Note Taking Guide

Rescue Technician—
Technical Rope Rescue

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The Maryland Fire and Rescue Institute of the University of Maryland is the State’s comprehensive training and education system for all emergency services.

The Institute plans, researches, develops, and delivers quality programs to enhance the ability of emergency service providers to protect life, the environment, and property.
Lesson 1-2: Introduction to Technical Rope Rescue

Student Performance Objective

- Given information from discussions, handouts, and reading materials, describe the aspects of rope, webbing, hardware, and harnesses that are applicable to technical rope rescues and demonstrate use of harnesses.

Overview

- Specific Personal Protective Equipment Requirements
- Rope and Webbing Review
- Rope and Webbing Strengths and Classifications
- Rescue Rope Hardware
- Rescue Harnesses
Specific Personal Protective Equipment Requirements

- Related factors
  - Terrain
  - Weather
  - Hazards present
  - Type of tasks
  - Availability of help
  - Specific AHJ requirements

Specific Personal Protective Equipment Requirements

- PPE
  - Head protection
  - Eye protection
  - Harnesses
  - Hand protection
  - Knee and elbow protection
  - Boots
  - Coveralls
  - Lights

Rope and Webbing Review

- Construction materials
  - Natural fibers
  - Synthetic materials
Rope and Webbing Review

- Synthetic Fibers
  - Provide greater strength for size
  - Have single fibers continuous throughout the rope
  - Withstand minor shock loading
  - Do not rot; age more slowly
  - Are of the following specific types
    - Nylon
    - Polypropylene and Polyethylene (Polyolefins)
    - Polyester
    - Aramid

Rope and Webbing Review

- Laid rope (hawser laid)
  - Has twisted strands
  - Has load-bearing fibers
  - Untwists under load

Rope and Webbing Review

- Kernmantle Rope
  - Has a Kern (core)
  - Has a Mantle (sheath)
  - Comes in three types
    - High-stretch (dynamic)
    - Medium-stretch
    - Low-stretch (static)
Rope and Webbing Review

- Webbing
  - Webbing is used to build anchor systems, create harnesses, package and secure victims, and lash rescue components together.

Rope and Webbing Review

- Care and storage
  - Life safety rope is only for life safety: Lifting people
  - Rope inspection
    - Inspect “pic” (50%)
    - Check if core is exposed
    - Feel kern for lumps
    - Check for chemical exposure

Rope and Webbing Review

- Rope and webbing cleaning
  - Soak in cool water and mild soap
  - Air dry away from sunlight and fluorescent lights
Rope and Webbing Review

- Rope and webbing storage
  - Store dry and without knots away from chemicals, gas, oil, and exhaust products.
  - Flake into rope bag with rope ends dressed.
  - Webbing should be rolled and stored in a clean, dry container or bag.

Rope and Webbing Strengths and Classifications

- Minimum breaking strength – rope
  - Low-stretch Kernmantle
    - 3/8” 4,500 lb.
    - 7/16” 6,000 lb.
    - 1/2” 9,000 lb.
    - 5/8” 13,000 lb.
Rope and Webbing Strengths and Classifications

- Minimum breaking strength – webbing
  - Tubular webbing
    1" 4,500 lb.
    2" 6,000 lb.
  - Flat webbing
    1" 6,000 lb.

Factors that affect strength
- Water absorption
- Extreme temperatures
- Chemical contact
- Shock-loading
- Dirt, sand, or grit in the core
- Friction heat damage
- Sharp edges
- Age of rope

NFPA Rope Classification System
- Working load is based on a 15:1 safety factor
- Class one-person life-safety rope
  - Safe working load less than 300 lbs.
  - Breaking strength minimum 4,500 lb.
- Class two-person life-safety rope
  - Safe working load less than 600 lbs.
  - Breaking strength minimum 9,000 lb.
Rescue Rope Hardware

Carabiners

Descent Control Devices

Figure-8 Rack
Rescue Rope Hardware
Ascenders

Rescue Rope Hardware
Pulleys

• Inadequate edge protection results in 90% of all rope failures

Rescue Rope Hardware
Edge Protectors
**Rescue Rope Hardware**

- Care and maintenance of hardware
  - Keep clean and dry
  - Use dry lubricant
  - Inspect hardware for deformity
  - Inspect forged and cast hardware for damage

**Rescue Rope Hardware**

- Care and maintenance of hardware
  - Do not overload equipment

Personal rated rack that has failed due to overloading the weight rating

Note the discoloration due to the heat buildup. When the weld failed this rack gave no warning.

**Rescue Harnesses**

- For
  - Rescuer access
  - Victim removal
  - Fall protection
  - Emergency self-rescue and egress
Rescue Harnesses

- NFPA Class I and II Harnesses
  - Class I and II harnesses are seat-style
  - Class II can be used for rescue
  - Both have the possibility of inversion fall

Rescue Harnesses

- NFPA Class III Harnesses
  - Are full-body
  - Have inversion protection
  - Can handle one or two persons
  - Are used as victim rescue harnesses

Rescue Harnesses

- Emergency Self-Rescue Harness
  - Site-made (Swiss seat)
Rescue Harnesses

• ANSI provides (Industrial) Harness Ratings for
  – Positioning belts
  – Chest harnesses
  – Full-body harnesses—Both ANSI and NFPA refer to this as a Class III
  – Site-made harnesses

Rescue Harnesses

• Care of harnesses
  – Care is similar to that of webbing and hardware
    • Soak like rope; don’t machine wash
    • Inspect and maintain hardware
    • Take damaged pieces out of service
    • Recertify damaged and repaired pieces
  – Service life depends on manufacturer (5-10 years)

Student Performance Objective

• Given information from discussions, handouts, and reading materials, describe the aspects of rope, webbing, hardware, and harnesses that are applicable to technical rope rescues and demonstrate use of harnesses.
Review

- Specific Personal Protective Equipment Requirements
- Rope and Webbing Review
- Rope and Webbing Strengths and Classifications
- Rescue Rope Hardware
- Rescue Harnesses
Lesson 2-1: Life Safety Knots for Rope Rescue Operations

Student Performance Objective

• Given information from discussion, handouts, and reading materials, identify the uses and characteristics of rescue knots and hitches, and define common knot terminology. Given demonstrations, and opportunity to practice, demonstrate tying rescue knots and hitches, and rig a load-releasing hitch.

Overview

• Uses and Characteristics of Rescue Knots and Hitches
• Common Knot Terminology
• Tying Rescue Knots and Hitches
• Rigging a Load-Releasing Hitch
Uses and Characteristics of Rescue Knots, Bends, and Hitches

- Anchoring
- Joining ropes and webbing
- Tying loops
- Using ascending devices
- Using Progress Capture Devices (PCDs)

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Uses and Characteristics of Rescue Knots, Bends, and Hitches

- Rescue knots, bends and hitches
  - Are easy to tie and untie
  - Are easily identifiable as being tied correctly
  - Once tied, dressed, and set, remain secure
  - Have an effect on rope strength
  - Must be dressed
  - Must be pre-loaded
  - Must be safetied

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Common Knot Terminology

- Running part or end: Part of the rope used for work such as pulling, hoisting, and belaying
- Working end: Part of the rope used to tie the knot (anchor end)
- Standing part or end: Part of the rope that is between the working end and the running end
- Bight: A "U" formed by bending the rope back onto itself while keeping the sides parallel
- Round turn: A bight with the ends crossed
- Loop: A section of rope that crosses over itself
Common Knot Terminology

- **Bend**: A knot used to join two ropes together
- **Hitch**: A knot used to fasten a rope to an object
- **Knot**: A manipulation of the rope to allow a purchase (a fixed loop)
- **Splice**: Weaving together two ropes
- **Whip**: Special wrap done on the end of a rope to prevent fraying
- **Anchor**: Immoveable object

Double Overhand Knot

- Used primarily as a safety knot for another knot
  - Make two loops in the rope
  - Put the running end through both loops and pull
  - Dress the knot
  - Pre-load the knot

Figure-8

- Used as a stopper knot
  - Make a loop in the rope
  - Pass the running end under the standing end and back down through the small loop
  - Dress the loop
  - Pre-load the knot
  - Secure the tail with a double overhand
**Figure-8 on a Bight**

- Used on the end of the line with a double overhand knot
  - Form a 3'-4' bight of rope
  - Form a small (1') round turn with the bight
  - Pass the bight back under the standing end, then up and back through the loop
  - Dress the knot
  - Pre-load the knot
  - Secure the tail with a double overhand

**Figure-8 Reweave or Follow Through**

- Used when the end of the line is looped around a large object
  - Tie a Figure-8 knot 3'-4' from the end of the rope
  - Loop the running end of the rope around an object
  - Weave the end of the rope backwards through the Figure-8
  - Dress the knot
  - Pre-load the knot
  - Secure the tail with a double overhand

**Figure-8 Bend or Follow Through**

- Used to join two ropes of equal or different sizes together
  - Tie a Figure-8 knot near the end of one rope
  - Weave the end of another rope backwards through the Figure-8
  - Dress the knot
  - Pre-load the knot
  - Secure the tail with a double overhand
Double Loop Figure-8
• Used to construct a load-sharing self-equalizing anchor system as well as other anchor-related tasks
  – Tie a Figure-8 on a bight
  – Allow the standing part of the loop to pass through the body to form a bight
  – Bring the top loop over the knot
  – Pull the standing part up to form two loops
  – Dress the knot
  – Pre-load the knot
  – Secure the tail with a double overhand

Water Bend, Ring Bend, or Follow Through
• Used to join webbing
  – Tie a loose overhand knot near the end of a piece of webbing.
  – Weave the end of another piece of webbing backwards through the overhand knot.
  – Dress the knot.
  – Pre-load the knot.
  – A safety is not required. Leave a minimum 6" tail protruding from each end of the bend.

Grapevine Knot (Double Fisherman’s or Barrel)
• Used to make a Prusik loop
  – Lay two rope ends together from opposite directions with approximately a 1" overlap
  – From the middle of the overlap, tie half of the knot with the running end of one rope and the standing end of another
  • Make two round turns around the standing rope, back towards the middle of the overlap
Grapevine Knot
(Double Fisherman’s or Barrel)
• Used to make a Prusik loop (continued)
  – From the middle of the overlap
    • Pass the running end between the two inside strands, and then pass through both turns.
    • Dress the knot. Should look like a barrel and should slide on the rope without coming untied.
  – Repeat tying the half knot from the other side of the overlap.
  – Slide the two halves of the knot together and tighten; the knot has been pre-loaded.
  – A safety knot is not required as this is a self-tightening knot.

Clove Hitch
• Around a pipe
  – Pass the running end around the pipe
  – Bring the running end out underneath the standing part and cross over to form a half-hitch
  – Continue the wrap around the pipe for an additional turn
  – Bring the running end under the wrap, continuing in the direction of the wrap

Clove Hitch
• Around a pipe (continued)
  – Pull the running end and the standing end to tighten
  – Dress the hitch
  – Pre-load the hitch
  – Secure the tail with a double overhand
**Clove Hitch**

- Passed over an object
  - Form two overhand loops, one on the left and one on the right
  - Pass the right loop in front of the left loop
  - Place both loops over the end of the object
  - Pull the running end and the standing end to tighten
  - Dress the hitch
  - Pre-load the hitch
  - Secure the tail with a double overhand

**Split Clove Hitch**

- On a railing
  - Pass the running end to the right of the “T” under the top part of the “T,” back over and to the right of the standing end of the rope.
  - Pass the running end over the standing end of the rope and by the vertical part of the “T.”
  - Pass the running end to the left of the “T,” create a loop over the top of the horizontal aspect of the “T,” pass under the horizontal aspect of the “T,” and then back up through the loop that was created.

- Pull the running end and the standing end to tighten
- Dress the hitch
- Pre-load the hitch
- Secure the tail with a double overhand
Munter Hitch

- For belay or self-rappel and to construct a load-releasing hitch
  - Form two loops, one in front of the rope and one behind
  - Place the loop in front of the rope on top of the loop that is behind the rope
  - Clip a carabiner through both loops

Butterfly Knot

- In-line loop that can be loaded in multiple directions
  - Pick up the rope where the loop is desired
  - Make two complete and relatively large loops in your hand; there will be three loops in your hand
  - Take the front loop that is closest to your fingertips and lift it back over the remaining two loops
  - Take the new front loop up and back over the remaining loops

Butterfly Knot

- In-line loop that can be loaded in multiple directions
  - Pull the last piece under, through, and in front of the other two loops, forming a bight
  - Pull the bight out to the desired size
  - Pull the running and the standing ends in opposite directions to flip and set the knot
  - Dress the knot
  - Pre-load the knot
**Prusik Hitch**

- For belay systems, ascending, and as a PCD
  - Start with the appropriately-sized Prusik loop
  - Lay the Prusik loop over the host rope and pull one end of the loop back through the other, forming a loose girth hitch
  - Using the inside loop as a bight, continue the inside wrap for two additional turns
  - Dress the knot; make sure the bight is at the center
  - Pre-load the knot

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**Rigging a Load-Releasing Hitch**

- Gather the necessary equipment
  - Cordalette – 33' of 9mm lifeline
  - Carabiners – 2 steel locking carabiners

- Find the center of the cordalette and put a bight in the cordage. Using this bighted section, tie a Munter hitch around the first steel carabiner (carabiner #1), leaving the bighted end sticking out of the carabiner approximately 10".

- Place the other steel carabiner (carabiner #2) in the bighted end loop and pull all the slack out of the bighted end of the rope. This should cause both carabiners to come close to each other.

- Using the long ends of the cordlette, wrap around the doubled section of cord between the two carabiners until the section is completely wrapped (approximately five wraps should do it).
Rigging a Load-Releasing Hitch

• Put a bight in the cordage near the wraps in each of the unused section of cordage and pull each bighted section of cordage through the hole where carabiner #2 is clipped. This should be somewhat difficult if the LRH is being tied correctly.

RES 205-PPT-2-1-27

Rigging a Load-Releasing Hitch

• Take both bighted sections of rope—treating all four strands as one rope—and tie an overhand knot around the long unused sections of cordage. Then tighten all six legs of cordage hanging from the overhand knot.
• Then chain the long unused ends of the cordalette through the two bights hanging from carabiner #2 to prevent tangling. If desired, the ends of the cordalette can be joined with a double overhand bend, then clipped into carabiner #1 for added safety.

RES 205-PPT-2-1-28

Rigging a Load-Releasing Hitch

• If desired by the rescuer, it is also correct to duplicate the above hitch using a 7/16" or 1/2" steel approved or rated tri-link in place of carabiner #1

RES 205-PPT-2-1-29
Student Performance Objective

- Given information from discussion, handouts, and reading materials, identify the uses and characteristics of rescue knots and hitches, and define common knot terminology. Given demonstrations, and opportunity to practice, demonstrate tying rescue knots and hitches, and rig a load-releasing hitch.

Review

- Uses and Characteristics of Rescue Knots and Hitches
- Common Knot Terminology
- Tying Rescue Knots and Hitches
- Rigging a Load-Releasing Hitch
Student Performance Objective

- Given information from discussion, handouts, and reading materials, identify and select safe and appropriate anchor points, and given demonstrations and opportunity to practice, construct single-point and complex anchor systems which include multiple anchor points, back-up anchor points, and self-equalizing anchor points.

Overview

- Personal Protective Equipment Requirements
- Types of Anchor Points
- Placement and Positioning of Anchor Points
- Back-up Anchor Points
- Anchor System Equipment
- Anchor System Principles
- Anchor System Safety Checks
- Constructing Anchor Systems
Personal Protective Equipment Requirements

- Head protection
- Foot protection
- Hand protection
- Fall protection

Types of Anchor Points

- Natural
  - Trees
  - Rocks or boulders

- Structural anchors
  - Look for signs of deterioration
  - Identify weak components
  - Use acceptable structural components
Types of Anchor Points

- Additional anchor points
  - Vehicles—lock and chock before use
  - Artificial anchor points

Placement and Positioning of Anchor Points

- Strength of anchors
  - Anchors must
    - Be “bombproof”
    - Withstand calculated safety factor
- Condition of anchor point
  - New versus old
  - Live versus dead

Placement and Positioning of Anchor Points

- Direction of pull on anchor points
  - Select anchors that are in-line with the pull of the system
  - Direction of the pull may change with the movement of the load
Placement and Positioning of Anchor Points

- Position of anchors
  - A position directly above the load is best
  - Anchor points may need to be offset
  - Move if conditions require (fire, falling objects, etc.)

Placement and Positioning of Anchor Points

- Directional anchor points
  - Can bring rope into favorable positions
  - Must be as strong as the main anchor

Back-up Anchor Points

- Back-up anchor points should be used because of
  - The uncertain strength of anchor points
  - The possibility of human error
  - The possibility of equipment failures
Back-up Anchor Points

- Techniques of backing-up anchor points
  - Locate more than a single anchor point
  - Attach back-up to an independent point, if possible
  - Locate multiple back-up points

Anchor System Equipment

- Rope to anchor point
  - Loop knot to anchor
  - Create a tensionless hitch (minimal tension)

Anchor System Equipment

- Webbing slings to anchor point
  - Pre-sewn slings
  - Anchor straps
  - Webbing
Anchor System Principles

- Multiple anchor points should be as strong as the main anchor point.
- Picket systems require more resources and time.
- Multi-point anchors can distribute shock load better and offer insurance if equipment fails.
- Back-up anchors must have little slack in case of shock loading.
- Angle between the legs should not exceed 90°.
- Load-distributing anchor systems share the load and provide readjustment if a point fails.

Anchor System Safety Checks

- Check stability of the anchor points.
- Ensure that multiple anchor points are strong.
- Test the position to ensure it can withstand the directional forces.
- Provide adequate edge and abrasion protection.
- Provide fall protection for rescuers.

Constructing Anchor Systems

Constructing a Single-Point Anchor

“Wrap 3, Pull 2”
Constructing Anchor Systems
Constructing a Tensionless Hitch

Constructing Anchor Systems
Constructing a Directional

Constructing Anchor Systems
Backing up an Anchor System
Constructing Anchor Systems
Constructing a Simple Load Distributing Anchor

Constructing Anchor Systems
Constructing a Complex Load Distributing Anchor

Student Performance Objective

- Given information from discussion, handouts, and reading materials, identify and select safe and appropriate anchor points, and given demonstrations and opportunity to practice, construct single-point and complex anchor systems which include multiple anchor points, back-up anchor points, and self-equalizing anchor points.
Review

- Personal Protective Equipment Requirements
- Types of Anchor Points
- Placement and Positioning of Anchor Points
- Back-up Anchor Points
- Anchor System Equipment
- Anchor System Principles
- Anchor System Safety Checks
- Constructing Anchor Systems
Lesson 8-1: Belaying

Student Performance Objective

• Given information from discussion, handouts, reading materials, and demonstrations, and opportunity to practice, describe the operation of a belay system, its capabilities and limitations, and emergency procedures to follow; demonstrate construction and operation of a simple belay system which includes the process to arrest a falling load.

Overview

• Capabilities and Limitations of a Belay System
• Personal Protective Equipment Requirements
• Components of a Belay System
• Belay Operations
• Application of Belay Devices
• Safety System Checks
• Constructing Belay Devices
• Belaying Loads
Capabilities and Limitations of a Belay System

- Types of belays
  - One-person belay
  - Rescue belays
- Situations requiring a belay
  - Hazardous terrain
  - Steep slopes
  - Confined space entry
  - Hazardous weather conditions
  - Vertical raises and lowers

Capabilities and Limitations of a Belay System

- Conditions that might preclude belays
  - Numerous lines in service
  - Long free drops

Capabilities and Limitations of a Belay System

- Limitations of belay systems
  - The belayer’s reaction is critical.
  - Fast line speeds are difficult to manually arrest.
  - Hardware must be compatible with the lines.
  - Shock loads and forces can injure an out-of-position belayer.
Capabilities and Limitations of a Belay System

• Limitations of belay systems (continued)
  – Accelerating forces may overwhelm the devices.
  – Moisture and dirt can cause the failure of the belay device.
  – Shock absorption should be inserted in the belay system.

Capabilities and Limitations of a Belay System

• Responsibilities in belaying
  – The ability to belay is a critical skill for anyone operating in the high-angle environment.
  – Accepting the assignment is a very serious commitment.
  – The well-being and life of the person at the end of the rope is in the belayer’s hands.
  – Inability, a lapse in attention, and lack of skill can result in severe injury or death for the person at the end of the rope.

Personal Protective Equipment Requirements

- Head protection
- Foot protection
- Hand protection
Personal Protective Equipment Requirements

Components of a Belay System

• Load
• Connection point to load
• Belay line
• Belay device
• Belayer
• Anchor

Belay Operations

• Belay commands
  – “On belay?”
  – “Belay on”
  – “On rappel/climb/raise/lower”
  – “Rappel/climb/raise/lower on”
  – “Off belay”
  – “Belay off”
  – “Stack”
  – “Tension”
Belay Operations

- Techniques of belaying
  - Focus attention on the load at all times.
  - Keep the body away from the system lines and hardware.
  - React quickly and properly.
  - Never insert yourself into the system.
  - Never remove hands from the belay device.
  - Belay or apply friction with the dominant hand.
  - Be aware that different devices apply different amounts of friction and control.
  - Maintain the proper slack in the line.

Application of Belay Devices

- Munter hitch
- Belay plate
- Tandem Prusiks
- Other devices are currently under testing and development which pass the drop tests, e.g., "540" device, mid-rope grab

Application of Belay Devices

- Application of a Munter hitch
  - Works best on high-stretch Kernmantle for a single-person belay system
  - Connect a carabiner to an independent anchor point
  - Tie the belay line with a Munter hitch to the carabiner
  - Give and acknowledge the commands
  - Bring the braking side of the rope to the load side of the rope to provide friction
Application of Belay Devices

- Application of a belay plate
  - Only for single-person belay systems
    - Connect a carabiner to an independent anchor point
    - Push a bight of rope through the plate
    - Connect the device and the bight into the carabiner
    - Give and acknowledge the commands
    - Bring the braking side of the rope 180° to the load side of the rope to provide friction

Application of Belay Devices

- Application of tandem Prusiks
  - Only belay system appropriate for more than a one-person load
    - Connect a carabiner to an independent anchor point
    - Apply two different-length Prusik loops with triple wrap Prusik knots to the belay line (53” + 63” x 8mm)
    - Connect both Prusiks to the carabiner
    - Give and acknowledge the commands
    - Release both Prusiks to provide friction

Safety System Checks

- The belay system is appropriate for the load.
- Appropriate personal protective equipment is worn.
- The belay person is trained and skilled with the belay device.
- Command terminology is understood by the entire team.
- Environmental conditions are acceptable for the belay mechanism.
- Fall protection is in use for any personnel close to the edge.
Constructing Belay Devices

- Construct a belay system with a Munter hitch and arrest a horizontal load.
- Construct a belay system with a belay plate and arrest a horizontal load.
- Construct a belay system with tandem Prusiks and arrest a horizontal load.

Belaying Loads

- Belay a vertical load with a Munter hitch.
- Belay a vertical load with a belay plate.
- Belay a vertical load with tandem Prusiks.

Student Performance Objective

- Given information from discussion, handouts, reading materials, and demonstrations, and opportunity to practice, describe the operation of a belay system, its capabilities and limitations, and emergency procedures to follow; demonstrate construction and operation of a simple belay system which includes the process to arrest a falling load.
Review

• Capabilities and Limitations of a Belay System
• Personal Protective Equipment Requirements
• Components of a Belay System
• Belay Operations
• Application of Belay Devices
• Safety System Checks
• Constructing Belay Devices
• Belaying Loads
Student Performance Objective

- Given information from discussion, handouts, and reading materials, describe how to conduct a target hazard analysis for highline operations, identify the types of highline systems and related equipment to construct them, and identify the rigging principles for system tensioning.

Overview

- Target Hazard Analysis
- Highline System Types
- Highline System Construction Equipment
- Highline Rigging Principles
Target Hazard Analysis

- Assess the rescue area
  - Utility hazards
  - Water hazards
  - Terrain hazards or features
  - Environmental exposure hazards
Crossing Dangerous or Difficult Terrain

- Canyons
- Marshes
- Industrial areas
- Heavy debris locations
- Areas where it would be dangerous or impractical to carry a litter

Single-Rope Highline

Rescuer is attached directly to the Kootenay Carriage

SINGLE MAIN LINE

SINGLE HAUL LINE

RESCUER IS ATTACHED DIRECTLY TO THE KOOTENAY CARRIAGE
Single-Rope Dual-Pulley System

Kootenay Carriage Pulley
Track Line
2:1 Change of Direction
Mind Prusiks when raising or lowering

Double-Rope (Kootenay) Highline

TRACK LINES
TAG LINE
CHANGE OF DIRECTION

Double-Rope (Kootenay) Dual-Pulley System

TRACK LINE
TRACK LINE 2
Highline System Construction

Equipment

- Rope
  - Do not use high-stretch Kernmantle; stretches under loading
  - Use a minimum 1/2" low-stretch Kernmantle
  - Use 7/16" rope to carry equipment on foot
  - Use the 15:1 safety factor as a guide for loading the rope

Highline System Construction

Equipment

- Hardware
  - Pulleys
  - Carabiners
  - Figure-8 DCDs
  - Brake bar racks
  - Screw links
  - Ascenders
  - Rigging plates
  - Edge rollers
  - Tripods
  - A-frames
  - Pickets
  - Stokes baskets
  - LSPs
  - SKEDs
  - Hook poles
  - Prusiks
  - Dynamometers
  - Line guns

Highline System Construction

Equipment

- Elevated anchor points
  - General guidelines
    - Highline or rope rescue operations are easier to manage using a steel beam or tree for the high anchor point.
    - Elevated anchor points are often unavailable or too weak to hold the load safely.
    - Systems can be made from scratch.
Highline System Construction Equipment

• Elevated anchor points
  – Types
    ▪ Tripods

Highline System Construction Equipment

• Elevated anchor points
  – Types
    ▪ Bipods (or A-frames)
    ▪ Monopods (or gin poles)

Highline Rigging Principles

Highline Elements
Highline Rigging Principles

Tensioning and Loading: Over-Tensioning

Ensure that the critical interior angle is NOT exceeded

120° of Sag or Less (Interior Angle)

Highline Rigging Principles

• Tensioning guidelines—the 10% Rule
  – The 10% rule is a reliable method to limit the force on a highline system.
  – The sag should equal 10% of the length of the span for every 200 pounds placed on the main line.
  – Example: A 200-pound load on a 200' span would have 20' of sag on the main line.

Student Performance Objective

• Given information from discussion, handouts, and reading materials, describe how to conduct a target hazard analysis for highline operations, identify the types of highline systems and related equipment to construct them, and identify the rigging principles for system tensioning.
Review

- Target Hazard Analysis
- Highline System Types
- Highline System Construction Equipment
- Highline Rigging Principles
Lesson 17-1: Tower and Turbine Rescue

Student Performance Objective

- Given information from discussion, handouts, and reading materials, the student will be able to describe the aspects of tower and turbine rescue.

Overview

- Risks During Tower and Turbine Rescue
- Tower Rescue Preplan Guidelines
- The Pre-Climb Checklist
- Tower and Turbine Climbing Equipment
- Fall Factors
- Suspension Trauma
Overview

- Types of Towers
- Performing Tower Rescue
- Wind Turbines
- Performing Turbine Rescue
- Isolating and Mitigating Energy Sources

Risks During Tower and Turbine Rescue

- High Winds
- High Voltage
- Sharp Edges
- Extreme Height
- Remote Location
- High Frequency Radiation

Tower Rescue Preplan Guidelines

- Preplan for locations on your first due
  - Schedule on-site visit.
  - Inspect towers and guide wires.
  - Inspect terrain and access points.
  - Obtain emergency contact information.
  - Familiarize team with safety equipment used by tower workers.
Tower Rescue Preplan Guidelines

- Preplan for locations on your first due
  - Inventory your equipment to ensure it is adequate.
  - Select equipment that is easy to deploy.
  - Assign specific tasks to personnel.
  - Consult with companies who may have employees at the tower.
  - Assign a staging area.
  - Assign area for medical personnel.

The Pre-Climb Checklist

- Perform the checklist before every climb
  - Ensure lockout/tagout is done.
  - Inspect all PPE.
  - Ensure RF mitigating equipment is working.
  - Review climbing route.
  - Discuss self-rescue techniques.
  - Assess structural integrity of tower.
  - Discuss weather forecast.

Tower and Turbine Climbing Equipment

- All equipment must be ANSI Z359 certified
- The purpose of the equipment is to
  - Keep the rescuer from falling
  - Allow rescuers to have two free hands
- The following equipment is required for tower and turbine rescue:
Fall Factors

- Fall factor is the ratio between the distance of the fall and the length of the item that will arrest the fall.
- To calculate the fall factor:
  - Divide the distance fallen by the length of the lanyard.
- Reduce fall factor by using anchor places high above your body.
**Suspension Trauma**

- Suspension trauma occurs when a person is hanging from the dorsal attachment point and blood flow is restricted in the femoral and carotid arteries.
- If the oxygen-starved blood reaches vital organs in a rush when the victim is released from hanging it can cause heart failure or renal damage.

**Types of Towers**

- **Telecommunications and Broadcast Towers**
  - Monopole towers
  - Guyed towers
  - Self-supporting towers

- **Electric Transmission Towers**
  - Monopole towers
  - Self-supporting tower
  - Lattice type tower
Performing Tower Rescue

- Subject packaging and other medical considerations
  - Patient care and packaging may be limited while the patient is suspended.
  - Radiation is a factor for rescuer and victim.

Performing Tower Rescue

- Ground-based tower rescue
  - Anchors
    - Structurally sound vehicle anchors are ideal.
    - Natural anchors may be an option.
    - Anchors for high points above the subject should be located as directly above the subject as possible.
  - A straight lower
    - Is used when the path of the victim is vertical and relatively free of obstructions.

Performing Tower Rescue

- A skate lock lower
  - Is similar to a straight lower because movement is controlled from the ground
  - Varies from a straight lower because the subjects are sent down the rope unattended because they are being lowered from a structure to the anchor point below
Performing Tower Rescue

- Top down tower rescues
  - Anchors
    - Anchors must be directly above the subject to avoid pendulum.
    - If pendulum can’t be avoided, anchor higher to decrease swing angle.
    - If no suitable anchors are found directly above the subject, use redirect anchors.

Performing Tower Rescue

- Pickoff rappel rescue
  - Rescuers must bring all rope and rigging with them.
  - If using a main and a belay line, two anchors must be established.
  - If using a main belay line for rescuer, an additional rescuer will be needed to man the belay line.
  - Configure the pickoff descent system before transferring subject from fall arrest to rescue system.
  - Once the system is configured rescuers must decide if they will raise or lower the subject.

Performing Tower Rescue

- Top-down lower rescue
  - Rescuers must bring all rope and rigging with them.
  - Rescuer and subject movement is controlled from above.
  - Communication between rescuer and belayer is very important.
  - Precautions for suspension trauma should be taken once subject arrives on the ground.
Wind Turbines

- Wind turbines are composed of four major parts.

- Always perform lockout/tagout before a turbine rescue.

Performing Turbine Rescue

- Turbine Rescues
  - Most turbine rescues will take place in the interior of the turbine.
  - Rescuers must be prepared for a lot of ladder climbing.
    - Ensure you have fully charged lights and spares.
    - Ensure you have fully charged radios and spares.

- Anchors
  - Anchors inside a turbine may be hard to come by.
  - Turbine manufacturers install engineered anchors.
  - Inspect all potential anchors before use.
  - Be aware that suitable anchors may only be located in the nacelle.
  - Exterior anchors on the top of the nacelle are few and far between.
Performing Turbine Rescue

- Interior wind turbine rescue
  - The subject’s location will affect the methods used for rescue.
  - Rescue inside the tower should be basic top-down lower.
  - Rescue from the nacelle or blades will require more complex confined-space rescue.
  - Platform decks and vertical ladders on the sidewall make rescue inside the tower much easier.

- Exterior wind turbine rescue
  - Exterior wind turbine rescue should only be attempted by rescuers who have done this type of rescue before.
  - Fall arrest must be worn by all rescuers exiting the nacelle.
  - Top-down rappel rescues work best.
  - Bagged ropes are recommended to prevent wind wrapping ropes around blades.
  - High winds may make radio and verbal communication impossible.

Isolating and Mitigating Energy Sources

- Types of Energy Sources
  - High Voltage
    - Rescuers should
      - Ensure lines are de-energized.
      - Treat all energy sources as if they were live.
      - Include qualified representatives from utility companies in the rescue plan.
      - When rescuing inside a wind turbine, always perform lockout/tagout.
Isolating and Mitigating Energy Sources
- RF and microwave sources
  - RF radiation is often found in telecom and broadcast towers.
  - The FCC requires tower owners to have the license number and emergency contact number on site.
  - Rescuers can search the FCC website for the owner's contact information.
  - On-site employees may be able to eliminate or reduce RF radiation by performing lockout/tagout procedures.

Isolating and Mitigating Energy Sources
- PPE for energy sources
  - PPE helps mitigate the effects of energy sources on the rescuers and includes:
    - Helmets (Class E for electrical hazards)
    - Gloves (rubberized)
    - Clothing (fire rated or RF rated)
    - Shields
    - Shoes (rubberized)

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- Tower and Turbine Climbing Equipment
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Review

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- Performing Tower Rescue
- Wind Turbines
- Performing Turbine Rescue
- Isolating and Mitigating Energy Sources