Chapter 8: Three Main Components of a Rope Rescue System

Scope: This chapter serves as an orientation to the three main components of a rope rescue system.
Terminal Learning Objective (TLO): At the end of this chapter, the student will be aware of rope rescue system construction requiring the assembly of individual items (rescue rope and related equipment) into functional components.
Enabling Learning Objectives (ELO):
1. Define key points about the component approach
2. Demonstrate a single RPM configuration
3. Demonstrate a prerigged dual RPM system

The construction of rope rescue systems requires the assembly of individual items (rescue rope and related equipment) into functional components that when put together form operating systems. Traditionally these individual items have been stored and transported as a cache of equipment grouped by like items to the rescue scene. Rescuers then assemble these individual items into components, and then into working systems. At best, this is not a timely or efficient approach to bring to the rescue scene.

Grouping these individual items into component systems, and prepackaging them into a standardized system will greatly reduce set-up time and simplify the construction and safe operation of low angle rope rescue systems. Local and regional standardization based on this concept will help ensure smooth interagency operations of these types.

This manual identifies three main components of low angle rope rescue operations.

1. **Belay/Safety Line Component**
2. **Main Line Component**: Can function as a lowering line, raising line, or fixed line for rappelling.
3. **Mechanical Advantage Component**: Can be independent or part of the main line.

Key Points about the Component Approach

- ❒ The basic system requires two lifelines: one to support a belay/safety line component and another to support a main line component.
- ❒ These two components can each be preassembled and carried on an apparatus, ready to be put into immediate service.
- ❒ The belay/safety line component is the back up to all other components of any rope rescue system in the event of its failure. This line will be loaded only if there is a failure in the main line system.
- ❒ The main line component carries the load in all rappel, lower, and raise operations. The main line component will convert into a part of the mechanical advantage or haul line system depending on what type of mechanical advantage is constructed.
- ❒ A main line component that carries a collection of equipment that includes a descent control device, pulley, and load-releasing device with one or two prusiks is commonly referred to as a **RPM**. The **"R"** refers to resistance, meaning a figure of eight descender or brake bar rack. The **"P"** refers to a pulley. The **"M"** refers to a Mariner's hitch, an early form of load releasing device.

❒ The mechanical advantage component is the minimum equipment required to construct any of the mechanical advantage systems shown in this manual. This equipment is commonly carried in the main line component rope bag equipment pocket or a separate equipment bag.

Belay/Safety Component

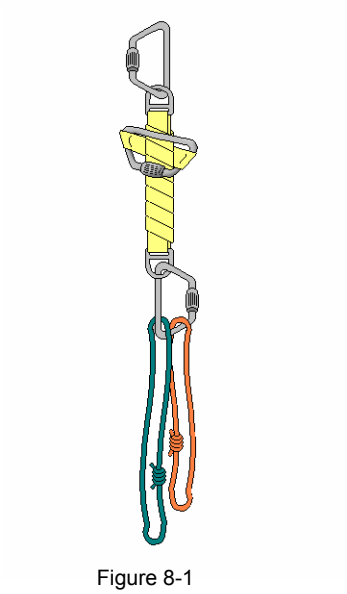

Figure 8-1

Function: This component will provide fall arrest for rescuers and victims and shall be included in all systems. Staffing this component shall be the sole responsibility of a competent individual.

Minimum equipment:

- ❒ LRD
- ❒ Two carabiners
- ❒ One short prusik
- ❒ One long prusik

May be stand-alone or part of an RPM.

Main Line Component (RPM)

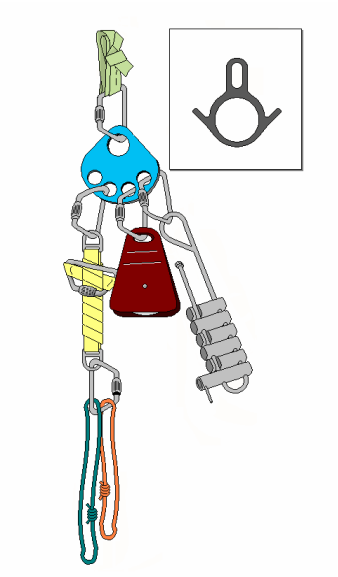

Figure 8-2

Function: This component will provide lowering capabilities for rescuers and victims during system operations. During lowering operations, the braking components (tandem prusiks) will be optional.

Minimum equipment:

- ❒ Anchor plate
- ❒ Descent control device
- ❒ Pulley
- ❒ LRD
- ❒ One short prusik
- ❒ One long prusik
- ❒ Five carabiners

Mechanical Advantage Component

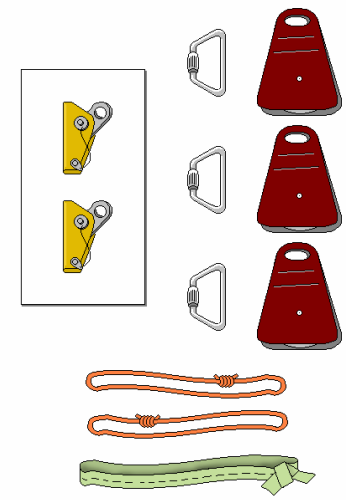

Figure 8-3

Function: To provide raising capabilities for rescuers and victims during system operation. During raising operations, the braking component will be required.

Minimum equipment:

- ❒ Three carabiners
- ❒ Three pulleys
- ❒ Two short prusiks or mechanical rope grabs
- ❒ One anchor sling (5' – 20') as needed

Supports the construction of 3:1 or 5:1 mechanical advantage systems.

Single RPM Configuration

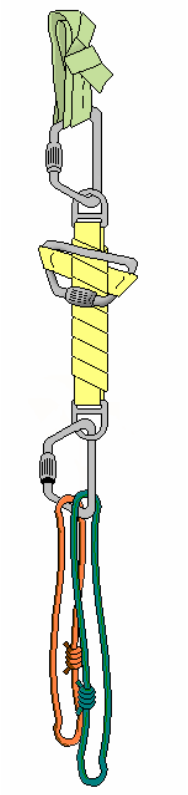

Figure 8-4: Single RPM Configuration Belay/Safety Line

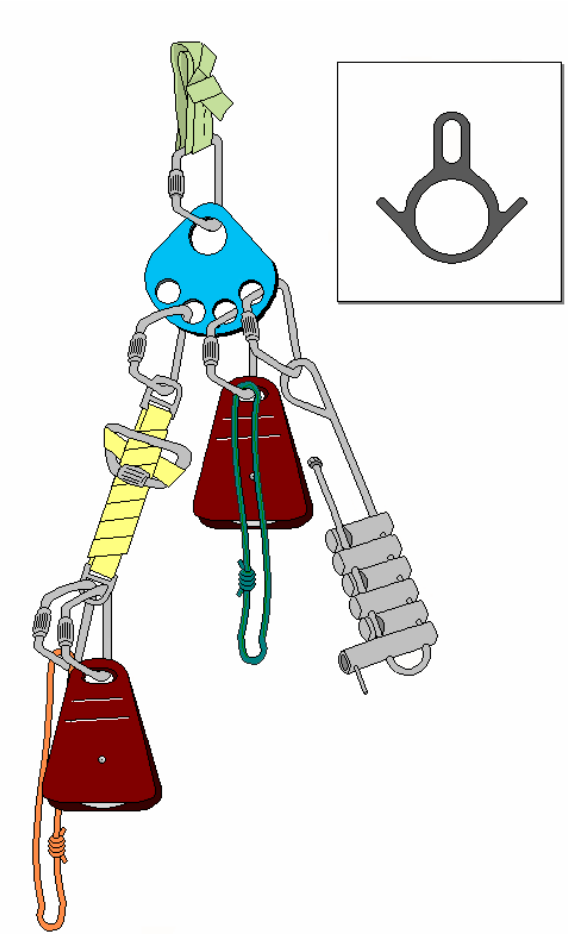

Figure 8-5: Single RPM Configuration Main Line

- Agencies that respond in more urban/structural environments often configure the RPM by attaching the equipment necessary to construct mechanical advantage systems directly to the collection plate. This simplifies operations in environments that provide larger operating distances between the main anchor and the working edge.
- Systems configured in this way minimize equipment needs and weight of systems utilized in high angle rope rescue operations.
- Although not specifically supported in this text, systems configured in this way are currently being used safely and efficiently in low angle rope rescue operations.
- **The instructor will modify the RPM configuration to best meet local and regional needs.**

Prerigged Dual RPM Systems

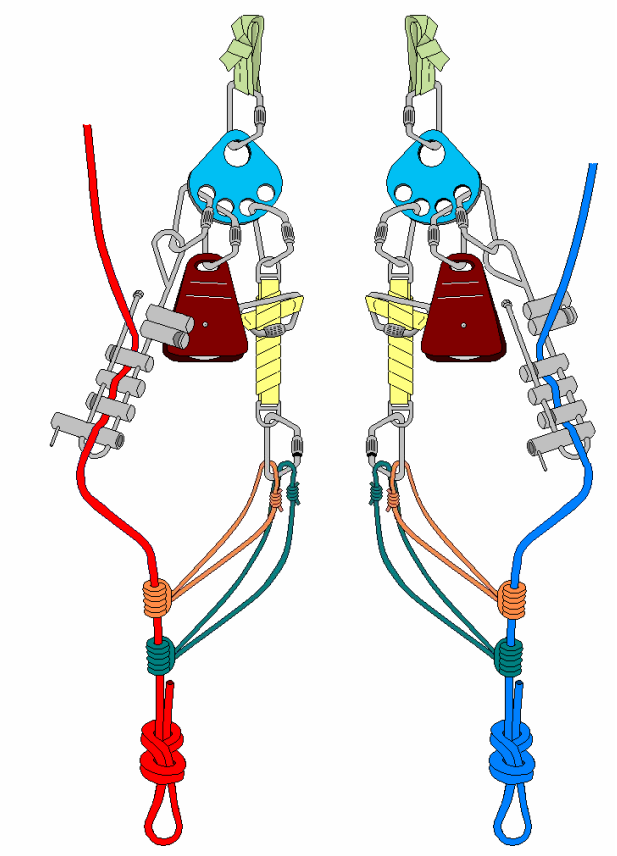

Figure 8-6: With Brake Bar Rack

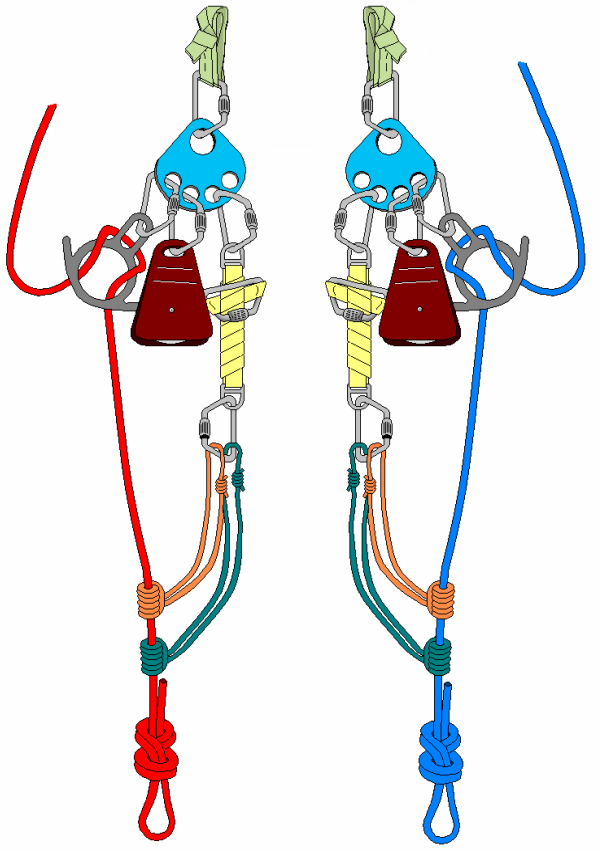

Figure 8-7: With Figure Eight Descender

- ❒ Prerigged dual RPMs with tandem prusiks are a common rural configuration where low angle rope rescue operations are most often, if not exclusively, utilizing a directional change pulley off the collection plate.
- ❒ When attached to anchors, the RPMs are configured with the load-releasing devices (LRDs) to the inside and adjacent as shown.
- ❒ This configuration is ideal for lower/raise operations in environments with a limited operating distance between the main anchor and the working edge. This is a common scenario in over the bank operations on narrow roadways.
- ❒ Either RPM can become the belay/safety or main line side of the system based on site specifics and operational needs.
- ❒ The equipment required for the construction of the mechanical advantage system is commonly carried in a pocket in one of the two rope bags, bagged separately, or preassembled and attached to a lifeline in a separate rope bag. (Figure 8-3)

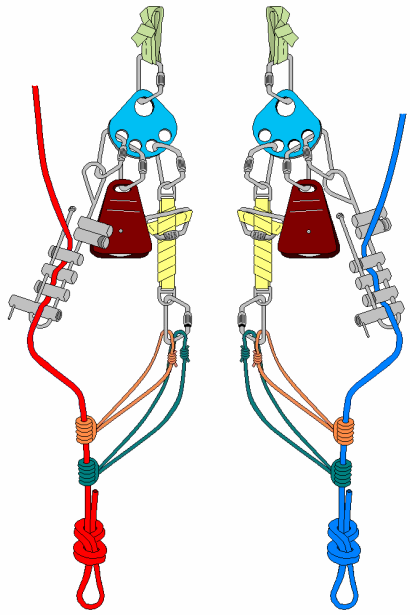

Figure 8-8: With Brake Bar Rack: As Stored

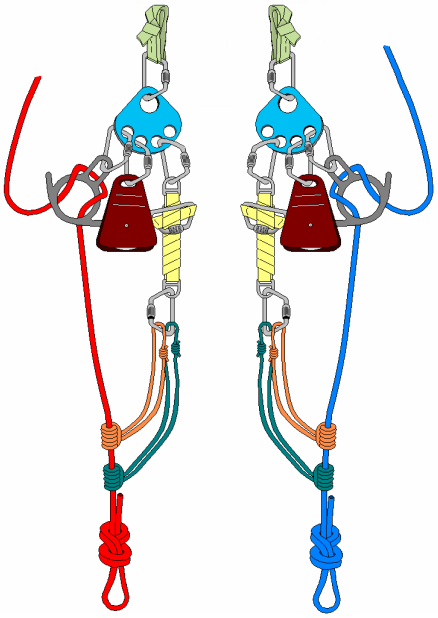

Figure 8-9: With Figure Eight Plate: As Stored

- ❒ Redundant RPM systems are stored in the configurations above.
- ❒ This allows for the use either as a belay/safety line or main line.

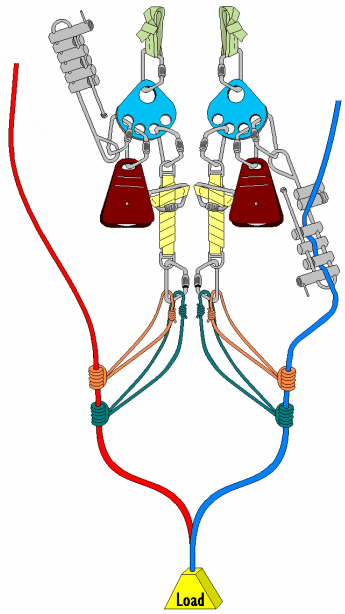

Figure 8-10: With Brake Bar Rack: In-service Lower

The main/lowering line tandem prusiks are optional during lowering operations.

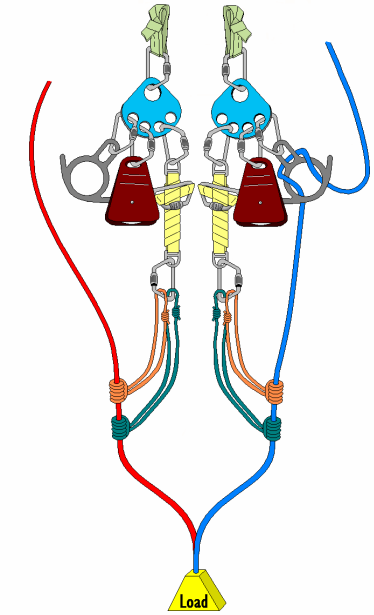

Figure 8-11: With Figure Eight Plate: In-service Lower

- ❒ To place the system in-service, the belay/safety line is removed from the descent control device.
- ❒ If the prusiks are left in-service for lowering, a main line brake tender is ***required***.

Chapter 9: Belay/Safety Line Systems

Scope: This chapter serves as an introduction to belay/safety line systems.
Terminal Learning Objective (TLO): At the end of this chapter, the student will be aware of the importance of utilizing a back-up line to catch the load in the event of a failure of the main line.
Enabling Learning Objectives (ELO):

1. Define key points regarding the operation of a belay/safety line system
2. Demonstrate belay/safety line configurations
3. Demonstrate lowering operations – basic configuration
4. Demonstrate retrieval operations – basic configuration
5. Demonstrate lowering operations – PMP configuration
6. Demonstrate retrieval operations – PMP configuration
7. Describe system variations

In all emergency operations, the words "Safety First" need to be more than a catchy phrase. Rope rescue operations are no exception to this rule. An important part of ensuring safety is the utilization of a back-up line to catch the load in the event of a failure of the main line.

Many teams refer to this back-up line as the "belay line." This is a mountaineering term meaning, "To hold fast or provide security."

Other teams refer to this line as the "safety line." With this orientation, the term "Safety First" can provide a verbal reference to the back-up line and reinforce the concept of staffing, checking, and attaching the safety line first in all operations.

This manual will use both terms with the understanding that local agencies will use one or the other as their reference. With that being said, the belay/safety line systems and operations that are presented here ***must be followed without exception***.

Key Points Regarding the Operation of Belay/Safety Line Systems

- ❒ The entire operation is only as safe as the belay/safety line system, its anchor, and its operator.
- ❒ Personnel staffing the belay/safety line must have sound operational skills. These skills are perishable and their maintenance requires regular hands-on practice under the supervision of a qualified person.
- ❒ **Communication is essential during the operation of these systems.** The "edge" position is a critical link in the safe operation of the belay/safety line system. The edge person will communicate to the belay/safety line tender the amount of line and speed needed to accommodate the rescuer's needs. On occasion, the rescuer may need to move rapidly over an area. **The edge person will direct the belay/safety line tender regarding the operation of the system during these situations.**
- ❒ The Technical Safety Officer or Rescue Group Supervisor may fill the roll of "edge" as dictated by staffing and operational needs.
- ❒ **Rope rescue operations are a go only when the "edge" position is filled.**

Belay/Safety Line Configurations

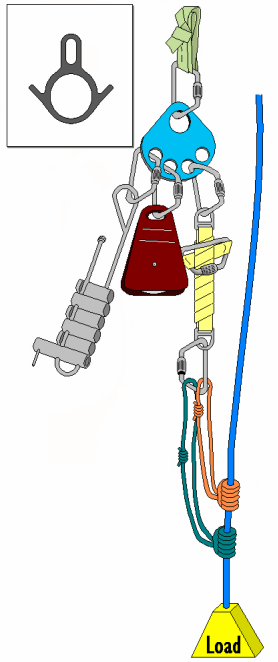

Figure 9-1: Basic Configuration

The basic belay/safety line configuration does not utilize the prusik minding pulley. This configuration does not provide for rapid retrieval of an unloaded line, however, it will allow the tender better "feel" of systems operation.

This configuration will minimize the potential of prusiks to grab or jam. The basic belay/safety line configuration also reduces the potential for damage to system components (line and prusiks) caused by the heat of friction. The potential for system problems associated with the use of the prusik minding pulley in the systems is eliminated.

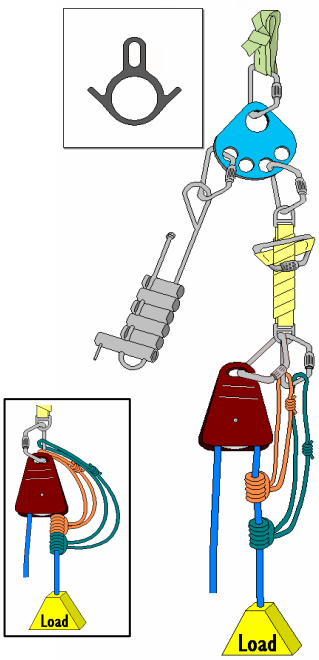

Figure 9-2: PMP Configuration

The prusik minding pulley (PMP) allows the belayer to retrieve the belay/safety line with hand over hand motion. This provides a quick method of retrieving a line that has been disconnected from the load.

This configuration can also be used while retrieving a belay/safety line during raising operations. The operator must ensure that the proper amount of tension is maintained in the prusik hitches around the belay/safety line. Excessive grip of the prusik to the line will cause the tandem prusiks to jam and/or be damaged due to the heat of friction.

Extreme caution must be used if utilizing this system to protect the load during lowering operations. The weight of the additional hardware can cause the tandem prusiks to grab unexpectedly. The system may be placed flat on the ground to prevent this. Prusik hitches that are too loose or improperly tended will not arrest a fall.

Lowering Operations – Basic Configuration

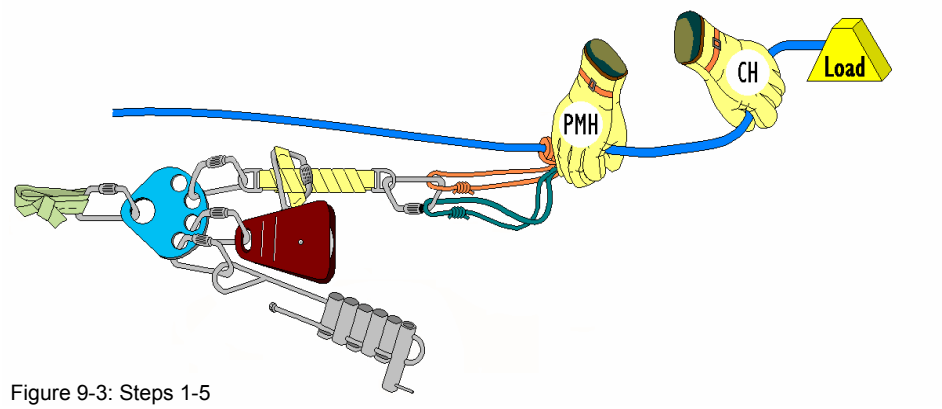

Figure 9-3: Steps 1-5

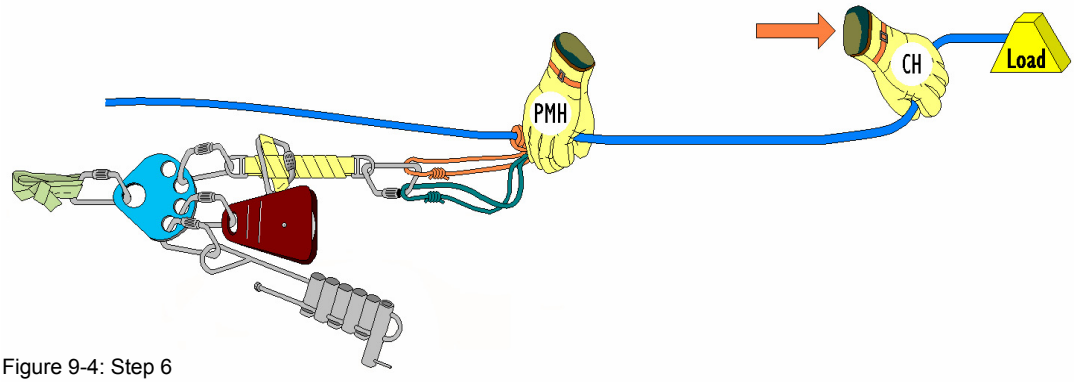

Figure 9-4: Step 6

1) **Prusik Minding Hand (PMH)** – Form a circle with the index finger and thumb around the line and against the load side of the long prusik.
2) **Control Hand (CH)** – Grasp the line on the load side of the tandem prusiks.
3) **Control Hand** – Angle the line with the hand as shown.
4) **Prusik Minding Hand** – Slide the long prusik toward the anchor until it contacts the short prusik and rest the remaining fingers of the **prusik minding hand** on the short prusik.
5) **Prusik Minding Hand** – Slide the tandem prusiks toward the anchor to develop 2"–3" of slack.
6) **Control Hand** – As the load moves away from the anchor, pull the line through the tandem prusiks to maintain less than 2 feet of slack in the line.
7) **Control Hand** – When arm's length is reached, repeat Step 6.

   When pull straightens the angle at the control hand, set the prusiks unless otherwise directed.

   Tandem prusiks are commonly set by "throwing" them towards the load with the prusik minding hand.

Retrieval Operations – Basic Configuration

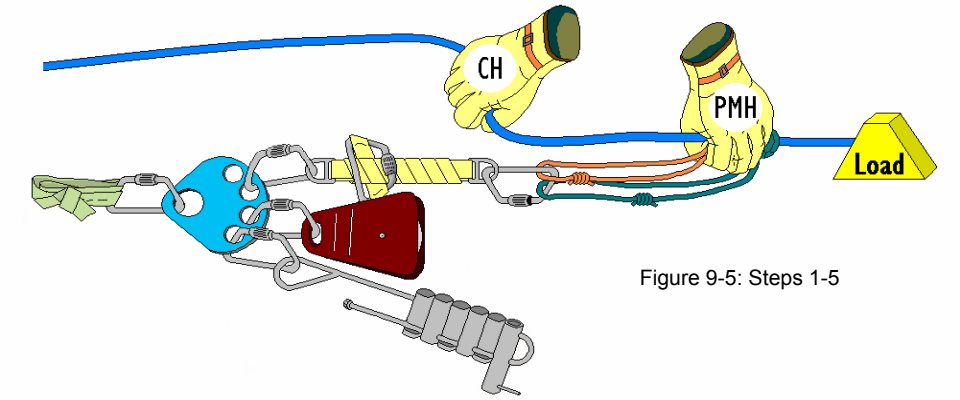

Figure 9-5: Steps 1-5

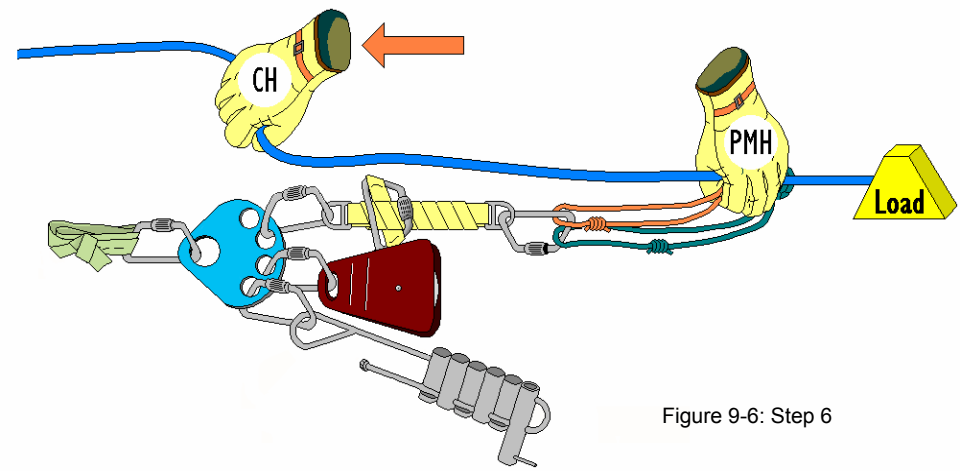

Figure 9-6: Step 6

1) **Prusik Minding Hand** – Form a circle with the index finger and thumb around the line and against the anchor side of the short prusik.
2) **Prusik Minding Hand** – Short prusik remains taut throughout the operation.
3) **Control Hand** – Grasp the line on the anchor side of the tandem prusiks.
4) **Control Hand** – Angle the line with the hand as shown.
5) **Control Hand** – As slack develops during retrieval, pull the line through the tandem prusiks to maintain a taut line.
6) **Prusik Minding Hand** – As the line is retrieved by the control hand, the long prusik will move to contact the short prusik. Rest the remaining fingers of the **prusik minding hand** on the long prusik.
7) **Control Hand** – When arm's length is reached, repeat Steps 3, 4, and 5.

   When direction of travel reverses, properly tended prusiks will set.

   Tandem prusiks are commonly set by "throwing" them towards the load with the prusik minding hand.

Lowering Operations – PMP Configuration (Optional)

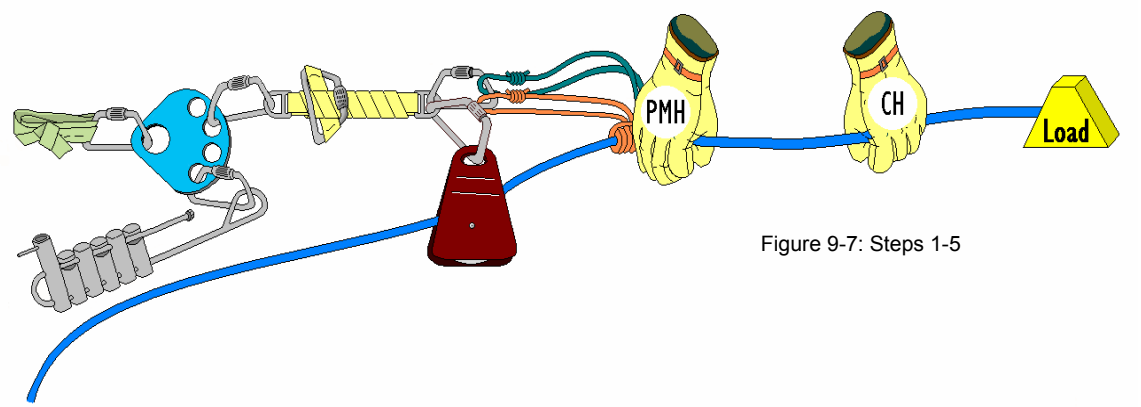

Figure 9-7: Steps 1-5

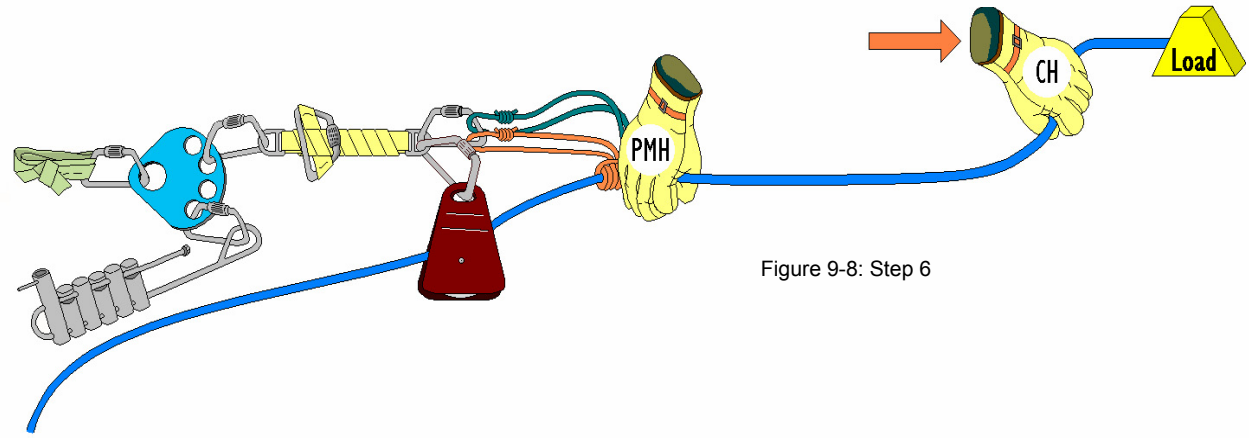

Figure 9-8: Step 6

If possible, open the angle of the line in the pulley as shown. This will allow the line to feed through the system more easily.

1) **Prusik Minding Hand** – Form a circle with the index finger and thumb around the line and against the load side of the long prusik.
2) **Control Hand** – Grasp the line on the load side of the tandem prusiks.
3) **Control Hand** – Angle the line with the hand as shown.
4) **Prusik Minding Hand** – Slide the long prusik toward the anchor until it contacts the short prusik and rest the remaining fingers of the **prusik minding hand** on the short prusik.
5) **Prusik Minding Hand** – Slide the tandem prusiks toward the anchor to develop 2" – 3" of slack.
6) **Control Hand** – As the load moves away from the anchor, pull the line through the tandem prusiks to maintain less than 2 feet of slack in the line.
7) **Control Hand** – When arm's length is reached, repeat Step 6.
   When pull straightens the angle at the control hand, set the prusiks unless otherwise directed.
   Tandem prusiks are commonly set by "throwing" them towards the load with the prusik minding hand.

Retrieval Operations – PMP Configuration (Optional)

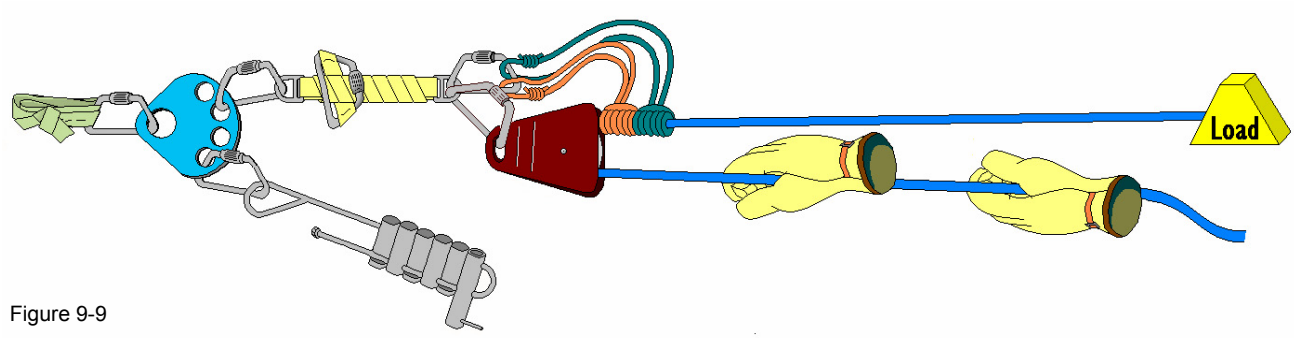

Figure 9-9

1) With one hand, grasp the line on the side opposite the tandem prusiks 2 feet below the pulley.
2) With the other hand, grasp the line on the same side of the pulley a comfortable distance away from the first hand.
3) Pull the line hand-over-hand, away from the anchor.

Key Points

- ❒ Maintain a two-foot spacing between hands and pulley to avoid possible entanglement in pulley.
- ❒ The line must be maintained at 180° in and out of the prusik minding pulley.
- ❒ Prusiks must ride squarely on the bottom edge of the pulley.
- ❒ Prusiks allowed to ride up the side of the pulley may jam or be damaged by the heat of friction.
- ❒ When direction of travel reverses, the prusiks will set.

System Variations

It is common to see the basic belay/safety system configuration utilized during lowering operations and the belay/safety line system with the prusik minding pulley utilized during retrieval operations.

Dual RPMs Configuration

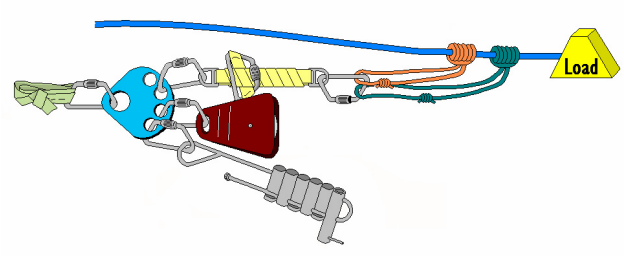

Figure 9-10: Basic Configuration – Lower

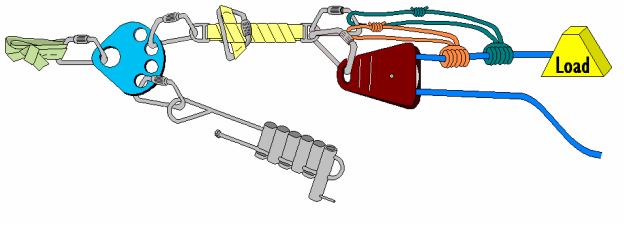

Figure 9-11: PMP Configuration – Retrieve

Belay/Safety Line Single Configuration (as shown in Chapter 8)

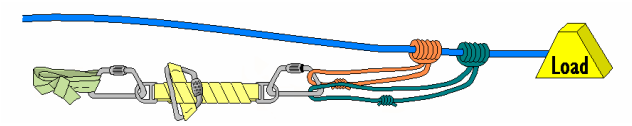

Figure 9-12: Single Configuration without PMP

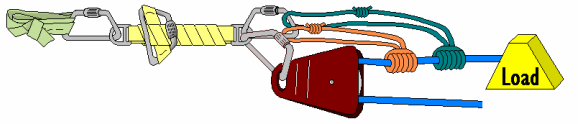

Figure 9-13: Single Configuration with PMP

Key Points

- ❒ A belay/safety line system shall be utilized any time a main line is used (two line systems).
- ❒ The belay/safety line system is the most critical part of any rope system as it provides for fall arrest in the event of main line system failure.
- ❒ The operation of this system is a critical skill requiring a high degree of knowledge and understanding.