Ropes, Knots, And Hitches

Introduction

- Ropes are widely used in the fire service.
- May be your only means for rescue
- Ropes and knots are an important part of training.
- A fire fighter must be able to tie simple knots accurately and without hesitation with gloves on and in the dark.

Objectives (1 of 3)

- Describe the differences between life safety rope and utility rope.
- List the three most common synthetic fiber ropes used for fire department operations.
- Describe the construction of a kernmantle rope.
- Describe how to use rope to support response activities.

Objectives (2 of 3)

- Describe how to clean and check ropes.
- Describe how to record rope maintenance.
- List the reasons for placing a life safety rope out of service
- Describe the knot types and their usage in the fire service.

Objectives (3 of 3)

- Describe how to tie various Fire Service knots.
- Describe the types of knots to use for given tools, ropes, or situations.
- Describe hoisting methods for tools and equipment.

Types of Rope

- Two primary types of rope are life safety and utility.
- Life safety
  - Used solely for supporting people
  - Must be used anytime a person is supported whether in training or in an actual emergency
- Utility
  - Used in most cases when it is NOT necessary to support a person, such as hoisting or lowering tools

Life Safety Rope

- Any rope dedicated solely for the purpose of supporting people during rescue, fire fighting, or other emergency operations, or during training evolutions supporting people
  - *As defined by NFPA 1983 Standard on Fire Service Life Safety Rope and System Components*

Life Safety Rope

- Never used as utility rope
- Must be used when supporting the weight of one or more persons
- NFPA 1983 specifies design, construction, and performance criteria.
- Types
  - One-person rope has a weight limit of 300 lb.
  - Two-person rope has a total weight limit of 600 lb.

Personal Escape Rope

- Used only for self-rescue in an extreme situation
- Designed for the weight of one person only
- Its purpose is to provide fire fighters with an escape method in a life-threatening emergency.
- Should be replaced after one use
- Always have an escape route and use the rope only as a last resort.

Utility Rope

- Is not used to support the weight of a person.
- Used for hoisting, lowering, and securing tools and equipment
- Requires regular inspection
- Must not be used where life safety rope needed
- Do not use life safety rope as a utility rope.
- Tagging recommended for easy identification

Rope Materials

- Ropes can be made of many types of materials.
- Earliest ropes were made from natural vines woven together
- Now ropes are made of synthetic material.
- Different materials are used for different situations.

Natural Fiber Rope

- Natural fiber ropes were often made of manila.
  - Fibers woven together
  - Various lengths twisted together for strands
- Current use for utility, not life safety tasks
- Disadvantages
  - Subject to mildew and deterioration
  - May absorb 50% of their weight in water
  - Very difficult to dry
  - No safe life

Synthetic Fiber Rope

- Nylon first manufactured in 1938
- Synthetic fibers have been used for ropes ever since.
- Types
  - Nylon
  - Polyester
  - Polypropylene
  - Polyethylene

Advantages of Synthetic Fiber Rope

- Stronger than natural fibers
- Use fibers that run the entire length of the rope for greater safety and strength
- More resistant to rotting and mildew
- More resistant to melting and burning
- Less absorbent and can be washed and dried
- Some will float on water

Disadvantages of Synthetic Fiber Rope

- Prolonged exposure to ultraviolet light, strong acids, or alkalis can damage the rope.
- Highly susceptible to abrasions and cutting

Synthetic Rope and Life Safety

- Life safety rope is always synthetic.
- NFPA 1983 specifies:
  - Continuous filament, virgin fiber
  - Block creel construction: no knots or splices
- Fiber comparison
  - Nylon is most common
  - Polyester is second most common
  - Polypropylene is lightest; good for water rescue, but not for life safety

Rope Construction

- There are several types of rope construction.
- The best choice depends on specific application.

Twisted Rope Construction

- Also called laid ropes
- Made of individual fibers twisted into strands
- Strands are twisted to make the rope.
- Both natural and synthetic fibers can be twisted.
- All fibers exposed to abrasion.
- Twisted ropes stretch and are prone to unraveling.

Braided Rope Construction

- Strands are woven like hair braiding.
- Exposes all of the strands to abrasion
- Synthetic fibers are most commonly used.
- Fibers stretch but not prone to twisting
- Double-braiding can protect inner core.

Kernmantle Rope Construction (1 of 2)

- Consists of two parts: the kern and the mantle
- Kern is the center core and provides 70% of rope's strength.
- Mantle is the sheath-like braided covering that protects kern from dirt and abrasion.

Kernmantle Rope Construction
(2 of 2)

- Kern and mantle are synthetic but may be different materials.
- Each fiber in the kern extends the entire length of the rope.
- Provides a very strong and flexible rope that is thin and lightweight
- Well-suited for rescue work

Dynamic and Static Rope Construction

- Dynamic
  - Designed to be elastic and stretches under load
  - Usually used by mountain climbers
- Static
  - Will not stretch under load
  - More suitable for rescue situations
- Difference due to the fibers used and the construction method
- Many rope rescue teams carry both.

Dynamic and Static Kernmantle Rope

- Dynamic is constructed with overlapping or woven fibers in the core; when loaded, the fibers pull tighter, giving elasticity.
- Static is constructed with all fibers parallel to each other, little elasticity, and limited elongation when loaded.

Rope Strength (1 of 2)

- Rated for specific amounts of weight under NFPA 1983
- Minimum breaking strength based on loading of 300 lb person with safety factor of 15:1
- Safety factor allows for knots, twists, abrasions, and other causes
- Also considers shock loading
- A personal escape rope is designed for a 300 lb person with a safety factor of 10:1.

Rope Strength (2 of 2)

Table 9-5 Required Strength of Life Safety Ropes

Classification	Rated Load (Persons)	Rated Load (Weight)	Minimum Breaking Strength	Safety Factor
Personal escape rope	One	300 lb	3,000 lbf (13.34 kN)	10:1
Light use life safety rope	One	300 lb	4,500 lbf (20 kN)	15:1
General use life safety rope	Two	600 lb	9,000 lbf (40 kN)	15:1

SOURCE: NFPA 1983, *Standard on Fire Service Life Safety Rope and System Components*

Technical Rescue

- Ropes often used to access and extricate individuals.
- Several hardware components may also be needed.
- Carabiner secures and connects lines.

Harnesses (1 of 2)

- Harnesses are used to secure a person to a rope or object
  - Ladder belt harness secures fire fighter to a ladder
  - Seat harness supports fire fighter during rescues
  - Chest harness supports fire fighter on life safety rope
- Harnesses must be cleaned and inspected regularly.

Harnesses (2 of 2)

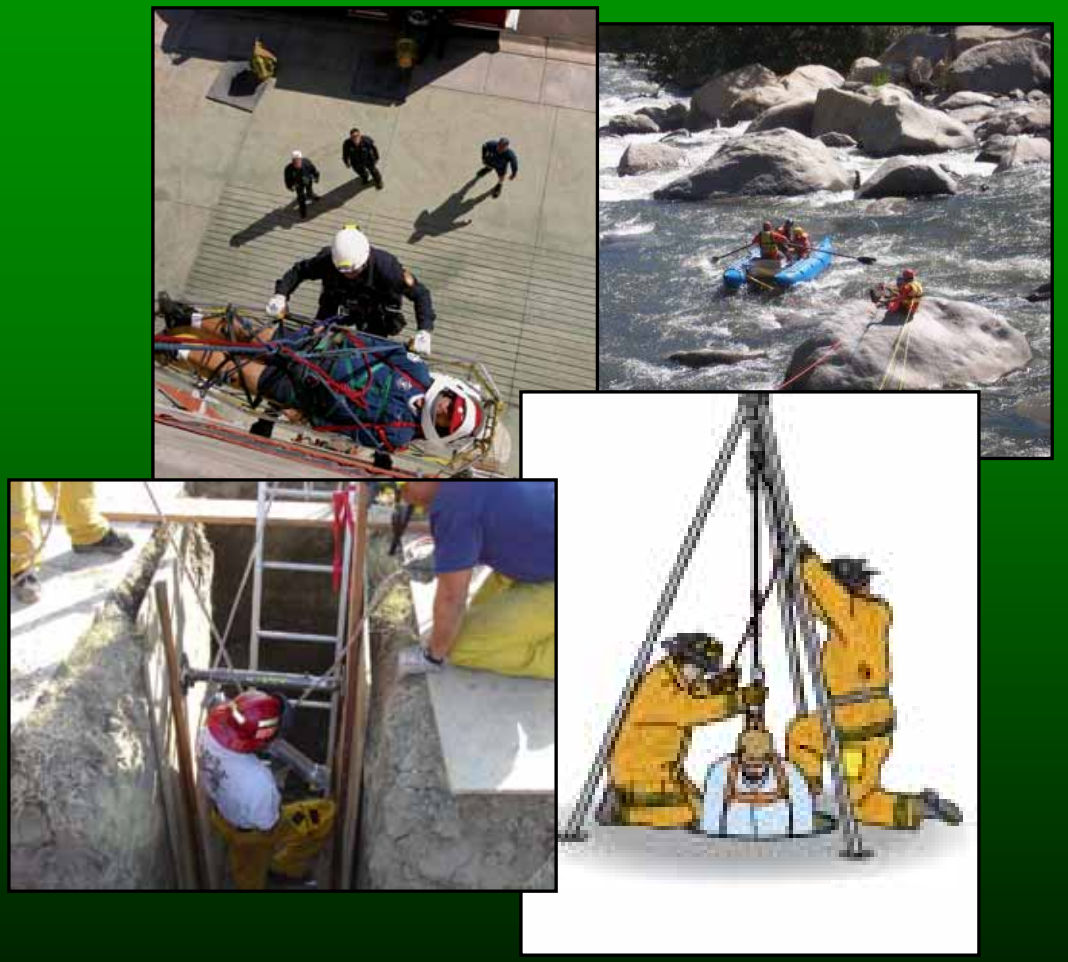
Class I harness
(ladder belt)

Class II harness
(seat)

Class III harness
(chest)

Types of Technical Rescue

- Rope Rescues
- Trench Rescues
- Confined Space Rescue
- Water Rescue



Rope Maintenance

- All ropes require proper care.
- Maintenance is essential for life safety rope.
- Four parts to maintenance:
  - Care
  - Clean
  - Inspect
  - Store

Care

- Protect from sharp and abrasive surfaces.
- Protect from heat, chemicals, and flame.
- Protect from rubbing against another rope.
- Avoid prolonged sunlight exposure.
- Never step on a rope.
- Follow manufacturer’s care guidelines.

Clean

- Use mild soap and water for synthetic fibers.
- Use a rope washer with a garden hose.
- May be able to use a mesh bag in a front-loading washer
- Use a mild detergent and NO bleach.
- Do not store wet or damp.
  - Air dry but not in direct sunlight.
  - Do not use a mechanical dryer.

Rope Inspection

- Inspect life safety rope after each use and on a regular schedule when unused.
- Inspect visually looking for cuts and damage as you run it through your fingers.
- Life safety rope that can no longer be used must be destroyed.
  - Sometimes, can be downgraded to utility rope if clearly marked
- Maintain record for life safety rope.

Storing Rope

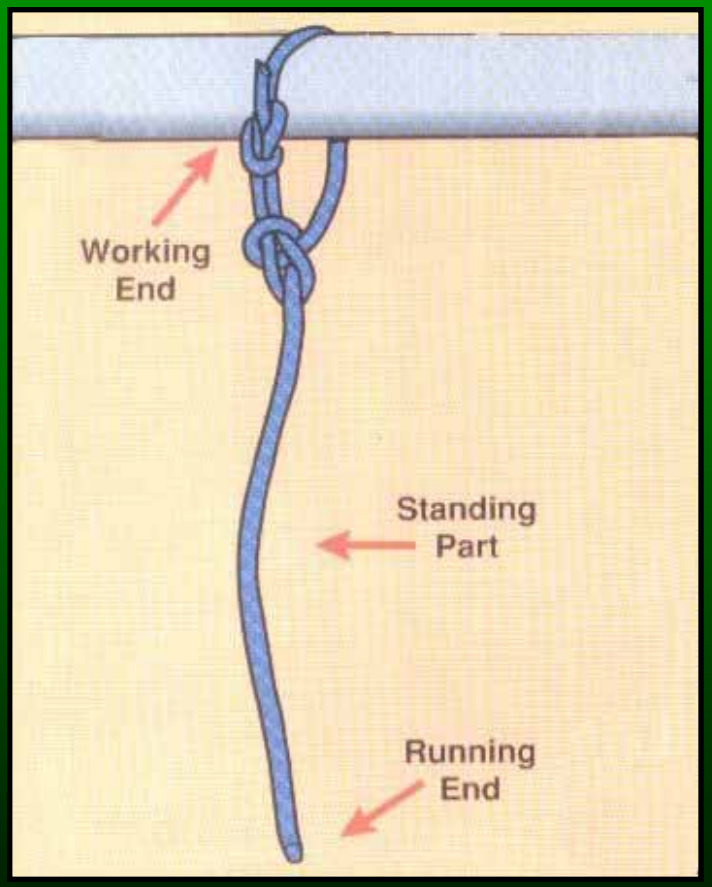
- Avoid temperature extremes and keep out of sunlight.
- Keep away from fumes of gasoline, oils, and hydraulic fluids.
- Use a separate apparatus compartment away from fuels.
- Do not place any heavy objects on the rope.
- Use rope bags to protect and store the rope.
- If shock loaded, inspect and consider removing from service.

Knots

- Knots are prescribed ways of fastening ropes and webbing to objects or each other.
- Fire fighters must know how and when to use knots.
- Knots are used for multiple purposes including hitches, loops, bends, and safety.
- Knots in rope reduce rope load-carrying capability by certain percentages.

Knot Terminology

- Working end
  - Used in forming knots
- Standing part
  - Between the working and the running end
- Running end
  - the part used for hoisting, pulling, or belaying



Elements of a Knot

The Bight

The Loop

The Round Turn

Basic Fire Service Knots

- Safety knot or Overhand
- Half hitch
- Clove hitch
- Square knot
- Becket bend
- Bowline
- Half Sheep Shank or Truckers Hitch
- Figure eight
- Figure eight on a bight
- Figure eight bend
- Figure eight with a follow-through
- Inline figure eight or directional eight
- Handcuff knot

Safety or Overhand Knot

- Also called an overhand or keeper knot
- Secures the leftover working end to standing part
- Used to attach webbing together
- Used on rope as added degree of safety
- Should always be used on synthetic ropes

Hitches

- Wrap around an object
- Used to secure working end to a solid object or to tie a rope to an object before hoisting it

Half Hitch

- Not secure used with other knots
- Used to align object handles with rope
- Used primarily for hoisting tools and equipment
- Can be used as a safety

Clove Hitch

- Used primarily to attach a rope to an object such as a post, pole, or hose line.
- Formed anywhere in the rope
- Tied properly will withstand pulls from either direction.

Square Knot

- Tie ropes of equal diameters together
- Should not be used on synthetic ropes
- Replaced by figure eight bend.

Sheet or Becket Bend

- Used to join two ropes of unequal diameters
- Can join rope to a chain or cable
- When tied bight goes in the large rope or item

Loop Knots

- Used to form a loop in the end of a rope
- Loops may be used for hoisting tools, securing a person, or for identifying the end of a stored rope.
- Will not slip easily but are easy to untie
- Includes
  - Figure eight family of knots
  - Bowline

Bowline

- Forms a loop to secure the rope to an object or anchor point
- Designed for tying to objects, not people
- Was the knot of choice replaced by Figure 8
- If tied in synthetic rope must have a safety

Figure Eight

- AKA - Stopper
- Seldom used alone
- Basic builder of all Figure Eight Family

Figure Eight on a Bight

- Creates a loop at the working end of a rope
- Loop may be any size in diameter
- Anchoring attachment
- Harness tie-in
- Can be tied anywhere in the rope

Figure Eight Bend

- Attaches two ropes of equal diameters
- Replaces square knot on synthetic rope
- Also known as figure eight follow through
- Must have safety knots

Figure Eight Follow Through

- Used when the working end must be wrapped around an object or passed through an opening, such as an anchor point.
- Also used to tie two ropes together (Fig. 8 Bend)

Inline Figure Eight

- Used to pull even tension on the knot.
  - Truckers hitch
  - Anchoring ladders in Ladder rescue

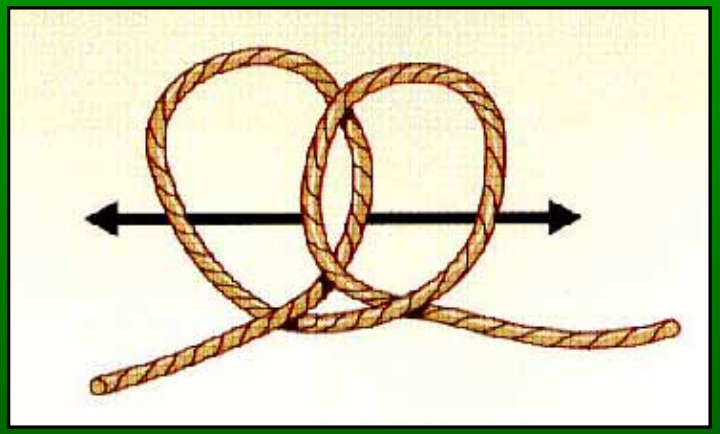
Inline Figure Eight

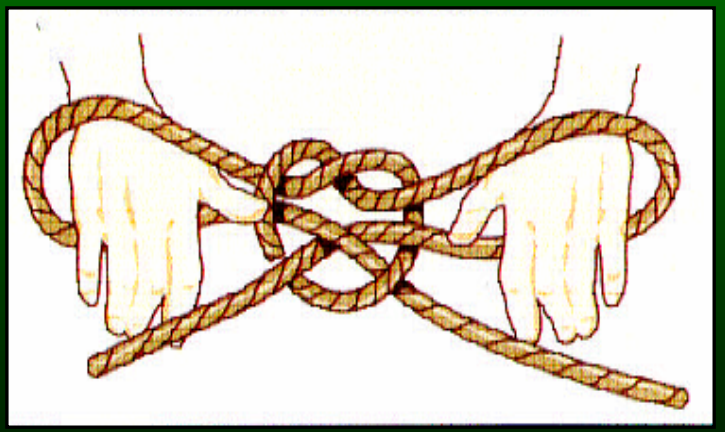
Handcuff Knot

- Used in RIC
  - Firefighter rescue
  - Simple and quick to tie
- AKA - Butterfly Knot

Handcuff Knot

- Form two loops in the rope.
- Pull the left side of the right loop down through the left loop while doing the same with the left loop
- Place the two loops over the victim's wrists, pull the slack out





Miscellaneous Knots

- Truckers Hitch
- Double Loop Figure Eight
- Water Knot
- The Double Fisherman's Bend




Methods of Knot Tying

- Find a method and use it all the time.
- Your department may require a specific method.
- You should be able to tie knots while wearing gloves, in the dark, and behind your back.

“Dressing” a Knot

- Knots are “dressed” by tightening and removing twists, kinks, and slack.
- Firmly finish in a fixed position
- Makes for easy inspection
- Always secure loose ends with safety knot to avoid accidental release of primary knot.

Knot Tying Practice

- Skills can be quickly lost without practice.
- Consider practicing while on the telephone or watching TV.

Hoisting Equipment

- In an emergency, you may have to raise or lower tools and equipment.
- Important that the object is properly secured.
- Coworkers must be able to quickly remove the object.
- When lowering, be sure no one is under the object.

Hoisting an Axe

- Place in vertical position with head down.
- Use a figure eight or a clove hitch on the handle at the head.
- Use half hitches along the handle.
- Keep the handle parallel to the rope.

Hoisting a Pike Pole

- Hoist in a vertical position for immediate use when untied.
- Secure the clove hitch close to the pole head.
- Half hitches keep the handle parallel to the rope.
- Secure the pole with second clove hitch.
- Leave length for a tag line.

Hoisting a Ladder

- Hoist in a vertical position.
- Attach a tag line for control.
- Retract hooks on all roof ladders.
- Tie a figure eight on a bight or a bowline for a secure hoist and easy release.

Hoisting an Uncharged Hose Line

- Fold the hose back on itself, with the nozzle on top.
- Hoist the hose with the fold at the top and the nozzle pointing down.
- Uses a half hitch at the fold and a clove hitch at the nozzle.
- To avoid weight drag, pull up sufficient hose before release.

Hoisting a Charged Hose Line

- It is preferable to hoist a dry hose line.
- Water weight makes hoisting difficult.
- Secure the nozzle in a closed position.
- Secure with clove hitch, half hitch, and safety.
- For easy release: remove tension, and slip the bight over the nozzle.

Hoisting an Exhaust Fan or Power Tool

- Use the same technique as for tools with strong, closed handles.
- Secure handles with a figure eight with a follow-through, and use half hitches for balance.
- Hoist power saws level to avoid leaks.

Hoisting Tips

- Practice hoisting the actual tools used in your department.
- You should be able to hoist tools automatically and in adverse conditions.
- Always use utility rope for hoisting tools and equipment.

Summary (1 of 2)

- Ropes and knots are widely used in fire service.
- Two primary types of fire service rope:
  - Life safety
  - Utility
- Ropes are made from many types of materials.
- There are several types of rope construction.
- Life safety rope is designed to carry a specific amount of weight.

Summary (2 of 2)

- Ropes are often used in technical rescue incidents.
- All ropes require proper care.
- Knots are used to fasten rope to objects or each other.
- Fire fighters must know how to raise and lower tools and equipment using ropes and knots.