*0.192*	*0.213*	*0.248*	*0.273*	*0.306*	*0.350*	*0.411*	*0.501*	*0.645*	*0.913*	*1.568*	*5.508*
4°	**PM**	**0.867**	**0.889**	**0.908**	**0.927**	**0.936**	**0.945**	**0.953**	**0.962**	**0.970**	**0.978**	**0.987**	**0.995**	**1.003**
	TM	*0.181*	*0.195*	*0.218*	*0.254*	*0.280*	*0.315*	*0.361*	*0.426*	*0.525*	*0.686*	*0.996*	*1.827*	*11.003*
5°	**PM**	**0.865**	**0.886**	**0.906**	**0.925**	**0.934**	**0.943**	**0.951**	**0.960**	**0.968**	**0.977**	**0.985**	**0.993**	-
	TM	*0.184*	*0.198*	*0.222*	*0.260*	*0.287*	*0.324*	*0.373*	*0.444*	*0.551*	*0.731*	*1.095*	*2.191*	-
6°	**PM**	**0.862**	**0.884**	**0.905**	**0.923**	**0.932**	**0.941**	**0.950**	**0.958**	**0.967**	**0.975**	**0.983**	**0.992**	-
	TM	*0.187*	*0.202*	*0.227*	*0.266*	*0.295*	*0.334*	*0.386*	*0.462*	*0.580*	*0.783*	*1.216*	*2.737*	-
7°	**PM**	**0.860**	**0.882**	**0.903**	**0.921**	**0.931**	**0.939**	**0.948**	**0.957**	**0.965**	**0.973**	**0.982**	**0.990**	-
	TM	*0.190*	*0.206*	*0.231*	*0.273*	*0.303*	*0.344*	*0.400*	*0.483*	*0.612*	*0.844*	*1.368*	*3.648*	-
8°	**PM**	**0.858**	**0.880**	**0.901**	**0.920**	**0.929**	**0.938**	**0.946**	**0.955**	**0.963**	**0.972**	**0.980**	**0.988**	-
	TM	*0.194*	*0.210*	*0.236*	*0.280*	*0.312*	*0.355*	*0.416*	*0.505*	*0.648*	*0.914*	*1.563*	*5.470*	-
9°	**PM**	**0.855**	**0.878**	**0.899**	**0.918**	**0.927**	**0.936**	**0.945**	**0.953**	**0.962**	**0.970**	**0.978**	**0.987**	-
	TM	*0.197*	*0.214*	*0.242*	*0.287*	*0.321*	*0.367*	*0.432*	*0.529*	*0.689*	*0.997*	*1.823*	*10.936*	-
10°	**PM**	**0.853**	**0.876**	**0.897**	**0.916**	**0.925**	**0.934**	**0.943**	**0.951**	**0.960**	**0.968**	**0.977**	-	-
	TM	*0.201*	*0.218*	*0.247*	*0.295*	*0.331*	*0.380*	*0.450*	*0.556*	*0.736*	*1.097*	*2.188*	-	-
11°	**PM**	**0.850**	**0.874**	**0.895**	**0.914**	**0.923**	**0.932**	**0.941**	**0.950**	**0.958**	**0.967**	**0.975**	-	-
	TM	*0.204*	*0.223*	*0.253*	*0.303*	*0.341*	*0.394*	*0.469*	*0.586*	*0.789*	*1.220*	*2.735*	-	-
12°	**PM**	**0.848**	**0.871**	**0.893**	**0.912**	**0.921**	**0.931**	**0.939**	**0.948**	**0.957**	**0.965**	**0.973**	-	-
	TM	*0.208*	*0.227*	*0.259*	*0.312*	*0.352*	*0.408*	*0.490*	*0.619*	*0.850*	*1.373*	*3.648*	-	-
13°	**PM**	**0.846**	**0.869**	**0.891**	**0.910**	**0.920**	**0.929**	**0.938**	**0.946**	**0.955**	**0.963**	**0.972**	-	-
	TM	*0.212*	*0.232*	*0.265*	*0.321*	*0.364*	*0.424*	*0.513*	*0.656*	*0.922*	*1.570*	*5.474*	-	-
14°	**PM**	**0.843**	**0.867**	**0.889**	**0.908**	**0.918**	**0.927**	**0.936**	**0.945**	**0.953**	**0.962**	**0.970**	-	-
	TM	*0.217*	*0.237*	*0.272*	*0.331*	*0.376*	*0.441*	*0.538*	*0.698*	*1.006*	*1.833*	*10.953*	-	-
15°	**PM**	**0.840**	**0.865**	**0.886**	**0.906**	**0.916**	**0.925**	**0.934**	**0.943**	**0.951**	**0.960**	-	-	-
	TM	*0.221*	*0.242*	*0.279*	*0.341*	*0.390*	*0.460*	*0.566*	*0.746*	*1.108*	*2.201*	-	-	-
16°	**PM**	**0.838**	**0.862**	**0.884**	**0.905**	**0.914**	**0.923**	**0.932**	**0.941**	**0.950**	**0.958**	-	-	-
	TM	*0.225*	*0.248*	*0.286*	*0.352*	*0.404*	*0.480*	*0.597*	*0.800*	*1.233*	*2.754*	-	-	-
17°	**PM**	**0.835**	**0.860**	**0.882**	**0.903**	**0.912**	**0.921**	**0.931**	**0.939**	**0.948**	**0.957**	-	-	-
	TM	*0.230*	*0.254*	*0.293*	*0.364*	*0.420*	*0.502*	*0.631*	*0.863*	*1.389*	*3.676*	-	-	-
18°	**PM**	**0.833**	**0.858**	**0.880**	**0.901**	**0.910**	**0.920**	**0.929**	**0.938**	**0.946**	**0.955**	-	-	-
	TM	*0.235*	*0.259*	*0.302*	*0.376*	*0.436*	*0.526*	*0.670*	*0.937*	*1.589*	*5.520*	-	-	-
19°	**PM**	**0.830**	**0.855**	**0.878**	**0.899**	**0.908**	**0.918**	**0.927**	**0.936**	**0.945**	**0.953**	-	-	-
	TM	*0.240*	*0.266*	*0.310*	*0.389*	*0.454*	*0.552*	*0.713*	*1.024*	*1.857*	*11.054*	-	-	-
20°	**PM**	**0.827**	**0.853**	**0.876**	**0.897**	**0.906**	**0.916**	**0.925**	**0.934**	**0.943**	-	-	-	-
	TM	*0.246*	*0.272*	*0.319*	*0.403*	*0.474*	*0.581*	*0.762*	*1.128*	*2.232*	-	-	-	-
21°	**PM**	**0.824**	**0.850**	**0.874**	**0.895**	**0.905**	**0.914**	**0.923**	**0.932**	**0.941**	-	-	-	-
	TM	*0.251*	*0.279*	*0.328*	*0.419*	*0.495*	*0.613*	*0.819*	*1.256*	*2.795*	-	-	-	-
22°	**PM**	**0.822**	**0.848**	**0.871**	**0.893**	**0.903**	**0.912**	**0.921**	**0.931**	**0.939**	-	-	-	-
	TM	*0.257*	*0.286*	*0.338*	*0.435*	*0.518*	*0.649*	*0.884*	*1.416*	*3.733*	-	-	-	-
23°	**PM**	**0.819**	**0.846**	**0.869**	**0.891**	**0.901**	**0.910**	**0.920**	**0.929**	**0.938**	-	-	-	-
	TM	*0.263*	*0.294*	*0.349*	*0.453*	*0.543*	*0.689*	*0.960*	*1.622*	*5.610*	-	-	-	-
24°	**PM**	**0.816**	**0.843**	**0.867**	**0.889**	**0.899**	**0.908**	**0.918**	**0.927**	**0.936**	-	-	-	-
	TM	*0.269*	*0.302*	*0.360*	*0.472*	*0.571*	*0.734*	*1.050*	*1.896*	*11.243*	-	-	-	-
25°	**PM**	**0.813**	**0.840**	**0.865**	**0.886**	**0.897**	**0.906**	**0.916**	**0.925**	-	-	-	-	-
	TM	*0.276*	*0.310*	*0.372*	*0.493*	*0.601*	*0.786*	*1.158*	*2.281*	-	-	-	-	-
26°	**PM**	**0.810**	**0.838**	**0.862**	**0.884**	**0.895**	**0.905**	**0.914**	**0.923**	-	-	-	-	-
	TM	*0.283*	*0.319*	*0.385*	*0.515*	*0.635*	*0.844*	*1.290*	*2.859*	-	-	-	-	-
27°	**PM**	**0.807**	**0.835**	**0.860**	**0.882**	**0.893**	**0.903**	**0.912**	**0.921**	-	-	-	-	-
	TM	*0.290*	*0.328*	*0.398*	*0.539*	*0.673*	*0.912*	*1.455*	*3.821*	-	-	-	-	-
28°	**PM**	**0.804**	**0.833**	**0.858**	**0.880**	**0.891**	**0.901**	**0.910**	**0.920**	-	-	-	-	-
	TM	*0.298*	*0.338*	*0.413*	*0.566*	*0.715*	*0.992*	*1.668*	*5.748*	-	-	-	-	-
29°	**PM**	**0.801**	**0.830**	**0.855**	**0.878**	**0.889**	**0.899**	**0.908**	**0.918**	-	-	-	-	-
	TM	*0.306*	*0.348*	*0.428*	*0.596*	*0.763*	*1.085*	*1.953*	*11.528*	-	-	-	-	-
30°	**PM**	**0.797**	**0.827**	**0.853**	**0.876**	**0.886**	**0.897**	**0.906**	-	-	-	-	-	-
	TM	*0.314*	*0.359*	*0.445*	*0.628*	*0.817*	*1.198*	*2.351*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.12. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 12°

		LOAD POSITION ANGLE, Θ = 12°												
TAG POS. ANGLE, θ_T	LINE MULT.	TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.865**	**0.888**	**0.909**	**0.928**	**0.938**	**0.947**	**0.956**	**0.965**	**0.975**	**0.984**	**0.993**	**1.002**	**1.011**
	TM	*0.186*	*0.200*	*0.223*	*0.258*	*0.283*	*0.315*	*0.358*	*0.416*	*0.500*	*0.630*	*0.855*	*1.334*	*3.016*
2°	PM	**0.863**	**0.886**	**0.907**	**0.926**	**0.936**	**0.945**	**0.954**	**0.964**	**0.973**	**0.982**	**0.991**	**1.000**	**1.009**
	TM	*0.189*	*0.203*	*0.227*	*0.263*	*0.289*	*0.323*	*0.368*	*0.431*	*0.522*	*0.665*	*0.920*	*1.498*	*4.015*
3°	PM	**0.861**	**0.883**	**0.905**	**0.924**	**0.934**	**0.943**	**0.953**	**0.962**	**0.971**	**0.980**	**0.989**	**0.998**	**1.007**
	TM	*0.192*	*0.207*	*0.231*	*0.269*	*0.297*	*0.332*	*0.380*	*0.447*	*0.545*	*0.703*	*0.996*	*1.711*	*6.015*
4°	PM	**0.858**	**0.881**	**0.902**	**0.922**	**0.932**	**0.941**	**0.951**	**0.960**	**0.969**	**0.978**	**0.987**	**0.996**	**1.006**
	TM	*0.195*	*0.211*	*0.236*	*0.275*	*0.304*	*0.342*	*0.392*	*0.464*	*0.571*	*0.747*	*1.086*	*1.994*	*12.015*
5°	PM	**0.856**	**0.879**	**0.900**	**0.920**	**0.930**	**0.940**	**0.949**	**0.958**	**0.967**	**0.976**	**0.985**	**0.995**	**-**
	TM	*0.198*	*0.214*	*0.240*	*0.282*	*0.312*	*0.352*	*0.406*	*0.483*	*0.599*	*0.796*	*1.193*	*2.391*	*-*
6°	PM	**0.853**	**0.877**	**0.898**	**0.919**	**0.928**	**0.938**	**0.947**	**0.956**	**0.965**	**0.975**	**0.984**	**0.993**	**-**
	TM	*0.202*	*0.218*	*0.245*	*0.289*	*0.320*	*0.362*	*0.420*	*0.503*	*0.631*	*0.853*	*1.325*	*2.986*	*-*
7°	PM	**0.851**	**0.874**	**0.896**	**0.917**	**0.926**	**0.936**	**0.945**	**0.954**	**0.964**	**0.973**	**0.982**	**0.991**	**-**
	TM	*0.205*	*0.222*	*0.250*	*0.296*	*0.329*	*0.374*	*0.435*	*0.525*	*0.666*	*0.919*	*1.490*	*3.979*	*-*
8°	PM	**0.848**	**0.872**	**0.894**	**0.915**	**0.924**	**0.934**	**0.943**	**0.953**	**0.962**	**0.971**	**0.980**	**0.989**	**-**
	TM	*0.209*	*0.227*	*0.256*	*0.303*	*0.338*	*0.386*	*0.452*	*0.549*	*0.705*	*0.995*	*1.703*	*5.965*	*-*
9°	PM	**0.846**	**0.870**	**0.892**	**0.913**	**0.922**	**0.932**	**0.941**	**0.951**	**0.960**	**0.969**	**0.978**	**0.987**	**-**
	TM	*0.212*	*0.231*	*0.261*	*0.311*	*0.348*	*0.398*	*0.469*	*0.575*	*0.750*	*1.086*	*1.986*	*11.924*	*-*
10°	PM	**0.843**	**0.868**	**0.890**	**0.911**	**0.920**	**0.930**	**0.940**	**0.949**	**0.958**	**0.967**	**0.976**	**-**	**-**
	TM	*0.216*	*0.235*	*0.267*	*0.320*	*0.359*	*0.412*	*0.488*	*0.605*	*0.800*	*1.194*	*2.383*	*-*	*-*
11°	PM	**0.841**	**0.865**	**0.888**	**0.909**	**0.919**	**0.928**	**0.938**	**0.947**	**0.956**	**0.965**	**0.975**	**-**	**-**
	TM	*0.220*	*0.240*	*0.273*	*0.328*	*0.370*	*0.427*	*0.509*	*0.637*	*0.858*	*1.327*	*2.979*	*-*	*-*
12°	PM	**0.838**	**0.863**	**0.886**	**0.907**	**0.917**	**0.926**	**0.936**	**0.945**	**0.954**	**0.964**	**0.973**	**-**	**-**
	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	**0.835**	**0.861**	**0.883**	**0.905**	**0.915**	**0.924**	**0.934**	**0.943**	**0.953**	**0.962**	**0.971**	**-**	**-**
	TM	*0.229*	*0.250*	*0.287*	*0.348*	*0.394*	*0.460*	*0.557*	*0.713*	*1.002*	*1.708*	*5.960*	*-*	*-*
14°	PM	**0.833**	**0.858**	**0.881**	**0.902**	**0.913**	**0.922**	**0.932**	**0.941**	**0.951**	**0.960**	**0.969**	**-**	**-**
	TM	*0.233*	*0.256*	*0.294*	*0.358*	*0.408*	*0.478*	*0.584*	*0.758*	*1.094*	*1.994*	*11.924*	*-*	*-*
15°	PM	**0.830**	**0.856**	**0.879**	**0.900**	**0.911**	**0.920**	**0.930**	**0.940**	**0.949**	**0.958**	**-**	**-**	**-**
	TM	*0.238*	*0.261*	*0.301*	*0.369*	*0.422*	*0.498*	*0.614*	*0.810*	*1.204*	*2.394*	*-*	*-*	*-*
16°	PM	**0.827**	**0.853**	**0.877**	**0.898**	**0.909**	**0.919**	**0.928**	**0.938**	**0.947**	**0.956**	**-**	**-**	**-**
	TM	*0.242*	*0.267*	*0.309*	*0.381*	*0.438*	*0.520*	*0.648*	*0.869*	*1.340*	*2.995*	*-*	*-*	*-*
17°	PM	**0.824**	**0.851**	**0.874**	**0.896**	**0.907**	**0.917**	**0.926**	**0.936**	**0.945**	**0.954**	**-**	**-**	**-**
	TM	*0.248*	*0.273*	*0.317*	*0.393*	*0.454*	*0.544*	*0.685*	*0.937*	*1.509*	*3.997*	*-*	*-*	*-*
18°	PM	**0.821**	**0.848**	**0.872**	**0.894**	**0.905**	**0.915**	**0.924**	**0.934**	**0.943**	**0.953**	**-**	**-**	**-**
	TM	*0.253*	*0.280*	*0.326*	*0.407*	*0.472*	*0.570*	*0.726*	*1.017*	*1.727*	*6.001*	*-*	*-*	*-*
19°	PM	**0.819**	**0.846**	**0.870**	**0.892**	**0.902**	**0.913**	**0.922**	**0.932**	**0.941**	**0.951**	**-**	**-**	**-**
	TM	*0.258*	*0.286*	*0.335*	*0.421*	*0.492*	*0.598*	*0.773*	*1.111*	*2.017*	*12.015*	*-*	*-*	*-*
20°	PM	**0.816**	**0.843**	**0.868**	**0.890**	**0.900**	**0.911**	**0.920**	**0.930**	**0.940**	**-**	**-**	**-**	**-**
	TM	*0.264*	*0.293*	*0.344*	*0.436*	*0.513*	*0.629*	*0.826*	*1.224*	*2.424*	*-*	*-*	*-*	*-*
21°	PM	**0.813**	**0.841**	**0.865**	**0.888**	**0.898**	**0.909**	**0.919**	**0.928**	**0.938**	**-**	**-**	**-**	**-**
	TM	*0.270*	*0.301*	*0.354*	*0.453*	*0.536*	*0.664*	*0.887*	*1.363*	*3.034*	*-*	*-*	*-*	*-*
22°	PM	**0.810**	**0.838**	**0.863**	**0.886**	**0.896**	**0.907**	**0.917**	**0.926**	**0.936**	**-**	**-**	**-**	**-**
	TM	*0.276*	*0.308*	*0.365*	*0.470*	*0.560*	*0.703*	*0.958*	*1.536*	*4.053*	*-*	*-*	*-*	*-*
23°	PM	**0.807**	**0.835**	**0.861**	**0.883**	**0.894**	**0.905**	**0.915**	**0.924**	**0.934**	**-**	**-**	**-**	**-**
	TM	*0.282*	*0.316*	*0.376*	*0.489*	*0.588*	*0.746*	*1.040*	*1.759*	*6.090*	*-*	*-*	*-*	*-*
24°	PM	**0.804**	**0.833**	**0.858**	**0.881**	**0.892**	**0.902**	**0.913**	**0.922**	**0.932**	**-**	**-**	**-**	**-**
	TM	*0.289*	*0.325*	*0.388*	*0.510*	*0.617*	*0.795*	*1.137*	*2.056*	*12.202*	*-*	*-*	*-*	*-*
25°	PM	**0.801**	**0.830**	**0.856**	**0.879**	**0.890**	**0.900**	**0.911**	**0.920**	**-**	**-**	**-**	**-**	**-**
	TM	*0.296*	*0.334*	*0.401*	*0.532*	*0.650*	*0.850*	*1.254*	*2.473*	*-*	*-*	*-*	*-*	*-*
26°	PM	**0.797**	**0.827**	**0.853**	**0.877**	**0.888**	**0.898**	**0.909**	**0.919**	**-**	**-**	**-**	**-**	**-**
	TM	*0.303*	*0.343*	*0.415*	*0.556*	*0.687*	*0.914*	*1.397*	*3.099*	*-*	*-*	*-*	*-*	*-*
27°	PM	**0.794**	**0.824**	**0.851**	**0.874**	**0.886**	**0.896**	**0.907**	**0.917**	**-**	**-**	**-**	**-**	**-**
	TM	*0.311*	*0.353*	*0.429*	*0.583*	*0.727*	*0.987*	*1.576*	*4.142*	*-*	*-*	*-*	*-*	*-*
28°	PM	**0.791**	**0.821**	**0.848**	**0.872**	**0.883**	**0.894**	**0.905**	**0.915**	**-**	**-**	**-**	**-**	**-**
	TM	*0.319*	*0.363*	*0.445*	*0.611*	*0.773*	*1.073*	*1.806*	*6.229*	*-*	*-*	*-*	*-*	*-*
29°	PM	**0.788**	**0.819**	**0.846**	**0.870**	**0.881**	**0.892**	**0.902**	**0.913**	**-**	**-**	**-**	**-**	**-**
	TM	*0.328*	*0.374*	*0.461*	*0.643*	*0.824*	*1.174*	*2.114*	*12.491*	*-*	*-*	*-*	*-*	*-*
30°	PM	**0.784**	**0.816**	**0.843**	**0.868**	**0.879**	**0.890**	**0.900**	**-**	**-**	**-**	**-**	**-**	**-**
	TM	*0.336*	*0.386*	*0.479*	*0.678*	*0.882*	*1.296*	*2.544*	*-*	*-*	*-*	*-*	*-*	*-*

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.13. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 13°

		LOAD POSITION ANGLE, Θ = 13°												
TAG POS.	LINE	TAG ANGLE, α_T												
ANGLE, θ_T	MULT.	10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.857	0.881	0.903	0.924	0.935	0.945	0.955	0.965	0.974	0.984	0.994	1.004	1.014
	TM	0.199	0.215	0.239	0.278	0.305	0.340	0.386	0.450	0.541	0.682	0.926	1.446	3.273
2°	PM	0.855	0.879	0.901	0.922	0.933	0.943	0.953	0.963	0.972	0.982	0.992	1.002	1.012
	TM	0.202	0.219	0.244	0.284	0.312	0.349	0.398	0.466	0.564	0.719	0.997	1.625	4.356
3°	PM	0.852	0.877	0.899	0.920	0.931	0.941	0.951	0.961	0.970	0.980	0.990	1.000	1.010
	TM	0.206	0.222	0.249	0.290	0.320	0.358	0.410	0.483	0.590	0.761	1.079	1.854	6.525
4°	PM	0.850	0.874	0.897	0.918	0.929	0.939	0.949	0.959	0.968	0.978	0.988	0.998	1.008
	TM	0.209	0.226	0.253	0.297	0.328	0.369	0.424	0.501	0.617	0.808	1.176	2.161	13.032
5°	PM	0.847	0.872	0.895	0.916	0.927	0.937	0.947	0.957	0.967	0.976	0.986	0.996	-
	TM	0.212	0.230	0.258	0.304	0.336	0.379	0.438	0.521	0.648	0.862	1.292	2.590	-
6°	PM	0.844	0.869	0.892	0.914	0.924	0.935	0.945	0.955	0.965	0.974	0.984	0.994	-
	TM	0.216	0.234	0.264	0.311	0.345	0.391	0.453	0.543	0.682	0.923	1.435	3.235	-
7°	PM	0.842	0.867	0.890	0.912	0.922	0.933	0.943	0.953	0.963	0.972	0.982	0.992	-
	TM	0.219	0.238	0.269	0.318	0.355	0.403	0.469	0.567	0.720	0.994	1.613	4.310	-
8°	PM	0.839	0.865	0.888	0.910	0.920	0.931	0.941	0.951	0.961	0.970	0.980	0.990	-
	TM	0.223	0.243	0.275	0.327	0.365	0.416	0.487	0.593	0.762	1.076	1.843	6.460	-
9°	PM	0.837	0.862	0.886	0.908	0.918	0.929	0.939	0.949	0.959	0.968	0.978	0.988	-
	TM	0.227	0.248	0.281	0.335	0.375	0.430	0.506	0.621	0.810	1.174	2.149	12.913	-
10°	PM	0.834	0.860	0.883	0.906	0.916	0.927	0.937	0.947	0.957	0.967	0.976	-	-
	TM	0.231	0.252	0.287	0.344	0.386	0.444	0.527	0.653	0.864	1.291	2.579	-	-
11°	PM	0.831	0.857	0.881	0.903	0.914	0.924	0.935	0.945	0.955	0.965	0.974	-	-
	TM	0.235	0.258	0.294	0.353	0.398	0.460	0.549	0.687	0.926	1.435	3.223	-	-
12°	PM	0.828	0.855	0.879	0.901	0.912	0.922	0.933	0.943	0.953	0.963	0.972	-	-
	TM	0.240	0.263	0.300	0.363	0.411	0.477	0.574	0.726	0.998	1.615	4.297	-	-
13°	PM	0.825	0.852	0.877	0.899	0.910	0.920	0.931	0.941	0.951	0.961	0.970	-	-
	TM	0.244	0.268	0.308	0.374	0.425	0.495	0.600	0.769	1.082	1.846	6.446	-	-
14°	PM	0.823	0.850	0.874	0.897	0.908	0.918	0.929	0.939	0.949	0.959	0.968	-	-
	TM	0.249	0.274	0.315	0.385	0.439	0.515	0.630	0.818	1.181	2.154	12.893	-	-
15°	PM	0.820	0.847	0.872	0.895	0.906	0.916	0.927	0.937	0.947	0.957	-	-	-
	TM	0.254	0.280	0.323	0.397	0.454	0.537	0.662	0.874	1.300	2.587	-	-	-
16°	PM	0.817	0.844	0.869	0.892	0.903	0.914	0.924	0.935	0.945	0.955	-	-	-
	TM	0.259	0.286	0.331	0.409	0.471	0.560	0.698	0.937	1.446	3.235	-	-	-
17°	PM	0.814	0.842	0.867	0.890	0.901	0.912	0.922	0.933	0.943	0.953	-	-	-
	TM	0.264	0.293	0.340	0.423	0.489	0.585	0.738	1.010	1.628	4.317	-	-	-
18°	PM	0.811	0.839	0.865	0.888	0.899	0.910	0.920	0.931	0.941	0.951	-	-	-
	TM	0.270	0.299	0.349	0.437	0.508	0.613	0.783	1.096	1.863	6.480	-	-	-
19°	PM	0.808	0.837	0.862	0.886	0.897	0.908	0.918	0.929	0.939	0.949	-	-	-
	TM	0.276	0.306	0.359	0.452	0.529	0.644	0.833	1.198	2.176	12.972	-	-	-
20°	PM	0.805	0.834	0.860	0.883	0.895	0.906	0.916	0.927	0.937	-	-	-	-
	TM	0.282	0.314	0.369	0.469	0.551	0.677	0.890	1.319	2.614	-	-	-	-
21°	PM	0.802	0.831	0.857	0.881	0.892	0.903	0.914	0.924	0.935	-	-	-	-
	TM	0.288	0.322	0.380	0.486	0.576	0.715	0.955	1.468	3.273	-	-	-	-
22°	PM	0.799	0.828	0.855	0.879	0.890	0.901	0.912	0.922	0.933	-	-	-	-
	TM	0.294	0.330	0.391	0.505	0.602	0.756	1.031	1.655	4.370	-	-	-	-
23°	PM	0.795	0.825	0.852	0.877	0.888	0.899	0.910	0.920	0.931	-	-	-	-
	TM	0.301	0.338	0.403	0.525	0.631	0.802	1.119	1.895	6.565	-	-	-	-
24°	PM	0.792	0.823	0.850	0.874	0.886	0.897	0.908	0.918	0.929	-	-	-	-
	TM	0.308	0.347	0.416	0.547	0.663	0.855	1.224	2.215	13.153	-	-	-	-
25°	PM	0.789	0.820	0.847	0.872	0.883	0.895	0.906	0.916	-	-	-	-	-
	TM	0.316	0.357	0.430	0.571	0.699	0.914	1.349	2.663	-	-	-	-	-
26°	PM	0.786	0.817	0.844	0.869	0.881	0.892	0.903	0.914	-	-	-	-	-
	TM	0.323	0.367	0.444	0.597	0.738	0.982	1.503	3.337	-	-	-	-	-
27°	PM	0.782	0.814	0.842	0.867	0.879	0.890	0.901	0.912	-	-	-	-	-
	TM	0.332	0.377	0.460	0.625	0.781	1.061	1.695	4.459	-	-	-	-	-
28°	PM	0.779	0.811	0.839	0.865	0.877	0.888	0.899	0.910	-	-	-	-	-
	TM	0.340	0.388	0.476	0.656	0.830	1.153	1.943	6.704	-	-	-	-	-
29°	PM	0.775	0.808	0.837	0.862	0.874	0.886	0.897	0.908	-	-	-	-	-
	TM	0.349	0.400	0.494	0.690	0.885	1.261	2.273	13.442	-	-	-	-	-
30°	PM	0.772	0.805	0.834	0.860	0.872	0.883	0.895	-	-	-	-	-	-
	TM	0.358	0.412	0.512	0.727	0.947	1.392	2.735	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.14. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 14°

		LOAD POSITION ANGLE, Θ = 14°												
TAG POS. ANGLE, θ_T	LINE MULT.	TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.850	0.875	0.899	0.921	0.932	0.943	0.953	0.964	0.975	0.985	0.996	1.006	1.017
	TM	0.212	0.230	0.256	0.298	0.327	0.365	0.415	0.483	0.582	0.734	0.998	1.559	3.531
2°	PM	0.847	0.873	0.896	0.919	0.930	0.941	0.951	0.962	0.972	0.983	0.994	1.004	1.015
	TM	0.216	0.233	0.261	0.304	0.335	0.374	0.427	0.500	0.607	0.774	1.073	1.751	4.700
3°	PM	0.844	0.870	0.894	0.917	0.928	0.938	0.949	0.960	0.970	0.981	0.991	1.002	1.013
	TM	0.219	0.237	0.266	0.311	0.343	0.385	0.441	0.519	0.634	0.819	1.162	1.998	7.038
4°	PM	0.842	0.868	0.892	0.914	0.925	0.936	0.947	0.958	0.968	0.979	0.989	1.000	1.011
	TM	0.223	0.241	0.271	0.318	0.351	0.395	0.455	0.538	0.664	0.870	1.266	2.329	14.054
5°	PM	0.839	0.865	0.889	0.912	0.923	0.934	0.945	0.955	0.966	0.977	0.987	0.998	-
	TM	0.226	0.245	0.276	0.325	0.360	0.407	0.470	0.560	0.697	0.927	1.391	2.791	-
6°	PM	0.836	0.863	0.887	0.910	0.921	0.932	0.943	0.953	0.964	0.975	0.985	0.996	-
	TM	0.230	0.250	0.282	0.333	0.370	0.419	0.486	0.583	0.733	0.993	1.545	3.485	-
7°	PM	0.833	0.860	0.885	0.908	0.919	0.930	0.941	0.951	0.962	0.972	0.983	0.994	-
	TM	0.234	0.254	0.288	0.341	0.380	0.432	0.504	0.609	0.774	1.069	1.736	4.642	-
8°	PM	0.831	0.857	0.882	0.905	0.917	0.928	0.938	0.949	0.960	0.970	0.981	0.991	-
	TM	0.238	0.259	0.294	0.349	0.390	0.446	0.523	0.636	0.819	1.157	1.983	6.957	-
9°	PM	0.828	0.855	0.880	0.903	0.914	0.925	0.936	0.947	0.958	0.968	0.979	0.989	-
	TM	0.242	0.264	0.300	0.358	0.402	0.460	0.543	0.667	0.870	1.262	2.313	13.904	-
10°	PM	0.825	0.852	0.877	0.901	0.912	0.923	0.934	0.945	0.955	0.966	0.977	-	-
	TM	0.246	0.269	0.307	0.368	0.414	0.476	0.565	0.700	0.928	1.388	2.774	-	-
11°	PM	0.822	0.850	0.875	0.899	0.910	0.921	0.932	0.943	0.953	0.964	0.975	-	-
	TM	0.250	0.274	0.314	0.378	0.426	0.493	0.589	0.738	0.995	1.542	3.467	-	-
12°	PM	0.819	0.847	0.873	0.896	0.908	0.919	0.930	0.941	0.951	0.962	0.972	-	-
	TM	0.255	0.280	0.321	0.389	0.440	0.511	0.615	0.779	1.072	1.735	4.621	-	-
13°	PM	0.816	0.844	0.870	0.894	0.905	0.917	0.928	0.938	0.949	0.960	0.970	-	-
	TM	0.260	0.286	0.328	0.400	0.454	0.531	0.644	0.825	1.162	1.983	6.931	-	-
14°	PM	0.813	0.842	0.868	0.892	0.903	0.914	0.925	0.936	0.947	0.958	0.968	-	-
	TM	0.265	0.292	0.336	0.412	0.470	0.552	0.675	0.878	1.268	2.314	13.862	-	-
15°	PM	0.810	0.839	0.865	0.889	0.901	0.912	0.923	0.934	0.945	0.955	-	-	-
	TM	0.270	0.298	0.345	0.424	0.486	0.575	0.710	0.937	1.396	2.778	-	-	-
16°	PM	0.807	0.836	0.863	0.887	0.899	0.910	0.921	0.932	0.943	0.953	-	-	-
	TM	0.275	0.305	0.353	0.438	0.504	0.600	0.748	1.005	1.552	3.474	-	-	-
17°	PM	0.804	0.833	0.860	0.885	0.896	0.908	0.919	0.930	0.941	0.951	-	-	-
	TM	0.281	0.311	0.363	0.452	0.523	0.627	0.791	1.083	1.747	4.635	-	-	-
18°	PM	0.801	0.831	0.857	0.882	0.894	0.905	0.917	0.928	0.938	0.949	-	-	-
	TM	0.287	0.319	0.372	0.467	0.543	0.656	0.838	1.175	1.998	6.957	-	-	-
19°	PM	0.798	0.828	0.855	0.880	0.892	0.903	0.914	0.925	0.936	0.947	-	-	-
	TM	0.293	0.326	0.383	0.483	0.565	0.689	0.892	1.284	2.334	13.925	-	-	-
20°	PM	0.795	0.825	0.852	0.877	0.889	0.901	0.912	0.923	0.934	-	-	-	-
	TM	0.299	0.334	0.393	0.501	0.589	0.725	0.953	1.414	2.804	-	-	-	-
21°	PM	0.791	0.822	0.850	0.875	0.887	0.899	0.910	0.921	0.932	-	-	-	-
	TM	0.306	0.342	0.405	0.519	0.615	0.764	1.023	1.573	3.509	-	-	-	-
22°	PM	0.788	0.819	0.847	0.873	0.885	0.896	0.908	0.919	0.930	-	-	-	-
	TM	0.312	0.351	0.417	0.539	0.644	0.809	1.104	1.773	4.685	-	-	-	-
23°	PM	0.785	0.816	0.844	0.870	0.882	0.894	0.905	0.917	0.928	-	-	-	-
	TM	0.320	0.360	0.430	0.561	0.675	0.858	1.198	2.029	7.038	-	-	-	-
24°	PM	0.781	0.813	0.842	0.868	0.880	0.892	0.903	0.914	0.925	-	-	-	-
	TM	0.327	0.369	0.443	0.584	0.709	0.914	1.310	2.372	14.097	-	-	-	-
25°	PM	0.778	0.810	0.839	0.865	0.877	0.889	0.901	0.912	-	-	-	-	-
	TM	0.335	0.379	0.458	0.609	0.746	0.977	1.444	2.852	-	-	-	-	-
26°	PM	0.774	0.807	0.836	0.863	0.875	0.887	0.899	0.910	-	-	-	-	-
	TM	0.343	0.389	0.473	0.637	0.788	1.050	1.608	3.572	-	-	-	-	-
27°	PM	0.771	0.804	0.833	0.860	0.873	0.885	0.896	0.908	-	-	-	-	-
	TM	0.351	0.400	0.489	0.667	0.834	1.134	1.813	4.773	-	-	-	-	-
28°	PM	0.767	0.801	0.831	0.857	0.870	0.882	0.894	0.905	-	-	-	-	-
	TM	0.360	0.412	0.507	0.699	0.886	1.231	2.078	7.175	-	-	-	-	-
29°	PM	0.764	0.798	0.828	0.855	0.868	0.880	0.892	0.903	-	-	-	-	-
	TM	0.370	0.424	0.525	0.735	0.944	1.347	2.430	14.384	-	-	-	-	-
30°	PM	0.760	0.795	0.825	0.852	0.865	0.877	0.889	-	-	-	-	-	-
	TM	0.379	0.437	0.545	0.775	1.011	1.487	2.924	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.15. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 15°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 15°												
		TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.842**	**0.869**	**0.894**	**0.918**	**0.930**	**0.941**	**0.952**	**0.964**	**0.975**	**0.986**	**0.998**	**1.009**	**1.021**
	TM	*0.225*	*0.244*	*0.273*	*0.317*	*0.349*	*0.389*	*0.443*	*0.517*	*0.623*	*0.786*	*1.070*	*1.672*	*3.791*
2°	PM	**0.840**	**0.867**	**0.892**	**0.916**	**0.927**	**0.939**	**0.950**	**0.961**	**0.973**	**0.984**	**0.995**	**1.007**	**1.019**
	TM	*0.229*	*0.248*	*0.278*	*0.324*	*0.357*	*0.400*	*0.456*	*0.535*	*0.649*	*0.829*	*1.151*	*1.878*	*5.045*
3°	PM	**0.837**	**0.864**	**0.889**	**0.913**	**0.925**	**0.936**	**0.948**	**0.959**	**0.970**	**0.982**	**0.993**	**1.005**	**1.016**
	TM	*0.232*	*0.252*	*0.283*	*0.331*	*0.366*	*0.410*	*0.471*	*0.555*	*0.678*	*0.877*	*1.245*	*2.143*	*7.554*
4°	PM	**0.834**	**0.861**	**0.887**	**0.911**	**0.923**	**0.934**	**0.946**	**0.957**	**0.968**	**0.979**	**0.991**	**1.002**	**1.014**
	TM	*0.236*	*0.256*	*0.288*	*0.339*	*0.375*	*0.422*	*0.486*	*0.576*	*0.710*	*0.931*	*1.356*	*2.497*	*15.082*
5°	PM	**0.831**	**0.859**	**0.884**	**0.909**	**0.920**	**0.932**	**0.943**	**0.955**	**0.966**	**0.977**	**0.989**	**1.000**	-
	TM	*0.240*	*0.261*	*0.294*	*0.346*	*0.384*	*0.434*	*0.502*	*0.598*	*0.745*	*0.992*	*1.490*	*2.992*	-
6°	PM	**0.828**	**0.856**	**0.882**	**0.906**	**0.918**	**0.930**	**0.941**	**0.952**	**0.964**	**0.975**	**0.986**	**0.998**	-
	TM	*0.244*	*0.265*	*0.300*	*0.355*	*0.394*	*0.447*	*0.519*	*0.623*	*0.784*	*1.063*	*1.654*	*3.736*	-
7°	PM	**0.825**	**0.853**	**0.879**	**0.904**	**0.916**	**0.927**	**0.939**	**0.950**	**0.961**	**0.973**	**0.984**	**0.995**	-
	TM	*0.248*	*0.270*	*0.306*	*0.363*	*0.405*	*0.461*	*0.538*	*0.650*	*0.827*	*1.144*	*1.860*	*4.976*	-
8°	PM	**0.822**	**0.851**	**0.877**	**0.901**	**0.913**	**0.925**	**0.936**	**0.948**	**0.959**	**0.970**	**0.982**	**0.993**	-
	TM	*0.252*	*0.275*	*0.312*	*0.372*	*0.416*	*0.475*	*0.558*	*0.680*	*0.876*	*1.238*	*2.124*	*7.456*	-
9°	PM	**0.819**	**0.848**	**0.874**	**0.899**	**0.911**	**0.923**	**0.934**	**0.946**	**0.957**	**0.968**	**0.979**	**0.991**	-
	TM	*0.256*	*0.280*	*0.319*	*0.382*	*0.428*	*0.491*	*0.580*	*0.712*	*0.930*	*1.350*	*2.476*	*14.898*	-
10°	PM	**0.816**	**0.845**	**0.872**	**0.897**	**0.909**	**0.920**	**0.932**	**0.943**	**0.955**	**0.966**	**0.977**	-	-
	TM	*0.261*	*0.286*	*0.326*	*0.392*	*0.441*	*0.508*	*0.603*	*0.748*	*0.992*	*1.485*	*2.970*	-	-
11°	PM	**0.813**	**0.842**	**0.869**	**0.894**	**0.906**	**0.918**	**0.930**	**0.941**	**0.952**	**0.964**	**0.975**	-	-
	TM	*0.265*	*0.291*	*0.333*	*0.402*	*0.454*	*0.526*	*0.629*	*0.788*	*1.063*	*1.649*	*3.710*	-	-
12°	PM	**0.810**	**0.840**	**0.867**	**0.892**	**0.904**	**0.916**	**0.927**	**0.939**	**0.950**	**0.961**	**0.973**	-	-
	TM	*0.270*	*0.297*	*0.341*	*0.414*	*0.469*	*0.545*	*0.656*	*0.832*	*1.145*	*1.855*	*4.945*	-	-
13°	PM	**0.807**	**0.837**	**0.864**	**0.889**	**0.901**	**0.913**	**0.925**	**0.936**	**0.948**	**0.959**	**0.970**	-	-
	TM	*0.275*	*0.303*	*0.349*	*0.425*	*0.484*	*0.566*	*0.687*	*0.881*	*1.241*	*2.121*	*7.416*	-	-
14°	PM	**0.804**	**0.834**	**0.861**	**0.887**	**0.899**	**0.911**	**0.923**	**0.934**	**0.946**	**0.957**	**0.968**	-	-
	TM	*0.280*	*0.309*	*0.357*	*0.438*	*0.500*	*0.588*	*0.720*	*0.937*	*1.354*	*2.474*	*14.830*	-	-
15°	PM	**0.801**	**0.831**	**0.859**	**0.884**	**0.897**	**0.909**	**0.920**	**0.932**	**0.943**	**0.955**	-	-	-
	TM	*0.286*	*0.316*	*0.366*	*0.451*	*0.518*	*0.612*	*0.757*	*1.000*	*1.490*	*2.970*	-	-	-
16°	PM	**0.798**	**0.828**	**0.856**	**0.882**	**0.894**	**0.906**	**0.918**	**0.930**	**0.941**	**0.952**	-	-	-
	TM	*0.291*	*0.323*	*0.375*	*0.465*	*0.536*	*0.639*	*0.797*	*1.072*	*1.657*	*3.713*	-	-	-
17°	PM	**0.795**	**0.825**	**0.853**	**0.879**	**0.892**	**0.904**	**0.916**	**0.927**	**0.939**	**0.950**	-	-	-
	TM	*0.297*	*0.330*	*0.385*	*0.480*	*0.556*	*0.668*	*0.843*	*1.156*	*1.865*	*4.953*	-	-	-
18°	PM	**0.791**	**0.822**	**0.851**	**0.877**	**0.889**	**0.901**	**0.913**	**0.925**	**0.936**	**0.948**	-	-	-
	TM	*0.303*	*0.338*	*0.395*	*0.497*	*0.578*	*0.699*	*0.893*	*1.253*	*2.133*	*7.433*	-	-	-
19°	PM	**0.788**	**0.819**	**0.848**	**0.874**	**0.887**	**0.899**	**0.911**	**0.923**	**0.934**	**0.946**	-	-	-
	TM	*0.309*	*0.345*	*0.406*	*0.514*	*0.602*	*0.733*	*0.951*	*1.369*	*2.491*	*14.875*	-	-	-
20°	PM	**0.785**	**0.816**	**0.845**	**0.872**	**0.884**	**0.897**	**0.909**	**0.920**	**0.932**	-	-	-	-
	TM	*0.316*	*0.354*	*0.417*	*0.532*	*0.627*	*0.772*	*1.016*	*1.508*	*2.992*	-	-	-	-
21°	PM	**0.781**	**0.813**	**0.842**	**0.869**	**0.882**	**0.894**	**0.906**	**0.918**	**0.930**	-	-	-	-
	TM	*0.323*	*0.362*	*0.430*	*0.552*	*0.654*	*0.814*	*1.090*	*1.677*	*3.745*	-	-	-	-
22°	PM	**0.778**	**0.810**	**0.840**	**0.867**	**0.879**	**0.892**	**0.904**	**0.916**	**0.927**	-	-	-	-
	TM	*0.330*	*0.371*	*0.442*	*0.573*	*0.684*	*0.861*	*1.176*	*1.890*	*4.999*	-	-	-	-
23°	PM	**0.774**	**0.807**	**0.837**	**0.864**	**0.877**	**0.889**	**0.901**	**0.913**	**0.925**	-	-	-	-
	TM	*0.337*	*0.381*	*0.456*	*0.596*	*0.717*	*0.913*	*1.276*	*2.163*	*7.507*	-	-	-	-
24°	PM	**0.771**	**0.804**	**0.834**	**0.861**	**0.874**	**0.887**	**0.899**	**0.911**	**0.923**	-	-	-	-
	TM	*0.345*	*0.391*	*0.470*	*0.620*	*0.753*	*0.972*	*1.395*	*2.528*	*15.036*	-	-	-	-
25°	PM	**0.767**	**0.801**	**0.831**	**0.859**	**0.872**	**0.884**	**0.897**	**0.909**	-	-	-	-	-
	TM	*0.353*	*0.401*	*0.485*	*0.647*	*0.793*	*1.040*	*1.537*	*3.039*	-	-	-	-	-
26°	PM	**0.764**	**0.798**	**0.828**	**0.856**	**0.869**	**0.882**	**0.894**	**0.906**	-	-	-	-	-
	TM	*0.362*	*0.412*	*0.501*	*0.676*	*0.837*	*1.117*	*1.712*	*3.806*	-	-	-	-	-
27°	PM	**0.760**	**0.795**	**0.825**	**0.853**	**0.867**	**0.879**	**0.892**	**0.904**	-	-	-	-	-
	TM	*0.371*	*0.423*	*0.518*	*0.708*	*0.886*	*1.205*	*1.930*	*5.084*	-	-	-	-	-
28°	PM	**0.756**	**0.791**	**0.822**	**0.851**	**0.864**	**0.877**	**0.889**	**0.901**	-	-	-	-	-
	TM	*0.380*	*0.436*	*0.537*	*0.742*	*0.941*	*1.309*	*2.211*	*7.642*	-	-	-	-	-
29°	PM	**0.753**	**0.788**	**0.819**	**0.848**	**0.861**	**0.874**	**0.887**	**0.899**	-	-	-	-	-
	TM	*0.390*	*0.448*	*0.556*	*0.780*	*1.003*	*1.432*	*2.586*	*15.317*	-	-	-	-	-
30°	PM	**0.749**	**0.785**	**0.816**	**0.845**	**0.859**	**0.872**	**0.884**	-	-	-	-	-	-
	TM	*0.400*	*0.462*	*0.577*	*0.822*	*1.073*	*1.580*	*3.111*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.16. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 16°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 16° TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.836**	**0.864**	**0.890**	**0.915**	**0.927**	**0.940**	**0.952**	**0.964**	**0.976**	**0.988**	**1.000**	**1.012**	**1.025**
	TM	*0.238*	*0.258*	*0.289*	*0.337*	*0.371*	*0.414*	*0.472*	*0.550*	*0.664*	*0.839*	*1.142*	*1.786*	*4.053*
2°	PM	**0.833**	**0.861**	**0.887**	**0.913**	**0.925**	**0.937**	**0.949**	**0.961**	**0.973**	**0.985**	**0.998**	**1.010**	**1.022**
	TM	*0.242*	*0.262*	*0.294*	*0.344*	*0.379*	*0.425*	*0.486*	*0.570*	*0.692*	*0.884*	*1.228*	*2.006*	*5.393*
3°	PM	**0.830**	**0.858**	**0.885**	**0.910**	**0.923**	**0.935**	**0.947**	**0.959**	**0.971**	**0.983**	**0.995**	**1.007**	**1.020**
	TM	*0.245*	*0.267*	*0.300*	*0.352*	*0.388*	*0.436*	*0.501*	*0.590*	*0.723*	*0.935*	*1.328*	*2.289*	*8.073*
4°	PM	**0.827**	**0.855**	**0.882**	**0.908**	**0.920**	**0.932**	**0.944**	**0.956**	**0.968**	**0.981**	**0.993**	**1.005**	**1.017**
	TM	*0.249*	*0.271*	*0.305*	*0.359*	*0.398*	*0.448*	*0.517*	*0.613*	*0.757*	*0.993*	*1.447*	*2.666*	*16.117*
5°	PM	**0.824**	**0.853**	**0.880**	**0.905**	**0.918**	**0.930**	**0.942**	**0.954**	**0.966**	**0.978**	**0.990**	**1.002**	-
	TM	*0.253*	*0.276*	*0.311*	*0.368*	*0.408*	*0.461*	*0.534*	*0.637*	*0.794*	*1.058*	*1.590*	*3.195*	-
6°	PM	**0.821**	**0.850**	**0.877**	**0.903**	**0.915**	**0.927**	**0.940**	**0.952**	**0.964**	**0.976**	**0.988**	**1.000**	-
	TM	*0.257*	*0.280*	*0.317*	*0.376*	*0.419*	*0.475*	*0.552*	*0.663*	*0.835*	*1.132*	*1.765*	*3.988*	-
7°	PM	**0.818**	**0.847**	**0.874**	**0.900**	**0.913**	**0.925**	**0.937**	**0.949**	**0.961**	**0.973**	**0.985**	**0.998**	-
	TM	*0.261*	*0.286*	*0.324*	*0.385*	*0.430*	*0.489*	*0.572*	*0.692*	*0.881*	*1.219*	*1.983*	*5.310*	-
8°	PM	**0.815**	**0.844**	**0.872**	**0.898**	**0.910**	**0.923**	**0.935**	**0.947**	**0.959**	**0.971**	**0.983**	**0.995**	-
	TM	*0.266*	*0.291*	*0.331*	*0.395*	*0.442*	*0.505*	*0.593*	*0.723*	*0.932*	*1.319*	*2.265*	*7.956*	-
9°	PM	**0.812**	**0.841**	**0.869**	**0.895**	**0.908**	**0.920**	**0.932**	**0.944**	**0.956**	**0.968**	**0.981**	**0.993**	-
	TM	*0.270*	*0.296*	*0.338*	*0.405*	*0.454*	*0.521*	*0.616*	*0.758*	*0.990*	*1.438*	*2.640*	*15.895*	-
10°	PM	**0.808**	**0.839**	**0.866**	**0.893**	**0.905**	**0.918**	**0.930**	**0.942**	**0.954**	**0.966**	**0.978**	-	-
	TM	*0.275*	*0.302*	*0.345*	*0.415*	*0.468*	*0.539*	*0.641*	*0.796*	*1.056*	*1.582*	*3.165*	-	-
11°	PM	**0.805**	**0.836**	**0.864**	**0.890**	**0.903**	**0.915**	**0.927**	**0.940**	**0.952**	**0.964**	**0.976**	-	-
	TM	*0.280*	*0.308*	*0.353*	*0.426*	*0.482*	*0.558*	*0.668*	*0.838*	*1.132*	*1.757*	*3.954*	-	-
12°	PM	**0.802**	**0.833**	**0.861**	**0.887**	**0.900**	**0.913**	**0.925**	**0.937**	**0.949**	**0.961**	**0.973**	-	-
	TM	*0.285*	*0.314*	*0.361*	*0.438*	*0.497*	*0.578*	*0.697*	*0.884*	*1.219*	*1.976*	*5.270*	-	-
13°	PM	**0.799**	**0.830**	**0.858**	**0.885**	**0.898**	**0.910**	**0.923**	**0.935**	**0.947**	**0.959**	**0.971**	-	-
	TM	*0.290*	*0.320*	*0.369*	*0.451*	*0.513*	*0.600*	*0.729*	*0.937*	*1.320*	*2.258*	*7.902*	-	-
14°	PM	**0.796**	**0.827**	**0.855**	**0.882**	**0.895**	**0.908**	**0.920**	**0.932**	**0.944**	**0.956**	**0.968**	-	-
	TM	*0.295*	*0.327*	*0.378*	*0.464*	*0.530*	*0.624*	*0.765*	*0.996*	*1.441*	*2.634*	*15.798*	-	-
15°	PM	**0.792**	**0.824**	**0.853**	**0.880**	**0.893**	**0.905**	**0.918**	**0.930**	**0.942**	**0.954**	-	-	-
	TM	*0.301*	*0.334*	*0.387*	*0.478*	*0.549*	*0.650*	*0.804*	*1.063*	*1.585*	*3.161*	-	-	-
16°	PM	**0.789**	**0.821**	**0.850**	**0.877**	**0.890**	**0.903**	**0.915**	**0.927**	**0.940**	**0.952**	-	-	-
	TM	*0.307*	*0.341*	*0.397*	*0.493*	*0.569*	*0.678*	*0.847*	*1.139*	*1.762*	*3.951*	-	-	-
17°	PM	**0.786**	**0.818**	**0.847**	**0.874**	**0.887**	**0.900**	**0.913**	**0.925**	**0.937**	**0.949**	-	-	-
	TM	*0.313*	*0.348*	*0.407*	*0.509*	*0.590*	*0.708*	*0.895*	*1.228*	*1.983*	*5.270*	-	-	-
18°	PM	**0.782**	**0.815**	**0.844**	**0.872**	**0.885**	**0.898**	**0.910**	**0.923**	**0.935**	**0.947**	-	-	-
	TM	*0.319*	*0.356*	*0.418*	*0.526*	*0.613*	*0.741*	*0.948*	*1.331*	*2.268*	*7.908*	-	-	-
19°	PM	**0.779**	**0.812**	**0.841**	**0.869**	**0.882**	**0.895**	**0.908**	**0.920**	**0.932**	**0.944**	-	-	-
	TM	*0.326*	*0.364*	*0.429*	*0.544*	*0.637*	*0.778*	*1.009*	*1.454*	*2.648*	*15.823*	-	-	-
20°	PM	**0.775**	**0.808**	**0.839**	**0.866**	**0.880**	**0.893**	**0.905**	**0.918**	**0.930**	-	-	-	-
	TM	*0.332*	*0.373*	*0.441*	*0.563*	*0.664*	*0.818*	*1.078*	*1.601*	*3.180*	-	-	-	-
21°	PM	**0.772**	**0.805**	**0.836**	**0.864**	**0.877**	**0.890**	**0.903**	**0.915**	**0.927**	-	-	-	-
	TM	*0.340*	*0.382*	*0.454*	*0.584*	*0.693*	*0.862*	*1.156*	*1.781*	*3.979*	-	-	-	-
22°	PM	**0.768**	**0.802**	**0.833**	**0.861**	**0.874**	**0.887**	**0.900**	**0.913**	**0.925**	-	-	-	-
	TM	*0.347*	*0.391*	*0.467*	*0.606*	*0.725*	*0.912*	*1.247*	*2.006*	*5.310*	-	-	-	-
23°	PM	**0.765**	**0.799**	**0.830**	**0.858**	**0.872**	**0.885**	**0.898**	**0.910**	**0.923**	-	-	-	-
	TM	*0.355*	*0.401*	*0.481*	*0.630*	*0.759*	*0.968*	*1.353*	*2.296*	*7.974*	-	-	-	-
24°	PM	**0.761**	**0.796**	**0.827**	**0.855**	**0.869**	**0.882**	**0.895**	**0.908**	**0.920**	-	-	-	-
	TM	*0.363*	*0.411*	*0.496*	*0.656*	*0.797*	*1.030*	*1.479*	*2.683*	*15.968*	-	-	-	-
25°	PM	**0.757**	**0.792**	**0.824**	**0.853**	**0.866**	**0.880**	**0.893**	**0.905**	-	-	-	-	-
	TM	*0.371*	*0.422*	*0.512*	*0.684*	*0.839*	*1.101*	*1.630*	*3.224*	-	-	-	-	-
26°	PM	**0.754**	**0.789**	**0.821**	**0.850**	**0.864**	**0.877**	**0.890**	**0.903**	-	-	-	-	-
	TM	*0.380*	*0.434*	*0.529*	*0.715*	*0.886*	*1.183*	*1.814*	*4.037*	-	-	-	-	-
27°	PM	**0.750**	**0.786**	**0.818**	**0.847**	**0.861**	**0.874**	**0.887**	**0.900**	-	-	-	-	-
	TM	*0.389*	*0.446*	*0.547*	*0.748*	*0.938*	*1.277*	*2.045*	*5.393*	-	-	-	-	-
28°	PM	**0.746**	**0.782**	**0.815**	**0.844**	**0.858**	**0.872**	**0.885**	**0.898**	-	-	-	-	-
	TM	*0.399*	*0.459*	*0.566*	*0.785*	*0.995*	*1.386*	*2.343*	*8.105*	-	-	-	-	-
29°	PM	**0.742**	**0.779**	**0.812**	**0.841**	**0.855**	**0.869**	**0.882**	**0.895**	-	-	-	-	-
	TM	*0.409*	*0.472*	*0.587*	*0.825*	*1.061*	*1.516*	*2.739*	*16.242*	-	-	-	-	-
30°	PM	**0.738**	**0.775**	**0.808**	**0.839**	**0.853**	**0.866**	**0.880**	-	-	-	-	-	-
	TM	*0.420*	*0.486*	*0.609*	*0.869*	*1.135*	*1.672*	*3.295*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.17. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 17°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 17°, TAG ANGLE, α_T: 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	0.829	0.858	0.886	0.913	0.926	0.938	0.951	0.964	0.977	0.990	1.003	1.016	1.029
	TM	0.251	0.272	0.305	0.356	0.392	0.439	0.500	0.584	0.705	0.891	1.214	1.901	4.317
2°	PM	0.826	0.856	0.883	0.910	0.923	0.936	0.949	0.961	0.974	0.987	1.000	1.013	1.026
	TM	0.254	0.276	0.311	0.364	0.401	0.450	0.515	0.604	0.735	0.940	1.306	2.135	5.743
3°	PM	0.823	0.853	0.881	0.907	0.920	0.933	0.946	0.959	0.972	0.984	0.997	1.010	1.024
	TM	0.258	0.281	0.316	0.372	0.411	0.462	0.531	0.626	0.767	0.994	1.412	2.435	8.597
4°	PM	0.820	0.850	0.878	0.905	0.918	0.931	0.944	0.956	0.969	0.982	0.995	1.008	1.021
	TM	0.262	0.286	0.322	0.380	0.421	0.475	0.548	0.650	0.803	1.054	1.538	2.836	17.159
5°	PM	0.817	0.847	0.875	0.902	0.915	0.928	0.941	0.954	0.967	0.979	0.992	1.005	-
	TM	0.266	0.290	0.329	0.389	0.432	0.488	0.566	0.675	0.842	1.123	1.690	3.398	-
6°	PM	0.814	0.844	0.872	0.899	0.913	0.926	0.938	0.951	0.964	0.977	0.990	1.003	-
	TM	0.270	0.295	0.335	0.398	0.443	0.503	0.585	0.703	0.886	1.202	1.875	4.241	-
7°	PM	0.811	0.841	0.870	0.897	0.910	0.923	0.936	0.949	0.961	0.974	0.987	1.000	-
	TM	0.275	0.301	0.342	0.407	0.455	0.518	0.606	0.733	0.935	1.294	2.107	5.647	-
8°	PM	0.807	0.838	0.867	0.894	0.907	0.920	0.933	0.946	0.959	0.972	0.984	0.997	-
	TM	0.279	0.306	0.349	0.417	0.467	0.534	0.628	0.767	0.989	1.400	2.406	8.459	-
9°	PM	0.804	0.835	0.864	0.891	0.905	0.918	0.931	0.944	0.956	0.969	0.982	0.995	-
	TM	0.284	0.312	0.356	0.428	0.480	0.552	0.652	0.803	1.050	1.527	2.804	16.896	-
10°	PM	0.801	0.832	0.861	0.889	0.902	0.915	0.928	0.941	0.954	0.967	0.979	-	-
	TM	0.289	0.318	0.364	0.439	0.494	0.570	0.679	0.843	1.120	1.678	3.362	-	-
11°	PM	0.798	0.829	0.858	0.886	0.899	0.913	0.926	0.938	0.951	0.964	0.977	-	-
	TM	0.294	0.324	0.372	0.450	0.509	0.590	0.707	0.887	1.200	1.864	4.199	-	-
12°	PM	0.794	0.826	0.856	0.883	0.897	0.910	0.923	0.936	0.949	0.961	0.974	-	-
	TM	0.299	0.330	0.380	0.463	0.525	0.612	0.738	0.937	1.292	2.096	5.595	-	-
13°	PM	0.791	0.823	0.853	0.881	0.894	0.907	0.920	0.933	0.946	0.959	0.972	-	-
	TM	0.304	0.337	0.389	0.476	0.542	0.635	0.772	0.992	1.399	2.395	8.388	-	-
14°	PM	0.788	0.820	0.850	0.878	0.891	0.905	0.918	0.931	0.944	0.956	0.969	-	-
	TM	0.310	0.344	0.398	0.490	0.560	0.660	0.809	1.054	1.527	2.793	16.768	-	-
15°	PM	0.784	0.817	0.847	0.875	0.889	0.902	0.915	0.928	0.941	0.954	-	-	-
	TM	0.316	0.351	0.408	0.504	0.580	0.687	0.850	1.125	1.680	3.352	-	-	-
16°	PM	0.781	0.814	0.844	0.872	0.886	0.899	0.913	0.926	0.938	0.951	-	-	-
	TM	0.322	0.358	0.418	0.520	0.600	0.716	0.896	1.206	1.867	4.189	-	-	-
17°	PM	0.777	0.811	0.841	0.870	0.883	0.897	0.910	0.923	0.936	0.949	-	-	-
	TM	0.328	0.366	0.429	0.537	0.623	0.748	0.946	1.300	2.101	5.586	-	-	-
18°	PM	0.774	0.807	0.838	0.867	0.881	0.894	0.907	0.920	0.933	0.946	-	-	-
	TM	0.335	0.374	0.440	0.555	0.647	0.783	1.003	1.409	2.402	8.381	-	-	-
19°	PM	0.770	0.804	0.835	0.864	0.878	0.891	0.905	0.918	0.931	0.944	-	-	-
	TM	0.342	0.383	0.452	0.574	0.673	0.822	1.067	1.538	2.804	16.768	-	-	-
20°	PM	0.766	0.801	0.832	0.861	0.875	0.889	0.902	0.915	0.928	-	-	-	-
	TM	0.349	0.392	0.464	0.594	0.701	0.864	1.139	1.694	3.367	-	-	-	-
21°	PM	0.763	0.798	0.829	0.858	0.872	0.886	0.899	0.913	0.926	-	-	-	-
	TM	0.356	0.401	0.478	0.616	0.731	0.911	1.222	1.884	4.212	-	-	-	-
22°	PM	0.759	0.794	0.826	0.856	0.870	0.883	0.897	0.910	0.923	-	-	-	-
	TM	0.364	0.411	0.492	0.639	0.765	0.963	1.318	2.122	5.621	-	-	-	-
23°	PM	0.755	0.791	0.823	0.853	0.867	0.881	0.894	0.907	0.920	-	-	-	-
	TM	0.372	0.421	0.506	0.664	0.801	1.022	1.430	2.428	8.439	-	-	-	-
24°	PM	0.752	0.788	0.820	0.850	0.864	0.878	0.891	0.905	0.918	-	-	-	-
	TM	0.380	0.432	0.522	0.692	0.841	1.087	1.562	2.836	16.896	-	-	-	-
25°	PM	0.748	0.784	0.817	0.847	0.861	0.875	0.889	0.902	-	-	-	-	-
	TM	0.389	0.443	0.539	0.721	0.885	1.162	1.721	3.408	-	-	-	-	-
26°	PM	0.744	0.781	0.814	0.844	0.858	0.872	0.886	0.899	-	-	-	-	-
	TM	0.398	0.455	0.556	0.753	0.934	1.248	1.916	4.267	-	-	-	-	-
27°	PM	0.740	0.777	0.811	0.841	0.856	0.870	0.883	0.897	-	-	-	-	-
	TM	0.408	0.468	0.575	0.788	0.988	1.347	2.160	5.699	-	-	-	-	-
28°	PM	0.736	0.774	0.807	0.838	0.853	0.867	0.881	0.894	-	-	-	-	-
	TM	0.418	0.481	0.595	0.826	1.049	1.462	2.473	8.563	-	-	-	-	-
29°	PM	0.732	0.770	0.804	0.835	0.850	0.864	0.878	0.891	-	-	-	-	-
	TM	0.428	0.495	0.617	0.868	1.118	1.599	2.892	17.159	-	-	-	-	-
30°	PM	0.728	0.766	0.801	0.832	0.847	0.861	0.875	-	-	-	-	-	-
	TM	0.439	0.510	0.640	0.915	1.196	1.764	3.478	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.18. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 18°

		LOAD POSITION ANGLE, Θ = 18°												
TAG POS. ANGLE, θ_T	LINE MULT.	TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.823**	**0.854**	**0.883**	**0.910**	**0.924**	**0.938**	**0.951**	**0.965**	**0.978**	**0.992**	**1.006**	**1.020**	**1.034**
	TM	*0.263*	*0.286*	*0.321*	*0.376*	*0.414*	*0.463*	*0.528*	*0.618*	*0.746*	*0.944*	*1.287*	*2.017*	*4.583*
2°	PM	**0.820**	**0.851**	**0.880**	**0.908**	**0.921**	**0.935**	**0.948**	**0.962**	**0.975**	**0.989**	**1.003**	**1.017**	**1.031**
	TM	*0.267*	*0.291*	*0.327*	*0.384*	*0.424*	*0.475*	*0.544*	*0.639*	*0.777*	*0.995*	*1.384*	*2.264*	*6.097*
3°	PM	**0.817**	**0.848**	**0.877**	**0.905**	**0.919**	**0.932**	**0.946**	**0.959**	**0.973**	**0.986**	**1.000**	**1.014**	**1.028**
	TM	*0.271*	*0.295*	*0.333*	*0.392*	*0.434*	*0.488*	*0.561*	*0.662*	*0.812*	*1.052*	*1.497*	*2.583*	*9.124*
4°	PM	**0.813**	**0.845**	**0.874**	**0.902**	**0.916**	**0.929**	**0.943**	**0.956**	**0.970**	**0.984**	**0.997**	**1.011**	**1.025**
	TM	*0.275*	*0.300*	*0.339*	*0.400*	*0.444*	*0.501*	*0.578*	*0.687*	*0.849*	*1.116*	*1.630*	*3.007*	*18.209*
5°	PM	**0.810**	**0.842**	**0.871**	**0.899**	**0.913**	**0.927**	**0.940**	**0.954**	**0.967**	**0.981**	**0.994**	**1.008**	-
	TM	*0.279*	*0.305*	*0.346*	*0.409*	*0.455*	*0.515*	*0.597*	*0.714*	*0.891*	*1.189*	*1.790*	*3.603*	-
6°	PM	**0.807**	**0.839**	**0.868**	**0.897**	**0.910**	**0.924**	**0.938**	**0.951**	**0.965**	**0.978**	**0.992**	**1.006**	-
	TM	*0.283*	*0.310*	*0.352*	*0.419*	*0.467*	*0.530*	*0.618*	*0.743*	*0.937*	*1.273*	*1.986*	*4.496*	-
7°	PM	**0.804**	**0.836**	**0.865**	**0.894**	**0.908**	**0.921**	**0.935**	**0.948**	**0.962**	**0.975**	**0.989**	**1.003**	-
	TM	*0.288*	*0.316*	*0.359*	*0.429*	*0.479*	*0.547*	*0.640*	*0.775*	*0.988*	*1.369*	*2.232*	*5.985*	-
8°	PM	**0.800**	**0.832**	**0.862**	**0.891**	**0.905**	**0.919**	**0.932**	**0.946**	**0.959**	**0.973**	**0.986**	**1.000**	-
	TM	*0.292*	*0.321*	*0.367*	*0.439*	*0.492*	*0.564*	*0.663*	*0.810*	*1.046*	*1.482*	*2.547*	*8.963*	-
9°	PM	**0.797**	**0.829**	**0.860**	**0.888**	**0.902**	**0.916**	**0.929**	**0.943**	**0.956**	**0.970**	**0.984**	**0.997**	-
	TM	*0.297*	*0.327*	*0.374*	*0.450*	*0.506*	*0.582*	*0.689*	*0.848*	*1.110*	*1.615*	*2.969*	*17.902*	-
10°	PM	**0.794**	**0.826**	**0.857**	**0.885**	**0.899**	**0.913**	**0.927**	**0.940**	**0.954**	**0.967**	**0.981**	-	-
	TM	*0.302*	*0.333*	*0.382*	*0.462*	*0.521*	*0.601*	*0.716*	*0.890*	*1.184*	*1.775*	*3.559*	-	-
11°	PM	**0.790**	**0.823**	**0.854**	**0.883**	**0.897**	**0.910**	**0.924**	**0.938**	**0.951**	**0.965**	**0.978**	-	-
	TM	*0.308*	*0.340*	*0.391*	*0.474*	*0.537*	*0.622*	*0.746*	*0.937*	*1.268*	*1.971*	*4.444*	-	-
12°	PM	**0.787**	**0.820**	**0.851**	**0.880**	**0.894**	**0.908**	**0.921**	**0.935**	**0.948**	**0.962**	**0.975**	-	-
	TM	*0.313*	*0.346*	*0.399*	*0.487*	*0.553*	*0.645*	*0.779*	*0.989*	*1.365*	*2.216*	*5.921*	-	-
13°	PM	**0.783**	**0.817**	**0.848**	**0.877**	**0.891**	**0.905**	**0.919**	**0.932**	**0.946**	**0.959**	**0.973**	-	-
	TM	*0.319*	*0.353*	*0.409*	*0.501*	*0.571*	*0.669*	*0.814*	*1.047*	*1.478*	*2.532*	*8.875*	-	-
14°	PM	**0.780**	**0.813**	**0.845**	**0.874**	**0.888**	**0.902**	**0.916**	**0.929**	**0.943**	**0.956**	**0.970**	-	-
	TM	*0.324*	*0.360*	*0.418*	*0.515*	*0.590*	*0.695*	*0.853*	*1.113*	*1.613*	*2.953*	*17.739*	-	-
15°	PM	**0.776**	**0.810**	**0.842**	**0.871**	**0.885**	**0.899**	**0.913**	**0.927**	**0.940**	**0.954**	-	-	-
	TM	*0.330*	*0.368*	*0.428*	*0.531*	*0.610*	*0.724*	*0.896*	*1.187*	*1.774*	*3.542*	-	-	-
16°	PM	**0.773**	**0.807**	**0.839**	**0.868**	**0.883**	**0.897**	**0.910**	**0.924**	**0.938**	**0.951**	-	-	-
	TM	*0.337*	*0.376*	*0.439*	*0.547*	*0.632*	*0.755*	*0.944*	*1.273*	*1.971*	*4.427*	-	-	-
17°	PM	**0.769**	**0.804**	**0.836**	**0.865**	**0.880**	**0.894**	**0.908**	**0.921**	**0.935**	**0.948**	-	-	-
	TM	*0.343*	*0.384*	*0.450*	*0.565*	*0.655*	*0.788*	*0.997*	*1.371*	*2.218*	*5.903*	-	-	-
18°	PM	**0.765**	**0.800**	**0.832**	**0.862**	**0.877**	**0.891**	**0.905**	**0.919**	**0.932**	**0.946**	-	-	-
	TM	*0.350*	*0.392*	*0.462*	*0.583*	*0.681*	*0.825*	*1.057*	*1.486*	*2.536*	*8.854*	-	-	-
19°	PM	**0.762**	**0.797**	**0.829**	**0.860**	**0.874**	**0.888**	**0.902**	**0.916**	**0.929**	**0.943**	-	-	-
	TM	*0.357*	*0.401*	*0.474*	*0.603*	*0.708*	*0.865*	*1.124*	*1.622*	*2.959*	*17.712*	-	-	-
20°	PM	**0.758**	**0.794**	**0.826**	**0.857**	**0.871**	**0.885**	**0.899**	**0.913**	**0.927**	-	-	-	-
	TM	*0.364*	*0.410*	*0.487*	*0.624*	*0.737*	*0.910*	*1.200*	*1.786*	*3.553*	-	-	-	-
21°	PM	**0.754**	**0.790**	**0.823**	**0.854**	**0.868**	**0.883**	**0.897**	**0.910**	**0.924**	-	-	-	-
	TM	*0.372*	*0.420*	*0.501*	*0.647*	*0.769*	*0.959*	*1.287*	*1.986*	*4.444*	-	-	-	-
22°	PM	**0.750**	**0.787**	**0.820**	**0.851**	**0.865**	**0.880**	**0.894**	**0.908**	**0.921**	-	-	-	-
	TM	*0.380*	*0.430*	*0.516*	*0.672*	*0.804*	*1.014*	*1.388*	*2.237*	*5.930*	-	-	-	-
23°	PM	**0.747**	**0.783**	**0.817**	**0.848**	**0.862**	**0.877**	**0.891**	**0.905**	**0.919**	-	-	-	-
	TM	*0.388*	*0.441*	*0.531*	*0.698*	*0.842*	*1.075*	*1.506*	*2.559*	*8.902*	-	-	-	-
24°	PM	**0.743**	**0.780**	**0.813**	**0.845**	**0.860**	**0.874**	**0.888**	**0.902**	**0.916**	-	-	-	-
	TM	*0.397*	*0.452*	*0.547*	*0.726*	*0.884*	*1.144*	*1.645*	*2.989*	*17.820*	-	-	-	-
25°	PM	**0.739**	**0.776**	**0.810**	**0.842**	**0.857**	**0.871**	**0.885**	**0.899**	-	-	-	-	-
	TM	*0.406*	*0.464*	*0.565*	*0.757*	*0.930*	*1.223*	*1.812*	*3.591*	-	-	-	-	-
26°	PM	**0.735**	**0.773**	**0.807**	**0.839**	**0.854**	**0.868**	**0.883**	**0.897**	-	-	-	-	-
	TM	*0.415*	*0.476*	*0.583*	*0.791*	*0.982*	*1.313*	*2.017*	*4.496*	-	-	-	-	-
27°	PM	**0.731**	**0.769**	**0.804**	**0.836**	**0.851**	**0.865**	**0.880**	**0.894**	-	-	-	-	-
	TM	*0.425*	*0.489*	*0.603*	*0.827*	*1.039*	*1.416*	*2.273*	*6.003*	-	-	-	-	-
28°	PM	**0.727**	**0.765**	**0.800**	**0.832**	**0.848**	**0.862**	**0.877**	**0.891**	-	-	-	-	-
	TM	*0.436*	*0.503*	*0.624*	*0.867*	*1.102*	*1.538*	*2.603*	*9.019*	-	-	-	-	-
29°	PM	**0.722**	**0.762**	**0.797**	**0.829**	**0.845**	**0.860**	**0.874**	**0.888**	-	-	-	-	-
	TM	*0.446*	*0.517*	*0.646*	*0.911*	*1.174*	*1.681*	*3.043*	*18.068*	-	-	-	-	-
30°	PM	**0.718**	**0.758**	**0.794**	**0.826**	**0.842**	**0.857**	**0.871**	-	-	-	-	-	-
	TM	*0.458*	*0.533*	*0.670*	*0.960*	*1.256*	*1.854*	*3.659*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements

Table A6.19. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 19°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 19° — TAG ANGLE, α_T 10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	**PM**	**0.817**	**0.849**	**0.879**	**0.908**	**0.923**	**0.937**	**0.951**	**0.965**	**0.980**	**0.994**	**1.009**	**1.024**	**1.039**
	TM	*0.275*	*0.300*	*0.337*	*0.395*	*0.436*	*0.488*	*0.557*	*0.651*	*0.787*	*0.997*	*1.361*	*2.134*	*4.852*
2°	**PM**	**0.814**	**0.846**	**0.876**	**0.906**	**0.920**	**0.934**	**0.948**	**0.963**	**0.977**	**0.991**	**1.006**	**1.021**	**1.036**
	TM	*0.279*	*0.304*	*0.343*	*0.403*	*0.446*	*0.500*	*0.573*	*0.674*	*0.820*	*1.051*	*1.462*	*2.395*	*6.453*
3°	**PM**	**0.811**	**0.843**	**0.873**	**0.903**	**0.917**	**0.931**	**0.946**	**0.960**	**0.974**	**0.988**	**1.003**	**1.018**	**1.033**
	TM	*0.283*	*0.309*	*0.349*	*0.412*	*0.456*	*0.514*	*0.591*	*0.698*	*0.856*	*1.111*	*1.581*	*2.731*	*9.656*
4°	**PM**	**0.807**	**0.840**	**0.870**	**0.900**	**0.914**	**0.928**	**0.943**	**0.957**	**0.971**	**0.985**	**1.000**	**1.015**	**1.030**
	TM	*0.287*	*0.314*	*0.356*	*0.421*	*0.467*	*0.528*	*0.609*	*0.724*	*0.896*	*1.178*	*1.722*	*3.180*	*19.268*
5°	**PM**	**0.804**	**0.837**	**0.867**	**0.897**	**0.911**	**0.926**	**0.940**	**0.954**	**0.968**	**0.983**	**0.997**	**1.012**	-
	TM	*0.292*	*0.319*	*0.363*	*0.430*	*0.479*	*0.542*	*0.629*	*0.752*	*0.940*	*1.255*	*1.891*	*3.808*	-
6°	**PM**	**0.801**	**0.833**	**0.864**	**0.894**	**0.908**	**0.923**	**0.937**	**0.951**	**0.965**	**0.980**	**0.994**	**1.009**	-
	TM	*0.296*	*0.325*	*0.370*	*0.440*	*0.491*	*0.558*	*0.650*	*0.783*	*0.988*	*1.343*	*2.098*	*4.752*	-
7°	**PM**	**0.797**	**0.830**	**0.861**	**0.891**	**0.906**	**0.920**	**0.934**	**0.948**	**0.963**	**0.977**	**0.991**	**1.006**	-
	TM	*0.301*	*0.331*	*0.377*	*0.450*	*0.504*	*0.575*	*0.673*	*0.817*	*1.042*	*1.445*	*2.357*	*6.325*	-
8°	**PM**	**0.794**	**0.827**	**0.858**	**0.888**	**0.903**	**0.917**	**0.931**	**0.946**	**0.960**	**0.974**	**0.988**	**1.003**	-
	TM	*0.306*	*0.336*	*0.384*	*0.461*	*0.517*	*0.593*	*0.698*	*0.853*	*1.102*	*1.563*	*2.689*	*9.471*	-
9°	**PM**	**0.790**	**0.824**	**0.855**	**0.885**	**0.900**	**0.914**	**0.928**	**0.943**	**0.957**	**0.971**	**0.985**	**1.000**	-
	TM	*0.311*	*0.342*	*0.392*	*0.473*	*0.532*	*0.612*	*0.725*	*0.893*	*1.170*	*1.704*	*3.134*	*18.913*	-
10°	**PM**	**0.787**	**0.821**	**0.852**	**0.882**	**0.897**	**0.911**	**0.926**	**0.940**	**0.954**	**0.968**	**0.983**	-	-
	TM	*0.316*	*0.349*	*0.401*	*0.485*	*0.547*	*0.632*	*0.754*	*0.938*	*1.248*	*1.872*	*3.756*	-	-
11°	**PM**	**0.783**	**0.817**	**0.849**	**0.879**	**0.894**	**0.908**	**0.923**	**0.937**	**0.951**	**0.965**	**0.980**	-	-
	TM	*0.321*	*0.355*	*0.409*	*0.498*	*0.564*	*0.654*	*0.785*	*0.987*	*1.336*	*2.079*	*4.690*	-	-
12°	**PM**	**0.780**	**0.814**	**0.846**	**0.876**	**0.891**	**0.906**	**0.920**	**0.934**	**0.948**	**0.963**	**0.977**	-	-
	TM	*0.327*	*0.362*	*0.419*	*0.511*	*0.581*	*0.678*	*0.819*	*1.041*	*1.438*	*2.337*	*6.247*	-	-
13°	**PM**	**0.776**	**0.811**	**0.843**	**0.873**	**0.888**	**0.903**	**0.917**	**0.931**	**0.946**	**0.960**	**0.974**	-	-
	TM	*0.333*	*0.369*	*0.428*	*0.525*	*0.600*	*0.703*	*0.856*	*1.102*	*1.557*	*2.669*	*9.363*	-	-
14°	**PM**	**0.772**	**0.807**	**0.840**	**0.870**	**0.885**	**0.900**	**0.914**	**0.928**	**0.943**	**0.957**	**0.971**	-	-
	TM	*0.339*	*0.377*	*0.438*	*0.541*	*0.620*	*0.731*	*0.897*	*1.171*	*1.698*	*3.112*	*18.712*	-	-
15°	**PM**	**0.769**	**0.804**	**0.837**	**0.867**	**0.882**	**0.897**	**0.911**	**0.926**	**0.940**	**0.954**	-	-	-
	TM	*0.345*	*0.384*	*0.449*	*0.557*	*0.641*	*0.760*	*0.943*	*1.249*	*1.868*	*3.733*	-	-	-
16°	**PM**	**0.765**	**0.801**	**0.833**	**0.864**	**0.879**	**0.894**	**0.908**	**0.923**	**0.937**	**0.951**	-	-	-
	TM	*0.351*	*0.392*	*0.460*	*0.574*	*0.663*	*0.793*	*0.993*	*1.339*	*2.075*	*4.665*	-	-	-
17°	**PM**	**0.761**	**0.797**	**0.830**	**0.861**	**0.876**	**0.891**	**0.906**	**0.920**	**0.934**	**0.948**	-	-	-
	TM	*0.358*	*0.401*	*0.471*	*0.592*	*0.688*	*0.828*	*1.048*	*1.442*	*2.335*	*6.219*	-	-	-
18°	**PM**	**0.758**	**0.794**	**0.827**	**0.858**	**0.873**	**0.888**	**0.903**	**0.917**	**0.931**	**0.946**	-	-	-
	TM	*0.365*	*0.410*	*0.483*	*0.611*	*0.714*	*0.866*	*1.111*	*1.563*	*2.669*	*9.327*	-	-	-
19°	**PM**	**0.754**	**0.790**	**0.824**	**0.855**	**0.870**	**0.885**	**0.900**	**0.914**	**0.928**	**0.943**	-	-	-
	TM	*0.372*	*0.419*	*0.496*	*0.632*	*0.743*	*0.908*	*1.181*	*1.706*	*3.115*	*18.655*	-	-	-
20°	**PM**	**0.750**	**0.787**	**0.821**	**0.852**	**0.867**	**0.882**	**0.897**	**0.911**	**0.926**	-	-	-	-
	TM	*0.380*	*0.429*	*0.510*	*0.654*	*0.773*	*0.955*	*1.261*	*1.878*	*3.739*	-	-	-	-
21°	**PM**	**0.746**	**0.783**	**0.817**	**0.849**	**0.864**	**0.879**	**0.894**	**0.908**	**0.923**	-	-	-	-
	TM	*0.388*	*0.439*	*0.524*	*0.678*	*0.807*	*1.006*	*1.352*	*2.088*	*4.676*	-	-	-	-
22°	**PM**	**0.742**	**0.780**	**0.814**	**0.846**	**0.861**	**0.876**	**0.891**	**0.906**	**0.920**	-	-	-	-
	TM	*0.396*	*0.449*	*0.539*	*0.704*	*0.843*	*1.064*	*1.458*	*2.351*	*6.238*	-	-	-	-
23°	**PM**	**0.738**	**0.776**	**0.811**	**0.843**	**0.858**	**0.873**	**0.888**	**0.903**	**0.917**	-	-	-	-
	TM	*0.405*	*0.460*	*0.555*	*0.731*	*0.883*	*1.128*	*1.581*	*2.689*	*9.363*	-	-	-	-
24°	**PM**	**0.734**	**0.772**	**0.807**	**0.840**	**0.855**	**0.870**	**0.885**	**0.900**	**0.914**	-	-	-	-
	TM	*0.413*	*0.472*	*0.572*	*0.761*	*0.927*	*1.200*	*1.727*	*3.141*	*18.740*	-	-	-	-
25°	**PM**	**0.730**	**0.769**	**0.804**	**0.837**	**0.852**	**0.867**	**0.882**	**0.897**	-	-	-	-	-
	TM	*0.423*	*0.484*	*0.590*	*0.793*	*0.975*	*1.283*	*1.903*	*3.773*	-	-	-	-	-
26°	**PM**	**0.726**	**0.765**	**0.801**	**0.833**	**0.849**	**0.864**	**0.879**	**0.894**	-	-	-	-	-
	TM	*0.433*	*0.497*	*0.609*	*0.828*	*1.029*	*1.377*	*2.117*	*4.723*	-	-	-	-	-
27°	**PM**	**0.722**	**0.761**	**0.797**	**0.830**	**0.846**	**0.861**	**0.876**	**0.891**	-	-	-	-	-
	TM	*0.443*	*0.510*	*0.630*	*0.866*	*1.088*	*1.485*	*2.386*	*6.305*	-	-	-	-	-
28°	**PM**	**0.718**	**0.758**	**0.794**	**0.827**	**0.843**	**0.858**	**0.873**	**0.888**	-	-	-	-	-
	TM	*0.453*	*0.525*	*0.652*	*0.908*	*1.155*	*1.612*	*2.731*	*9.471*	-	-	-	-	-
29°	**PM**	**0.713**	**0.754**	**0.790**	**0.824**	**0.840**	**0.855**	**0.870**	**0.885**	-	-	-	-	-
	TM	*0.464*	*0.539*	*0.675*	*0.954*	*1.230*	*1.762*	*3.192*	*18.972*	-	-	-	-	-
30°	**PM**	**0.709**	**0.750**	**0.787**	**0.821**	**0.837**	**0.852**	**0.867**	-	-	-	-	-	-
	TM	*0.476*	*0.555*	*0.700*	*1.004*	*1.315*	*1.943*	*3.838*	-	-	-	-	-	-

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Table A6.20. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 20°

		LOAD POSITION ANGLE, Θ = 20°												
TAG POS. ANGLE, θ_T	LINE MULT.	TAG ANGLE, α_T												
		10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.812**	**0.845**	**0.876**	**0.907**	**0.922**	**0.937**	**0.952**	**0.967**	**0.982**	**0.997**	**1.012**	**1.028**	**1.044**
	TM	*0.287*	*0.313*	*0.353*	*0.414*	*0.457*	*0.512*	*0.585*	*0.685*	*0.829*	*1.051*	*1.435*	*2.251*	*5.124*
2°	PM	**0.808**	**0.842**	**0.873**	**0.904**	**0.919**	**0.934**	**0.949**	**0.964**	**0.979**	**0.994**	**1.009**	**1.025**	**1.041**
	TM	*0.291*	*0.318*	*0.359*	*0.423*	*0.467*	*0.525*	*0.602*	*0.709*	*0.863*	*1.107*	*1.542*	*2.527*	*6.813*
3°	PM	**0.805**	**0.838**	**0.870**	**0.901**	**0.916**	**0.931**	**0.946**	**0.961**	**0.976**	**0.991**	**1.006**	**1.022**	**1.038**
	TM	*0.295*	*0.323*	*0.366*	*0.432*	*0.478*	*0.539*	*0.621*	*0.734*	*0.901*	*1.170*	*1.667*	*2.881*	*10.194*
4°	PM	**0.802**	**0.835**	**0.867**	**0.898**	**0.913**	**0.928**	**0.943**	**0.958**	**0.973**	**0.988**	**1.003**	**1.019**	**1.035**
	TM	*0.300*	*0.328*	*0.372*	*0.441*	*0.490*	*0.554*	*0.640*	*0.761*	*0.943*	*1.241*	*1.815*	*3.353*	*20.336*
5°	PM	**0.798**	**0.832**	**0.864**	**0.895**	**0.910**	**0.925**	**0.940**	**0.955**	**0.970**	**0.985**	**1.000**	**1.016**	**-**
	TM	*0.304*	*0.334*	*0.379*	*0.451*	*0.502*	*0.569*	*0.661*	*0.791*	*0.989*	*1.321*	*1.992*	*4.016*	*-*
6°	PM	**0.795**	**0.829**	**0.861**	**0.892**	**0.907**	**0.922**	**0.937**	**0.952**	**0.967**	**0.982**	**0.997**	**1.012**	**-**
	TM	*0.309*	*0.339*	*0.387*	*0.461*	*0.515*	*0.586*	*0.683*	*0.823*	*1.039*	*1.414*	*2.210*	*5.010*	*-*
7°	PM	**0.791**	**0.825**	**0.858**	**0.889**	**0.904**	**0.919**	**0.934**	**0.949**	**0.964**	**0.979**	**0.994**	**1.009**	**-**
	TM	*0.313*	*0.345*	*0.394*	*0.472*	*0.528*	*0.603*	*0.707*	*0.858*	*1.096*	*1.520*	*2.482*	*6.667*	*-*
8°	PM	**0.787**	**0.822**	**0.854**	**0.886**	**0.901**	**0.916**	**0.931**	**0.946**	**0.961**	**0.976**	**0.991**	**1.006**	**-**
	TM	*0.318*	*0.351*	*0.402*	*0.483*	*0.542*	*0.622*	*0.733*	*0.896*	*1.159*	*1.645*	*2.832*	*9.982*	*-*
9°	PM	**0.784**	**0.819**	**0.851**	**0.882**	**0.898**	**0.913**	**0.928**	**0.943**	**0.958**	**0.973**	**0.988**	**1.003**	**-**
	TM	*0.324*	*0.357*	*0.410*	*0.495*	*0.558*	*0.642*	*0.761*	*0.938*	*1.230*	*1.792*	*3.300*	*19.930*	*-*
10°	PM	**0.780**	**0.815**	**0.848**	**0.879**	**0.895**	**0.910**	**0.925**	**0.940**	**0.955**	**0.970**	**0.985**	**-**	**-**
	TM	*0.329*	*0.364*	*0.419*	*0.508*	*0.574*	*0.663*	*0.791*	*0.985*	*1.311*	*1.970*	*3.954*	*-*	*-*
11°	PM	**0.777**	**0.812**	**0.845**	**0.876**	**0.892**	**0.907**	**0.922**	**0.937**	**0.952**	**0.967**	**0.982**	**-**	**-**
	TM	*0.335*	*0.371*	*0.428*	*0.521*	*0.591*	*0.686*	*0.824*	*1.036*	*1.404*	*2.186*	*4.937*	*-*	*-*
12°	PM	**0.773**	**0.808**	**0.842**	**0.873**	**0.889**	**0.904**	**0.919**	**0.934**	**0.949**	**0.964**	**0.979**	**-**	**-**
	TM	*0.340*	*0.378*	*0.437*	*0.535*	*0.609*	*0.711*	*0.859*	*1.093*	*1.511*	*2.458*	*6.575*	*-*	*-*
13°	PM	**0.769**	**0.805**	**0.838**	**0.870**	**0.886**	**0.901**	**0.916**	**0.931**	**0.946**	**0.961**	**0.976**	**-**	**-**
	TM	*0.346*	*0.385*	*0.447*	*0.550*	*0.628*	*0.737*	*0.898*	*1.157*	*1.636*	*2.806*	*9.853*	*-*	*-*
14°	PM	**0.765**	**0.802**	**0.835**	**0.867**	**0.882**	**0.898**	**0.913**	**0.928**	**0.943**	**0.958**	**0.973**	**-**	**-**
	TM	*0.352*	*0.393*	*0.458*	*0.566*	*0.649*	*0.766*	*0.941*	*1.230*	*1.784*	*3.272*	*19.687*	*-*	*-*
15°	PM	**0.762**	**0.798**	**0.832**	**0.864**	**0.879**	**0.895**	**0.910**	**0.925**	**0.940**	**0.955**	**-**	**-**	**-**
	TM	*0.359*	*0.401*	*0.469*	*0.583*	*0.671*	*0.797*	*0.989*	*1.311*	*1.962*	*3.924*	*-*	*-*	*-*
16°	PM	**0.758**	**0.795**	**0.829**	**0.861**	**0.876**	**0.892**	**0.907**	**0.922**	**0.937**	**0.952**	**-**	**-**	**-**
	TM	*0.365*	*0.409*	*0.480*	*0.600*	*0.695*	*0.831*	*1.041*	*1.405*	*2.180*	*4.903*	*-*	*-*	*-*
17°	PM	**0.754**	**0.791**	**0.825**	**0.858**	**0.873**	**0.889**	**0.904**	**0.919**	**0.934**	**0.949**	**-**	**-**	**-**
	TM	*0.372*	*0.418*	*0.492*	*0.619*	*0.720*	*0.867*	*1.099*	*1.513*	*2.452*	*6.535*	*-*	*-*	*-*
18°	PM	**0.750**	**0.787**	**0.822**	**0.854**	**0.870**	**0.886**	**0.901**	**0.916**	**0.931**	**0.946**	**-**	**-**	**-**
	TM	*0.380*	*0.427*	*0.505*	*0.639*	*0.748*	*0.907*	*1.164*	*1.640*	*2.802*	*9.800*	*-*	*-*	*-*
19°	PM	**0.746**	**0.784**	**0.819**	**0.851**	**0.867**	**0.882**	**0.898**	**0.913**	**0.928**	**0.943**	**-**	**-**	**-**
	TM	*0.387*	*0.437*	*0.518*	*0.661*	*0.777*	*0.951*	*1.238*	*1.790*	*3.270*	*19.597*	*-*	*-*	*-*
20°	PM	**0.742**	**0.780**	**0.815**	**0.848**	**0.864**	**0.879**	**0.895**	**0.910**	**0.925**	**-**	**-**	**-**	**-**
	TM	*0.395*	*0.446*	*0.532*	*0.684*	*0.809*	*1.000*	*1.321*	*1.970*	*3.924*	*-*	*-*	*-*	*-*
21°	PM	**0.738**	**0.777**	**0.812**	**0.845**	**0.861**	**0.876**	**0.892**	**0.907**	**0.922**	**-**	**-**	**-**	**-**
	TM	*0.403*	*0.457*	*0.547*	*0.709*	*0.844*	*1.054*	*1.417*	*2.190*	*4.907*	*-*	*-*	*-*	*-*
22°	PM	**0.734**	**0.773**	**0.808**	**0.842**	**0.858**	**0.873**	**0.889**	**0.904**	**0.919**	**-**	**-**	**-**	**-**
	TM	*0.412*	*0.468*	*0.563*	*0.735*	*0.882*	*1.114*	*1.527*	*2.465*	*6.545*	*-*	*-*	*-*	*-*
23°	PM	**0.730**	**0.769**	**0.805**	**0.838**	**0.854**	**0.870**	**0.886**	**0.901**	**0.916**	**-**	**-**	**-**	**-**
	TM	*0.420*	*0.479*	*0.579*	*0.764*	*0.924*	*1.181*	*1.656*	*2.819*	*9.823*	*-*	*-*	*-*	*-*
24°	PM	**0.726**	**0.765**	**0.802**	**0.835**	**0.851**	**0.867**	**0.882**	**0.898**	**0.913**	**-**	**-**	**-**	**-**
	TM	*0.430*	*0.491*	*0.597*	*0.795*	*0.969*	*1.256*	*1.809*	*3.292*	*19.657*	*-*	*-*	*-*	*-*
25°	PM	**0.722**	**0.762**	**0.798**	**0.832**	**0.848**	**0.864**	**0.879**	**0.895**	**-**	**-**	**-**	**-**	**-**
	TM	*0.439*	*0.504*	*0.616*	*0.828*	*1.020*	*1.342*	*1.992*	*3.954*	*-*	*-*	*-*	*-*	*-*
26°	PM	**0.718**	**0.758**	**0.795**	**0.829**	**0.845**	**0.861**	**0.876**	**0.892**	**-**	**-**	**-**	**-**	**-**
	TM	*0.449*	*0.517*	*0.635*	*0.865*	*1.075*	*1.440*	*2.217*	*4.948*	*-*	*-*	*-*	*-*	*-*
27°	PM	**0.713**	**0.754**	**0.791**	**0.825**	**0.842**	**0.858**	**0.873**	**0.889**	**-**	**-**	**-**	**-**	**-**
	TM	*0.460*	*0.531*	*0.657*	*0.905*	*1.137*	*1.554*	*2.497*	*6.605*	*-*	*-*	*-*	*-*	*-*
28°	PM	**0.709**	**0.750**	**0.787**	**0.822**	**0.838**	**0.854**	**0.870**	**0.886**	**-**	**-**	**-**	**-**	**-**
	TM	*0.471*	*0.546*	*0.679*	*0.948*	*1.207*	*1.686*	*2.859*	*9.921*	*-*	*-*	*-*	*-*	*-*
29°	PM	**0.705**	**0.746**	**0.784**	**0.819**	**0.835**	**0.851**	**0.867**	**0.882**	**-**	**-**	**-**	**-**	**-**
	TM	*0.482*	*0.561*	*0.703*	*0.996*	*1.285*	*1.843*	*3.341*	*19.869*	*-*	*-*	*-*	*-*	*-*
30°	PM	**0.700**	**0.742**	**0.780**	**0.815**	**0.832**	**0.848**	**0.864**	**-**	**-**	**-**	**-**	**-**	**-**
	TM	*0.494*	*0.577*	*0.729*	*1.048*	*1.374*	*2.031*	*4.016*	*-*	*-*	*-*	*-*	*-*	*-*

NOTES:

1) When possible, lift operations should employ tag line multipliers less than 1.0.
2) Caution should be excercised for lift operations involving load line multipliers between 1.0 - 2.0.
3) All lift operations involving tag line multipliers exceeding 2.0 for dedicated trolley tag applications should be considered "special" due to the potential excessive load multipliers and involve communication with a qualified engineer as deemed necessary by a qualified person to ensure the structure and selected attachment point(s) may safely support the resulting rigging forces.

Cordage Institute
International Guideline

CI 2001-04

Fiber Rope
Inspection and Retirement Criteria

The Guideline that can Provide Enhanced Fiber Rope Durability and Important Information for the Safer Use of Fiber Rope

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Cordage Institute

International Guideline

CI 2001-04
First Edition

FIBER ROPE INSPECTION AND RETIREMENT CRITERIA

Guidelines to enhance durability and the safer use of fiber rope

⚠ WARNING

The use of rope and cordage products has inherent safety risks which are subject to highly variable conditions and which may change over time. Compliance with standards and guidelines of the Cordage Institute does not guarantee safe use under all circumstances, and the Institute disclaims any responsibility for accidents which may occur. If the user has any questions or uncertainties about the proper use of rope or cordage or about safe practices, consult a professional engineer or other qualified individual.

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1. INTRODUCTION

1.1 Purpose

Careful and frequent inspection of fiber rope, using procedures contained in this document, reflects prudent safety management required to protect personnel and property. This Guideline provides information and procedures to inspect ropes and to establish criteria for evaluation. This document provides inspectors with help to make reasonable decisions regarding retirement or continued use, including repairing or downgrading.

1.2 Basis for Inspection and Retirement

1.2.1 Fiber ropes are employed in a large variety of applications that differ greatly in the severity of use. In some applications, ropes can serve for many years. In more severe applications or under different conditions, the same rope may degrade rapidly. Also, ropes of different size, construction or material can show substantial differences in longevity in the same application. For each specific fiber rope application the user must establish a basis for retirement that considers conditions of use, experience with the application and the degree of risk present. See Section 4.4.

1.2.2 An inspector should always act conservatively when evaluating a rope and making recommendations for further use. Residual strength in a used rope can only be estimated and destructive test methods are required to be definitive. The visual or tactile methods described herein can only provide an estimate of rope condition.

1.2.3 Ropes that have been properly selected and used may be kept in service with some wear if inspected and evaluated in accordance with these guidelines.

1.2.4 This document provides guidance for situations where extensive usage history, documentation, inspection facilities and testing laboratories are available; however, this is most frequently not the case. Less comprehensive inspections are very worthwhile and should be carried out. Actions that are considered minimal are marked ◆.

1.3 Rope Materials and Construction

1.3.1 The ropes covered by these Guidelines are made from synthetic fibers suitable for use in rope or from natural (organic) fibers. For descriptions and performance data for synthetic fibers commonly used in rope refer to Ref. 1, CI 2003 "Fiber Properties".

1.3.2 Rope constructions include the following:

- 3 and 4 strand laid rope - Figure 1 (3 strand only shown)
- 8-strand plaited - Figure 2
- 8 and 12 strand single braid - Figure 3 (12 strand only shown)
- Double braid - Figure 4
- Wirelay - Figure 5
- Jacketed Industrial and Marine Ropes - Figure 6 (braided jacket construction is shown)
- Kernmantle (jacketed) Ropes - Figure 7 (rescue, climbing, rapelling)

1.3.3 This guideline may apply to ropes of other materials and constructions; however, the inspector should seek advice from the rope manufacturer or other knowledgeable source regarding rope types not specifically identified herein.

1.4 Thimbles

1.4.1 Thimbles are an important part of many rope applications. They are used to protect the eye termination of spliced ropes and grommets and should be inspected if present. Figure 8 and 9 show thimbles which are often used on fiber rope.

1.5 Limitations

1.5.1 This guideline does not cover the selection of rope types and materials for specific applications, nor does it provide procedures for safe operation and use. Persons selecting rope must consider their own experience or consult qualified persons, rope standards, manuals, regulations, operating guidelines or the rope manufacturer for information on selection and use of fiber rope. See Appendix A for a partial list of reference publications regarding rope use.

1.6 Order of Precedence

1.6.1 In the event of conflict between the information in this guideline and other guidelines, standards or regulations, the user must determine the order of precedence. When in doubt consult with appropriate authorities.

2. REFERENCES AND RELATED PUBLICATIONS

2.1 References

The following Cordage Institute (CI) and other publications provide additional information about the properties, testing, care and safe use of fiber ropes:

1. **CI 2003:** Fiber Properties (Physical, Mechanical and Environmental) for Cable, Cordage, Rope and Twine
2. **CI 1202:** Terminology for Fiber Rope
3. **CI 1500**: Test Methods for Fiber Ropes. Provides the test methods to determine both the basic and the more advanced physical properties of fiber ropes.
4. **CIB-1.4**: Fiber Rope Technical Information Manual (Cordage Institute). Contains basic information for the selection, application and safe use of rope.
5. **CIE-1:** Splicing Handbook, Second Edition, Barbara Merry. (Available from the Cordage Institute.)

2.2 Related Documents

See Appendix A for a list of other rope related publications that may be a useful supplement to this guideline.

3. TERMINOLOGY

3.1 Terms specific to this document.

Qualified person**:** A person who, by possession of a recognized degree or certificate of professional standing, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

Working load limit (WLL)**:** The working load that must not be exceeded for a particular application as established by a regulatory or standards setting agency. The WLL is calculated by dividing the new rope minimum break strength by a design factor. Absent any official publication of a WLL for an application, design factors should be established by a qualified person. Design factors for rope commonly vary between 5 and 12.

Visual inspection**:** Examination of the exterior or interior of a rope by visual methods, which may include magnification.

Tactile inspection**:** Manipulation of the rope by hand or other means to determine hardness and flexibility.

Overloading: Exceeding the WLL by 2 or more times or loading a rope to excess of 50% of its published breaking strength.

Shock loading: A sudden application of force at such a rate of speed that the rope can be seen to react violently. The dynamic effects can be estimated to be well in excess of the WLL. Arresting a falling weight is the most common example.

3.2 Other terms and definitions.

Other definitions for terms used in this Guideline may be found in Ref. 2, CI 1202, “Terminology for Fiber Rope”.

4. INSPECTION AND RETIREMENT PROGRAM

4.1 General

The following sections present the requirements for an effective inspection and retirement program.

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.

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.

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

4.2 Training

4.2.1 ◆ Personnel assigned the responsibility for rope inspections should be properly trained to recognize rope damage and to understand the rope inspection procedures and retirement criteria contained in this guideline. The Cordage Institute can provide information on training resources.

4.3 Log and Record Keeping

4.3.1 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. Typical logs are shown in Appendix B.

4.4 User Established Retirement Criteria

The user is responsible for inspecting and making decisions on the disposition of used rope, based on user established retirement criteria. Refer to Appendix C and the following key points.

4.4.1 User experience with the application shall be considered when preparing retirement criteria.

4.4.2 Any relevant regulatory standards and guides should be reviewed and the relevant requirements incorporated into the program

4.4.3 Examples of sources are:
American National Standards Institute (ANSI)
Occupational Safety and Health Administration (OSHA)
Code of Federal Regulations (CFR**)**

5. USED ROPE INSPECTION AND EVALUATION

5.1 Introduction

5.1.1 ◆ During the inspection, identify the rope specimen by a dated tag with separate designation codes for each specimen.

5.1.2 ◆ The inspector determines the disposition of each rope by comparing results of the evaluation to the user defined retirement criteria.

5.1.3 Complete used rope evaluation includes familiarization with rope history, visual and tactile inspection, and supplemental testing if necessary. A general knowledge of the usage history of the rope can aid the inspection process by identifying potential types or locations of damage. Supplemental testing may be necessary when more quantitative assessments are required; these may include destructive strength tests, microscopic examination or chemical analysis.

5.2 Review of Records and History

5.2.1 Ascertain the type and size of the rope and obtain the specifications for strength if possible.

5.2.2 ◆ Determine the conditions of use by witnessing the operation or by interviewing personnel.

5.2.3 ◆ Identify and quantify, if possible, unusual events that may have damaged the rope; such as, overloading, impact loading, long duration of sustained loading, sunlight or chemical exposure, and heat exposure.

5.2.4 Determine the time in service.

5.2.5 ◆ If a rope log is available, examine it for rope identification, specifications and history. Try to verify that the data matches the specimen.

5.3 Inspection Process

5.3.1 Prepare Inspection Record Sheets or make entries in a log (refer to Section 4.3). Fill-in known rope information, such as: type, diameter/circumference, fiber material, length, manufacturer, length and type of service. Add name of the inspector, date and location.

5.3.2 Photograph the rope if appropriate.

5.3.3 ◆ Lay out the rope in a straight line, on a smooth surface, under hand tension. Attempt to apply enough tension to straighten the rope (in increments if space is limited). Small diameter ropes may be inspected by pulling segments hand-over-hand. For long lengths of larger ropes, it is best to utilize a mechanical advantage to apply light tension on the rope while it is being inspected.

5.3.4 If a rope is long, it may be marked and coded in evenly spaced intervals. For easier identification, mark each fifth and tenth length interval more strongly. If the rope is very dirty, intervals could be marked by using knotted twine pieces passed through the rope. Tape is also appropriate if wrapped completely around the rope

5.3.5 ◆ Visually examine, stepwise, the entire rope length for detectable damage and deterioration; include eye splices and/or end-to-end splices [long or short]. Record all findings; identify end-to-end location of detectable damage areas.

5.3.6 ◆ Sight the rope down its length as you would a plank or mast. Inspect for high or low strands and randomly uneven cross sections. Look for twist in braided and plaited ropes, and corkscrewing in stranded ropes.

5.3.7 ◆ For ropes small enough for a tactile inspection, feel for unevenness, rough spots and stiff (lacking flexibility) sections.

5.3.8 Measure the rope circumference. Determine the circumference in a number of places, in particular in any damaged areas. This is most easily done with a thin whipping twine, thin metal or fabric tape measure or a pi-tape, wrapped around the rope with slight hand tension. Make note of nominal circumference, and any point on the rope where the circumference varies more than 10 percent from what is found on most of the rope. Ropes may decrease in circumference if well used and may be less than specified for new ropes.

5.3.9 Look for variations in the lay length (in a twisted rope) or pick length (in a braided or plaited rope). Apply a small tension to the rope and check this length at various locations along the rope. Note any appreciable deviations in lay or pick length. This length should not vary by more than ± 5 percent over the rope length. On long specimens, the tension must be high enough to minimize the effects of friction with the ground

5.3.10 ◆ Examine the rope for abrasion, cuts, broken yarns. Make a note of the type, location and level of damage such as, number of broken or noticeably damaged yarns, depth and length of abrasion or wear spots, frequency and spacing of damage, if damage is one strand or multiple strands. Estimate the loss of strength by comparing abraded or cut fibers as a percentage of the rope diameter or strand diameter. Lengthwise damage of several adjacent strands should be summed the same as if it were around the circumference.

5.3.11 Check any broken rope specimens in detail. A meaningful inspection must include both ends of a broken rope. Note location and nature of break. If possible, identify the conditions that caused the damage, such as rough hardware surfaces, points of contact, excessively sharp bends, or introduction of twist from winching practices.

5.3.12 ◆ Open the rope and examine the interior. Turn twisted rope slightly to open the interior for observation. Push on single braided or plaited ropes and/or use a fid to open the interior to view. On double braided ropes, push on the rope and use a fid to open a small hole to view the core. Be careful not to pull strands excessively. Look for broken filaments, fuzzy areas, kink bands.

5.3.13 ◆ Check braided ropes for hardness. Pushing on the rope should cause the braids to open. Braided ropes should be supple and bend easily. They should flatten slightly when compressed laterally

5.3.14 ◆ Check Kernmantle, jacketed ropes or double braids for core breaks. This is manifested by sudden reduction in diameter and can be felt by running hands over the rope.

5.4 Destructive Testing

5.4.1 For more definitive estimate of residual strength, a portion of the rope or its components (yarns or strands) can be removed and tested for residual strength. For used ropes from the same or similar applications, periodic destructive testing for strength and elongation can provide important data for purposes of evaluation. Samples from the actual rope or its components can be tested to provide comparative data. Testing may use the procedures of Ref. 3, CI 1500, “Test Methods for Fiber Rope”. Used rope and rope component testing and evaluation should be directed by a qualified person.

6. TYPES AND EFFECTS OF DAMAGE

Appendix C provides evaluation guidance for the various types of damage. The applicable section letter in this appendix is shown in brackets [ ] after the title.

6.1 Introduction [A]

Knowing the causes and appearance of damage is essential to a good rope inspection and essential in determining retirement criteria. This section describes the most common causes of rope damage and describes the effects. Appendix D contains pictures or diagrams illustrating these conditions.

Smaller ropes, due to their reduced bulk, suffer a proportionately larger loss of strength than larger ropes due to cuts, abrasion, and environmental exposure. Extra attention is recommended when inspecting small diameter ropes.

6.2 Excessive Tension / Shock Loading [B]

6.2.1 Overloading or shock loading a rope above a reasonable working load limit can cause significant loss of strength and/or durability. However, the damage may not be detectable by visual or tactile inspection. The usage history of a rope is the best method to determine if excessive tension or shock loading has occurred. Overloading and shock loading are difficult to define and the inspector must take a conservative approach when reviewing the history of the rope. Repeated overloading will result in similar damage as that caused by cyclic fatigue as described in Section 6.3. Shock loading may cause internal melting of fiber.

6.3 Cyclic Tension Wear [C]

6.3.1 ◆ Ropes that are cycled for long periods of time within a normal working load range will gradually lose strength. This loss of strength is accelerated if the rope is unloaded to a slack condition or near zero tension between load cycles. The subsequent damage is commonly referred to as fatigue. Although there are various mechanisms for the breakdown of synthetic fibers under cyclic tension, the most common is fiber to fiber abrasion. See Figure D-001 where long term loading and unloading has caused a breakdown of yarns in the outer braid of a double braided rope (lower picture). This rope was also extremely hard due to internal compaction of broken fibers. Compare to the upper picture of relatively new rope which was soft and flexible.

6.3.2 ◆ Braided ropes develop many broken filaments at the crossover points of strands in the braid due to fiber-on-fiber abrasion. Occasionally, the broken ends of yarns may appear as if cut square (a magnifying glass may be necessary). These broken filaments give the rope a fuzzy appearance on the outside and over the entire length that was under load; this can be so extreme as to obscure the underlying braid structure. Figures D-002 shows extreme examples of braided ropes that exhibit excessive damage from frequent loading and unloading.

6.3.3 ◆ For braided ropes, broken filaments within the rope can also mat, entangle and/or leave a powdery residue. Extreme internal filament breakage will make the rope very hard, lose flexibility and be noticeably larger in diameter (with a subsequent reduction in length); it may be so hard that it is impossible to pry the rope open to examine the interior structure. Melted fiber and fusion may be observed in the core rope or between core and cover. See Figure D-003 for exposing the inside of the structure.

6.3.4 ◆ For 3 strand twisted and 8-strand plaited ropes most of the wear will occur on the inside of the rope where the strands rub on each other. Broken, matted filaments and a powdery residue may be observed. Figure D-004 shows how to expose the inside of the structure by pushing on the rope and possibly exposing one strand. For laid ropes, twist the rope in the opposite direction of the lay.

6.3.5 Wirelay and Kernmatle ropes usually have a non-load bearing jacket and must be examined under the jacket. Broken filaments, powdery residue or fusion may be observed if the interior can be examined.

6.4 External Abrasion [D]

6.4.1 ◆ Most external abrasion is localized. Gouges and strips along one side of the rope are common; these display cut fibers and are often accompanied by fusion. Damage sufficient to degrade the rope is usually obvious. More uniform abrasion may be seen in ropes that are used over fixed objects that bear along a considerable portion of its length, Figure D-005. Also, dragging over a rough surface will show uniform abrasion. External abrasion can be distinguished from cyclic fatigue since the interior of the rope will not have damage and the damage is rarely uniform as seen in Figures D-006, D-007 and D-008.

6.4.2 ◆ The surface of the rope may be melted and appear black due to sliding while bent over surfaces when under high tension. See Figure D-010.

6.4.3 ◆ Jacketed ropes require inspection of the outer sheath. The load bearing core should not be exposed. Loose strands that may snag could be a consideration in some cases.

6.5 Cutting [E}

6.5.1 ◆ It is obvious during visual inspection to see where fibers have been cut sufficiently to degrade a rope. Damage assessment includes an evaluation of the amount of affected fiber, and location and orientation of the cut. For multiple cuts, the space between damaged areas is important. Figure D-011.

6.5.2 For jacketed ropes where the jacket is non-load bearing, a cut that does not damage the core will probably not affect the strength. See Figure D-012. However, core deformation or herniation could occur on subsequent use if the cover is not repaired. Cores can shift relative to the jacket; further inspection in the vicinity of the jacket should be performed to ensure integrity of the core. Cuts to jackets may cause other adverse effects such as handling difficulties, inability to slide through fittings smoothly, and exposing the core to grit.

6.6 Pulled Strands and Yarns [F]

6.6.1 ◆ Strands and rope yarns can be snagged and pulled out of the rope structure. The level of damage is a function of the percentage of the rope cross section that has been lost. See Figures D-013, D-014 and D-015.

6.6.2 Pulled strands in braided rope appear as in Figures D-014 and D-015.

6.7 Flex Fatigue – Pulleys, Rollers, Chocks, Fairleads, Blocks [G]

6.7.1 Constant bending of any type of rope causes internal and external fiber abrasion. This is frequently caused by running on pulleys. But, other types of flexing such as frequent bending over a small radius surface, can also cause fatigue damage. Flexing over fixed surfaces is often accompanied by surface wear, especially if sliding action is also present. Wear will appear on the surface of the contact area. The fibers will become matted on the surface and/or glazed from heat build-up, especially with ropes using polypropylene fibers. Broken filaments and fusion, as noted under Section 6.2, will be found inside the rope over the bending zone but not elsewhere in the rope. Figure D-016.

6.8 Spliced Eyes and Other Terminations [H]

6.8.1 ◆ Check for a properly made eye and end-for-end splices; splices should always be based on manufacturer's instructions, Cordage Institute Guidelines (CI 2100 through 2102), or sources such as Reference 5, CIE-1. A long splice for end-for-end is about 80% efficient; consider this when establishing a WLL. A properly made 3-strand eye splice is shown in Figure D-017.

6.8.2 ◆ Damage is common at splices. See figures D-018, D-019, and D-020. This area always needs to be examined closely. Look for broken strands at the leg junction (See Figure D-12)., surface wear in the back (apex) of the eye, flattening where the rope bears on pins or bollards, slippage of tucks in stranded or twisted ropes and displacement of core/cover for braided rope with buried splices.

6.8.3 ◆ Eye splices used on small pins (less than one to two times the rope diameter) are likely to have internal and external damage. See Figure D-020.

6.8.4 ◆ Tucks in 3 ,8 strand and tucks in tuck splices in single braided may have slipped in the splice. The buried leg in single and double ropes may have slipped. Freshly exposed fiber in tucks or buried legs will look clean or have a slightly different appearance where it has pulled out of the body of the rope. See Figure D-018, an example of a poorly made splice.

6.8.5 Lock stitching should be used with bury splices on single braided rope. Check to see if they are present. They are often found on double braided ropes. In both cases, they should not be broken

6.8.6 Parallel fiber ropes and some parallel strand ropes require a continuous whipping function. Damage that allows the whipping to come loose can be dangerous.

6.8.7 The following should be noted when inspecting thimbles.

- ◆ Inspect for corrosion, cracks or sharp edges that indicate weakness or the potential to cut or abrade the rope.
- ◆ Check that the groove in the thimble for the rope is slightly larger (5%-15%) than the rope when there is little or no tension.

- ◆ Check security of thimbles in the eye of a rope. Fiber rope thimbles, Figure 8, have ears that prevent the eye from turning in the thimble or allowing the thimble to fall out. If wire rope thimbles are used, they should be tight in the eye or lashed to the legs of the eye to prevent turning or falling out. Adhesives have also been used successfully to secure rope in a thimble
- Figure 9 shows a different approach to fiber rope thimble design. The round spool and hood eliminate the problems of turning and falling out.
- Fiber rope thimbles designed for nylon, polyester or polypropylene ropes may not have sufficient strength if used with very high strength fiber ropes. Heavy duty wire rope thimbles are suitable for these ropes when the fiber rope and wire rope size are the same. If data is available, determine strength compatibility.
- Thimble rated load must always exceed the WLL for an application. Ideally, if the breaking strength of a thimble is known, it should exceed the rope strength.
- ◆ In some cases, a thimble should be used but is not and excessive wear has occurred in the back of the eye. Figure D-021, upper, shows the rope eye directly on a shackle without a thimble. The rope is bent over about the same diameter as the rope itself. This can give adequate strength when the rope is new or for very few loadings, but wear can be rapid in severe applications. Figure D-021, lower, shows a wire rope thimble in the same application.

6.8.8 Other Terminations

◆ Mechanical, potted or other types of terminations may be used with fiber ropes if it can be verified that they have been qualified for the particular service and installed strictly in accordance with instructions provided by the manufacturer. These must be examined carefully in accordance with the recommendations of the manufacturer or qualified person. Always inspect the interface for abrasion where the rope joins the fitting.

6.9 Knots [I]

6.9.1 Some ropes are intended to be used with knots; examples are: rescue, climbing and arborist ropes. These ropes should be inspected for wear in the rope as it enters or exits the knot. See Figure D-022

6.9.2 ◆ Unless the application is specifically designed to use knots, they must not be used unless the working load is reduced by an appropriate amount (base on 50% of published rope strength unless specific contrary data is available). It is cause for retirement or downgrading if a knot is not called for and cannot be removed or the rope reveals structural damage due to knotting.

6.9.3 ◆ The inspector should endeavor to determine if a knot is suitable for the application and was properly tied.

6.10 Creep (cold flow) [J]

6.10.1 Ropes made of materials that creep (Reference 1) will be measurably longer if loaded continuously for long periods of time. Creep rates depend on the material, time, temperature and load relative to breaking strength. The inspector should research the loading history of the rope and determine if the fiber material is subject to significant creep at the operating conditions. Ropes made of HMPE and polypropylene are particularly susceptible and nylon is somewhat susceptible.

6.10.2 Ropes that fail due to creep often retain relatively high strength until they are very close to failure; thus the need to check for operating conditions that may suggest excessive creep.

6.10.3 Creep also reduces the elongation at failure during a strength test. Maintaining relative high stretch before failure is important in some applications. In most cases, loss of stretch can only be determined by a destructive test. Strength testing may not reveal the true condition of the rope unless stretch is also checked and compared to normal values.

6.10.4 Visual inspection for creep is only possible if the rope is cycled at moderate load a few times to set the structure; then gauge marks are placed on the rope and the length carefully measured under reference tension before it goes into service. The recorded length is then compared to the used length measured under the same reference tension.

6.11 Axial Compression and Kink Bands [K]

6.11.1 Ropes that have a braided or extruded jacket over an inner, load bearing core are subject to axial compression, as manifested by kink bands. This occurs mostly in ropes with a very tight jacket. In severe cases, the rope will have bulges in zones where kinks are concentrated (bulges often repeat at a uniform cycle length). If the inner core can be inspected, bands of kinked fibers or yarns that have a Z appearance may be seen. If damage is severe, the filaments at the Z points will be severed as with a knife. If the jacket cannot be opened for internal inspection, destructive inspection or testing may be the only means of evaluation.

6.11.2 Kink bands can also appear in splices of very high strength, high modulus ropes. This is an indication that serious damage could be present. Destructive testing may be the only means of evaluation.

6.12 Hockle, Twist, Kink or Corkscrew [L]

6.12.1 ◆ If a loop is introduced into a 3-strand rope (or other multi-strand laid rope), it will tend to hockle when tension is applied. Once set, hockles cannot be turned back to restore the rope structure and this indicates severe damage. See Figure D-023.

6.12.2 ◆ Some ropes will display a corkscrew appearance and must not be used unless restored to normal appearance. Figure D-024.

6.12.3 ◆ Braided and plaited ropes should display little or no twist, and those that do must not be used unless restored to normal appearance. Figure D-025

6.13 Sunlight Degradation [M]

6.13.1 ◆ Ultra-violet (UV) radiation from direct sunlight will cause brittle and weak outer rope yarns. UV degradation is difficult to inspect visually. Discoloration and brittleness in the filaments may be observed in some cases. Strength testing of a few surface fibers or the entire rope is required for a definitive assessment. Figure D-026.

6.13.2 The affect on the rope is much less as diameter increases. Damage to very small ropes can be rapid; ropes over 1 inch in diameter are much less affected. UV degradation is stronger in the lower latitudes and will progress with time of exposure. Non-load-bearing jackets or coatings will protect the core rope. Assessment can be difficult and advice of a qualified person should be sought if there is potential for UV damage.

6.14 Chemical and Heat Degradation [N]

6.14.1 ◆ Synthetic fiber materials generally resist chemical attack and heat exposure in normal circumstances but can be weakened in certain situations. Visual inspection may reveal discoloration and brittleness of the fibers. Melting, bonding of fibers, (Figure D-019) hardening or stickiness may be observed. However, these manifestations are not always present. The inspector should research the exposure history of the rope.

6.14.2 ◆ Nylon ropes, when wet, can be seriously degraded by long term contamination with rust. This can be detected by the reddish or brown color.

6.14.3 Fiber ropes stored at even moderately high temperatures for long periods of time can be degraded without any visual indication of damage.

6.14.4 Refer to CI 2003 for information on the temperature and chemical resistance of fiber materials.

6.15 Dirt and Grit [O]

6.15.1 ◆ Dirt and grit cause internal fiber abrasion in ropes that are in regular use. Most ropes can be forced open for internal inspection. A magnifying glass may be helpful for identification of fine particles. Figure D-027.

6.15.2 ◆ Sea water that has dried and has left a salt deposit can be damaging due to internal abrasion if the rope is used in the dry condition.

6.15.3 ◆ Oil and grease deposits, of themselves, do not damage most rope materials. However, they trap dirt and grit and may make the rope difficult or unpleasant to handle. The inspector needs to assess the effects in the light of the application.

7. DISPOSITION

7.1 Introduction

It is expected that a rope will be left in normal service if no significant damage is identified. However, when a rope is considered to be damaged, in accordance with the inspection and evaluation criteria, a decision must be made to repair, downgrade or retire the rope based on the results of the inspection.

7.2 Repair

7.2.1 If the rope shows severe damage only in a few concentrated areas, it may be possible to remove the damaged sections and resplice the rope. After completion of new eye splices or end-to-end splices, pretension or load cycle to set the splice if possible. For end-for-end splices, assume 100% strength for a short splice and 80% for a long splice.

7.2.2 Caution: Splicing of a heavily used rope may be impossible, or very difficult (double braided nylon rope can be particularly bad). In such cases, there is often a significant strength loss; consultation with a qualified person may be appropriate. For jacketed ropes where the core is the strength member, it may be possible to repair the jacket. Follow manufacturers' or other governing guidelines or directions of a qualified person.

7.3 Downgrade

7.3.1 If a rope is damaged and cannot be repaired, the residual strength of a rope can only be estimated by the inspector. The decision to downgrade a rope must be made very conservatively.

7.3.2 Destructive strength testing of yarns or of a specimen of the rope can be utilized to estimate residual strength when making the decision to downgrade. Test ropes in accordance with Cordage Institute Standard Test Method CI 1500-(current).

7.3.3 Using estimates of the reduced breaking strength of a degraded rope, the inspector or user must determine a working load limit (WLL) based on a design factor established by the user.

7.3.4 The user must make certain that downgraded ropes do not find their way into the original or other applications that require full strength.

7.3.5 Downgrading may also apply to ropes that have been repaired by splicing as used rope splices may have questionable strength.

7.4 Retire

7.4.1 Rope must be retired if it is damaged and cannot otherwise be repaired or a use cannot be found for it in a downgraded condition.

7.4.2 Retired ropes must be disposed of in accordance with any applicable regulations and rendered unsuitable for future use.

8. KEYWORDS

Rope
Rope inspection
Fiber rope
Used rope
Thimbles

APPENDIX A

RELATED DOCUMENTS

The following Cordage Institute (CI) and other publications provide additional information about the properties, testing, care and safe use of fiber ropes:

1. **ASME B30.9** Sling Standard, Chapter 4 (Synthetic Fiber Rope Slings)
2. **ASTM D4268** (current): Test Methods for Testing Fiber Rope. Provides the test methods to determine the basic physical properties of fiber ropes.
3. **ASTM F1740** Standard Guide for Inspection (includes log example)
4. **CI 1201** (current): Fiber Ropes: General Standard. Covers general characteristics and requirements for all fiber cordage and ropes.
5. **CI 1401** (current): Safe Use Guidelines: Appendix (last page) to specific rope specifications issued by the Cordage Institute after 1995 (for instance CI 1201, cited above).
6. **CI Publication List** of standards for specific constructions and fibers.
7. **ISO 2307**

Documents listed above and references listed in Section 2.1 can be obtained from the following sources:

1. ASME (American Society of Mechanical Engineers), 345 East 47th Street, New York, NY 10017
2. ASTM (American Society for Testing Materials), 100 Bar Harbor Drive, West Conshohocken, PA 19428-2959
3. Cordage Institute, 994 Old Eagle School Road, Suite 1019, Wayne, PA 19087-1866; Phone: 610-971-4854; Fax: 610-971-4859; E-mail: info@ropecord.com; Web: www.ropecord.com.

APPENDIX B

SAMPLE MOORING LINE LOG

Vessel __________ I.D. NUMBER_____________

Size______________Fiber _______________Construction________________

Length__________Number Eyes_______Size Eyes___________/__________

Mfg or NSN____

Spliced by________________________Date________________________

Inspection Schedule ____

HISTORY

Date put in service___________ Mooring station______________________

Date	Inspection or Incident	Comments

TOWING LINE LOG

Vessel __________ I.D. NUMBER_____________

Size_____________Fiber_____________Construction___________________

Length___________Type end fitting_______________/_______________

Mfg or NSN____

Spliced by________________________Date________________________

Inspection Schedule ____

HISTORY

Date put in service___________ Mooring station______________________

Date	Inspection or Incident	Comments

APPENDIX C

EVALUATION GUIDE

DEFINITIONS

8-stand = 8-stand plaited ropes		**Damage Description =** A brief description of types of damage. See the section reference for a more detailed information.
3-strand = 3 and 4 strand laid ropes		**Repair - Yes =** Repair must be made to justify **No** recommendation in **Retire** column. See Section 7.2. Repairs may not be feasible in some cases.
All braids = 8 and 12 strand single braids and double braids		**Downgrade** - Ropes may find use in a less demanding or critical application. This is not recommended, however. See Section 7.3
Jacketed = Jacketed ropes with wire lay, parallel sub-rope, parallel strand or parallel fiber load bearing cores		**Retire - Yes =** Do not use for original application. **- Best action =** Preferred that rope be downgraded or retired.

A. INITIAL EVALUATION - GENERAL

Rope type	Damage Description	Sect. Ref	Fig. Ref.	Repair	Downgrade	Retire
All ropes	Rope displays moderate wear. No history of use, no records or no specifications. Time in service unknown. No severe damage. Potential personal injury or material damage exists if rope should break.	5.1.3 5.2	None	No	Possible	Best action

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B. EXCESSIVE TENSION / SHOCK LOADING

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All ropes	History of excessive tension (for example, over 50% of published strength) or shock loading. No visible damage.	5.2	None	No	Possible	Best action
3-strand 8-strand All braids	Visible damage; i.e., broken strands, splice slippage, measurable creep or internal fusion. History of excessive tension or shock loading.	6.2.1	None	No	No	Yes
All ropes	Back of eye flattened and hard; cannot be softened	6.8.2 6.8.3	D-019	No	Possible	Best action

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C. CYCLIC TENSION WEAR

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All braids	Broken or seemingly cut outer filaments that are packed into the surface or protrude, uniformly over working length. Fuzzy appearance uniform over length. Broken internal filaments over length. Packing of broken filaments that hardens rope giving less than normal flexibility; rope cannot be pried open for internal inspection.	6.3.1 6.3.2 6.3.3 6.3.4 6.3.5	D-001 D-002 D-003	No	Possible	Best action
3-strand 8-strand	Broken, powdered or matted filaments at strand rub areas at center of rope. Twist or compress rope to expose interior between stands.	6.3.4	D-003 D-004	No	Possible	Best action
Jacketed Kernmantle	Broken filaments on interior filaments of core rope. Fusion or hard spots on core. Powdered, broken or matted filaments at cover/core interface.	6.3.5	None	No	No	Yes

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D. EXTERNAL ABRASION

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
Double braids	Outer braid worn away by less than 10% of the circumference or 10% over one fourth of strands along the length; core not exposed significantly.	6.4.1	D-005 D-006 D-007	No.	Possible	Best action
Double braids	Outer braid worn away by more than 10% of the circumference or over one fourth of the strands along the length; core exposed.	6.4.1	D-005 D-006 D-007	No	No	Yes
3-strand 8-strand plait 12-strand braid	10% loss of fiber cross-section in whole rope or in an individual strand cross-section. Crowns of strands badly worn reducing strand diameter by more than 10%.	6.4.1	D-005 D-006 D-008 D-009	No	Possible	Best action
All ropes	Localized hard or burn areas, area less than 15% of rope circumference in width; penetration less than 5% of rope diameter.	6.4.2	D-010	No	No	No
All ropes	Localized hard or burn areas, area more than 15% of rope circumference in width; or length in excess of one half number of strands; and penetration more than 5% of rope diameter.	6.4.2	D-010	No	No	Yes

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Jacketed Kernmantle	Load bearing component (core of jacketed rope) is damaged by more than 5% of the cross sectional area.	6.4.3	None	No	Not recommended	Best action
Jacketed or Kernmantle -Jackets	When core undamaged, non-load bearing jacket abrasion assessment depends on the criticality of coverage for a particular application. Loss of 10% of strands at one area is cause for concern but occasional breakage of jacket strands along length is probably not so critical.	6.4.3	None	Not recomm-ended	Possible	Case by case

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E. CUTTING

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
Double braids	Outer braid cut by less than 5% of the circumference or 10% of diameter of one fourth of number of total strands along one cycle length; core not exposed.	6.5.1	None	Tuck loose ends	No	No
Double braids	Outer braid cut by more than 5% of the circumference or 10% of diameter of one fourth of number of total strands along one cycle length; core not exposed.	6.5.1	None	No	No	Yes
3-strand 8-strand plait 12-strand braid	10% loss of fiber cross-section in whole rope or in an individual strand cross-section	6.5.1	D-011	No	Possible	Best action
3-strand 8-strand plait	Over 10% loss of fiber cross-section section in whole rope or in an individual strand cross-section	6.5.1	D-011	No	No	Yes
Jacketed	Loadbearing component (core of jacketed rope) is damaged by more than 5% of the cross sectional area.	6.5.2	D-012	No	Possible	Best action

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Jacketed Ropes - Jackets	Core undamaged. Jackets are not load bearing. Damage assessment depends on the criticality of coverage for a particular applications. Also, jackets might be repaired .	6.5.2	D-012	Possible	Possible	Case by case

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F. PULLED STRANDS AND YARNS

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
3-Strand 8-Strand	Rope yarns may be pulled out from main strands. Less than 10% of rope yarns in a strand are out of place	6.6.1	D-013	Yes	No	No
8-Strand Braids	Main strands, less than 15% of number present are pulled out of position a moderate amount can be worked back into the rope to conform to the original structure	6.6.1 6.6.2	D-013 D-014 D-015	Yes	No	No
8-Strand Braids	Main strands are pulled out of position, more than 20% of number present or so much that they cannot be worked back into the rope to conform to the original structure	6.6.1 6.6.2	D-013 D-014 D-015	No	Possible	Best action
Double braids Jacketed ropes	Inner core protrudes through jacket. Rope can be massaged back into original structure without kinking.	6.6.1	D-012	Yes	Possible	Best action
Double braids Jacketed ropes	Inner core protrudes through jacket. Rope cannot be massaged back into original structure without kinking. displays moderate wear		D-012	No	No	Best action

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G. FLEX WEAR ON PULLEYS, ROLLERS, CHOCKS AND FAIRLEADS

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All braids	Broken outer filaments that are packed into the surface with fuzzy appearance uniform over flex length. Broken internal filaments over flex length. Packing of broken filaments that hardens rope giving less than normal flexibility; rope cannot be pried open for internal inspection. Non-recoverable flattening.	6.7.1	None	No	Possible	Best action
3-strand 8-strand	Broken filaments and evidence of wear on strand crowns on surface on flex length. Broken filaments and powder at strand rub points at center of rope. Internal fusion.	6.7.1	None	No	Possible	Best action
Jacketed	Broken filaments and evidence of wear on surface in flex length. Broken filaments on interior filaments of core rope. Fusion or hard spots on core. Powder or broken filaments at cover/core interface. Figure shows core with jacket removed.	6.7.1	D-016	No	No	Yes

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H. SPLICED EYE – WEAR, FABRICATION, THIMBLES

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All ropes	Improperly made splices. Check for correct fabrication. Refer to qualified person, manuals or published procedures. Old splice can be cut out and new one made.	6.8.1 6.8.5 6.8.6	D-017 D-018	Yes	Possible Splices in used rope often not reliable	Best action
All Ropes	Surface abrasion or cut damage in splice eye. See Sections C & D above	6.3.2 6.3.3 6.4.1	D-019	No	Possible	See C & D
3-strand 8-strand Braids	Splice has slipped. Strand tails have pulled back into rope. Old splice can be cut out and new one made.	6.8.4	None	Yes	Possible Splices in used rope often not reliable	Best action
Braids	Leg junction shows cut or ragged strands. Old splice can be cut away and new splice made	6.8.2	D-020	Yes	Possible Splices in used rope often not reliable	Best action
All ropes	Damaged or improper splice cannot be remade with confidence that strength is not compromised.		None	No	No	Yes

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Thimbles	Thimbles have sharp edges or corrosion. Thimble loose in eye. Rope does not fit thimble. Thimble can be replaced. Assess rope damage in accordance with Sections C & D.	6.8.7	None	Yes	No	No
Thimbles	Thimbles may be required. Eye damage may be occur because thimble is not used. Minor rope damage is present; thimble can be added.	6.8.7	D-021	Yes	No	No
Other Termin-ations	Mechanical, potted and terminations other than splices with or without thimbles should be verified as to strength capability. Action as indicated if in doubt unless fitting can be replaced by splicing.	6.8.8	None	No	No	Yes

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I. KNOTS

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All Ropes that can be spliced	A knot has been used instead of a splice and cannot be removed or replaced by a splice. No damage at knot. Assume strength has been reduced 50% and calculate working load limit on this basis - compare to actual and check if greater.	6.9.1 6.9.2 6.9.3	D-022	No	Possible	Best action
All Ropes that can be spliced	Knot/s have been placed in body of rope between splices and cannot be removed without damage or, if they are, the length previously in the knot is abraded or kinked.	6.9.2	None	No	No	Yes
Ropes for use with knots, not spliceable	Working load limit is based on 50% of published breaking strength. Little (10% or less) fiber damage at knot.	6.9.2	D-022	No	No	No
Ropes for use with knots, not spliceable	Working load limit is based on 50% of published breaking strength - compare to actual and found not acceptable or there is in excess of 10% fiber damage at knot.	6.9.2	D-022	No	Possible	Yes

APPENDIX C

EVALUATION GUIDE

J. **CREEP** (cold flow)

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All ropes	Rope is very close to or exceeds the creep limit set by the user or rope maker. Creep is checked by procedures set by user or rope maker and found to be near limit.	6.10.1 6.10.2 6.10.3	None	No	No	Yes
All Ropes	Rope type is subject to creep and history of use shows that it may have experienced excessive creep. Rope has been used for extended time at high loads expected to cause creep.	6.10.1	None	No	Possibly	Best action

APPENDIX C

EVALUATION GUIDE

K. AXIAL COMPRESSION AND KINK BANDS

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
Jacketed	Body of rope shows distinctive periodic bulges along its length. Internal inspection is not possible.	6.11.1	None	No	Possible	Yes
Jacketed	Internal inspection reveals distinctive Z shaped kink bands in portions of the load bearing core. More than 10% of the cross section is affected. These tend to repeat in a regular pattern along the length	6.11.1	None	No	No	Yes
Splices	Splices in ropes made of high modulus fiber may exhibit kink bands. Damage is very difficult to access without destructive testing.	6.11.2	None	No	No	Yes

APPENDIX C

EVALUATION GUIDE

L. HOCKLE, TWIST, KINK OR CORKSCREW

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
3-strand Ropes	A loop has been pulled tight causing hockle; rope structure cannot be turned back easily without leaving the rope distorted.	6.12.1	D-023	No	No	Yes
3-strand Ropes	3-strand ropes display a corkscrew appearance when laid out straight and without tension. Corkscrew can be removed by twisting in opposite direction.	6.12.2	D-024	Yes	No	No
3-strand Ropes	3-strand ropes display a corkscrew appearance when laid out straight and without tension. Corkscrew cannot be removed by twisting in opposite direction (often result of bad splice or manufacturing defect).	6.12.2	D-024	No	Possibly	Best action
3-strand Ropes	Rope is unlaid (strands do not stay together).	6.12.3	None	No	No	Yes
3-strand	Swivel has been used with 3-strand ropes	6.12.3	None	No	No	Yes
8-strand All braids	Rope has been used in series with wire rope without a swivel (unless wire is non-rotating)	6.12.3	None	No	No	Yes
Braided and plaited ropes	Discernable twist when laid out straight, even under tension. Twist can be removed by twisting in opposite direction.	6.12.3	D-025	Yes	No	No

EVALUATION GUIDE

All ropes	Kinking is present. Kink will not disappear completely when slight tension is applied or springs back when tension is removed. Rope is hard and flattened at kink.		None	No	No	Yes

M. SUNLIGHT DEGRADATION

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repa ir	Downgrade	Retire
Polypropylene Ropes	Polypropylene rope with many brittle and broken filaments on the surface	6.13.1	D-026	No	No	Yes
All ropes without non-load bearing jackets	Ropes less than 1 inch diameter that are known to have had extensive exposure (year or more) to bright sunlight. Especially nylon, aramid and polypropylene.	6.13.1 6.13.2	None	No	Possible	Best action
All ropes with non-load bearing jackets	Jacket completely covers the rope, or can be patched to cover the rope, and is not subject to severe wear. Underlying core has been protected.	6.13.1	None	Yes	No	No
All ropes with non-load bearing jackets	Jacket appears severely affected and cannot be repaired. Jacket shows signs of sunlight degradation and is subject to rough service.	6.13.1	None	No	No	Yes

APPENDIX C

EVALUATION GUIDE

N. CHEMICAL AND HEAT DEGRADATION

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All Ropes	Known that there has been significant exposure to chemicals and/or high temperatures. No information from qualified persons or rope manufactures	6.14.1 6.14.3 6.14.4	None	No	No	Yes
All ropes	Discoloration, brittle fibers, fusion, bonding of fibers together, hardness. Chemical exposure is suspected.	6.14.1	None	No	No	Yes
Nylon rope	Rope has been used or stored when wet in contact with iron or steel that is rusted. Rope is reddish or brown. The condition has existed for an extended period.	6.14.2	None	No	No	Yes

APPENDIX C

EVALUATION GUIDE

O. DIRT AND GRIT

Rope type	Damage Description	Sect. Ref	Fig. Ref	Repair	Downgrade	Retire
All Ropes	Ropes exhibit grit or silt deposits on the inside. Broken or powdery fiber material may be present. The grit tends to fall out when the rope is dry and it is flexed.	6.15.1	D-027	No	No	Yes
All ropes	Seawater has dried and left a salt deposit on the inside of the rope. The rope has been used extensively when dry with the salt present.	6.15.2	None	No	Possible	Yes
All ropes	Seawater has dried and left a salt deposit on the inside of the rope. The rope has not been used extensively when dry. Rope can be rinsed thoroughly with fresh water.	6.15.2	None	Yes	No	No
All ropes	Rope has been significantly impregnated with oil or sticky substances. This material attracts and retains dirt and grit. It is not possible to clean the rope.	6.15.3	None	No	No	Yes

APPENDIX D

ROPE TYPES AND FITTINGS

Figure 1
3-Strand Rope

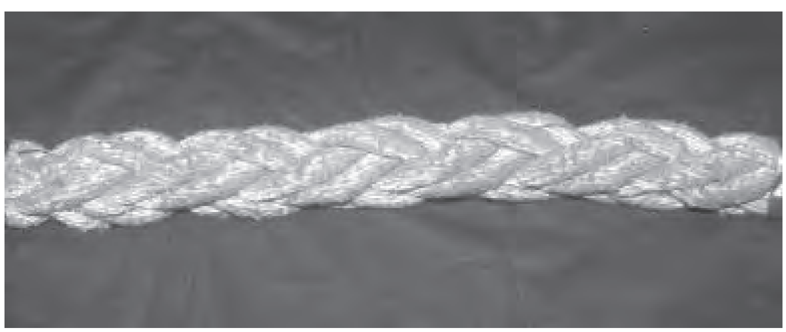

Figure 2
8-Strand Plaited Rope

Figure 3
12-Strand Braided Rope

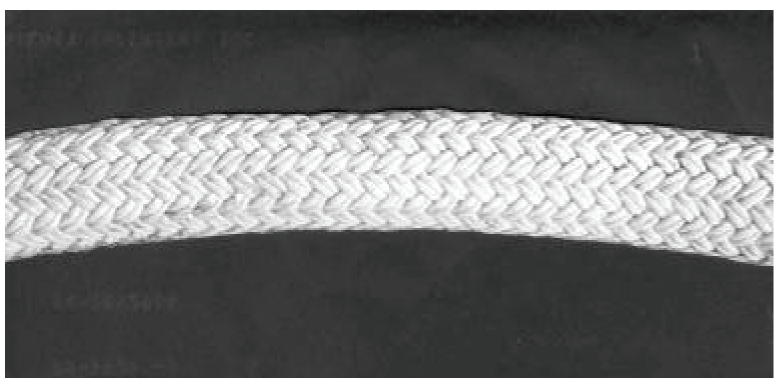

Figure 4
Double Braided Rope

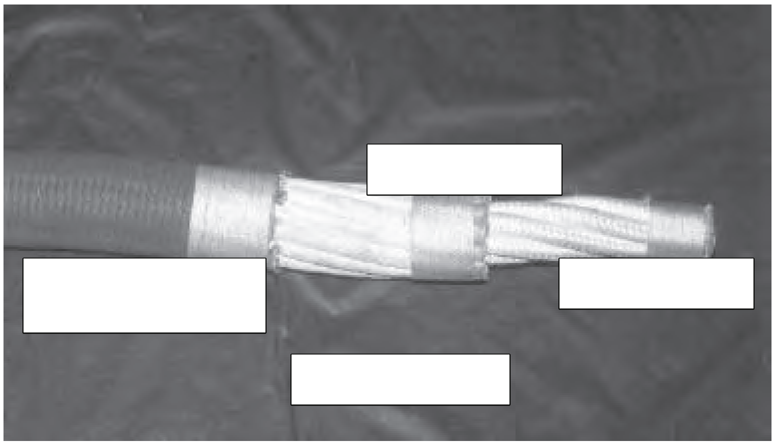

Figure 5
Wire Lay Rope

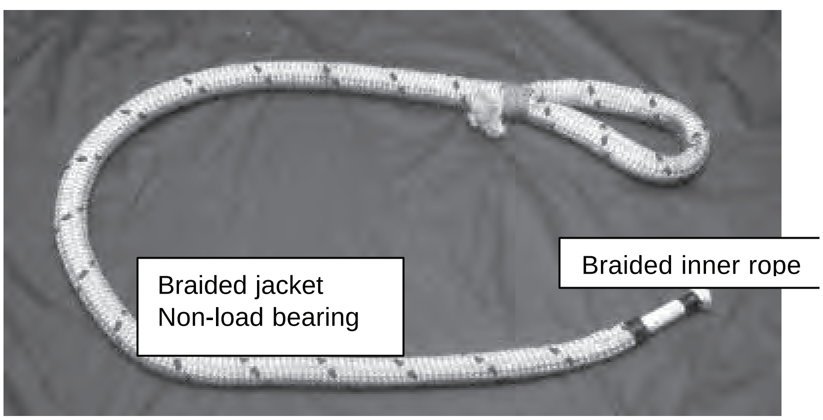

Figure 6
Jacketed Rope

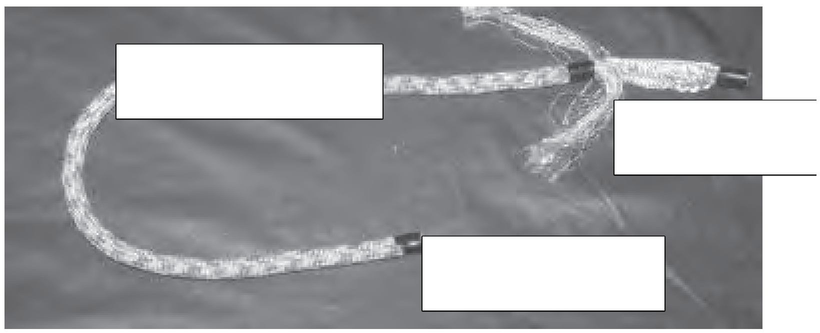

Figure 7
Climbing (kernmantle) Rope

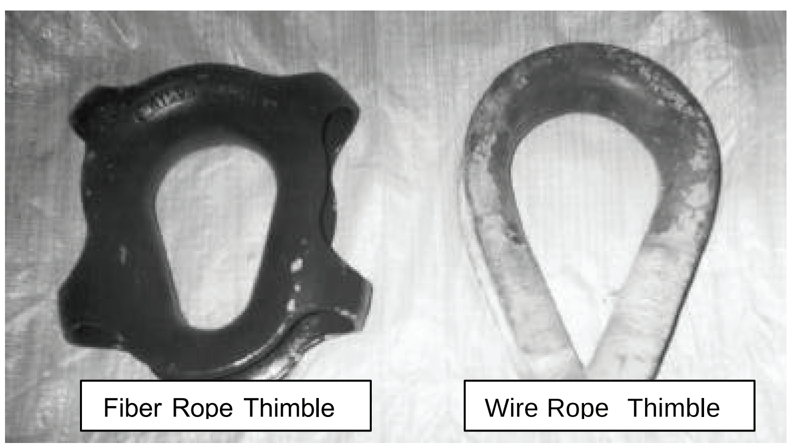

Figure 8
Thimbles

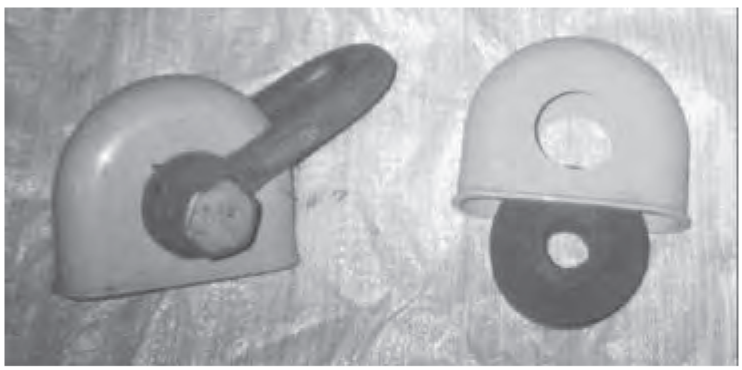

Figure 9
Plastic Thimble for Fiber Rope

APPENDIX D

DAMAGE ILLUSTRATIONS

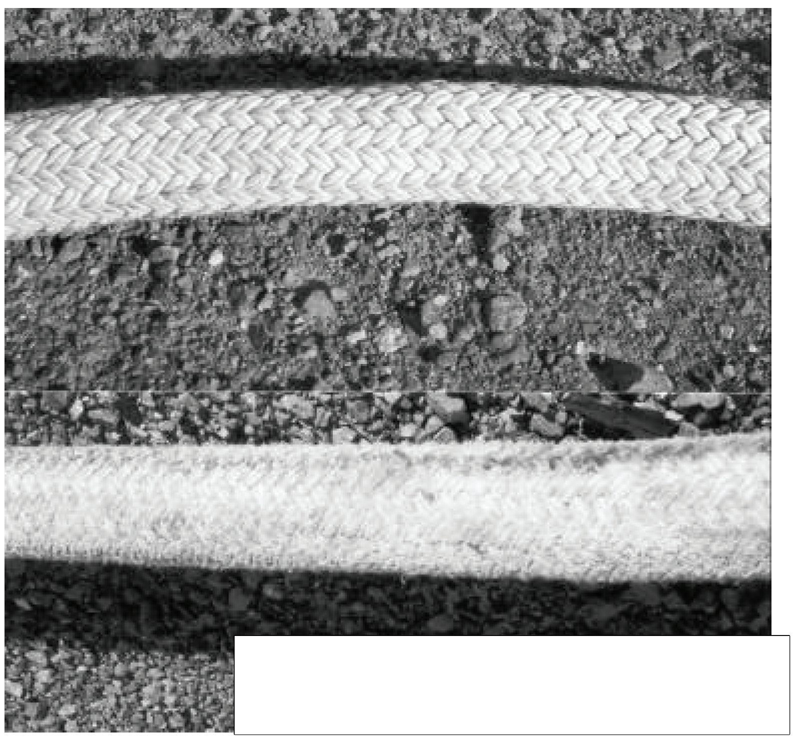

Figure D-001
Fiber Abrasion – Cyclic Tension
Undamaged - Upper Photo

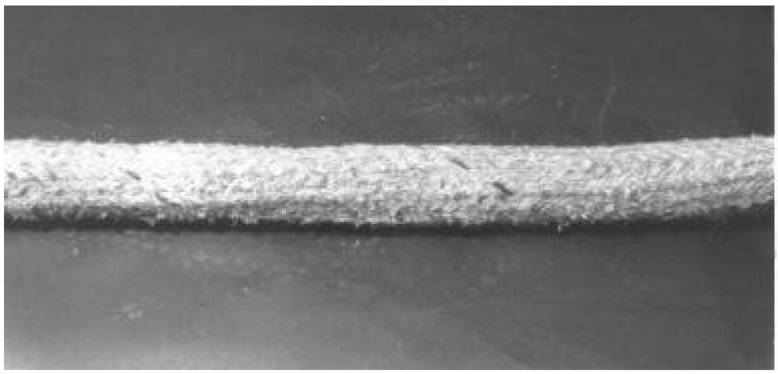

Figure D-002
Fiber Abrasion – Cyclic Tension
(extreme wear)

Figure D-003
Inter-Strand Abrasion
(Exposed internal area reveals wear at strand internal contact points)

Figure D-004
Matted Internal Yarns
(Exposed stands reveal internal matting)

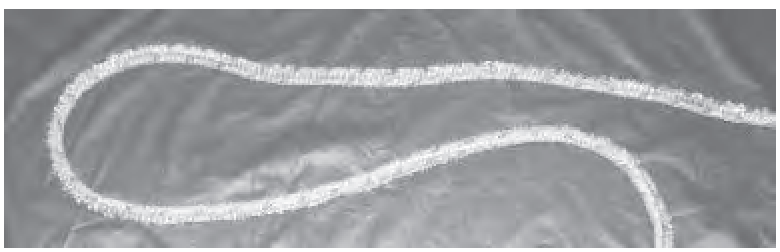

Figure D-005
Uniform Surface Abrasion
(Tree limb bull line)

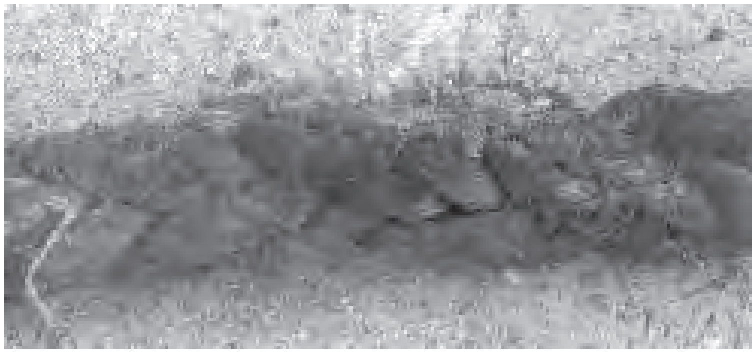

Figure D-006
Extensive External Abrasion

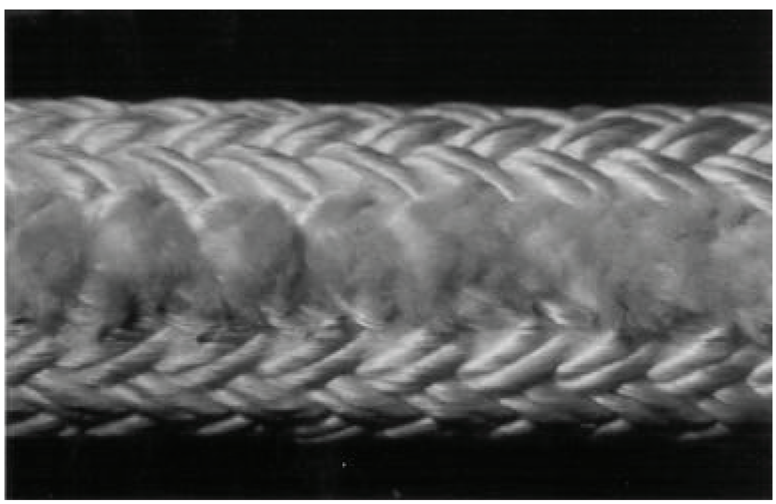

Figure D-007
Localized External Abrasion

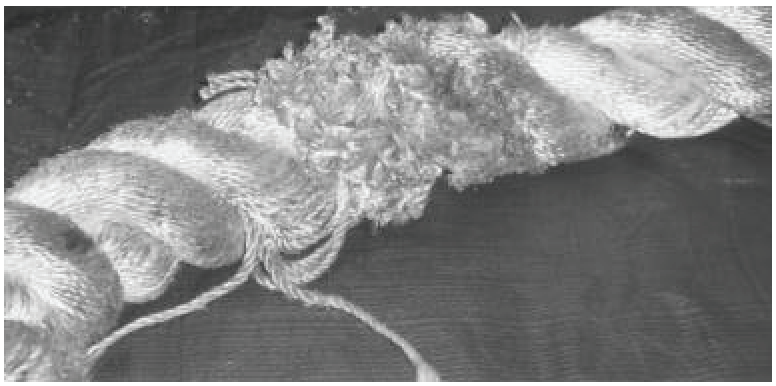

Figure D-008
Localized External Abrasion

Figure D-009
Localized Jacket Wear

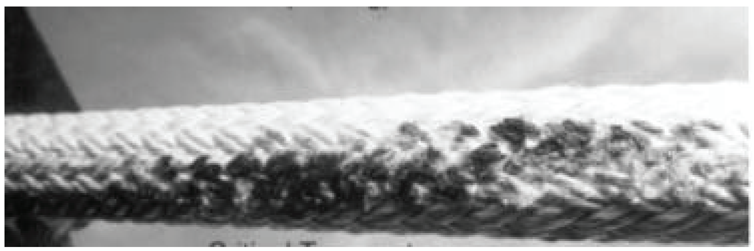

Figure D-010
Burn and Melting from External Abrasion

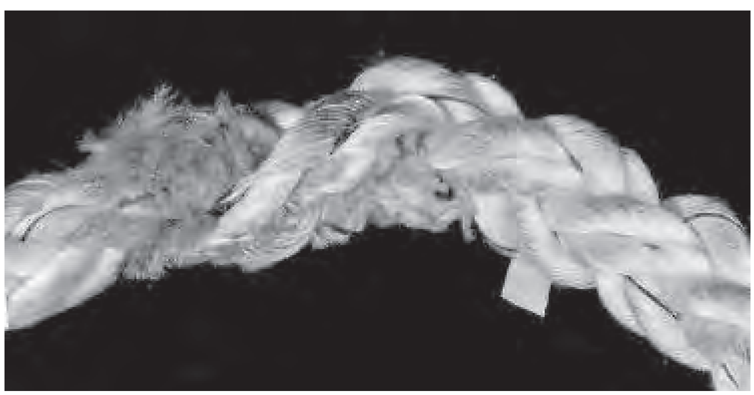

Figure D-011
Cutting

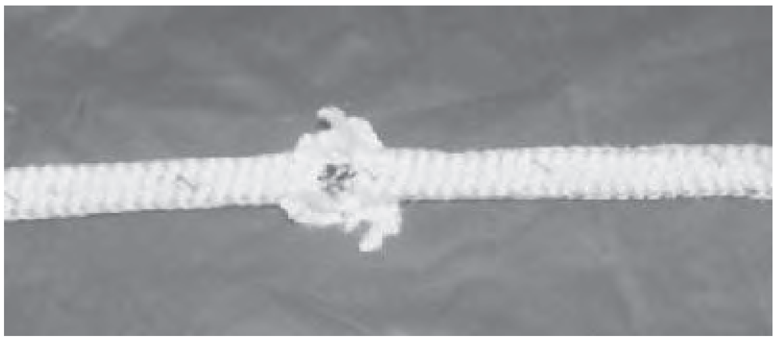

Figure D-012
Cut in Jacket Exposing Core

Figure D-013
Pulled Strand in 8 Strand Rope

Figure D-014
Pulled Strand in Worn Double Braid
(note color difference due to external dirt)

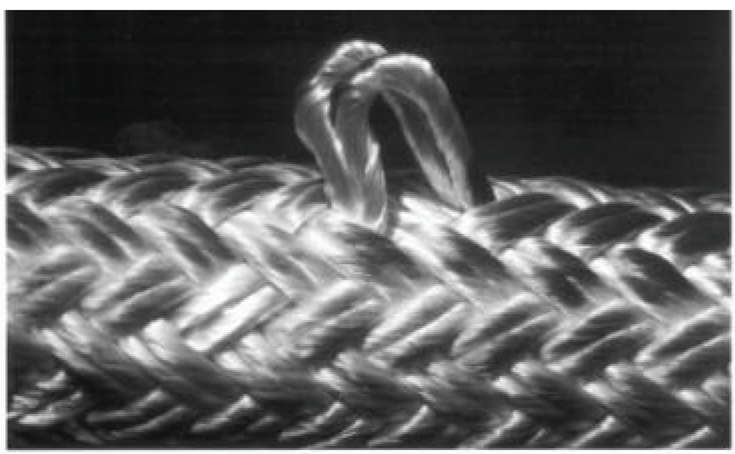

Figure D-015
Pulled Strand in New Double Braid

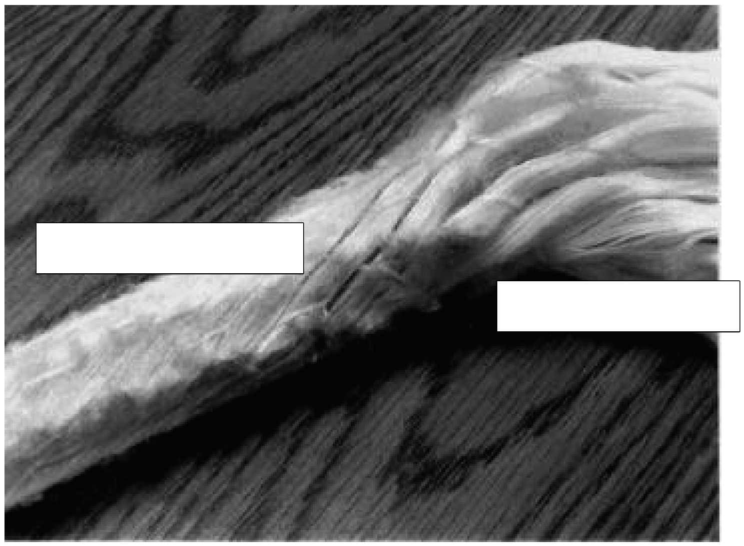

Figure D-016
External & Internal Damage – Running Over Pulley

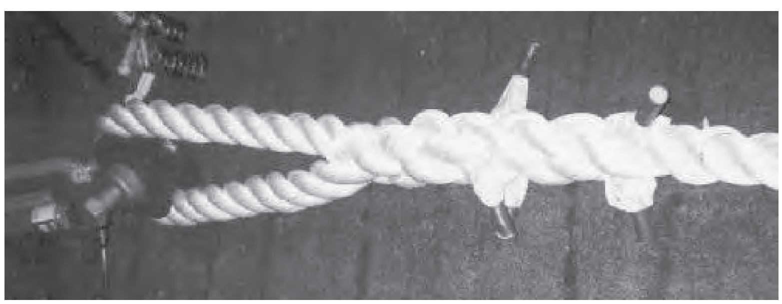

Figure D-017
Properly Made 3-Strand Eye Splice
(correctly made – shown for reference)

Figure D-018
3-Strand Splice of Poor Quality

Figure D-019
Wear in Double Braid Eye Splice

Figure D-020
Tearing at Leg Junction of Eye Splice

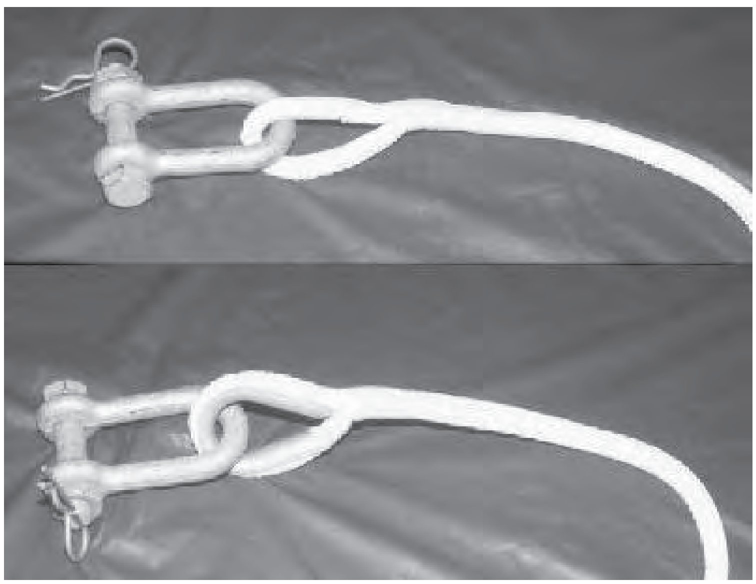

Figure D-021
Rope with Thimble (lower**) and Without (**upper**)**

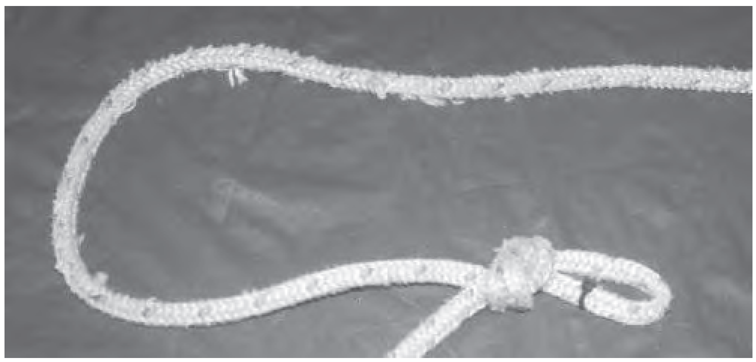

Figure D-022
Knot in Non-Spliceable Rope

Figure D-023
Hockle

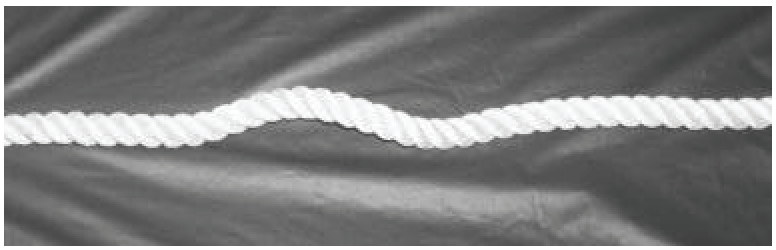

Figure D-024
Corkscrew Due to Twist

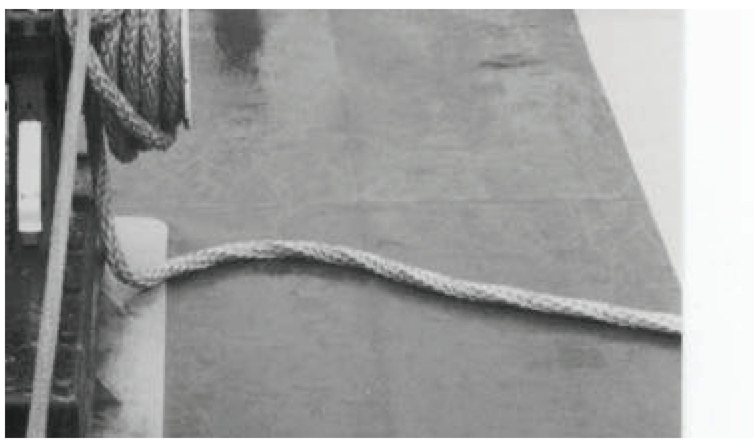

Figure 25
Twist in 12-Stand Braid

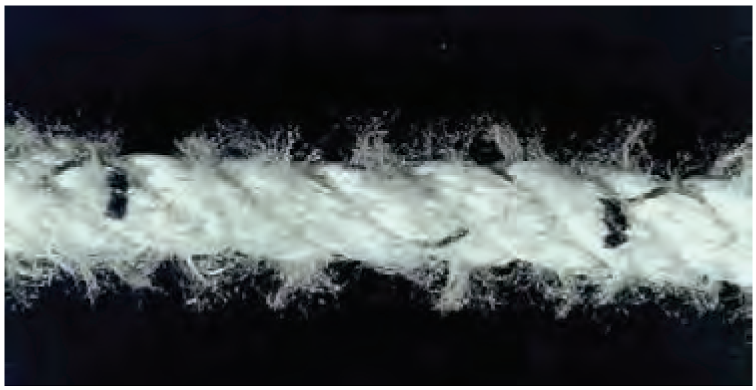

Figure D-026
UV (Sunlight) Degradation of Polypropylene Rope

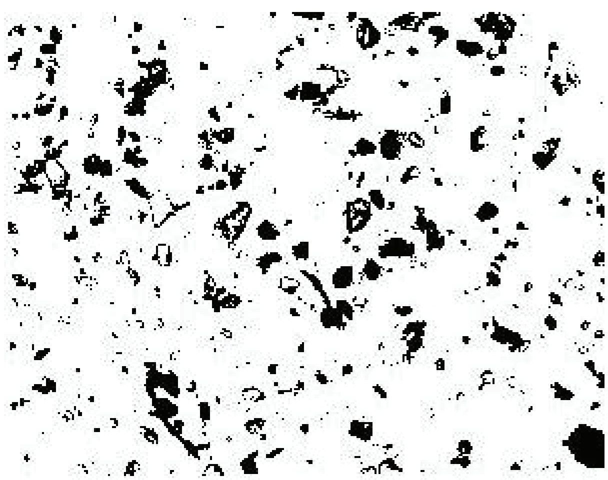

Figure D-027
Dirt and Grit
(revealed by low level magnification)