ADVANCED RIGGING PRINCIPLES TRAINING COURSE

Student Workbook

Susan Harwood Grant #SH-05018-SH8

NATE Elevate Wireless

NATE WIN WIRELESS INDUSTRY NETWORK

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

Enhance...
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

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 mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.

Introduction

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Introduction

ADVANCED RIGGING PRINCIPLES

Hoisting Applications Using Synthetic Rope

U.S. Department of Labor - OSHA
Susan Harwood Grant
SH-05018-SH8

Acknowledgement

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Introduction

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

Turning Point Technology

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

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

Pancake : Griddle :: Hamburger : ?

A. Lettuce

B. Grill

C. Bun

D. Ketchup

What is your age?

A. 18-24

B. 25-34

C. 35-44

D. 45-54

E. 55-64

F. 65 and up

What is the size of your employer?

A. I don't know

B. 2-10 employees

C. 11- 50 employees

D. 51 - 100 employees

E. More than 150 employees

Does your company directly perform on-site construction?

A. Yes

B. No

Do you create rigging plans?

A. Yes

B. No

What primary sector do you service?

A. Wireless

B. Broadcast

C. Wireless and Broadcast

D. Utilities

E. Public Safety


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

NOTES:

Section 1

Introduction to NATE and OSHA

Topics

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

About NATE

- Global Leader in Industry Safety and Best Practices for 24 Years
- Voice of Tower Construction, Service and Maintenance Industry
- Diverse Membership make-up consisting of over 815 member companies

NATE

About OSHA

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

NATE OSHA®

What Does OSHA Do?

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

NATE

Workers Have the Right To:

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

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

NATE

Employers Must:

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

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

OSHA Whistleblower Protection

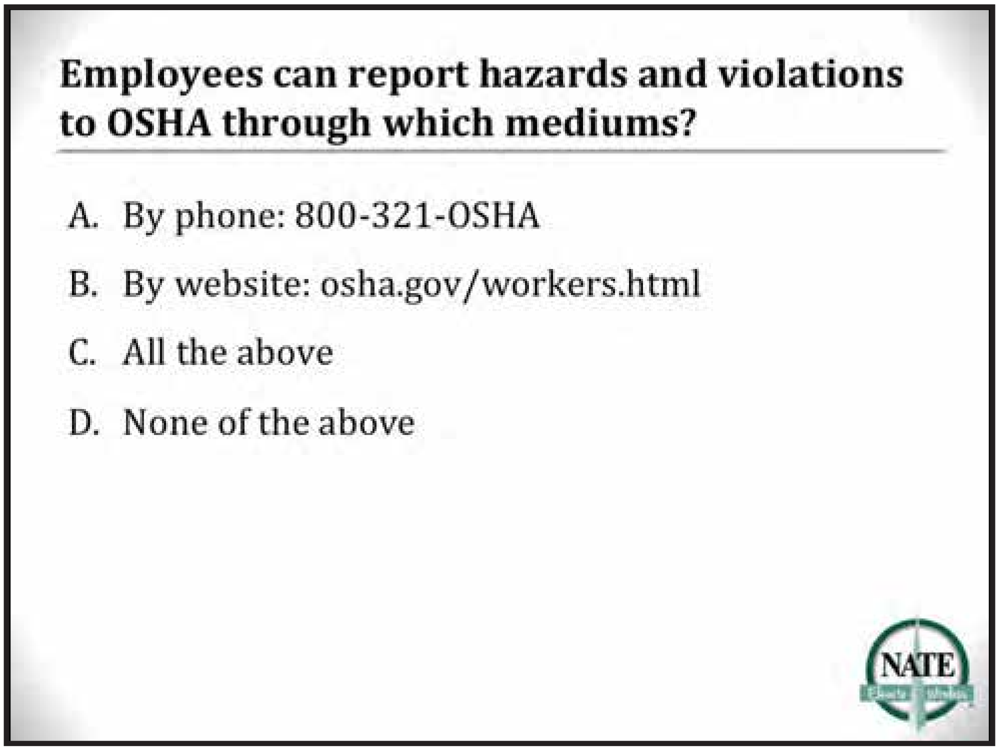
- Visit www.osha.gov/workers.html or call **800-321-OSHA.**
- Be prepared to provide specific details regarding your company and the type of hazard or discrimination being reported.
- Keep a confidential record of all details.
- Once a complaint is filed or reported, an investigation is normally warranted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

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

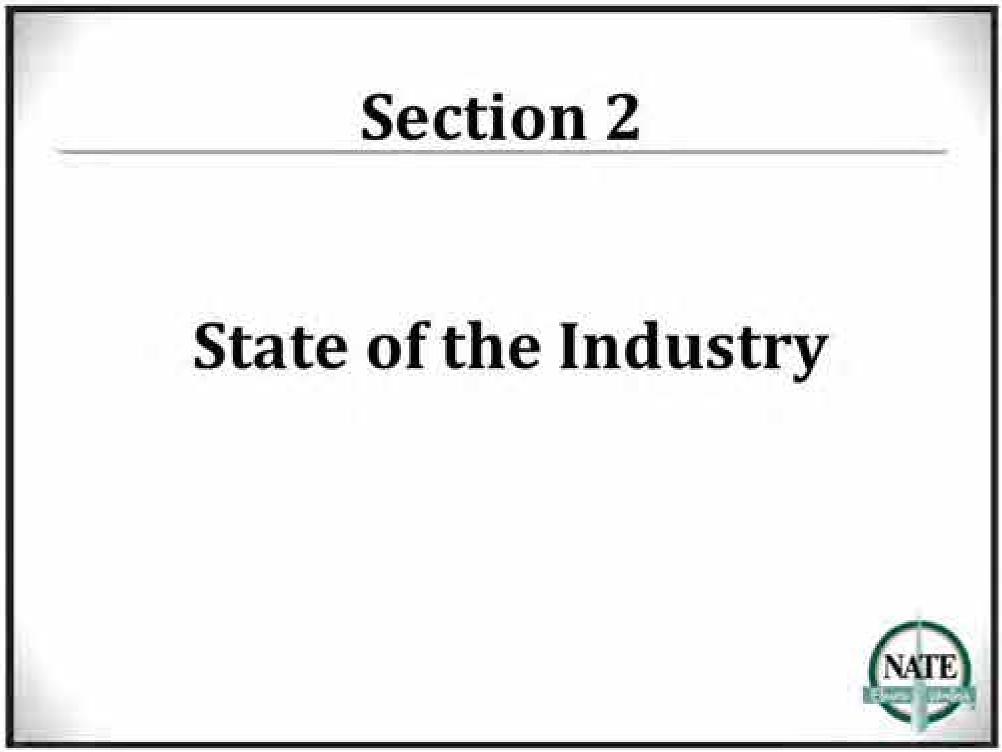
SECTION 1
REVIEW QUESTIONS

OSHA's Whistleblower statutes are design to provide employees the freedom to report violations and protect employees from the following acts of retribution?

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


Employees can report hazards and violations to OSHA through which mediums?
A. By phone: 800-321-OSHA
B. By website: osha.gov/workers.html
C. All the above
D. None of the above
NATE

NOTES:


Section 2
State of the Industry
NATE


Topics
Industry Statistics
Incident Review
Rigging Failures and Near Misses
NATE

Perspective Industry Fatality Statistics

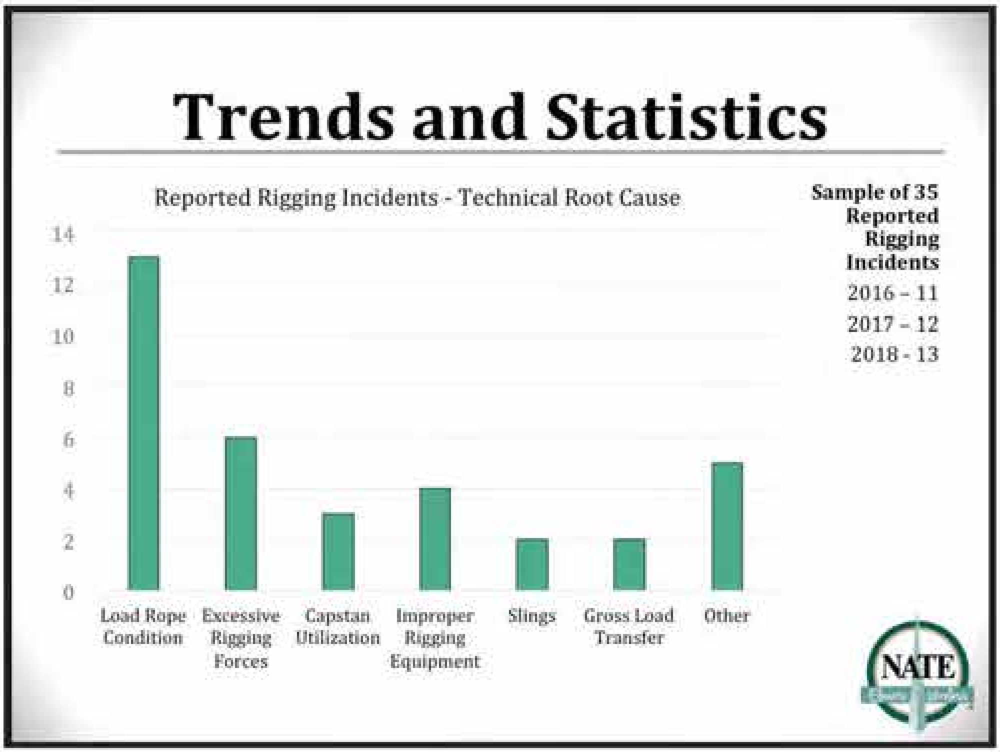
Year	Fatalities
2003	15
2004	11
2005	7
2006	19
2007	11
2008	12
2009	5
2010	7
2011	7
2012	1
2013	14
2014	10
2015	4
2016	7
2017	8
2018	5
Total Fatalities	143

CTIA – The Wireless Association

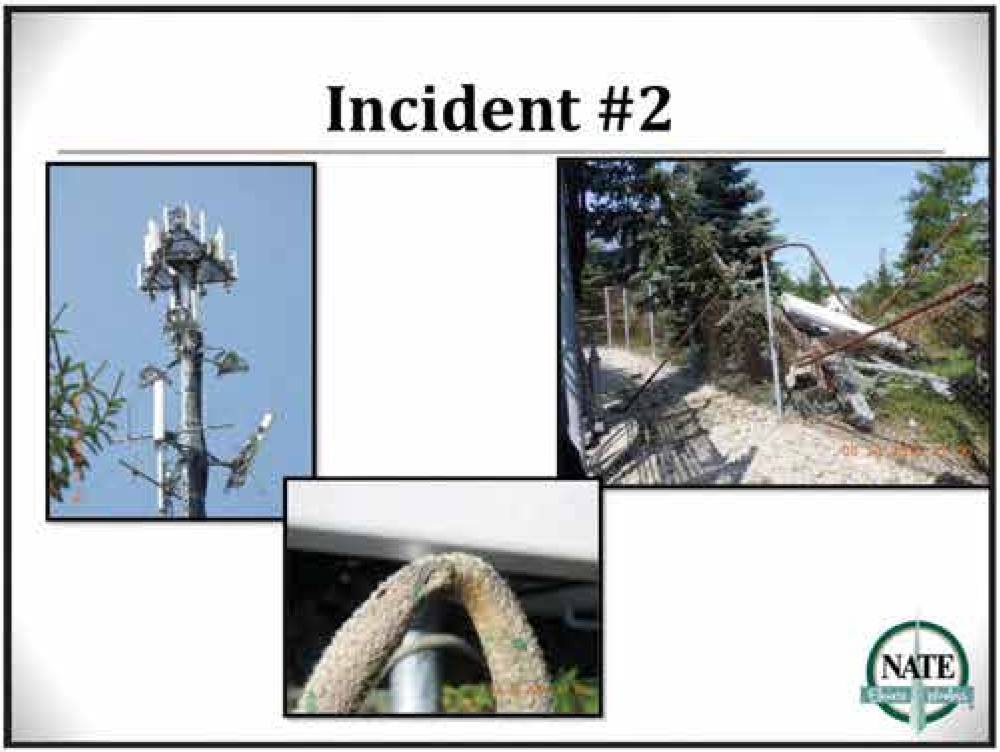
2018 Wireless Snapshot

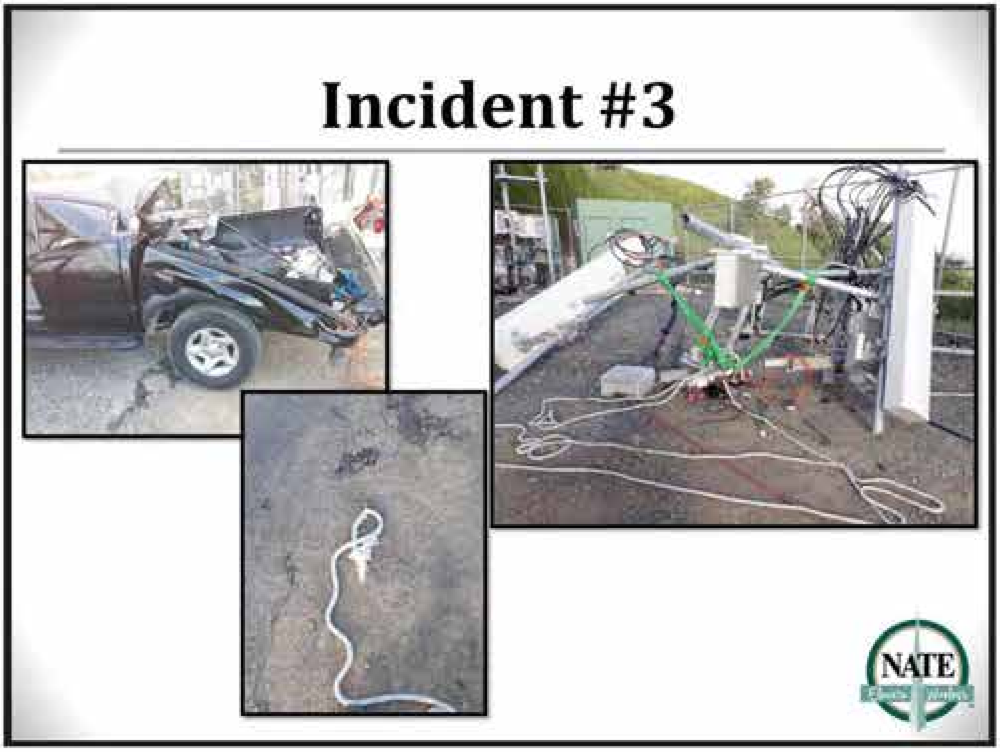
- Over **15 trillion MB** carried over U.S. wireless networks last year, which is another annual record.
- A record **323,448 cell sites** were in operation at the end of 2017.
- CTIA indicates that today's **average download speed of 22.69 Mbps is a 60% increase** from 2014.

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


Trends and Statistics
Reported Rigging Incidents - Technical Root Cause
14
12
10
8
6
4
2
0
Load Rope Condition
Excessive Rigging Forces
Capstan Utilization
Improper Rigging Equipment
Slings
Gross Load Transfer
Other
Sample of 35 Reported Rigging Incidents
2016 – 11
2017 – 12
2018 - 13
NATE


Incident #1
NATE


Incident #2
NATE


Incident #3
NATE


Incident #4
NATE


Incident #5
NATE

Trends and Statistics

Reported Rigging Incidents Per SOW

Sample of 35 Reported Rigging Incidents

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

Trends and Statistics

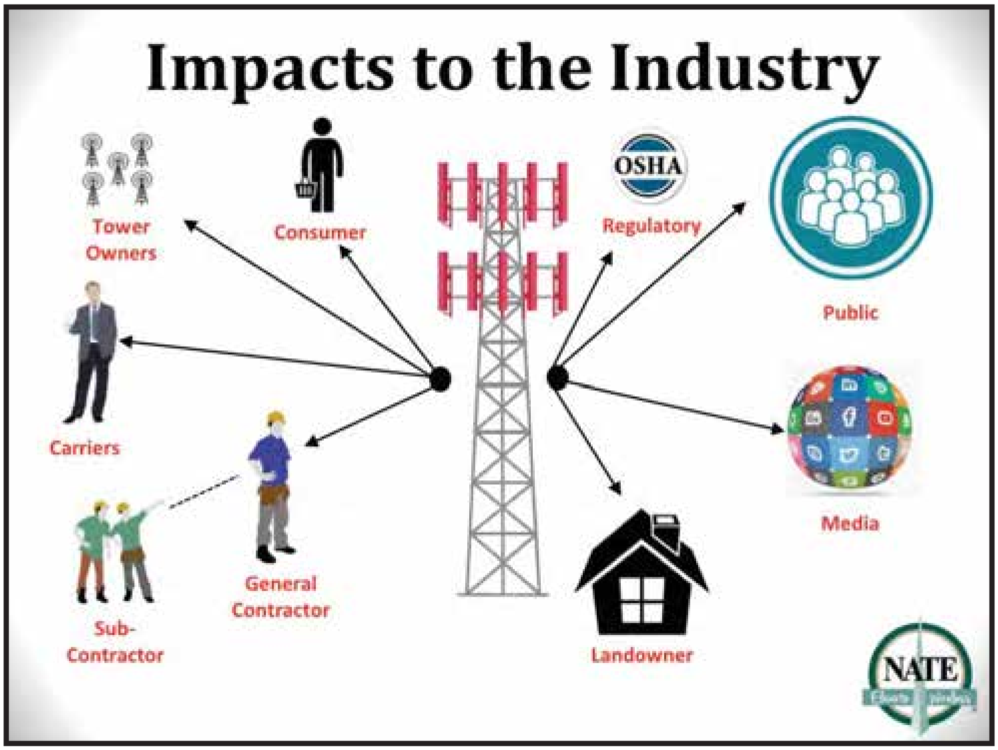
Antenna & Line Construction:

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

Tower Modification Construction:

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

State of the Industry



NOTES:

Section 3

Primary Regulations, Codes, Standards and Policies

Topics

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

Primary Regulations, Codes, Standards and Policies

Regulations, Codes, Standards, and Policies

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

Rigging Equipment Standards

- Standard rigging equipment used for lifting and load handling purposes shall be specifically certified for such applications in accordance with applicable ANSI/ASME B30 Standards

  ASME B30.9: Slings

  ASME B30.10: Hooks

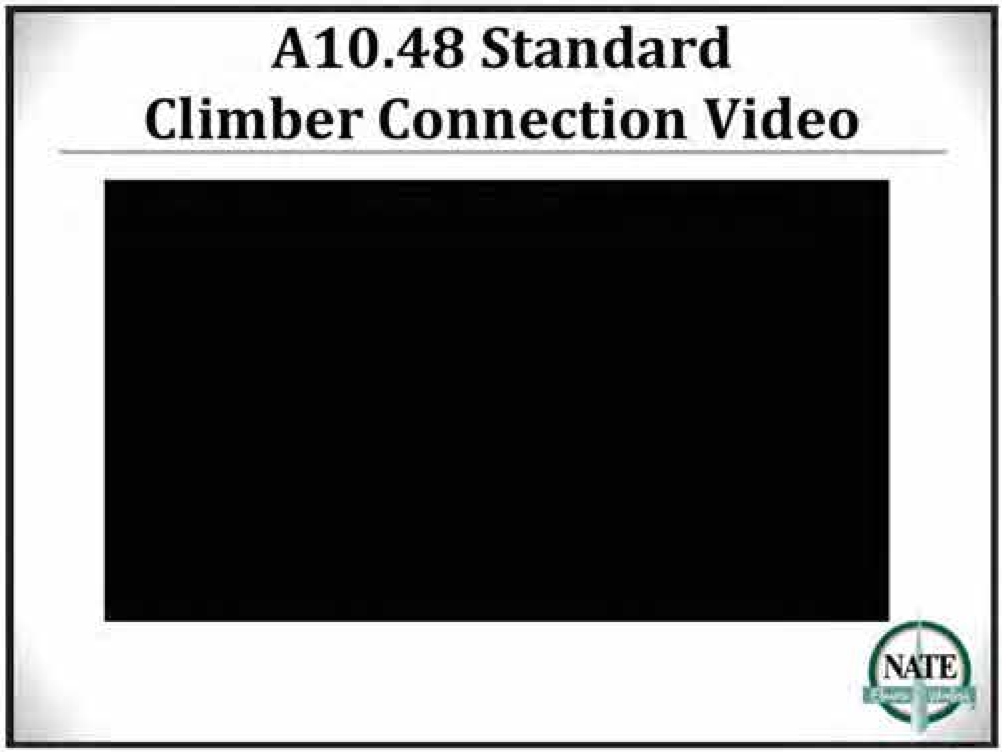
  ASME B30.26: Shackles, Links, Rings, Rigging Blocks, and Load Indicating Devices

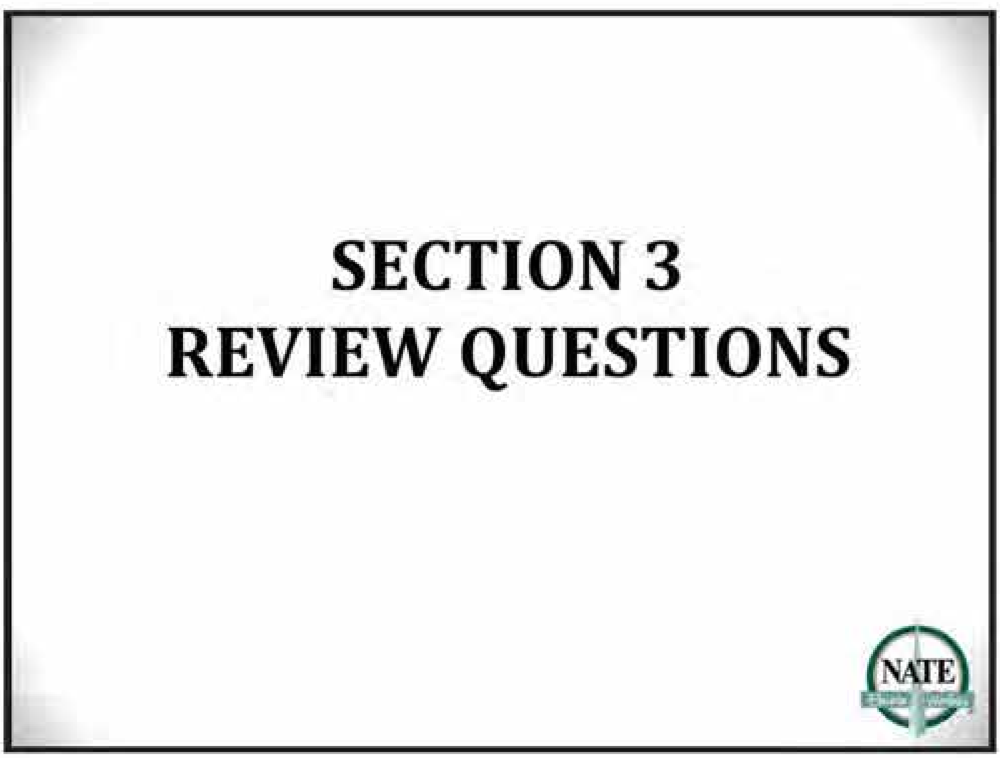
Applicable ANSI Standards

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

Rope Standards

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


A10.48 Standard
Climber Connection Video
NATE


SECTION 3
REVIEW QUESTIONS
NATE

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

A. ANSI/TIA 322

B. ANSI/ASME B30.26

C. OSHA 29 CFR 1926

D. ANSI/ASSE A10.48

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

A. Tower Technician II

B. Qualified Person

C. Competent Rigger

D. Qualified Engineer

Which construction class always requires engagement of a qualified engineer?

A. Class IV
B. Class I
C. Class III
D. Class II

Which standard contains inspection and retirement criteria for synthetic ropes?

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

Section 4

Synthetic Rope

Topics

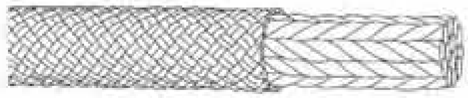
Having knowledge of all equipment in your lifting plan is critical.

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

Synthetic Rope

Kernmantle Rope

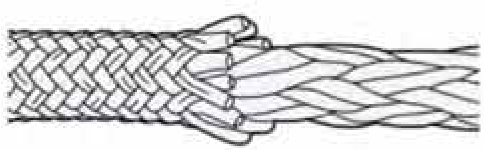
- Ideal for use in rescue, lifelines, ascent/decent rope access work.
- Highest Strength/Weight Ratio.
- The most frequent kernmantle rope diameters used in telecom is 12mm (1/2").



NATE

Double Braid Rope

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



NATE

3 Strand Rope

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

NATE

Know Your Rope

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

NATE

Terms for Rigging

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

Diameter & MBS

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

Example:

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

Calculating WLL

Breaking Strength ÷ Factor of Safety

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

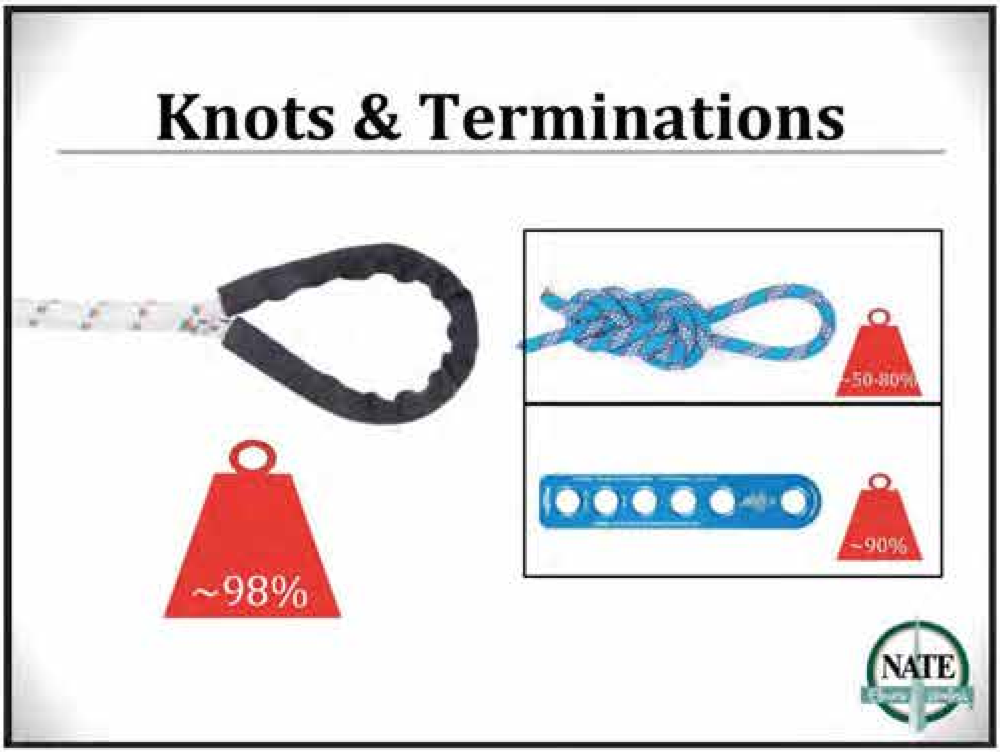
What is the WLL that can be safely lifted?

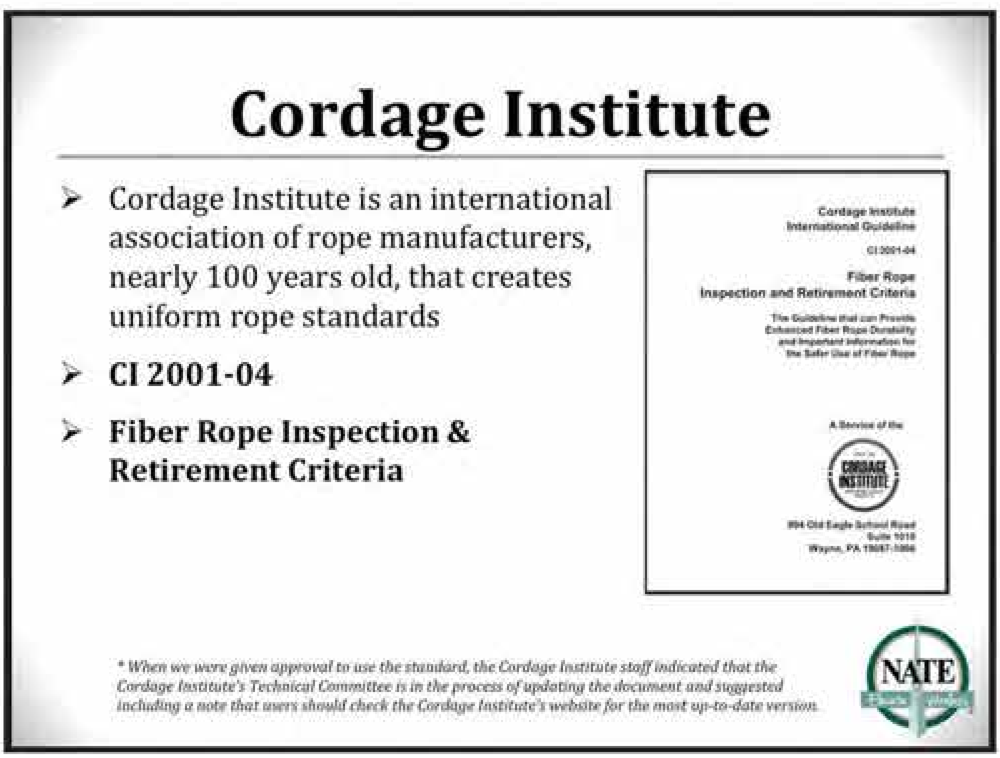
Calculating WLL

Breaking Strength ÷ Factor of Safety

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

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


Knots & Terminations
~50-80%
~90%
~98%
NATE


Cordage Institute
➢ Cordage Institute is an international association of rope manufacturers, nearly 100 years old, that creates uniform rope standards
➢ CI 2001-04
➢ Fiber Rope Inspection & Retirement Criteria
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
A Service of the
* When we were given approval to use the standard, the Cordage Institute staff indicated that the Cordage Institute's Technical Committee is in the process of updating the document and suggested including a note that users should check the Cordage Institute's website for the most up-to-date version.
NATE

CI 2001-04 Guidelines

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

CI 2001-04 Guidelines

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

CI 2001-04 Requirements

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

CI 2001-04 Requirements

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

Rope Inspection Log

- CI 2001-4.3
  - "An important tool for rope evaluation is a log. This will include data on the type of rope, time in service and description of intended use. The details of every inspection should be entered in the log as to date, location and conclusions. The log should include a regular inspection schedule."
- CI 2001-5.1.1
  - During the inspection, identify the rope with a tag.
  - Shrink tube is an inexpensive solution.

Sample Rope Log

Rope Inspection

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

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

Rope Inspection

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

Rope Inspections

Can this rope be used safely?

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

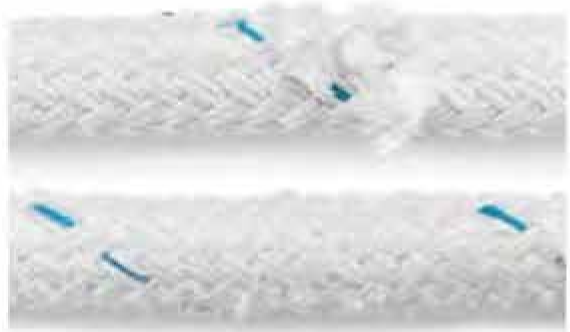
Rope Inspections

Can this rope be used safely?

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

Rope Inspections

Can this rope be used safely?



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

Rope Inspections

Can this rope be used safely?

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

Rope Care & Maintenance

Washing

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

Drying

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

Recording

- Record the cleaning in your rope log.

Rope Storage

Storage

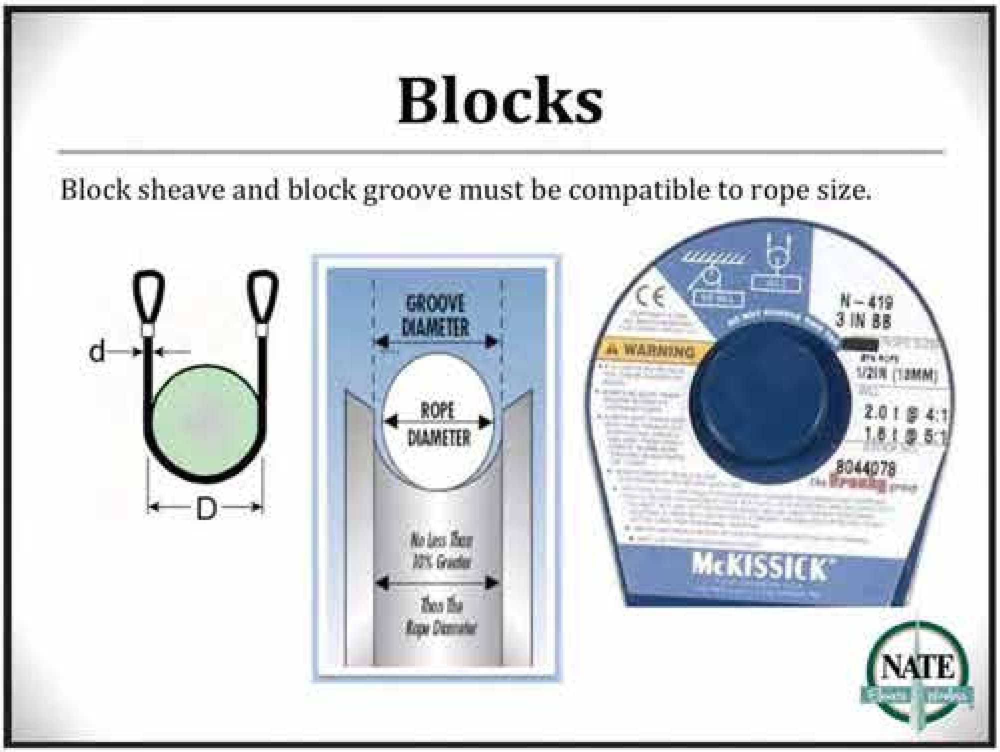
- Store your rope in a cool, clean, dark, dry environment.
- Excess humidity will damage your rope.

Other Components

ANSI B30 Compliant Blocks, Shackles, Slings

Blocks

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


Blocks
Block sheave and block groove must be compatible to rope size.
d
D
GROOVE DIAMETER
ROPE DIAMETER
No Less Than 10% Greater Than the Rope Diameter
N – 419
3 IN BB
WARNING
2.0 t @ 4:1
1.8 t @ 5:1
McKISSICK
NATE


DO NOT USE
NATE

Block Marking Requirements

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

Block Inspections

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

Block Retirement

- Rigging blocks shall be removed from service if conditions such as those included in, but not limited to, the list below are present:
  - Missing/illegible identification
  - Misalignment or wobble in sheaves
  - Excessive sheave groove wear
  - Loose more missing hardware
  - Indications of heat damage including weld 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

Sling Marking Requirements

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

ASME B30.9 Sling Inspections

Sling Inspections

Can these slings be used safely?

Sling Inspections

Can these slings be used safely?

Sling Inspections

Can these slings be used safely?

Inspection Requirements

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

Endless Synthetic Sling Chart

Part No.	Color		Rated Capacity (lbs.)* 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	8	2.8	2 3/4	4	2
EN800	Olive		66,000	52,800	132,000	93,000	8	3.4	3 1/8	4 5/8	2 1/8
EN1000	Black		90,000	72,000	180,000	127,000	8	4.3	3 5/8	5 1/4	2 1/2

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

Shackle Marking Requirements

Per ASME B30.26, each shackle shall have:

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

Shackle Inspections

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

Shackle Retirement

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

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.

NATE

SECTION 4
REVIEW QUESTIONS

What information must be durably marked on the rigging block?

A. Working load limit

B. Rope length

C. Date of manufacture

D. Part number

Synthetic Rope

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

A. 2,200 lbs.

B. 5,500 lbs.

C. 11,000 lbs.

D. 1,100 lbs.

The best place to store rope not in use is?

A. The bed of a truck

B. A moist location

C. Clean, dark, dry location

D. The ground

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

A. American Society of Mechanical Engineers

B. Cordage Institute

C. TIA (Telecommunications Industry Association)

D. OSHA

It is important to regularly clean your rope because?

A. A clean rope is a good rope

B. It protects it from the sun

C. Prevents rope tangling

D. Dirt causes internal friction and weakens rope

What information should be included in a rope inspection log?

A. Date of manufacturing

B. Storage method

C. Country of manufacturing

D. Temperature

What is the weakest link in this hoisting system?

A. 1,000 lbs. Capstan Hoist

B. 3/8" Double Braid Rope with 5,000 MBS

C. Block (2 tons)

D. ½" Shackle (2 tons)

Section 5

Rigging Forces and Lift Systems

Topics

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

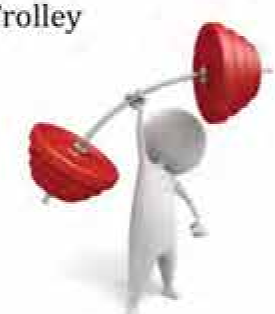
Calculation Notes

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

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

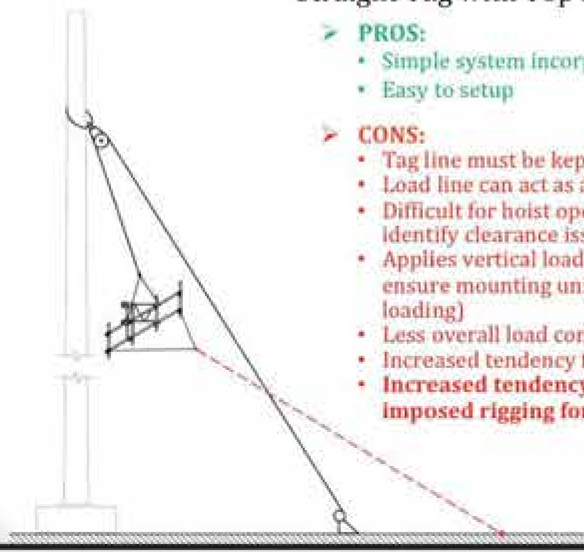
Typical Lift Configurations

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



Typical Lift Configurations

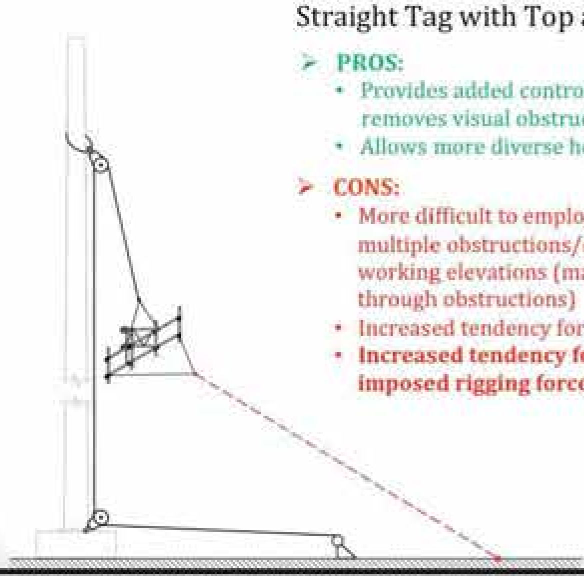
Straight Tag with Top Block Only:



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

Typical Lift Configurations

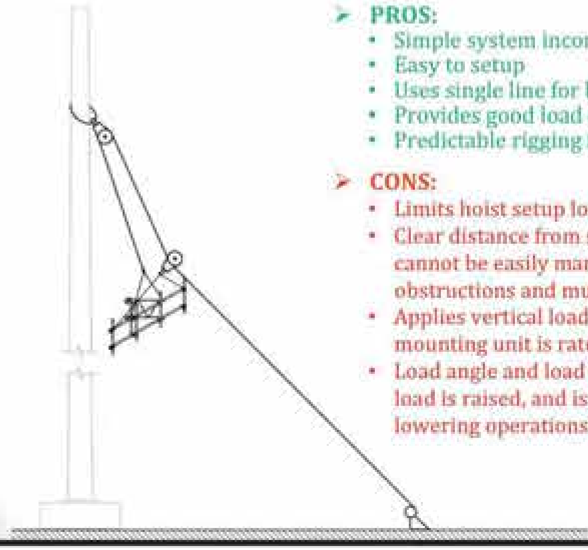
Straight Tag with Top and Heel Blocks:



- **PROS:**
  - Provides added control to lead line and removes visual obstruction
  - Allows more diverse hoist setup options
- **CONS:**
  - More difficult to employ on towers with multiple obstructions/equipment below working elevations (may require reeving through obstructions)
  - Increased tendency for shock/impact loads
  - **Increased tendency for developing high imposed rigging forces due to tag forces**

Typical Lift Configurations

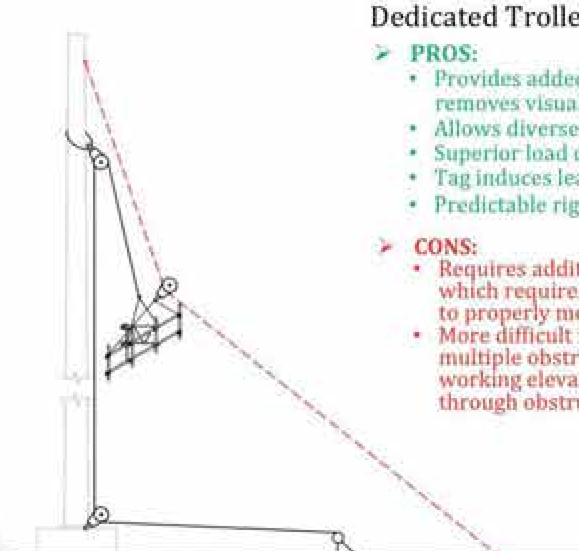
Integrated Trolley (aka Self-Trolley):



- **PROS:**
  - Simple system incorporating only one block
  - Easy to setup
  - Uses single line for both lifting and control
  - Provides good load control
  - Predictable rigging forces in load line
- **CONS:**
  - Limits hoist setup locations
  - Clear distance from structure/obstructions cannot be easily manipulated during lift (issue for obstructions and multiple work elevations)
  - Applies vertical load to hoisting unit (must ensure mounting unit is rated for vertical loading)
  - Load angle and load line clear distance reduces as load is raised, and is significantly less during lowering operations due to sheave friction

Typical Lift Configurations

Dedicated Trolley:



- **PROS:**
  - Provides added control to lead line and removes visual obstruction
  - Allows diverse hoist setup options
  - Superior load control
  - Tag induces least force onto load
  - Predictable rigging forces in load line
- **CONS:**
  - Requires additional rigging attachments which requires additional crew members to properly monitor
  - More difficult to employ on towers with multiple obstructions/equipment below working elevations (may require reeving through obstructions)

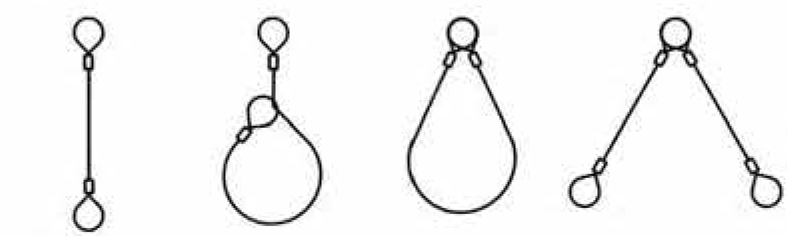
Sling Forces

To determine Sling Force, must know:

1) Applied load
2) Sling hitch configuration
3) Sling angle

Sling Forces

Types of Hitches:

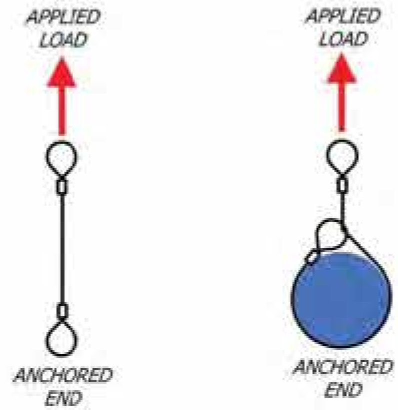


Vertical Hitch | Choker Hitch | Basket Hitch | Bridle Hitch *Multiple Slings*

Sling Forces

Vertical and Choker Hitches:

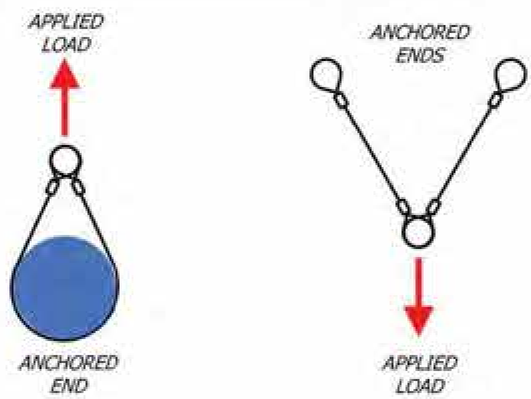
$$\text{Sling Leg Force} = \text{Applied Load}$$



Sling Forces

Symmetrically Loaded Basket Hitches & 2-Leg Bridle Hitches:

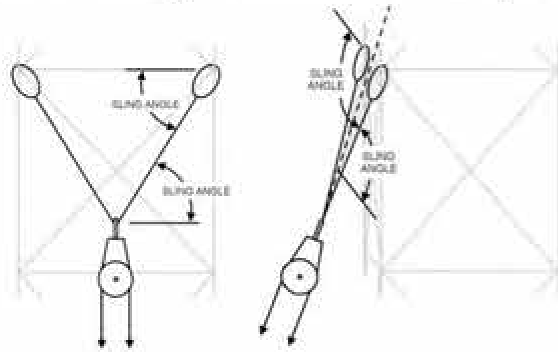
$$\text{Sling Leg Force} = \left(\frac{\text{Applied Load}}{2}\right) \times \text{Angle Factor}$$



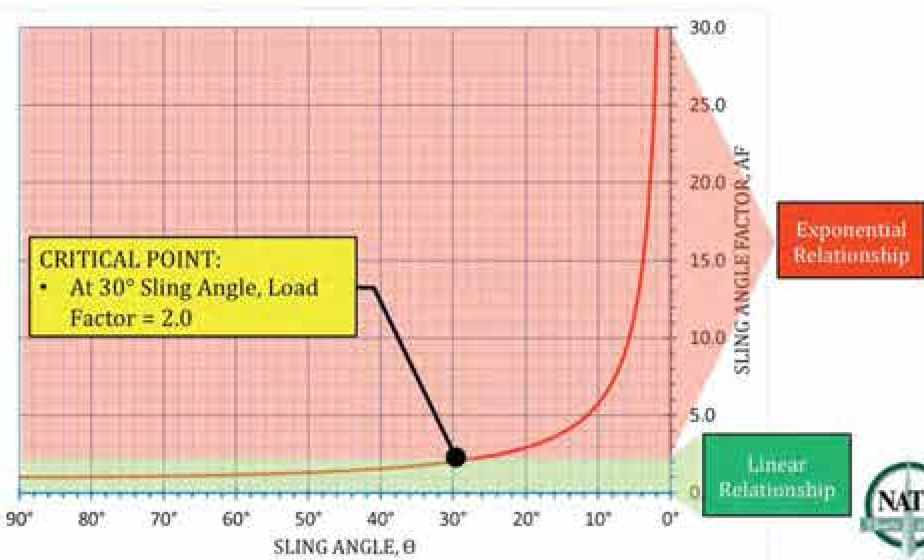
Sling Forces

Sling Angle:

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



Sling Forces



Sling Forces

Sling Angle Factors:

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

Critical Angles To Remember:

1) 60°: Recommended Min Angle per ANSI/ASSE A10.48

2) 45°: Min Angle per ANSI/ASSE A10.48 ~ Below 45° Requires Special Approval

3) 30°: Min Angle per ASME B30.9 ~ Below 30° Requires Special Attention

Block Forces

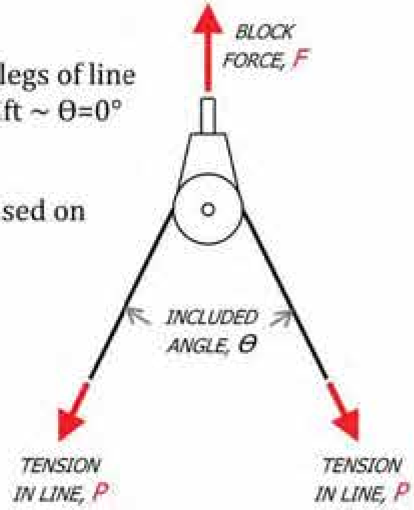
To determine Block Force, must know:

1) Line tension
2) Block included angle

Block Forces

Block Force = Line Tension × 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 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

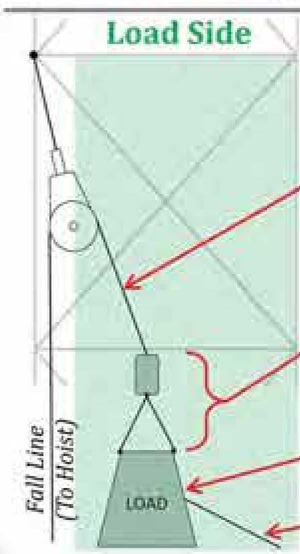
Two Key Standard Angle Factors To Remember:

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

Line Forces

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

Line Forces



Gross Load, WT:

WT = Lifted Load + Rigging Weight on Load Side

Load Line Weight
- Do not need to include fall line weight to hoist

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

Load Weight

Tag Line Weight
- Only include for Straight Tag configurations

Line Forces

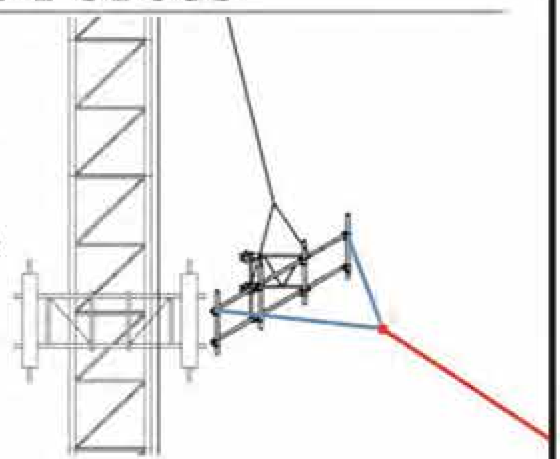
Tag Method:

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

Line Forces

Straight Tag:

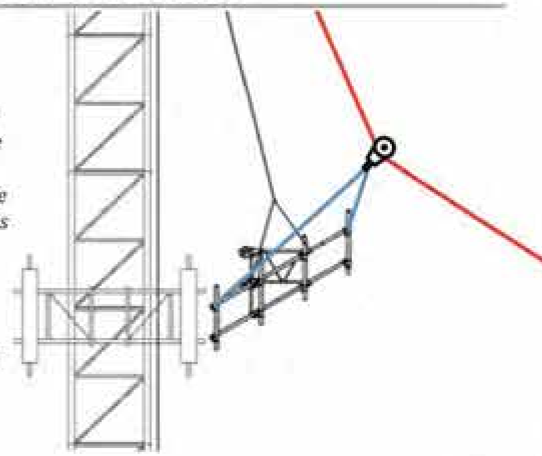
- Tag Line force is directly transferred into the Load Line
- Increased tendency for developing excessive forces in the Load Line
- Increased tendency for shock/impact loading
- Provides simple means for controlling the load with minimal attachments



Line Forces

Trolley Tag:

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

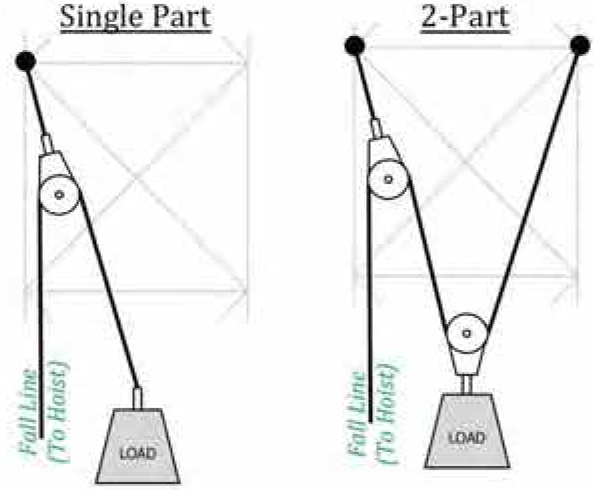


NATE

Line Forces

Number of Line Parts:

Single Part | 2-Part



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Line Forces

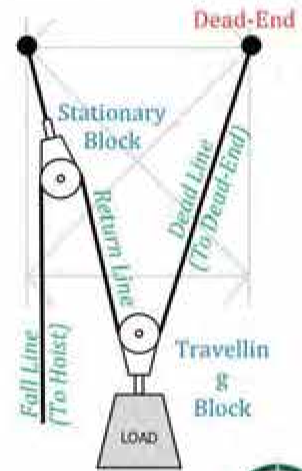
Line Parting Principles:

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

Line Forces

Line Parting Principles:

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



Line Forces

Mechanical Advantage for Typical 2-Part Arrangements:

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

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

Table based on common Bearing Constants, K, as specified

NOTE:

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

Line Forces

Sheave Frictional Resistance:

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

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

Line Forces

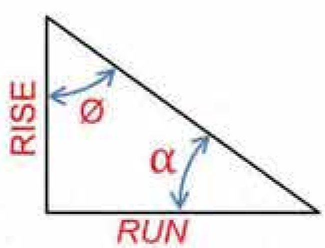
Load Position and Tag Angles:

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

Line Forces

Load Position and Tag Angles:

$$\frac{RISE}{RUN}$$



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

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

Line Forces

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

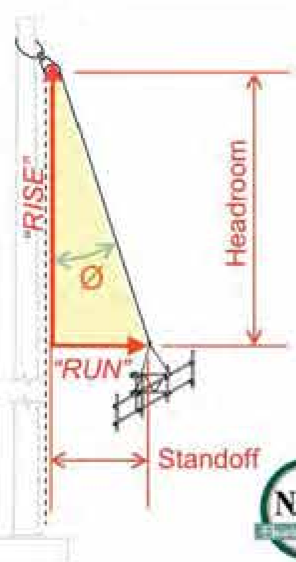
Line Forces

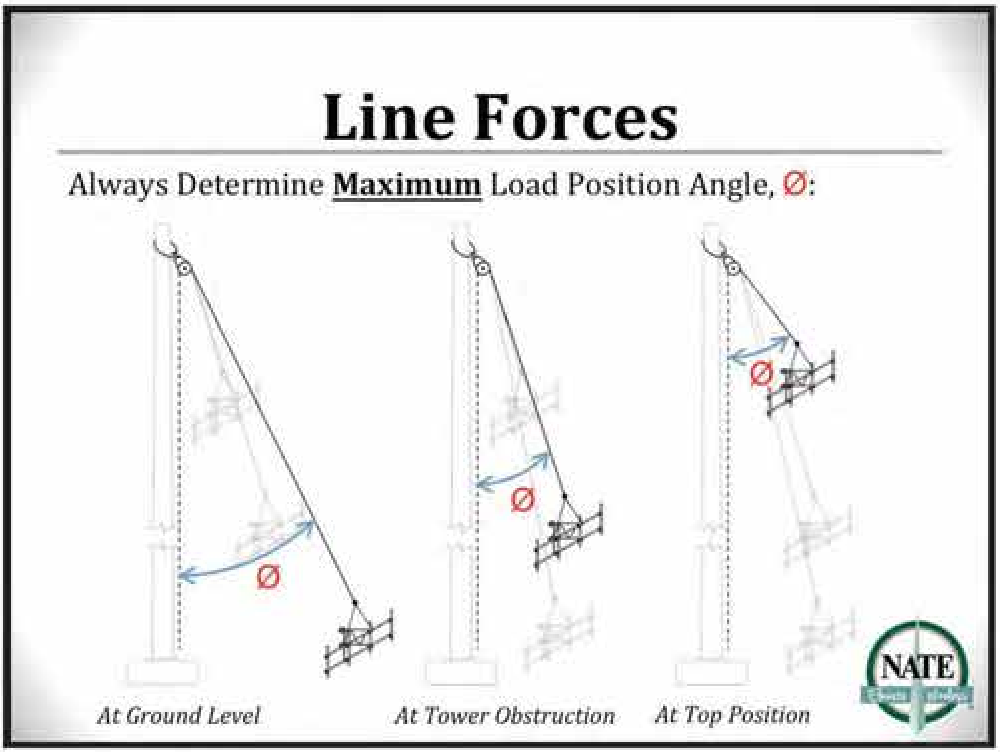
Load Position Angle, Ø:

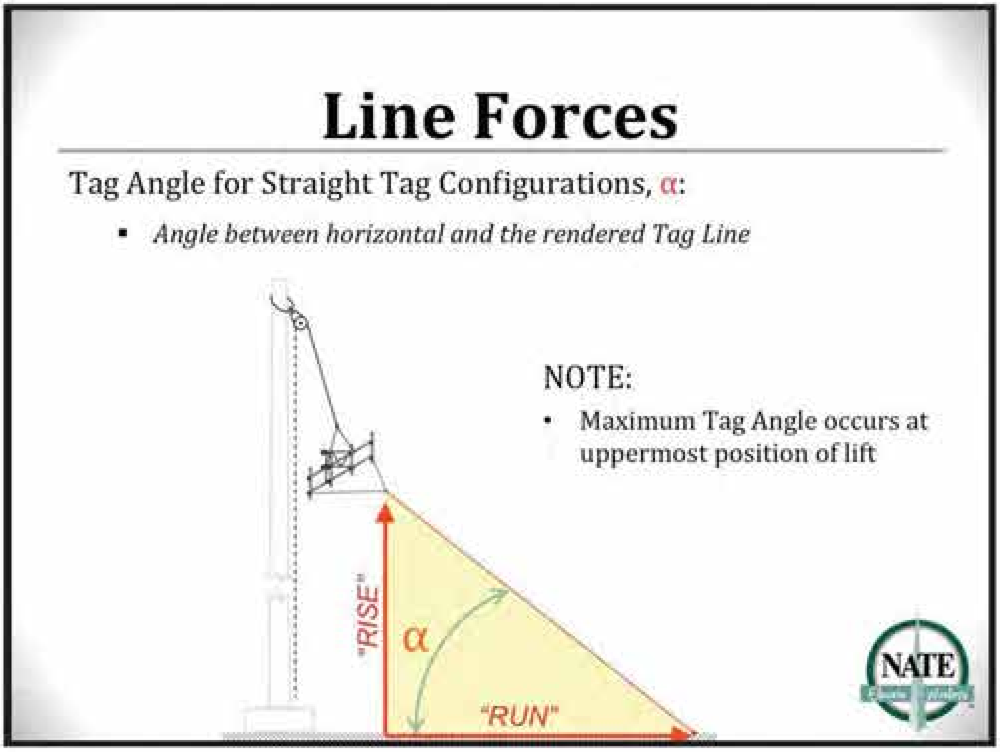
- *Angle between true vertical and the rendered Load Line*
- *Best practice is to limit to 5° or less*
- *Once you exceed 10° on Straight Tag configurations, Load Line force can become excessive*

NOTE:

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




Line Forces
Always Determine **Maximum** Load Position Angle, Ø:
Ø
Ø
Ø
At Ground Level
At Tower Obstruction
At Top Position
NATE


Line Forces
Tag Angle for Straight Tag Configurations, α:
Angle between horizontal and the rendered Tag Line
NOTE:
Maximum Tag Angle occurs at uppermost position of lift
"RISE"
α
"RUN"
NATE

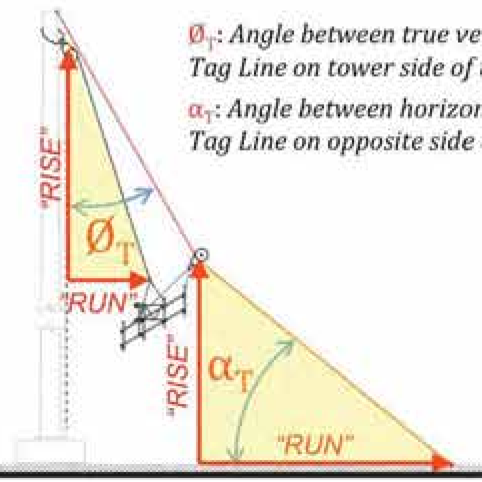
Line Forces

Tag Angles for Dedicated Trolley Configurations, $Ø_T$ & α_T:

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

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

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



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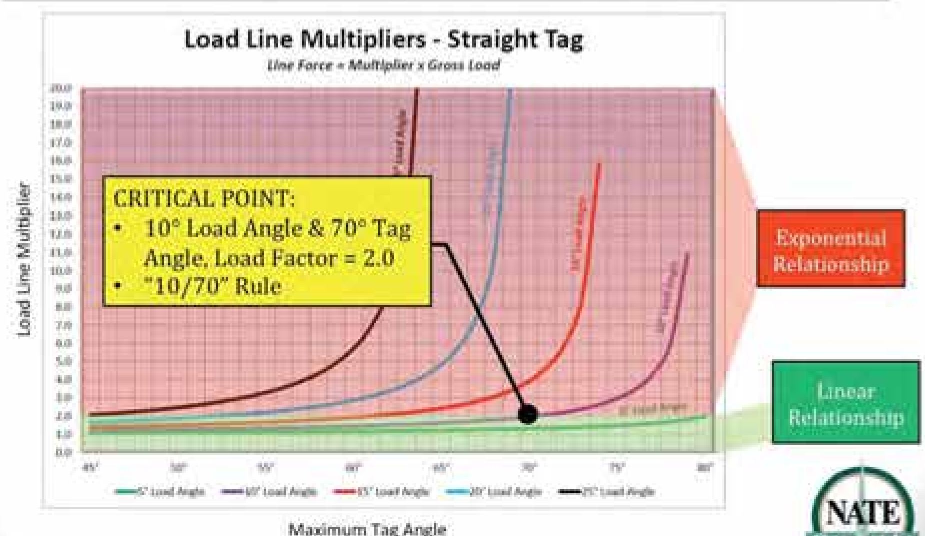
Line Forces



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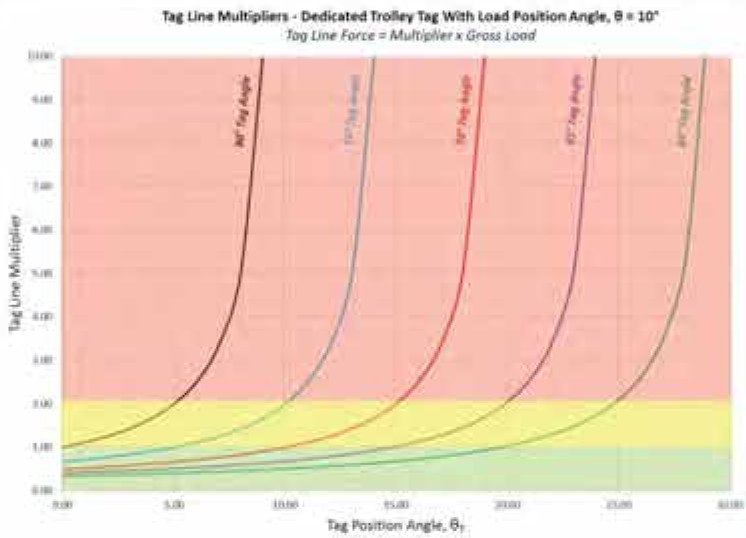
Line Forces



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=**1.0** for Uppermost Position*

TM = Tag Line Multiplier (Refer to Handbook)

N_P = Number of Line Parts in Load Line

N_T = Number of Line Parts in Tag Line

Line Forces

Load Line Pull at Hoist:

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

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.)

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Line Forces

Trolley Block Force:

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

Trolley Block

Where:

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

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Worked Examples

- *Refer to the loose Straight Tag Example and forms provided in your Handbook*
- *Turn to Page 98 of your Handbook to locate the Tables we'll be using for this example*

Straight Tag Example

- *Refer to loose handouts in the back of your Handbook for the STRAIGHT TAG EXAMPLE:*

Straight Tag Example

STRAIGHT TAG EXAMPLE.

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

Load Line Force at Load:________________

Tag Line Force at Load:________________

Load Line Force at Hoist:________________

Top Block Force:________________ Top Block Sling Leg Force:________________

Heel Block Force:________________ Heel Block Sling Leg Force:________________

Straight Tag Example

STEP 1) Determine the Gross Load Weight

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

Straight Tag Example

STEP 1) Determine the Gross Load Weight

Load Info									
	Load Weight: 400 lbs	Actual ☐	Est ☐	Load Line Weight: 20 lbs	Actual ☐	Est ☐	Tag Line Weight: 20 lbs	Actual ☐	Est ☐
	Rigging Weight: 25 lbs	☐	☐	Overhaul Ball Weight: 0	☐	☐	Misc Weight: 0	☐	☐
	GROSS LOAD, **WT**: **465 lbs**			FALL LINE WEIGHT, **FLW**: 20 lbs			Maximum Load Elevation: 130 ft		

Load Line Weight:
145 ft x 0.14 plf = Approx. 20 lbs

Tag Line Weight:
145 ft x 0.14 plf = Approx. 20 lbs

GROSS LOAD WEIGHT:
400 + 20 + 20 + 25 = **465 lbs**

Fall Line Weight, FLW:
145 ft x 0.14 plf = Approx. 20 lbs

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

NATE

Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

NATE

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:				

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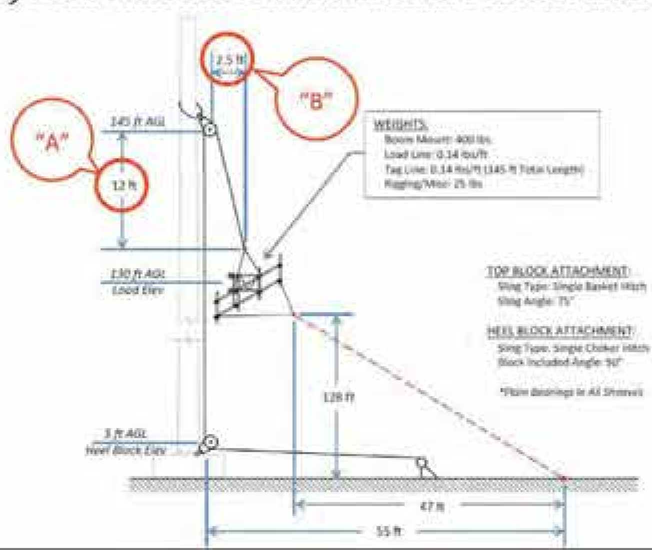
Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles



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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

Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Table A4. Rise-to-Run Angle Conversion

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

RISE/RUN =12/2.5 =4.80 ~ *Results in Load Position Angle of* 12°

NATE

5

ADVANCED RIGGING PRINCIPLES TRAINING COURSE STUDENT WORKBOOK

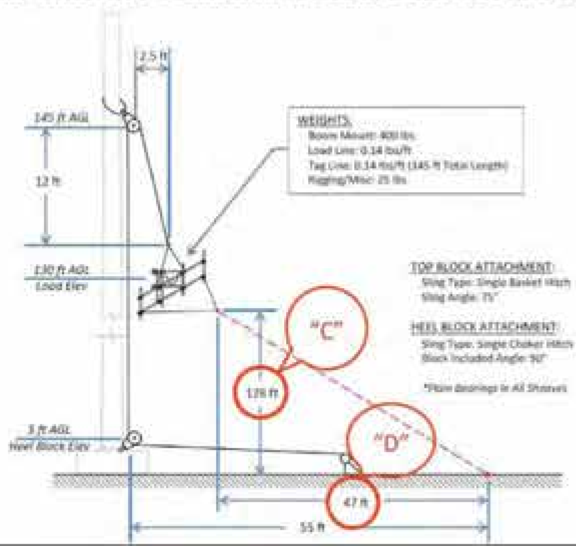
Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

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

Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles



Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

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

RISE/RUN =128/47 =2.72

Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

Table A4. Rise-to-Run Angle Conversion

θ (deg)	RISE/RUN	α (deg)	θ (deg)	RISE/RUN	α (deg)	θ (deg)	RISE/RUN	α (deg)
90°	—	0°	60°	0.58	30°	30°	1.73	60°
89°	0.02	1°	59°	0.60	31°	29°	1.80	61°
88°	0.03	2°	58°	0.62	32°	28°	1.88	62°
87°	0.05	3°	57°	0.65	33°	27°	1.96	63°
86°	0.07	4°	56°	0.67	34°	26°	2.05	64°
85°	0.09	5°	55°	0.70	35°	25°	2.14	65°
84°	0.11	6°	54°	0.73	36°	24°	2.25	66°
83°	0.12	7°	53°	0.75	37°	23°	2.36	67°
82°	0.14	8°	52°	0.78	38°	22°	[illegible]	[illegible]
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°	[illegible]	[illegible]
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°
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°

RISE/RUN =128/47 =2.72 ~ *Results in Tag Angle of* 70°

Straight Tag Example

STEP 2) Determine the Maximum Load Position and Tag Angles

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

Straight Tag Example

STEP 3) Determine the Corresponding Load and Tag Line Multipliers

Tag Method & Lift Angles

Tag Method: X Straight Tag ☐ Integrated Trolley (Self-Trolley) ☐ Dedicated Trolley ☐ Special

Tag Distance: 55 ft

[1]Max Load Position Angle, θ: 12 deg ;round up to nearest degree

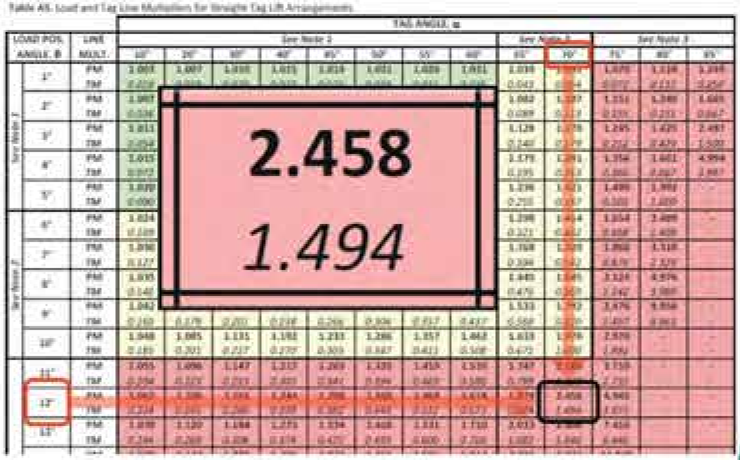
[1]Max Tag Angle, α/α_T: 70 deg ;round up to nearest 5 deg increment

[1]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: N/A ;round up to nearest degree

Straight Tag Example

STEP 3) Determine the Corresponding Load and Tag Line Multipliers



Straight Tag Example

STEP 3) Determine the Corresponding Load and Tag Line Multipliers

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

Straight Tag Example

STEP 4) Determine the Load and Tag Line Forces

LINE FORCES AT LOAD		
Max Load Line Multiplier, **PM**: 2.458	Number of Parts of Load Line, N_P: 1	Load Line Force, **P** = (WT x PM) ÷ N_P: **1,143 lbs**
Max Tag Line Multiplier, **TM**: 1.494	Number of Parts of Tag Line, N_T: 1	Tag Line Force, **T** = (WT x TM) ÷ N_T: **695 lbs**

Load Line Force, P:
$P = (WT \times PM) \div N_P = (465 \times 2.458) \div 1 =$ **1,143 lbs**

Tag Line Force, T:
$T = (WT \times TM) \div N_T = (465 \times 1.494) \div 1 =$ **695 lbs**

Straight Tag Example

STEP 4) Determine the Load and Tag Line Forces

Table A3. Sheave Friction Factors

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

Load Line Configuration → 1-Part

Example States Plain Bearings in all Sheaves

Total Number of Reeved Sheaves = 2

Sheave Friction Factor, SFF = **1.188**

EXAMPLE
TOP BLOCK ATTACHMENT:
Sling Type: Single Basket Hitch
Sling Angle: 75°

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

*Plain Bearings in All Sheaves

Straight Tag Example

STEP 4) Determine the Load and Tag Line Forces

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

Line Pull at Hoist, P_H:

P_H = (P - FLW) x SFF x AM = (1143 - 20) x 1.188 = **1,334 lbs**

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Straight Tag Example

STEP 5) Determine the Block Forces

Table A2. Block Angle Factors

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

Top Block Min Included Angle = 0° when setting load

Top Block Angle Factor, AF = **2.000**

Heel Block Min Included Angle = 90°

Heel Block Angle Factor, AF = **1.414**

EXAMPLE

TOP BLOCK ATTACHMENT:
Sling Type: Single Basket Hitch
Sling Angle: 75°

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

*Plain Bearings in All Sheaves

NATE

Straight Tag Example

STEP 5) Determine the Block Forces

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

Top Block Force, F_{TB}:

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

Heel Block Force, F_{HB}:

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

Straight Tag Example

STEP 6) Determine the Sling Forces

Table A1. Sling Angle Factors

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

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

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

Top Block Sling Angle Factor, AF = **1.035**

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

Heel Block Angle Factor, AF = **1.000**

EXAMPLE

TOP BLOCK ATTACHMENT:
Sling Type: Single Basket Hitch
Sling Angle: 75°

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

*Plain Bearings in All Sheaves

Straight Tag Example

STEP 6) Determine the Sling Forces

SLING FORCES

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

Number of Sling Legs, N_{STB}: 2 ; "1" for typical vertical or choker hitches, or "2" for typical basket or 2-leg bridle hitches

Sling Angle (for Basket/Bridle Hitches): 75° Sling Angle Factor, AF_{STB}: 1.035 Sling Leg Force, $F_{SLTB} = (F_{TB} \times AF_{STB}) \div N_{STB}$: 1,183 lbs

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

Number of Sling Legs, N_{SHB}: 1 ; "1" for typical vertical or choker hitches, or "2" for typical basket or 2-leg bridle hitches

Sling Angle (for Basket/Bridle Hitches): 90° Sling Angle Factor, AF_{SHB}: 1.000 Sling Leg Force, $F_{SLHB} = (F_{HB} \times AF_{SHB}) \div N_{SHB}$: 1,616 lbs

Top Block Sling Leg Force, F_{SLTB}:

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

Heel Block Sling Leg Force, F_{SLHB}:

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

Straight Tag Example

STRAIGHT TAG EXAMPLE.

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

Load Line Force at Load: 1,143 lbs

Tag Line Force at Load: 695 lbs

Load Line Force at Hoist: 1,334 lbs

Top Block Force: 2,286 lbs

Heel Block Force: 1,616 lbs

Top Block Sling Leg Force: 1,183 lbs

Heel Block Sling Leg Force: 1,616 lbs

Remember where we started:

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

Straight Tag Video

SECTION 5
REVIEW QUESTIONS

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

A. 1.414

B. 2.000

C. 1.155

D. 1.000

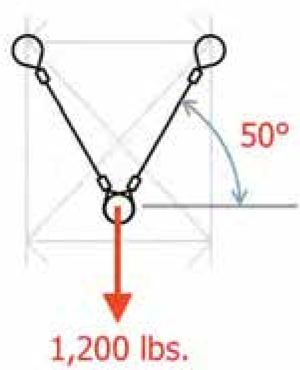
What is the sling force in each sling leg for the straight vertical bridle hitch configuration shown below?

A. 934 lbs.

B. 1,566 lbs.

C. 1,200 lbs.

D. 783 lbs.



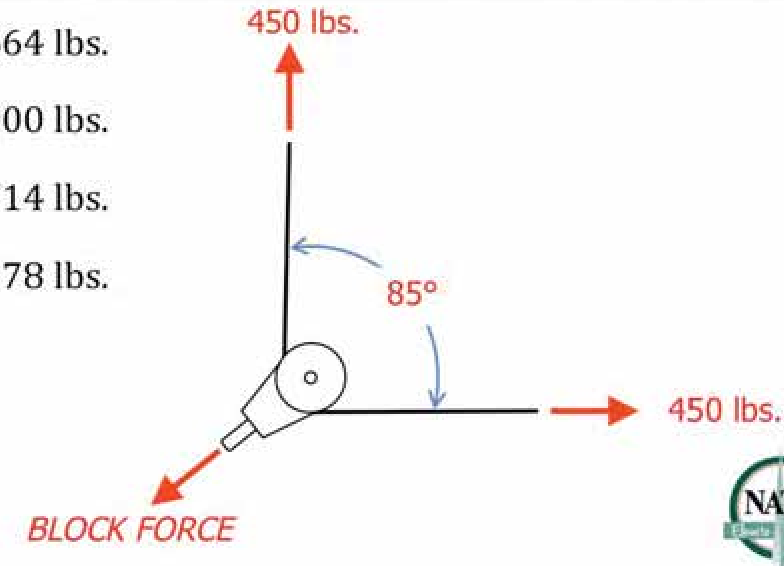
What is the heel block force for the configuration shown below with a hoist line pull of 450 lbs.?

A. 664 lbs.

B. 900 lbs.

C. 714 lbs.

D. 578 lbs.



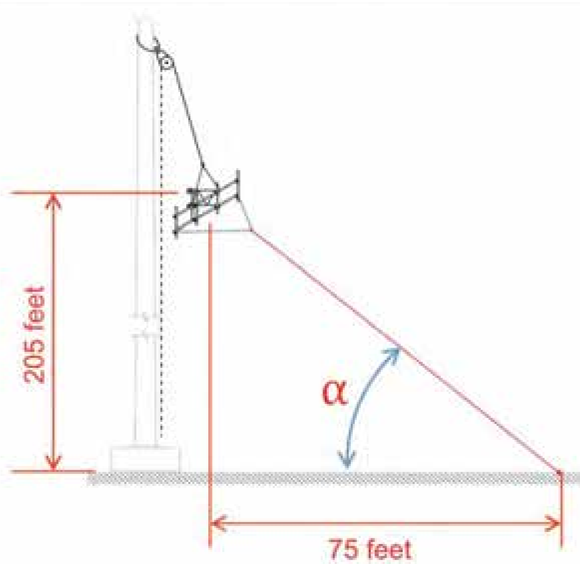
For a load set at 205 feet with the tag positioned at 75 feet away, what is the approximate tag angle when the load is set?

A. 50°

B. 20°

C. 60°

D. 70°



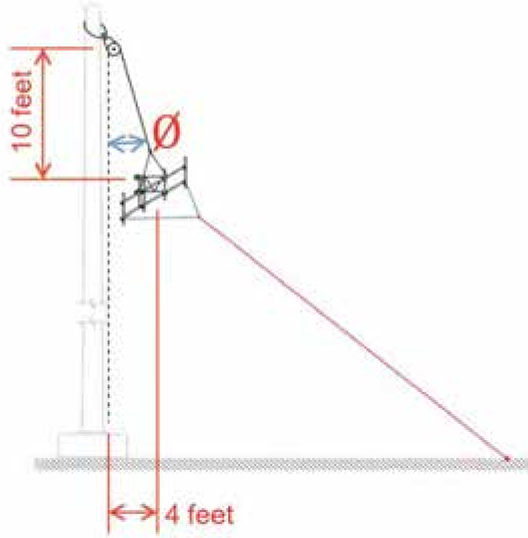
For a load located 10 feet below the top block and tagged out 4 feet, what is the approximate load position angle, Ø?

A. 22°

B. 8°

C. 14°

D. 68°



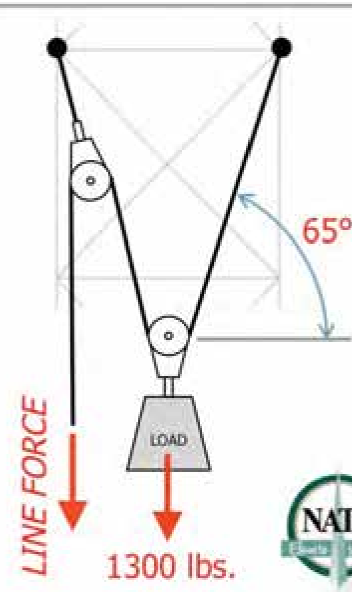
What is the line force at the load for the configuration shown below, assuming no friction factor and no tag?

A. 650 lbs.

B. 717 lbs.

C. 1,434 lbs.

D. 1,300 lbs.



Section 6

Hoisting Operations, Execution and Communication

NATE

Topics

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

NATE

Hoist

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

Capstan Hoist

NOT ALLOWED FOR PERSONNEL LIFTING

Must be equipped with Deadman Switch and Safety Bar

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Hoist Anchorages

What makes up the hoist anchorage in this example?

How can we verify it?

Anchorage Verification

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

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

Field Verification Methods

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

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

Example:

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

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

NATE

Proof Loading

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

NATE

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Load Testing

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

Load Testing

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

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

We put the information in the Rigging Plan

NATE

What's the purpose of the Rigging Plan?

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

NATE

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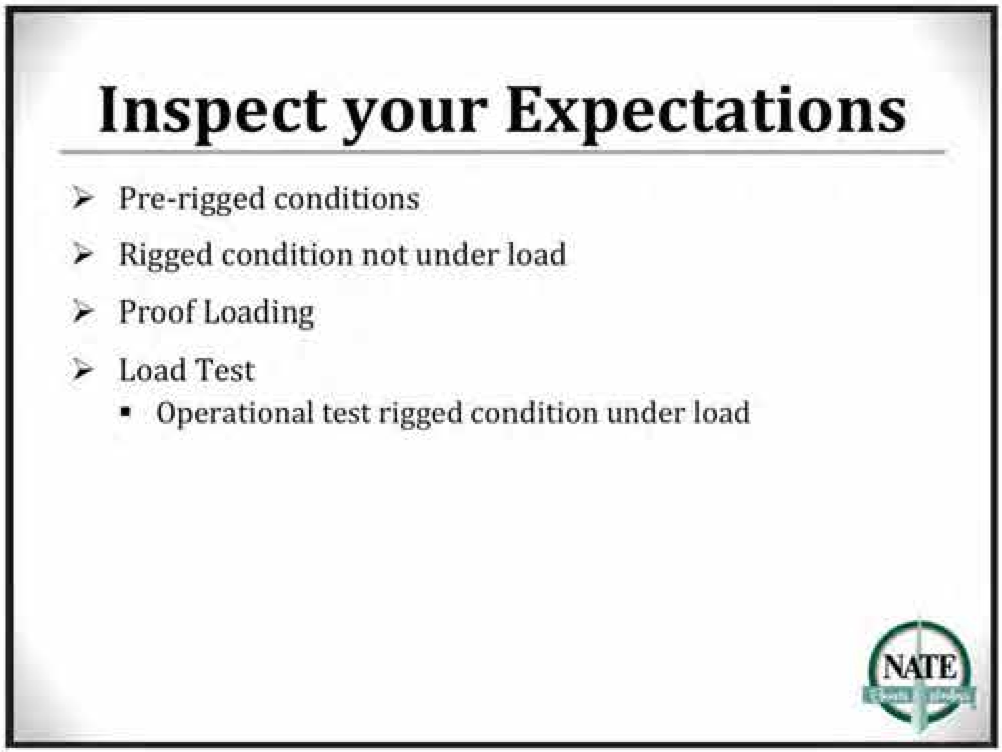
The Plan

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

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


Inspect your Expectations
Pre-rigged conditions
Rigged condition not under load
Proof Loading
Load Test
Operational test rigged condition under load
NATE


What happens when you can't follow the plan Rigging Plan?
You change it!
NATE

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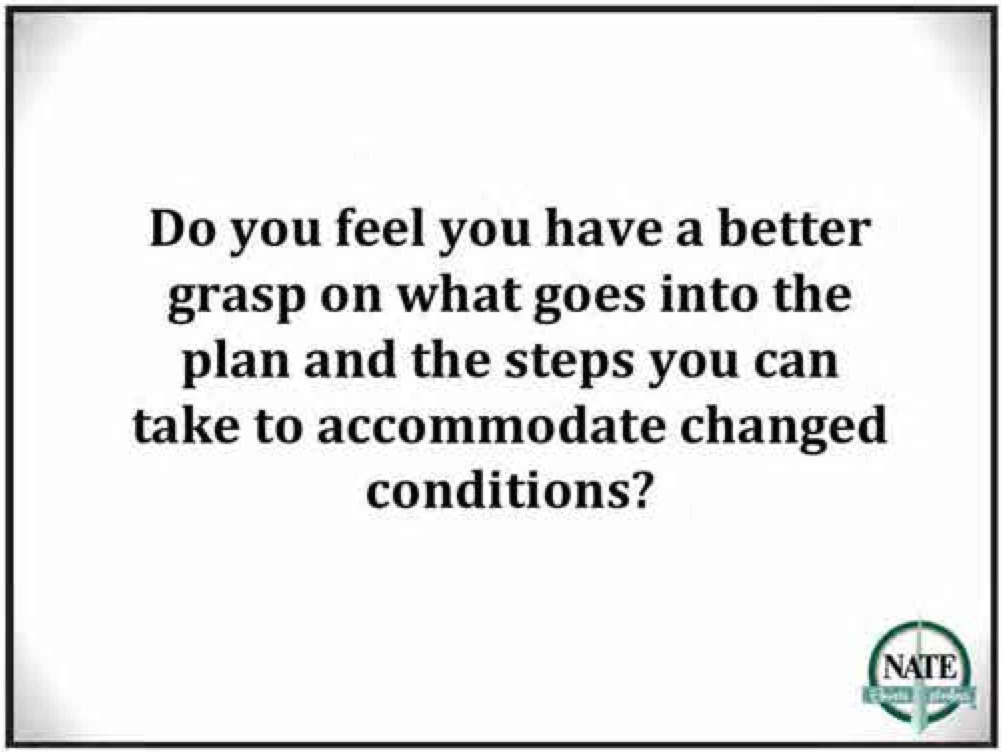
Changing the Plan

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

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


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


How do you typically learn about industry standards?
NATE

99

SECTION 6
REVIEW QUESTIONS

NATE

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

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

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

NATE

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

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

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

A. Class I
B. Class II
C. Class III
D. Class IV

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

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

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

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

NOTES:

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:	

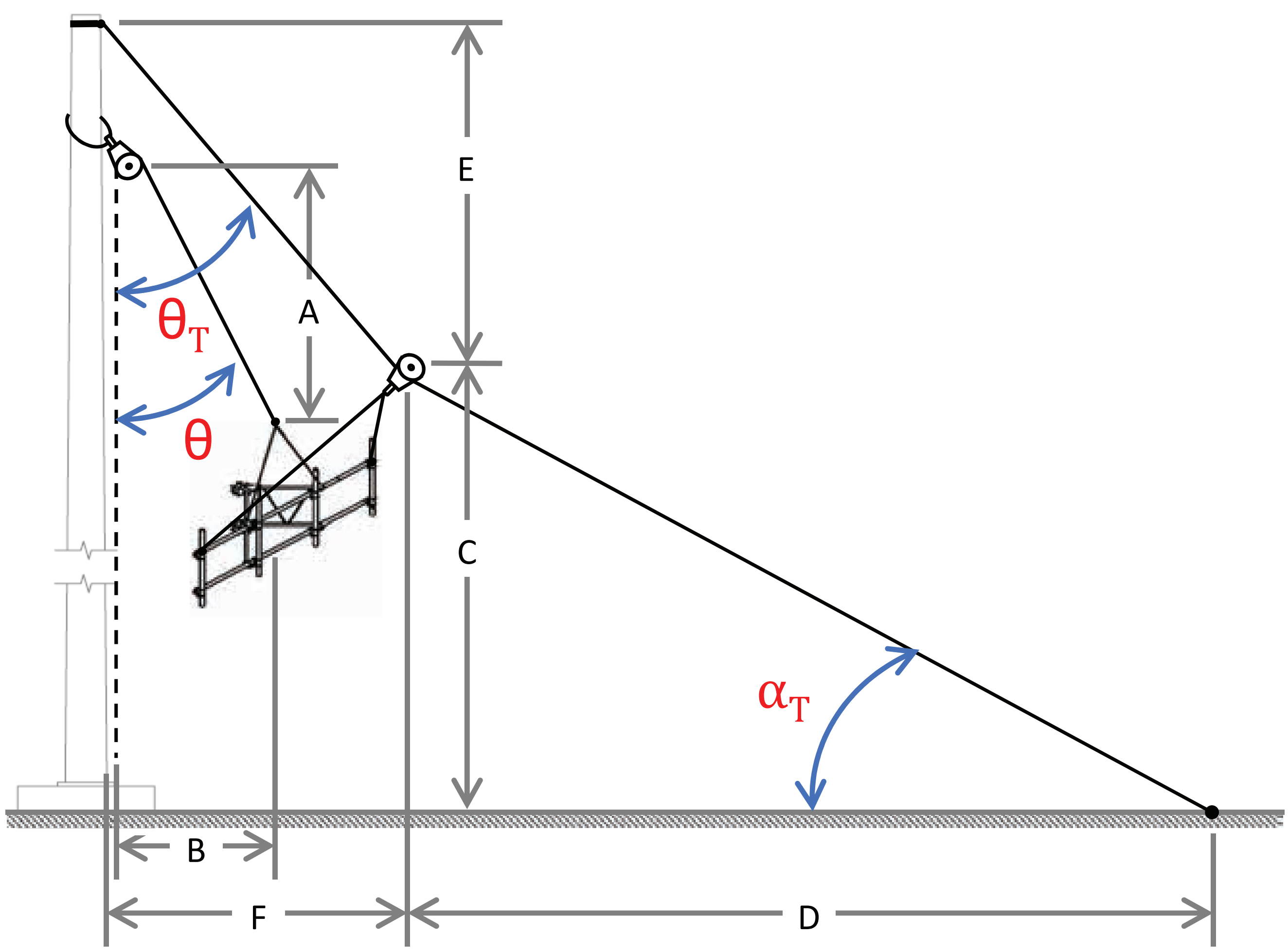
Rigging Plan Class: ☐ Class I ☐ Class II ☐ Class III ☐ Class IV

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:

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

Tag Distance: ______

†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 x PM) ÷ N_P: ______

Max Tag Line Multiplier, **TM**: ______

Number of Parts of Tag Line, N_T: ______

Tag Line Force, **T** = (WT x TM) ÷ N_T: ______

LOAD LINE FORCE AT HOIST

Sheave Friction Factor, **SFF**: ______

Additional Multipliers, **AM**: ______

Line Pull at Hoist, P_H = (P - FLW) x SFF x 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 x AF_{TB}: ______

Min Heel Block Included Angle: ______

Heel Block Angle Factor, AF_{HB}: ______

Heel Block Force, F_{HB} = P x AF_{HB}: ______

Min Trolley Block Included Angle: ______

Trolley Block Angle Factor, AF_{TRB}: ______

Trolley Block Force, F_{TRB} = T x 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} x AF_{STB}) ÷ 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} x AF_{SHB}) ÷ 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} x AF_{STRB}) ÷ 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:

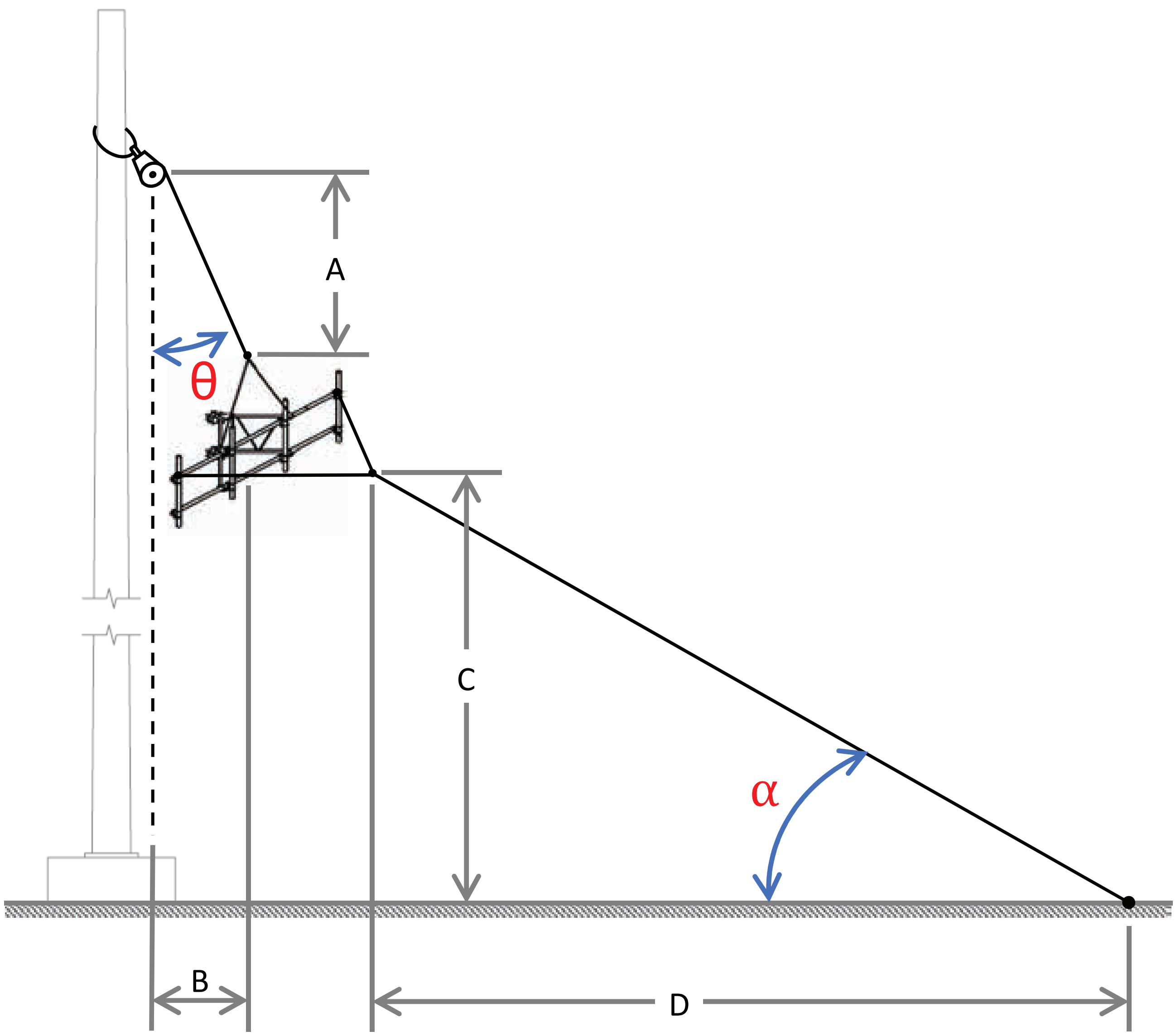


Figure A1. Sling Hitch Types

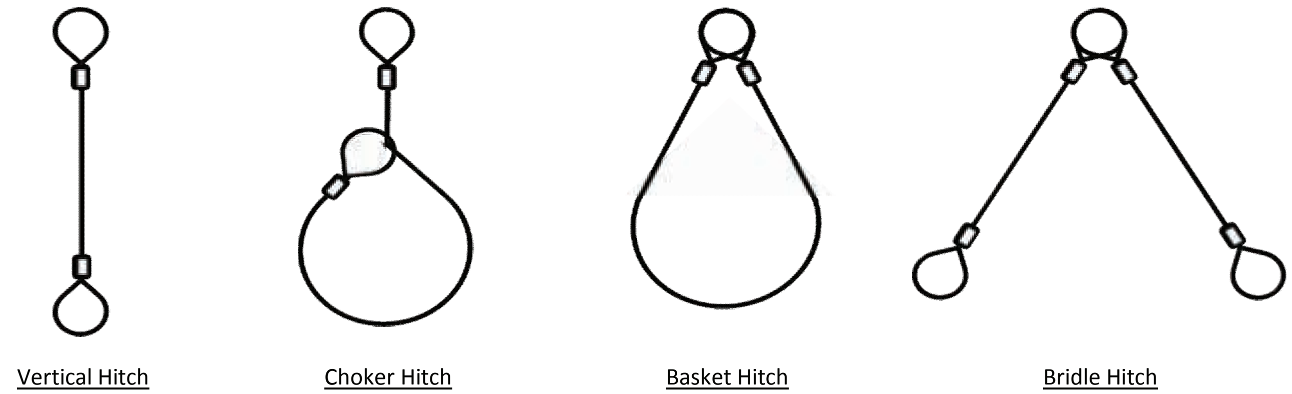
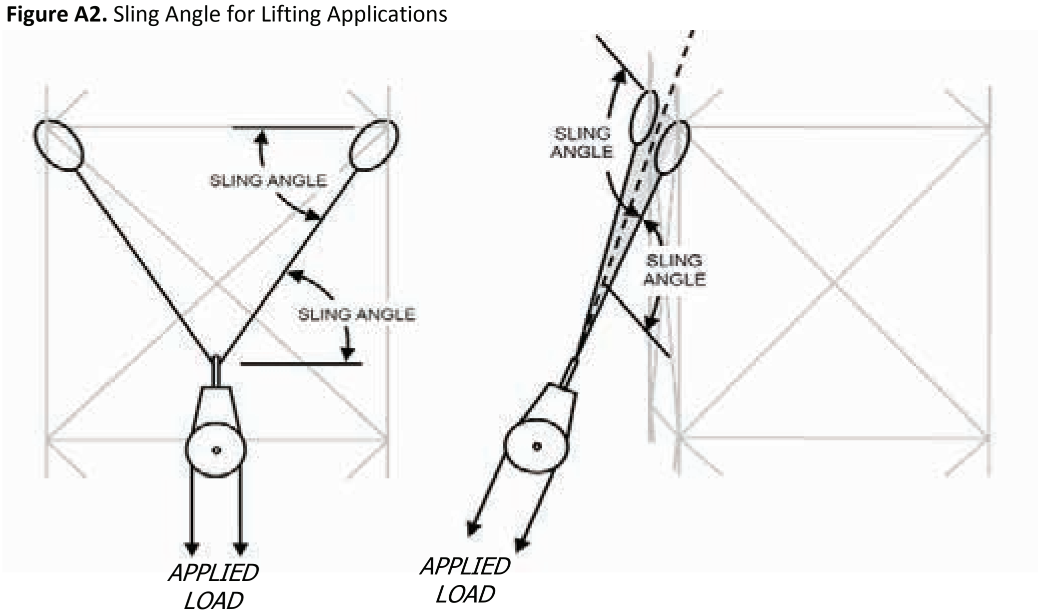


Figure A2. Sling Angle for Lifting Applications



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 qualified person.

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

Block Angle Factors

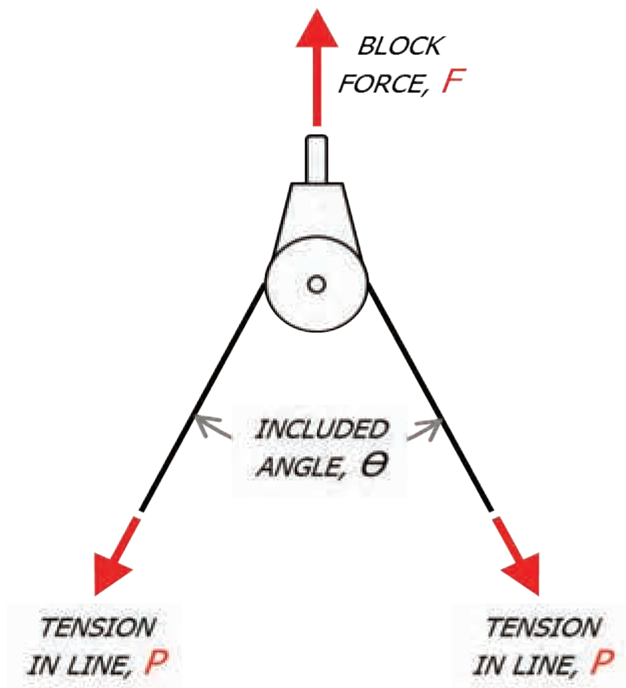


Table A2. Block Angle Factors

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.

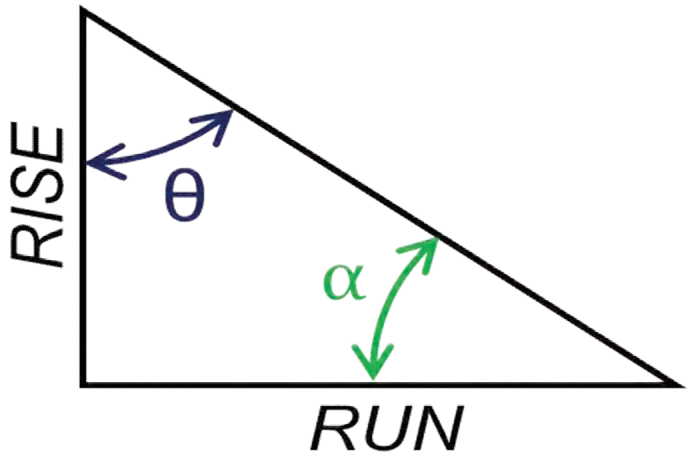


Table A4. Rise-to-Run Angle Conversion

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°

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

			TAG ANGLE, α												
	LOAD POS.	LINE	*See Note 1*								*See Note 2*		*See Note 3*		
	ANGLE, θ	MULT.	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 exercised 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 exercised 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°

		LOAD POSITION ANGLE, Θ = 2°												
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**	**0.972**	**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 exercised 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 A6.3. 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 exercised 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 A6.4. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 4°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 4° 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 exercised 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 A6.5. 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. ANGLE, θ_T	**LINE MULT.**	**TAG ANGLE, α_T**												
		10°	**20°**	**30°**	**40°**	**45°**	**50°**	**55°**	**60°**	**65°**	**70°**	**75°**	**80°**	**85°**
1°	**PM**	**0.934**	**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 exercised 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 exercised 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 exercised 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°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 8° 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 exercised 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 A6.9. 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 exercised 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 exercised 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 exercised 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°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 12° 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 exercised 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 A6.13. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 13°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 13°												
		TAG ANGLE, α_T												
		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 exercised 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 A6.14. 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.	LINE	TAG ANGLE, α_T												
ANGLE, θ_T	MULT.	10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
1°	PM	**0.850**	**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 exercised 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 A6.15. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 15°

TAG POS.	LINE	LOAD POSITION ANGLE, Θ = 15°												
ANGLE, θ_T	MULT.	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 exercised 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 exercised 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 A6.17. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 17°

TAG POS.	LINE	LOAD POSITION ANGLE, Θ = 17°												
		TAG ANGLE, α_T												
ANGLE, θ_T	MULT.	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 exercised 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 A6.18. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 18°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 18° 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 exercised 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 exercised 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 A6.20. Load and Tag Line Multipliers for Dedicated Trolley Tag Arrangements with the Load Position Angle Equal to 20°

TAG POS. ANGLE, θ_T	LINE MULT.	LOAD POSITION ANGLE, Θ = 20° 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 exercised 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

A Service of the

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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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Appendices

List of Illustrations

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

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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

APPENDIX C

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	Repair	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

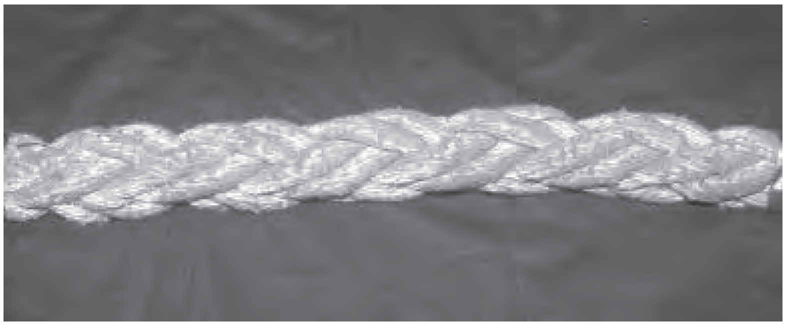

Figure 2
8-Strand Plaited Rope

Figure 3
12-Strand Braided Rope

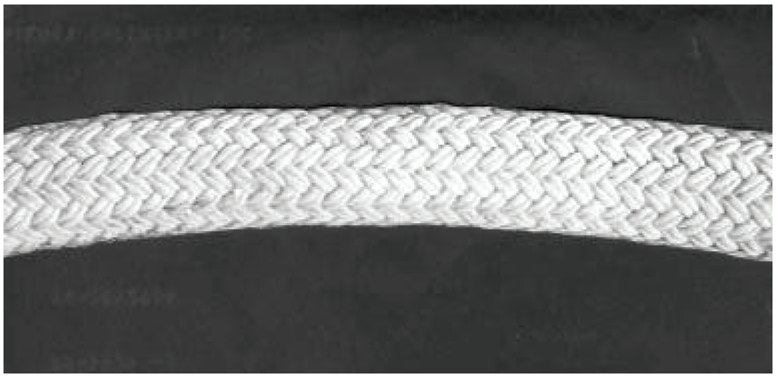

Figure 4
Double Braided Rope

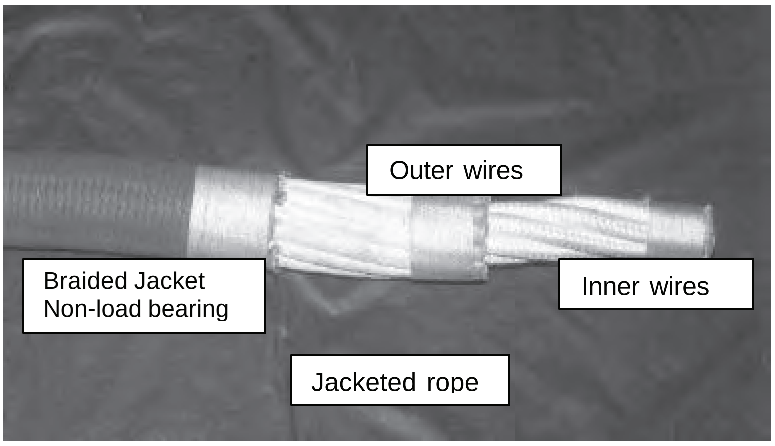

Figure 5
Wire Lay Rope

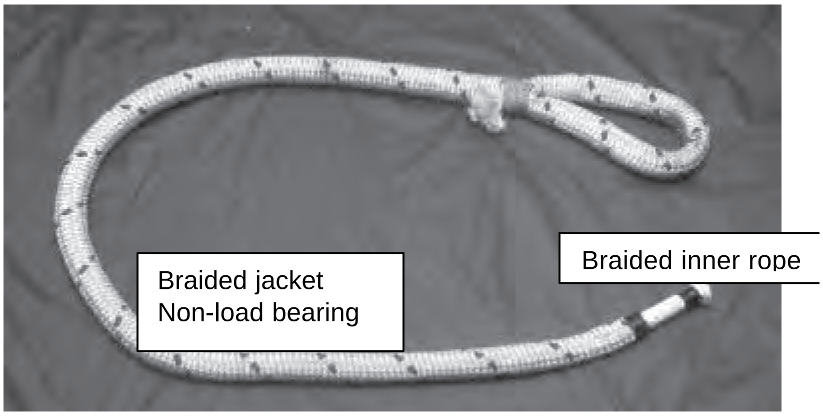

Figure 6
Jacketed Rope

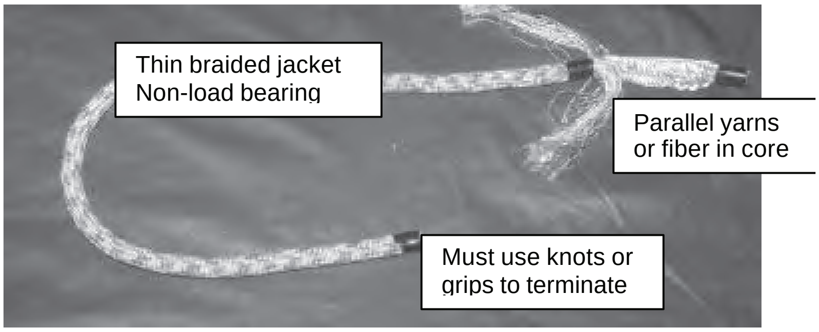

Figure 7
Climbing (kernmantle) Rope

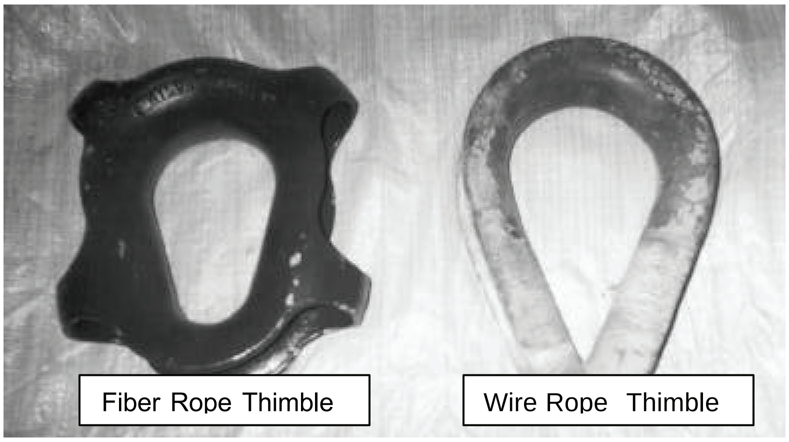

Figure 8
Thimbles

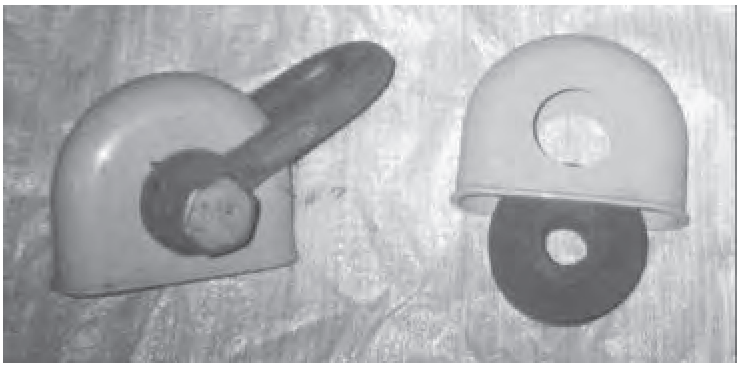

Figure 9
Plastic Thimble for Fiber Rope

APPENDIX D

DAMAGE ILLUSTRATIONS

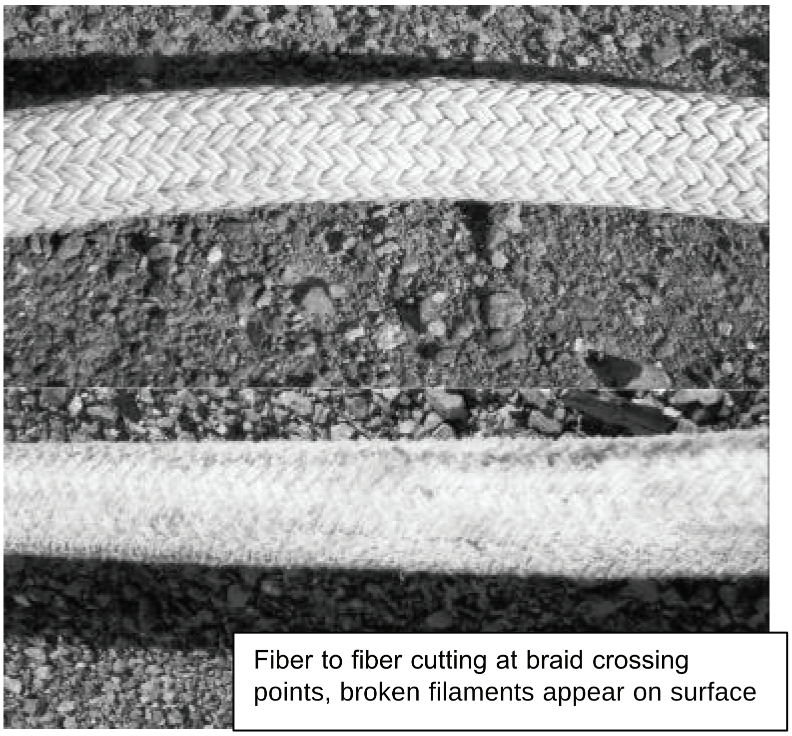

Figure D-001
Fiber Abrasion – Cyclic Tension
Undamaged - Upper Photo

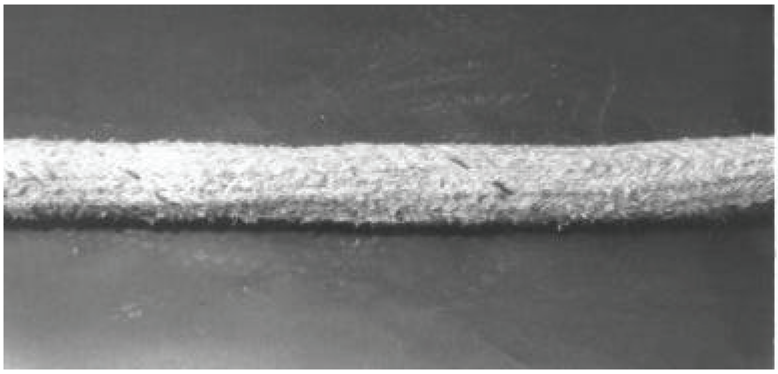

Figure D-002
Fiber Abrasion – Cyclic Tension
(extreme wear)

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)

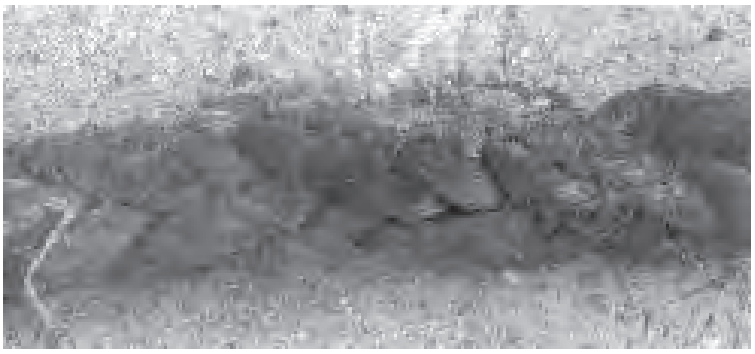

Figure D-006
Extensive External Abrasion

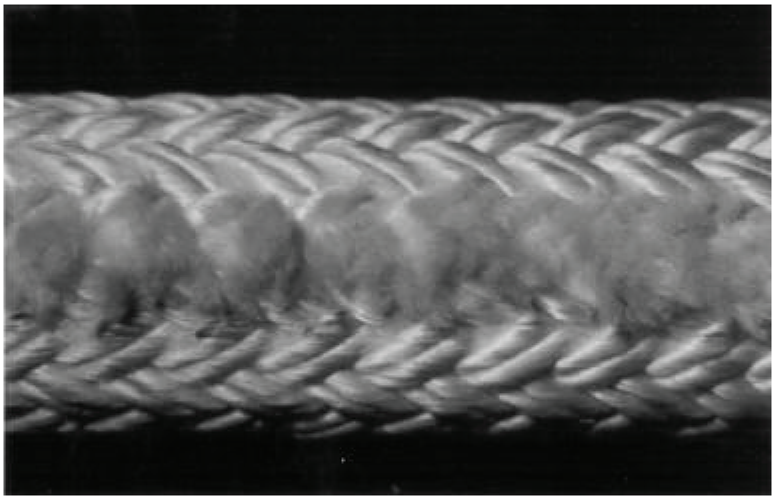

Figure D-007
Localized External Abrasion

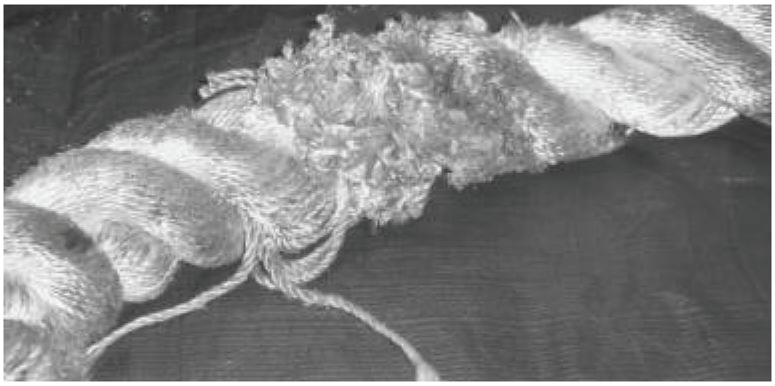

Figure D-008
Localized External Abrasion

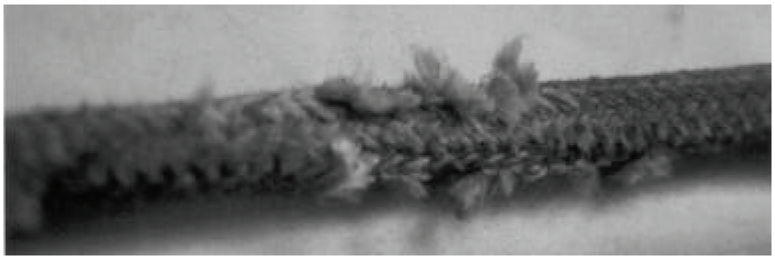

Figure D-009
Localized Jacket Wear

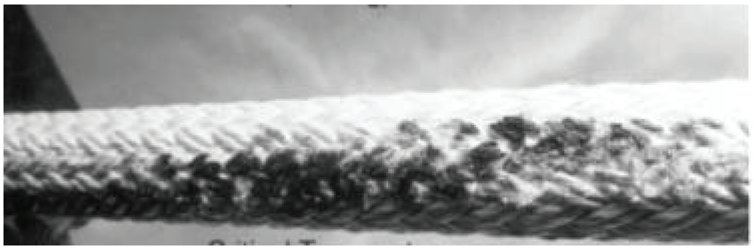

Figure D-010
Burn and Melting from External Abrasion

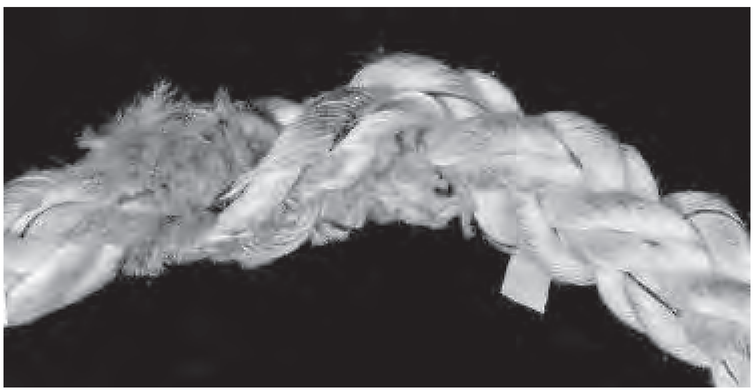

Figure D-011
Cutting

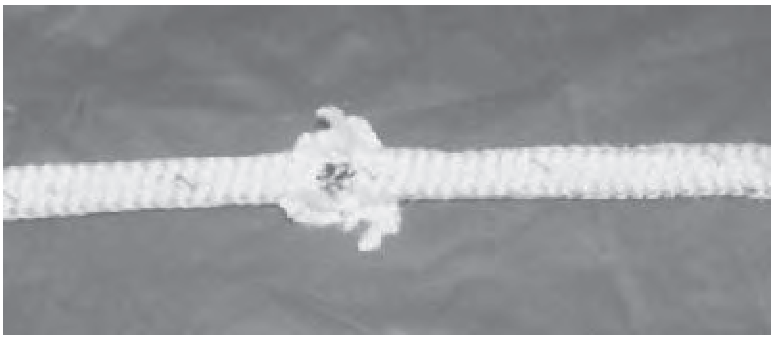

Figure D-012
Cut in Jacket Exposing Core

Figure D-013
Pulled Strand in 8 Strand Rope

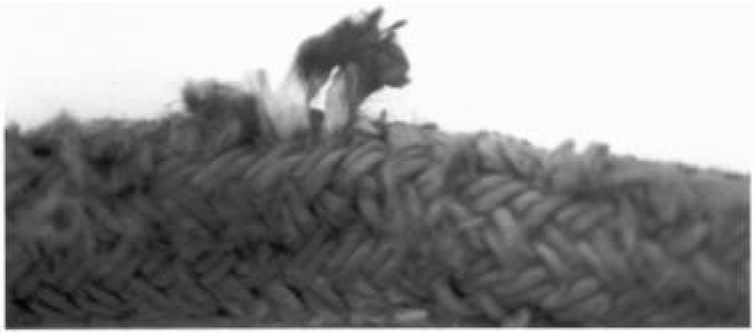

Figure D-014
Pulled Strand in Worn Double Braid
(note color difference due to external dirt)

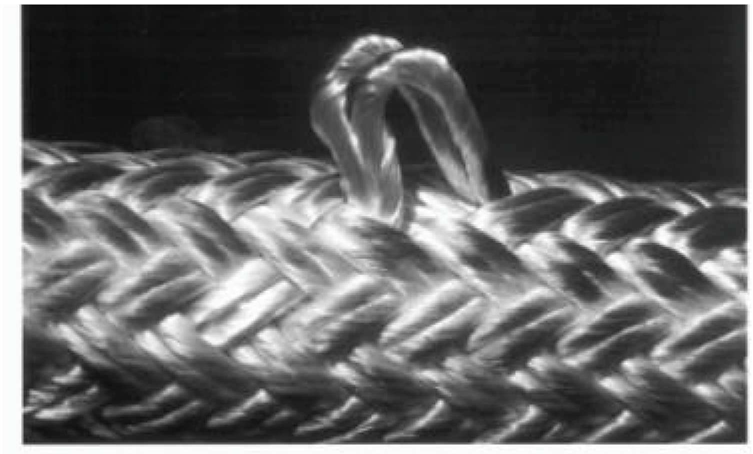

Figure D-015
Pulled Strand in New Double Braid

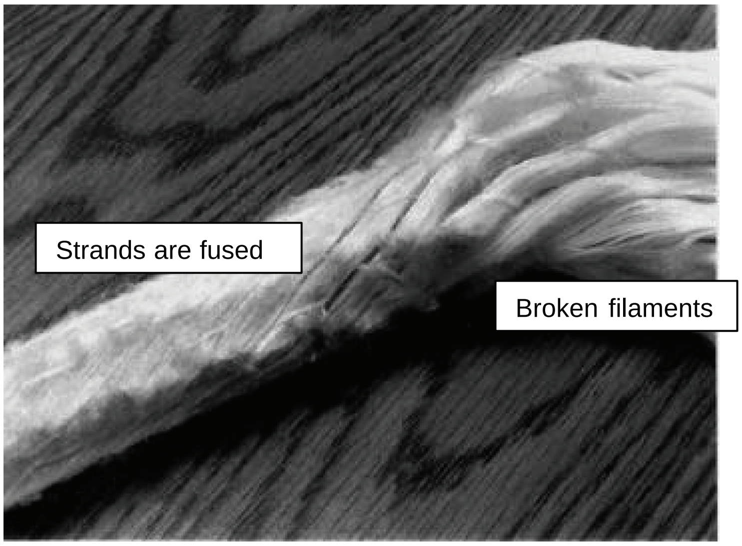

Figure D-016
External & Internal Damage – Running Over Pulley

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

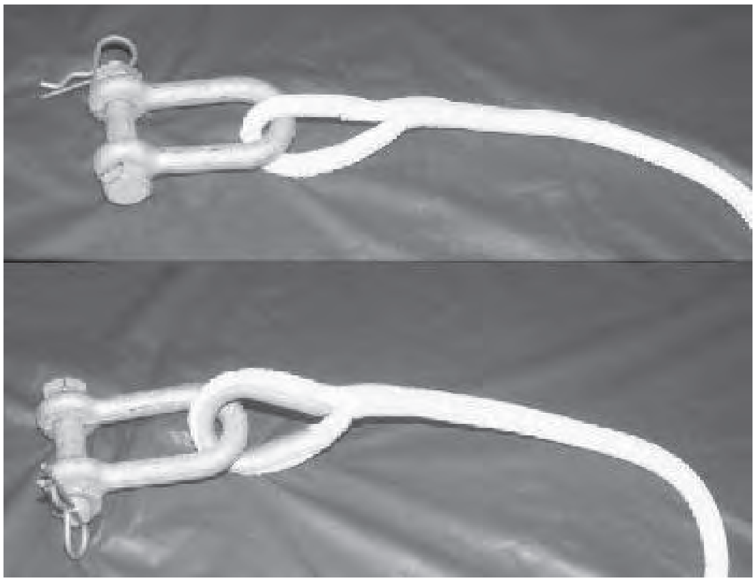

Figure D-021
Rope with Thimble (lower**) and Without (**upper**)**

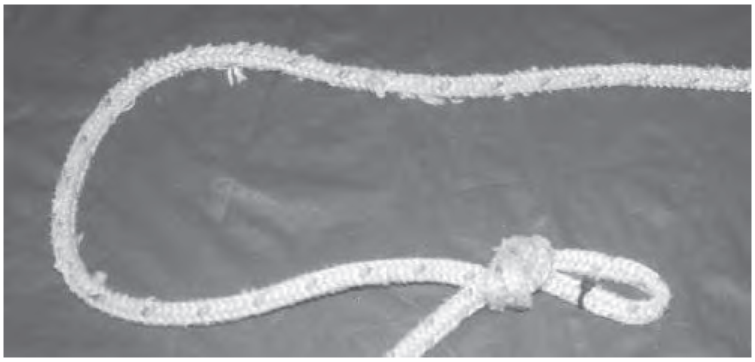

Figure D-022
Knot in Non-Spliceable Rope

Figure D-023
Hockle

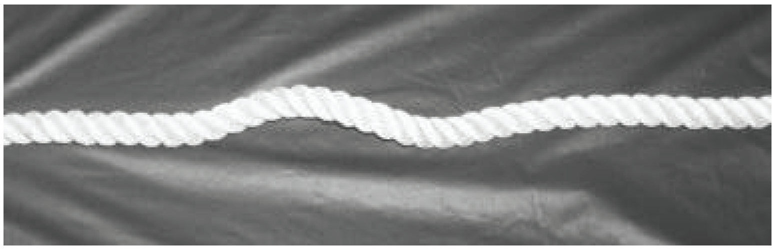

Figure D-024
Corkscrew Due to Twist

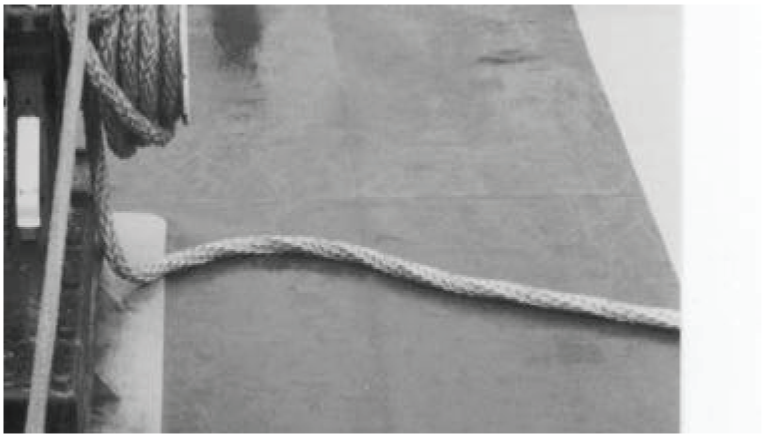

Figure 25
Twist in 12-Stand Braid

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

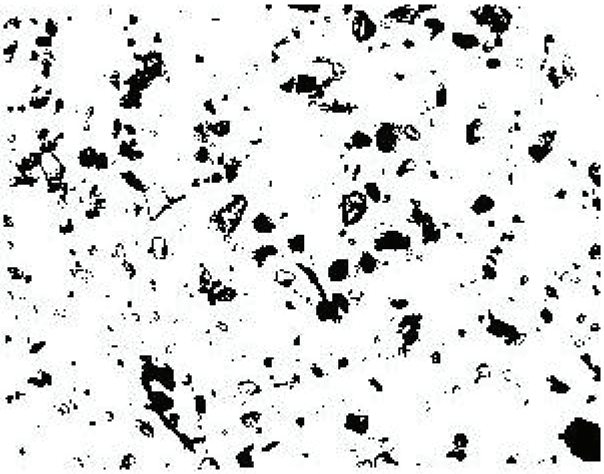

Figure D-027
Dirt and Grit
(revealed by low level magnification)