Chapter 8: Rescue Equipment

Chapter Overview

The type and condition of the equipment used in rope rescue operations is critical to the efficacy of rescue efforts and the safety everyone involved. NFPA 2500 (1983) provides baseline performance requirements for rescue gear, though the AHJ has final say over the appropriateness of equipment. NFPA 2500 (1983) ratings are useful tools when determining tools should be used and when.

Carabiners, screw links, braking devices, rope grabs, anchorages, and pulleys are essential components any rope rescue operation. By establishing a rope rescue equipment program, measures can be put in place to ensure that each piece of equipment is properly suited for a particular task and able to function in a variety of conditions. Such a program can also ensure that each piece of equipment is in proper working condition and all damaged equipment is disposed of in order to prevent its use in the field. Equipment programs can also help ensure that essential training is provided when needed and identify the pieces of equipment that require more or less user experience in order to be safe and effective.

Understanding the types of equipment available for rope rescue activities, the safety implications, hazards, and regulations is key to increasing the safety of a given operation.

Objectives and Resources

**Knowledge Objectives**

After studying this chapter, you should be able to:

 Describe the components of a rope rescue equipment program. (pp. 115 – 117)

 List the considerations in selecting rope rescue equipment to respond safely to an incident. (pp. 115 – 117)

 Identify documentation and recordkeeping recommendations for rope rescue equipment. (NFPA 1006: 5.2.3, p. 143)

 Explain the strength ratings used for rope rescue equipment. (pp. 117 – 119)

 Define and describe load ratios. (pp. 117 – 119)

 Describe the purpose of carabiners in rope rescue systems. (pp. 117 – 119)

 Describe the purpose of screw links in rope rescue systems. (pp. 126 – 127)

 Describe the purpose of braking devices and descenders in rope rescue systems. (pp. 127 – 131)

 Describe the difference between autolocking and nonautolocking braking devices. (pp. 127 – 131)

 Describe the purpose of belay devices in rope rescue systems. (pp. 136 – 137)

 Describe the purpose of brake bar racks in rope rescue systems. (pp. 131 – 136)

 Describe the purpose of escape devices in rope rescue systems. (pp. 135 – 136)

 Describe the purpose of rope grabs and ascenders in rope rescue systems. (pp. 137 -139)

 Describe the purpose of anchorage connectors in rope rescue systems. (pp. 139 – 140)

 Describe the purpose of pulleys in a rope rescue system. (pp. 140 – 141)

 Describe how to clean rope rescue equipment. (NFPA 1006: 5.2.3, p. 125)

 Describe how to inspect rope rescue equipment. (NFPA 1006: 5.2.3, pp. 143–145)

 Identify the signs of damage, defects, or wear in rope rescue equipment. (NFPA 1006: 5.2.3, p. 144)

**Skill Objectives**

After studying this chapter, you should be able to:

 Clean rope rescue equipment. (NFPA 1006: 5.2.3, p. 125)

 Inspect rope rescue equipment for damage, defects, or wear. (NFPA 1006: 5.2.3, 5.2.7, pp. 143–145)

 Document rope rescue equipment inspection and maintenance. (NFPA 1006: 5.2.3, p. 143)

Support Materials

 Dry-erase board and markers or chalkboard and chalk

 LCD projector, slide projector, overhead projector, and projection screen

 PowerPoint presentation or slides

 **Navigate for Students**

 **Advantage**

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 Online and offline accessibility ensures that the eBook is always available. Offline interactions are captured, cached, and uploaded the next time they are connected to the Internet.

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Reading and Preparation

Review all instructional materials, including *Rope Rescue: Principles and Practice,* Fifth Edition, Chapter 8 and all related presentation support materials.

Chapter Presentation Overview

Pre-lecture

I. You Are the Rescuer

Small-Group Activity/Discussion

Purpose

The purpose of this activity is to introduce students to concepts surrounding the understanding and management of water rescue incidents.

Instructor Directions

1. Direct students to read the “You Are the Rescuer” scenario found at the beginning of Chapter 8 (p. 114).

2. You may assign students to a partner or a group. Direct them to review the discussion questions at the end of the scenario and prepare a response to each question. Facilitate a class dialogue centered on the discussion questions.

3. You may also assign this as an activity and ask students to turn in their comments on a separate sheet of paper.

Lecture

I. Introduction

A. Review the learning objectives

B. Selection of equipment for rope rescue operations depends on several factors

1. Organizational factors

a. Operational preplanning

b. Hazard analysis

c. Staffing

d. Training

2. Occupational factors

a. Anticipated incidents within the jurisdiction

b. Hazards likely to be present during a rope rescue

c. Number and qualifications of rescuer

d. Defined standard operating procedure

e. Type and frequency of training rescuers receive

C. Once equipment is selected and placed into service, consideration should be given to organizing equipment for optimal, streamlined deployment at a rescue scene, which should include the following:

1. Labeling

2. Color-coding

3. Preoperational configuration of gear

4. Well-planned approach to packing and storing equipment

D. Rope rescue agencies and organization should develop and implement a program for the selection, care, and maintenance of appropriate life safety rope and related equipment.

E. NFPA 2500, *Standards for Operations and Training for Technical Search and Rescue Incidents and Life Safety Rope and Equipment for Emergency Services,* is a good resource upon which rope rescue agencies can build equipment programs.

1. Incorporates information previously found in NFPA 1858, *Standard on Selection, Care, and Maintenance of Life Safety Rope and Equipment for Emergency Services*

2. Designed to help users establish basic criteria for the selection, inspection, and care of life safety rope and associated equipment

3. Focuses largely on equipment that is compliant with NFPA 2500 and its predecessor NFPA 1983, *Standard on Life Safety Rope and Equipment for Emergency Services*, to which much of the equipment used in technical rescue is certified

II. Rope Rescue Equipment Program

**A. A systematic approach to rope rescue equipment selection, care, and maintenance will help with the following:**

1. Ensure the availability of appropriate equipment that is suitable for the intended use

2. Maintain life safety rope and equipment in a safe, usable condition

3. Remove equipment that is unfit for service

**B. A rope rescue equipment program should have standard operating procedures (SOPs)**

1. An SOP is a document listing the roles and responsibilities of both the organization and of responsible personnel, and equipment records.

2. SOPs should include guidelines for the following:

a. Equipment selection

b. Equipment inspection

c. Cleaning and decontamination

d. Guidelines and policies for repair

e. Storage

f. Retirement and disposition

**C. A program should be well-documented both in terms of how it works as well as the equipment records.**

1. Documentation will help to facilitate training and provide a reference when information is needed about a specific piece of equipment.

2. The following details should be recorded and maintained for each item of life safety rope and rescue equipment in an equipment record:

a. Equipment identification

b. A copy of all manufacturer guides

c. Date of purchase

d. Date placed in service

e. Service location (if applicable)

f. Manufacturer and model number

g. Month and year of manufacture

h. Dates of use, including how the equipment was used, weather conditions, potential damage, and other circumstances relating to use

i. Dates of cleaning and inspection

j. Removal from service, as applicable

3. Recordkeeping should include labeling and color coding.

4. The authority having jurisdiction (AHJ) should determine which markings/criteria are important to the organization, which may include:

a. Ownership

b. Date placed in service

c. Identification of what cache/location an item belongs to

d. Duty assignment

e. Assigned vehicle

f. Other criteria

**D. Equipment should be organized and stored on responding vehicles in a way that lends itself to the necessary sequence of deployment to increase operational efficiency at the scene, which may include the following:**

1. Gear kits organized by functionality (e.g., an anchor kit, lead climbing kit, or patient restraint kit)

2. Gear kits pre-rigged into rapid deployment solutions for lowering, raising, or other technical operations

3. If equipment is staged in kits or collections, or if it is pre-rigged into a hasty deployment solution, marking and labeling bags or containers with contents, weight, or other information may also be helpful.

III. Equipment Selection Considerations

**A. Selection of rope rescue equipment begins with a clear understanding of the types of incidents within the jurisdiction where rope rescue operations might be required, including the following:**

1. Environmental factors

2. Incident locations

3. Steep to vertical terrain

4. Frequency of incidents

5. Frequency of training

6. Cooperative agreements with other agencies

**B. The types of incidents that might require rope rescue capabilities might include the following:**

1. Industrial accidents

2. Municipal incidents

3. Utilities incidents

4. Climbing/caving accidents

5. Confined space incidents

6. Car-over-the-edge accidents

7. Farm machinery incidents

8. Remote/wilderness accidents

9. Water incidents

10. Snow/ice responses

**C. Often, the same types of rope rescue equipment can be used across multiple environments; in other cases, the unique circumstances of incident types may dictate the need for specialized equipment.**

1. The AHJ has final authority over which equipment is used, with consideration to the appropriateness for intended uses, whether or not it meets relevant standards, and the training/skill levels of rescuers.

2. A competent person should take into consideration at least the following factors when evaluating rope rescue equipment:

a. The appropriateness of the available equipment to the anticipated need

b. The rope diameters used by the organization and others with whom they are likely to work

c. The compatibility of hardware (descenders, rope grabs, pulleys, etc.) with the rope diameters used

d. Whether equipment is, or needs to be, compliant with NFPA 2500 (1983) or other relevant standards

e. The minimum breaking strength (MBS) of equipment in its intended rigging configuration

f. Desired MBS of the system

g. Potential fall distances, swing fall potential, and other hazards

h. Skills/training of available personnel with the intended equipment

**D. Where applicable, organizations should prioritize equipment that is certified as being compliant with the current edition of NFPA 2500 (1983).**

1. NFPA 2500 (1983) covers the following:

a. Baseline performance requirements for various components of gear

b. *Standards for Operations and Training for Technical Search and Rescue Incidents and Life Safety Rope and Equipment for Emergency Services*, including NFPA 1670, NFPA 1983, and NFPA 1858

2. The NFPA does not directly evaluate or approve products or equipment.

3. It can give the AHJ confidence that selected equipment meets the minimum performance criteria for the intended use.

a. The AHJ may sometimes choose to allow or acknowledge equipment that does not meet NFPA standards.

b. The NFPA 2500 (1983) equipment standard addresses only the most commonly used components in urban rescue operations.

c. There is a great deal more equipment out there that is designed and used for other disciplines.

i. The fact that this equipment is not marked as meeting NFPA standards does not negate its value.

ii. It is imperative that rescuers understand the performance capabilities and limitations of all equipment before putting it into use.

d. Sometimes users equate a mark or designation as inherently safe, to the point of being completely unaware of what that mark means in terms of strength and performance.

e. Although a piece of equipment may meet some standard other than NFPA 2500 (1983), this should not be presumed as an “equivalency.”

f. NFPA 2500 (1983) boasts some of the most robust requirements in the life safety equipment standards world:

i. Extremely high performance criteria

ii. Third-party testing

iii. Manufacturer surveillance program to ensure quality and consistency

g. A manufacturer’s claim that a piece of equipment meets the requirements of NFPA 2500 (1983) holds no sway unless that piece of equipment is truly tested, marked, and listed by a qualified testing laboratory.

**E. Compatibility between components is another key consideration.**

1. Various items may be designed for different diameters of rope, different intended uses and applications, and different environments.

2. Any rescuer who might use a piece of equipment should be trained in it is capabilities and limitations, including matters of compatibility.

**F. When equipment is delivered to the organization, prior to placing it into service it should be inspected by a competent person to ensure it arrived as ordered, meets the organization’s specifications, and was not damaged during shipment.**

**G. The AHJ should also ensure that rescuers have been appropriately trained on the equipment prior to it being placed into service.**

**H. The components of the equipment addressed in this chapter should be considered in context of the rope chosen and used by the responding agency.**

IV. Equipment Strength and Safety Factors

**A. Aside from being compatible with other components of the system, all equipment should also provide the following:**

1. Sufficient strength to offer appropriate performance under whatever load might be applied.

2. Offer a sufficient factor of safety above and beyond that (i.e., loads greater than a single body weight and forces intensified by rigging angles and friction)

**B. NFPA 2500 (1983) classifies equipment into three ranges:**

1. G (General)

a. Intended for general use

b. Most closely replicates the historical requirements of NFPA 198

c. Grounded in a philosophy that if each and every component is highly durable and very strong, even moderately trained rescuers are unlikely to create systems that will overload it

2. T (Technical)

a. Introduced into NFPA 1983 in the 1990s

b. Based on the philosophy that more highly skilled technicians who are trained to think in terms of system safety can build and analyze systems that are sufficiently strong and appropriate even with components of lower strength

c. Allows for equipment with lower performance requirements than G-rated gear, but higher than E-rated gear

3. E (Escape)

a. Lower test requirements than G or T classes

b. Expected to be used only in a limited capacity, for personal escape

c. Lower requirements allow for lighter, smaller, more portable gear that may be more compact and conducive to being carried on by rescuers and thus readily available for life-threatening emergencies.

4. Misunderstandings

a. There is a lot of misunderstanding about these classifications, as rescuers have tried to extrapolate user information from this manufacturer’s standard over the years.

b. In different versions of the standard, the T classification has changed several times. It was first introduced as “P,” which stood for Personal Use, and then to “L,” which stood for Light Use, and now it is “T,” which stands for Technical Use.

5. The actual performance requirements are not the same for all components.

a. Hard goods (e.g., carabiners) tend to have somewhat lower strength requirements than soft goods (e.g., ropes) due to their lesser susceptibility to degradation through wear and tear.

b. G, T, and E classifications give manufacturers a way of classifying gear, but these classifications only differentiate the absolute minimum performance levels.

i. Many pieces exceed the minimum performance requirements, offering experienced users the potential for even greater flexibility and margin of safety.

ii. Rescuers should also be aware of the actual strength and other ratings marked on the products to facilitate.

**C. Load ratios**

1. One area where knowing the actual strength ratings is important is in determining the load ratios used for safety factors.

2. When rescuers are inclined to think in terms of the forces placed on their system as the forces relate to the strength of various points in that system, E, T, and G ratings is less useful.

3. The NFPA states that users of T-rated equipment are expected to understand system forces in context of specific equipment strength and performance criteria.

4. The NFPA 2500 (1983) tests strike a more realistic balance between laboratory test repeatability and actual field use where other standards might only, a factor that should be carefully considered when selecting equipment that meets standards other than NFPA 2500 (1983).

5. When equipment is manufactured, it helps if the maker has some target or desired strength for it to be capable of withstanding.

a. To have confidence that the equipment can consistently support this use-load, manufacturers incorporate a load factor so that the equipment is somewhat stronger than the expected use.

b. There is no consistent formula for what load factor is used by a given manufacturer. The load for which a product is designed is known as the design load.

6. In the case of technical rescue equipment, a value known as minimum breaking strength (MBS) is derived from the design load.

a. MBS is the force at which tested samples of equipment actually fail during testing; life safety equipment standards typically state a required MBS for compliance.

b. MBS is calculated by a testing laboratory as three standard deviations below the mean breaking strength of a minimum number of samples tested in manner of use.

c. This testing/reporting criteria helps to ensure a high level of confidence in the cited MBS of the product, providing a good baseline from which to determine the system safety factor (SSF).

d. Rescuers in the field use MBS information in conjunction with their knowledge of forces applied by rescue systems to ensure sufficient system strength. By choosing life safety equipment with a known MBS, a rescuer has a foundational tool for analyzing the strength of that component against the anticipated load.

e. The ratio between the MBS and an equipment component is known as a component safety factor. For example, if a rope rated to 9000 pounds (4082 kg) is used for a rescue system with a mass of 600 pounds (272 kg), this might be said to be a 15:1 component safety factor.

7. This concept of component safety factors has long created misunderstanding in fire-rescue communities because design loads were used from the earliest versions of NFPA 1983 to establish standardized component MBS requirements.

a. The original versions of that standard built on a concept first born from a white-paper called *Line to Safety*, which established the following:

i. While a 7:1 or 10:1 safety factor might be adequate for industrial safety, it was not appropriate for critical rescue use in emergencies.

ii. A two-person load would be assumed to be 600 pounds (272 kg).

iii. A 15:1 safety factor would be applied to rescue rope.

b. Using the white paper as a guide, the first edition of NFPA 1983 established the following:

i. One-person life safety rope would be designed to have a maximum working load of no less than 300 pounds (136 kg).

ii. Two-person life safety rope would have a maximum working load of no less than 600 pounds (272 kg).

iii. Minimum breaking strength requirement for two-person rope should be 40 kN, or approximately 9000 lbf, with a corresponding MBS requirement for single-person rope (dividing that 9,000-lbf rope strength by the 600-lb rescue load, we get 15:1).

c. In 2001, the NFPA 1983 document removed references to load ratios, numbers of persons, and safety factors, but still the misinformation about 15:1 safety factors (and a related concept of 10:1 safety factors) remains among trainers and rescuers.

d. This topic was addressed at the International Technical Rescue Symposium as early as 2005, but many rescuers still believe that NFPA standards specify a 15:1 safety factor.

8. The determination of an appropriate safety factor is left to the AHJ and should be based on situationally relevant information, including hazards, risk, levels of training, and probability and consequence of failure.

9. The factor of safety with which the AHJ should be most concerned is NOT the component safety factor at all, but the SSF.

a. The SSF is determined by analyzing the strength of the entire system, as each component is interconnected with other components in the system and comparing that against the anticipated force or load at that point.

b. The ratio between the least strong point in the system and the potential load at that point is the SSF.

c. A static SSF is analyzed as the ratio during normal static loading, while a dynamic SSF is analyzed as the ratio during worst case dynamic loading.

d. Knowing the expected breaking strength of each component is essential in determining an SSF, but knowing the strength of those components as they interact together is even more important.

i. This knowledge comes only with experience and devoted study.

ii. This is the reason that seasoned, experienced rescuers lean toward equipment that is marked with minimum breaking strength (MBS) ratings.

iii. Markings to safe working loads (SWLs) or working load limits (WLLs) do not provide the user with sufficient information for determining even a proximal SSF, leaving the true level of protection offered by the system in question.

V. Carabiners

**A. Carabiners are a type of self-closing connector that link together different elements of the high-angle system.**

**B. NFPA 2500 (1983) classifies carabiners in to two categories (there is no separate classification for escape carabiners):**

1. G – tested to a rated strength of 40 kN (9000 lbf); intended for use by any trained organization performing rescues at a level where higher strength may be required to achieve the desired level of safety

2. T – tested to a rated strength of 22 kN (5000 lbf); intended to be used by highly trained rescuers who might benefit from lighter weight and/or smaller profile equipment, and who are capable of maintaining an acceptable level of safety despite a lower strength rating

**C. Material**

1. Carabiners are most often constructed of either aluminum alloy or steel.

a. Pros and cons to aluminum alloy include:

i. It is significantly lighter in weight and less expensive than steel and does not rust.

ii. The locking mechanism may wear out; severe shock loading may cause permanent damage.

iii. Some aluminum carabiners are not as strong as comparable steel designs.

b. Pros and cons to steel include:

i. The locking mechanism on steel carabiners tends to be less susceptible to wear and tear, and steel carabiners may also hold up better under severe shock loading.

ii. It is heavier than aluminum and is typically more expensive.

iii. Unless plated, steel is susceptible to rust, and as a result, steel carabiners generally require more maintenance than the aluminum type.

iv. Plated carabiners must also have stainless steel hinge springs.

v. While stainless steel is more resistant to corrosion, high-quality equipment whose springs, pins, and other components should also made of stainless steel.

vi. Corrosion-resistant gear is no substitute for proper care and maintenance.

**D. Carabiner components**

1. The basic parts of a carabiner are the frame and the gate.

a. The gate is secured to the frame by way of a hinge, while a latch at the nose helps to maintain the integrity of the unit when the gate is closed.

b. Many users prefer a smooth latching mechanism.

c. Notched latch mechanisms are arguably more secure, but they can snag during use.

d. Some carabiners also feature a locking mechanism that helps to secure the opening between the gate and frame when locked.

2. A carabiner is typically strongest along its long axis, especially when the load is focused along the part known as its spine; a secure gate is integral to maintaining the overall rated strength of the carabiner.

3. If the gate is opened, whether intentionally or inadvertently, the strength of the carabiner is compromised.

**E. Basic carabiner shapes**

1. Carabiners are manufactured in a wide variety of shapes and sizes.

2. While originally oval in shape, features and configurations have been developed to maximize strength, gate opening, ease of handling, and other characteristics.

3. Commonly used carabiner shapes include the following:

a. D – helps to shift the load to a more optimal position along the spine

b. Modified D – makes for a slightly larger gate opening (at the cost of a small amount of strength)

c. Pear or HMS (an acronym for the German word Halbmastwurfsicherung) – has an even larger gate opening, and accommodates the Munter hitch well, but sacrifices strength

**F. Strength**

1. The strength of a carabiner will be different in each direction (axis) and configuration in which it is loaded.

2. In addition to the long-axis locked strength of a carabiner, the long-axis unlocked strength rating, long-axis gate open strength rating, and short-axis (gate cross-loaded) strength rating should be known.

3. A larger size carabiner will help to facilitate proper loading of the carabiner when it is expected to be loaded with heavy loads or dimensionally larger materials.

a. Carabiners are strongest along the spine.

b. When material is stuffed into the carabiner to the point that it approaches the gate side of the carabiner, strength is compromised.

4. Carabiners are typically marked in some way to show the strength or performance rating of the item. These markings are typically derived from the standard(s) to which the item is marked and include the following:

a. Reference to the standard

b. Name or logo of the manufacturer

c. Label of the third party that certifies that the product meets the standard

5. NFPA-certified carabiners also have either a “T” or a “G” stamped into the frame.

a. T – carabiner is for “Technical Use” and designed for experienced users, having a major axis minimum breaking strength, with gate closed, of 22 kN (5000 lbf).

b. G – carabiner is for “General Use”, with a more forgiving minimum major axis gate-closed breaking strength of 40 kN (9000 lbf).

c. Carabiners marked to older editions of NFPA 1983 (prior to 2012) may be marked with an “L” instead of a “T.”

6. In some cases, it may also be fine for carabiners marked to other standards to be used for rope rescue applications, even within the fire service. This is the prerogative of the AHJ, with the main priority being that the determination has been made by a competent person qualified to do so.

7. Testing

a. Not all of standards utilize the same three-sigma method of calculating MBS; some require only that each sample tested by the test lab exceed the requirements of the standard.

b. According to NFPA 2500 (1983) test method requirements, a minimum of five samples are tested, and then an MBS is calculated by subtracting three times the standard deviation from the mean (average) of the test result numbers.

i. That result, or lower, is what the manufacturer is required to advertise.

c. NFPA’s approach to using a three-sigma calculated MBS results in a reported value that is statistically significant.

i. NFPA is the only rescue equipment standard that mandates a certified Quality Assurance program, periodic sample testing, and annual retesting of certified equipment.

ii. Other standards permit up to several years between retesting, or even have no retest requirements at all.

d. Some carabiners carry no labeling and may not be tested to any standard.

i. If the carabiner is not labeled in accordance with a relevant standard (NFPA, ANSI, etc.), you may not be able to be sure about factors such as open gate strength, the strength of minor and major axes, and other qualities.

ii. If the actual rated breaking strength is not stamped on the item, it is best to check the referenced standard to find out just what the stamp means.

iii. Fire fighters working in an industrial environment may find carabiners marked to the ANSI Z359.12 standard, some of them even designated for coworker-assisted rescue.

iv. The major difference between ANSI Z359.12 carabiners and the others mentioned here is their gate loading strength.

e. Even among carabiners with similar specifications, there is a balance to be struck between mass, weight, size, and strength.

f. For heavy-duty rescue use, carabiners of solid aluminum or steel are a better choice than lightweight hollow aluminum models. The AHJ should determine which types of carabiners are most relevant to their intended use.

**G. Strength rating for carabiners**

1. Strength ratings for carabiners usually represent the ideal situation.

2. Carabiner strengths are typically marked using scientific notation, with the unit of measurement being kilonewtons.

3. One newton (1 N) equals about 0.225 lbf, or about the weight of an apple.

4. One thousand newtons would be referred to as a kilonewton (1 kN), which equals about 225 lbf.

**H. Gate openings**

1. Gate opening dimensions should be considered when choosing carabiners.

2. When opened to its maximum, the dimensional gap will determine the size and bulk of material that can be inserted into the carabiner.

3. While a smaller opening can help prevent overstuffing, for some activities the carabiner gate opening must be larger.

**I. Locking mechanisms**

1. The main job of a carabiner is to maintain its link with the other elements of the rope rescue system.

a. The carabiner gate must remain securely closed.

b. If it does not remain closed, the connecting elements can come unlinked and the system will fail.

2. Carabiner gates can come open accidentally in several ways. Among the most common are as follows:

a. The carabiner is pressed against the edge of a wall or rock, forcing the gate open.

b. A rope or piece of webbing is pulled across the carabiner gate, forcing it open.

c. To prevent accidental gate opening, locking carabiners should be used for rescue.

3. Although specific designs vary with the manufacturer, locking carabiners usually fall into the following categories:

a. Manual-locking carabiner (screw-lock) – feature a locking sleeve that manually screws over threads to ensure closure. The sleeve may be mounted in one of two ways:

i. On the gate and extend over the nose of the carabiner as it is screwed closed

ii. On the frame of the carabiner and extend over the gate as it is screwed closed

b. Autolocking carabiners (autolock) – feature a spring-loaded sleeve that automatically snaps into place as the carabiner closes, with no separate action required by the rescuer

i. Unlocking these may simply require a twist of the sleeve.

ii. An additional safety mechanism may be present that necessitates an additional action to open.

4. Regardless of type, users are responsible for ensuring that the carabiner gate stays closed during use.

5. Carabiners should be retired from service if the carabiner persistently becomes jammed in a locked position, which may be an indication of overuse or wear.

6. If a screw-lock carabiner becomes jammed in a locked position, you can try to release it using the following procedure:

a. If the carabiner is not already on a seat harness, attach it to one. Have the wearer move to a secure position, away from the edge of any drop.

b. Connect to the carabiner by another means (sling or another carabiner) and connect to an anchor.

c. Reload the carabiner by leaning into it, or sitting down with it attached to the anchor point.

d. Check to see if the locking nut then can be loosened easily while under tension.

e. If it still cannot be loosened, tightly wrap a short piece of webbing around the locking nut to gain leverage.

f. If the previous step does not work, the only option may be careful use of a pair of pliers, after which the carabiner should be considered for retirement.

**J. Use considerations**

1. A carabiner should be used only in the manner of function approved by the manufacturer.

2. Typically, the expectation is that a carabiner will be loaded along its major axis, or lengthwise.

3. Because the weakest point of a carabiner is the gate, side loading stresses the gate and puts an unnatural force on the carabiner.

a. The carabiner is less strong in this configuration, so it may be more susceptible to failure if misused in this way.

b. A side-loading situation can be inadvertently created when a carabiner is rigged so that it cannot rotate with the forces placed on it.

i. This twisting force can cause the carabiner to break.

ii. This is especially a cause for concern when a carabiner is hard-linked to one or more points.

4. Hard linking

a. Examples of hard linking include a carabiner clipped into eyebolts on a wall, clipped into a second carabiner that cannot rotate, or clipped directly into a vehicle tow hook.

b. To avoid the pitfalls of hard linking, a soft link may be clipped between the hard links.

i. Soft link – a short section of rope, webbing, or cordage whose primary purpose is to provide flexibility and strength, especially when connecting two hard components to one another

ii. A soft link may be created by inserting a length or loop of cordage or webbing between the hard points.

iii. If you intend to add a soft link to your system, be sure you know the performance specifications in the configuration in which you plan to use it, whether end-to-end, looped, girth hitched, etc.

iv. A swivel may also be used to help mitigate the effects of twisting during use, but they can be less forgiving of certain loading configurations.

5. Misuse can lead to malfunction.

a. All equipment used in the high-angle environment is designed to be used in a specific manner of function.

b. Any equipment used in a manner other than that which it was designed may result in failure of the equipment and severe injury or death.

**K. Inspection and maintenance**

1. Carabiners are an important link in the life safety chain, and as such should be used only if in good condition.

2. Discontinue use carabiners if it has been damaged, sustained significant impact loading, has been dropped.

3. Always inspect carabiners prior to use.

a. Visually inspect the carabiner for the following, cracks, sharp edges, corrosion, burrs, and excessive wear.

b. Check for proper gate function, and look for signs of excessive loading, including frame deformation, damaged hinge pins, dented latches, and deep gouges, dents, corrosion, or other damage to the body.

c. Locking mechanisms should function smoothly and properly.

4. Clean carabiners function best.

a. Light dust and dirt may be brushed or blown from the frame and hinge.

b. Dirtier or sticky gates may be washed in warm, soapy water or a citrus-based cleaner.

c. It is especially important to clean and lube carabiners after contact with saltwater, salt air, or other corrosive environments.

i. Be sure to dry carabiners thoroughly before placing them back in storage.

ii. Carabiners may be lubricated with dry graphite or any dry, waxed-based lubricant, focusing on critical areas such as hinge pins, springs, latches, and locking knobs.

iii. Wipe off excess lubricant before storing the carabiners.

VI. Screw Links

**A. Triangular or semicircular screw links are another type of connector that is used, especially where smaller dimensions are desirable.**

1. Screw links have a screw locking sleeve that must be manually closed to secure the opening.

2. Users should avoid side loading, which stresses the gate, puts an unnatural force on the screw link, and severely reduces its strength, possibly causing failure.

3. These types of connectors must be manually screwed completely closed, which requires numerous turns to the sleeve.

a. Failing to securely close a screw link, or it working itself open during use, are very real potential hazards.

b. When screw links are used, they should be integrally connected (that is, using a tool) before work begins, and left in place throughout, rather than opening and closing repeatedly.

4. NFPA 2500 (1983) life safety equipment standards do not address screw links.

5. Not all screw links are intended for life safety applications.

6. The European standard, EN362 Personal protective equipment against falls from a height – Connector is the only standard that addresses screw links for safety applications.

a. Hardware store screw links are not tested to this standard and are quite a bit less expensive than those tested and marked to EN362.

b. Only those explicitly tested and marked in accordance with EN362 should be used for life safety applications.

7. A screw link is strongest when loaded on its primary axis, with the sleeve locked.

a. Loading a screw link in any other way is dangerous and can result in failure at lower loads.

b. EN 362 calls for a screw link to be rated to 25 kN (5600 lbf) along the major axis (gate closed and locked) and 10 kN (2250 lbf) along the minor axis (gate closed).

c. The idea that a screw link is as strong in a short axis as it is in its primary axis is a myth.

d. Unlike carabiners, screw links are not tested in a gate open configuration.

i. They are not self-closing and their integrity is completely dependent on their being screwed closed properly.

ii. They are particularly susceptible to human error, as when not screwed fully closed.

8. Because they are often used in lifting, screw links are typically marked with a WLL that is one-fifth of the rated breaking strength, rather than with the breaking strength itself.

a. This WLL approach is typical of the cranes/lifting industry, but should be used with caution in rescue rigging.

b. WLL dictates a component safety factor, but the figures used are not derived from three-sigma calculations for statistical significance.

c. Most rescuers prefer to work with minimum breaking strength information so that they can more accurately assess system safety factors.

d. The differences in the ways in which EN362 and NFPA should be taken into consideration when comparing strengths.

i. The EN requires only that the samples tested exceed the required minimum, whereas the NFPA standard requires statistical analysis of at least five samples tested by the test lab.

ii. This approach is designed to protect the user; without statistical analysis, data can be misleading.

9. Screw links are not inappropriate but should be used with care, and with full understanding of their capabilities and limitations.

10. A key advantage of screw links is that they are diminutive in size, and can shorten the length of an otherwise cumbersome system, as when used with a footloop in an ascending system.

11. Because it is so important that they be screwed completely closed before loading, screw links are best used where they can be integrally mounted into a system (e.g., screwed closed and tightened with a tool so that they cannot be unintentionally released in the field).

VII. Braking Devices and Descenders

**A. Braking device**

1. A piece of hardware that is used to help manage the rate at which a load is lowered in a system or at which a rescuer descends.

**B. Most braking devices rely on friction to perform their function.**

**C. Rescuers must be attentive to the potential for heat buildup, which is a natural result of friction.**

1. Heat buildup is increased by heavier weights and/or faster speeds.

2. In extreme cases, heat buildup in descenders can result in the following:

a. Damage to the rope or other equipment

b. Second-degree burns to bare ski

c. Other adverse effects

3. Choosing a descender designed to dissipate heat, and not running rope too quickly through the device, will help control heat buildup during use.

**D. A braking device may be used in the following ways:**

1. As a true braking device, used in a stationary position, fixed to an anchorage with the rope running through it

2. As a descender, which moves along the rope, such as in a rappel

**E. Braking devices offer different features and specifications for different applications.**

1. Heavy rescue litter lower, for example, may not be the best choice for emergency personal escape.

2. A good understanding of braking device features and performance specifications will help the AHJ select the best option(s) for each application.

3. Common uses for braking devices in a rescue organization include the following:

a. Nonemergency rappel or single-person descent

b. Emergency rappel or bailout

c. For lowering a rescuer, a litter, or both

d. As a belay device

e. Any combination of the above

4. Selecting the appropriate braking device for a given application is a matter of taking into consideration not just rope diameters and compatibility but also the following:

a. Intended use

b. Rescue methods used by the organization

c. Weight considerations

d. Multifunctionality

e. Training of personnel

5. Descenders that are reeved through the descender in a linear fashion, rather than requiring the rope to wrap or twist, are best for rope management and care.

6. Some descenders are intended for use with a specified diameter (or diameter range) of rope.

7. Experienced rope users will find that even braking devices that are not designated by the manufacturer as being rope-specific will perform a bit differently with different ropes. Generally speaking, the following are true:

e. Smaller diameter ropes will run more quickly through a braking device than larger diameter ropes through the same descender.

f. Polyester ropes will run more quickly through a braking device than nylon ropes.

g. Dry treated ropes will run more quickly through a braking device than standard ropes.

h. Harder/stiffer ropes will run more quickly through a braking device than softer/flimsier ropes.

i. The more rope weight hanging below the device, the faster it will run.

**F. Autolocking and manual devices**

1. One of the greatest challenges to rescuers these days is that both autolocking and manual devices are used in the field – and each has its own set of advantages and disadvantages, depending on application.

a. Autolocking devices

i. An autolocking device requires the operator to engage some sort of override to permit the rope to slide through.

ii. Will automatically stop the rope in the event that the operator completely lets go

iii. While completely letting go of a device is not considered normal operation, rescuers who are accustomed to the additional measure of security this feature offers may be inclined to develop habits that rely on this feature.

b. Manual devices

i. Many experienced rescuers prefer a manual device that requires the operator to consistently maintain an active grip on the rope to perform a braking function.

ii. Should the rescuer let go of this type of device, the rope will run freely through it (unless stopped by a secondary safety system).

iii. Manual devices tend to be simpler to operate, have fewer moving parts, and be less sensitive to rope diameter than autolocking devices.

c. Each type has its own unique advantages and disadvantages, but in either case adequate training and experience is imperative.

2. Specifications to consider when selecting a braking device:

a. Whether an autolocking device is required

b. Whether a panic-lock feature is required

c. Ability to adjust friction

d. Size and weight of the device

e. Compatibility with the organization’s life safety ropes for rappel or belay

f. Compatibility with the organization’s escape rope or webbing

g. Material of construction

h. Ability to dissipate heat

i. Levels of training required for personnel competency in desired skills

3. Additional considerations

a. Variable friction

i. This is an important consideration during lowering or descending operations where the weight of the load is likely to change, or when the weight of the rope beneath person descending varies (such as on a long rappel).

ii. Such a device goes beyond a simple stop/go function to include ability to wrap, clip, or add friction components as necessary.

b. Performance specifications must be balanced with the size, shape, and weight of the equipment as in the following examples:

i. For lowering and raising operations next to a road, a truck-mounted capstan may be a desirable choice.

ii. Where rescuers must carry equipment into the field, size and weight are considerations.

c. Compatibility with other equipment:

i. Some devices are able to be used with a wide range of rope and/or webbing, while other devices are quite dependent on being used with a particular construction, material, or diameter.

ii. Responding organizations usually change out their ropes and soft goods more frequently than hard goods such as descenders, and so this is a consideration.

iii. Most hard goods manufacturers do not also actually manufacture their own rope (even if it is so labeled), so descenders that function with a range of ropes are generally a safer option.

iv. The best descenders are not acutely rope specific, although compatibility with a narrow range of diameters is not unusual.

d. Markings

i. Rescuers will notice a marked difference in the performance of their braking device even with ropes of the same make and model, depending on the age and condition of the rope.

ii. It is important to train on the same kinds of ropes as are deployed on actual operations.

e. Material

i. The material of which a descender is made will have some influence on its weight, friction imparted, ability to dissipate heat, durability, resistance to corrosion, susceptibility to wear, and other performance considerations.

ii. While rescuers will appreciate the durability and smooth operation of steel, they will be less keen on carrying it into the field.

iii. Aluminum is lighter, but more susceptible to wear.

f. Rescuers should be trained to carefully inspect rope paths for wear, and retire any excessively worn descenders.

**G. Friction and heat**

1. Friction

a. The means by which most braking devices perform their function, and a natural by-product of friction is heat.

2. The heavier the load, the greater the friction, and the longer the descent, the more heat buildup there is.

3. A very hot braking device can result in the following:

a. Burn hazard to rescuers’ skin as well as to ropes and soft goods

b. Diminished strength of the device

4. When selecting and operating a braking device, rescuers should give heed to the intended use – the weight of anticipated loads and the distance(s) these loads will normally be lowered.

5. Heat dissipation derives from greater surface area and an open design.

6. If a device does become overheated during use, dousing it with water can help to cool it through convection.

H. Guidelines for selecting a braking device

1. The descender must be sized properly for the diameter of rope you will be using.

2. The descender should create enough friction to give absolute control over the descent without using brute strength; the rescuer should be able to go as slowly as desired and be able to stop at any time.

3. Hardware and equipment make the rescuer significantly heavier than their “street weight.” You may also be wearing gloves.

4. The rescuer must be able to lock-off the device before they use it, so that they can secure themselves and remain stopped on the rope with hands off the device.

5. The descender is strong enough to have an adequate safety factor for the intended use.

6. The descender must be adequate for the length of descent needed.

7. The device must be adequate for intended application (i.e., lowering or descending).

I. Types of braking devices

1. Response organizations should choose braking devices with consideration to the purpose(s) for which they will be used; desired performance capabilities; and the frequency, level, and type of training that will be available to users.

2. At a minimum, braking devices (whether used for lowering or descending) should meeting the following criteria:

a. Provide suitable control over the speed of descent

b. Offer smooth braking, without bouncing or undue shock loads

c. Not cause abrasion, plucking, milking, or stripping of the rope sheath

d. Not become accidentally detached from the rope

3. An organization may choose a range of braking devices to be used for different purposes (e.g., lowering, descending, and personal escape).

4. When equipment finds its way to the field, rescuers must have sufficient knowledge to determine which device is best for a given operation with consideration to the following:

a. Weight of load

b. Length of lower

c. Environmental factors

d. Available rope

e. Auxiliary equipment

5. NFPA classifies descenders into the same three categories it does other equipment: E (escape), T (technical), and G (general).

a. The biggest difference among these three classifications is the load and use for which they are intended.

b. In addition to echoing certain test methods and requirements from the ISO standard, NFPA also requires deformation testing.

i. G-rated devices must withstand at least 11 kN (2470 lbf) without deformation.

ii. T-rated devices must withstand at least 5 kN (1124 lbf) without deformation.

iii. E-rated devices are subjected to a dynamic test.

J. Braking devices for rescue

1. Autolocking devices

a. Fail-safe advantages of autolocking devices have increased in popularity.

b. There are pros and cons to using devices with autolocking and panic-lock features.

i. They are less versatile but offer peace of mind for a broader spectrum of users.

ii. These devices tend to be very rope-specific and are capable of being used only with a very narrow range of diameters.

iii. Using an autolocking descender with a diameter of rope other than that for which it is designed can create additional hazards, including insufficient friction, jamming, or even accidental disengagement.

c. Most autolocking devices function in the following way:

i. The rope is wrapped, either fully or part-way, around a moving bollard, or block of metal.

ii. Tension is applied to the working end of the rope pulls the bollard in such a way that the rope is compressed or pinched against a block, and progress stopped.

iii. In many cases, the bollard is enclosed by a shell, which opens to allow insertion of the rope, and closes to keep it in place.

d. Most of these devices can be used not just as a descender, but also as a progress capturing pulley for raising operations.

i. Typically, these devices are fitted with a handle by which the braking mechanism can be rotated, releasing pressure on the rope.

ii. Feeding rope through the device is a two-handed operation, with one hand operating the handle and the other serving to apply friction on the tail of the rope.

2. Climbing technology sparrow

a. Climbing technology sparrow

i. Self-braking descender designed for descent and ascent

b. An external brake-spur permits rapid addition of a modicum of friction while the automatic-returning brake lever offers speed control. When the lever is pulled too far, the speed is reduced, but not stopped altogether.

c. The climbing technology sparrow is designed for use with an 11-mm rope.

3. CMC MPD

a. The CMC MPD incorporates a bollard and is designed to serve as both a braking mechanism and a pulley.

b. It permits switching from lowering to raising without any change in hardware.

c. This device is available in two models, one for 11-mm rope and the other for 12.5-mm rope.

4. Harken clutch

a. The Harken clutch includes the following features:

i. Stainless steel rotating sheave, which, stationary in the locking direction, is designed to make an audible clicking noise in the other.

ii. Autolocking feature

iii. Panic-lock

iv. Unique force limiting feature to prevent overload

v. Becket, which is a hole for attaching a carabiner, so that it may be integrated into haul systems, and rope can be installed without removing the device from its anchorage

b. It is designed to work only with 11-mm rope.

5. ISC D4/D5

a. The ISC D4/D5 Work Rescue Descenders are designed for 11-mm and 12-mm rope, respectively.

b. The offset bollards of these double-stop devices are unique for the range of control that they offer.

c. These devices include both autolocking and anti-panic features.

d. It is designed to slip between 4 and 6 kN (890 and 1349 lbf), so as to be able to be used as a fall-arrest/belay device.

e. It can be rigged to the rope without removing it from its anchorage connection because it is designed for heavier loads.

f. It features a release mechanism that is designed to reduce the risk of accidental opening but is easily operated with gloves.

6. Petzl ID

a. The Petzl ID is one of the earliest bollard-type devices to be designed for the professional market that is advertised as a self-braking descender/braking device.

b. Different handle positions are available for descent, panic stop, and storage.

c. There are two versions of this device, each make to accommodate different loads:

i. 10- to 11.5-mm rope (maximum load 150 kg [330 lb])

ii. 11.5- to 13-mm rope (maximum load 250 kg [550 lb])

d. The ID is known for having a relatively narrow sweet spot, which can be problematic for lighter loads or low slopes. A button at the end of the control handle is designed to offset operational difficulties that occur when forces on the device are lower.

7. Petzl Maestro

a. The bollard of the Petzl Maestro is really a large-diameter sheave, like a pulley.

b. It is fixed in one direction, but rotates in the other, making it quite efficient for raising.

c. The outside shell features a protruding horn, allowing the user to temporarily increase the amount of friction applied by a moderate amount, as long as the brake hand holds friction on the rope.

i. When loaded, the device automatically locks off, and the braking mechanism is released by pulling the handle; the more the handle is pulled, the more the moving brake plate disengages to let the rope run.

ii. This device does not have a panic-lock; if the handle is pulled too far, the rope can run freely through the device – possibly causing loss of control.

iii. This device should be used with care, especially by less experienced persons.

iv. The Maestro is available in two versions, one for use with ropes from 10.5 mm to 11.5mm in diameter (maximum working load 250kg [550 lb]), the other for use with ropes from 12.5 mm to 13 mm (maximum working load 280 kg [617 lb]).

8. Skylotec Lory

a. It is designed for professional rescue, work positioning, restraint, and anchorage, in addition to standard belay, lowering, and raising operations.

b. It is especially adept at feeding and taking rope, and blocks automatically in case of a fall.

c. The Skylotec Lory features both autolock and panic stop elements and is equipped with a descent handle that ensures maximum security and control.

d. It is designed solely for use with 11-mm rope.

9. Skylotec Sirius

a. The Skylotec Sirius is designed to be an ergonomic, durable, ultra-compact device that prevents twisting, kinking, and excessive wear on the rope.

b. Its autoreturning lever has a minimal range of motion for maximum efficiency and safety.

c. A small hole at the top can be rigged with cordage for remote operation.

d. A secure attachment point permits installation of rope without removal from the anchor point and a becket accommodates integration into haul systems.

e. According to the manufacturer, the Sirius has been submitted for NFPA testing for a G rating with both 11-mm and 12.5-mm rope, with the same device.

10. SMC Spider

a. It works with rope diameters of 10 mm to 12.5 mm.

b. It functions best for lowering, descent, and positioning, and is designed such that the rope may be installed or removed without having to unclip from its anchorage.

c. The SMC Spider is autolocking in a hands-free mode and has a very wide sweet spot, which is the adjustment at which the rope travels freely through the device, before the handle finally reaches a panic-lock position.

K. Precautionary notes

1. It is extremely important to use the correct rope diameter in these devices because most autolocking devices function with only a very narrow range of rope diameters.

2. The very narrow range also means that ropes of different hands, or hardnesses, will also perform somewhat differently in them.

3. If an organization that uses a certain combination of rope and device plans to change either rope or device, the following should occur:

a. Field evaluation of compatibility should be performed prior to that change.

b. Personnel should be provided ample training time to become accustomed to the differences prior to a possible response.

4. It should also be noted that wet, icy, or muddy ropes will perform differently in a braking device than dry ones.

a. This difference is much more notable with autolocking devices than with nonautolocking devices.

b. If such use is likely or expected, rescuers should practice under these conditions to become accustomed to the difference in friction and feel.

c. It is important to ensure that debris does not become lodged in the shell of the device, as this could impede proper function or even damage the rope.

5. Care should be taken when using autolocking devices for heavy loads, long lowers, or extended descents.

a. These devices may not (by themselves) offer sufficient friction for heavy loads and/or may jam up when there is a great deal of rope weight beneath them, as on a long rappel, due to their limited range and capacity.

b. The limited rope path and smaller mass of most of these devices means that they do not dissipate heat as well as, for example, a brake rack.

L. Nonautolocking

1. Nonautolocking braking devices should be used only by those with specialized training and skill.

2. The pros of these devices include the following:

a. Versatility, capability of being used with a wider range of rope diameters

b. Adjustable friction

c. Optimization for especially long descents

3. These devices should be used only by very experienced users because they do not automatically lock when the user lets go.

4. Nonautolocking devices can be retrofitted to achieve the benefits of an autolocking device by utilizing a self-jamming friction hitch to create an autoblock, in the system.

VIII. Brake Bar Racks

A. A brake bar rack is most conducive to adjusting friction over a wide range, even while under load.

B. SMC Gear offers a brake bar rack assembly that meets the NFPA 2500 (1983) equipment standard.

C. The pros and cons of the brake rack include:

1. Pros

a. Good control

b. Ability to easily adjust the amount of friction during use

c. Excellent for very long rappels

d. Works well for lowering heavier loads

2. Cons

a. Free-running

b. Does not autolock

D. The brake bar rack consists of two primary elements:

1. Frame

a. Most frames are made of stainless steel.

b. Titanium versions are less common and more expensive, but are lightweight.

2. Bars

a. Designed to fit over the frame, with a hole drilled in one end so that the bars slide freely along one side of the frame and a notch on the opposite end to clip on and off of the other side of the frame

b. Larger bars tend to create greater friction than small-diameter bars.

c. Most brake bars are made of hollow steel bars, although aluminum bars are used in some older designs.

E. There are two common frame configurations:

1. J rack – open-ended frame with one leg longer than the other

a. The user clips to the device by means of an eye on the leg of the longer bar at the open end.

b. For rappelling, it works most efficiently with the open side of the rack toward the ground.

i. Some seat harnesses have a horizontal D ring as a clip-in point; this positions the open side of the rack facing the rappeler’s side.

ii. To compensate for this, some versions of the rack have a 90-degree twist in the eye so that the rack remains with the open side toward the ground.

2. U rack – has legs of equal length

a. Operated with the U in the usual position

b. When used, a carabiner is clipped across the bend at the bottom part of the U.

3. With either frame configuration, the rope is woven through the bars to create an optimum amount of friction.

a. Under tension, the rope keeps the bars in place on the frame.

b. Friction is controlled in any of the following ways:

i. Applying pressure with the brake hand on the rope below the rack

ii. Varying the bar spacing

iii. Varying the number of bars engaged on the rope. The bars must be loaded in the correct sequence for safe operation of the device. Longer frames accommodate more bars, making them an excellent choice for long drops or situations where a wide range of friction adjustment is desirable.

F. When a brake rack is used correctly, the bars are the only elements that wear out.

1. Bars must be replaced from time to time.

2. Depending on the bars’ requirements for friction, they can be purchased in a variety of sizes.

a. In the most common configuration, the rack is arranged with a 1-inch (2.5-cm) diameter top bar.

b. On J racks, this top bar may be grooved to keep the rope in the middle of the bars as it runs through the device.

c. On U racks, the second bar down is often grooved. The remainder of the rack usually is filled out with five aluminum bars, each 7/8 inch (2.2 cm) in diameter.

d. Some brake racks also have a tie-off bar.

i. This makes it easy to add friction or to tie off the rope.

ii. A pin at the end of the bar helps keep the rope from slipping off the bar.

iii. On the six-bar rack, a tie-off bar can be placed at the top.

iv. Some short versions of the U rack have two tie-off bars, with the second one as the bottom bar.

G. Scarab

1. Compact version of a bar-type device is very small compared to a typical rack and offers similar performance characteristics.

2. Pros and cons of scarabs are as follows:

a. Pros

i. Not twisting the rope

ii. Ability to vary friction

iii. May be used with a wide range of rope (9–13 mm)

iv. Can be rigged in single rope or dual-rope configurations

v. Very strong

b. Cons

i. Limited friction

ii. Not sufficient for a very wide range

iii. Does no dissipate heat as well as a larger device

iv. Does not have autolocking or panic-lock features

3. The frame and crossbar of the scarab should be monitored closely, and the unit retired when the crossbar is worn more than 0.030 in. or the frame is worn more than 0.090 in.

H. Alpine Brake Tube

1. Originally fabricated by Tom Fiore and then Phil Leuthy of Alpine Rescue Team in Colorado, the Alpine Break Tube evolved from the Forrest Wonder Bar in the 1970s

2. Pros and cons of the Alpine Brake tube include the following:

a. Excels in accommodating multiple ropes simultaneously and in passing knots

b. Offers ability to adjust friction to accommodate very light to very heavy loads, making it conducive to both low-angle and high-angle operations

3. This tubular, knot-passing device was created for long, low-angle rescues in the Rocky Mountains where anchors are few, but long ropes are impractical to carry.

4. Construction features of modern Alpine Brake Tubes include the following:

a. Thick aluminum tubing that dissipates heat well

b. Risers help to keep it off the ground during lowering operations.

c. Protruding pins serve as tie-off retainers.

d. Brake tubes are relatively bulky, and heavy, but function effectively with virtually any size life safety rope.

5. Where the need to pass knots and/or run multiple ropes through a single device, the brake tube is an excellent choice.

I. Figure 8 descender

1. Pros of the Figure 8 descender include the following:

a. Shaped rather like the numeral 8, but having rings of unequal size

b. Smaller ring (or lower one when in use) is clipped into a seat harness or anchor with a carabiner or screw link.

c. The rope passes through the larger ring (or upper one when in use) to create friction.

d. Figure 8s are made of either steel or anodized aluminum alloy.

e. Figure 8s are a free-running type of device, with the user controlling the speed of the load with a brake hand; the amount of grip or tension on the rope determines speed.

f. These devices may be used with any type and diameter of rope, including doubled ropes, and they dissipate heat well.

g. Open shape is quite versatile and offers several rigging options.

2. Cons of the Figure 8 descender include:

a. It does not offer autolocking or panic-locking features.

b. It tangles ropes.

c. Offers a limited amount of friction for descending

d. Can be difficult to take rope through while belaying

e. Generally not considered a good choice for heavier loads

f. Figure 8s have become all but obsolete, even for recreational use.

3. Conventional Figure 8 features the following:

a. Sizes range from the very small Escape 8 to larger styles used in recreational climbing, thought they are often found in small sizes with a rounded or slightly squared large ring.

b. Some have protruding “ears” fabricated into the large ring.

i. Known as Rescue 8s, these are specifically designed so that the rope contours better around the large ring and is less susceptible to accidental girth hitching.

ii. This type of Figure 8 is typically of a larger size than recreational 8s, offering greater heat dissipation and facilitating use with larger diameter ropes.

4. The most commonly used configuration, the standard rig offers a modicum of friction and is easy to rig.

a. This mode induces twist into the rope, and requires disconnection from the harness to de-rig.

b. This higher friction method of rigging offers additional control for heavier loads.

c. Care should be taken when using this method to avoid accidentally unlocking the host carabiner.

d. Note, also, that the host carabiner should never be opened while under load.

e. This is an advanced method of rigging a Figure 8 that is especially helpful in environments where the user might want to escape the system rapidly.

f. This advantage, however, is likewise a potential disadvantage in that it could inadvertently come off the rope when unweighted.

g. While not considered an autolocking device, a Figure 8 rigged in this manner will autolock when the tail of the rope is trapped between the tensioned part and the device.

i. To release it, simply pull down on the small ring of the 8 with one hand while continuing to control speed with the brake hand.

ii. This method works better on descent than in lowering mode.

5. The choice of wraps will depend on the following:

a. Skill level

b. Weight of the load

c. Type of rope

d. Conditions

e. Device dimensions

IX. Escape Devices

A. Escape devices are designed to be more compact, and suited to a smaller diameter of rope (usually 7–9 mm) so that they may be easily carried by a rescuer in a pocket or small pouch, ready to be deployed in a life-threatening emergency.

B. Some escape devices are autolocking, and some are not.

C. There are two general bodies of thought on escape ropes:

1. Because escape ropes tend to be so thin, descent may be difficult to control and therefore the descender should be both autolocking and panic-locking.

2. The idea of a real emergency escape is to evacuate rapidly, and autolocking features increase the risk of becoming inadvertently stuck on rope.

3. It is left to the AHJ to weigh the risks, to determine which of these is of greater concern, and to purchase equipment and train personnel accordingly.

D. Escape devices: Autolocking

1. Petzl EXO

a. The Petzl EXO is an autolocking descent system that evolved from the Petzl GriGri recreational belay device.

b. Features include the following:

i. Self-braking system as well as anti-panic function, permitting the user to control descent on a slim escape rope

ii. Can be held open manually as the user moves across a horizontal surface

iii. Requires special training before use

2. Sterling F4

a. The Sterling F4 features a simple design with smooth, beveled holes.

b. It includes a lever that allows rope to feed when activated, and to lock when released.

c. The rescuer operates the device by activating the device with one hand while controlling the free end of the rope with the other.

d. When the device is released, descent stops; in the event that a person is injured or incapacitated while descending they would simply stop, suspended on the rope.

e. Rigging the F4 is simple:

i. Rope is reeved through the holes to the extent necessary for the anticipated load.

ii. The number of holes reeved will depend on the type and diameter of rope, and the weight of the user.

E. Escape devices: Nonautolocking

1. A number of options are available.

2. There is no room for error: If a user lets go of the brake hand, the device will not lock off.

3. These devices are easier to feed and adjust quickly, making them less likely to jam in the heat of an emergency.

4. Escape 8

a. The Escape 8 is a smaller version of the Figure 8.

b. It was designed as a personal escape descender for fire fighters in bailout situations.

c. This device works well for either single or double ropes.

d. The Escape 8 can be used for ropes from 7.5 mm in diameter all the way up to 12 mm in diameter.

e. When needed, particularly with smaller diameter ropes, an additional wrap can help add friction.

f. It is lightweight and easy to carry, and the squared-off shape also contributes to better friction.

5. PMW hook

a. The PMW hook is designed to function in a variety of ways, including the following:

i. As a personal escape descender

ii. As a way to make a rescue lower

iii. As an anchorage connector

b. It is available in two sizes.

c. For lowering or descent, the device is rigged by taking a bight of rope through the large hole and looping it over the neck of the device, similar to the manner in which a Figure 8 is rigged.

d. Friction may be easily adjusted by taking additional wraps around the top part of the hook.

X. Belay Devices

A. Belaying

1. The process of protecting a person from falling by controlling an unloaded rope (the belay rope) in a way that secures the person on the rope in case the individual’s main line rope or support fails

B. Belaying a rescue load is different from belaying one person.

C. Commonly used recreational climbing devices and techniques that work well for a single body weight may not be adequate for belaying a rescue load.

D. Climbers have traditionally belayed one another by attaching the belay rope directly to both the belayer and to the person being belayed.

E. The oldest belay technique is the body belay.

1. With this technique, the climber runs the belay rope around the body of the belayer (usually around the waist). In this way:

a. The rope can be brought tight if the person on the end of the rope (the climber, rappeler, worker, or rescuer) falls.

b. The rope is held by friction around the belayer’s body.

2. Body belaying has significant disadvantages:

a. The force of the fall may cause the belayer to lose control of the rope and drop the climber.

b. The force of the fall can easily injure the belayer.

c. The belayer can become entangled in the rope. If the belayer does catch the climber, they must hold the individual until the climber can become secure.

d. Because of these problems, alternatives to body belaying have been developed and are preferable.

F. Belay devices are addressed by NFPA 2500 (1983).

1. The NFPA classifies them into two categories:

a. Technical-use belay devices

b. General-use belay devices

2. The performance specifications for each of these class ratings includes a relevant drop test.

G. Several types of belay devices work through friction generated when the device presses the rope against a carabiner.

1. Belay plate

a. Classically designed belay plates consist of a small metal plate with one or two holes.

i. A bight of rope is fed through the plate and secured with a carabiner on the opposite side.

ii. The carabiner is clipped into an anchor.

iii. When the two strands of rope are pulled apart, a high degree of friction is created on the rope. This stops the fall of the climber.

b. Although commercial versions of these are available, the small hole of a Figure 8 descender may also be used to create a belay plate for personal loads.

i. By poking a bight of rope through the small hole of the Figure 8 and clipping it with a carabiner, the device may be used for belaying.

ii. This method allows rope to be played out quickly when belaying, and is the only use of the Figure 8 that does not induce twisting.

2. Air Traffic Controller (ATC) by Black Diamond (Salt Lake City, Utah) (personal belay devices)

a. The ATC can be used with ropes ranging from 8.5 to 11 mm in diameter.

b. Some personal belay devices work through a camming action on the rope (e.g., Beal Birdie).

c. Personal belay devices are not covered by NFPA 2500 (1983), but may be a valuable tool for rescue personnel to carry in the event that they may need to belay another rescuer across a leading edge or while lead climbing.

d. A personal belay device may not be the most appropriate device for catching loads of more than one person’s body weight.

i. Before using any device or system to belay a rescue load, it should be tested under conditions similar to those that will encounter in an actual rescue situation.

ii. This ensures that the rescuer will be able to catch the load when it falls.

H. Some braking devices are also approved by the manufacturer for belaying of a rescue load.

1. Always follow manufacturer instructions and guidelines when using a braking device for belay, as some devices are not well suited for dynamic impact loads.

2. The commonly used twin tensioned rescue belay method calls for the use of two descenders rather than a belay device.

3. Münter hitch (or Italian hitch)

a. This device only requires only a rope, an anchor, and a carabiner.

b. When properly tied, it can work as personal belay systems for falls with a low fall factor.

c. It is less effective with heavy loads, but may be suitable if there is sufficient friction in the system.

d. The ability to catch a load with a Münter hitch varies, depending on the rigging situation (e.g., it may be easier to catch a load with a Münter hitch if the rope runs across an edge or face or through directional pulleys).

e. These elements in a high-angle system add friction and help absorb the force of a falling load.

I. No belay device or technique is perfect for all rescue loads and in every rescue environment.

1. Great caution must be exercised in choosing any belay device for rescue loads.

2. Devices should be tested under realistic conditions before being put into use.

J. In selecting devices and methods for belaying, the rescuer should follow the guidelines set forth by the AHJ with respect to the following:

1. The maximum potential impact load and arrest distance for the load

2. The anticipated static load to which the device (and system) might be subjected, considering system configuration and methods used

3. Possible approaches to mitigating potential impact force through reduction of mass, reduction of fall distance, additional means of energy absorption, or some other manner

4. Operational capabilities and training levels of the users

5. Operational conditions, such as weight and environment

XI. Rope Grabs and Ascenders

A. Rope grabs

1. Devices that grip the rope that have a variety of uses in rope rescue; a broad spectrum of devices, usually metallic in nature with a camming device that is designed to grip the rope firmly.

B. The following questions should be asked when selecting ascenders for use:

1. What size rope are they designed for?

2. What is their strength rating and how is it determined?

3. Can they be operated easily (placed on and taken off the rope) with one hand?

4. Do they have a secure safety catch to prevent them from accidentally coming off the rope?

5. Are they comfortable in the hand?

6. Can they be used easily while wearing gloves?

C. Rope grabs typically slide freely in one direction and lock off in the other and provide adequate safety only when attached to run in the proper direction.

D. Different rope grabs are constructed to meet specific needs.

1. Fall arrest

a. Rescuers may come into contact with fall arrest rope grabs when working in an industrial environment or on towers.

b. The following should be noted regarding fall arrest rope grabs:

i. Some are intended for use on rope, while others are designed for cable.

ii. They are typically of a design that is not easily removed from the rope.

iii. Fall arrest rope grabs are intended to be used with a fall arrest lanyard and, in some cases, a force absorbing lanyard.

iv. They do not function properly when they are grabbed during a fall, nor when attached to the wrong size rope.

v. They generally quite specific with regard to the type of rope or cable upon which they are designed to be used.

vi. Some fall arrest rope grabs, such as the Petzl ASAP, are approved by the manufacturer for rescue belay. Always follow manufacturer’s instructions for such use.

c. A fall arrest rope grab should always be attached to the rope in the proper direction.

i. Many have an arrow on them, which should point along the lifeline towards the anchor point.

ii. A firm tug in the direction of potential fall will help to ensure that it is properly attached.

d. The following should be noted with regard to use:

i. During use, the device should be kept as high as feasible above the rescuer, to minimize potential fall distance.

ii. Some fall arrest rope grabs are designed to self-trail while others must be manually adjusted.

iii. Care should be taken to not grip or squeeze the activation feature of the rope grab during a fall as this could prevent it from working properly.

e. A “parking feature” can be activated on some devices to lock the device at any desired point on the lifeline; care should be taken to release this feature before climbing.

2. Rigging

a. Rope grabs designed for rigging, such as the PMI/SMC Grip, may be marked to NFPA general use or technical use ratings.

i. G-rated rope grabs must hold 11 kN (2500 lbf) without permanent damage to the device or the rope upon which it is tested.

ii. T-rated rope grabs should hold 5 kN (1124 lbf) without permanent damage to the device or the host rope.

b. Rope grabs designed for rigging should not be used for fall arrest.

i. These rope grabs may be used to grip rope for progress capture or other purposes in rescue rigging.

ii. Most rigging rope grabs do not have handles.

iii. An enclosed, clamshell type body is often used and must be taken apart to be placed on rope.

iv. While perhaps more tedious to put onto the rope, once they have been assembled, they are not likely to come off until intentionally removed.

c. The camming device on many rope grabs designed for rigging is often designed with a ridged cam.

i. This design allows contact over a maximum amount of surface area to grip a rope firmly while imparting a minimal amount of damage to the host rope.

ii. The ridged cam is less likely to clog up with ice or snow than a toothed cam.

iii. The rope grab may also have a notch in the shell where the cam meets the body to improve grip and reduce likelihood of damage.

iv. Under very high or shock loads, even a rope grab such as this may damage rope.

d. Although ascenders may simply be considered as one type of rope grab, they differ in the following ways:

i. A rigging rope grab is generally of a clamshell or similar design that requires two hands to install and remove from rope and is less likely to become inadvertently disconnected.

ii. An ascender has a more open design that can be readily applied and removed from rope, often one-handed.

3. Personal handled ascender

a. Operation

i. A personal handled ascender (e.g., CT Quick Roll) works on the same principle as other rope grabs.

ii. When used properly, it is designed to slide freely in one direction (up) and to lock in place under a downward force.

iii. For the system to work effectively, at least two devices are generally required. The rescuer ascends rope by sliding one ascender up the rope while supported by the other, then alternating the action to progress up rope.

iv. Handled ascenders like these are typically used in conjunction with a personal lanyard for safety, and an etrier or footloop.

v. A hole or two at the bottom end of the device will help facilitate different ascending styles, and features like a built-in pulley can accommodate climb-assist systems.

b. The following should be considered when selecting an ascender:

i. Fits the hand comfortably

ii. Does not come off the rope accidentally

iii. Has a sufficient working load for the needs of the operation

c. A slotted cam will help prevent accumulation of mud or ice.

i. The cams of personal ascenders often have very fine, sharp teeth angled in a downward direction to provide a firm bite on the rope.

ii. While useful for recreational climbing and mountaineering, these teeth can snag and jam with heavier rescue loads, and may be more likely to inflict damage and increased rope wear.

d. Not all ascenders have handles.

i. Some people prefer to use ascenders by wrapping their fingers around the upper shell rather than using the handle.

ii. Elimination of the handled portion of the device makes it lighter and more compact.

iii. Chest ascender – handleless ascender mounted onto the harness at chest level to provide progress capture as the rescuer climbs.

iv. Chest ascenders are often designed with a small twist in the frame (e.g., Petzl Croll) to help it lie more ergonomically in a vertical position and parallel to the body of the user when rigged between the sternal and the ventral attachment.

v. Others (e.g., the Beal Hold Up), incorporate a specially designed vertical attachment point that achieves the same result.

e. Personal ascenders should not be used in hauling systems and other rescue rigging involving loads much greater than one person’s body weight, nor as belay devices, because they are more likely to damage the rope under high weight loading and shock loading.

XII. Anchorage Connectors

A. Making an appropriate connection to a sufficient anchorage is a foundational part of rope rescue.

B. Anchorages used in rescue may be comprised of an existing structure or natural element.

1. They may be installed as necessary.

2. The method used for attaching to it will at least in part determine its performance.

C. The connecting components should be of sufficient strength to achieve the desired goal, and should be attached in such a way so as to prevent unwanted movement or disengagement of the rescue system from the anchorage.

D. Anchor slings

1. Anchor slings are made of/feature the following:

a. Webbing

b. Rope

c. Metal D rings or sewn loops at each end where a carabiner can be clipped (typically included)

2. These straps can be a quick way of setting reliable anchors.

3. Anchor straps come in two basic types, as outlined in NFPA 2500 (1983):

a. Heavy-duty (NFPA G designation) – typically have an end-to-end breaking strength of about 8000 pounds (35.6 kN)

b. Lighter-weight versions (NFPA rated T) – typically may have an end-to-end breaking strength of 4945 pounds (22 kN)

4. Features

a. Strap breaking strengths may be higher when the straps are rigged to form a basket.

b. Slings with a larger ring at one end may be used to form a choker.

c. Some anchor straps (e.g., PMI Self-Padded Choker Sling) are fitted with a presewn pad to help protect the load bearing part of the strap.

d. Others straps may have a heavy-duty buckle.

i. Allows strap to be adjusted to various lengths

ii. May slip with a force less than the rated breaking strength of the strap

5. Some presewn slings are simply sewn into a circular loop, without specific terminations for connection.

a. These are very versatile, and may be also used as an anchor sling among other things.

b. The following should be considered when choosing presewn slings:

i. Adequate tensile strength is needed to achieve the desired safety factor.

ii. When abrasion or cutting is a concern, steel anchor strops are an excellent choice that offer additional abrasion resistance and cut protection.

iii. Fall protection is imperative and is often provided through steel cables with terminating swaged loops at each end.

iv. Strength ratings is also a concern and generally hovers around the 5000-pound (2268-kg) mark, but by using multiples an adequate rescue anchorage can be constructed.

6. When selecting anchor slings, consider the AHJ’s requirements in respect to the following:

a. Length

b. Width

c. Weight

d. Terminations

e. Material

f. Adjustability

g. Color

E. Beam clamps

1. The angular steel structures found in many industrial plants and urban environments can be challenging to anchor to for the following reasons:

a. The edges of these beams are destructive to anchor slings.

b. They are quite large, and may or may not be conducive to wrapping.

2. The typical use for these is industrial fall protection, so rescuers may find the 5000-pound (2268-kg) rated breaking strength to be wanting.

3. However, utilization of multiple anchor points can result in a sufficiently strong anchor for rescue.

F. Bolt anchors

1. Industrial sites and urban structures often will have preengineered fall protection anchors over commonly accessed area.

a. Locations:

i. Confined space entry points

ii. Tanks

iii. Vaults

iv. Other work surfaces

b. Important points to take into account before use:

i. Before using any installed bolt anchorage point, be sure that it is rated for life safety use and find out what its strength is.

ii. Most fall arrest anchorages are rated to only 5000 lbf, with positioning anchorages rated to 3000 lbf.

iii. It may be necessary to use two or more existing anchorages to achieve your desired strength.

2. Some bolt anchors are fixed, or stationary, while others may swivel.

a. The anchorage connector should be adequately positioned for the intended direction of pull.

b. Some bolt anchors are designed to be removable, used either in concrete or in a steel structure. These vary widely in strength and performance, and are highly dependent on the quality and nature of material into which they are inserted.

3. It is up to the rescuer, under the authority of the AHJ, to ensure that the anchorages used are adequate and appropriate for rescue loads.

G. Portable anchors

1. In some situations, tripods—or their advanced cousin the multipod—provide an excellent solution.

a. Known as portable anchors, these devices require extensive training, but adept use can expand the capabilities of a rescue team dramatically.

b. The need for such a device should be considered based on a risk assessment, training, and the organization’s response capabilities.

c. When considering such a device, important factors include the following:

i. Number and type of head attachments

ii. Height and strength of the unit

iii. Optional accessories

2. Packaging, storing, and transporting a tripod or multipod can be a particular challenge due to its size.

3. It is particularly important to keep components together and ready for quick assembly and for rescuers to be adequately trained in prompt deployment.

4. Adaptations on the tripod concept (e.g,. Arizona Vortex and the TerrAdaptor) are advanced concepts in high rigging that can be rigged in as simple, or as complex, a manner as needed.

a. The TerrAdaptor is unique in that it is designed to be used as a monopod, bipod, tripod, quadpod or even in a davit configuration, and may be coupled with additional units in an endless range of configurations.

b. It is adjustable from 4 feet (1.2 m) to upwards of 12 feet (3.7 m) in height, and available with a variety of feet and attachment options to adapt to any terrain.

c. It may be used as an anchorage, as a change of direction, or simply as a high point for lifting a rope system off the ground.

H. Pickets

1. A picket system is an alternative in a natural area where no anchors are available.

2. These systems can work very well when correctly rigged.

3. These systems also present several challenges:

a. Establishing it properly usually takes a great deal of time.

b. Not all soil types can hold pickets securely.

c. Loose, sandy, or muddy soil, or snow, may not hold well regardless of the number of pickets used.

4. Construction

a. Pickets should be made of appropriate material for the specific use or environment, with good sheer strengths.

b. Most picket anchor systems consist of several rows of pickets.

XIII. Pulleys

A. A pulley is designed primarily to reduce rope friction, but this capability makes it useful in a number of functions in the rope rescue environment.

B. Pulleys also can be used as follows:

1. Change the direction of a running rope

2. Position a rope more conveniently, such as to an area where people using the rope will be less exposed to falling, dropped objects, or where rescuers may have more room

3. Reduce abrasion on a rope (e.g., a pulley could be used to hold a rope up from an edge or to bring it away from other rope or webbing)

4. Develop a mechanical advantage in hauling systems

C. As with other auxiliary equipment, NFPA 2500 (1983) classifies pulleys either as “T” (technical) or “G” (general).

D. When selecting pulleys for a rescue organization, the AHJ should consider the following:

1. Efficiency: Ball-bearing pulleys are more efficient than bronze-bushing pulleys, but not quite as strong. They also do not take stress, such as sudden blows, as well as the bronze bushing.

2. Single or double: Double pulleys work better than two pulleys side-by-side where two lines follow a common rope path; however, double pulleys should not be used in a single pulley configuration.

3. Ratchet: If a Prusik will be used as a progress capture, a Prusik minding pulley should be selected.

4. Size and overall dimensions: Consider the bulk, weight, and number of pulleys to be carried, balancing this with selecting a large enough diameter to optimize efficiency.

5. Sheave width: Rescue pulleys are manufactured in ½-in. (12.5-mm) and 5/8-in. (16-mm) widths.

6. Sheave diameter: Selecting pulleys with a sheave diameter of at least four times the diameter of rope helps to optimize system efficiency.

7. Strength: The side plates generally are the weakest part of a pulley. Pulley strength should correspond at least in part to the strength of the rope with which it is intended for use. Pound for pound, steel side plates are stronger than those made of aluminum.

8. Compatibility with rope: It is okay to use smaller ropes on a larger sheave, as long as the rope is not so small that it will get caught between the pulley wheel and the side plate during use. It is not okay to use a larger rope on a smaller sheave.

9. Side plates: Movable side plates allow the pulley to be placed on the rope anywhere along its length; side plates that extend beyond the edge of the sheave help to protect the rope.

E. Specialized pulleys

1. The large sheave of the knot passing pulley is designed so that knots connecting lengths of rope can pass over it easily.

a. This type of pulley also travels well across multiple ropes simultaneously, making it useful for highlines.

b. Fitted with locking pins, when the sheave of this pulley is locked into place it makes an excellent high strength tie-off.

2. Prusik minding pulleys are designed with squared off sideplates.

a. This allows a prusik hitch to push up against it without jamming or being sucked into the pully.

b. The squared off sideplates do such a good job holding the hitch open this type of pulley has come to be known as a prusik minding pulley.

XIV. Other Hardware

A. Rigging plates

1. Rigging plates serve as collection points for multiple anchors and/or rigging points.

2. Rigging plates can provide the following benefits:

a. Help keep anchor rigging organized

b. Save time in setting anchors

c. Add a degree of safety by helping rigging personnel quickly visualize and understand their rigging

3. Rigging plates commonly are used where multiple lines come together at a common point:

a. At an anchor

b. At the master attachment point on a litter

c. Where multiple anchor lines are collected at one point

4. Look for rigging plates that are strong (NFPA rated G) and that have contoured edges that are less likely to damage rope and carabiners.

5. The holes should be large enough to accept large locking carabiners easily.

B. Swivels

1. Swivels may be used in rope systems to help prevent rope and equipment entanglements.

2. They are particularly useful for reducing the potential for torque, or to reduce spin.

XV. Maintenance and Inspection

A. Care

1. Equipment should be stored in a clean, dry place, and protected from exposure to potentially hazardous chemicals or fumes.

2. Storing equipment in bags or containers helps to secure and protect it, and makes it easier to carry when the time comes to deploy it.

3. Before storing equipment, follow the manufacturer’s instructions on cleaning the equipment.

B. Inspection and recordkeeping

1. Rescuers should be on the lookout for inconsistencies and potential problems with equipment at all times when using it. This, however, does not preclude the need for establishing an intentional program for inspection of gear at regular intervals.

2. Equipment should be inspected as follows:

a. Before placing it into service

b. Before any use

c. At regularly scheduled intervals

3. Equipment should be first inspected prior to placing it into service.

a. This is also a good time to complete the following tasks:

i. Remove packaging.

ii. Mark the equipment for future traceability.

iii. Make an equipment log form.

iv. Examine the item in detail to ensure that there are no signs of manufacturing defects or shipping damage.

b. This inspection should be quite thorough, including detailed examination of any subcomponents, buckles, and moving parts.

4. Before use inspection is a bit less detailed, but no less important.

a. This inspection includes both visual and tactile inspection – that is, looking at and touching the item to affirm that it is in good working order.

b. Many agencies choose to do a before use inspection as they are putting gear away from its previous use, but this does not preclude the need for additional inspection as the gear comes out of storage for the next operation.

c. It is important to ensure the following:

i. Critters have not chewed on textile parts.

ii. Pieces have not been damaged by being pinched or slammed in compartment doors.

iii. The gear is safe for use.

5. In addition to these inspections, provision should be made for a thorough inspection at regular intervals.

a. There is no set “right” time to do these, but intervals between thorough inspections should not be more than 1 year.

b. Most organizations choose to do a thorough inspection at least twice a year, and very busy organizations may do them as often as every month.

c. A thorough inspection is a time-consuming process, with a significant amount of time spent on each and every item inspected.

d. This is the time for in-depth visual and tactile examination of the item itself along with any records that might accompany it.

6. How to inspect

a. In addition to following industry best practice and information provided in manufacturer’s instructions, the following should be taken into consideration:

i. Each piece’s particular use

ii. Any specific hazards or contaminants to which the equipment might be exposed in the environment

b. While a rescuer can be trained in what to look for, using the information gained to make an informed decision about continued usage and retirement is more difficult. Such decisions are rather subjective in nature and expertise is attained only through a combination of training and experience, including tutelage under an experienced competent person.

c. When performing a thorough inspection of equipment, the following should be considered in context of the results of visual and tactile inspection to make a final decision:

i. Known information about the product

ii. Age

iii. Purchase date

iv. Usage history

d. Lives are saved by adhering to the maxim, “when in doubt, throw it out.”

e. Soft goods – when inspecting soft goods, the mnemonic T-CHAPS is a good reminder of what to check for:

i. T: Thermal. Thermal damage typically presents as glazed, charred, or hardened fibers. Look for shiny, slick, or hard areas of rope, and feel for overly smooth or stiff areas.

ii. C: Contamination. Visual clues might include discoloration, while tactile indicators may be spots that are overly stiff or soft to the touch. Odor may also be an indicator of contamination.

iii. H: History. A check of the usage log is an especially important part of soft goods inspection. Ropes that have record of unusually high frequency of use, heavier loads than normal, or use in harsh conditions may warrant earlier retirement.

iv. A: Age. All fibers deteriorate with age; an experienced inspector should factor this together with rope history and visual/tactile inspection to make a determination about life expectancy.

v. P: Physical damage. Physical damage might be visible as hourglassed or bulging sections of rope, or as cuts, abrasion, tears, or even fuzzy spots. It is important to both look and feel for physical damage.

vi. S: Soiling. While dirt is not necessarily caustic, a very dirty rope is harder to inspect and may signal contamination.

f. Hard goods – hardware items, such as carabiners, descenders, pulleys, etc., can be inspected using the mnemonic ACADEMIC, with each letter representing a specific consideration:

i. A: Alignment. Is the item properly aligned with itself, as manufactured?

ii. C: Cracks. Are there visible hairline cracks, especially at connecting points?

iii. A: Action. Does the item function as intended, without sticking or jamming?

iv. D: Deformation. Are there any deformities in the body of the item?

v. E: Edges. Are there sharp or excessively worn edges, especially at rope paths?

vi. MI: Missing. Is any subcomponent missing or loose?

vii. C: Corrosion. Do you observe corrosion, especially at joints?

viii. While still a factor, age is less of a concern in hard goods than in hard goods because metallic items do not decompose as readily as textile products. See Chapter 7, Hazard-Specific Personal Protective Equipment, for more information on inspecting soft and hard goods.

g. Damaged equipment

i. Equipment that does not pass inspection even after cleaning should be removed from service.

ii. If the manufacturer (or a relevant standard) has cited a maximum lifespan or obsolescence date, equipment should not be used beyond that date.

iii. Equipment should be destroyed or rendered inoperable on retirement to prevent further use.

iv. In some cases, it may be acceptable to modify a piece of equipment at the point of damage as long as that modification does not become a factor in use. For example, if a rope sustains specific damage at a certain point but is known to be otherwise in great condition, a decision to cut the damaged part out of the line and place the resulting shorter lengths back into service may be perfectly acceptable. However, in this case the equipment placed back into service must be unquestionably sound.

XVI. Summary

 **An established rope rescue equipment program will help ensure that the right equipment is in working order and ready for rescuers to utilize in an emergency.**

 **A rope rescue equipment program contains guidelines on equipment selection, inspection, maintenance, and documentation.**

 **The selection of rope rescue equipment begins with the identification of the type of emergency to which rescuers are responding.**

 **Rescuers should understand equipment specifications and how those relate to their intended use.**

 **NFPA 2500 (1983) establishes the baseline performance requirements for rescue gear and the AHJ has final say over the appropriateness of equipment.**

 **NFPA 2500 (1983) classifies equipment into three ranges: G (General), T (Technical), and E (Escape).**

 **Carabiners are a key piece of rope rescue equipment. NFPA 2500 (1983) classifies carabiners in to two categories: G and T.**

 **Carabiners are constructed from either aluminum alloy or steel. Commonly used carabiner shapes include D, modified D, and pear or HMS.**

 **The strength of a carabiner will be different in each direction and configuration in which it is loaded.**

 **Triangular or semicircular screw links are another type of connector that is used, especially where smaller dimensions are desirable.**

 **A braking device is a piece of hardware that is used to help manage the rate at which a load is lowered in a system or at which a rescuer descends.**

 **Braking devices include autolocking and nonautolocking and the NFPA classifies descenders into E (escape), T (technical), and G (general).**

 **Belaying is the process of protecting a person from falling by controlling an unloaded rope (the belay rope) in a way that secures the person on the rope in case the individual’s main line rope or support fails.**

 **Rope grabs encompasses a broad spectrum of devices, usually metallic in nature with a camming device that is designed to grip the rope firmly.**

 **Anchorages used in rescue may be comprised of an existing structure or natural element, or they may be installed as necessary.**

 **Pulleys are primarily designed to reduce rope friction and also can be used as follows:**

 **Change the direction of a running rope**

 **Position a rope more conveniently, such as to an area where people using the rope will be less exposed to falling, dropped objects, or where rescuers may have more room**

 **Reduce abrasion on a rope (e.g., a pulley could be used to hold a rope up from an edge or to bring it away from other rope or webbing)**

 **Develop a mechanical advantage in hauling systems**

 **Additional hardware utilized in rope rescue systems includes rigging plates and swivels.**

 **In order to ensure that rope rescue equipment is ready to be utilized in an emergency, follow the manufacturer’s instructions for cleaning, inspecting, and storing equipment.**

Post-lecture

I. After-Action Review

Individual/Small-Group Activity/Discussion

On Scene

This activity is designed to help the student understanding how to approach a fire investigation. This activity incorporates both critical thinking and the application of basic trench rescue knowledge.

Purpose

To allow students an opportunity to develop responses to critical thinking questions.

Instructor Directions

1. Direct students to read the “On Scene” questions located in the After-Action Review section at the end of Chapter 8 (p. 146).

2. Direct students to read and individually answer the discussion questions. Allow approximately 10 minutes for this part of the activity. Facilitate a class review and discussion of the answers, allowing students to correct responses as needed.

3. You may also assign these as individual activities and ask students to turn in their comments on a separate piece of paper.

Answers

1. How might a braking device for personal use differ from a braking device used for a rescue load?

- Personal use devices may not be rated for as high a load as devices intended for rescue.

- Devices intended for personal use may be physically smaller than those intended for rescue.

- Devices intended for personal use may be tuned for smaller diameter ropes.

- Devices intended for rescue loads may offer a greater range of friction control.

2**.** How can the NFPA 2500 (1983) designations of G, T, and E be useful? How might they be misused or misinterpreted?

Usefulness: Quick reference for ascertaining baseline performance classification according to NFPA 2500 (1983) criteria

Potential for Misinterpretation: NFPA classification criteria does not address all factors related to field usability and features; classifications do not reveal actual performance data – just pass/fail criteria.

3.What questions/concerns might you have about a load rating that you find stamped on a piece of equipment?

- What does it mean? Should I consider this to be a minimum expectation, an average expectation, a maximum expectation, or some other meaning?

- What test method(s) were used to determine that rating?

- What statistical significance does the rating have?

- Was the information verified by a third party testing laboratory?

- How can I expect that rating to change with time / use?

4.When inspecting a piece of life safety/rescue equip­ment, what kinds of things will you be looking for?

Visual and tactile clues as to deformation, discoloration, damage, corrosion, excessive wear or other abnormalities; proper form and function, with no missing parts or poorly operating mechanisms; and within manufacturers guidelines for age and wear.

5.How would you respond to an associate from a neighboring agency who claims that they primarily use equipment meeting European EN standards because there are more lightweight options available?

(Specific responses will vary by reader/locale, but may include reference to examples such as the following)

- Remind the associate that the performance specifications found in European (EN) standards are, in some cases, significantly lower than NFPA performance specifications.

- Remind the associate that equipment meeting these lower specification standards is often less robust than equipment meeting NFPA 2500(1983).

- Remind the associate that the “standard load” assumed by most European standards is 80 kg (176 lb) while U.S. standards (NFPA, ANSI) assume a 300–310 pound (136–140 kg) load – which may better represent a fully equipped American rescuer.

- Discuss performance specifications of specific components of equipment for the purpose of coming to agreement on which pieces of gear are / are not appropriate for use on joint operations.

6.How can you tell if a piece of equipment is third-party verified to a given standard?

- It will bear the mark of a third party certification organization.

- I can verify the authenticity of the claim of compliance for that piece of equipment directly with the third-party certification organization.

II. Lesson Review

Discussion

Note: Facilitate the review of this lesson’s major topics using the review questions as direct questions or slides. Answers are found throughout this lesson plan.

1. What is an SOP? (Lecture II B)

2. Identify incidents in which rope rescue capabilities might be required. (Lecture III B)

3. Identify and describe the three types of equipment as classified by NFPA 2500 (1983). (Lecture IV B)

4. Identify the components of a carabiner. (Lecture V D)

5. Identify the cause of heat buildup in braking devices and descenders. (Lecture VII C)

6. What are the pros and cons associated with brake racks. (Lecture VIII C)

7. Describe the traditional belaying method. (Lecture X D)

8. What questions should be asked when selecting ascenders for use? (Lecture XI B)

9. Identify the various ways in which pulleys can be used. (Lecture XIII B)

10. Describe the proper way in which equipment should be stored. (Lecture XV A)

III. Assignments

Lecture

A. Advise students to review materials for a quiz (determine the date/time).

B. Direct students to read the next chapter in *Rope Rescue: Principles and Practice*, Fifth Edition, as listed in your syllabus (or reading assignment sheet) to prepare for the next class session.