Chapter 12: Fall Protection and Belay Operations

Chapter Overview

In order to prevent a person or load from falling during rope rescue operations, it is critical that all individual working within the operation perfect the skill of belaying. The role of belayer is a serious commitment, as the well-being and life of the person at the other end of the line is in the belayer’s hands. The belayer must be able to devote all of their attention to the operation at hand and possess expert knowledge of the devices, ropes, and procedures involved in the proper execution of this skill.

Knowing when to use belays, both as a primary and backup system, and the type of devices and techniques to employ in any given situation is also important. No operation involving belaying can operation without clear communications; guidelines should be created, enforced, and shared among team members in order to eliminate the possibility confusion on-scene. As a result of the critical nature of the belayer’s role and the unpredictability of the environments in which rope rescue operations occur, real-world practice is required to master the skill of belaying.

Objectives and Resources

**Knowledge Objectives**

After studying this chapter, you should be able to:

 Identify conditions where a belay should be used. (pp. 220–221)

 Explain the purpose of a belay. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, pp. 220–223)

 Define active and self-belay. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, p. 221)

 Describe commonly used active fall protection equipment and systems. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, p. 223)

 Describe the components of active belay systems. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, pp. 223–224)

 Describe the controlling actuation of a belay system. (NFPA 1006: 5.2.10, 5.2.11, pp. 224–237)

 Explain the purpose of assisted-braking devices. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, pp. 224–237)

 Explain the considerations for belaying a rescue load. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, pp. 224–237)

 Explain the process of anchor selection and use in a belay system. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, pp. 224–237)

 Describe the considerations for belaying a load during a raising or lowering operation. (NFPA 1006: 5.2.10, 5.2.11, pp. 224–237)

 Describe the steps of a preoperational safety check of a belay system. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, p. 229)

 Describe the safety considerations when operating a belay. (NFPA 1006: 5.2.10, 5.2.11, pp. 238–239)

**Skill Objectives**

After studying this chapter, you should be able to:

 Practice utilizing a light load belay system. (NFPA 1006: 5.2.10, pp. 226–228)

 Conduct a preoperational safety check on a rigged belay system. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, p. 229)

 Communicate belay status effectively. (NFPA 1006: 5.2.9, 5.2.10, 5.2.11, pp. 228–229)

 Practice rescue load belays. (NFPA 1006: 4.2.11, pp. 230–231)

 Construct a radium release hitch. (NFPA 1006: 5.2.9, pp. 232–233)

 Construct the tandem Prusik belay system. (NFPA 1006: 5.2.9, p. 234)

 Operate (tend) the tandem Prusik belay. (NFPA 1006: 5.2.10, p. 235)

 Release the radium-release hitch. (NFPA 1006: 5.2.10, p. 236)

 Rig the Prusik minding pulley. (NFPA 1006: 5.2.9, p. 237)

 Operate Prusik minding pulley. (NFPA 1006: 5.2.10, p. 237)

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**

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Reading and Preparation

Review all instructional materials, including *Rope Rescue: Principles and Practice,* Fifth Edition, Chapter 12, 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 12 (p. 220).

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. Belay is applying the use of equipment and methods to stop a load from falling; a term most often used in recreational climbing circles.

C. In the rope rescue environment, the principle of belaying is used to keep a person or load from falling.

D. The ability to belay is a critical skill for anyone operating in the rope rescue environment.

E. Assuming the role of belayer is a very serious commitment.

1. The well-being, perhaps even the life, of the person(s) at the end of the rope is in the belayer’s hands.

2. If a rescuer says that they can belay when they cannot or allowing their attention to lapse from the job of belaying could result in severe injury or death for the person at the end of the rope.

II. Situations Requiring a Belay

**A. A belay may be called for anytime exposure to the danger of falling arises, as in the following examples:**

1. A rescue situation involves the danger of falling (e.g., it would be appropriate to attach a belay line to a rescuer attempting to aid a person threatening to jump from a bridge).

2. A person is crossing an area not generally considered to be dangerous, but that includes a small area of exposure to falling.

3. A person is unsure in attempting a new skill, such as rappelling for the first time.

4. A person’s physical or mental capabilities are diminished, for example, because of injury, vertigo, exhaustion, or hypothermia.

5. Environmental factors, such as possible rock falls or areas slick with ice, increase the danger of falling.

6. A person is rock climbing or mountaineering in hazardous terrain. Should the climber slip, a proper belay can hold the individual.

7. A secondary, or backup, means of safety is desired for one or more people who are being lowered by rope, such as in a rescue.

**B. Decisions on when to belay**

1. In some cases, the need for a belay is not completely clear-cut, such as in the following situations:

a. A belay may cause a greater problem than not having one (e.g., several rope lines may already be involved, and an additional line from a belay could cause entanglement).

b. A free drop is involved, in which the load may spin. A belay line could entangle the main line and stop everything from moving.

c. The system is moving through flowing water or other medium where accidental jamming of the belay could have catastrophic results.

d. The need for conservation of resources or time is greater than the potential risk posed by not having a belay.

2. Judgments about these situations must be made locally by well-trained and experienced individuals.

a. At a minimum, belays should be used anytime the combined potential for and consequences of a fall are unacceptable to the situation.

b. As a general rule, if you are not sure, it is probably best to belay.

III. Belays as Safety Backups

**A. If the failure of a rope rescue system would lead to the injury or death of a person, then a backup system should be introduced into the system for safety. There are two general approaches to this:**

1. Self-belay

a. A form of fall protection that a person manages themselves (e.g., a rope grab)

2. Active belay

a. Generally refers to a rope rescue system that consists of a secondary brake device operated by a belayer

**B. Some means of secondary safety should be considered for all rescue operations, with belay considered compulsory the following instances:**

1. There is a high likelihood of failure of the main system.

2. The consequence of failure of the main system would be severe.

3. The protection provided by the belay outweighs the potential disadvantages or hazards that the belay might create.

**C. Sometimes, rope rescuers may determine that a belay is not necessary (e.g., where the probability of failure is so low that the additional equipment, personnel, and complexity of a belay system is simply not warranted).**

1. As an example, rope rescuers responding to a car-over-the-edge incident may use a low-angle scree evac–type system to raise subjects up a slope and back to the road.

a. Exposed only to low loads, rescue equipment and rigging are unlikely to become overloaded or to fail in such an operation.

2. Now consider an incident that involves a school bus with several children inside.

a. Applying the equipment and personnel that would otherwise be committed to a belay could potentially double the speed at which the subjects could be brought to safety.

3. Other situations where a belay might be contraindicated for rescue systems include those where the function of a belay is likely to create greater risks for personnel, such as where a high probability of entanglement exists, where inadvertent activation of a belay is likely to leave the rescuer(s) and/or subject(s) in a precarious position, or where a belay would not protect against any real hazard.

**D. Self-belay**

1. Self-belay is a method used by recreational climbers who wish to climb solo, without the need for a partner to belay them, while still maintaining a backup rope for safety.

2. There are a number of specific techniques for this, but most involve setting a fixed rope to which a device is attached that will slide along the slack rope as the climber ascends.

a. If a fall occurs, the device is supposed to catch the climber.

3. Self-belayed climbing is also sometimes called roped-solo climbing and, in some circles, passive belay.

4. These methods are not completely unlike methods used for fall arrest in workplace environments.

5. Industrial safety professionals do not use the term self-belay, but instead refer to these systems as active fall protection. Some active fall arrest systems used for workplace safety include the following:

a. Lanyard with force absorber

b. Vertical lifeline fall arrest system

c. Self-retracting lifeline

d. Rope access backup

6. While the mechanisms used by these systems differ, the premise is the same: a person, wearing a harness, is connected to some secure point by means of a safety system, which activates to catch them in the event of a fall.

7. Passive fall protection, a term that refers to stationary systems that do not move, do not require the use of personal protective equipment (PPE), and require no active participation from the worker.

a. This might include such methods as guardrails or netting systems.

**E. Fall protection equipment**

1. Rope rescuers should become familiar with the types of equipment used for active fall protection for two reasons:

a. They may have occasion to rescue workers using this type of equipment during responses in their area.

b. They may have occasion to use this type of equipment to protect themselves while performing a rescue.

2. While a lanyard with force absorber is a very common type of fall protection system used by workers, it is also the least versatile.

a. These systems function best in an environment where a worker is able to stand on secure footing and is likely to remain in one place for an extended period of time.

b. It requires the use of a fixed-point anchorage above the worker, to which a lanyard (generally not exceeding 6 feet [1.8 m]) with a force absorber is attached.

i. If the worker falls, the built-in force absorber dissipates some of the energy of the fall to reduce the force on the worker’s body and on the anchor.

ii. Fixed systems like this are of limited use, which drives many employers to seek more dynamic systems that protect the worker even while they are moving.

c. A self-retracting lifeline (SRL) is one type of such a system.

i. In this system, a cable or fiber line is wound around a tensioned reel (or block) inside an enclosed case. A centripetal brake in the block mechanism locks off in the event of sudden impact.

ii. Some SRLs feature a block fixed directly to the dorsal D ring, with the line anchored above, while others are designed for the block to be attached to an anchorage above the user.

iii. As the user moves, the tensioned reel allows the line to extend and retract as the user moves.

iv. If there is a sudden increase in velocity, such as in a fall, the brake will engage to stop the fall. The brake will not release until weight is removed.

d. Similarly, a vertical lifeline fall arrest system is another type of fall protection system that moves with the user.

i. It is most often used by workers who are working on an elevated platform or climbing a ladder.

ii. In these systems, a rope grab travels along a rope or cable that is anchored from above.

iii. The user is connected to the rope grab with as much as a 6-foot (1.8-m) lanyard between it and their harness, typically at the dorsal attachment point. If there is a fall, the rope grab activates.

iv. Again, once it is locked, weight must be removed to release the brake.

3. A rope access backup is perhaps the most versatile of the active fall protection systems described here.

a. Similar to the vertical lifeline system, the user relies on a rope grab that travels up and down along a rope that is anchored from above.

b. In this case, however, the lanyard between the rope grab and the user is much shorter in length (typically 3 feet (0.9 m) or less) and connects to the sternal harness attachment point rather than the dorsal attachment point.

4. Rescuers who work in urban environments and who may respond to incidents involving construction, workplace, or industrial fall protection should be familiar with these types of systems, both as an option for their own use and in case they might need to rescue someone who has fallen while using such a system.

5. The main advantages of using personal fall arrest systems for rescuer safety are as follows:

a. The systems require no extra personnel.

b. A trained rope rescuer ascending a rope or climbing a structure with an active fall protection system already anchored above can operate the system themselves.

6. However, there are limitations to personal fall arrest systems:

a. The system must be able to be anchored above the work to be performed, in advance of their use.

b. The user must be capable of monitoring and ensuring the proper function of the system at all times while working.

c. Passive belay systems are generally suited only for single-person loads, not for rescue loads.

**F. Active belay**

1. An active belay is one that requires a trained belayer to operate.

2. Variations on this method may be used for belaying one person, or for a larger rescue load.

3. Active belay methods used by climbers often involve a tubular-type belay device that permits the rope, managed by the belayer, to run freely until/unless the belayer applies hand tension to lock it off.

4. This method does offer more flexibility in use, particularly in complicated environments, and permits a modicum of control by the belayer.

a. The possibility of human error is a hotly debated issue regarding the use of these systems.

b. These associated benefits may still result in an active belay being a “safer” choice for a given operation.

IV. The Belay System

**A. The following elements constitute a one-person belay system:**

1. A load (in this case a person) that is at risk of falling (this may be a person rappelling, ascending, or climbing).

2. A harness, worn by the belayed person. The harness should be fit to the climber so that it is able to safely hold them without causing injury when caught by the rope.

3. A rope, connected to the harness by means of a carabiner or a knot, and extending toward an anchorage system.

4. An anchorage system that is capable of withstanding the highest potential shock load that could result from the fall of the person being belayed.

5. A belay device is a type of braking mechanism through which rope can be easily fed in either direction, but that is easy to lock off in the event of uncontrolled loading.

6. A rope, called the belay line, is rigged into the belay device according to manufacturer’s instructions.

7. The belayer

a. This is a properly trained individual who controls the rope as it passes through the belay device so that in the event of an uncontrolled descent or fall by the load, they are able to exert a slowing or stopping action on the line.

8. The belayer must manage the rope so that excessive slack does not increase the shock load to the rope if the load should fall.

**B. Hybrid systems**

1. This system is a good compromise belay option.

2. The device operated by the belayer offers an assisted catch by self-activating when the rope or line is pulled rapidly, such as in a fall.

3. The belayer can quickly feed rope in either direction, maintaining versatility, but if the working end of the rope is pulled rapidly, a secure locking mechanism will engage.

4. Sometimes referred to as an autolocking or autoblock function, manually operated belay devices with this feature generally also offer a mechanism—such as a handle—that permits the belayer to release tension from the locked-off device without having to lift the load.

5. Some descenders also function well as belay device – but the methods used in operating the device will differ depending on whether the operator is lowering or belaying.

V. Light Load Versus Rescue Load Belays

**A. In this resource, we will refer to loads ranging from 50 to 300 pounds (23 to 136 kg) as light loads and will refer to loads of 300 to 600 pounds (136 to 272 kg) as rescue loads.**

1. This is not terminology from the National Fire Protection Association (NFPA).

2. However, it is used in this resource to provide perspective related to the differences associated with handling loads of different weights.

**B. Some devices that may work well for belaying light loads create insufficient friction for catching heavier loads—and some devices that may work well for belaying heavy loads are not easy to feed rope through when belaying light loads—so understanding the capabilities and limitations of the system(s) used in a rescue is imperative.**

**C. Active belay systems – light loads**

1. The most frequently belayed light load that a rescuer will handle is that of another rescuer.

2. There are a wide variety of belay systems that are appropriate for belaying light loads.

a. They all work essentially the same way: they create a braking action on the rope to prevent the person at the end of the rope from falling far enough to be injured.

3. Light loads and short fall distances pose less of a danger to the belayer and the person on the rope.

4. The Münter hitch

a. The Münter hitch is the subject of some controversy.

i. It may not offer sufficient friction to control heavy rescue loads.

ii. However, it is a versatile and useful tool that is always in a rope rescuer’s toolkit as long as the rescuer has a rope and a carabiner. For this reason alone, it is worth knowing.

b. The ideal carabiner for use with a Münter hitch is one specifically designed for this purpose.

i. Such carabiners are called HMS (an acronym for the German word Halbmastwurfsicherung) or Münter hitch carabiners.

ii. The HMS carabiner has a pear-shaped design with gentle curves at the base that allow the Münter hitch to move freely back and forth through the carabiner.

iii. Angulated carabiners such as a D design may be used, but are prone to causing a jamming condition.

c. Several factors should be considered when using a Münter hitch:

i. Where the force will ride on the carabiner in the event of a failure

ii. How the rigging can be created to reduce the probability of the moving rope opening the carabiner gate

iii. Ideally, the part of the line that carries the load should extend from the spine-side of the carabiner, as this results in optimum strength and alignment for the system. This, however, places the working part of the rope controlled by the belayer’s hand nearest the carabiner gate.

iv. The belayer must take care to avoid running the moving rope across the carabiner gate, as this could cause it to unlock or even open.

d. The Münter hitch is particularly useful for belaying light loads, and in testing has even proven successful with heavier loads as long as there is additional friction (such as an edge) in the system.

e. For maximum control when using the Münter hitch, keep the angle between the braking side of the rope and the rope going to the load as narrow as practicable to achieve as much friction as possible.

5. Using a free-running belay device

a. Another way to belay a light load is to use a tubular or slot-type, free-running device.

b. Many designs are available, many of which use variations on the old sticht plate design (c. 1970s).

c. Modern tubular versions are less prone to jamming.

i. These typically feature elongated openings, through which a bight of rope is pushed and then clipped with a locking carabiner to the anchor.

d. This simple bend in the rope is easy to feed in either direction, but should the rescuer fall, the resulting friction against the rope as it is pressed between the carabiner and the belay device provides sufficient braking assistance to stop a fall.

e. These devices typically have two slots (to accommodate a dual rope rappel or double-rope climbing techniques); however, only one slot is used for belaying in a single-rope system.

6. Assisted-braking belay devices

a. Some personal belay devices are designed to provide an assisted catch (i.e., in the event of sudden loading, a mechanical action helps brake the rope).

b. This action is also sometimes called autolocking or autoblock.

i. Popular devices include the GriGri 2 (Petzl), the Birdie (Beal), and the Alpine Up (Climbing Technology).

c. Assisted-catch devices are designed to stop a falling climber more quickly than free-running devices do.

i. They should always be used according to manufacturers’ directions.

ii. These devices should be belayed in such a way that the belayer is not relying on the assisted catch; the brake hand should be considered to be the primary source of belay activation and arrest.

7. Practicing a light load belay system

a. The practice system for a light load will consist of the following elements:

i. A belay system, consisting of anchorage, rope, belay device, and enough connectors to hold it all together

ii. A weight or a dummy of sufficient mass to simulate the weight of a falling person

iii. A method of raising the weight on a separate system, such as a winch or mechanical advantage hauling system

iv. A quick-release device capable of releasing the load while under tension

v. A belayer

vi. An instructor

vii. Additional personnel as required for raising the load or assisting with the training

b. See Skill Drill 12-1: Light Load Belay Practice System

8. Communications

a. It is essential to use appropriate commands during belay operations and to establish communications guidelines for individuals to use during operations.

b. Any life-safety communications procedures should be grounded in the concept of closed loop communications.

9. Closed-loop communications

a. Closed-loop communications are those in which persons on both the initiating side and the receiving side of a message confirm the message.

b. In the case of a belay operation, this would involve the person who is on rope and ready to be belayed asking a relevant question, such as “On belay?” and the person providing the service of belay to respond in kind with a statement such as “Belay on.”

c. Establishing a system in which the cadence, rhythm, number of syllables, and order of usage are unlikely to be confused will help to maintain safety during the operation.

d. Note, in the event that the climber calls a stop, it should be the climber who initiates movement again. Of course, it may also become necessary for the belayer to call a stop for whatever reason. The key points are as follows:

i. The person on the sharp end of the rope should always be the one to initiate movement.

ii. Anyone can call a stop.

iii. Communications should be closed loop.

10. When anchoring in as a belayer, the rescuer should never place themselves into the system.

a. That is, they should not belay with a device clipped to the front of their harness and the anchor clipped to the back of their harness.

i. Doing so essentially makes them a link in the anchor system of the belay.

ii. Should the climber fall and the system shock load, the rescuer could be severely injured, possibly suffering a fractured pelvis; they could be disabled or incur a life-threatening injury.

iii. Even if they are not injured, making themselves part of the anchor system for a belay limits their ability to correct problems like snagged ropes.

iv. Belay devices should go directly to an anchor system. If a rescuer prefers to be clipped in, they should clip into the anchor in a manner that allows them to tie off the belay easily and move away to resolve any problem that may occur.

VI. Belaying a Rescue Load

**A. Rescuers should think about every part of the rescue system to try to identify the weakest points, the parts of the system most likely to fail, and the greatest risks to the system.**

1. Critical point is one that, if it fails, will result in failure of the entire system (e.g., anchor points or rope). To perform a critical point test:

a. Examine the system.

b. Identify any point or points at which failure would result in catastrophic failure (i.e., complete failure of the entire system).

c. Evaluate methods by which protection can be provided in the rope rescue system to prevent failure of the critical point(s) from resulting in catastrophic failure.

d. Determine whether the methods of protection improve safety enough to warrant the complexity and resources that they would add to the rope rescue system.

**B. The critical point test can be applied both to equipment and to team members.**

**C. When there is high risk, characterized by an unacceptably high probability and an unacceptably high consequence of failure, a belay may be used to build redundancy into the system to ensure that the failure of any one point does not result in catastrophic failure.**

1. Redundancy must be balanced with complexity. More redundancy does not necessarily mean more safety. As a system becomes more complex, it can become more difficult to manage, which in turn can increase potential for failure.

**D. When considering the options for belaying during rescue, take into account the effects of the heavier load, the fall line, the equipment being used, and the consequence of a potential failure.**

1. There is no one perfect solution for all circumstances.

2. The unique aspect of belaying a rescue load lies in the fact that you are usually protecting a relatively heavy load (perhaps even as much as 600 pounds [272 kg]) with relatively short fall potential on a static or low-stretch rope, whereas the single person belay methods described earlier in this chapter are generally intended to catch a lighter load (less than 300 pounds [136 kg]) with potentially larger fall distances, and often on a dynamic rope.

**E. Manually operated assisted belay for rescue**

1. The same basic premise that applies for assisted-catch or autolocking belay devices with light loads may also be applied to belaying rescue loads, with the caveat that the devices used for belaying rescue loads are typically more robust than those used for light or personal loads.

2. Often, devices that are sufficient for belaying a rescue load have as their primary function the role of braking, or lowering.

a. Of primary concern when catching a rescue load is to ensure that the force will not cause damage to the device or to the rope, and that it is able to be released readily after the catch.

b. Some of the devices that offer an autolocking feature conducive to belaying rescue loads include:

i. ISC D4

ii. CMC MPD

iii. Petzl ID

3. Each of these devices is unique in its specific function, and should always be used according to manufacturer’s directions. Rescuers must do the following:

a. Belay with these devices in such a way that they are not relying on the assisted catch.

b. Consider their brake hand to be the primary source of belay activation and arrest.

4. Rescuers should practice with the belay device they will be using.

**F. Rescue load belay practice**

1. The practice system for rescue load belay consists of the following elements:

a. A belay system, consisting of anchorage, rope, belay device, and enough connectors to hold it all together

b. A weight or a dummy weighing enough to simulate the weight of your typical rescue load

c. A method of raising the weight on a separate system, such as a winch or mechanical advantage hauling system

d. A quick-release device capable of releasing the load while under tension

e. A belayer

f. An instructor

g. Additional personnel as required for raising the load or assisting with the training

2. When belaying, it is essential that personnel use standard voice signals (also called commands or calls) that will be understood by teammates. Even momentary confusion could cause an accident.

3. See Skill Drill 12-2: Practicing Rescue Load Belays

VII. Tandem Prusik Belay System

**A. The tandem Prusik belay system may be used with any rescue system, but it was devised specifically to provide hands-free safety to free-running lowering devices such as the brake rack and brake tube.**

**B. A tandem Prusik belay is composed of two triple-wrapped Prusiks placed in line about a hands-width apart on the belay rope and anchored securely.**

**C. If rigged and managed correctly, in the event of a failure the Prusiks exert a clutching action, working together to grab the rope amid just enough slip to prevent an abrupt shock load from occurring.**

**D. There are limitations with tandem Prusiks belays in that under certain conditions, they may not catch as anticipated. For example:**

1. The equipment is icy or muddy.

2. A Prusik cord of the wrong diameter or material is used.

3. The hitches are not tied tightly enough, in which the belay rope may slip through the Prusiks.

4. The system is used in a high-impact situation tandem, in which the device can cause the belay line to fail by pinching it until the rope separates.

5. The Prusik material fails, particularly if the wrong size or type of Prusik cord is used to build the tandem three-wrap Prusik belay system.

**E. The success of a tandem Prusik belay depends on the characteristics of materials used, and on the interaction of the Prusik cord material with the rope material. There are a few rules of thumb (though no specific rules) that have emerged from various testing performed over the years:**

1. Pinch test

a. Pinch a bight of Prusik cord firmly between the thumb and forefinger.

b. The Prusik should be stiff enough that it does not pinch flat against itself, but leaves a small eye that is just a bit smaller than the diameter of the Prusik cord.

c. If the cord is too stiff it will not grab, but if it is too floppy, then it will grab too aggressively, resulting in failure of the system.

2. Prusiks used for a tandem Prusik system should be about 4 mm smaller in diameter than the host rope.

a. The bigger the difference between diameters, the more readily the Prusiks will grab and hold.

b. Prusiks with less than 2.5 mm of difference may not grab consistently, and Prusiks with greater than 5 mm of difference may be too grabby.

3. Prusiks of two different lengths should be chosen such that when applied to the host rope there is about 4 inches (10 cm), or a hand’s width, of distance between them.

4. While Prusik loops may be tied, commercially produced Prusiks with sewn terminations provide more consistent length and performance, and are often considered easier to use.

**F. Load-releasing hitches**

1. A properly constructed Prusik belay system requires some means of releasing the Prusiks should they become engaged.

a. There are several ways to release the load, and these techniques usually involve a load-releasing (LR) hitch, also known as an LRH.

2. Radium-release hitch

a. The radium release hitch is simply one particular method for tying an LR hitch.

b. It can withstand high shock loads and to lower the arrested load under control.

c. Note that not all LR hitches provide shock-absorbing capacity.

d. A radium release hitch serves two primary purposes:

i. If the belay line becomes loaded accidentally, the LR hitch can be used to shift the load back to the main line.

ii. The radium release hitch has some shock-absorbing capacity.

3. In addition, the LR hitch can be used for some purposes other than belaying, such as changing over from a raising system to a lowering system or from a lowering system to a raising system.

4. See Skill Drill 12-3: Construct a Radium-Release Hitch

**G. Constructing the Tandem Prusik Belay System**

1. The tandem Prusik belay system is highly dependent on precision and detail in rigging.

a. Before relying on a tandem Prusik belay, rescuers must test the exact setup they plan to use to affirm its catching ability and holding power.

b. See Skill Drill 12-4: Constructing the Tandem Prusik Belay System.

2. Tandem Prusik belays do not work in all rescue conditions. Prusiks can slip on ropes that are muddy or icy. A Prusik-type belay may not be appropriate in a hazardous environment in which a hang-up or a failure to catch could cause severe injury or death.

3. A tandem Prusik belay must be tended by a person who is knowledgeable in its operation and who remains alert at all times during its use.

**H. Operating the tandem prusik belay**

1. The basic technique for Prusik tending includes the following:

a. One hand should be cupped on the Prusiks as the rope is pulled in or let out.

b. The other hand should be used to take up or pull out the belay slack and to feel the tension so that the rescuer can decide if more or less rope is needed.

c. See Skill Drill 12-5: Operating (Tending) the Tandem Prusik Belay.

2. Releasing the radium-release hitch

a. See Skill Drill 12-6: Releasing the Radium-Release Hitch.

3. Prusik minding pulley

a. A Prusik minding pulley (PMP) may be used in raising operations to help operate the Prusiks.

b. The tandem Prusiks, when rigged correctly, catch on the edge of the pulley side plates as the rope enters the pulley.

c. The side plates of the PMP are designed to keep the Prusik knots sliding on the rope and to prevent them from binding in the pulley.

d. The PMP is designed such that should a failure occur, the tandem Prusiks will grasp the rope and catch the load.

e. See Skill Drill 12-7: Rigging the Prusik Minding Pulley.

f. See Skill Drill 12-8: Minding the Prusik Minding Pulley.

g. As with any Prusik safety system, the Prusiks must be tight enough to grasp the rope automatically if the rope should start to slip through them. The rescuer who tends the Prusik minding pulley must make sure the Prusiks remain tight and properly dressed.

VIII. Additional Words of Caution for Belayers

**A. Arranging the belay direction**

1. The main elements of the belay system—the anchor, the belay device, and the load—must be in as direct a line as possible so that the instant the load falls, the force comes directly onto the belay device and the anchor.

2. If these elements are not in a direct line, then any or all of the following could happen:

a. The belay device could fail to work properly.

b. The belayer could be thrown off position.

c. The anchor could fail.

d. The system could be shock loaded.

3. The belay rope must not be around or against the belayer or any other person, because that individual could be injured by the rope suddenly coming taut.

**B. Maintaining proper slack in the belay rope**

1. The appropriate amount of slack in a belay rope varies with the device type and the rescue system being used. The following should be attended to or noted:

a. The rescuer must pay attention to the amount of slack that they are maintaining in the belay rope during practice.

b. If belaying an individual to protect their progress on another rope or along a surface, a rope that is too taut could interfere with their movement.

c. If the belay is a safety for a separate lowering system, a too-taut rope could interfere with the brakeman’s actions.

i. Practice helps develop good judgement for this situation.

d. Unless operating a two-tensioned rope system, the rope should have at least some visible slack, but not so much that intense shock loading of the rope would occur during a fall.

2. Securing the belayer

a. If the belayer is near a place where they could fall, they should be secured to an anchor by a safety line.

b. If you are the belayer, connect your safety line to an anchor separate from the belay if possible. This helps ensure that you, as the belayer, are not endangered by a falling load and that whatever happens, you will remain secure and capable of continuing the belay or otherwise assisting with the operation.

3. Bottom belay (for rappelling only)

a. A bottom belay is a pull on the rappel rope from a position below the rappeller; In essence, it is a substitute for the rappeller’s control hand.

i. A bottom belay can be performed by an individual at the bottom of the belay or by a second rappeller on a separate line who is lower than the belayed rappeller.

ii. Pulling on the belayed rappeller’s line increases friction on the rappeller’s descender. This method may be used to assist a rappeller who is in danger of losing control.

b. A bottom belay is not a substitute for the belays previously described. It should be used only in an emergency and when a top belay is not available. Bottom belays have significant drawbacks, including the following:

i. The rope can easily slip out of the grip of the person at the bottom.

ii. The belayer can exert only as much pressure as their body weight. This often is sufficient if the belayer is directly below the rappeller and the rappeller has not gained too much momentum out of control. However, it frequently is not effective if applied from an angle or from so far beneath the rappeller that the pull is rendered ineffective by stretch in the rope.

iii. A bottom belay is not effective with all rappel devices.

iv. A person doing a bottom belay is in danger of being hit by objects such as rocks dislodged by the person or rope above.

v. A bottom belay does not provide backup for failure of the mainline rope, anchor, or rappel device, but only for an out-of-control rappel.

vi. The effectiveness of a bottom belay may depend on the length of the drop. A longer drop, involving greater lengths of rope, may not be as effective as a short drop involving shorter lengths of rope.

4. Body belays

a. An additional technique for belaying is known as the body belay; the belayer creates friction by running the rope around their body, usually around the waist.

b. Except in emergencies, this technique is not recommended, for the following reasons:

i. It is not as easy to stop a fall as with a belay device.

ii. It can injure the belayer.

iii. The belayer’s ability to hold a fall is only as strong as their pain threshold.

iv. If the belayer is at the top of a drop, they could be pulled over.

v. The belayer can become entangled in the rope.

vi. If the climber falls, the belayer may be entrapped in a position from which they cannot assist the climber.

5. Belay failure: the human element

a. When a belay fails, it is typically due to the weak link in the system: failure of the belayer. Such accidents are most often caused by one factor or a combination of two factors:

i. The belayer’s attention drifts momentarily just as the load falls.

ii. The belayer does not perform the correct actions due to either lack of training or complacency.

b. Because of the potential for belay accidents, some organizations adopt a philosophy that a belay should catch when the belayer is “hands free.”

i. This is not effective in every case because it does not always provide the most efficient or maneuverable system.

ii. It can also be counterproductive, because a human’s natural reaction at the moment of truth may not necessarily be to let go.

c. In a sudden emergency, humans respond with what is instinctive.

i. Such emergency situations could relate to driving experience under the threat of a vehicular accident or to weapons training in a law enforcement confrontation.

ii. Belaying is a similar activity in that it must be thoroughly learned under realistic conditions, followed by constant practice, until it becomes instinctive. Otherwise, the belayer may fail to take the correct action when the emergency suddenly occurs. Such failure could result in severe injury or death.

IX. Dual Tension Rope Systems as Backup Systems

**A. Dual tension rope systems (DTRS) can be any one of a number of lowering systems in which both the primary and the backup system are loaded. Examples include:**

1. The two-tensioned rescue system (TTRS), which is an operations-level skill as they may be utilized with or without a rescuer being suspended from the system(s)

2. The traveling brake system (TBS), which is a technician skill, as the second system is operated by a rescuer who is on rope.

**B. Two-Tensioned Rescue Systems (TTRS)**

1. This is type of moving DTRS in which both the primary system and the belay line are essentially identical, often a mirror image of one another, both operated from secure (but usually separate) anchor points.

2. Some TTRS involve two ropes running through one braking device, such as a brake tube or multipurpose device. Other systems use two brakes, each controlling a rope attached to the rescue load. In two-brake systems each lowering device backs up the other.

3. TTRS offer several advantages in certain situations:

a. They do not require special equipment solely for the belay.

b. The roles of brakeman and belayer require the same skills and can be interchanged easily. Also, TTRS usually do not accidentally engage and hang up, they do not require LR hitches, they provide a soft catch, and they are predictable in the way they will perform.

4. There are a couple of disadvantages:

a. In such a system, the individuals operating the brakes must be well coordinated and alert for failure of the other system.

b. With certain devices, there may also be difficulty with changing direction suddenly from lowering to hauling.

5. As with all rescue operations, equipment and methods should be selected based on circumstances and need.

a. The TTRS may be operated using any descent device that is also capable of being used as a belay.

b. In remote rescue operations, even tube-style sticht plate type devices are sometimes used for this purpose.

c. In general, considerations for evaluating a device to perform these dual functions include the following:

i. Load range/maximum rated load

ii. Ease of use

iii. Smooth transition during initial release of heavy load

iv. Ease of transition from lower to raise (and vice-versa)

v. Whether additional friction is required for heavy loads

vi. Effective function as a progress capture

**C. Operating the TTRS**

1. Use of this system requires approximately the same number and distribution of personnel as any other vertical system—the main difference being that instead of a belayer, there is simply an extra brakeman.

a. It should be established between the two brakemen at the outset which will serve as “Brake” and which as “Belay,” as responsibility for system control will rest primarily with the “Brake” (in accord with the attendant).

2. The braking/belay device used for both ropes should be capable of controlling the full load, if necessary.

a. The two devices need not be identical, but they should be essentially interchangeable; that is, each individually capable of both braking and belaying.

b. The two should be able to see and hear one another, and both should be aligned with the fall line.

c. Because these systems are typically rigged very similar to one another, this is often referred to as a “mirrored system.”

3. With both ropes attached to the load in an approximately equal manner, and such that the failure of any one point will not result in catastrophic failure, the two ropes should be passed through the braking/belay devices.

a. As the attendant prepares to back over the edge, both brake and belay should feed rope through the system such that the brake is taking about 75 percent of the load and the belay has just light tension on it.

b. If there is too much friction for the attendant to pull both lines through both devices smoothly, the primary brake should serve as primary while the belay actively feeds line through the secondary device, keeping it just hand tight.

c. This takes practice, but with experience becomes a smooth operation. A high directional can be helpful during this transition, allowing the attendant to pull a bit harder.

4. If, at any time, there is reason for the brake and belay to switch roles, this should be communicated directly between the two.

a. Ideally, such changes are initiated by the brake, with language such as “Transition to your load.”

b. Once majority of the load has been transitioned to the belayer, they should respond by saying “My load, I am brake,” to which the original brakeman (now belayer) should respond “Your load, I am belay.”

5. The beauty of a TTRS that incorporates autolocking bollard-type devices is that it can be easily transitioned to become a raising system.

a. This is best achieved by simply attaching a pulley (with a rope grab) to the mainline of each system to create a 3:1 mechanical advantage on each of the lines.

i. If additional mechanical advantage is needed, this can easily be adapted to an in-line 5:1 in the usual manner.

ii. With coordination, approximately equal tension can be maintained on the two lines by hauling on both at the same time.

iii. The goal is to maintain roughly the same amount of tension on both lines so that they have approximately the same amount of stretch.

iv. If resources are limited, it is possible to rig the haul system on just one line and use the second line as belay only, but the efficiency of this system will be somewhat reduced, and in the event of a failure, the load will travel further.

X. Summary

 **A belay may be called for anytime the risk of falling arises. At a minimum, belays should be used anytime the combined potential for and consequences of a fall are unacceptable to the situation.**

 **There are two approaches to belay. Self-belay is a form of fall protection that a person manages themselves. Active belay refers to a rope rescue system that consists of a secondary brake device operated by a belayer.**

 **Some industries use the term active fall protection instead of self-belay. Some active fall arrest systems used for workplace safety include the following:**

 **Lanyard with force absorber**

 **Vertical lifeline fall arrest system**

 **Self-retracting lifeline**

 **Rope access backup**

 **Passive fall protection refers to stationary systems that do not move, do not require the use of personal protective equipment, and require no active participation from the worker. This might include such methods as guardrails or netting systems.**

 **A belay system includes a load, a harness, a rope, an anchorage system, a belay system, a belayer.**

 **How a load is belayed will depend upon its weight.**

 **Rescuers must think about every part of the rescue system to try to identify the weakest points, the parts of the system most likely to fail, and the greatest risks to the system. This can be accomplished by examining every element of a rope rescue system and applying the critical point test.**

 **Dual tension rope systems (DTRS) can be any one of a number of lowering systems in which both the primary and the backup system are loaded. The two-tensioned rescue system is perhaps the most commonly used of these, and are an operations-level skill as they may be utilized with or without a rescuer being suspended from the system(s).**

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 12 (p. 242).

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. Are there ever situations in which a belay or secondary system might be contraindicated for a rescue load? If so, under what conditions might this occur?

Yes, there are. Conditions include when the probability or consequence of failure is so minimal that it does not warrant the time, resources, or complexity to rig a secondary system, and/or where a secondary system could create or introduce additional, unwarranted risk.

2. In what situations might an active belay be preferred over a passive belay?

- Where heavier (rescue) loads are involved

- Where greater maneuverability is required

- Where the user needs to be able to monitor the system for performance during use

- Where it is not feasible to secure a passive system in place prior to access

3. Under what circumstances might a free-running belay device be preferred over an autolocking device?

- Where variable friction may be required

- Where the load is too light (or force too small) to activate an autolocking mechanism

- Where the jamming of an autolocking device could create unacceptable risk

4.What are the limitations of a tandem Prusik belay system?

- Inconsistent in performance

- Can be difficult to release

- Must be managed properly and continuously during use

5.What are the advantages/disadvantages of a TTRS?

Advantages – Do not require special equipment solely for the belay; roles of brake person and belayer require the same skills/are interchangeable; usually do not accidentally engage and hang up; do not require load-releasing hitches; lower impact forces in the event that one fails; highly predictable

Disadvantages – Operation of both lines must be well coordinated; redundancy may be limited, especially if operated by one brakeman; challenges associated with managing two devices simultaneously; may pose challenges with changing direction suddenly from lowering to hauling

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 factors should be considered when deciding whether or not a belay should be used? (Lecture II B)

2. What is the difference between active belay and self-belay? (Lecture II A)

3. Identify the characteristics of a hybrid belay system. (Lecture IV B)

4. Why is the Münter hitch controversial? (Lecture V C)

5. Describe the elements of rescue load belay practice. (Lecture VI F)

6. What steps are required to complete a pinch test? (Lecture VII E)

7. What failures are associated with the improper alignment of the main belay elements? (Lecture VII A)

8. Describe factors influencing the amount of slack to be applied to a belay rope. (Lecture VIII B)

9. Identify two examples of DTRS systems. (Lecture IV A)

10. Identify the requirements for any braking/belay device in a DTRS. (Lecture IX C)

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.