Chapter 14: Lowering Systems

Chapter Overview

The line between low-angle and high-angle evacuation in not always easily defined; therefore, rescuers must understand and be able to differentiate between the terminology used to refer to various evacuation environments. It is additionally important that personnel become familiar the roles and responsibilities of the technician- and operations-level rescuer in order to set proper expectations and keep everyone involved safe.

High-angle evacuations often require the execution of additional techniques and skills (e.g., two-tension rescue system, tag-lines, belays, etc.) in order to optimize safety while lowering a subject down vertical surfaces. However, low-angle evacuations are not without challenges. Additionally, these operations can be resource intensive. As with any other rope rescue environment, personnel, communications, and equipment should be carefully considered and selections made based on the unique situations presented by the site. As with any rope rescue situation, regular, real-life practice is indispensable and crucial to the team’s ability to execute an operation.

Objectives and Resources

**Knowledge Objectives**

After studying this chapter, you should be able to:

 Differentiate between a low-angle and a high-angle environment. (pp. 268–269)

 Describe the elements of low-angle operations.(pp. 269–270)

 Identify the components of a low-angle lowering system. (NFPA 1006: 5.2.12, 5.2.13, p. 270)

 Identify the minimum positions to be staffed for a rope rescue operation (NFPA 1006: 5.2.21, pp. 270–271)

 Identify the duties of each staffing position in a rope rescue team. (NFPA 1006: 5.2.21, pp. 270–271)

 Discuss the roles of litters in low-angle rescue operations. (p. 274)

 Describe the types of litter lowering systems in low-angle rescue operations. (NFPA 1006: 5.2.21, p. 275)

 Describe the methods of attaching a litter into a low-angle lowering system. (NFPA 1006: 5.2.21, pp. 275–277)

 Describe the methods of fall protection for litter attendants. (NFPA 1006: 5.2.21, p. 277)

 Explain the principles of effective communication during a lowering operation. (NFPA 1006: 5.2.21, p. 280)

 Describe the safety considerations when operating a low-angle lowering system. (NFPA 1006: 5.2.21, pp. 283–285)

 Describe the elements of high-angle operations for operations-level rescuers. (NFPA 1006: 5.2.14, pp. 285–295)

 Identify the components of a high-angle lowering system. (NFPA 1006: 5.2.12, 5.2.23, pp. 285–288)

 Describe the methods of attaching a litter into a vertical lowering system. (NFPA 1006: 5.2.23, pp. 291–295)

**Skill Objectives**

After studying this chapter, you should be able to:

 Use webbing to create a harness. (NFPA 1006: 5.2.13, p. 273)

 Lower an ambulatory person. (NFPA 1006: 5.2.13, p. 274)

 Rig a lowering system. (NFPA 1006: 5.2.12, 5.2.13, pp. 274–275)

 Rig a litter for low-angle evacuation by tying the mainline rope directly to the head of the litter. (NFPA 1006: 5.2.21, p. 276)

 Rig a litter for low-angle evacuation by tying a closed loop directly to the head of the litter. (NFPA 1006: 5.2.21, p. 277)

 Secure rescuers into a low-angle lowering system, including using an adjustable tie-in. (NFPA 1006: 5.2.22, pp. 278–279)

 Direct a lowering operation in a low-angle environment. (NFPA 1006: 5.2.21, pp. 280–283)

 Communicate effectively during a low-angle evacuation. (NFPA 1006: 5.2.21, p. 281) Perform a knot pass. (pp. 282–283)

 Lower a rescuer on a dual tension lowering system. (NFPA 1006: 5.2.23, p. 289)

 Lower a rescuers litter on a mainline belay system. (NFPA 1006: 5.2.23, pp. 289–290)

 Attach tag-lines to a litter. (NFPA 1006: 5.2.23, p. 293)

 Manage a litter during a vertical lowering operation. (NFPA 1006: 5.2.14, 5.2.23, pp. 293–295)

 Prepare a two-tensioned rescue system. (NFPA 1006: 5.2.23, p. 293)

 Direct a lowering operation with two-tensioned rescue system in a high-angle environment. (NFPA 1006: 5.2.14, 5.2.23, p. 294)

 Direct a lowering operation with a mainline and belay in a high-angle environment. (NFPA 1006: 5.2.14, 5.2.23, p. 294)

 Direct a lowering operation with an aerial ladder slide in a high-angle environment. (NFPA 1006: 5.2.23, p. 295)

 Conduct a preoperational system safety check on a lowering system. (NFPA 1006: 5.2.12, 5.2.13, 5.2.21, 5.2.22, 5.2.23, pp. 271, 281–282)

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 14, 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 14 (p. 268).

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. Rescues should be conducted with the least possible amount of risk to rescuers; generally speaking, the steeper the angle of the evacuation, the greater the potential hazard to rescuers and subject.

C. Terminology

1. Low-angle evacuation

a. A term commonly used to describe rope-based systems used on steep but not vertical terrain

2. Scree evac

a. A term that is somewhat synonymous with the term low-angle evacuation, but is generally more applicable in describing wilderness terrain than urban. In mountaineering, the word scree refers to loose and rocky slopes.

3. Vertical evacuation

a. A term used to describe very steep or vertical rope-based rescue systems, which may also be referred to as high-angle evacuation

D. The point where low-angle evacuation ends, and high-angle evacuation begins, is not always easily defined

1. Some organizations suggest a slope angle of 35 to 45 degrees as the differentiator, but other factors, including terrain, environment, footing, and even resources, can have an impact.

2. The essential differences really have more to do with the way the litter and the rescue personnel are used than a specific slope angle.

3. The National Fire Protection Association (NFPA) does not pre-define or specify a slope angle at which this differentiation is made.

E. According to NFPA 1006 and NFPA 2500, the primary differences between an operations-level rope rescuer and a technician-level rope rescuer are as follows:

1. An operations-level rescuer is expected to be capable of moving a subject from one stable environment to another stable environment without performing rescue skills from within an unstable environment.

2. A technician-level responder is expected to be capable of moving a subject from an unstable (mid-air, etc.) environment to a stable one using methods up to and possibly including exposing themselves to, and functioning in, the unstable environment.

F. Lowering systems teach us to work with gravity; to read the terrain, slope angles, and fall line; and to juxtapose gravity and friction to achieve an end

II. Low-Angle Rope Rescue Overview

**A. Low-angle evacuation can pose significant challenges for rescuers**

1. Low-angle evacuation involves any inclined or rugged area over which a litter must be carried and where it is difficult or dangerous to do so without the assistance of a rope.

2. Under some conditions, low-angle evacuation is also called broken-ground evacuation.

**B. Examples of low-angle evacuation sites include the following:**

1. Highway cuts and fills

2. Embankments

3. Construction sites

4. Landfills

5. Urban stairs

6. Industrial environments

7. Natural sloping hills

8. Snow and icy slopes

9. Rugged, broken terrain

**C. Prior to evacuation, a subject should be carefully packaged in an appropriate litter using some means to ensure their security and comfort.**

**D. In keeping with NFPA 1006 and 2500 (1670), an operations-level rescuer might be required to execute the following skills:**

1. Access, enter, and perform rope rescue skills in a low-angle environment where the surface would otherwise be stable enough to allow them to maintain their position without a rope system but for the additional difficulties presented by the work they are doing.

a. In such cases, rescuers may choose to use a rope rescue system to help protect themselves and/or the subject from falling or rolling down the slope.

2. Move a subject from one stable location to another (but not to perform rescue skills while they themselves are in the unstable environment).

**E. Elements of a low-angle evacuation system**

1. A low-angle rope rescue evacuation is usually composed of the following:

a. An anchor system

b. A rope

c. A braking device (usually)

d. A litter (if the subject is not ambulatory)

2. The number of personnel required to perform the necessary tasks will vary depending on several factors, including:

a. The weight of the subject

b. Whether or not the subject is injured

c. Slope angle

d. Distance to be traveled

e. Whether or not a litter wheel is used

III. Roles and Responsibilities in a Low-Angle Lowering Operation

**A. A low-angle lowering operation can be achieved with just a couple of rescuers to assist a capable and ambulatory subject in a secure, low-risk environment.**

1. As complexity increases, so do requirements for personnel. At the very least, any rope rescue operation requires the following:

a. Someone to be in charge (operations leader)

b. Someone to assist the subject (rope rescuer)

c. Someone to rig the system (rigger)

d. Someone to control the brake (brakeman)

e. Someone to monitor safety (safety officer)

**B. By sharing roles, as few as two rescuers might be able to carry out a rescue.**

1. The operations leader might also serve as brakeman, with the rescuer also performing the duties of rigger, and the role of safety officer shared or assigned to one of the two.

2. There are risks associated with shared roles, so the goal should always be to assign separate individuals to be responsible for specific tasks.

**C. Operations leader**

1. Operations leader is the person in charge of the rescue operations.

2. Under the incident command system (ICS), site operations may be the direct responsibility of the Operations chief (in a small operation) or their designee (in a larger structure). For this reason, they will be simply referred to as operations leader.

3. This being a weighty responsibility, it should ideally be the only role assigned to this person.

4. The Operations leader is responsible for the execution and supervision of all operational activities at a rescue site, including the following:

a. The method and route for evacuation

b. Personnel assignments

c. Effective fulfillment of strategic goals

5. Depending on the size of the operation, the operations leader may have branches, divisions, groups, strike teams, task forces, or single resources working within a tiered structure or directly for them.

**D. Rope rescuer**

1. One or more rescuers will be assigned roles consistent with extracting the subject.

2. The focal point of any rescue being the subject, in a rope rescue operation it is the rope rescuer who is first assigned.

3. Rope rescuer is the rescuer primarily tasked with extrication and removal of the subject from the hazard.

a. When a rescuer is being lowered into place by means of a rope, that rescuer effectively takes charge of the operation for as long as the system is in play.

b. It is at their command that the load is lowered, stopped, raised, or otherwise adjusted.

4. Medical intervention is not always a requirement in a rope rescue operation; sometimes the only need is to remove the subject from harm.

a. A rope rescuer may be responsible for medical care at the basic life support (BLS) level, but need not necessarily possess advanced medical skills (unless otherwise mandated by the AHJ [authority having jurisdiction] or by circumstances).

b. In the event that significant medical intervention is required, it is not advisable to divide the attention of the rope rescuer between that and the rope safety system.

5. The rope rescuer must:

a. Be comfortable on the sharp end of a rope

b. Have sufficient technical rigging skill to adequately care for themselves and the subject in the terrain and environment where the rescue is taking place

c. Be adept in managing a distraught subject, including providing a sense of security and calm

**E. Rigger**

1. The rigger is arguably the most critical position on any rope rescue operation.

2. The rigger must be able to execute the following tasks:

a. Analyze a rescue system in context of a rescue site, and making good decisions accordingly.

b. Understand equipment, systems, forces, terrain, fall lines, and evacuation routes so that they can effectively predict not just what will happen, but what will happen after that, and prepare the anchorage(s), rescue system(s), and backup system(s) (if applicable) in light of this information.

c. Modify systems after the rescue has commenced, due to changing circumstances.

**F. Brakeman**

1. Brakeman is the person responsible for the rate at which the load travels down the slope when the rope runs through a braking system to create friction.

2. The brakeman quite literally holds the safety of the subject and rescuer(s) in their hands.

3. Good communication between the rope rescuer and the brakeman is essential, as it is from this individual that the brakeman takes their cues.

4. A brakeman should practice lowering through the device(s) used by the AHJ with different-sized loads and on different slopes so that they become familiar with what is—and what is not—a comfortable and smooth method and rate of lowering.

5. Having some experience as a rope rescuer is also helpful, as it gives the brakeman more understanding of what is happening on the other end of the rope.

6. Radios are often useful for communicating between the brakeman and the load.

a. The rope rescuer can generally add this duty to the others they are performing, but it is generally preferred that someone other than the brakeman operate the radio at the top.

**G. Safety officer**

1. The safety officer’s job is to do nothing other than constantly monitor the entire operation to look for risks and hazards.

2. This individual should be an experienced person who thoroughly understands equipment, rigging, and rescue techniques.

3. If they do see a threat to safety, they should immediately call a stop to the operation until the matter is corrected.

4. The safety officer must be able to stand back with an objective viewpoint and must never be sucked into the operation itself.

a. Safety officers check for the following:

i. Hazards, including hazardous atmospheres and falling debris

ii. Personal safety equipment, including helmets, gloves, and breathing apparatus

iii. Rescue rigging, including belays, anchors, rope padding, and unlocked carabiners

iv. Personal rigging, including seat harnesses, locked carabiners, and knots tied correctly

v. This is another position that is best performed by someone who has no other responsibilities; it is not a position on which to scrimp, even if personnel are limited.

5. The safety officer should have knowledge and experience in every aspect of the operation, including as a rigger, brakeman, and rope rescuer.

6. They should be capable of spotting—and even predicting—potential errors and hazards almost as second nature.

**H. Optional additional roles**

1. Medical attendant(s)

a. For a very ill, severely injured, or especially distressed subject, it may be wise to send a separate medical attendant to care for them so that the rope rescuer can focus on the technical aspects of the evacuation.

2. Litter attendant(s)

a. If a litter evacuation is necessary, litter attendants will be required to manage the litter.

b. Depending on the slope angle, the subject’s weight, and the system safety factor, the number of litter attendants may range from three to six. The rope rescuer can serve as one of these.

3. Litter captain

a. This individual is responsible for directing the movement of the litter, communicating with the brakeman, and ensuring safety of the litter team.

4. Radio attendant

a. Having someone else—either a dedicated person, the site manager, or the rope handler—operate the radio is best for safety as it allows the brakeman to focus solely on the security and rate of speed of the rope running through the braking device.

5. Rope handler

a. Assists by feeding the brakeman the rope and removing kinks and tangles before they reach the brakes

6. Scouts

a. Can move ahead of the litter to clear a path or to warn the team of debris and other hazards

b. They work a short distance ahead of the litter and maintain voice contact with the litter team to provide direction and information.

7. Haul team

a. If a raising system will be required, one, two, or more rescuers will be required to pull on the haul system when it becomes necessary to raise the load.

IV. Ambulatory Subjects

**A. Gentle/moderate slopes**

1. Handline may be used to help provide stability and security for a subject as they walk themselves to safety when there is no need to place the subject in a litter, and where the slope is not particularly steep.

2. A handline typically consists of a secure anchor to which a fixed rope is attached for the subject (and perhaps rescuers) to grasp as they negotiate uneven terrain.

3. Anchoring the handline at both ends, with a little tension between, offers the additional benefit of helping users to maintain a consistent path of travel.

4. Handlines are best used where there is minimal risk of injury should the user let go or fail to use it properly. If the subject is unable to walk facing downslope, the slope is likely too steep for a handline. The angle at which this occurs will depend on several factors, including:

a. The experience, skill, and comfort level of the subject

b. Presence of debris or loose footing along the path of travel

c. Environmental factors (visibility, moisture, etc.)

5. Rescuers may or may not also need the handline, and in fact might even walk alongside as the subject grasps the line.

**B. Steeper slopes**

1. An ambulatory subject may be secured into a harness (manufactured or improvised) and connected to the end of a rope so that they can be lowered.

2. If the subject is not wearing a seat harness, one can be improvised using an 18- to 22-foot (5.5- to 6.7-m) length of rope or webbing.

3. There are many ways of tying an improvised full-body harness.

a. The tied webbing harness, with its use of both leg loops and shoulder-straps, is one example.

i.The advantages include:

1 High frontal attachment

2 Optimum security

3 A connection point that is high enough of the subject’s body to provide good security and helps prevent the webbing from slipping down over the hips when not loaded.

4 See Skill Drill 14-1: Tied Webbing Harness

**C. Ambulatory subject lower method**

1. The ambulatory subject lower method requires minimal person power to assist a subject down a slope while largely supported by rope.

a. The accompanying rescuer helps to guide and direct the subject as the two of them, together, back slowly down the slope.

2. This approach should be used with caution, and only with a subject who is relatively sure-footed.

3. Skill Drill 14-2: Ambulatory Subject Lower Method

**D. Litters and nonambulatory subjects**

1. Nonambulatory subjects often require the use of a litter and a greater number of rescuers to carry it.

2. Typically, the lower the slope angle, the more litter attendants are required.

a. As the slope angle steepens, more of the load is taken on the rope and thus fewer litter attendants are needed.

3. Although there may be as many as four or even six litter attendants, plus a subject in a litter, loading the business end of a low-angle evacuation system, the force applied to the system will rarely be anywhere near the combined weight of the load.

V. Low-Angle Rope Rescue Systems

**A. The principles of anchoring for low-angle evacuation are essentially the same as for other types of rope rescue: the anchor systems must be of sufficient strength to withstand the highest possible force applied during loading, plus a safety factor.**

**B. Anchorages chosen for a low-angle evacuation should be positioned at the top of the intended evacuation slope, preferably back far enough from the edge where the slope begins to drop to permit sufficient working room for the rigging team.**

**C. The anchor point should be in line with the anticipated evacuation route, and of sufficient strength to ensure an adequate safety factor.**

**D. Low-angle system braking devices**

1. A braking device will be attached to the anchorage connector to serve as the primary means of friction for controlling the rate of speed at which the subject, litter, and/or rescuers are lowered down the slope.

2. Rescuers should consider the different features and performance offered by different devices to determine which is most conducive to their intended operation.

3. Autolocking devices

a. Autolocking devices have become the standard for many rescue organizations; however, they can be frustrating to operate in a low-angle slope evacuation because the devices are designed to work within a certain, specific range of force.

b. With forces at the lower end of the spectrum, the device may not actuate properly and feeding rope through becomes quite difficult.

c. For low-angle rescue systems where it is determined that a secondary rope system for belay is not required, the autolocking function can provide the following advantages:

i. They can provide a measure of backup to the brakeman.

ii. Most bollard-type autolocking devices are conducive to a quick and easy transition from lower to raise and back again, without the need to rig a completely separate system, which is a potential advantage where single-rope systems are concerned.

4. Nonautolocking

a. Devices without a panic lock and without a hands-free lock can be advantageous in low-angle operations.

b. The wide range of compatibility with different loads makes it easier for the brakeman to adapt to the constantly varying forces that are inevitable as the litter attendants jostle down the slope.

5. Adjustable friction devices

a. Often in the case of terrain that varies between steep and gentle, rescuers find devices with easily adjustable friction (e.g., the brake rack) to be especially smooth.

b. There is often not enough force on the system to maintain a consistent speed.

c. Most adjustable-friction devices are not autolocking, so these should be used only by those who have been specifically trained in doing so.

6. Friction wrap

a. Turns of rope are taken around any substantial object (a post, stanchion, tree, etc.) to gain friction for controlling the load; also called the tree wrap.

b. This is particularly useful when there is a shortage of equipment for braking systems, or an abundance of substantial objects that are not easily damaged.

i. It also offers the added advantage of resolving both anchor and brake at once.

c. This method is best used with bagged rope and should be practiced in training before being used in an actual rescue.

**E. Rope**

1. The rope runs through the braking device and then usually is attached to the head end of the litter for a low-angle slope evacuation.

2. To maintain greater control over the operation, most rescuers prefer a rope with a minimum of stretch, such as a static kernmantle rope.

a. Static rope, classified as having less than 6 percent elongation at 10 percent of its minimum breaking strength, works best for low-angle evacuations.

b. Because large impact loads are less likely during low-angle evacuations, the force-absorbing advantages that a low-stretch rope might otherwise offer over a static rope are not a factor.

3. The operations leader determines whether or not a secondary, or backup, anchor or belay system is required, depending on risk (or the probability of failure plus the consequence of failure).

a. If a secondary anchor is required, it should be further back from the edge than the main anchor, but as near as possible to being in line with the main anchor.

**F. Litter**

1. Rigid basket litters

a. Typically preferred for low-angle rope rescue operations, both to protect the subject and to facilitate ease of handling

b. Advantages include the following:

i. Helps rescuers maintain an envelope of protection for the subject despite stresses and unequal loading

ii. Strong enough to withstand the weight of the subject and rescuers while being supported by rope

iii. Protects the subject from impact with obstacles common in low-angle operations

2. Flexible litters may be used for low-angle evacuation, but require specialized rigging and handling by litter attendants, as they provide fewer options for holding, attaching, and carrying.

3. The following should be noted with regard to subjects who will undergo a low-angle evacuation:

a. They should be carefully packaged into a litter in a manner that keeps them securely in place and prevents them from slipping down toward the foot end of the litter due to gravity (e.g., simple straps over the subject).

b. Some method of restraining the subject lengthwise is also necessary.

i. Depending on injury, a subject may be able to help themselves by maintaining firm pressure against a foot loop that is secured to a litter rail.

ii. Other approaches might include a pelvic restraint or seat harness

c. Care should be taken in packaging to ensure a patent (open) airway, including the ability to roll the litter onto its side if the subject begins to vomit.

4. The litter is attached to the end of the rope, either directly or by means of a closed-loop litter bridle.

5. Tying the mainline rope directly to the head of the litter

a. If the distance of the low-angle evacuation is only one rope length and the rope does not have to be detached from the litter during the operation, the mainline rope may be tied directly onto the head of the litter.

b. This is achieved by looping the rope several times around the head of the litter and then terminating with an end knot, such as the figure 8 follow-through knot.

c. See Skill Drill 14-3: Tying a Mainline Rope to the Head of a Litter.

d. Consider the following safety concerns:

i. This technique cannot be used on plastic litters on which the plastic material covers the rail at both ends of some models.

ii. This technique uses clove hitches at each corner where the litter side rails meet the head end of the litter. Make sure to tie the clove hitches so that there is no slack between them in the part of the rope that is inside the litter.

iii. Do not make the V of your tie-in too big, as this increases the hazard of it snagging on things and getting in the way during the evacuation. It is good practice to keep the angle at the figure 8 knot less than 120 degrees; although you would be unlikely to overload anything at this point, too great an angle can compromise the knot.

6. Tying a closed-loop bridle to the head of the litter

a. Litter bridle helps to facilitate quick removal and re-attachment to the litter for low-angle evacuations involving transition from one lowering system to another, and when the litter must be freed quickly from the system.

i. In this case, the mainline rope is attached to the bridle simply by means of an end-knot or manufactured termination that is clipped with a locking carabiner.

b. See Skill Drill 14-4: Tying a Closed Loop Bridle to the Head of a Litter

c. For a more stable tie-in, start the wrap of the litter rail with a clove hitch and end it with a second clove hitch on the opposite side.

i. This prevents the bridle from slipping around as the direction of the load shifts.

d. When the rope is tied directly to the head of the litter, generally a retrace-8 is the termination of choice.

i. While a bowline knot may be used in place of the figure 8 follow-through, rescuers should take into account the following considerations:

(i) Make sure the bowline knot is tied correctly.

(ii) Back up the bowline knot with a safety knot, such as the double overhand backup (barrel) knot.

(iii) Monitor the bowline knot so that it does not “capsize” when being pulled over an obstruction such as a rock, tree, or building edge.

e. Always rig to the large, primary litter rail – usually this is the top rail.

f. Be sure to spread out the force evenly along the rail by wrapping the attachment around the rail several times. This also helps to stabilize the litter in use.

VI. Low-Angle Litter Management

**A. Litter management in low-angle roped evacuation systems is very different from management of a litter on level terrain.**

1. Level terrain

a. The usual number of people carrying a litter is six (plus any additional personnel attending to the subject’s medical needs).

b. The full weight of the litter is on these individuals; they are completely supporting their own weight as they maneuver their way across the terrain.

2. Low-angle rope terrain

a. The rope is usually tied to the head-end of the litter so that the subject is carried feet-first, with their head uphill.

b. Care must be taken to package the subject effectively so that they do not slip down in the litter.

i. Secure firmly but comfortably into the litter.

**B. Generally speaking, the steeper the slope, the fewer the number of litter attendants required.**

1. As the slope becomes less stable, or as it becomes less steep, more litter attendants will be required.

2. The more litter attendants there are, however, the more they tend to get in each other’s way; too many litter attendants on a very steep slope can create undue stress on the system. Balance between the two is key.

**C. Low angle: no tie-in**

1. For a very mild slope where the rope is providing more peace of mind than actual security, the low-angle evacuation will largely represent a standard six-person carry with minimal variation other than the fact that there is a rope tied to the head of the litter.

a. Performing a no-tie-in slope evacuation is quite taxing with fewer than six litter attendants.

2. Litter attendants align themselves two abreast, on opposite sides of the litter, facing downhill.

a. In addition to lifting and carrying the litter, they will also need to exert downhill pressure to effectively pull against the braking system.

3. The brakeman must be quite attentive to not overbrake the system, as this makes the job of litter attendants even more difficult.

4. A nonautolocking braking device generally works best for this type of lower.

5. This method should be used with care, and only in situations where the litter attendants would be otherwise capable of effectively maintaining footing and carrying the litter even without the rope.

a. In this case, a rope simply provides an added sense of security, somewhat akin to the handline described above for ambulatory subjects.

**D. Low angle: tie in to rope**

1. Litter attendants can protect themselves from a fall by also clipping into the lowering system.

2. Pigtails

a. Pigtails can be run down from the litter evacuation rope to each of the three or four litter attendants, who wear seat harnesses and clip into the ventral attachment.

b. Attendants face uphill (toward the brakeman) and clip into the pigtails with a carabiner attached to adjustable hitches or knots. In this case, they do not lean into the rope system, but they are secured to it in case they fall.

c. Using this method, the litter attendants grasp the litter rail with their hands and proceed as they would for a standard litter carry – with the exception that there are only four (or sometimes even three) of them, and they are walking backward. By pulling the litter downhill, against the rope system, they can leverage the rope system to achieve some assistance from the rope.

d. These techniques may work well on smooth, gentle slopes that do not have broken terrain, but on steeper slopes with more rugged terrain, attendants could lose grasp of the litter rail, causing the team to drop the litter, along with the subject.

e. Benefits of this system include the ability for it to be modified to incorporate three, four, or even five litter attendants and the potential to reduce strain on the rope and rescue system.

f. Alternative methods that involve litter attendants tying directly to the litter offer certain advantages in leverage, lift, and security.

**E. Low angle: tie in to litter**

1. Another method of tying into the system for low-angle evacuation is for litter attendants to place a short lanyard between their seat harness connection and the litter rail.

a. When litter attendants clip themselves directly into the litter rail, they can create additional leverage against the system by leaning back into the tie-ins so that their legs—rather than their arms—do most of the work.

b. As litter attendants leverage against the rope system, the weight of the loaded litter is taken by the rope, braking device, and anchors. On a steep enough slope, and with experienced litter attendants, this essentially creates a hands-free lift.

2. Any number of methods may be used as low-angle litter tie-ins, including:

a. Pickoff strap

b. Webbing loop

c. Prusik

d. Adjustable low-angle litter tie-in

3. The tie-in can be attached to the litter top rail with a girth hitch, and then to the waist attachment point on the litter attendant’s harness.

4. Because each person’s body proportions (e.g., trunk size and arm length) are different, a variable length tie-in allows different rescuers to use the same tie-in, and (once attached) the litter attendant can quickly adapt to varying terrain and circumstances.

5. See Skill Drill 14-5: Constructing an Adjustable Tie-In

6. The optimum length for a low-angle litter evacuation tie-in is one that lifts the litter off the ground as the litter attendant pulls back against the system with their legs, placing the litter at height where the litter attendant’s hand can rest comfortably on the rail, arm bent.

7. Effective use of this method requires practice, teamwork, and cooperation. At the command of the litter captain, all litter attendants lean back into their tie-ins and allow the litter and rope system to take the weight.

8. As with any rappel, stability can be improved by placing feet wide apart and as high as practicable on the slope in relation to the person’s body.

a. A litter attendant who slips continues to hold onto the litter rail and pulls their body taut on the tie-in. The rope system and the other team members usually can keep the litter stable and prevent the attendant from falling. The litter team, in concert with the rope, acts as a sort of self-equalizing table and provides stable transportation for the subject.

b. If more than one litter attendant loses footing or the terrain becomes particularly treacherous, the team captain can call “Stop” to halt the descent temporarily.

i. This gives the team the chance to regain its stability.

9. An attentive litter captain who gives firm, clear commands and monitors team members to optimize efficiency will help the operation go much more smoothly.

10. This method works best with four litter attendants, but can be modified to incorporate two, three, or even five litter attendants, depending on slope angle, weight of the subject, and other factors.

**F. Low-angle evacuation with a litter wheel**

1. Any of the methods described previously—with or without tie-ins—may be adapted to incorporate the use of a litter wheel.

a. This is particularly useful where personnel resources are limited and works best where terrain is relatively smooth.

b. Large chunks of concrete, debris, or vegetation are not conducive to inclusion of a litter wheel.

2. When performing a low-angle evacuation with a litter wheel attached, the number of litter attendants required to lift the load is generally lower.

a. The litter wheel changes the physics of the system, shifting the balance of the system and creating a destabilizing pivot point.

b. The effects of any one litter attendant pulling too hard in one direction, or even falling, can be magnified by this pivot point.

3. As with any technical rescue system, it is imperative to practice methods for low-angle evacuation while using a litter wheel before putting this method to use in a real operation.

**G. Practicing low-angle litter evacuation**

1. Most rescue organizations will perform far more low-angle rescues over the course of a year than vertical evacuations, so teams should practice and become skilled in executing these.

2. Systems for steep angle rescues are loaded with the combined weight of several attendants plus the subject, but because the load is not hanging completely from the rope, the actual force on the system is often less than what people might assume.

a. This is because the majority of the force is being transmitted into the ground through the feet of the litter attendants.

3. A foundational precept of performing rope rescue at the operations level of training and skill is that the rope system is intended to assist with the tasks of moving the load and negotiating obstacles through a steep slope environment, from one stable location to another.

4. The most advantageous means of providing security to operations-level rope rescuers and their subject(s) in this low-angle environment is arguably the low-angle tie-in to litter method.

**H. Communications**

1. Good communication and coordination, especially between the litter team and the brakeman, are essential to a successful rope rescue operation.

a. Communication must be simple, clear, and to the point.

b. Once the rope rescue operation commences, voice communications should be limited to a very few people – most notably, the litter captain and secondarily the brakeman.

c. Any time a rescuer is on rope, that rescuer’s communications take top priority.

2. If a radio is being used, the channel should be cleared and dedicated to the rope rescue operation until its completion.

a. If radios are not available, a relay person may be stationed in a position where they can hear both sides of the system. Everyone else should keep quiet.

3. SUDOT is a recognized whistle command system used in rope rescue.

a. **S** – Stop (one blast)

b. **U** – Up (two blasts)

c. **D** – Down (three blasts)

d. **O** – Off rope (four blasts)

e. **T** – Trouble! (continued long blast)

4. Verbal commands

a. If verbal commands are intended to be used during a rope rescue system, the parties involved (particularly the brakeman and the litter captain) should agree to the sequence of commands that will be exercised.

b. The person who is *on rope* (or, if a litter team, the litter captain) should be the one who provides the cues for moving, stopping, etc.

c. By agreeing upon a pre-established set of words and their intended response, the brakeman and the rescuer can become more effective in the lowering operation.

d. Words selected for rope rescue operations commands should effectively communicate the appropriate information while altering cadence, intonation, and sound enough to prevent misunderstanding.

e. Communications should follow a statement-and-response pattern.

f. These commands may be used in any order, as dictated by need/situation.

5. The specific communications used matter much less than the agreement made among the people using them on a given operation as to how the communication should be used.

6. Details may vary somewhat among rescue groups, but the basic premise remains: communications should be closed loop, and all those involved in the low-angle rescue agree on the particular sequence of commands and responses.

**I. A typical low-angle lowering operation**

1. Preparation

a. Before the litter moves, all major elements of the low-angle evacuation system should be in place and prepared. The safety officer should verify the following:

i. The subject has been medically assessed, treated, and packaged, and their condition is being monitored.

ii. All systems have been properly rigged.

iii. The rope has been properly attached to the litter.

iv. Secure anchors have been set and a braking device or descender attached to them.

v. The rope is wrapped in the braking device or descender and locked off.

vi. The brakeman has the rope in hand and is ready to run the braking device.

vii. The rope handler is ready to feed the rope to the brakeman.

viii. The belay line is set in the belay device (if applicable).

ix. The belayer is ready to belay (if applicable).

x. The litter attendants are attached to the litter with tie-ins and are ready to lift the litter.

b. When the operations leader senses that all systems are ready, they initiate the process as follows:

i. *Operations leader:* “Roll call!” Gets everyone’s attention. Operations are about to begin. This is a sort of “quiet on scene.”

ii. *Operations leader:* Safety Ready?

iii. *Safety officer:* Safety Ready (or, “Standby, X Minutes”)!

iv. *Operations leader:* “Brakeman ready?”

v. *Brakeman:* “Brakeman Ready!” The device is unlocked and in hand.

vi. Or “Standby X Minutes!”

vii. *Operations leader:* “Litter ready?”

viii. *Litter captain:* “Litter ready!”

ix. *Operations leader:* “Litter, on your command.”

x. *Litter captain* (directing the litter team to lift the litter): “One, two, three, lift.”

xi. *Litter captain:* “Tension.” Litter team members remove slack from the rope by holding the litter downhill against the rope and leaning into their own tie-ins to apply tension to the system. The brakeman holds the braking system fixed. This pretests the system and ensures that everything is in order and that the litter team’s tie-ins are correctly set.

xii. When the litter captain determines that the system is stable and the team is prepared, he commences lowering as follows:

xiii. *Litter captain:* “Down slow.” The brakeman begins to let the rope through the braking system. The litter team leans into the system and moves downhill. (The litter captain may say, “Down faster” if they want to move downslope faster, or “Down Slow” if they want the litter to move more slowly.) If anything begins to go wrong (e.g., a kink slips past the rope handler and jams the brakes or a litter attendant begins to lose a boot), anyone can call, “Stop!”

xiv. The rope handler is responsible for monitoring the amount of rope remaining to be fed into the braking device. At some point before lack of rope becomes critical, perhaps when around 20 feet (6.1 m) are remaining, he warns the brakeman that the rope is running out by calling or radioing, “Twenty feet of rope!”

xv. The litter captain looks for a good place to set down the litter. When the litter has reached that place, the litter captain calls, “Stop!”

xvi. The captain then directs the team to set the litter down. When the litter is secure and the team is in a stable position, the captain calls, “Off rope.”

2. Evacuation of more than one rope length

a. Sometimes, low-angle evacuations occur in areas where the litter must travel a distance down a slope further than the length of available rope. In this case, the operations leader has two choices:

i. They can either extend the system by tying another rope onto the end of the first one.

ii. They can establish a new anchor system downslope and move the system.

b. In either case, close coordination is needed to ensure smooth and effective transitions.

c. Adding a rope

i. Where a determination is made to simply tie another rope onto the end of the first one, it may be necessary to perform a knot pass.

ii. It may be possible to simply set the litter down and re-reeve the descender on the other side of the knot, but if not, a well-practiced team can perform a knot pass with minimal interruption to the operation by using a second anchor, a second brake, and a transfer line to temporarily control the load while the first device is detached and moved to the other side of the knot.

iii. A transfer line can be made using a 30- to 50-foot (9.1- to 15.2-m) piece of anchor rope, or simply by borrowing the unused and of the new (second) rope.

iv. See Skill Drill 14-6: Performing a Knot Pass.

v. While this may sound complicated, with practice the transition can be very smooth and efficient, with minimal interruption to the lowering operation.

d. Transferring to a new braking system

i. Another option is to establish a new anchor and braking system at a strategic location downslope and leapfrogging a new brakeman into place, ready to receive the load just before the first rope runs out.

ii. Ideally this anchor and braking system would be set some 20 feet (6.1 m) before the original brake runs out of rope, but this is not always something that can be custom ordered.

iii. Setting a new anchor and braking system can be resource intensive, consuming a significant amount of time, equipment, and personnel.

1 Prerigging and leapfrogging can be used to avoid the operation having to come to a screeching halt.

iv. Preriggingisthe practice of rigging the anchor and brake systems ahead of the litter team, providing enough equipment and skilled personnel are available.

v. With prerigging, anchors should be set so that the litter just passes the new braking system by about 10 feet, where it can be set down while connection is made between the new braking system and the litter.

1 A new rope can be used (if available) or the original rope that is already attached to the head of the litter can simply be released from the first braking system, pulled down the hill, and attached to the second one.

vi. Leapfrogging is the use of two sets of rigging teams and brake teams to alternate the rigging of anchors and the operation of the brake.

1 While the first team operates the first set of brakes, the second team rigs the second set of anchors below the first team.

2 After the litter rope has been detached from the first set of brakes, the first team derigs the first anchors and moves them down below the second team to the position for the third anchor and brake system.

vii. Leapfrogging can be a very effective system and can speed the evacuation of a rescue subject; however, the rigging teams must be skilled at anchoring, knowledgeable about the equipment, and self-reliant.

VII. Safety Considerations in Low-Angle Rope Rescues

**A. According to NFPA 1006 and 2500 (1670), operations-level rope rescuers are expected to steer clear of trying to perform rescue in an unstable environment**

1. Unstable environment is an environment where rescuers would normally not be able to travel without a rope.

2. This means that the premise behind using a low-angle rope rescue system should be that it is the rescue itself that necessitates the rope, not just the slope angle or terrain.

**B. Slope safety lines**

1. It is sometimes useful to incorporate a safety line on a slope to help rescuers more safely move up and down the slope for rigging, medical evaluation, litter rigging, and other tasks.

2. The additional stresses associated with an ongoing rescue operation present challenges with route finding, footing, or dislodging debris from the slope, all of which can result in dangerous conditions for all involved.

a. One of the first actions on the scene should be immediate establishment of a restricted area (sometimes called a hot zone) to reduce the danger to the rescuers and subject.

b. Only personnel directly involved in the rescue should be allowed into this area. In particularly steep terrain, rescuers can establish personnel safety lines.

c. These lines should be well anchored and rigged off to the side so that personnel can travel up and down them without endangering those below.

3. Once the safety lines have been established, they can be treated as handlines, or personnel can attach to them with a rope adjuster, such as an autolocking descender, rope grab, or sliding hitch, to provide security as they move up and down the slope.

4. Handled ascenders made for climbing rope should not be used for where they might be impact loaded as the result of a fall.

5. The belay question

a. The question of whether to utilize a secondary safety, or belay, in a low-angle evacuation is controversial and depends on several factors, including the following:

i. How steep is the slope?

ii. Is the footing particularly loose or treacherous?

iii. Is the slope icy or muddy?

iv. What would happen if the litter team fell?

v. Are the mainline brake anchors questionable?

vi. Would a belay be beneficial or detrimental to the operation?

vii. What is the risk of rockfall being created by the extra line?

b. The determination can only be determined on the scene by trained, experienced personnel who can weigh the risk versus benefit of the second line. These decisions generally boil down to two questions:

i. What is the probability of failure?

ii. What is the consequence of failure?

c. If the probability of failure is minimal, and if the consequence of failure is little more than a skinned knee or bruised ego, the potential benefit of the extra rigging may not be worth the increased demands and complexity on personnel, equipment, and time.

VIII. Summarizing Low-Angle Evacuations

**A. Low-angle rescue operations are an extremely common form of rope rescue, and can be highly demanding in terms of both resources and need for close cooperation.**

**B. Rescuers should become familiar with and practice sloped rope rescue techniques in the environment(s) in which they may be called upon to perform them.**

IX. High-Angle Rope Rescue Overview

**A. High-angle rope rescue is the controlled lowering of a rescue subject down a surface where rope is necessary for suspension; also called vertical rope rescue.**

1. If the subject’s injuries are severe enough, the lowering is done with the subject packaged in a litter.

2. When the subject is uninjured or only slightly injured, it may be possible to lower the individual without the litter, either alone or with a rescuer.

**B. The differentiator between NFPA technician- and NFPA operations-level functions is not in the steepness of the incline nor the need for verticality, but simply in *how* the rescue is achieved.**

1. According to NFPA 1006 and NFPA 2500 (1670), the operations-level rescuer is expected to be able to transfer a subject from one stable location to another, but is not expected to be capable of performing rescue skills in an unstable environment (e.g.,, free hanging, with air under their feet).

a. Operations-level rescuer may be called upon to lower a subject from an elevated platform or structure through an unstable environment to ground level, but they are expected to use methods and techniques that do not require them to accompany the subject through said unstable environment.

2. Operations-level rescuers may also find themselves in need of being lowered (or raised) to reach a subject in a stable location.

a. As long as the rescuer is not performing rescue skills or tending to the subject while they are in the unstable environment (e.g., hanging in free air or in a place where they would not be able to stand normally without assistance of a rope), this is still considered an operations-level skill.

**C. The following sites are some of the environments in which a high-angle lowering may be used:**

1. Cliffs

2. Buildings

3. Industrial sites, either outside a structure or inside a vessel

4. Construction sites, such as tower cranes

5. Other structures, such as stacks, silos, wind turbines, or towers

6. Cliff faces

7. Vertical caves

**D. Vertical lowering may take place on the outside of a structure (e.g., a building or stack, or on the inside, such as the interior of a silo or tank)**

1. As rescuers lower the load, it may run down against the side of a steep, vertical incline, such as the side of a building, structure, or cliff face, or it may be *free* (not touching the wall).

2. This depends on the nature of environment where the rescue is taking place. If the top of the drop is overhung, the litter will naturally hang out away from the wall.

X. High-Angle Rope Rescue System

**A. There are many correct ways to rig and operate a high-angle rope rescue system, but there are a few key points that these should always have in common:**

1. Primary anchor system

2. Mainline (rope)

3. Braking device

4. Belay system

5. Means of securing the subject to the system

6. Optional tag-lines for the management of the load

7. If the subject is not ambulatory, a litter and bridle may also be required (optional)

**B. At the operations level of response, the litter will typically be unaccompanied through the unstable portion of the lower, with load control provided by some means such as tag-lines.**

1. The vertical system should be relatively simple and should achieve the stated goal of transferring the subject from one stable location to another.

**C. Primary anchor system**

1. In selecting an anchor for a lowering system, the following should be considered:

a. Direction of travel

b. Mass of the load to be lowered

c. Potential for belay

d. Likelihood of the system needing to be converted to raise

2. The anchor point for a lowering system should be built based on the following principles:

a. Secure

b. In line with the intended pull

c. Able to withstand the anticipated loads with a comfortable margin of safety

3. Note that the direction of pull may vary throughout the course of the rescue, especially if tag-lines will be used to help direct the movement of the load.

4. The anchor should be set in line with and as close as reasonably comfortable to the subject, yet with enough working room available for the rescuer(s) at the top to work efficiently.

a. A setback of at least 6 feet (1.8 m) from the edge to the braking device is a good goal, but of course the rescue site may not be conducive to such distance.

b. In any case, there should be sufficient working space at the anchor to allow for the rescuer(s) to be comfortably positioned to package the subject, operate the braking device, and effect the rescue.

5. The anchor should be kept relatively high in relation to the edge that the load will have to go over as it begins descent, but not so high as to make the brakeman’s job harder.

a. Rigging a slingshot-type system, with the braking system low and the rope redirected through a pulley block at a secure high point, can really help with loading.

b. This makes edge negotiation easier while still allowing the braking device to be set back from the edge for safety.

**D. Ropes for lowering**

1. Ropes selected for lowering should be of a design specifically manufactured and intended for life safety use.

a. NFPA 2500 (1983) T (Technical) Rated or G (General) Rated alternatives (or equivalent) may be appropriate, depending on local protocol and operational demands.

b. A static rope, with less than 6 percent elongation at 10 percent of its minimum breaking strength, will provide maximum control, system responsiveness, and minimal creep, while a low-stretch rope offers greater force absorption in the event of a dropped load.

2. Whichever ropes are used, they must be compatible in size and construction with other components of equipment presently on the market.

a. In the past, all G-Rated rope was at least of a ½ inch (12.5 mm) diameter, but with the recent proliferation of G-Rated 7/16-inch (11-mm) rope, there is an increased hazard of having mismatched equipment in the field.

b. Rescuers should be attentive to ensuring compatibility in every connection.

**E. Braking systems for high-angle lowering**

1. The principles governing the use of a braking device for high-angle lowering are similar to those already discussed:.

a. The device imparts friction to the rope running through it.

b. Some of these devices are autolocking, some have panic locks, some offer adjustable friction, and some are free-running.

2. Any braking device used in lowering must provide an adequate margin of control over the load being lowered.

a. This concept is not the same as *strength*.

i. Strength refers to how strong something is, not how much friction something imparts.

b. Experience and discretion are required when considering friction, as the same device will offer varying degrees of friction depending on several factors, including (but not limited to) the rope with which it is used, environmental conditions (wet/dry), wear and tear, amount of load applied, etc.

3. The braking device will be attached to the anchor, as for a low-angle operation, and with it a brakeman will control the rate at which the litter is lowered.

4. Autolocking devices are a good choice for safety, particularly where the ability of the brakeman to hold the load might be in question.

**F. Belays for high-angle lowering**

1. Belays are nearly always appropriate in high-angle rescue operations for professional rescuers.

a. Keeping in mind the juxtaposition of probability and consequence, the goal is to ensure that the failure of any one point does not result in the complete failure of the rope rescue system.

b. A belay is typically achieved by building redundant systems wherein if one system fails, another catches the load, for example:

i. A typical system involving a belay that is both apart from the main lowering system and on a separate anchor

ii. Two separate lowering lines that provide back up to one another [i.e., dual tension rope system (DTRS)]

2. If the main lowering line is run through a high directional anchor, rescuers must decide whether to also run the belay line through a high directional. In this case, it depends on how secure the high point is.

a. Structural high points, such as an overhead beam or eye bolts, are often very secure and unlikely to be compromised.

3. In such cases, where the high point directional anchor is unquestionably sound, matching the path of the mainline is advisable, as this reduces the amount of potential drop in the system in the unlikely event of a failure.

a. If there is any question as to the integrity of the high point, such as it being part of an artificial high directional system where there is likelihood of failure, the belay line may be more secure if it is left at ground level.

4. When a belay is used, it should be rigged so that it and the primary system do not interfere with one another or become entangled.

a. However, they should be close enough together to prevent a dangerous pendulum should the main system fail and the belay be forced to catch the load.

b. Potential drop distances should be managed to a minimum, but belayers must still remain aware of the potential impact, swing fall, and shock load.

5. A two-tensioned belay is essentially nothing more than a mirrored replicate of the primary lowering system.

6. Local protocols should be followed.

**G. Two-Tensioned Rescue Systems**

1. Two-tensioned rescue system (TTRS) is a system that uses two anchored friction devices to control the two ropes at the same time, with both under load; sometimes called a twin-tensioned rescue system.

a. If properly controlled, this can result in each rope supporting one-half of the load as it is being lowered.

b. In reality, the two lines are rarely loaded equally, so the term *twin-tensioned* is a bit of a misnomer—thus the alternative term, two-tensioned rescue system.

2. That fact that both ropes are loaded enough to mitigate excessive shock load to the other due to slack in the event that one line fails is more important that the fact that they are not each carrying exactly 50 percent of the load.

a. In any dual tension system, neither rope is officially designated as belay, but if either line fails for any reason, the other will function as a belay.

b. This differs from a traditional mainline system with an untensioned belay, where inherent system slack and rope stretch can result in higher impact forces in the event of a failure.

3. For maximum redundancy, the two rescue systems in a TTRS should be anchored separately and run by two separate belayers.

a. The downside of this approach is that the brakemen controlling the friction devices in a TTRS may not always operate the two systems at exactly the same speed for many reasons, including:

i. Different experience levels

ii. Unequal edge friction between the two ropes

iii. Ropes with different elongation

iv. The nature of friction in physics

b. In this case, the system that operates slower will end up carrying the entire load while the faster system will become slack.

4. One way to help reduce the operator-induced differences is for the same brakeman to operate both ropes.

a. To do so, identical devices should be used for both systems, and they should be placed as close together as possible so that the brakeman can operate both handles (if so equipped) with one hand, and grasp the free ends of both ropes with the other hand.

b. The downside of this approach is that the shared anchorage eliminates redundancy in one of the highest risk areas of rigging (the anchor), and having only one brakeman likewise fails to protect against human error.

i. This also protects only against operator-induced tension differences—it does not do anything for the friction-induced or rope-induced differences in tension between the two systems.

5. The only other option for balancing tension between the two systems is to slow the faster system until the slack in the slower system is caught up.

a. If two brakemen are used, it can be helpful to designate one of the two-tensioned systems as primary, or lead.

b. The individual operating the primary system takes charge and sets the pace for the operation, while the operator of the second system focuses on following the lead so that the systems are balanced as equally as possible.

c. This approach gives more structure to the operation and reduces confusion between the brakemen; it also helps eliminate confusion for rescuers who are more experienced with traditional mainline/belay systems and allows for more consistency in utilizing familiar terminology.

d. Designating one of the two-tensioned ropes as the mainline and the other rope as safety is one way to differentiate and help reduce or eliminate confusion between rope systems.

**H. Rigging a System for Lowering**

1. Although rescuers at the operations level are not expected to perform rescue skills in a free-hanging or other unstable environment, it is quite possible that an operations-level rescuer may need to be lowered (or raised) from one stable environment to another to reach a subject who is in need of care.

2. To practice this skill, the following will be needed:

a. A lowering system

b. A raising system

c. A brakeman

d. A secondary brakeman or belayer

e. An operations leader

f. A safety officer

g. A rescuer

3. The following actions should be established before practicing this skill:

a. A short vertical face (approximately 20 feet [6.1 m]) where the top breaks over gradually into a steep face

b. Two secure high-angle lowering system anchor points safely back from the edge previously

i. If possible, have the anchor points high off the ground to assist the rescuer in going over the edge. A high directional anchor between the main anchor and the load is a good solution for this.

ii. If there is any danger that the brakeman might be exposed to a potential fall, they should be secured to a safety system that is not part of the rescue system.

4. A dual-tension lowering system may be used to lower the load, offering all the same advantages of any other dual tension rescue system.

a. For optimum redundancy two separate lines should be used, supported by two separate anchors, just as would be the case for a rescue system with primary and belay lines.

b. If there is any risk that any of the persons operating the system might be exposed to a potential fall, they, too, should be tied into a safety line that is not part of the rescue system.

c. Edge protection should be placed to guard the ropes from abrasion if needed.

5. See Skill Drill 14-7: Practicing a High-Angle Lowering of a Rescuer with a Dual-Tension Lowering System.

6. Alternatively, a rescuer or other load may be lowered using a mainline with belay system.

7. See Skill Drill 14-8: Practicing a Lower with a Mainline/Belay System.

**I. Practicing a high-angle litter lower**

1. Because the high-angle litter lower is generally unattended at the operations level, some other means of controlling the load should be employed so that it does not careen off obstructions or spin out of control as it is lowered.

2. The operations leader should ensure prior to commencing the operation that both parts of the DTRS are rigged with a safety factor appropriate to the load that will be on the system.

3. The braking devices must be attached to the anchor systems such that the following are achieved:

a. The brakemen are close enough to the edge to hear voice communication from the litter attendant, there is positive radio communication, or an edge attendant can relay communications between the brakemen and the litter attendant.

b. There is enough room at the top between the brakes and the edge so that the litter can be rigged safely (and, if applicable, so that the litter attendant can also be tied in safely).

4. Litter orientation

a. In some parts of the world, rope rescue operations are frequently performed with the litter in a vertical orientation, not unlike the system used for a low-angle evacuation.

b. In the United States, vertical (or high-angle) rope rescue systems have evolved in such a way that the litter is typically oriented in a horizontal configuration unless there is a specific reason to do otherwise.

c. A horizontal configuration, in which the subject lies as though on a cot, is usually a more comfortable and reassuring position for the subject and is also more conducive to medical care.

d. A vertical litter orientation may be more prudent in a confined space rescue or when obstructions on the face require a small cross-section for the litter.

5. Securing the subject in the litter

a. During a high-angle rescue, the subject must be securely packaged into the litter, with appropriate consideration to injuries and medical care.

i. If the subject is on a spine board, they must be securely packaged onto the board, which, as a unit with the individual, is connected to the safety lines.

ii. The subject should also be secured in the litter with lacing across the top to prevent shifting in the litter.

b. The subject should be wearing a harness, and a safety sling should run from the subject’s harness to the master attachment point at the top of the litter spider.

i. This safety sling is designed to catch the subject should they somehow become disconnected from the litter.

ii. Slack must always be left in the safety sling so that the subject is not pulled upward if the litter tilts.

c. A subject packaged for rescue with the litter positioned in the vertical configuration will need some extra protection from the potential for slipping out the end of the litter.

i. A seat harness, foot loops, or other methods for holding the body may be used, but consider carefully how these will be loaded when the litter is stood on end.

ii. It is natural for the body to want to slip down with gravity, so a patient that is packaged with the litter lying horizontally and then stood on end may shift significantly.

6. Attaching the litter to the main rescue line

a. The means by which a litter is attached to the rescue system will dictate its orientation during the evacuation, among other things.

b. A different kind of litter bridlefrom that used for low-angle evacuation may be fashioned from various components to join the mainline lowering rope to the litter.

c. Litter spider is the term sometimes used to describe a litter bridle used for vertical evacuation.

i. A single-point litter spider for lowering a litter in a horizontal orientation should have a minimum of four legs, each supporting the litter at multiple points along the litter rail, with these collected back to a central point where it is attached to the mainline lowering rope.

ii. The connection where the litter harness and rope rescue systems come together is called the master attachment point.

iii. Commercially made litter spiders that are adjustable for height and angle, and that incorporate tie-in systems for litter attendants, are available from a number of manufacturers.

iv. In use, the litter harness should be adjusted so that the subject rides in the litter slightly head up (unless medical reasons dictate head down). Riding head down adds to the subject’s anxiety and disorientation.

7. Rigging without a litter attendant

a. While operations-level rescuers should be capable of performing high-angle rescue operations, they should be capable of doing so without employing a litter attendant to ride the litter with the subject.

b. In an operations high-angle rope rescuer scenario, the subject should be packaged into the litter at a stable location, attached to the rope rescue system, then lowered (or raised) from that stable location to another stable location where they can be removed safely from the system.

c. Lowering a subject without an accompanying rescuer is fraught with challenges.

i. This is not an option if the subject requires medical attention or management during the lower or raise.

ii. However, if the vertical segment is a wall, tower, cliff face, or other structure, preventing the litter from bumping and slamming into protrusions and obstructions along the way would seem to be a priority.

(i) If the vertical segment to be transited is free hanging, presumably the biggest problem would simply be limiting spin.

d. Tag-line is a non–load-bearing line that connects to the litter to help move it side to side to avoid obstacles, prevent swing-fall, or attain a more advantageous position.

i. Tag-lines must be managed by tag-line attendants, who take rope in or let it out as the load is moved to manage it around obstacles or away from the structure, or to prevent spin.

ii. While tag-lines are simple to use, it is often difficult to control the load precisely.

e. Tag-line skill level

i. Some rescuers erroneously consider tag-lines to be a technician-level rescue skill.

ii. The primary difference between tag-lines and other methods is that tag-lines should be managed by hand, with no auxiliary equipment to create mechanical advantage on the tag-line component.

iii. The reason tag-lines become a technician-level skill when haul systems are incorporated into them is because of the potential force amplification that can occur; however, it is still good practice for operations-level rescuer to consider using directional pulleys, additional friction, or braking devices on tag-lines to help manage the load.

f. Tag-line friction

i. The use of friction is often essential to help effectively control tag-lines. The caution here is to not use additional mechanical advantage that can exert undue forces on the system.

ii. Because tag-lines are intended, by design, to exert forces in opposition to one another, care must be taken to ensure that these forces are not so great that they compromise the safety of the system.

iii. This is the reason that the use of haul systems in tag-line operations is discouraged at this level of skill, but to instead rely simply on the manual hauling ability of one tag-line operator at a time.

g. Tag-line ropes and connections

i. Ropes used to construct tag-lines need not be G- or T-rated ropes, as long as they are not also intended to double as a belay or load-bearing line. In fact, use of a lighter weight line in the 7mm to 8-mm range may offer advantages in rope management and weight.

ii. Tag-lines may be attached either to the bridle main attachment point, or to hard points on the litter.

1 In the unlikely event that a tag-line will be expected to double as a haul or belay line, it is best attached to the rigging plate above the litter.

iii. Connection to the main attachment point rather than the litter itself offers an additional advantage in that it does not imbalance the litter when a tag-line is pulled.

1 Tag-lines attached directly to the litter rail at the head-end or foot-end of the litter have more immediate, direct, and positive control—for example when negotiating edges; however, these may cause the basket to pull out of level, which can be disconcerting to the subject.

h. Other notes about tag-lines

i. There may be one or more tag-lines, depending on the direction(s) in which the litter needs to be controlled.

ii. Most often it is advisable to place multiple tag-lines in opposition to one another for optimum control.

iii. Tag-lines are typically controlled by personnel positioned beneath the load (outside the hazard zone), who pull on the lines manually to provide tension and deflect the litter's path.

iv. There is much to be said for the simplicity of nonanchored tag-lines, but if the consequence of a tag-line attendant accidentally letting go would be critical or catastrophic impact with something, additional friction (or an extra set of hands) should be considered.

v. Friction may be provided by means of an appropriate friction device, such as a braking device with an autolocking function.

vi. The device selected for controlling and securing tag-lines should be capable of quickly and seamlessly transitioning between applying and releasing tension so that there is no delay in response as needs change during the course of the lower.

vii. Use of nonautolocking devices is often appropriate here.

viii. Note that autolocking braking devices are typically rope-size dependent, so when using those be sure to select an appropriate device for the diameter of tag-line(s) that will be used in the system.

ix. For optimum efficiency, use tag-lines attached to the ends of the litter, ensure good offset angle with the main system, and train regularly with them.

x. See Skill Drill 14-8: Practice a Lower with a Mainline/Belay System.

8. Practicing high-angle litter lower techniques

a. Skills for lowering a litter should be practiced in whatever environment(s) where operations-level rescuers anticipate possibly needing to achieve a rescue.

b. See Skill Drill 14-9: Connecting a Tagline to a Litter.

c. See Skill Drill 14-10: Rigging a Litter for a Single Point Suspension High-Angle Litter.

d. See Skill Drill 14-11: Preparing a Two-Tensioned Rescue System.

e. Control movement of the litter with the tag-lines, following these steps:

i. As the load is lowered, the tag-line attendants should practice pulling tension or giving slack through the tag-line braking device(s) to move the load away from obstacles or to direct its path.

ii. The litter manager should practice calling for the litter to move in various directions by specifically directing the brakemen and tag-line operator(s) to stop, haul, and lower as appropriate.

f. Throughout the entire evolution, the litter manager should remain in command of the movement of the litter.

i. Although anyone may call a stop at any time, it is the litter manager who should direct the rate and direction(s) in which the litter is lowered.

ii. Tag-line operations require clear, direct communication and close coordination.

g. As an alternative to the TTRS, the litter lower may be performed using a mainline with belay.

i. See Skill Drill 14-12: Practicing a Lower with a Two-Tensioned Rescue System.

h. See Skill Drill 14-11.

i. To execute the lower with main and belay lines, the steps in Skill Drill 14-11 should be followed except that during the entire evolution, the belay operator should strive to maintain a slightly loose belay line rather than sharing half the tension with the primary system.

**J. Aerial ladder slide lowers**

a. Using an aerial ladder as a slide for the litter to follow is one alternative to tag-lines, particularly for urban structural rescue operations.

i. This method converts what would otherwise be a high-angle (or vertical) lower into a low-angle operation, with the ladder providing a track for the litter to slide down as the rate of lower is controlled by a rope system.

ii. This approach works best where an aerial ladder truck can be positioned adjacent to the structure with a safe working angle, and where adequate anchorages are available for the rope lowering system.

b. The subject should be packaged in a rigid basket litter that has a gap between the top rail and basket. The following will be needed:

i. Properly constructed lowering system (similar to what might be used for a low-angle evacuation is needed)

ii. Aerial ladder

iii. Pike pole (to hold the litter off the rungs of the ladder, allowing it to travel more smoothly down the ladder)

c. At least three rescuers are typically required to securely lift the subject into the litter, package them, and move the litter onto the ladder slide. One of these three will serve as a litter attendant.

d. Subject should be secured into the litter using an adequate patient restraint.

e. See Skill Drill 14-13: Practicing a Litter Lower with a Mainline and Belay.

f. The aerial ladder slide method is a convenient and low-stress method of simplifying a high-angle (vertical) operation.

i. It is dependent on the ability to position the apparatus near the structure with an appropriate working angle, access to the subject, and availability of basic rope rescue equipment.

ii. The aerial operator must have adequate training in load capacities, tip angles, and device function to be competent and comfortable with the operation.

g. It is also possible to execute this technique with a ground ladder.

i. Extra care must be taken to ensure security of the ladder before using these methods.

ii. Ladder methods are not explicitly called out by NFPA 1006 or 2500 (1670).

iii. Specific instruction from a competent trainer should be obtained before using this approach.

XI. Summary

 **A rescuer trained at the operations level is expected to be capable of moving a subject from one stable location to another.**

 **A stable environment is one in which a rescuer would be capable of maintaining their position and/or moving comfortably without a rope system but for the additional difficulties presented by the work they are doing.**

 **The operations-level rescuer is not expected to perform rescue functions in an unstable (vertical, free-hanging) environment.**

 **The difference between high-angle and low-angle rescues has less to do with a specific slope angle than with the type of system most appropriate for use given the circumstances at hand.**

 **The type of system will depend on multiple factors, including slope angle, foot friction, available resources, environment, and more.**

 **A low-angle evacuation may be appropriate for moving a subject down a slope where a simple litter carry without roped assistance would be hazardous.**

 **A low-angle evacuation can be resource intensive.**

 **Rope may be attached to the litter for a low-angle evacuation either by means of direct tie-in, or with a litter bridle.**

 **The core members of rope rescue operation are:**

 **Someone to be in charge (operations leader)**

 **Someone to assist the subject (rope rescuer)**

 **Someone to rig the system (rigger)**

 **Someone to control the brake (brakeman)**

 **Someone to monitor safety (safety officer)**

 **Operations-level rescuers can perform unattended high-angle (or vertical) litter lowers.**

 **The litter may be positioned laterally or longitudinally to the slope for a vertical litter lower.**

 **Tag-lines may be used in a vertical litter lower to help control horizontal movement of the litter, and to keep it away from obstacles.**

 **An aerial ladder may be used to create a litter slide, effectively turning a vertical litter lower into a low-angle evacuation.**

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 14 (p. 297).

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. You respond to reports of an injured subject on the track of a roller coaster. What factors will you use to determine whether to use low-angle methods to lower them down the track, or high-angle methods to lower them over the edge of the structure?

- Accessibility

- Which provides greater protection to the rescuers/subject

- Which provides the best route to safety

- Location of anchorages

2.What is the best way to attach a rope to a litter for a low angle evacuation, and why?

Answers/preference may vary – EITHER of the following may be correct:

1. By tying the evacuation rope directly to the head of the litter (because it eliminates extra components) OR

2. By wrapping a closed-loop bridle around the head of the litter (because it allows fast attachment/detachment to the evacuation system rope)

3.How many people would you need to staff a low-angle litter lower and what would their respective roles be?

Answers may vary by preferred methods and local protocol but generally the answer will be approximately 6, to include:

- Someone to be in charge (operations leader)

- Someone to rig the system (rigger)

- Someone to control the brake (brakeman)

- People to carry the litter (litter attendants) (1 if no litter, 2 with litter+wheel, 4 with litter and no wheel)

- Someone to monitor safety (safety officer)

Some agencies might add

- Belay Operator

- Medic

… And/or some agencies might combine roles

4.How many people would you need to staff a high-angle litter lower at the operations level, and what would their respective roles be?

Answers may vary by preferred methods and local protocol.

- Someone to be in charge (operations leader)

- Someone to assist the subject (rope rescuer)

- Someone to rig the system (rigger)

- Someone to control the brake (brakeman)

- Someone to control the tag line(s) (tag line operator)

- Someone to monitor safety (safety officer)

Some agencies might add

- Additional Tag Line(s)

- Edge Attendant(s)

5.Talk through how to perform a system safety check for a high-angle litter lower at the operations level.

Answers may vary but should include at least:

- Discussion of analysis and mitigation of hazards, to include environment, falls from height, and dropped objects

- Verification that appropriate personal safety equipment is being used properly, including helmets, gloves, and fall protection.

- Correctly rigged anchors, knots tied and set, well rigged rescue system, effective belay, adequate edge protection, all components used properly

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. Explain the difference between low-angle evacuation, scree evac, and vertical evacuation. (Lecture I C)

2. Identify examples of low-angle evacuation sites. (Lecture II C)

3. What are the minimum personnel requirements for a low-angle lowering operation? (Lecture III B)

4. What is the safety officer’s job during a low-angle lowering operation? (Lecture III H)

5. Under what circumstances can a handline be used? (Lecture IV A)

6. Identify the components of a low-angle lowering system. (Lecture V A)

7. Identify examples of high-angle evacuation sites. (Lecture IX C)

8. Identify the components of a high-angle rope rescue system. (Lecture X A)

9. Define two-tensioned rescue system (TTRS). (Lecture X G)

10. What is a tag-line? (Lecture X I)

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.