Ropes and Knots

Fire Fighter I

Knowledge Objectives

After studying this chapter, you will be able to:

- Describe the three primary types of fire service rope. (NFPA 5.3.20.A, p 260)
- List the two types of life safety rope and their minimum breaking strength. (NFPA 5.3.20.A, p 260–261)
- Describe the characteristics of escape rope. (NFPA 5.3.20.A, p 261)
- Describe the characteristics of utility ropes. (NFPA 5.3.20.A, p 261–262)
- List the advantages of synthetic fiber ropes. (NFPA 5.3.20.A, p 262–263)
- List the disadvantages of synthetic fiber ropes. (NFPA 5.3.20.A, p 263)
- List the types of synthetic fibers that are used in fire service rope. (NFPA 5.3.20.A, p 263)
- Describe how twisted ropes are constructed. (NFPA 5.3.20.A, p 263–264)
- Describe how braided ropes are constructed. (NFPA 5.3.20.A, p 264)
- Describe how kernmantle ropes are constructed. (NFPA 5.3.20.A, p 264–265)
- Explain the differences between dynamic kernmantle rope and static kernmantle rope. (NFPA 5.3.20.A, p 265)
- List the four components of the rope maintenance formula. (NFPA 5.3.20.A, p 268)
- Describe how to preserve rope strength and integrity. (NFPA 5.3.20.A, p 268–270)
- Describe how to clean rope. (NFPA 5.5.1, p 268–269)
- Describe how to inspect rope. (NFPA 5.5.1, p 269–270)
- Describe how to keep an accurate rope record. (NFPA 5.5.1, p 270)
- Describe how to store rope properly. (NFPA 5.5.1, p 270–271)
- List the terminology used to describe the parts of a rope when tying knots. (NFPA 5.3.20.A, p 271)
- List the common types of knots that are used in the fire service. (NFPA 5.3.20.A, p 272)
- Describe the characteristics of a safety knot. (NFPA 5.3.20, p 272–273)
- Describe the characteristics of a hitch. (NFPA 5.3.20, p 272–278)
- Describe the characteristics of a half hitch. (NFPA 5.3.20, p 272)
- Describe the characteristics of a clove hitch. (NFPA 5.3.20, p 272–273)
- Describe the characteristics of a figure eight knot. (NFPA 5.3.20, p 279)
- Describe the characteristics of a bowline knot. (NFPA 5.3.20, p 279)
- Describe the characteristics of a bend. (NFPA 5.3.20, p 279, 286)

Skills Objectives

After studying this chapter, you will be able to perform the following skills:

- Care for life safety ropes. (NFPA 5.5.1.A, 5.5.1.B, p 268)
- Clean fire department ropes. (NFPA 5.5.1.A, p 268–269)
- Inspect fire department ropes. (NFPA 5.5.1, p 270)
- Place a life safety rope in a rope bag. (NFPA 5.5.1, p 270–271)
- Tie a safety knot. (NFPA 5.1.2, 5.3.20.B, p 272–273)
- Tie a half hitch. (NFPA 5.1.2, 5.3.20.B, p 272, 274)
- Tie a clove hitch in the open. (NFPA 5.1.2, 5.3.20.B, p 273, 276–277)
- Tie a clove hitch around an object. (NFPA 5.1.2, 5.3.20.B, p 273–274, 277–278)
- Tie a figure eight knot. (NFPA 5.1.2, 5.3.20.B, p 279–280)
- Tie a figure eight on a bight. (NFPA 5.1.2, 5.3.20.B, p 279, 281)
- Tie a figure eight follow-through. (NFPA 5.1.2, 5.3.20.B, p 279, 282)
- Tie a figure eight bend. (NFPA 5.1.2, 5.3.20.B, p 279, 283)
- Tie a bowline. (NFPA 5.1.2, 5.3.20.B, p 279, 284)
- Tie a sheet or Becket bend. (NFPA 5.1.2, 5.3.20.B, p 279, 285–286)
- Tie a water knot. (NFPA 5.1.2, 5.3.20.B, p 286)
- Hoist an axe. (NFPA 5.1.2, 5.3.20.B, p 287–288)
- Hoist a pike pole. (NFPA 5.1.2, 5.3.20.B, p 288–289)
- Hoist a ladder. (NFPA 5.1.2, 5.3.20.B, p 289–290)
- Hoist a charged hose line. (NFPA 5.1.2, 5.3.20.B, p 289, 291)
- Hoist an uncharged hose line. (NFPA 5.1.2, 5.3.20.B, p 289, 292)
- Hoist an exhaust fan or power tool. (NFPA 5.1.2, 5.3.20.B, p 290–291, 293)

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CHAPTER

10

Fire Fighter II — FFII

Knowledge Objectives

After studying this chapter, you will be able to:

- Describe the hardware components used during a rope rescue. (NFPA 6.4.2, p 265–268)
- Describe the characteristics of a carabiner. (NFPA 6.4.2, p 265–266)
- Describe the characteristics of a harness. (NFPA 6.4.2, p 266)
- List the types of incidents that might require a rope rescue. (p 266–268)

Skills Objectives

There are no separate Fire Fighter II skill objectives for this chapter.

Additional NFPA Standard

- NFPA 1983, *Standard on Life Safety Rope and Equipment for Emergency Services*

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You Are the Fire Fighter

You and your partner are on the fourth floor of a multistory apartment building and find yourself trapped by a rapidly progressing fire. You get to a bedroom at the front of the building and know your only escape route is out the window. You don't have time to wait for the aerial ladder to get to you, so you quickly consider your training for self-rescue. You pull out your rope and begin the most important task you have ever done in your life.

1. What type of rope would you want to use for this type of activity?
2. What rope construction method would be used for this rope?
3. What type of knot would you use?

Introduction

In the fire service, ropes are widely used to hoist or lower tools, appliances, or people; to pull a person to safety; or to serve as a life line in an emergency. A rope might be your only means of accessing a trapped person or your only way of escaping from a fire.

Learning about ropes and knots is an important part of your training as a fire fighter. This chapter gives you a basic understanding of the importance of ropes and knots in the fire service. You can then build on this foundation as you develop skills in handling ropes and tying knots. You must be able to tie simple knots accurately without hesitation or delay.

This chapter discusses different types of rope construction and the materials used in making ropes. It covers the care, cleaning, inspection, and storage of ropes. It also shows how to tie eight essential knots and explains how to secure tools and equipment so that they can be raised or lowered using ropes. Finally, it discusses additional uses for ropes in various rescue situations.

Types of Rope

Three primary types of rope are used in the fire service, each of which is dedicated to a distinct function. Life safety rope is used solely for supporting people. It must be used whenever a rope is needed to support a person, whether during training or during firefighting, rescue, or other emergency operations FIGURE 10-1. Escape rope is a single-purpose, emergency self-escape, self-rescue rope. Utility rope is used in most other cases, when it is not necessary to support the weight of a person, such as when hoisting or lowering tools or equipment.

FIGURE 10-1 A life safety rope is a critical tool for fire fighters.

■ Life Safety Rope

The life safety rope is a critical tool used *only* for life-saving purposes; it must never be used for utility purposes FIGURE 10-2. Life safety rope must be used in every situation where the rope must support the weight of one or more persons. In these situations, rope failure could result in serious injury or death.

Because a fire fighter's equipment must be extremely reliable, the criteria for design, construction, and performance of life safety rope and related equipment are specified in NFPA 1983, *Standard on Life Safety Rope and Equipment for Emergency Services*.

NFPA 1983 lists very specific standards for the construction of life safety rope. This standard also requires the rope manufacturer to include detailed instructions for the proper use, maintenance, and inspection of the life safety rope, including the conditions for removing the rope from service. In addition, the manufacturer must supply a list of criteria that must be reviewed before a life safety rope that has been used in the field can be used again. If the rope does not meet all of the criteria, it must be retired from service.

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Types of Life Safety Ropes

NFPA 1983 defines the performance requirements for two types of life safety rope: technical use life safety rope and general use life safety rope. Technical use life safety rope by definition has a diameter that is 3/8" (9.5 mm) or greater, but is less than 1/2" (12.5mm). In addition to its smaller diameter, technical use life safety ropes are also weaker than general use life safety ropes. With a minimum breaking strength of 4496 pounds force (lbf) (20 kN), technical use life safety ropes are used by highly trained rescue teams that deploy to very technical environments such as mountainous and/or wilderness terrain TABLE 10-1.

TABLE 10-1 Life Safety Rope Strength

Rope Classification	Life Safety Rope Strength
Escape rope (NFPA 1983)	3304 lbf (13.5 kN)
Technical use life safety rope (NFPA 1983)	4496 lbf (20 kN)
General use life safety rope (NFPA 1983)	8992 lbf (40 kN)

FIGURE 10-2 A life safety rope.

The most common life safety rope carried by the fire service in the United States is the general use life safety rope. With a minimum breaking strength of 8992 lbf (40 kN), the general use life safety rope allows the technical rescuer a much greater margin of safety. With respect to its diameter, a general use life safety rope can be no larger than 5/8" (16 mm) and no smaller than 7/16" (11 mm).

FIGURE 10-3 An escape rope is designed to be used by only one person.

Escape Ropes

An escape rope is intended to be used by a fire fighter only for self-rescue from an extreme situation. This rope is designed to carry the weight of only one person and to be used only one time FIGURE 10-3. Its purpose is to provide the fire fighter with a method of escaping from a life-threatening situation. The escape rope should be replaced by a new rope if the escape rope is exposed to an immediate danger to life and health environment.

When you are fighting a fire, you should always have a safe way to get out of a situation and reach a safe location. You might be able to go back through the door that you entered, or you might have another exit route, such as through a different door, through a window, or down a ladder. If conditions suddenly change for the worse, having an escape route can save your life.

Sometimes, however, you can find yourself in a situation where conditions deteriorate so quickly that you cannot use your planned exit route. For example, the stairway you used might collapse behind you, or the room you are in might suddenly flash over (a phase in the development of a contained fire in which exposed surfaces reach ignition temperature more or less simultaneously and fire spreads rapidly throughout the space), blocking your planned route out. In such a situation, you might need to take extreme measures to get out of the building. The escape rope was developed specifically for this type of emergency self-rescue situation. It can support the weight of one person and fits easily into a small packet or pouch FIGURE 10-4.

FIGURE 10-4 A fire fighter can easily carry an escape rope.

FIRE FIGHTER Tips

Escape ropes are not classified as life safety ropes.

Utility Rope

Utility rope is used when it is not necessary to support the weight of a person. Fire department utility rope is used for hoisting or lowering tools or equipment, for making

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FIGURE 10-5 Utility ropes are used for hoisting and lowering tools.

ladder halyards (rope used on extension ladders to raise a fly section), for marking off areas, and for stabilizing objects FIGURE 10-5. Utility ropes also require regular inspection.

Utility ropes must not be used in situations where life safety rope is required. Conversely, life safety rope must not be used for utility applications. A fire fighter must be able to recognize instantly the type of rope from its appearance and markings.

Fire Fighter Safety Tips

Many fire departments use color coding or other visible markings to identify different types of rope. This allows a fire fighter to determine very quickly if a rope is a life safety rope or a utility rope. The length of each rope should also be clearly marked by a tag or a label on the rope bag.

Rope Materials

Ropes can be made from many different types of materials. The earliest ropes were made from naturally occurring vines or fibers that were woven together. Today, ropes are made of synthetic materials such as nylon or polypropylene. Because ropes have many different uses, certain materials can work better than others in particular situations.

Natural Fibers

In the past, fire departments used ropes made from natural fibers, such as manila, because there were no alternatives. In these ropes, the natural fibers are twisted together to form strands. A strand can contain hundreds of individual fibers of different lengths. Today, ropes made from natural fibers are still used as utility ropes but are no longer acceptable as life safety ropes TABLE 10-2. Natural fiber ropes can be weakened by mildew and deteriorate with age, even when properly stored. A wet manila rope can absorb 50 percent of its weight in water, making it very susceptible to deterioration. A wet natural fiber rope is also very difficult to dry.

TABLE 10-2 Drawbacks to Using Natural Fiber Ropes

- Lose their load-carrying ability over time
- Subject to mildew
- Absorb 50 percent of their weight in water
- Degrade quickly

Synthetic Fibers

Since the introduction of nylon in 1938, synthetic fibers have been used to make ropes. In addition to nylon, several newer synthetic materials—such as polyester, polypropylene, and polyethylene—have been used in rope construction FIGURE 10-6. Synthetic fibers have several advantages over natural fibers TABLE 10-3. For example, synthetic fibers are generally stronger than natural fibers, so it is possible to use a smaller diameter rope without sacrificing strength. Synthetic materials can also produce very long fibers that run the full length of a rope to provide greater strength and added safety.

FIGURE 10-6 Synthetic fibers are generally stronger than natural fibers are.

Synthetic ropes are more resistant to rotting and mildew than natural fiber ropes are and do not degrade as rapidly. Depending on the material, they might also provide more resistance to melting and burning than natural fiber ropes do. In addition, synthetic ropes absorb much less water when wet and can be washed and dried. Some types of synthetic rope can float on water, which is a major advantage in water rescue situations.

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TABLE 10-3 Advantages to Using Synthetic Fiber Ropes

- Strength-to-diameter ratio
- Difficult to meet block creel construction requirement with natural fibers
- Longevity over natural fibers

However, ropes made from synthetic fibers do have some drawbacks. Prolonged exposure to ultraviolet light as well as exposure to strong acids or alkalis can damage some synthetic ropes and decrease its life expectancy.

Life safety ropes are always made of synthetic fibers. Before any rope can be used for life safety purposes, it must meet the manufacturing requirements outlined in the current NFPA 1983. These standards specify that life safety rope must be woven of block creel construction (without knots or splices in the yarns, ply yarns, strands, braids, or rope). Rope of any other material or construction may not be used as a life safety rope.

The most common synthetic fiber used in life safety ropes is nylon. It has a high melting temperature with good abrasion resistance and is strong and lightweight. Nylon ropes are also resistant to most acids and alkalis. Polyester is the second most common synthetic fiber used for life safety ropes. Some life safety ropes are made of a combination of nylon and polyester or other synthetic fibers.

FIRE FIGHTER Tips

Ropes used for water rescue are often kept in special throw bags. The rescuer holds onto one end of the rope and throws the bag for the victim to catch. The rescuer then uses the rope to pull the victim to shore.

FIGURE 10-7 Polypropylene rope is often used in water rescues.

Polypropylene is the lightest of the synthetic fibers. Because it does not absorb water and floats, polypropylene rope is often used for water rescue situations FIGURE 10-7. However, polypropylene is not as suitable as nylon for fire department life-safety uses because it is not as strong, it is hard to knot, and it has a low melting point.

Rope Construction

Several types of rope construction are possible. The best choice of rope construction depends on the specific application.

Twisted and Braided Rope

Twisted ropes, which are also called laid ropes, are made of individual fibers twisted into strands. The strands are then twisted together to make the rope FIGURE 10-8A. This method of rope construction has been used for hundreds of years. Both natural and synthetic fibers can be used to make twisted rope.

This method of construction does have a disadvantage in that it exposes all of the fibers to the outside of the rope, where they are subject to abrasion. Abrasion can damage the rope

Near Miss REPORT

Report Number: 08-0000031
Report Date: 01/17/2008

Event Description: During the stabilization for performing extrication, a fire fighter used a bungee cord to tie open the passenger door of a SUV that was lying on its side. I (EMT/Fire Fighter) was performing patient care and had been leaning into the vehicle to work with the patient. The door broke loose from the bungee cord and slammed my dominant hand between the door and frame. As the door bounced back up, I pulled my hand out and the fire fighter who had improperly tied off the door had his thumb shut in the door. After regaining my composure, I returned to patient care until the ambulance arrived. We were both put out of service once the ambulance arrived with a crew to continue patient care. We both had to have x-rays. No broken bones, but I am still under doctor's care.

At our next fire meeting, I took the fire fighter out to our medical unit and opened the compartment which holds our c-collars (which we had used on the scene) and showed him that there were two sections of rope lying right there in plain sight. Had I been leaning in the vehicle door when the door broke free, my neck would have been smashed in the door instead, and I would most likely be dead.

Lessons Learned: The lesson learned for the fire fighter is that bungee cords do NOT replace ropes. Additional extrication training is being scheduled along with additional training in ICS and the need for appointing a safety officer on every scene.

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A.

B.

FIGURE 10-8 **A.** Twisted rope. **B.** Braided rope.

fibers and reduce rope strength. Twisted ropes tend to stretch and are prone to unraveling when a load is applied.

Braided ropes are constructed by weaving or intertwining strands—typically synthetic fibers—together in the same way that hair is braided FIGURE 10-8B. This method of construction also exposes all of the strands to the outside of the rope where they are subject to abrasion. Braided rope stretches under a load, but it is not prone to twisting. A double-braided rope has an inner braided core covered by a protective braided sleeve so that only the fibers in the outer sleeve are exposed to the outside; the inner core remains protected from abrasion in this construction.

Kernmantle Rope

Kernmantle rope consists of two distinct parts: the kern and the mantle. The kern is the center or core of the rope. The mantle, or sheath, is a braided covering that protects the core from dirt and abrasion. Although both parts of a kernmantle rope are made with synthetic fibers, different fibers can be used for the kern and the mantle.

Each fiber in the kern extends for the entire length of the rope without knots or splices. This block creel construction is required under NFPA 1983 for all life safety ropes. The continuous filaments produce a core that is stronger than one constructed of shorter fibers that are twisted or braided together.

Kernmantle construction produces a very strong and flexible rope that is relatively thin and lightweight FIGURE 10-9. This construction is well suited for rescue work and is very popular for life safety rope.

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FIGURE 10-9 The parts of a kernmantle rope.

Dynamic and Static Rope

A rope can be either dynamic or static, depending on how it reacts to an applied load. A dynamic rope is designed to be elastic and stretch when it is loaded. A static rope has a limited range of elasticity. The differences between dynamic and static ropes result from both the fibers used and the construction method.

Dynamic rope is typically used in safety lines for mountain climbing because it stretches and cushions the shock if a climber falls for a long distance. A static rope is more suitable for most fire rescue situations, where falls from great heights are not anticipated. Teams that specialize in rope rescue often carry both static and dynamic ropes for use in different situations.

Dynamic and Static Kernmantle Ropes

Kernmantle ropes can be either dynamic or static. A dynamic kernmantle rope is constructed with overlapping or woven fibers in the core. When the rope is loaded, the core fibers are pulled tighter, which gives the rope its elasticity.

In the core of a static kernmantle rope, all of the fibers are laid parallel to each other. Such a rope has very little elasticity and limited elongation under an applied load. Most fire department life safety ropes use static kernmantle construction. This type of rope is well suited for lowering a person and can be used with a pulley system for lifting individuals. It can also be used to create a bridge between two structures. In this type of rope, the manufacturer includes an imbedded trailer. This trailer includes the name of the manufacturer, model number, make number, serial number, and date of manufacture.

FIRE FIGHTER II

Technical Rescue Hardware

During technical rescue incidents, ropes are often used to access and extricate individuals. In addition to the rope itself, several hardware components might be used. Fire fighters, for example, often use a carabiner, FIGURE 10-10. This device

FIGURE 10-10 Carabiners.

Near Miss REPORT

Report Number: 09-0000302
Report Date: 03/20/2009

Event Description: We were wrapping up training at the local drill tower by packing and stowing ropes. A fire fighter dropped a full 200' rope bag from the second story walkway of the drill tower. It landed by two other fire fighters who were packing another rope bag. It could have broken a fire fighter's neck.

Lessons Learned: Teamwork; safety; concern for fellow fire fighters; equipment care; and common sense need to be more important than personal convenience.

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FIRE FIGHTER II

is used to connect one rope to another rope or to other hardware such as an anchor plate, swivel, or pulley. Several types of carabiners are available, and you should know how to operate the type used by your department.Only a few are recognized for use in the fire service and rescue. Refer to NFPA 1983.

Harnesses

A harness is a piece of rescue or safety equipment made of webbing and worn by a person. It is used to secure the person to a rope or to a solid object. Two types of harnesses—Class II and Class III—can be used by rescuers, depending on the circumstances encountered:

- Class II harness (seat harness) fastens around the rescuer's waist and legs and has a design load of 600 lbs (272 kg). It is used to support a fire fighter, particularly in rescue situations FIGURE 10-11.
- Class III harness (full body harness) fastens around the rescuer's waist and thighs as well as secures the rescuer's waist and shoulders. It is the most secure type of harness and is often used to support a fire fighter who is being raised or lowered on a life safety rope FIGURE 10-12.

FIGURE 10-11 Class II harness (seat harness).

Harnesses need to be cleaned and inspected regularly, just as life safety ropes do. Follow the manufacturer's instructions for cleaning and inspecting harnesses.

Rope Rescue

Rope rescue involves raising and lowering rescuers to access injured or trapped individuals, as well as raising or lowering victims who are rescued so that they can be given appropriate medical treatment. This chapter outlines the basics of rope rescue and gives you a foundation for learning the more complex parts of rope rescue. An approved rope rescue course is required to attain true proficiency in rope rescue skills.

Rope rescue courses cover the technical skills needed to raise or lower people using mechanical advantage systems and to remove someone from a rock ledge or a confined space

FIRE FIGHTER II

FIGURE 10-12 Class III harness (full body harness).

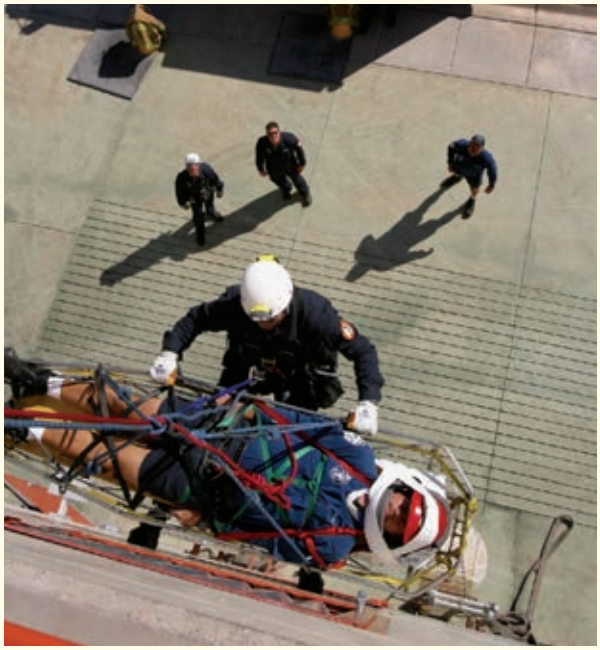

FIGURE 10-13 Rope rescues require intense technical training.

FIGURE 10-13. They also cover the equipment and skills needed to accomplish these rescues safely.

Rope Rescue Incidents

Most rope rescue incidents involve people who are trapped in normally inaccessible locations such as a mountainside or the outside of a building FIGURE 10-14. Rescuers often have to

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FIRE FIGHTER II

FIGURE 10-14 Ropes are invaluable when a person is trapped in an inaccessible area, such as outside a high building.

lower themselves using a system of anchors, webbing, ropes, carabiners, and other devices to reach the trapped person. Once rescuers reach the person, they then have to stabilize him or her and determine how to get the person to safety. Sometimes the victim has to be lowered or raised to a safe location. Extreme cases could involve more complicated operations, such as transporting the victim in a basket lowered by a helicopter.

The type and number of ropes used in a rope rescue depend on the situation. There is almost always a primary rope that bears the weight of the rescuer (or rescuers) as he or she attempts to reach the victim. The rescuers often have a second line attached to them, known as a belay line, which serves as a backup if the main line fails. Additional lines might be needed to raise or lower the trapped individual, depending on the circumstances.

Trench Rescue

Rescues in collapsed trenches often are complicated and involve a number of different skills, such as shoring, air quality monitoring, confined-space operations, and rope rescue. Ropes are often used to stabilize and remove the trapped person. After the rescuers shore the walls of the trench and remove the dirt covering the victim, they place the person in a Stokes basket or on a backboard and lift him or her to the surface. If the trench is deep, ropes might be used to raise the victim to the surface.

Confined-Space Rescue

A confined-space rescue can take place in locations as varied as tanks, silos, underground electrical vaults, storm drains, and similar structures. It is often very difficult to extricate an unconscious or injured person from these locations because of the poor ventilation and limited entry or exit area. For this reason, ropes are often used to remove an injured or unconscious victim FIGURE 10-15.

FIRE FIGHTER II

FIGURE 10-15 Ropes are often used to remove an injured or unconscious victim from a confined space.

Water Rescue

Ropes can be used in a variety of ways during water rescue operations. The simplest situation involves a rescuer on the shore throwing a rope to a person in the water and pulling that individual to shore. A more complicated situation could involve a rope stretched across a stream or river FIGURE 10-16. A boat

FIGURE 10-16 Ropes ensure rescuer safety during water rescues.

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might be tethered to the rope, and rescuers on shore might maneuver the boat using a series of ropes and pulleys.

Rope Maintenance

All ropes—but especially life safety ropes—need proper care to perform in an optimal manner. Maintenance is necessary for all kinds of equipment and all types of rope, and it is absolutely essential for life safety ropes. Your life and the lives of others depend on the proper maintenance of your life safety ropes.

There are four parts to the maintenance formula:

- Care
- Clean
- Inspect
- Store

Care for the Rope

You must follow certain principles to preserve the strength and integrity of rope TABLE 10-4:

- Protect the rope from sharp and abrasive surfaces. Use edge protectors when the rope must pass over a sharp or unpadded surface.
- Protect the rope from rubbing against another rope or webbing. Friction generates heat, which can damage or destroy the rope.
- Protect the rope from heat, chemicals, and flames.
- Protect the rope from prolonged exposure to sunlight. Ultraviolet radiation can damage rope.

TABLE 10-4 Principles to Preserve Strength and Integrity of Rope

- Protect the rope from sharp, abrasive surfaces.
- Protect the rope from heat, chemicals, and flames.
- Protect the rope from rubbing against another rope.
- Protect the rope from prolonged exposure to sunlight.
- Follow the manufacturer's recommendations.

FIRE FIGHTER Tips

A shock load can occur when a rope is suddenly placed under unusual tension—for example, when someone attached to a life safety rope falls until the length of the rope or another rescuer stops the drop. A utility rope can be shock-loaded in a similar manner if a piece of equipment that is being raised or lowered drops suddenly.

Any rope that has been shock-loaded should be inspected and might have to be removed from service. Although there might not be any visible damage, shock loading can cause damage that is not immediately apparent. Repeated shock loads can severely weaken a rope so that it can no longer be used safely. Keeping accurate rope records helps identify potentially damaged rope.

- Do not step on a rope! Your footstep could force shards of glass, splinters, or abrasive particles into the core of the rope, damaging the rope fibers.
- Follow the manufacturer's recommendations for rope care.

To care for life safety ropes properly, follow the steps in SKILL DRILL 10-1 (Fire Fighter I, NFPA 5.5.1):

1. Protect the rope from sharp and abrasive edges; use edge protectors.
2. Protect the rope from rubbing against other ropes.
3. Protect the rope from heat, chemicals, flames, and sunlight.
4. Avoid stepping on a rope.

Clean the Rope

Many ropes made from synthetic fibers can be washed with a mild soap and water. In addition, a special rope washer can be attached to a garden hose FIGURE 10-17. Some manufacturers recommend placing the rope in a mesh bag and washing it in a front-loading washing machine.

When washing a rope, use a mild detergent. Do not use bleach because it can damage rope fibers. Follow the manufacturer's recommendations for specific care of your rope. Do not pack or store wet or damp rope. Air drying is usually recommended. The drying rope should be suspended and should not lie on the floor. The use of mechanical drying devices is not usually recommended. Rope should never be dried or stored in direct sunlight.

FIGURE 10-17 Some fire departments use a rope washer to clean their ropes.

Follow the steps in SKILL DRILL 10-2 to clean fire department ropes:

1. Wash the rope with mild soap and water. (STEP 1)
2. Use a rope washer or machine, if recommended by the rope's manufacturer. (STEP 2)
3. Air dry the rope out of direct sunlight.
4. Inspect the rope and replace it in the rope bag so that it is ready for use. (STEP 3)

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SKILL DRILL 10-2 Cleaning Fire Department Ropes

(Fire Fighter I, NFPA 5.5.1)

1 Wash the rope with mild soap and water.

2 Use a rope washer or machine if recommended by the rope's manufacturer.

3 Air dry the rope out of direct sunlight. Inspect the rope and replace it in the rope bag so that it is ready for use.

Inspect the Rope

Life safety ropes must be inspected after each use, whether the rope was used for an emergency incident or in a training exercise TABLE 10-5. Unused rope should also be inspected on a regular schedule. Some departments inspect all rope, including life safety and utility ropes, every three months. Obtain the inspection criteria from the rope manufacturer.

Inspect the rope visually, looking for cuts, frays, or other damage as you run it through your fingers. Make sure that your grasping hand is gloved to protect yourself from sharp objects imbedded in the rope. Because you cannot see the inner core of a kernmantle rope, feel for any depressions (flat spots or lumps on the inside). Examine the sheath for any discolorations, abrasions, or flat spots FIGURE 10-18. If you have any doubt about whether the rope has been damaged, consult your company officer TABLE 10-6.

TABLE 10-5 Questions to Consider When Inspecting Life Safety Ropes

- Has the rope been exposed to heat or flame?
- Has the rope been exposed to abrasion?
- Has the rope been exposed to chemicals?
- Has the rope been exposed to shock loads?
- Are there any depressions, discolorations, or lumps in the rope?

FIGURE 10-18 Rope inspection is a critical step.

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TABLE 10-6 Signs of Possible Rope Deterioration

- Discoloration
- Shiny markings from heat or friction
- Damaged sheath
- Core fibers poking through the sheath

A life safety rope that is no longer usable must be pulled from service and either destroyed or marked as a utility rope. A downgraded rope must be clearly marked so that it cannot be confused with a life safety rope.

Follow the steps in SKILL DRILL 10-3 (Fire Fighter I, NFPA 5.5.1) to inspect fire department ropes:

1. Inspect the rope after each use and at regular intervals.
2. Examine the core by looking for depressions, flat spots, or lumps.
3. Examine the sheath by looking for discolorations, abrasions, flat spots, and imbedded objects.
4. Remove the rope from service if it is damaged.

Rope Record

Each piece of rope must be marked for identification. In addition, a rope record must be kept for each piece of life safety rope. This record should include a history of when the rope was purchased, when it was used, how it was used, and what kinds of loads were applied to it. Each inspection should also be recorded. Fire departments should maintain rope records for both utility ropes and life safety ropes.

Store the Rope

Proper care ensures a long life for your rope and reduces the chance of equipment failure and accident. Store ropes away from temperature extremes, out of sunlight, and in areas where there is some air circulation. Avoid placing ropes where fumes from gasoline, oils, or hydraulic fluids might damage them. Apparatus compartments used to store ropes should be separated from compartments used to store any oil-based products or machinery powered by gasoline or diesel fuel. Do not place any heavy objects on top of the rope FIGURE 10-19.

Rope bags are used to protect and store ropes. Each bag should hold only one rope. Rope may also be coiled for storage FIGURE 10-20. Very long pieces of rope are sometimes stored on spools FIGURE 10-21.

Follow the steps in SKILL DRILL 10-4 to place a life safety rope into a rope bag:

1. Inspect rope to be certain it is fit for service.
2. Carefully load the life safety rope into the rope bag. (STEP 1)
3. Do not try to coil the rope in the bag because this action will cause the rope to kink and become tangled when it is pulled out.
4. Return the rope and the rope bag to its proper location for storage or service. (STEP 2)

FIGURE 10-19 Ensure that ropes are stored safely.

FIGURE 10-20 Ropes may be coiled for storage.

FIGURE 10-21 Long sections of rope are sometimes stored on spools.

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SKILL DRILL 10-4 Placing a Life Safety Rope in a Rope Bag

(Fire Fighter I, NFPA 5.5.1)

1 Inspect rope to be certain it is fit for service. Carefully load the life safety rope into the rope bag.

2 Do not try to coil the rope in the bag because this action will cause the rope to kink and become tangled when it is pulled out. Return the rope and the rope bag to its proper location for storage or service.

Knots

Knots are prescribed ways of fastening lengths of rope or webbing to objects or to each other. As a fire fighter, you must know how to tie certain knots and when to use each type of knot. Knots can be used for one or more particular purposes. Hitches, such as the clove hitch, are used to attach a rope around an object. Knots, such as the figure eight and the bowline, are used to form loops. Bends, such as the sheet bend or Becket bend, are used to join two ropes together. Safety knots, such as the overhand knot, are used to secure the ends of ropes to prevent them from coming untied.

Any knot reduces the load-carrying capacity of the rope in which it is placed by a certain percentage TABLE 10-7. You can avoid an unnecessary reduction in rope strength if you know which type of knot to use and how to tie the knot correctly.

TABLE 10-7 Effect of Knots on Rope Strength

Group	Knot	Reduction in Strength
Loop knots	Figure eight on a bight	20%
	Figure eight follow-through	19%
	Bowline	33%

Terminology

Specific terminology is used to refer to the parts of a rope in describing how to tie knots FIGURE 10-22:

- The working end is the part of the rope used for forming the knot.
- The running end is the part of the rope used for lifting or hoisting.
- The standing part is the rope between the working end and the running end.
- A bight is formed by reversing the direction of the rope to form a U bend with two parallel ends FIGURE 10-23.
- A loop is formed by making a circle in the rope FIGURE 10-24.
- A round turn is formed by making a loop and then bringing the two ends of the rope parallel to each other FIGURE 10-25.

FIGURE 10-22 The sections of a rope used in tying knots.

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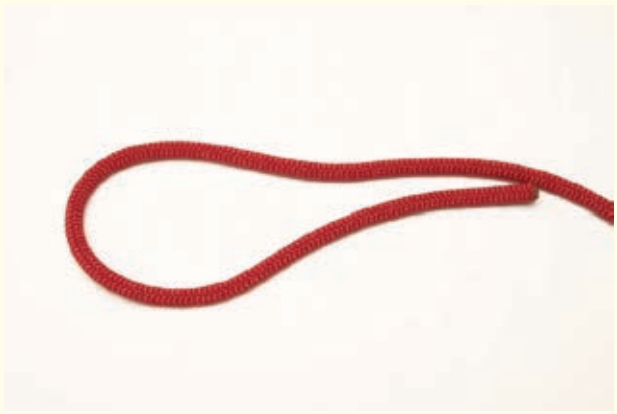

FIGURE 10-23 A bight.

FIGURE 10-24 A loop.

FIGURE 10-25 A round turn.

A fire fighter should know how to tie and properly use these simple knots:

- Safety knot (overhand knot)
- Half hitch
- Clove hitch
- Figure eight
- Figure eight on a bight
- Figure eight follow-through
- Figure eight bend
- Bowline
- Bend (sheet or Becket bend)

Safety Knot

A safety knot (also referred to as an overhand knot or a keeper knot) is used to secure the leftover working end of the rope. It provides a degree of safety to ensure that the primary knot will not become undone. A safety knot should always be used to finish the other basic knots.

A safety knot is simply an overhand knot in the loose end of the rope that is made around the standing part of the rope. It secures the loose end and prevents it from slipping back through the primary knot.

Follow the steps in SKILL DRILL 10-5 to tie a safety knot:

1. Take the loose end of the rope, beyond the knot, and form a loop around the standing part of the rope. (STEP 1)
2. Pass the loose end of the rope through the loop. (STEP 2)
3. Tighten the safety knot by pulling on both ends at the same time.
4. Test whether you have tied a safety knot correctly by sliding it on the standing part of the rope. A knot that is tied correctly will slide. (STEP 3)

Hitches

Hitches are knots that wrap around an object, such as a pike pole or a fencepost. They are used to secure the working end of a rope to a solid object or to tie a rope to an object before hoisting it.

Half Hitch

The half hitch is not a secure knot by itself, which is why it is used only in conjunction with other knots. For example, when hoisting an axe or pike pole, you use the half hitch to keep the hoisting rope aligned with the handle. On long objects, you might need to use several half hitches.

Follow the steps in SKILL DRILL 10-6 to tie a half hitch:

1. Grab the rope with your palm facing away from you. (STEP 1)
2. Rotate your hand so that your palm is facing you. This will make a loop in the rope. (STEP 2)
3. Pass the loop over the end of the object. (STEP 3)
4. Finish the half-hitch knot by positioning it and pulling tight. (STEP 4)

Clove Hitch

A clove hitch is used to attach a rope firmly to a round object, such as a tree or a fencepost. It can also be used to tie a hoisting rope around an axe or pike pole. A clove hitch can be tied anywhere in a rope and will hold equally well if tension is applied to either end of the rope or to both ends simultaneously.

There are two different methods of tying this knot. A clove hitch tied in the open is used when the knot can be formed and then slipped over the end of an object, such as an axe or pike

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SKILL DRILL 10-5 Tying a Safety Knot

(Fire Fighter I, NFPA 5.5.2)

1 Take the loose end of the rope, beyond the knot, and form a loop around the standing part of the rope.

2 Pass the loose end of the rope through the loop.

3 Tighten the safety knot by pulling on both ends at the same time. Test whether you have tied a safety knot correctly by sliding it on the standing part of the rope. A knot that is tied correctly will slide. Note: When complete, the safety knot should sit directly next to any accompanying knots.

pole. It is tied by making two consecutive loops in the rope. Follow the steps in SKILL DRILL 10-7 to tie a clove hitch in the open:

1. Starting from left to right on the rope, grab the rope with crossed hands with the left positioned higher than the right. (STEP 1)
2. Holding onto the rope, uncross your hands. This will create a loop in each hand. (STEP 2)
3. Slide the right-hand loop behind the left-hand loop. (STEP 3)
4. Slide both loops over the object. (STEP 4)
5. Pull in opposite directions to tighten the clove hitch.
6. Tie a safety knot in the working end of the rope. (STEP 5)

If the object is too large or too long to slip the clove hitch over one end, the same knot can be tied around the object. Follow the steps in SKILL DRILL 10-8 to tie a clove hitch around an object:

1. Place the working end of the rope over the object. (STEP 1)
2. Make a complete loop around the object, working end down. (STEP 2)

FIRE FIGHTER Tips

When tying a safety knot in a clove hitch, the end of the rope should pass around the object the clove hitch is being tied to and the overhand safety knot is tied onto the rope.

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SKILL DRILL 10-6

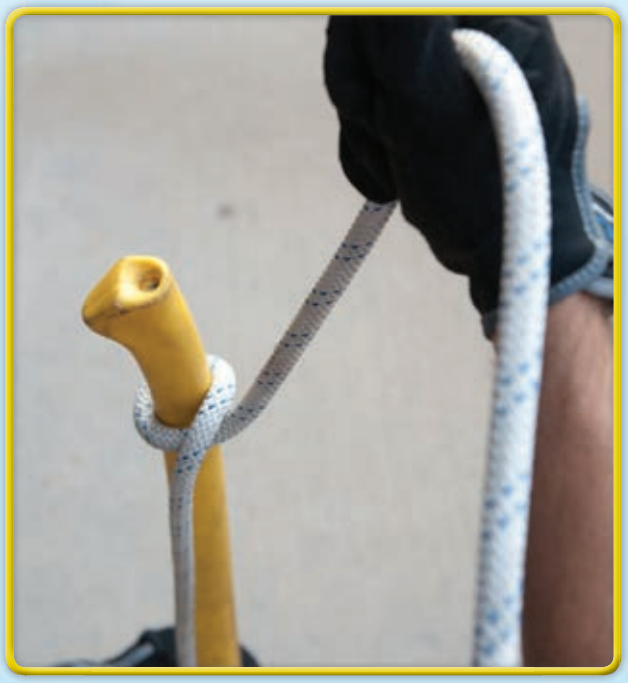
Tying a Half Hitch

(Fire Fighter I, NFPA 5.5.2)

1 Grab the rope with your palm facing away from you.

2 Rotate your hand so that your palm is facing you. This will make a loop in the rope.

3 Pass the loop over the end of the object.



4 Finish the half-hitch knot by positioning it and pulling tight.

3. Make a second loop around the object a short distance above the first loop.
4. Pass the working end of the rope under the second loop, above the point where the second loop crosses over the first loop. (STEP 3)
5. Tighten the knot and secure it by pulling on both ends. (STEP 4)
6. Tie a safety knot in the working end of the rope. (STEP 5)

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VOICES OF EXPERIENCE

Sunday mornings in the summer are fun. As a lieutenant and training officer for my company, if I'm not teaching at the training academy, you will find me leading an entertaining drill at the station with the fire fighters who randomly show up that day. Our township has a mixture of unique features, which demand a solid core of all-around skills. Coming up with skills to review on a Sunday morning is not difficult.

When the tones dropped, we were in the middle of reviewing tool tying. The dispatcher announced, "Rescue box 73-88, the rod and gun club, a water rescue." As I boarded the apparatus, I never could have anticipated what we would find on scene.

The rod and gun club is situated on hilly terrain. Hidden in the back, behind the two-story club house, is a normally small stream. On that day it was a torrent. Heavy rain had caused a deluge of water to pour down from the northern counties, turning what was a 30 foot-wide, shallow trickling brook, into a 12 mile-per-hour, 4 foot deep section of rapids and trapping three 12-year-old children on a narrow island in the middle.

The action plan developed by our chiefs called for us to erect a modified Tyrolean traverse (water highline). The plan was to establish a secure line onto which the rescuers, along with their victims, could be attached and assisted to the safe bank of the span. I would become the master rigger for the evolution. I sent four fire fighters down stream with a 100 foot static kernmantle lifeline and orders to find a way to get across and establish a catch line should any of our team or the children become caught in the water and propelled downstream. Once the down stream team had completed their task, I attached one end of a 100 foot static kernmantle lifeline to a 3 foot diameter tree down stream from the rescue sight at a safe place on the bank using a tensionless hitch. I then ordered two fire fighters upstream to attempt a crossing, realizing that even if they made it, they would need to compensate for the water flow to intersect the island. I had them take rescue harnesses, webbing, Prusik cords, and carabineers, anticipating their success. This way the children could be properly packaged and the rescuers safely connected to the highline during the retrieval phase.

Once the rescuers reached the island, they secured the other end of the rope to a similar sized tree using a clove hitch on a bight and began the task of packaging the children. While this was going on, I ordered the fashioning of a simple Z-rig and the placement of a change of direction pulley on a tree directly in front of the island rescue point. We then tensioned the line, holding it fast with progress capture Prusik cords. With the highline in place, the children harnessed and fastened securely to the rescuers and the rescuers properly fastened to the highline using long Prusik cords, the rescuers were able to safely carry the children to the bank.

The next day I went back to the site of the rescue. I walked across the babbling brook, staying well above the water using the stones, thinking, this is exactly how those children crossed. As I gathered the ropes from the other side, I took a moment to reflect on how my practiced skills had helped three youngsters escape a flash flood on a sunny Sunday morning without a cloud in the sky. I felt satisfied.

Andrew S. Gurwood
Bucks County Public Safety Training Center
Northampton, Pennsylvania

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SKILL DRILL 10-7

Tying a Clove Hitch in the Open

(Fire Fighter I, NFPA 5.5.2)

1 Starting from left to right on the rope, grab the rope with crossed hands with the left positioned higher than the right.

2 Holding onto the rope, uncross your hands. This will create a loop in each hand.

3 Slide the right-hand loop behind the left-hand loop.

(*Continued*)

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SKILL DRILL 10-7 Tying a Clove Hitch in the Open (*Continued*)

(Fire Fighter I, NFPA 5.5.2)

4 Slide both loops over the object.

5 Pull in opposite directions to tighten the clove hitch. Tie a safety knot in the working end of the rope.

SKILL DRILL 10-8 Tying a Clove Hitch Around an Object

(Fire Fighter I, NFPA 5.5.2)

1 Place the working end of the rope over the object.

2 Make a complete loop around the object, working end down.

(*Continued*)

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SKILL DRILL 10-8

Tying a Clove Hitch Around an Object (*Continued*)

(Fire Fighter I, NFPA 5.5.2)

3 Make a second loop around the object a short distance above the first loop. Pass the working end of the rope under the second loop, above the point where the second loop crosses over the first loop.

4 Tighten the knot and secure it by pulling on both ends.

5 Tie a safety knot in the working end of the rope.

Near Miss REPORT

Report Number: 10-1038

Synopsis: Knot overlooked during rope training.

Event Description: Our rescue unit was staffed one day with untrained personnel. The apparatus was scheduled for rope training and the untrained member was going to rappel. All safety equipment was checked and appropriate rigging and knots were tied and checked for safe operation. As the untrained member stepped into position to rappel, someone noticed that the knot wasn't properly attached to the member's harness. The member was pulled away from the edge and the equipment was checked again.

Lessons Learned: Untrained personnel should not be allowed to participate in training if they are not educated in all areas of the training.

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Loop Knots

Loop knots are used to form a loop in the end of a rope. These loops can be used for hoisting tools, for securing a person during a rescue, for securing a rope to a fixed object, or for identifying the end of a rope stored in a rope bag. When tied properly, these knots will not slip, yet are easy to untie.

Figure Eight Knot

A figure eight is a basic knot used to produce a family of other knots, including the figure eight on a bight, the figure eight follow-through, and the figure eight bend. Follow the steps in SKILL DRILL 10-9 to tie a figure eight knot:

1. Form a bight in the rope. (STEP 1)
2. Loop the working end of the rope completely around the standing end of the rope. (STEP 2)
3. Thread the working end through the opening of the bight. (STEP 3)
4. Tighten the knot by pulling on both ends simultaneously. When you pull the knot tight, it will have the shape of a figure eight. (STEP 4)

Figure Eight on a Bight

The figure eight on a bight knot creates a secure loop at the working end of a rope. This loop can be used to attach the end of the rope to a fixed object or a piece of equipment or to tie a life safety rope around a person. Follow the steps in SKILL DRILL 10-10 to tie a figure eight on a bight:

1. Double over a section of the rope to form a bight. The closed end of the bight becomes the working end of the rope. (STEP 1)
2. Hold the two sides of the bight as if they were one rope.
3. Form a loop in the doubled section of the rope. (STEP 2)
4. Pass the working end of the bight through the loop. (STEP 3)
5. Pull the knot tight. Pulling the knot tight locks the neck of the bight and forms a secure loop. (STEP 4)
6. Use a safety knot to tie the loose end of the rope to the standing part. (STEP 5)

Figure Eight Follow-Through

A figure eight follow-through knot creates a secure loop at the end of the rope when the working end must be wrapped around an object or passed through an opening before the loop can be formed. It is very useful for attaching a rope to a fixed ring or a solid object with an "eye." Follow the steps in SKILL DRILL 10-11 to tie a figure eight with a follow-through:

1. Tie a simple figure eight in the standing part of the rope, far enough back to make a loop. Leave this knot loose. (STEP 1)
2. Thread the working end through the opening or around the object, and bring it back through the original figure eight knot in the opposite direction. (STEP 2)
3. Once the working end has been threaded through the knot, pull the knot tight. (STEP 3)
4. Secure the loose end with a safety knot. (STEP 4)

Figure Eight Bend

The figure eight bend or tracer 8 is used to join two ropes together. Follow the steps in SKILL DRILL 10-12 to tie a figure eight bend:

1. Tie a figure eight near the end of one rope. (STEP 1)
2. Thread the end of the second rope completely through the knot from the opposite end.
3. Pull the knot tight. (STEP 2)
4. Tie a safety knot on the loose end of each rope to the standing part of the other. (STEP 3)

Bowline

A bowline knot also can be used to form a loop. This type of knot is frequently used to secure the end of a rope to an object or anchor point. It can also be used to hoist equipment. Follow the steps in SKILL DRILL 10-13 to tie a bowline:

1. Make the desired sized loop and bring the working end back to the standing part. (STEP 1)
2. Form another small loop in the standing part of the rope with the section close to the working end on top.
3. Thread the working end up through this loop from the bottom. (STEP 2)
4. Pass the working end over the loop, around and under the standing part, and back down through the same opening. (STEP 3)
5. Tighten the knot by holding the working end and pulling the standard part of the rope backward. (STEP 4)
6. Tie a safety knot in the working end of the rope. (STEP 5)

Bends

Bends are used to join two ropes together. The sheet bend or Becket bend can be used to join two ropes of unequal size. A sheet bend knot also can be used to join rope to a chain or to pull up a rope of a different diameter. It should not be relied upon to support a human load. Follow the steps in SKILL DRILL 10-14 to tie a sheet or Becket bend:

1. Form a bight in the working end of one rope. If the ropes are of unequal size, the bight should be made in the larger rope. (STEP 1)
2. Pass the end of the second rope up through the opening of the bight, between the two parallel sections of the first rope. (STEP 2)
3. Loop the second rope completely around both sides of the bight.
4. Thread the second rope under itself and on top of the two sides of the bight. (STEP 3)

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SKILL DRILL 10-9

Tying a Figure Eight Knot

(Fire Fighter I, NFPA 5.5.2)

1 Form a bight in the rope.

2 Loop the working end of the rope completely around the standing part of the rope.

3 Thread the working end back through the bight.

4 Tighten the knot by pulling on both ends simultaneously.

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SKILL DRILL 10-10

Tying a Figure Eight on a Bight

(Fire Fighter I, NFPA 5.5.2)

1 Form a bight and identify the closed end of the bight as the working end of the rope.

2 Holding both sides of the bight together, form a loop.

3 Feed the working end of the bight back through the loop.

4 Pull the knot tight.

5 Secure the loose end of the rope with a safety knot.

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SKILL DRILL 10-11 Tying a Figure Eight Follow-Through

(Fire Fighter I, NFPA 5.5.2)

1 Tie a simple figure eight in the standing part of the rope, far enough back to make a loop. Leave this knot loose.

2 Thread the working end through the opening or around the object, and bring it back through the original figure eight knot in the opposite direction.

3 Once the working end has been threaded through the knot, pull the knot tight.

4 Secure the loose end with a safety knot.

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SKILL DRILL 10-12

Tying a Figure Eight Bend

(Fire Fighter 1, NFPA 5.1.2)

1 Tie a figure eight near the end of one rope.

2 Thread the end of the second rope completely through the knot from the opposite end. Pull the knot tight.

3 Tie a safety knot on the loose end of each rope to the standing part of the other.

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SKILL DRILL 10-13

Tying a Bowline

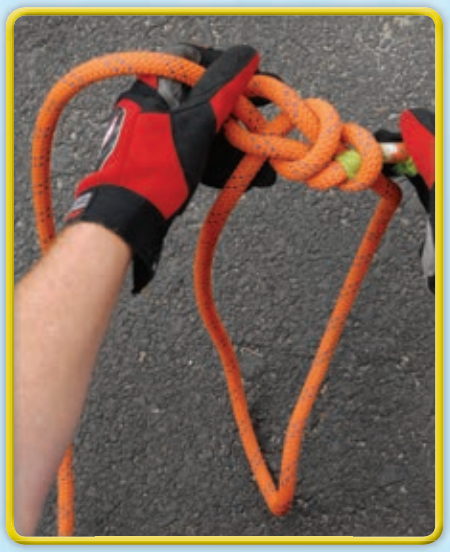
(Fire Fighter I, NFPA 5.5.2)

1 Make the desired sized loop and bring the working end back to the standing part.

2 Form another small loop in the standing part of the rope with the section close to the working end on top. Thread the working end up through this loop from the bottom.

3 Pass the working end over the loop, around and under the standing part, and back down through the same opening.

4 Tighten the knot by holding the working end and pulling the standard part of the rope backward.



5 Tie a safety knot in the working end of the rope.

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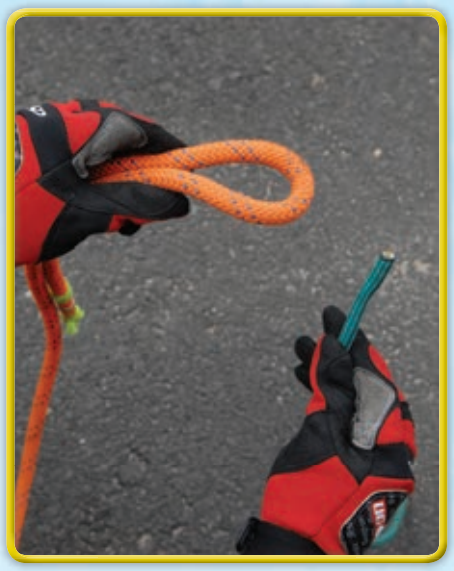
SKILL DRILL 10-14 Tying a Sheet or Becket Bend

(Fire Fighter I, NFPA 5.5.2)



1 Using your left hand, form a bight at the working end of the first (larger) rope.

2 Thread the working end of the second (smaller) rope up through the bight.

3 Loop the second (smaller) rope completely around both sides of the bight. Pass the working end of the second (smaller) rope between the original bight and under the second rope.

4 Tighten the knot.

5 Tie a safety knot in the working end of each rope.

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SKILL DRILL 10-15 Tying a Water Knot

(Fire Fighter I, NFPA 5.5.2)

1 In one end of the webbing, approximately 6 inches (152 mm) from the end, tie an overhand knot.

2 With the other end of the webbing, start retracing from the working end through the knot until approximately 6 inches (152 mm) is left on the other end.

3 Tie an overhand knot on each tail as a safety.

5. To tighten the knot, hold the first rope firmly while pulling back on the second rope. (STEP 4)
6. Use a safety knot to secure the loose ends of both ropes. (STEP 5)

Water Knot

The water knot or ring bend is used to join webbing of the same or different sizes together. When a single piece of webbing is used and the opposite ends are tied to each other, a loop or sling is created. Follow the steps in SKILL DRILL 10-15 to tie a water knot:

1. In one end of the webbing, approximately 6 inches (152 mm) from the end, tie an overhand knot. (STEP 1)
2. With the other end of the webbing, start retracing from the working end through the knot until approximately 6 inches (152 mm) is left on the other end. (STEP 2)
3. Tie an overhand knot on each tail as a safety. (STEP 3)

There are many ways to tie each of these knots. Find one method that works for you and use it all the time. In addition, your department might require that you learn how to tie other knots. It is important to become proficient in tying knots. With practice, you should be able to tie these knots in the dark, with heavy gloves on, and behind your back.

A knot should be properly "dressed" by tightening and removing twists, kinks, and slack from the rope. The finished knot is then firmly fixed in position. The configuration of a properly dressed knot should be evident so that it can be easily inspected.

Knot-tying skills can be quickly lost without adequate practice. Practice tying knots while you are on the telephone or watching television FIGURE 10-26. You never know when you will need to use these skills in an emergency situation. For

FIGURE 10-26 To maintain your knot-tying skills, practice tying different knots frequently.

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added practice, try tying these knots with your gloves on or in darkness. These are conditions you will encounter often as a fire fighter.

Hoisting

Tying knots is not an idle exercise but rather a practical skill that you will frequently use on the job. In emergency situations, you might have to raise or lower a tool to other fire fighters. It is important for you to learn how to raise and lower an axe, a pike pole, a ladder, a charged hose line, an uncharged hose line, and an exhaust fan.

It is essential to ensure that the rope is tied securely to the object being hoisted so that the tool does not fall. Additionally, your co-workers must be able to remove the rope and place the tool into service quickly. When you are hoisting or lowering a tool, make sure no one is standing under the object. Keep the scene clear of people to avoid any chance of an accident.

Hoisting an Axe

An axe should be hoisted in a vertical position with the head of the axe down. After receiving the end of the utility rope from the fire fighter above, follow the steps in SKILL DRILL 10-16 to hoist an axe:

1. Tie the end of the hoisting rope around the handle near the head using either a figure eight on a bight or a clove hitch. Slip the knot down the handle from the end to the head. (STEP 1)

SKILL DRILL 10-16 Hoisting an Axe
(Fire Fighter I, NFPA 5.5.2)

1 Tie the end of the hoisting rope around the handle near the head using either a figure eight on a bight or a clove hitch. Slip the knot down the handle from the end to the head.

2 Loop the standing part of the rope under the head.

3 Place the standing part of the rope parallel to the axe handle.

4 Use one or two half hitches along the axe handle to keep the handle parallel to the rope. Communicate with the fire fighter above that the axe is ready to raise.

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2. Loop the standing part of the rope under the head. (STEP 2)
3. Place the standing part of the rope parallel to the axe handle. (STEP 3)
4. Use one or two half hitches along the axe handle to keep the handle parallel to the rope.
5. Communicate with the fire fighter above that the axe is ready to raise. (STEP 4)

To release the axe, hold the middle of the handle, release the half hitches, and slip the knot up and off.

Hoisting a Pike Pole

A pike pole should be hoisted in a vertical position with the head at the top. After receiving the end of the utility rope from the fire fighter above, follow the steps in SKILL DRILL 10-17 to hoist a pike pole:

1. Place a clove hitch over the bottom of the handle and secure it close to the bottom of the handle.
2. Leave enough length of rope below the clove hitch for a tag line while raising the pike pole. (STEP 1)

SKILL DRILL 10-17 Hoisting a Pike Pole

(Fire Fighter I, NFPA 5.5.2)

1. Place a clove hitch over the bottom of the handle and secure it close to the bottom of the handle. Leave enough length of rope below the clove hitch for a tag line while raising the pike pole.

2. Place a half hitch around the handle above the clove hitch to keep the rope parallel to the handle.

3. Slip a second half hitch over the handle and secure it near the head of the pike pole.

4. Communicate with the fire fighter above that the pike pole is ready to raise.

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3. Place a half hitch around the handle above the clove hitch to keep the rope parallel to the handle. (STEP 2)
4. Slip a second half hitch over the handle and secure it near the head of the pike pole. (STEP 3)
5. Communicate with the fire fighter above that the pike pole is ready to raise. (STEP 4)

Hoisting a Ladder

A ladder should be hoisted in a vertical position. A tag line should be attached to the bottom to keep the ladder under control as it is hoisted. If it is a roof ladder, the hooks should be in the retracted position. After receiving the end of the utility rope from the fire fighter above, follow the steps in SKILL DRILL 10-18 to hoist a ladder:

1. Tie a figure eight on a bight to create a loop, approximately 3 or 4 feet (1–1.3 meters) in diameter, that is large enough to fit around both ladder beams. (STEP 1)
2. Pass the rope between two beams of the ladder, three or four rungs from the top.
3. Pull the end of the loop under the rungs and toward the tip at the top of the ladder. (STEP 2)
4. Place the loop around the top tip of the ladder and pull on the running end of the rope to remove the slack from the rope. (STEP 3)
5. Attach a tag line to the bottom rung of the ladder to stabilize it as it is being hoisted.
6. Communicate with the fire fighter above that the ladder is ready to be raised.
7. Stabilize the bottom of the ladder as it is being hoisted by holding on to the tag line. (STEP 4)

Hoisting a Charged Hose Line

It is almost always preferable to hoist a dry hose line because water adds considerable weight to a charged line. Water weighs 8.33 pounds (3.79 kilograms) per gallon, which can make hoisting a charged line much more difficult. However, there can be occasions when it is necessary to hoist a charged hose line. After receiving the end of the utility rope from the fire fighter above, follow the steps in SKILL DRILL 10-19 to hoist a charged hose line:

1. Make sure that the nozzle is completely closed and secure. A charged hose line should have the nozzle secured in a closed position as it is hoisted because an unsecured handle (known as the bale) could get caught on something as the hose is being hoisted. The nozzle could open suddenly, resulting in an out-of-control hose line suspended in midair, with the potential for causing serious injuries and damage.
2. Use a clove hitch, 1 or 2 feet (0.3–0.6 meter) behind the nozzle, to tie the end of the hoisting rope around a charged hose line.
3. Use a safety knot to secure the loose end of the rope below the clove hitch. (STEP 1)
4. Make a bight in the rope even with the nozzle shut-off handle, which must be in the forward (completely off) position.
5. Insert the bight through the handle opening and slip it over the end of the nozzle. When the bight is pulled tight, it will create a half hitch and secure the handle in the off position while the charged hose line is hoisted.
6. Communicate with the fire fighter above that the hose line is ready to hoist. (STEP 2)

The knot can be released after the line is hoisted by removing the tension from the rope and slipping the bight back over the end of the nozzle.

Hoisting an Uncharged Hose Line

Before hoisting a dry hose line, you should fold the hose back on itself and place the nozzle on top of the hose. This action ensures that water will not reach the nozzle if the hose is accidentally charged while being hoisted. It also eliminates an unnecessary stress on the couplings by ensuring that the rope pulls on the hose and not directly on the nozzle. After receiving the end of the utility rope from the fire fighter above, follow the steps in SKILL DRILL 10-20 to hoist an uncharged hose line:

1. Fold about 3 feet (1 meter) of hose back on itself and place the nozzle on top of the hose. (STEP 1)
2. Make one or two half hitches in the rope and slip it over the nozzle. Move the half hitch along the hose and secure it about 6 inches (15 centimeters) from the fold. (STEP 2)
3. Tie a clove hitch near the end of the rope, wrapping the rope securely around both the nozzle and the hose. The clove hitch should hold both the nozzle and the hose. (STEP 3)
4. Communicate with the fire fighter above that the hose line is ready to hoist.
5. Hoist the hose with the fold at the top and the nozzle pointing down.
6. Before releasing the rope, the fire fighters at the top must pull up enough hose so that the weight of the hanging hose does not drag down the hose. (STEP 4)

FIRE FIGHTER II Tips FFII

Ropes and knots are challenging in the best of circumstances. To be proficient and to work in an effective and efficient manner when tying knots and moving equipment, you should consistently work on your rope and knot skills. Keep a short piece of rope close at hand so that you can practice your skills during down times.

Hoisting an Exhaust Fan or Power Tool

Several types of tools and equipment—including an exhaust fan, a chainsaw, a circular saw, or any other object that has a strong closed handle—can be hoisted using the same

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SKILL DRILL 10-18 Hoisting a Ladder

(Fire Fighter I, NFPA 5.5.2)

1 Tie a figure eight on a bight to create a loop, approximately 3 or 4 feet (1–1.3 meters) in diameter, that is large enough to fit around both ladder beams.

2 Pass the rope between two beams of the ladder, three or four rungs from the top. Pull the end of the loop under the rungs and toward the tip at the top of the ladder.

3 Place the loop around the top tip of the ladder.

4 Pull on the running end of the rope to remove the slack from the rope. Attach a tag line to the bottom rung of the ladder to stabilize it as it is being hoisted. Communicate with the fire fighter above that the ladder is ready to be raised. Stabilize the bottom of the ladder as it is being hoisted by holding on to the tag line.

technique. In this situation, the hoisting rope is secured to the object by passing the rope through the opening in the handle. A figure eight with a follow-through knot is then used to close the loop.

Some types of equipment require that you use additional half hitches to balance the object in a particular position while it is being hoisted. For example, power saws are hoisted in a level position to prevent the fuel from leaking out.

You should practice hoisting the actual tools and equipment used in your department. You should be able to perform this task automatically and in adverse conditions.

Remember that you always use utility rope for hoisting tools. You do not want to get oil or grease on designated life safety ropes. If a life safety rope becomes oily or greasy, it should be taken out of service and destroyed so that it will not be mistakenly used again as a life safety rope. The damaged rope can be cut into short lengths and used for utility rope.

After receiving the end of the utility rope from the fire fighter above, follow the steps in SKILL DRILL 10-21 to hoist an exhaust fan:

1. Tie a figure eight knot in the rope about 3 feet (1 meter) from the working end of the rope. (STEP 1)

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SKILL DRILL 10-19 Hoisting a Charged Hose Line

(Fire Fighter I, NFPA 5.5.2)

1 Make sure that the nozzle is completely closed and secure. Use a clove hitch, 1 or 2 feet (0.3–0.6 meters) behind the nozzle, to tie the end of the hoisting rope around a charged hose line. Use a safety knot to secure the loose end of the rope below the clove hitch.

2 Make a bight in the rope even with the nozzle shut-off handle. Insert the bight through the handle opening and slip it over the end of the nozzle. When the bight is pulled tight, it will create a half hitch and secure the handle in the off position while the charged hose line is hoisted. Communicate with the fire fighter above that the hose line is ready to hoist.

2 Loop the working end of the rope around the fan handle and back to the figure eight knot. (STEP 2)

3 Secure the rope by tying a figure eight with a follow-through by threading the working end back through the first figure eight in the opposite direction.

4 Attach a tag line to the fan for better control.

5 Communicate with the fire fighter above that the exhaust fan is ready to hoist. (STEP 3)

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SKILL DRILL 10-20 Hoisting an Uncharged Hose Line

(Fire Fighter I, NFPA 5.5.2)

1 Fold about 3 feet (1 meter) of hose back on itself and place the nozzle on top of the hose.

2 Make one or two half hitches in the rope and slip it over the nozzle. Move the half hitch along the hose and secure it about 6 inches (15 centimeters) from the fold.

3 Tie a clove hitch near the end of the rope, wrapping the rope securely around both the nozzle and the hose. The clove hitch should hold both the nozzle and the hose.

4 Communicate with the fire fighter above that the hose line is ready to hoist. Hoist the hose with the fold at the top and the nozzle pointing down. Before releasing the rope, the fire fighters at the top must pull up enough hose so that the weight of the hanging hose does not drag down the hose.

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SKILL DRILL 10-21 Hoisting an Exhaust Fan or Power Tool

(Fire Fighter I, NFPA 5.5.2)

1 Tie a figure eight knot in the rope about 3 feet (1 meter) from the working end of the rope.

2 Loop the working end of the rope around the fan handle and back to the figure eight knot.

3 Secure the rope by tying a figure eight with a follow-through by threading the working end back through the first figure eight in the opposite direction. Attach a tag line to the fan for better control. Communicate with the fire fighter above that the exhaust fan is ready to hoist.

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Wrap-Up

Chief Concepts

- The three primary types of rope in the fire service are:
  - *Life safety rope*. Used to support people during a rescue. This type of rope is used only for life-saving purposes.
  - *Escape rope*. Used as a single-purpose emergency self-escape rope.
  - *Utility rope*. Used to perform all other tasks, such as hoisting equipment.
- Life safety ropes are rated as either technical use life safety rope or general use life safety rope.
- An escape rope is designed to be used once by one fire fighter.
- Ropes can be made of natural or synthetic fibers. Natural fibers can be weakened by mildew and age, so they cannot be used to make life safety ropes. Synthetic fibers are generally stronger than natural fibers and are used in life safety ropes.
- Synthetic fibers can be damaged by ultraviolet light.
- Nylon is the most common synthetic fiber used in life safety ropes, followed by polyester and polypropylene. Polypropylene does not absorb water, so it is often used for water rescues.
- Common rope construction includes the following types:
  - *Twisted ropes*. Individual fibers twisted into strands that are twisted together to form the rope.
  - *Braided ropes*. Constructed by weaving or intertwining strands together in the same way that hair is braided.
  - *Kernmantle ropes*. Consists of the kern and the mantle. The kern is the core of the rope and the mantle is the braided covering that protects the core. These ropes can be either dynamic or static.
- During technical rescue incidents, several hardware components are used in addition to rope to rescue victims:
  - *Carabiner*. Connects one rope to another rope or a harness
  - *Harness*. Webbing that secures a person to a rope or solid object
- Most rope rescue incidents involve people who are trapped in normally inaccessible locations such as trenches, confined spaces, and open water.
- All ropes need proper care to perform in an optimal manner. The four parts to the rope maintenance formula are the following:
  - Care
  - Clean
  - Inspect
  - Store
- The principles of caring for a rope include the following:
  - Protect the rope from sharp and abrasive surfaces.
  - Protect the rope from rubbing against another rope or webbing.
  - Protect the rope from heat, chemicals, and flames.
  - Protect the rope from prolonged exposure to sunlight.
- When inspecting life safety rope, consider these questions:
  - Has the rope been exposed to heat or flame?
  - Has the rope been exposed to abrasion?
  - Has the rope been exposed to chemicals?
  - Has the rope been exposed to shock loads?
  - Are there any depressions, discolorations, or lumps in the rope?
- A rope record for a life safety rope includes a history of when the rope was purchased, when it was used, how it was used, each inspection, and what kinds of loads were applied to it.
- Ropes should be stored away from temperature extremes, out of sunlight, and in areas with good air circulation. Rope bags can be used to protect and store ropes.
- Knots can be used for one or more particular purposes. Hitches, such as the clove hitch, are used to attach a rope around an object. Knots, such as the figure eight and the bowline, are used to form loops. Bends, such as the sheet bend or Becket bend, are used to join two ropes together. Safety knots, such as the overhand knot, are used to secure the ends of ropes to prevent them from coming untied.
- Specific terminology is used to refer to the parts of a rope in describing how to tie knots:
  - The working end is the part of the rope used for forming the knot.
  - The running end is the part of the rope used for lifting or hoisting.
  - The standing part is the rope between the working end and the running end.
  - A bight is formed by reversing the direction of the rope to form a U bend with two parallel ends.
  - A loop is formed by making a circle in the rope.
  - A round turn is formed by making a loop, and then bringing the two ends of the rope parallel to each other.
- The knots that a fire fighter should know how to tie are as follows:
  - *Safety knot*. Used to finish other basic knots
  - *Half hitch*. Knots that wrap around an object
  - *Clove hitch*. Used to attach a rope to a round object

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- *Figure eight*. Basic knot used to produce a family of other knots
- *Figure eight on a bight*. Used to create a secure loop at the working end of a rope
- *Figure eight follow-through*. Used to create a secure loop at the end of the rope when the working end must be wrapped around an object or passed through an opening before the loop can be formed.
- *Bowline*. Used to create a loop
- *Water Knot*. Used to join the ends of webbing together.
- The bends that a fire fighter should know how to create in order to join two ropes together are the sheet bend and the Becket bend.

Hot Terms

Bend A knot used to join two ropes together.

Bight A U shape created by bending a rope with the two sides parallel.

Block creel construction Rope constructed without knots or splices in the yarns, ply yarns, strands or braids, or rope. (NFPA 1983)

Braided rope Rope constructed by intertwining strands in the same way that hair is braided.

Carabiner An auxiliary equipment system item; load-bearing connector with a self-closing gate used to join other components of life safety rope. (NFPA 1983)

Depressions Indentations felt on a kernmantle rope that indicate damage to the interior (kern) of the rope.

Dynamic rope A rope generally made from synthetic materials that is designed to be elastic and stretch when loaded. Dynamic rope is often used by mountain climbers.

Escape rope A system component; a single-purpose, one-time use, emergency self-escape (self-rescue) rope; not classified as a life safety rope. (NFPA 1983)

Harness A piece of equipment worn by a rescuer that can be attached to a life safety rope.

Hitch A knot that attaches to or wraps around an object so that when the object is removed, the knot will fall apart. (NFPA 1670, *Standard on Operations and Training for Technical Search and Rescue Incidents*)

General use life safety rope A life safety rope that is no larger than 5/8" (16 mm) and no smaller than 7/16" (11 mm), with a minimum breaking strength of 8992 lbf (40 kN).

Kernmantle rope Rope made of two parts—the kern (interior component) and the mantle (the outside sheath).

Knot A fastening made by tying together lengths of rope or webbing in a prescribed way. (NFPA 1670)

Ladder halyards Rope used on extension ladders to raise a fly section.

Life safety rope Rope dedicated solely for the purpose of supporting people during rescue, firefighting, other emergency operations, or during training evolutions. (NFPA 1983)

Loop A piece of rope formed into a circle.

Rope bag A bag used to protect and store rope so that the rope can be easily and rapidly deployed without kinking.

Rope record A record for each piece of rope that includes a history of when the rope was placed in service, when it was inspected, when and how it was used, and which types of loads were placed on it.

Round turn A piece of rope looped to form a complete circle with the two ends parallel.

Running end The part of a rope used for lifting or hoisting.

Safety knot A knot used to secure the leftover working end of the rope.

Shock load An instantaneous load that places a rope under extreme tension, such as when a falling load is suddenly stopped as the rope becomes taut.

Standing part The part of a rope between the working end and the running end.

Static rope A rope generally made out of synthetic material that stretches very little under load.

Technical use life safety rope A life safety rope with a diameter that is 3/8" (9.5 mm) or greater, but is less than 1/2" (12.5mm), with a minimum breaking strength of 4496 lbf (20 kN). Used by highly trained rescue teams that deploy to very technical environments such as mountainous and/or wilderness terrain.

Twisted rope Rope constructed of fibers twisted into strands, which are then twisted together.

Utility rope Rope used for securing objects, for hoisting equipment, or for securing a scene to prevent bystanders from being injured. Utility rope must never be used in life safety operations.

Water Knot A knot used to join the ends of webbing together.

Working end The part of the rope used for forming a knot.

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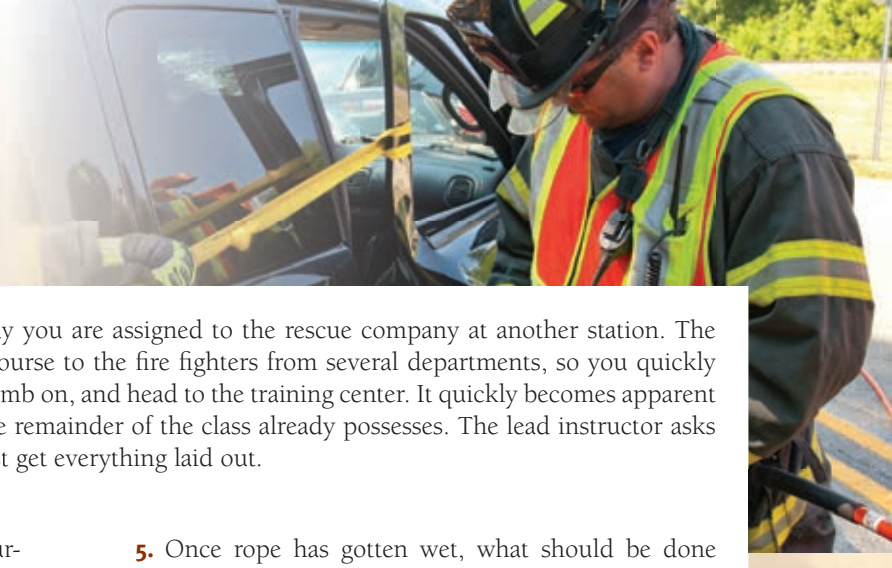
FIRE FIGHTER *in action*



You are normally assigned to a truck company, but today you are assigned to the rescue company at another station. The captain is scheduled to teach the Intro to Tech Rescue course to the fire fighters from several departments, so you quickly familiarize yourself with the location of the equipment, climb on, and head to the training center. It quickly becomes apparent that one particular student lacks basic rope skills that the remainder of the class already possesses. The lead instructor asks you to review the basics with the fire fighter while the rest get everything laid out.

1. What type of rope is designed to be used for securing objects, hoisting equipment, and blocking off scenes?
   - **A.** Technical use life safety rope
   - **B.** General use life safety rope
   - **C.** Utility rope
   - **D.** Escape rope
2. The part of a rope used for lifting or hoisting is called the _____.
   - **A.** Standing end
   - **B.** Running end
   - **C.** Bight
   - **D.** Round turn
3. The knot used to secure the leftover working end of the rope.
   - **A.** Safety
   - **B.** Figure eight
   - **C.** Bowline
   - **D.** Half hitch
4. A _____ rope is a rope generally made out of synthetic material that stretches very little under load.
   - **A.** Dynamic
   - **B.** Twisted
   - **C.** Braided
   - **D.** Static
5. Once rope has gotten wet, what should be done with it?
   - **A.** Lay it in the sunlight so that it does not mold.
   - **B.** Air dry it out of direct sunlight.
   - **C.** Place it in a clothes dryer on high heat.
   - **D.** The rope can no longer be used.
6. Which knot is used to create a secure loop at the end of the rope when the working end must be wrapped around an object or passed through an opening before the loop can be formed?
   - **A.** Figure eight follow-through
   - **B.** Figure eight on a bight
   - **C.** Half hitch
   - **D.** Clove hitch
7. A _____ is when a piece of rope is looped to form a complete circle with the two ends parallel.
   - **A.** Bight
   - **B.** Hitch
   - **C.** Round turn
   - **D.** Loop

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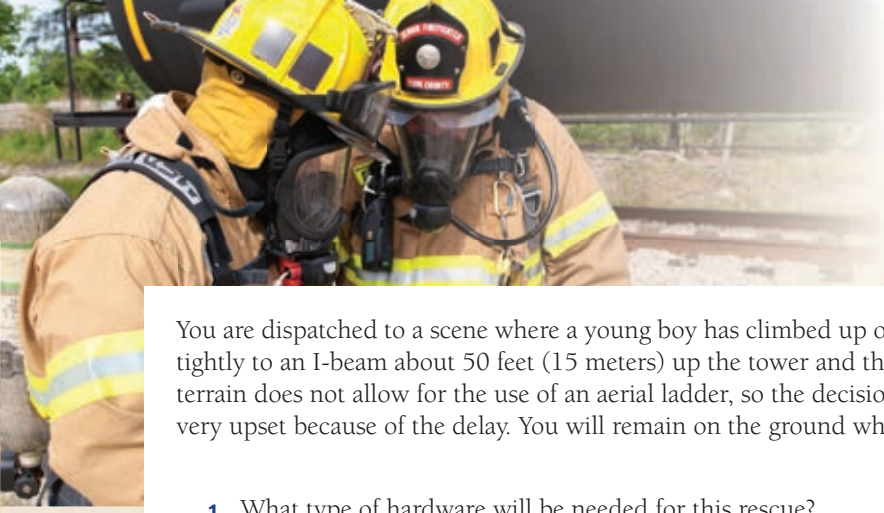

FIRE FIGHTER II
in action

You are dispatched to a scene where a young boy has climbed up on a cell tower. On your arrival, you find that he is clinging tightly to an I-beam about 50 feet (15 meters) up the tower and the parents of the boy are on-scene and they are frantic. The terrain does not allow for the use of an aerial ladder, so the decision is made to use a high-angle rescue. The crowd is getting very upset because of the delay. You will remain on the ground while the rope rescue technician makes the ascent.

1. What type of hardware will be needed for this rescue?
2. What type of harness will be needed for this rescue?
3. How will the parents be reassured?
4. How will emotions of the crowd be manged

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