TC 3-37.51

Urban Search and Rescue

AUGUST 2020

Headquarters, Department of the Army

Foreword

Warriors, if you are reading this publication, you are a member of or will soon assume duties in America's Chemical, Biological, Radiological, and Nuclear Response Enterprise. The Chemical, Biological, Radiological, and Nuclear Response Enterprise is an insurance policy for a nuclear detonation of an improvised device or some other catastrophic chemical, biological, radiological, and nuclear (CBRN) event on what would be America's worst day. Responding to a CBRN event or any other significant disaster will require the skills outlined in this training circular. I ask that you take full advantage of the time you have prior to an event. Read, study, and practice the tactics, techniques, and procedures outlined in this training circular to ensure that you are prepared to act decisively. Remember, if asked to respond, it will most likely be to a nonpermissive CBRN environment that is affected by fog, friction, drastically shortened decision-making cycles, and tremendous pressure to save lives. Study and train hard, America will need you at the top of your game.

This urban search and rescue (US&R) training circular was developed by the Maneuver Support Center of Excellence (MSCoE) Homeland Defense/Civil Support Office in coordination with the Joint Task Force Civil Support, the National Guard Bureau, and various United States Army units as a supplementary tool for US&R personnel. It condenses and codifies technical training information collected from multiple sources, including the International Fire Service Training Association (IFSTA) manual, United States Army Corps of Engineers/Urban Search and Rescue Field Operations Guide, Pipeline and Hazardous Materials Safety Administration Emergency Response Guidebook, and multiple National Fire Protection Association (NFPA) standards.

This US&R training circular includes sections expounding on common core US&R capabilities as well as rope, confined space, trench, structural collapse, vehicle, and machinery rescues. This training circular is used in conjunction with the MSCoE Homeland Defense/Civil Support Program's new US&R course, which graduated its first rescuer Level I and II class in September 2018. TC 3-37.51 will advance the understanding of US&R in support of civil authorities across the Army. In addition to this training circular and the schoolhouse, the CBRN domestic response manual, also being developed at MSCoE, will consolidate Chemical, Biological, Radiological, and Nuclear Response Enterprise doctrine from across a spectrum of documents and create a single reference for Soldiers, Sailors, Marines, and Airman, whether they are experienced Chemical, Biological, Radiological, and Nuclear Response Enterprise members or are brand new to the Chemical, Biological, Radiological, and Nuclear Response Enterprise and defense CBRN response force.

The US&R training circular serves as one module of the common operational doctrine for the defense CBRN response force and the entire CRE. Its central idea, adapted to the unique conditions of the homeland operational environment, represents the Army's unique contribution to civil support. It will support our doctrine, our training, and our leader professional development programs.

WILLIAM A. HALL
MAJOR GENERAL, USA
COMMANDER

This publication is available at the Army Publishing Directorate site (https://armypubs.army.mil) and the Central Army Registry site (https://atiam.train.army.mil/catalog/dashboard).

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No. 3-37.51

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Washington, D.C, 25 August 2020

Urban Search and Rescue

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Preface

TC 3-37.51 serves as a training product for US&R/urban search and extraction operations. This training circular helps the Chemical, Biological, Radiological, and Nuclear Response Enterprise task force level units conducting US&R/urban search and extraction missions and below to prepare their training plan for the unit's specific mission to the defense support of civil authorities. Using this training circular, a unit can tailor the training plan for the unit's specific mission by grouping related missions into one function.

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States, international, and in some cases host-nation laws and regulations. Commanders at all levels ensure that their Soldiers operate in accordance with the law of war and the rules of engagement. (See FM 6-27.)

TC 3-37.51 uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. Terms for which TC 3-37.51 is the proponent publication (the authority) are italicized in the text and are marked with an asterisk (*) in the glossary. Terms and definitions for which TC 3-37.51 is the proponent publication are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

TC 3-37.51 applies to the Active Army, Army National Guard/Army National Guard of the United States, United States Army Reserve, Air Force, Air National Guard, and the Air Force Reserve unless otherwise stated.

The proponent and preparing agency of TC 3-37.51 is the Assistant Chief of Staff/Directorate of Training and Doctrine (DOTD), MSCoE. Send comments and recommendations on DA Form 2028 (*Recommended Changes to Publications and Blank Forms*) to Commander, MSCoE, ATTN: ATZT-OPD-D, 14000 MSCoE Loop, Suite 270, Fort Leonard Wood, MO 65473-8929; by e-mail to usarmy.leonardwood.mscoe.mbx.cbrndoc@mail.mil; or submit an electronic DA Form 2028.

Unless this publication states otherwise, masculine nouns or pronouns do not refer exclusively to men.

Chapter 1
Common Core

US&R involves the location, rescue (extrication), and initial medical stabilization of individuals trapped in confined spaces, trenches, vehicles, machinery, and structural collapses. This chapter will assist in setting up teams, developing a site lay out, and preparing for rescue or recovery operations.

STANDARDS FOR PERSONAL PROTECTIVE EQUIPMENT

1-1. Personal protective equipment (PPE) is addressed in specific Occupational Safety and Health Administration (OSHA) standards for general industry, maritime, and construction. OSHA requires that many categories of PPE meet or be equivalent to the standards developed by the American National Standards Institute (ANSI). This section highlights OSHA standards and documents related to PPE.

1-2. Being familiar with the PPE used in the technical rescue environment will ensure a safe and efficient response. Rescuer safety should be addressed in every incident action plan. Below are the standards for PPE.

NATIONAL FIRE PROTECTION ASSOCIATION STANDARDS

1-3. PPE is the required protection for all personnel during rescuer missions. During US&R operations it is vital that the proper PPE be worn at all times and that PPE for the victim be considered. PPE includes—

- Protective ensembles for technical rescues (refer to NFPA 1951).
- Head protection.
- Face and eye protection.
- Outerwear that includes protective coats, trousers, and reflective vests.
- Hand protection, such as—
  - Leather work gloves.
  - Rope gloves.
  - Extrication gloves.
  - Emergency medical service protective gloves.
- Foot protection.
- Protective ensemble for confined space rescuer (refer to NFPA 1981), to include a—
  - Supplied air respirator (SAR).
  - Self-contained breathing apparatus (SCBA).
  - Purified air powered respirator (PAPR).

AMERICAN NATIONAL STANDARDS INSTITUTE

1-4. The ANSI is the organizational institute that recognizes standards for businesses, homes, or abroad safeguarding all personnel. The ANSI equipment standards is to protect and strengthen the ability to prepare for and respond safely and effectively to emergencies, disasters, and chemical, biological, radiological, nuclear, and explosives incidents.

1-5. The ANSI provides the standards for several PPE items for rescuers during their mission. Proper eye protection, hearing, and knee and elbow pads are key PPE items for the rescuer during breaching operations. Equipment includes—

- Safety glasses and torch cutting goggles shade.
  - 3.0 is used with oxygen acetylene and petrogen.
  - 5.0 is used with exothermic.
- Hearing protection.
- Knee and elbow protection.

INCIDENT COMMAND SYSTEM

1-6. The US&R incident command system (ICS) is designed to identify positions and teams in order to conduct a mission in the operational environment in which they will conduct their assigned missions. The unit standard operating procedures (SOPs) will dictate assignments and duties. These positions are the base positions for all rescuer operations and referenced throughout the training circular.

1-7. US&R teams are comprised of 44 to 50 members. Key positions identified are the team leader, platoon sergeant, safety officer, operation officer, squad leader, and the rescuer specialists. It is the leader's responsibility to manage and assign duties. Positions and certain functions are discussed in the following paragraphs:

- **Team leader (platoon leader).** The US&R team leader (platoon leader) manages all aspects of a mission including operational and administrative issues. The leader develops and completes all task force tactical objectives.
- **Noncommissioned officer in charge (platoon sergeant).** The US&R noncommission officer in charge (platoon sergeant) manages and coordinates for all Class I and IV items (such as meals, water, and lumber). The noncommissioned officer in charge assists in the development of the incident action plan.
- **Safety officer.** The safety officer ensures that personnel accountability is maintained. He monitors rest cycles, rotations, and rehabilitation.
- **Operation officer.** The operation officer maintains and documents the incident objectives on the ICS Form 201 (*Incident Briefing)* form. He provides situation reports to the team leader.
- **Squad leader.** The US&R squad leader executes the rescue mission according to the incident action plan. The leader directly supervises the rescue squads and other assigned personnel.
- **Rescue specialists.** Rescue specialists are tactically and technically proficient in assigned duties. They implement technical skills and operate equipment necessary for completing the rescue.

FORMS AND REFERENCE MATERIALS

1-8. The ICS forms are used in the ICS process for incident management activities. ICS forms identified with an asterisk (*) are typically included in an incident action plan. See table 1-1.

Table 1-1. US&R forms

Incident Command System Form	*Form Title*	*Typically Prepared By—*	*Description*
ICS Form 201	*Incident Briefing*	US&R Team Leader	Provides the incident command/unified command and general staffs with basic information regarding the incident situation and the resources allocated to the incident.
*ICS Form 202	*Incident Objectives*	Planning Section Chief	Describes the basic strategy and objectives for use during each operational period.

Table 1-1. US&R forms (continued)

Incident Command System Form	***Form Title***	***Typically Prepared By—***	***Description***
*ICS Form 204	*Assignment List*	Squad Leader, Noncommissioned Officer in Charge	Used to inform personnel of assignments.
ICS Form 206	*Medical Plan*	Competent Medical Personnel	Location, staffing, and resources available to the incident medical aid station including the types and locations of ambulances, and contact information for hospitals.
*ICS Form 208	*Safety Message/Plan*	Safety Officer	ICS Form 208 expands on the safety message and site safety plan.
ICS Form 209	*Incident Status Summary*	All Sections and Units	Summarizes incident information for staff members and external parties, and provides information to the public information officer for preparation of media releases.
ICS Form 210	*Resource Status Change*	All Sections and Units	Used to record status change information received on resources assigned to the incident.
ICS Form 214	*Activity Log*	All Sections and Units	Provides a record of unit activities. Unit logs can provide a basic reference from which to extract information for inclusion in any after action report.
* Form is typically included in an incident action plan.			

1-9. The references in table 1-2 are needed for rescue operations and developing training standards.

Table 1-2. US&R references

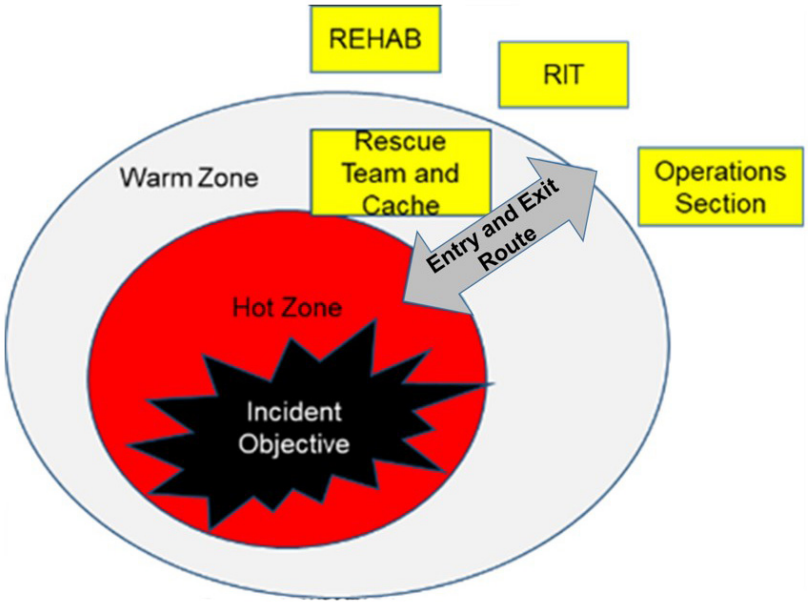
Urban Search and Rescue References	***Title***	***Description***
International Fire Service Training Association (IFSTA) Manual	*Fire Service Technical Search and Rescue*	A helpful guide in rescue standards designed off National Fire Protection Association (NFPA) 1006.
United States Army Corps of Engineers/Urban Search and Rescue Shoring Operations Guide	*Shoring Operations Guide*	The United States Army Corps of Engineers/Urban Search and Rescue Shoring Operations Guide (SOG) has been prepared to guide smaller urban search and rescue teams and local fire/rescue department personnel to perform search, building assessment, and shoring operations during major disasters or emergencies
NFPA 1006	*Standard for Technical Rescue Personnel Professional Qualifications*	Establishes the minimum job performance requirements necessary for the fire service and other emergency response personnel who perform technical rescue operations.
NFPA 1983	*Standard on Life Safety Rope and Equipment for Emergency Services*	Specifies minimum performance criteria, design criteria, and test methods for new life safety rope and system components.
NFPA 1072	*Standard for Hazardous Materials/Weapons of Mass Destruction Emergency Response Personnel Professional Qualifications*	Covers the competencies required for awareness, operation, technician, and specialist levels of responders.

Table 1-2. US&R references (continued)

Urban Search and Rescue References	***Title***	***Description***
Emergency Response Guidebook (ERG)	*ERG*	A guidebook intended for use by first responders during the initial phase of a transportation incident involving dangerous goods/hazardous materials.
National Institute for Occupational Safety and Health (NIOSH) Guidelines	*NIOSH Pocket Guide to Chemical Hazards*	NIOSH Pocket Guide to Chemical Hazards as intended as a source of general industrial hygiene information for workers, employers, and occupational health professionals.
NFPA 1670	*Standard on Operations and Training for Technical Search and Rescue Incidents*	Identifies and establishes levels of functional capability for safely and effectively conducting operations at a technical rescue incident.
NFPA 1951	*Standard on Protective Ensembles for Technical Rescue Incidents*	Covers protective clothing and equipment used in technical rescue.
NFPA 1981	*Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*	Establishes levels of respiratory protection and functional requirements for SCBA used by emergency services personnel.

SITE OPERATIONS

1-10. All rescue operations in this training circular will conduct site operations, size up, and search operations in fundamentally the same manner. There are four personnel and equipment areas that will need to be setup. The unit SOP will dictate the arrangement and layout of the base of operations and if more sites are needed. See figure 1-1.



Legend:
rehab — rehabilitation
RIT — rapid intervention team

Figure 1-1. Base of operation

SITE OPERATION

1-11. The selection of a suitable site operations is an important decision made during a deployment. The specific location may be predetermined by the local jurisdiction or the incident commander prior to the arrival of the rescue team. The platoon leader must identify an appropriate site and the following factors should be considered:

- Rapid intervention team.
- Operations/command post area.
- Rescue/cache area.
- Rehabilitation (commonly known as rehab) area.

ZONES

1-12. Ensure that the hot, warm, and cold zones are established prior to site set up. See figure 1-1.

- **Hot zone.** The hot zone is a restricted zone where rescue is taking place. Only personnel who are dealing directly with the treatment or freeing of victims are allowed.
- **Warm zone.** The warm zone is located immediately outside the hot zone and is for personnel directly supporting the rescuers in the hot zone.
- **Cold zone.** The cold zone area surrounds the warm zone and is used for staging vehicles, equipment, and contains the command post.

Note. If in a hazardous material environment, all areas are located in the cold zone.

SITE LAYOUT

1-13. The following are other areas of consideration when developing the site layout:

- **Logistics area.** The logistics area is used for—
  - Coordinating, managing, and supervising all logistical activities.
  - Maintaining accurate and timely records and reports.
  - Ensuring accountability, maintenance, and repairs for all task force equipment.
- **Maintenance area.** When in a maintenance area—
  - Ensure that all tools and equipment are inventoried.
  - Ensure that all operational losses and maintenance requirements of tools and equipment are documented.
  - Track and maintain a listing of the losses of any operational equipment or potential maintenance requirements according to the SOP.
- **Medical treatment area.** The medical treatment area is for when victims have been rescued from the incident site. The rescuers will transfer the patient to a medical specialist for further treatment and evaluation.
- **Medical evacuation area.** The medical evacuation area is a site where ambulances stage to provide ground support to a hospital or a helicopter landing zone.

COMMUNICATION

1-14. Effective communications at technical rescue incident scenes are an absolute necessity. Rescuers and team members will—

- Use clear text and plain English.
- Not use slang “10/4” codes or military jargon due to civilian entities.
- Be clear, concise, and speak at a reasonable pace.
- Use assigned radio designations.

SIZE UP OPERATIONS

1-15. Size up is defined in civilian rescue services as the ongoing evaluation of problems confronted within a rescue operation. Size up starts with the receipt of a mission and continues until the rescue operation is under control. This process is carried out many times and by many different individuals at each rescue event.

1-16. Size up operations is performed upon arrival. Rescuers must confirm that the information received at the reception, staging, onward movement, and integration matches what is actually happening on the ground. The following are areas of consideration:

- Complete a 360-degree assessment.
- Gather/relay information to higher command.
- Conduct a risk/benefit analysis. An acceptable level of risk can only be justified when the potential to save lives is great. When no lives or property can be saved, there is no justification to expose rescue personnel to avoidable risks. This is ongoing throughout the operation.

INCIDENT HAZARDS

1-17. Incident hazards should be managed. Effective scene management should limit access to only those responder's who have a specific operational assignment in order to reduce congestion and confusion. Hazards include—

- Physical hazards.
  - Surface hazards involve debris that is lying about the rescue area on the surface.
  - Unstable debris such as pieces of rubble or other debris that suddenly shift and fall.
  - Overhead obstructions such as loose debris and power lines.
- Environmental hazards.
  - Temperature extremes and adverse weather (such as rain, snow, ice, and wind).
  - High-noise levels.
  - Limited visibility (such as fog, darkness, and smoke).
- Atmospheric hazards.
  - Oxygen deficiencies.
  - Oxygen enrichment.
  - Chemical vapors.

PERSONNEL ACCOUNTABILITY SYSTEMS

1-18. Conduct personnel accountability systems whenever rescue personnel enter the hot zone. The operation's section must track, record, and identify all personnel entering and exiting the hot zone.

- **Radio communications.** The number one accountability system is through radio communications.
- **A name-tag system.** When rescuers are tasked to enter the hot zone, they will give their name tags to the operations section signaling that they are in the hot zone.
- **Unit identifier.** Military units can be identified by their unit patches and unit identification number.

SEARCH OPERATIONS

1-19. Search operations consist of several different types of searches. The team leader must determine the best method of search to conduct given the size up information. During the chaos of the disaster, it is vital that rescuers stay focused on their area of search operations and be expedient and professional.

INCIDENT AREA

1-20. When search teams go into the incident area, they are usually assigned a search area and a search technique they are expected to use. As a trained rescuer, you need to understand the different search techniques.

- **Physical search.** A physical search is performed without using specialized equipment.
  - **Hasty search.** A hasty search is a rapid detection of potential victims.
  - **Secondary search.** A secondary search involves a thorough systematic search and redundant checks.
  - **Hailing/listening.** Rescuers stop regularly to call out and listen for victims.
- **Pattern search.** A pattern search is a tactic used to divide the search area into smaller blocks to prevent overlapping.
- **Technical search.** A technical search involves seismic devices, listening devices, search cameras, and thermal imagers.
  - **Seismic devices.** Seismic devices are electronic devices that are extremely sensitive to movement.
  - **Listening devices.** Listening devices are electronically enhanced to detect sounds. A tiny microphone in the end of a probe can be inserted into openings too small for a rescuer to enter.
  - **Search cameras.** Search cameras are specialized video cameras that use lenses attached to fiber-optic cables. These cameras can be used to look inside voids and other dangerous spaces.
  - **Thermal imagers.** Thermal imagers are infrared heat energy waves similar to light energy. The heat signature from bodies and other heat-producing objects can be blocked by a barrier such as a thick layer of dust.

VICTIM MARKINGS

1-21. Victim marking during a search is necessary to identify the location of potential and known victims. The victim location marks are made by the search team or others aiding the search and rescue operations whenever a known or potential victim is located and is not immediately removed.

- **V.** Make a "V" near the location of the known or potential victim. Mark the name of the search team inside the "V." An arrow indicates the direction and distance of the victim. See figure 1-2.
- **V, with circle.** A "V" with a circle indicates a confirmed live victim's location. See figure 1-3.
- **V, with horizontal line**. A "V" with a horizontal line indicates a confirmed deceased victim. If more than one confirmed deceased victim, mark the total number under the "V." See figure 1-4, page 1-8.
- **V, crossed out**. A "V" crossed out mark an "X" through markings when victims are removed. See figure 1-5, page 1-8.

Figure 1-2. Victim location

Figure 1-3. V with circle

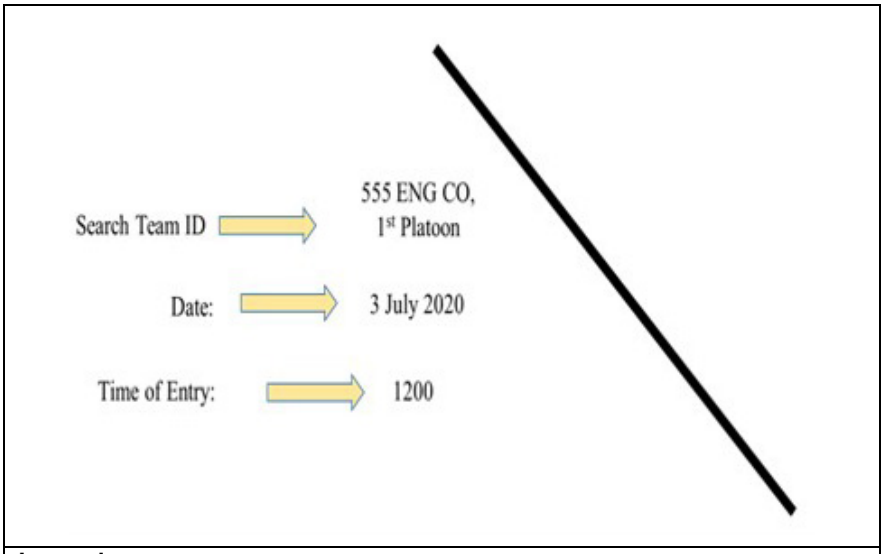
Figure 1-4. V with horizontal marking

Figure 1-5. V crossed out

BUILDING MARKINGS

1-22. As rescuers conduct searches, it is crucial that the structures are marked to avoid confusion and to prevent the same areas from being searched unnecessarily multiple times. See figure 1-6. Ensure that the building marking includes—

- A diagonal line to represent ongoing operations.
- The search teams identification.
- The time of entry.
- The date.

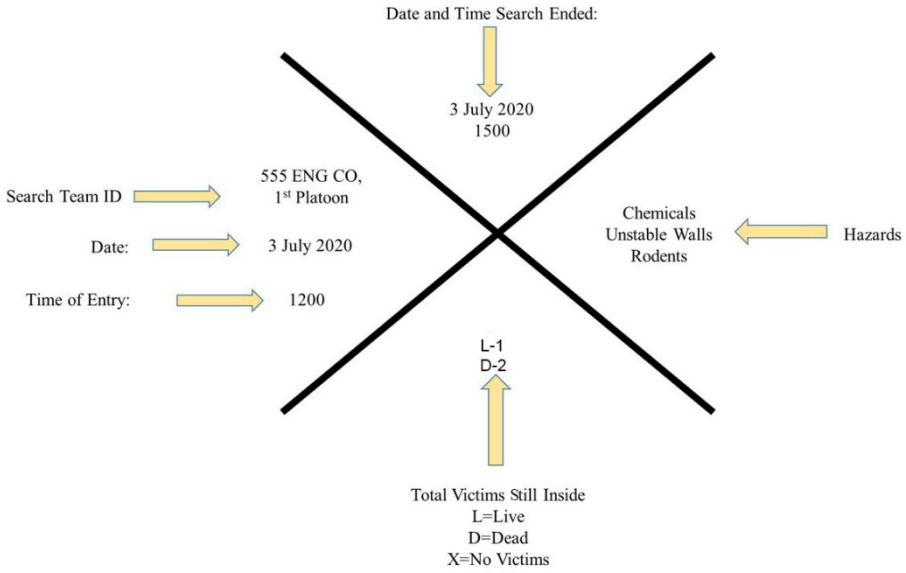


Legend:

CO	company	ID	identification
ENG	engineer		

Figure 1-6. Entry building markup

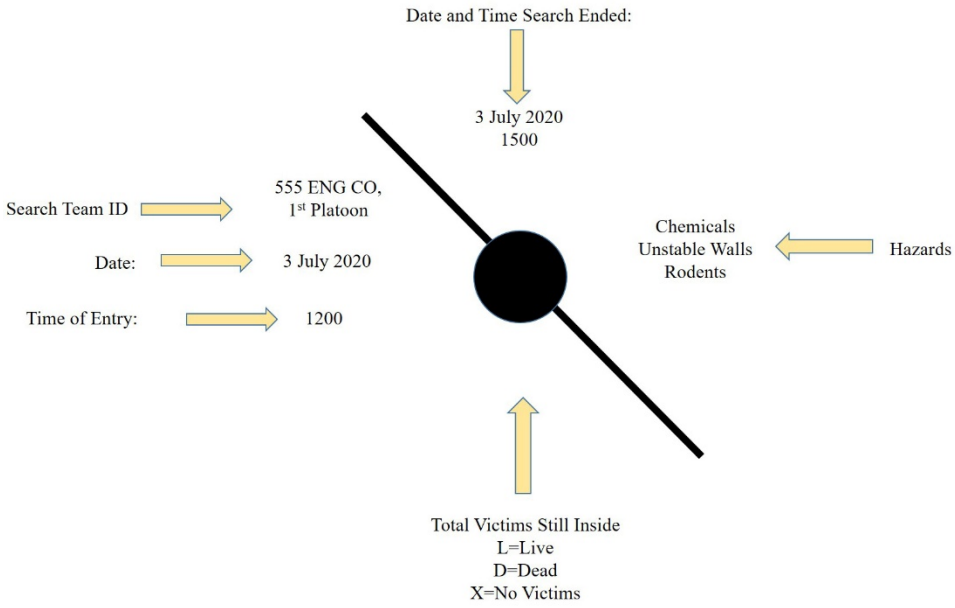
- When search operations are completed, mark with an "X" (see figure 1-7) and include the following:
  - Total victims found (live and dead) in the lower quadrant.
  - Hazards found in the right quadrant.
  - Date and time the search team exited the structure.
- When operations are incomplete (see figure 1-8, page 1-10) add a circle to the middle of the diagonal slash indicating that the structure was not complete. Fill out all the information that is known (unit, date, time, hazards, victims).



Legend:

CO	company
ENG	engineer
ID	identification

Figure 1-7. Completed search, building marking



Legend:

CO	company
ENG	engineer
ID	identification

Figure 1-8. Incomplete building marking

KNOTS, BENDS, AND HITCHES

1-23. There is a technical difference between knots, bends, and hitches. The general term "knots" is used in this manual to denote any of the following three, except where specific names denote the difference.

- **Knot.** A knot creates a closed loop for attachment.
- **Bend.** A bend is used to join ropes together (for example double fisherman, square knot, water knot).
- **Hitch.** A hitch is used to attach a rope (webbing) to an object. Once the object is removed, the hitch will fall apart.

1-24. There are several rescue knots that rescuers need to know how to tie and know the application of each during the rescue operation. Below are the knots that are required for the rescue operations.

- **Overhand knot (safety knot).** The overhand knot is used as a safety to secure the loose end. See figure 1-9. Make an overhand knot by—
  - Forming a loop in the rope.
  - Inserting the end of the rope through the loop.
  - Dressing the knot by pulling on both ends of the rope at the same time.

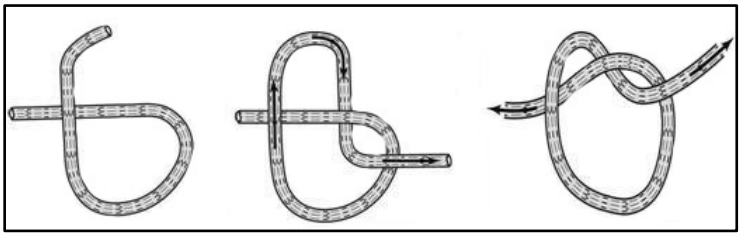


Figure 1-9. Overhand safety knot

- **Figure-eight knot.** A figure-eight knot is used to stop the rope end from moving through a device (brake bar rack, and so forth). See figure 1-10. Make a figure-eight knot by—
  - Making a bight near the end of the rope.
  - Holding the bight and wrapping the running end around the standing end one full turn to make a loop.
  - Passing the running end through the original bight.
  - Dressing the knot.

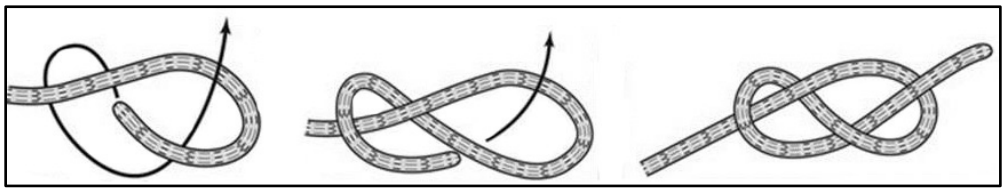


Figure 1-10. Figure-eight knot

- **Figure-eight on a bight.** The figure-eight on a bight is used as an anchor knot that creates a single loop that will not slip. See figure 1-11. Make a figure-eight on a bight by—
  - Forming a bight approximately 12 inches long on the running end of the rope.
  - Passing it over the standing end to form a loop.
  - Passing the bight under the standing end and then over the loop and down through it.
  - Extending the bight through the knot to whatever size working loop is needed.
  - Tightening the knot by pulling on both ends simultaneously.
  - Dressing the knot.

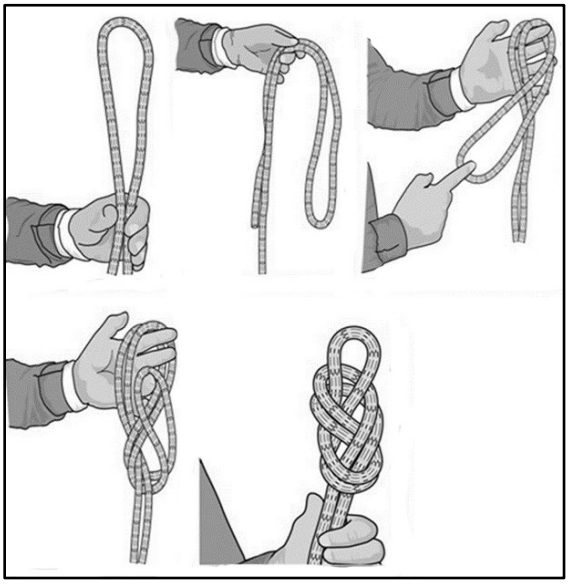


Figure 1-11. Figure-eight on a bite

- **Figure-eight follow through.** A figure-eight follow through is used as an anchor knot, tied around an object. See figure 1-12, page 1-12. Make a figure-eight follow through by—
  - Tying a loose figure-eight knot.
  - Passing the running end of the rope around the object to be secured.
  - Routing the running end of the rope back through the original figure eight in reverse order.
  - Exiting the knot beside the standing end to complete the knot.
  - Dressing the knot.

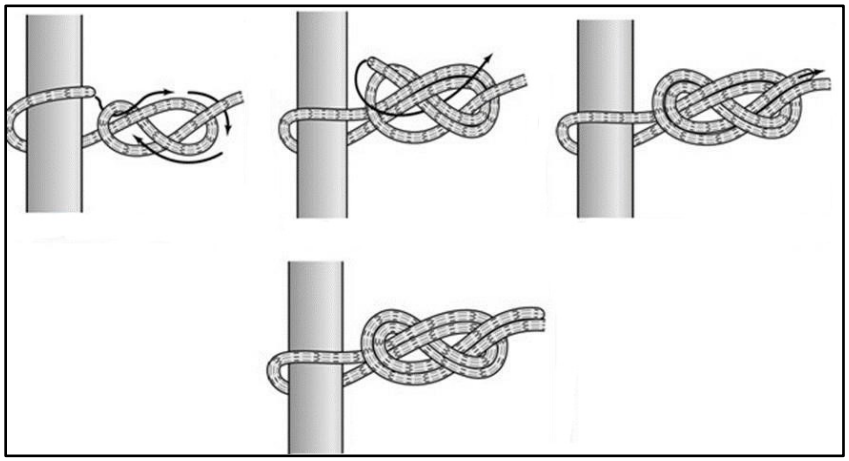


Figure 1-12. Figure-eight follow through

- **Butterfly knot.** A butterfly knot is used as a bridle knot that provides a midline attachment point and is designed to take a three directional pull. See figure 1-13. Make a butterfly knot by—
  - Holding one hand thumb up with the palm facing the body.
  - Placing the rope across the palm.
  - Wrapping the rope from the top of the hand around the hand to form a loop that crosses in the palm towards the wrist.
  - Making another wrap with the rope so this loop is nearest the wrist.
  - Pulling the middle wrap away from the palm and towards the wrist so it forms a bight.
  - Pushing the bight between the remaining wraps and the palm and towards the fingers.
  - Tightening the knot slightly and then pulling the bight in one hand and the two legs in the other.
  - Setting the knot by pulling the two legs in opposite directions.
  - Dressing the knot.

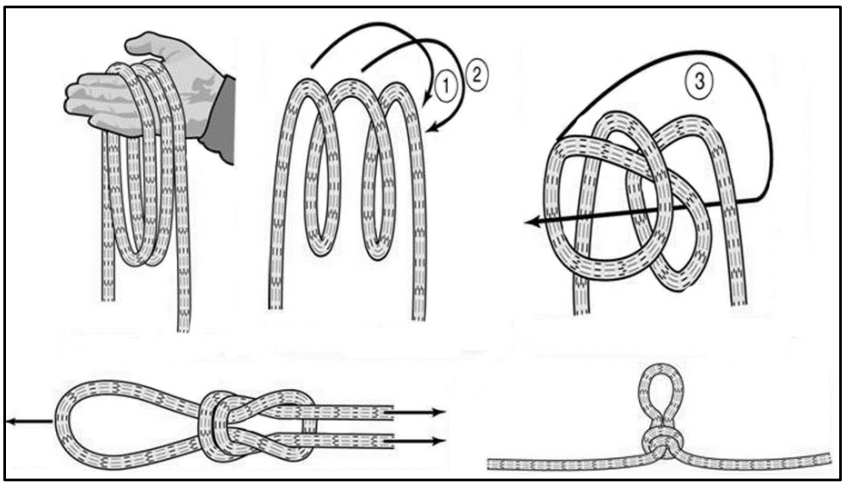


Figure 1-13. Butterfly knot

- **Figure-eight on a bend.** A figure-eight on a bend is used to join two ropes together for load bearing purposes. See figure 1-14. Make a figure-eight on a bend by—
  - Tying a figure-eight knot on one end of the first rope.
  - Feeding the end of the second rope through the figure-eight knot in reverse so it follows the exact path of the first knot.

- Pulling the knot tight from both ends.
- Safetying the knot by making an overhand knot using the working end of each side of the knot.
- Dressing the knot.

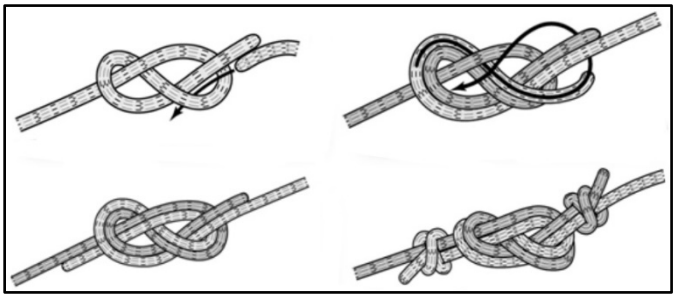


Figure 1-14. Figure-eight on a bend

- **Square knot.** A square knot is used to "bind" two ropes of the same diameter together. See figure 1-15. Make a square knot by—
  - Taking one line in your right hand, one line in your left, and laying the right over the left.
  - Passing the right end over the left end and back under the left.
  - Passing the left end over the right end and back under the right.
  - Checking the knot (the two loops should slide on each other).
  - Tightening by pulling both ends on each side of the knot.
  - "Safetying" the square knot by making an overhand knot using the working end of each side of the knot.

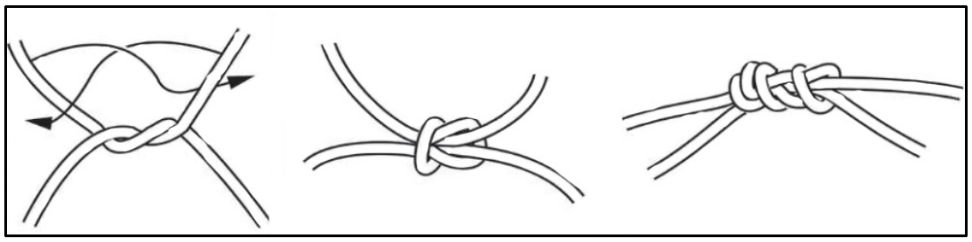


Figure 1-15. Square knot

WARNING

Square knots should not be used in load-bearing applications or to support a human load. Always safety the loose ends.

- **Water knot.** A water knot is used to join two pieces of webbing for load bearing applications. (The knot loses 50 percent efficiency when tied.). See figure 1-16. Make a water knot by—
  - Tying a loose overhand knot with one end of the webbing.
  - Feeding the other end back through the knot, following the path of the first rope in reverse.
  - Drawing tight and pulling all of the slack out of the knot.
  - Dressing the knot.

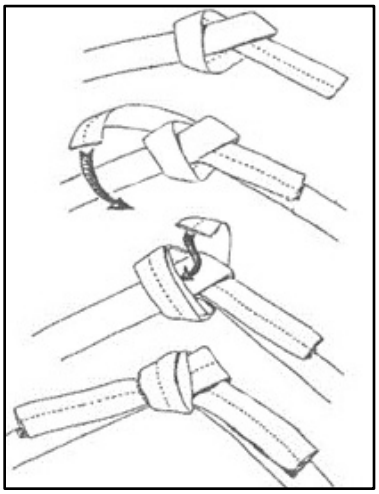


Figure 1-16. Water knot

- **Double fisherman's knot.** A double fisherman's knot is used to join two ropes of equal (or slightly unequal) diameter together for load-bearing applications. See figure 1-17. Make a double fisherman's knot by—
  - Holding two ropes horizontally and parallel to each other, with the tails in opposite directions.
  - Using one tail and forming a loop around the other rope so the loop crosses itself.
  - Continuing to wrap the tail end around the same side of the cross for two full wraps.
  - Passing the tail end of the rope through the center of its own loops.
  - Dressing this half of the knot.
  - Repeating the procedure in the opposite direction with the other tail.
  - Pulling the ropes in opposite directions so both knots slide together.

Note. When complete, the knot should have two crosses on one side and four wraps on the other.

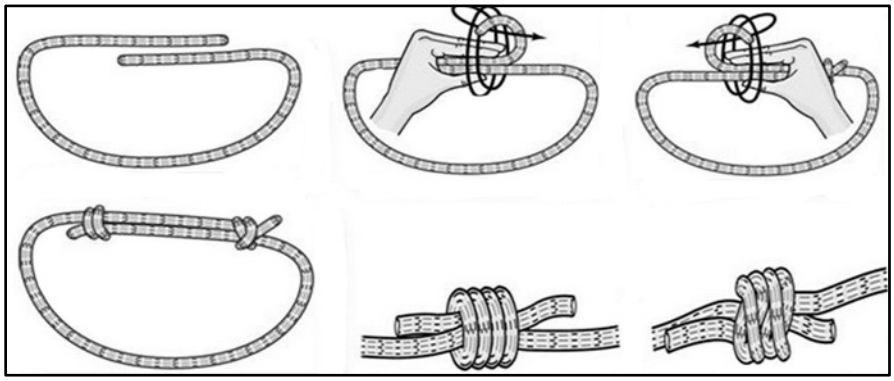


Figure 1-17.Double fisherman's bend

- **Clove hitch (middle of the rope)**. A clove hitch (middle of the rope) is an adjustable anchor hitch that can be used horizontally or vertically. See figure 1-18. Make a clove hitch (middle of the rope) by—
  - Forming a loop in your left hand with the running end to the right crossing under the standing end.
  - Forming another loop in your right hand (creating a round turn) with the running end crossing under the standing end.
  - Sliding the right-hand loop on top of the left-hand loop.
  - Holding the two loops together at the rope forming the clove hitch.
  - Sliding the knot over the object.
  - Pulling the ends in opposite directions to tighten.

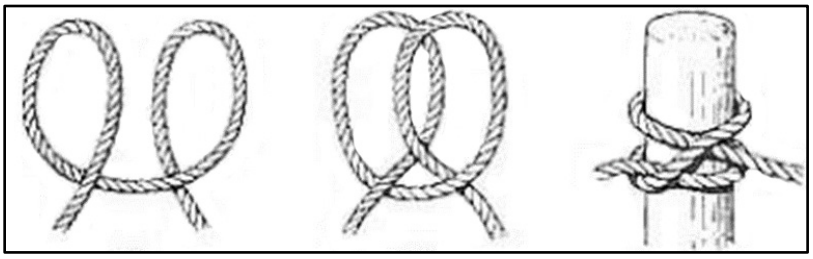


Figure 1-18. Clove hitch (middle of the rope)

- **Clove hitch (end of the rope).** A clove hitch (end of the rope) is an adjustable anchor hitch that can be used horizontally or vertically. See figure 1-19. Make a clove hitch (end of the rope) by—
  - Making a complete loop around the object and crossing the working end over the standing end.
  - Completing the round turn around the object just above the first loop.
  - Passing the working end under the upper wraps, just under the cross "X."
  - Securing the knot by tying an overhand knot on the standing end of the rope.

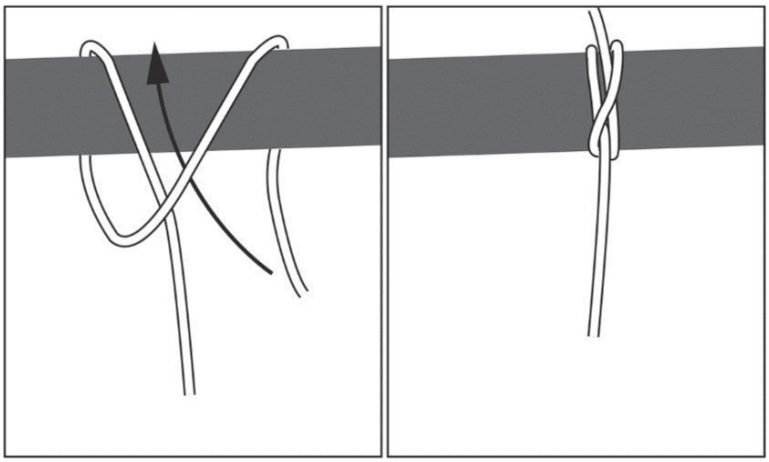


Figure 1-19. Clove hitch (end of the rope)

- **Girth hitch.** A girth hitch is used to anchor rope or webbing as a choker. See figure 1-20, page 1-16. Make a girth hitch by—
  - Creating a bight in the rope.
  - Wrapping the bight of the rope around the object it is to be attached.
  - Feeding both ends (tails) of the rope through the bight.
  - Pulling both ends of the rope to tighten the hitch.

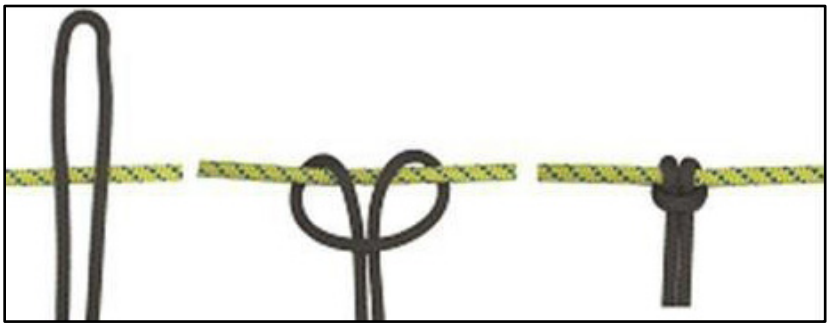


Figure 1-20. Girth hitch

- **Prusik hitch.** A Prusik hitch is used for hauling, ascending, and self-rescue. The hitch serves as a "soft" rope grab around a larger diameter rope. See figure 1-21. Make a Prusik hitch by—
  - Placing the Prusik cord under the main line rope.
  - Wrapping the loop of the Prusik cord around the main line rope two or three times depending on the intended use.
  - Grab the Prusik hitch on one side of the knot and pulling so that a loop is created with the knot along the side of the loop.
  - Dressing the knot so there is maximum surface contact between the Prusik cord and the main line rope.

Note. This hitch is formed around a rope using an accessory cord tied into a loop with the double fisherman knot.

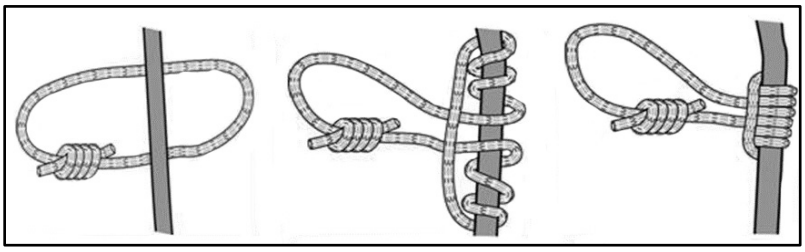


Figure 1-21. Prusik hitch

ROPES USED IN RESCUE OPERATIONS

1-25. Rope systems may be the only means of reaching and moving victims to ground level that are trapped or stranded above or below grade. It may be necessary to lower rescuers into a rescue environment and to hoist a victim out using life safety rope, webbing, and hardware. In some cases, the victims themselves must be lowered. This section describes the components used to combine ropes and related tools into efficient systems for moving people and tools in many environments and situations.

NATIONAL FIRE PROTECTION ASSOCIATION ROPE STANDARDS

1-26. Refer to NFPA 1983 for NFPA's rope standards. Standards include—

- **Rescue ropes, harnesses, and equipment.**
  - One person load (300 pounds).
  - Two person load (600 pounds).
- **Software.** Software includes—
  - Kernmantle rope: 9,000 pounds minimum breaking strength.
  - Tubular webbing: 4,000 pounds minimum breaking strength.

- Flat webbing: 6,000 pounds minimum breaking strength.
- Anchor straps: 10,000 pounds minimum breaking strength.

- **Hardware.** Hardware includes—
  - Carabiners: 9,000 pounds minimum breaking strength.
  - Anchor/rigging plates: 8,000 pounds minimum breaking strength.
  - Brake bar rack: 5,000 pounds minimum breaking strength.
  - Figure-eight plate: 5,000 pounds minimum breaking strength.
  - Pulleys: 8,000 pounds minimum breaking strength.
  - Mechanical rope grabs: 2,500 pounds to a maximum of 5,000 pounds minimum breaking strength.
- **Inspection criteria.** The inspection criteria for all US&R rescue equipment must include the following:
  - Not visibly damaged.
  - Never expose to heat, direct flame impingement, or abrasion.
  - Never subject to any impact load.
  - Never expose ropes to hazardous liquids, solids, gases, mists, or vapors because they will deteriorate the rope.
  - Passes the manufacturer's recommended inspection procedures before and after.
- **Rope retirement.** Rope retirement requires the manufacturer of the rescue rope to provide the purchaser with the retirement criteria. Remove the rope from service if there is—
  - Sheath damage.
  - Core damage.
  - A shock force (such as a 300 pound load falling 1 foot on a 4-foot section of rope). This is a fall factor of .25 and, assuming a 5 percent stretch, generates a force of approximately 1,600 pounds.
  - Severe overloading. General use ropes are limited to support load masses less than 600 pounds.

ROPE MAINTENANCE AND USAGE LOG

1-27. In order for rescue rope to be ready and safe for use when needed, it must be properly maintained. This maintenance involves following the manufacturers' recommendations for proper inspection, cleaning, and storage of the rope. NFPA 1983 requires manufactures of certified life safety rope and component systems to furnish purchasers with inspection procedures, maintenance procedures and retirement procedures. See figure 1-22, page 1-18.

STATIC SYSTEM SAFETY FACTOR

1-28. The Static System Safety Factor (SSSF) is the strength of the weakest rescue system component divided by the load placed upon it. Assess the safety factors of each component (or manufactured system) within the rescue system to determine which one is the weakest link and, therefore, the ultimate overall strength of the system. The rope rescue SSSF must be greater than 10:1.

1-29. For example, a carabineer rated at 9,000 pounds breaking strength has a force of 600 pounds placed upon it. There is a 15:1 component safety factor (9,000/600 = 15).

RESCUE ROPE USAGE HISTORY

Bag Number: EVAC #1	Manufacturo: Sterling
Lot Number: 1524	Date of Manufacture: Yr 15 wk 24
Date of Purchase:	Type: Nylon
In Service Date: 5 Jan 2016	Date of Issue: 5 Jan 2016
Diameter: 1/2"	Brand: Super Static 2
Length: 200'	Color: Blue

Date Used	LOCATION	TYPE OF USE	ROPE EXPOSURE	DATE INSPECTED	INITIALS	CONDITIONS/COMMENTS
23 Jul 19	North Tower	Belay	NA	23 Jul 19	FOL	Pick Off
24 Jul 19	North Tower	Belay	NA	24 Jul 19	FOL	Pick Off
25 Jul 19	North Tower	Belay	NA	25 Jul 19	FOL	Pick Off
23 Aug 19	Machine Shed	Belay	NA	23 Aug 19	FOL	Ascend/Descend
24 Aug 19	Machine Shed	Belay	NA	24 Aug 19	FOL	Ascend/Descend
30 Sep 19	North Tower	Belay	NA	30 Sep 19	FOL	Pick Off
2 Oct 19	North Tower	Belay	NA	2 Oct 19	FOL	Man Made
19 Oct 19	Machine Shed	Belay	NA	19 Oct 19	FOL	Ascend/Descend
21 Oct 19	Machine Shed	Belay	NA	21 Oct 19	FOL	Ascend/Descend
26 Oct 19	Machine Shed	Belay	NA	26 Oct 19	FOL	Ascend/Descend

SAMPLE

Figure 1-22. Sample rescue rope usage history

ANCHORS AND ANCHOR SYSTEMS

1-30. The following paragraphs expands on the knowledge and introduces anchors and anchor systems that are important for the rescuers to understand.

ANCHORS

1-31. All anchors must fulfill the same function—to provide a safe and dependable means of securing the rope rescue system to an anchor point.

- Bombproof anchors include—
  - Live trees greater than 6 inches in diameter and trees with deep root systems.
  - Large rocks.
  - Structural support beams.
  - Supports for large machinery.
  - Large-diameter steel pipe.
  - Reinforced or bulk masonry.
  - Reinforced structural concrete columns.
  - Vehicles.
- Avoid the following anchor points:
  - Bolted or welded railings in a stairwell.
  - Insulated pipe.
  - Lightweight or unsupported handrails.
  - Fire hydrants or monitors.
  - Corroded metals.
  - Cast-iron or small-diameter threaded pipes.

- Rooftop air-conditioning units.
- Vent pipes.

ANCHOR SYSTEMS

1-32. Once the anchor has been identified, it is the rescuers responsibility to determine which anchor system to use. The situation and the mission will determine which system to use and what equipment they have on hand.

- **Tensionless anchor.** The diameter of the anchor must be at least 4 times the rope diameter. A minimum of four wraps is required. For example, a 1/2-life safety rope must use a minimum anchor that is 2 inches in diameter.
- **Anchor strap.** The anchor strap is sheathed in heavy duty nylon webbing to protect the inner core from abrasion and wear, and is one of the most cost effective anchor systems.
- **Wrap three/pull two.** Three wraps on the back side of the anchor and two on the front side.
- **Basket hitch.** A basket hitch employs a closed loop made of rope or webbing.

CONSTRUCT A BELAY SYSTEM

1-33. Belay systems are used in all rope rescue operations as a redundant safety mechanism to support the entire weight of the load (rescuer, victim, and any device) should some element of the system fail completely. The belay system will always be tended in order to minimize the possibility of any free fall hazard. The responder tending the belay rope, extends or retracts this rope as the responder moves within the hazard zone.

- Construct a tandem Prusik belay. See figure 1-23.
  - Construct an anchor system for the given incident (use a different anchor than the main line).
  - Attach an anchor plate to the anchor system with a carabineer.
  - Reeve the rope around the Prusik minded pulley.
  - Attach the Prusik minding pulley to the anchor plate with a carabineer.
  - Tie both pieces of accessory cord into the Prusik loops and attach to the “load” side of the pulley using a triple wrap Prusik that is the shortest and should be closest to the pulley.
  - Attach both loops to the carabineer.
  - Place edge protection.
  - Keep the thumbs up when operating the belay.

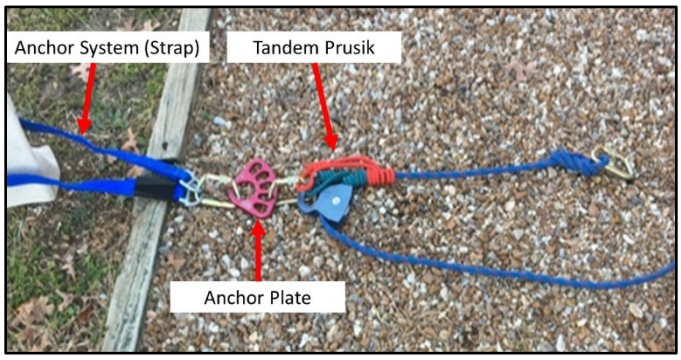


Figure 1-23. Construct a belay system

MECHANICAL ADVANTAGES

1-34. The mechanical advantage is a measure of the ratio of output force to input force in a system. This is used to analyze the forces in simple machines like levers and pulleys. Despite changing the forces that are applied, the conservation of energy is still true and the output energy is still equal to the input energy.

1-35. Construct a 3:1 mechanical advantage system by—

- Reaving the haul line around the sheave of a traveling pulley.
- Attaching a triple wrap Prusik to the load line close to the edge.
- Connecting the traveling pulley with a carabineer to the triple wrap Prusik.
- Conducting a system safety check.

1-36. Constructing a 5:1 mechanical advantage system (see figure 1-24) by—

- Constructing a 3:1 mechanical advantage system (see figure 1-25).
- Reaving the haul line around the sheave of a stationary pulley.
- Attaching the stationary pulley to the anchor plate with a carabineer.
- Reaving the haul line around the sheave of a second traveling pulley.
- Connecting the second traveling pulley with the same carabineer that was used in the 3:1 mechanical advantage system.
- Conducting a system safety check.

Figure 1-24. 5:1 mechanical advantage system

Figure 1-25. 3:1 mechanical advantage system

MARINER'S HITCH (LOAD RELEASING HITCH)

1-37. See figure 1-26. The mariner's hitch is used in the rack, pulley mariner ahead of a directional change pulley to allow tension on the main line to be released in the event the load becomes caught on a rock or other obstacle. It is also used to capture the main line during a change over from a lowering to raising system, and vice versa.

- Make a mariner's hitch using the following equipment:
  - Three carabineers.
  - One 16-foot length of 1-inch webbing.
  - Always construct two mariner's hitches.

- Construct a mariner's hitch by—
  - Folding the 16 to 20 foot length of webbing in half with no twists.
  - Tying the two ends together with a water knot.
  - Attaching a carabineer to a bight of the webbing (not on the knot).
  - Forming a "X" in the webbing 12 inches from the first carabineer (needs to be longer than a brake bar rack).
  - Connecting a second carabineer through both strands of webbing.
  - Folding the webbing back onto itself and passing it back through the first carabineer.
  - Wrapping the webbing back through the second carabineer.
  - Frapping the remaining webbing around the outside of the wrappings that were already created.
  - Passing the end of the webbing through the center of the original wrappings.
  - Attaching a third carabineer to the end of the webbing (this carabineer will remain unlocked).
  - Securing the unlocked carabineer to a locked carabineer to prevent the hitch from unwinding.

Figure 1-26. Mariner's hitch

- Attach the rack, pulley mariner system to the anchor system. See figure 1-27. Attach the—
  - Brake bar rack with a carabineer to the hole on the left side of the anchor plate.
  - Pulley with a carabineer to one of the middle holes.
  - Long Prusik loop to the same carabineer as the pulley.
  - Mariner's hitch to the hole on the right side with the carabineer.
  - Prusik minding pulley and the Prusik loop to the carabineer on the opposite end of the mariner's hitch.

Figure 1-27. Attach the rack, pulley mariner system to the anchor system

- Operate the mariner's hitch by—
  - Removing the carabineer that secures the end of the webbing.
  - Slowly unwrapping the webbing between the two carabineers.
  - Releasing the tension on the system.
  - Threading the webbing through the bight to extend the release length of the hitch.

LOWERING SYSTEMS

1-38. Once lowering operations are completed, the rescuer and victim most often must be pulled back up to a safe area. This is accomplished by using mechanical advantage or haul systems. In order to accomplish this, the rescuer must know how to convert a lowering system to a raising system. This initial conversion process will be the same for all mechanical advantage systems in this course. See figure 1-28.

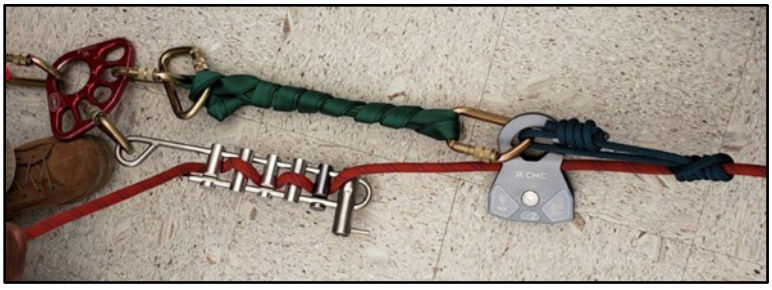


Figure 1-28. Lowering system

- Lower to raise conversion—3:1 in-line rack, pulley mariner.
  - Tie off the decent control device as shown. See figure 1-29.
  - Attach the Prusik to the line.
  - Set the ratchet Prusik.
  - Remove the line from the decent control device.

Figure 1-29. Lower to a raise conversion

  - Route the line through the change of direction pulley. See figure 1-30.
  - Attach to the single carabineer of the mariner's hitch.
  - Attach the haul Prusik to the line as close to the edge, the high directional, or other change of direction pulley as possible.
  - Install the haul line in the mechanical advantage pulley.
  - Connect the mechanical advantage pulley to the haul Prusik with a carabineer.

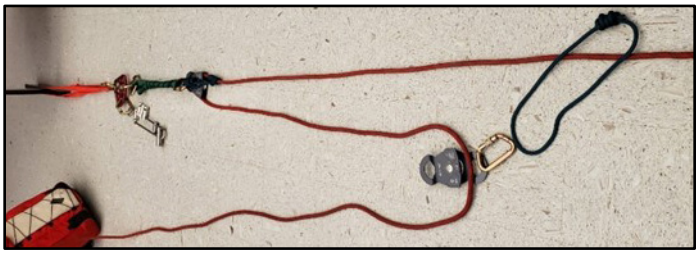


Figure 1-30. Change of direction pulley

- Construct a raising (mechanical advantage) systems. See figure 1-31.
  - Attach the haul Prusik to the line on the haul side of the change of direction pulley on the rack, pulley mariner.
  - Install the haul line in the second mechanical advantage pulley.
  - Connect the second mechanical advantage pulley to the haul Prusik with a carabineer.

Figure 1-31. Raising system 3:0

VICTIM MANAGEMENT

1-39. One of the most challenging aspects of managing a technical search and rescue incident may be handling the victims of the incident. Responders must be prepared to assess and treat a variety of injuries while maintaining professionalism. Rescuers must also protect both themselves and the victims while minding the operational aspects of the incident. The size up report should identify what type of packaging device will be required.

VICTIM PACKAGING AND REMOVAL

1-40. The long spine board, also known as a backboard, is used to provide complete immobilization of a victim's spinal column. Other variations include the Miller board. Use the following procedures to package and remove a victim:

- Use the log roll technique for spine board (apply a cervical collar). See figure 1-32, page 1-24.
  - First the rescuer will place their hands on the victims shoulder and the waist (step 1 in figure 1-32).
  - The second rescuer will place their hand on the victim's hip and one on the thigh (step 2 in figure 1-32).
  - The third rescuer will place their hand on the victim's knee and one on the ankle.
  - The rescuers roll the victim slightly toward them.
  - The rescuers turn the victim's head keeping it in straight line with the spine (step 3 in figure 1-32).
  - The rescuers reach across the victim with one hand and grasp the spine board at its closed edge.
  - The rescuers slide the spine board against the victim.
  - The rescuers reach across the board and hold in place to prevent board movement.
  - The rescuers slowly roll the victim back on the board.
  - The rescuers place the victim's wrist together at the waist and tie them together loosely (step 4 in figure 1-32, page 1-24).

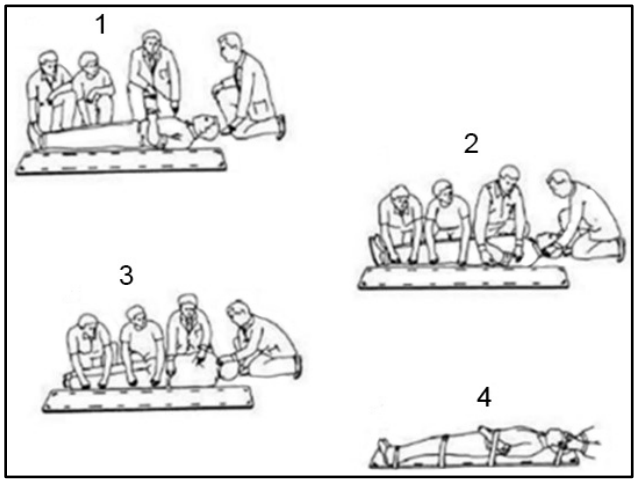


Figure 1-32. Log roll technique

- Secure the victim to the long spine board (used anytime a victim is placed in a Sked® or Stokes) by—
  - Securing the victim's torso and lower extremities with straps placed across the victim's waist, thighs, lower legs, and chest.
  - Securing the victims head to the board with straps or cravats.
  - Placing material on each side of the victims head.
  - Using a cravat-like material across the forehead, and tie it to the back board so head does not move.
  - Ensuring that a strap is not placed over an injury or a joint.

YATES© SPECIALTY PAK

1-41. A Yates Specialty Pak is a patient packaging and extrication system that combines the backboard immobilization of a short board with the suspension and support of a full body harness. Package a victim by doing the following steps:

- Remove the harness from the bag.
- Open the self-stick straps on the sliding head block.
- Rotate the victim onto their side while maintaining spinal immobilization.
- Place the harness against the back of the victim.
- Ensure the victim's waist is positioned at the waist belt strap.
- Rotate the victim flat onto their back while maintaining spinal immobilization.
- Ensure that all straps are accessible.
- Secure the waist belt strap around the victim using the buckle and pull snug.
- Secure the leg straps using the buckle and pull snug.
- Secure the chest strap using the buckle and pull snug.
- Secure the victim's head to the sliding head block using self-stick straps.

SKED BASIC RESCUE SYSTEM

1-42. A Sked Basic Rescue System is used for the most demanding, ascending, descending, and confined spaces with or without a spine board based on situation. Use the Sked system by—

- Securing the victim into the Sked by doing the following:
  - Unfasten the retainer strap, step on the foot end of the Sked, and unroll completely.
  - Immobilize the victim as needed. Typically a back board is used in conjunction with the Sked.
  - Buckle the cross straps.

- Lift the sides of the Sked system and feed the four cross straps to the buckles directly opposite the cross straps.
- Pull the four straps until each one is secured through the buckles.
- Tie the excess straps with a half hitch and tuck the excess on the inside of the Sked system.
- Tighten the straps enough to hold the victim in place.
- Buckle the foot straps.
- Feed the foot straps through the unused grommets located at the bottom cross strap (near the foot end) from the inside through to the outside.
- Pull the two foot straps and feed them to the buckles located on the same side.
- Tie the excess foot straps with a half hitch and tuck the excess on the inside of the Sked.

- Setting up horizontal lift/descent by—
  - Securing the head end of the Sked system up and over the patients head by tying the preattached handle to a convenient cross strap.
  - Using the shorter of the lifting straps at the head end.
  - Inserting one end of the head strap through the angled slot at the head end of the stretcher.
  - Bringing the strap under the Sked and through the lift slot on the opposite side.
  - Repeating the procedure with the other strap at the foot end.
  - Equalizing all four straps and securing them to the two steel locking carabineers.
  - Connecting the carabineers to the rope rescue system.
- Setting up vertical lift/descent (as needed) by—
  - Securing the head end of the Sked system up and over the victim's head by tying the preattached handle to a convenient strap.
  - Tying a figure eight on a bight in the middle of the 30-foot half-inch kernmantle rope.
  - Passing each end of the rope through grommets at the head end of stretcher from the outside inward.
  - Pulling the knot up against the Sked system.
  - Feeding the rope through the unused grommets and each carrying handle all the way to the foot end of the Sked.
  - Passing the rope ends through the grommets at the foot end of the Sked system from the inside outward.
  - Tying the ends of the rope together with a square knot.
  - Bringing the ends of rope up over the end of the Sked and passing them through the carrying handles and tying the ends together with a square knot.
  - Inserting the large locking carabineer.
  - Unscrewing the locking gate on the large carabineer and opening to accept the sling ends.
  - Inserting the large carabineer through one of the ends of the head horizontal lift sling.
  - Inserting the large carabineer through both ends of the foot horizontal lift sling.
  - Inserting the large carabineer through the horizontal lift sling.
  - Locking the gate on the large carabineer.
  - Performing final safety check.

STOKES BASKET

1-43. A Stokes basket is used for low/high angle rescue. See figure 1-33, page 2-27. Use the Stokes basket by—

- Securing the victim in the Stokes basket by—
  - Securing the victim on a long spine board or Miller board.
  - Preparing the basket.

- Placing the victim in the basket and ensuring that the victim is wearing a harness.
- Securing the victim in the basket.
- Tying a girth hitch around the head of the spine board handle using one end of a 5-foot piece of webbing.
- Tying the two round turns with two overhand safeties around the bottom rail of the basket with the other end of the 5-foot piece of webbing.
- Pulling the slack to ensure that it is tight before tying the two round turns with the two overhand safeties.
- Finding the center of a 20-foot piece of webbing by folding it in half.
- Tying a girth hitch around the victim's carabineer with the middle section of the webbing.
- Tying the two round turns with two overhand safeties around the vertical post found at the top (head end) of the basket using one of the legs of the 20-foot piece of webbing.
- Pulling the slack from the leg to ensure that it is tight before tying the two round turns with the overhand safety.
- Tying another two round turns with two overhand safeties around the vertical post found at the top (head end) of the basket using the other leg of the 20-foot piece of webbing.
- Pulling the slack from the leg to ensure that it is tight before tying the two round turns with two overhand safeties.
- Finding the center of another 20-foot piece of webbing by folding it in half.
- Tying a girth hitch around the victim's carabineer with the middle section of the webbing.

Note. Do not cross load the carabineer.

- Tying two round turns with two overhand safeties around the vertical post found at the bottom (foot end) of the basket using one of the legs of the 20-foot piece of webbing.
- Pulling the slack from the leg to ensure that it is tight before tying the two round turns with two overhand safeties.
- Tying another two round turns with two overhand safeties around the vertical post found at the bottom (foot end) of the basket using the other leg of the 20-foot piece of webbing.

Note. Pull the slack from the leg to ensure that it is tight before tying the two round turns with two overhand safeties.

- Securing the exterior lashing (diamond lashing) by—
  - Finding the center of a 30-foot piece of webbing by folding it in half.
  - Tying a girth hitch around the bottom rail of the basket litter at the foot of the basket with the middle section of webbing.
  - Lacing the webbing back and forth (crossing) through opposite points along the side rails of the basket toward the head using a round turn on each vertical post.

Note. Always go around vertical posts and never the top rail.

WARNING

Never lash horizontally across the upper chest near the neck. This could strangle the victim if they slide down.

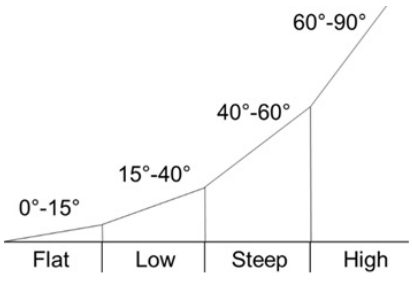
- Pulling the slack from each leg, when each leg of webbing of the lashing reaches chest height, to ensure that it is tight before tying the two round turns with two overhand safeties.

- Rigging the Stokes basket for a vertical lift by—
  - Tying a figure-eight-on-a-bight in the middle of a 25-foot rope. You have two ends of the rope.
  - Routing both ends of the rope through the vertical posts and wrapping each end three times around horizontal bar.
  - Being sure to keep the figure-eight-on-a-bight in between the two vertical posts and as close as possible to the head of the basket.
  - Taking one end and intertwine the rope around the top rail all the way to the foot end of the Stokes basket. Ensuring that you do the same thing to the other side of the top rail with the other end piece of the rope.
  - Create a round turn around the post. There are two vertical posts just like the two at the head end. Each end of the rope needs to go in between the two vertical posts. Create a round turn around the post.
  - Tying a square knot with safety knots on both ends.

Figure 1-33. Secure victim in Stokes basket

LOW-ANGLE RESCUE

1-44. Low-angle rescues may occur either above or below grade where the angle of the slope is shallow enough to allow safe movement without a rope. Depending on the assistance the victims need, one or more hauling systems may be used. If a victim must be moved in a basket litter, a team will carry the litter. Hazards at a low-angle rescue include navigation of any irregularities in terrain and the possible presence of wildlife. Figure 1-34 is a graph that depicts what a low angle is and progresses to a high angle.



Nontechnical	Technical
• Litter carries. • One rope belay possible. • Rescuers not tied to system. • Less risk. • Majority of weight on the ground.	• Two rope system required. • Two person belay. • Rescuers tied into the system. • Much greater risk. • Majority of weight on the rope.

Figure 1-34. Degree of slope

1-45. The following consists of the procedures to conduct a low angle rescue:

- Perform litter tender duties with three rescuers by—
  - Building a lowering system to accommodate the load.
  - Building a belay system.
  - Rigging the Stokes basket for a vertical lift as previously discussed.
  - Attaching the belay system to the Stokes basket.
  - Tying a butterfly knot 4 to 6 feet from the terminal end.
  - Attaching the butterfly to the alpine lace with a carabineer.
  - Placing the terminal end into the basket.
  - Attaching the main line rope to the Stokes basket and rescuers.
- Attach the rescuers to the Stokes basket.
  - **Rescuer one.** Rescuer one is located on the right side of the patients head will secure himself to the Stokes basket using a short Prusik cord girth hitched around the top rail of the basket and secured to his harness with a carabineer.
  - **Rescuer two.** Rescuer two is located at the patient's feet and secures himself to the Stokes basket.
  - **Rescuer three.** Rescuer three is located on the left side of the patients head. He secures himself to the Stokes basket using a short Prusik cord girth hitched around the top rail of the basket and secured to his harness with a carabineer.
- Prepare to descend down range by—
  - Ensuring that the edge tender uses the following commands: *main line ready*, *on belay*, and *lower*.
  - Maneuvering down the grade and around the obstacles to the victim.
  - Securing the victim to the transfer device.
  - Attaching the belay line to the victim.
  - Attaching the terminal end to the victims harness with a carabineer.
  - Attaching the rescuers to the main line and basket.
- Lift the victim.
  - All three litter bearers should face toward the victims head, kneel, and grab the litter handles.
  - The number one position gives the preparatory command *prepare to lift* and *lift*.
  - Upon the command of execution *lift*, all three litter bearers will stand simultaneously.
  - Once the litter is lifted off of the ground and all three litter bearers are standing, the command to proceed is *three person carry, move*.
  - The number one rescuer gives the preparatory command *prepare to haul* to the haul team.

TERMINATE THE INCIDENT

1-46. The US&R team leader establishes incident objectives, strategies, and priorities during the termination phase. The team leader

- Assumes overall responsibility for the incident termination.
- Sends reports to the incident commander and manages the transfer of responsibilities.
- Ensures incident safety, provides information to internal and external stakeholders, and establishes and maintains liaison with other agencies participating in the incident.
- Directs the recovery of the tactical response.
- Submits briefings and situation reports to the incident commander, and ensures all personnel are debriefed.
- Maintains reports, forms, and all rescue related objectives according to the unit SOPs and regulations.
- Conducts the incident debriefing (after action review).

Chapter 2

Rope Rescue

Rope rescue is a subset of technical rescue that involves the use of hardware and software associated to rope rescue. Kernmantle (kern = core and mantle = sheath) rope as it is called, is available in various types—dynamic or static (actually low stretch), which is most commonly used in rescue and industrial rope work. The key to any type of rescue is understanding and identifying the principles which are involved. Once the principles are identified, appropriate techniques or methods, which fits the circumstances can be determined and applied.

ROPE RESCUE LEVEL I

2-1. Rope rescue involves using ropes, webbing, and equipment to access and remove victims who are located on a higher or lower level than the rescuers. This chapter expands on the knowledge and introduces more advanced concepts that are important for the responder to understand.

2-2. Personnel will be certified in the following tasks according to NFPA 1006:

- Construct a multiple-point anchor system.
- Anchor angle forces.
- Construct a picket anchor system.
- Construct mechanical advantage systems.
- Construct a fixed rope system.
- Ascend and descend a fixed rope.
- Establish procedures for passing a knot.

MULTIPLE-POINT ANCHOR SYSTEM CONSTRUCTION

2-3. Multiple-point anchor systems are constructed from multiple single point anchors. This system is used when there may be some doubt that one anchor point is sufficient to carry the expected load.

LOAD SHARING

2-4. Load-sharing anchor systems allow the load to be distributed between two or more anchor points. These systems work well as long as the direction of pull remains constant; however, if the direction of pull changes, the entire load can shift to one of the anchors. The SSSF is the ratio between the force that will be applied to a component in a system and the minimum breaking strength of the component. If the SSSF is less than one, it means that the force exceeds the strength and the component will fail. Follow the procedures below to determine the SSSF:

- Calculate the SSSF. (See chapter 1.)
- Construct the anchor system (see figure 2-1, page 2-2) by—
  - Establishing at least two separate single point anchors. Loading sharing anchors may contain as many anchor points as needed.
  - Tying a wrap 3-pull-2 around each anchor.
  - Ensuring that all anchor connections are tight and that one anchor point does not bear more weight than the others.
  - Attaching each anchor leg to the anchor plate with a carabiner.

- Conducting a system safety check. Each rope rescue system must be safety checked prior to operation.

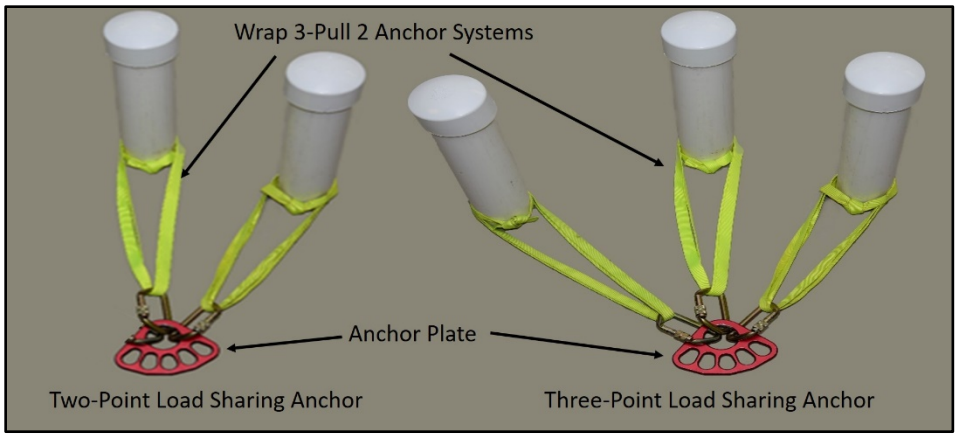


Figure 2-1. Wrap 3-pull 2 anchor system

LOAD DISTRIBUTING

2-5. Self-adjusting multipoint anchor systems are used in the same situations as load sharing systems—when a single anchor point is not strong enough to support the anticipated load—and when the directional pull is also likely to change during the rescue operation. The most commonly employed load-distributing anchors are the two-point and three-point system. The situation at hand will dictate which is most appropriate. In US&R rope operations, rescuers must complete numerous steps, from determining the anchor point(s) to building the prop anchor system(s). In a rope rescue operation, determining and constructing the proper anchor system(s) will be the key in a safe rope rescue operation. Construct the anchor system (see figure 2-2) by—

- Establishing two separate single-point anchors.
- Tying a wrap 3-pull 2 anchor system around each anchor.
- Tying a water knot using a different piece of webbing.
- Crossing the legs of the webbing forming an X.
- Clipping a carabiner into the X.
- Attaching the web loop to each wrap 3-pull 2 anchor system using carabiners.
- Ensuring that the load is equally distributed.

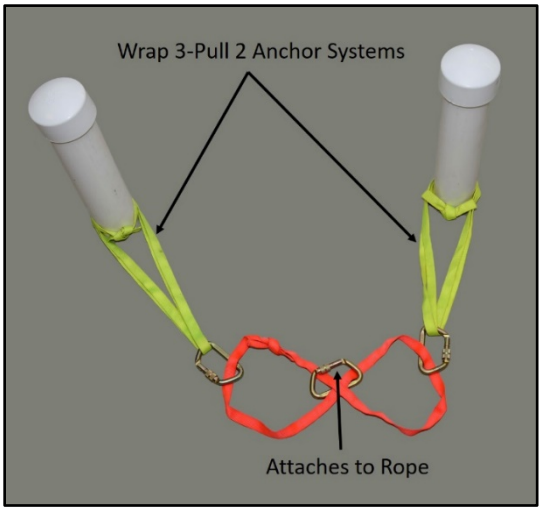


Figure 2-2. Load distributing anchor system

ANCHOR ANGLE FORCES

2-6. One important consideration when developing directional legs of any type within a rescue system is the effect of the angle of each of the legs on the forces exerted within the system. A factor that must be considered when rigging any anchor is to avoid creating too wide of an angle between the anchor legs. The angles referred to can be measured inside the system's legs above the point of attachment.

2-7. Given the difficulty of measuring an angle in the field, responders should rig the systems so that the angle remains less than 90 degrees (70 percent of the load per leg).

2-8. Monitoring these angles is critical in determining the safety of the system due to the extreme force that can be applied to the anchors when improper angles are used. As the angle between the legs increases, so do the forces exerted. See figure 2-3. The degree of angle is key in determining the amount of force that will be applied to each anchor. The higher the degree the more stress is applied to each anchor. It is key for rescuers to understand the amount of force at each angle as shown below.

- 45-degree angle—approximately 50 percent.
- 90-degree angle—approximately 70 percent.
- 120-degree angle—approximately 100 percent.
- 150-degree angle—approximately 200 percent (the load at each anchor point is twice the weight of the working load).

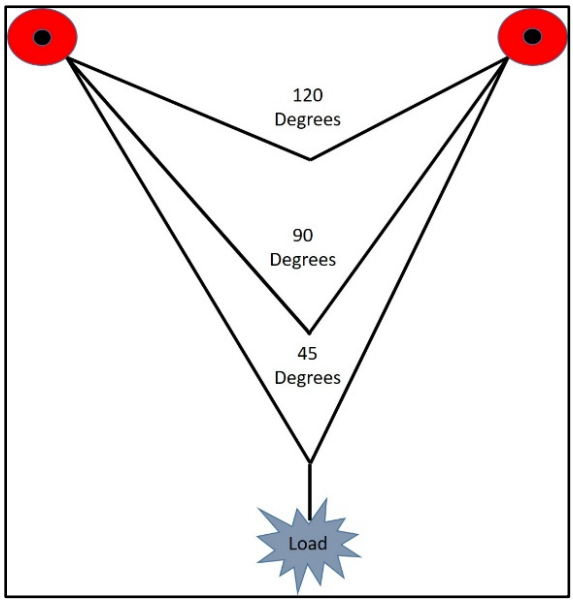


Figure 2-3. Critical angles

2-9. The critical angle should never be more than 120 degrees in rigging applications. An angle greater than 120 degrees can result in anchor failure and should never be used.

2-10. For the hasty critical angle method, extend your thumb by keeping your fingers together to create a 90-degree angle. Extend your entire fingers and thumb to get a hasty 120-degree angle. See figure 2-4.

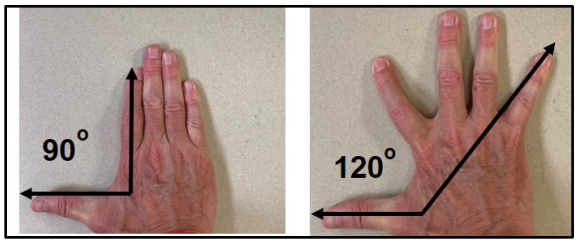


Figure 2-4. Hasty critical angle method

PICKET ANCHOR SYSTEM CONSTRUCTION

2-11. When it is not possible to use readily available anchors, a picket anchor system can be constructed. Although a picket anchor system enables rescuers to construct a solid anchor, it has some inherent limitations. The system is only as strong as the picket material and the soil in which it is being driven. Additionally, proper construction of a picket anchor system takes time and is a skill that requires frequent practice.

2-12. A picket should be 4-feet long and 1 inch in diameter. Ideally, the picket should be constructed out of 1-inch cold rolled steel. Pickets can be configured in a multitude of ways. See table 2-1.

Table 2-1. Picket configuration

Picket Load Capacity	
Single Picket	700 pounds
1-1	1,400 pounds
1-1-1	1,800 pounds
2-1	2,000 pounds
3-2-1	4,000 pounds

2-13. Pickets are directional anchors and should be driven into the ground 2/3rds of their length. The length of the picket (4 feet) should separate each picket. To minimize movement and to ensure that the load is distributed evenly throughout the system, pickets must be connected with webbing or rope.

MECHANICAL ADVANTAGE SYSTEMS CONSTRUCTION

2-14. Mechanical advantage systems can be either simple (see chapter 1), compound, or complex. In a simple system, one rope is routed between pulleys on the anchor and load, and all of the pulleys that move (for example, the traveling pulleys) do so at the same speed and in the same direction as the load.

COMPOUND ADVANTAGE SYSTEMS

2-15. In a compound advantage system, all traveling pulleys move in the same direction, but at different rates of speed. The pulley furthest from the load will move faster. A compound system may also be described as two simple systems working together. Mechanical advantage is a measure of the force amplification achieved by using a rope rescue system. The system is using pulleys and other hardware devices designed to decrease the amount of manpower required to move a load in a high- and or low-angle environment.

2-16. The joining of pulleys or systems to create a compound system has a cumulative effect on the calculation of the mechanical advantage. For example, a 2:1 system added within a 3:1 system results in a 6:1 mechanical advantage overall (2:1 x 3:1 = 6:1). See figure 2-5.

- Mechanical advantage system. Construct a 6:1 system. See figure 2-5.
  - Construct a 3:1 mechanical advantage system.
  - Construct a 2:1 mechanical advantage system without the progress capture device.
  - Connect the 2:1 mechanical advantage system to the 3:1 mechanical advantage system’s haul line with a Prusik.

Figure 2-5. Compound 6:1 advantage system

- Construct a 9:1 compound mechanical advantage system. See figure 2-6.
  - Construct a 3:1 mechanical advantage system.
  - Reave the rope around the sheave of a pulley and attach it to the anchor plate with a carabiner.
  - Reave the rope around the sheave of a traveling pulley.
  - Attach a Prusik to the load line.
  - Connect the traveling pulley to the Prusik with a carabiner.

Figure 2-6. Compound 9:1 mechanical advantage system

COMPLEX MECHANICAL ADVANTAGE SYSTEMS

2-17. In a complex mechanical advantage system, the placement of additional pulleys creates a system of pulleys moving in different directions and at different rates of speed. The joining of pulleys or systems to create a complex system has a summative effect on the calculation of the mechanical advantage. For example, a 2:1 system added within a 3:1 system results in a 5:1 mechanical advantage overall (2:1 + 3:1 = 5:1). See figure 2-7, page 2-6.

Figure 2-7. Complex 5:1 mechanical advantage system

FIXED ROPE SYSTEM

2-18. A fixed rope system is a rope which is anchored to a point of protection in the terrain by its upper end. The number of anchors can also be more than just one (multipoint anchors). A fixed rope therefore, does not move, is not taken in, and is simply pulled tight so that the rescuer can travel along it by rappelling, or ascending and descending.

CONSTRUCT A FIXED ROPE SYSTEM

2-19. Refer to chapter 1 for the required software and hardware. See figure 2-8. Construct a fixed rope system by—

- Attaching an anchor plate to the anchor system.
- Tying a figure eight on a blight on the standing end of the rope.
- Attaching the figure eight on a bight to the anchor plate.
- Placing the edge protection (as needed).
- Tying off the edge protection to prevent movement.
- Conducting a system safety check.

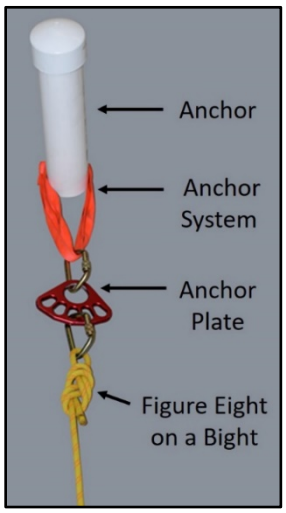


Figure 2-8. Fixed rope

RAPPEL WITH FIGURE EIGHT DEVICE

2-20. Rappelling is a tactic used during descending operations to move personnel or material from a high place to a low place in a high-angle plane using a system of ropes and harnesses. During your size up, the rescuer will determine the best option to rappel a fixed rope. Below are advantages of both.

Rappel With a Brake Bar Rack

2-21. Rappel with a brake bar rack by—

- Rigging the brake bar rack. See figure 2-9.
- Reaving the rope around the brake bar rack by first laying the rope over the top bar.
- Securing the second bar to the brake bar rack by lightly squeezing the frame and snapping in place.
- Pulling the rope back up towards you and making a bight that goes around the second bar and snap the third bar into place.
- Continuing to alternate the rope up and down, inserting the bars as you go, until all six bars are in place.

Figure 2-9. Rig the brake bar rack

Rappel

2-22. Begin the rappel by—

- Stepping down with one foot, then a taking a short step with the other foot, and regaining a balanced position.
- Maneuvering down the side of the rappel site into a good "L" position by spreading the bars apart toward you, and easing your grip on the rope with your brake hand.
- Continuing the descent down the slope in a controlled manner by controlling your descent with the brake hand and if necessary, with the guide hand on the bars.

Lock Off Brake Bar Rack

2-23. Lock off the brake bar rack (see figure 2-10, page 2-8) by—

- Leaning back so that the rope between the brake bar rack and the anchor is taut.
- Taking the rope with your brake hand and pulling it away from you, to the top of the brake bar rack, and toward the anchor.

- Pulling the rope over to the side of the brake bar rack and across the hyperbar (with your brake hand), between the brake bar rack frame and the pin at the end of the hyperbar so that the rope runs across the top bar.
- Bringing the rope back toward you, pulling it taut so that it locks all of the bars together.
- Bringing the rope through the two legs of the brake bar rack and across the bottom bar.
- Pulling the rope away from you, toward the anchor, in the same path as you did before to the "stop" position.
- Forming a large bight of rope and tying a double overhand knot on the standing part of the rope just above the brake bar rack.

Figure 2-10. Brake bar rack locked off

Unlock Brake Bar Rack

2-24. Unlock the brake bar rack by—

- Untying the overhand knot, while maintaining constant tension on the rope with your brake hand.
- Slowly lowering the rope to return to the "stop" position.
- Resuming your guide hand's normal position of cradling the bars.
- Rappelling down in a controlled manner until you reach the desired ending point.

2-25. Rappel with a figure eight device by—

- Attaching the figure eight device. See figure 2-11.
- Removing the device from the carabiner.
- Passing a bight of rope through the "big" hole.
- Pulling the bight over the small hole and allowing it to locate in the shank of the device as the bight is pulled tight.
- Clipping the "small" hole of the device back to the carabiner (attached to the D-ring of the harness).
- Beginning the rappel (same as using the brake bar rack).

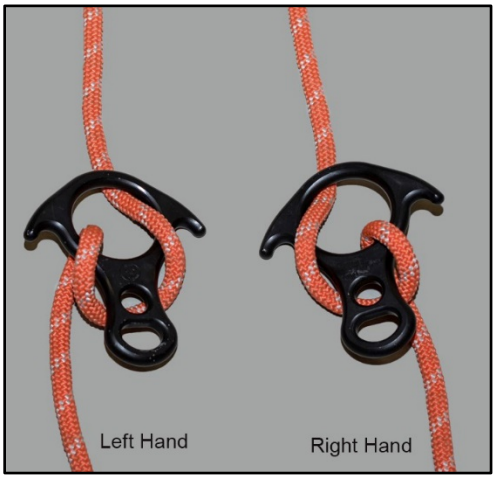


Figure 2-11. Figure eight device

Lock Off Figure Eight Device

2-26. Lock off the figure eight device by—

- Gripping the rope with the brake hand.
- Allowing the rope to slide through the descender until the brake hand is about one foot from the rappel device.
- With your brake hand, hold the rope taut and with a continuous motion, pull the rope in an arc straight out in front of you.
- Passing the brake side of the rope below the main line where the rope is 180 degrees from your rappel position.
- Using your brake hand, take the rope and pull it towards you.
- Pulling the rope toward the anchor, you should hear a pop.

ASCEND AND DESCEND A FIXED ROPE

2-27. During ascend and descend operations the victim may have been suspended in his harness for several minutes. Several types of deaths occur after upright suspension in a harness and are categorized as suspension syndrome deaths. In these closely related syndromes, victims may appear stable and uninjured while suspended and before being freed. Sometimes, the patient will feel faint or have already fainted prior to the release but will not have suffered any physical injuries. These patients, including those with no injuries at all and no feeling of faintness, are at risk of death upon rescue if the responders are not aware of the appropriate care.

ASCEND A FIXED ROPE

2-28. Ascend a fixed rope by—

- Donning a life safety harness.
- Attaching a belay line to the dorsal point of the life safety harness with a carabiner.
- Attaching the top ascender mechanical rope grab, or triple wrap a Prusik to the main line rope system.
- Girth hitching around the chest D-ring on the life safety harness.
- Attaching a carabineer to the Prusik loop and top ascender.
- Double wrapping the long Prusik for the foot loop to the fixed rope below the top ascender making this the bottom foot ascender.

Note. The long Prusik will be called the bottom ascender.

- Conducting a system safety check.
- Giving the commands *on belay* and *ascending*.
- Sliding the top ascender up the rope as high as it will go.
- Sliding the bottom foot ascender about waist high.
- Standing in the bottom foot ascender loop, or "stirrup," and putting your weight on it.
- Sliding the top ascender as far up the main line rope system as it will go.
- Transferring weight from the bottom foot ascender to the top ascender.
- Sliding the bottom foot ascender about waist high again.

DESCEND A FIXED ROPE

2-29. Descend a fixed rope by—

- Giving the commands *on belay* and *descending*.
- Standing in the bottom foot ascender and putting your weight on it.
- Sliding the top ascender down between the chest and navel area.
- Transferring weight from the bottom ascender to the top ascender.
- Repeating the process until you descend to the desired point on the rope.
- Descending to the ground in a controlled manner.
- Removing the ascenders from the main line rope system.
- Giving commands *off belay* and *rescuer on the ground*.

KNOT PASSING

2-30. When performing rope rescue, use a two-rope system (main line and belay line). However, if the rescue plan involves placing the load on the belay and disconnecting the main line to pass a knot, you no longer have the redundancy of a two-rope system. This is not a good idea when you are faced with an unplanned event, because there may be a time when switching to the belay line is not an option. That said, you must still be able to perform the task as a stand-alone operation without relying on another system.

2-31. A key task that a certified Level II rope rescuer will have to perform is passing a knot on the main line. This task is normally accomplished using a piggyback system and incorporating a progress capture device.

- Allow the rope to travel right up to the brake bar rack. See figure 2-12.
- Lock off/tie off with all bars (if needed).
- Push the tandem Prusiks attached to the load releasing hitch as far forward as possible (away from the brake bar rack).
- Untie the brake bar rack and slowly lower the load until the weight is on the Prusiks of the load releasing hitch.
- Derig the brake bar rack, and take out the main line.
- Rerig the brake bar rack with the knot just in front of the brake bar rack.

Figure 2-12. Knot at brake bar rack

Note. Ensure that the knot is far enough in front of the brake bar rack to allow reconnection before lowering resume.

- Locking off/tying off with all bars, if needed. See figure 2-13.
- Telling the belayer that you are going to lower slightly so the belay line does not get stuck.
- Releasing the load releasing hitch to allow the weight of the load to begin shifting to the brake bar rack.
- Removing the load releasing hitch and all of its components.
- Replacing the load releasing hitch, reconnecting the pulley and tandem Prusiks.

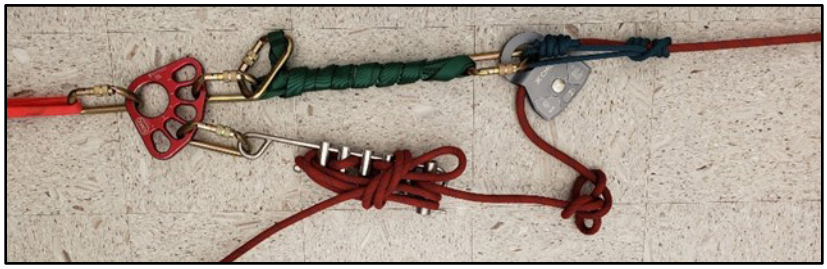


Figure 2-13. Tie off brake bar rack

- Ensuring that the load releasing hitch and its components are reconnected between the knot and brake bar rack. See figure 2-14.
- Telling the belayer you are ready to lower.
- Lowering the load.

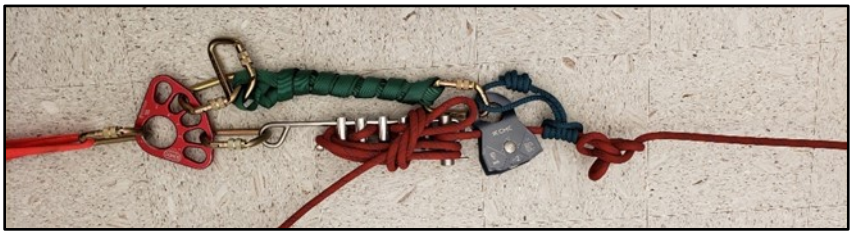


Figure 2-14. Replace load releasing hitch

ROPE RESCUE LEVEL II

2-32. Rope rescue was originally practiced by fellow climbers or bystanders using the standard mountaineering equipment and techniques. Over time, these methods have been replaced by specialized rescue teams, and equipment designed specifically for rescue purposes. Different terms have been used for this type of rescue, including vertical rescue, technical rescue, and high-angle rescue. *High angle* is defined as a very steep environment in which a person is primarily supported by the rope system. One or more ropes

are necessary to prevent the person from falling. This type of rescue should be considered as a last resort, and used only when all other methods have been exhausted.

2-33. Managing and requesting the appropriate resources are the responsibility of the team leader. The ICS is expandable based on the needs of the incident. On small-scale incidents only those parts of the ICS that are needed to safely and effectively handle the incident should be implemented. This gathering of information will assist the team leader and rescuers to perform a safe rescue.

PICK OFFS

2-34. A *pick off* is a term used to describe a type of rescue performed by a rescuer who rappels or is lowered to a person suspended from a line. This type of pick off requires that the rescue subject's weight be transferred entirely from the static line upon which he is suspended to the rescuer's system.

2-35. Equipment requirements include the following:

- A lowering system or rappel system with a brake bar rack as the descent control device.
- A rack, pulley mariner system.
- A tandem Prusik belay system.
- A hauling system.
- One simple "piggyback" mechanical advantage system attached to the main line.

Note. A "piggyback" system is all that is required.

- A full body Class 3 harness for the rescuer.
- One short Prusik to attach the patient to the main line.
- One short and one long Prusik.

2-36. Use the procedures for preparing the lowering system as previously taught. Use the following additional steps:

- Attach a single Prusik to the main line and attach a carabineer and leave unlocked.
- Attach the end knot to the rescuer to be lowered.
- Construct a belay line and attach tandem Prusiks approximately two feet from the end knot and attach to the rescuer. Attach a carabineer to the end knot and leave unlocked.
- Attach the end knot from the belay line to the victim's harness with the unlocked carabineer.
- Attach the single Prusik from the main line with a carabineer to the victim's primary harness connection point.
- Haul the rescuer and victim to transfer both individual's weight to the rescuers system.
- Remove the rescue victim's lanyard or other suspension attachment.
- Communicate to the team above to release the progress capture device from whatever haul method is chosen and transfers the load back to the descent control device to begin the lowering. Lower the rescuer and the subject to the ground.
- Detach the rescuer and the victim from the system once on the ground.

2-37. Procedures for static pick offs with a potential spinal injury include the following:

- The rescuer should not rappel in this rescue so that his hands and legs may be used to hold their patient immobile.
- The rescuer should make all connections while avoiding movement of the patient.
- Once the rescuer makes connections, he should place his hands and forearms on either side of the patient's head to provide manual stabilization. The rescuers legs may be placed on the patient's body to keep the body in alignment with the head.
- A tag line can be preattached to the back of the rescuer so that they may be pulled away from the structure, negotiating obstacles and obstructions, without assistance from the rescuer.

2-38. A *standing pick off* is a term used to describe a type of pick off rescue performed by a rescuer who rappels or is lowered to a person trapped, "standing" on a ledge, or other platform. This is commonly seen in situations where persons are trapped due to fire or are unable to make egress by normal means and has no issue with suspension syndrome since they are not suspended. This type of pick off is almost exactly the same as a static line pick off except that no transfer of weight is necessary since the rescue subject is not suspended.

2-39. Equipment requirements include the following:

- A lowering system or rappel system with a brake bar rack as the descent control device.
- A rack, pulley mariner system.
- A tandem Prusik belay system to be constructed.
- An adjustable pick-off strap.
- A full body Class 3 harness for the rescuer.

2-40. Procedures to prepare the lowering system include—

- Constructing a main line and attach the end knot to the rescuer to be lowered.
- Constructing a belay line and attach tandem Prusiks approximately two feet from the end knot and attach to the rescuer.
- Attaching an unlocked carabineer to the end knot.
- Attaching the pick-off strap to the rescuer's harness and the other end to an equipment sling.
- Lowering to a point where you can reach the connection points of the patient's harness.
- Attaching a commercial harness or hasty harness to the victim.
- Connecting the belay to the victim.
- Connecting the pick-off strap to the victim and lock the carabineer.
- Taking up the stack on the pick-off strap.
- Straddling the ledge to allow the victim to come off the ledge.
- Coaching the rescue subject to load the rope system.
- Instructing the victim to get into a seated position.
- Placing the victim's legs in between your legs. See figure 2-15, page 2-14.
- Instructing the victim to place his hands on top of your legs for support.
- Instructing the victim to slowly swing down between your legs until his weight comes onto the strap.

Figure 2-15. Pick off

HIGH-ANGLE LITTER TENDING

2-41. There may be times that require a nonambulatory patient to be raised or lowered in a rescue litter, while being tended by a litter attendant. This may be due to patient care needs, edge management issues, patient packaging issues, and/or the need to negotiate obstacles. There are two ways to conduct litter duties—either a vertical or a horizontal lift. During the rescuer size up and the operational environment will determine which method to use. The litter attendant—

- Rigs the basket for a vertical lift (see chapter 1) by—
  - Measuring the belay line by placing it next to the Stokes basket/litter.
  - Setting the working end at the foot of the basket.
  - Tying a butterfly knot at the head of the basket.
  - Connecting the Alpine Lace figure eight on a bight knot to the butterfly knot using a carabineer.
  - Tying two Prusiks (short and long) onto the belay line halfway between the Alpine Lace figure eight on a bight knot and the working end.
  - Connecting the two Prusiks to the victim's hasty harness.
  - Measuring the main line by placing it next to the basket.
  - Setting the working end at the feet of the basket.
  - Running the line toward the head making a bight.
  - Bringing the rope back to the midpoint of the basket.
  - Tying a butterfly knot.
  - Connecting the Alpine Lace figure eight on a bight knot to the butterfly knot using a carabineer.
  - Attaching a mechanical rope grab device between the Alpine Lace figure eight on a bight knot and working end of the main line.
  - Attaching a Prusik hitch below the mechanical rope grab.
- Connects the belay line to the dorsal attachment point of the rescuer by—
  - Connecting the mainline to the waist attachment point of the rescuer's harness.
  - Connecting the mechanical rope grab to the chest attachment point on the rescuer harness.

- Perform a system safety check.

- Rigs the basket for a horizontal lift (see figure 2-16) by—
  - Connecting the bridle to the basket using manufacturer specification.
  - Measuring the belay line by placing it next to the Stokes basket/litter.
  - Setting the working end at the foot of the basket.
  - Tying a butterfly knot at the head of the basket.
  - Connecting the bull ring on the bridle to the butterfly knot using a carabineer.
  - Tying two Prusiks (short and long) on the belay line halfway between the bullnose and working end.
  - Connecting the two Prusiks to the victim's harness.
  - Measuring the main line by placing it next to the basket.
  - Setting the working end at the feet of the basket.
  - Running the main line towards the head making a bight.
  - Bringing the rope back to the midpoint of the basket.
  - Tying a butterfly knot.
  - Connecting the bull ring on the bridle to the butterfly knot using a carabineer.
  - Attaching a mechanical rope grab device between the bullnose and working end of the main line.
  - Attaching a Prusik hitch below the mechanical rope grab.
  - Connecting the belay line to the dorsal attachment point of the rescuer.
  - Connecting the mainline to the waist attachment point of the rescuer's harness.
  - Connecting the mechanical rope grab to the chest attachment point on the rescuer's harness.
  - Performing a system safety check.

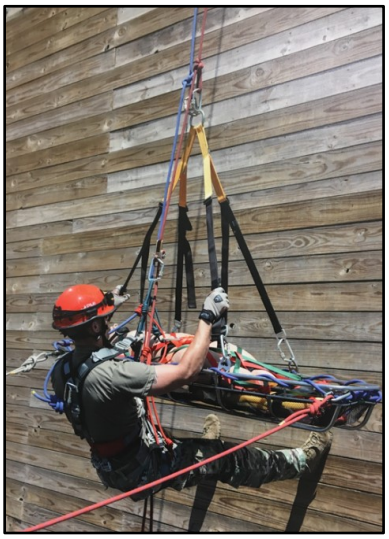


Figure 2-16. Horizontal litter

- Performs litter operations by—
  - Short hauling the basket by the haul/lower team until it is approximately 1 foot off the ground.
  - Adjusting the bridle straps to level the patient.

Note. In vertical operations, adjust the rescuer mechanical rope grabs so the rescuer is comfortable.

MAN-MADE STRUCTURES

2-42. Rescuers may come across a situation when they cannot reach a victim stranded on a man-made structure because they are unable to be lowered from above. In these situations, the rescuer must climb the structure in order to gain access to the victim and set up an anchor or directional change for their rope rescue system. The rescuer must maintain two points of contact with the structure at all times for safety reasons. Prepare the rescuer to ascend or descend in order to conduct a man-made rescue. The rescuer will need to attach additional hardware and software to his harness in order to conduct a safe rescue. The rescuer—

- Attaches the fall-arrest lanyard to the rescuer's life safety harness by—
  - Attaching the lanyard to the rescuer's waist attachment point on the harness.
  - Attaching the snap links on both ends of the fall-arrest lanyard to the structure.
- Attaches the running ends of the belay and main line systems to the rescuer by—
  - Attaching a triple wrap Prusik with a carabineer to the belay and main line.
  - Attaching the terminal end of the main line to the rescuer's sternal attachment point.
  - Attaching the Prusik on the belay line to the rescuer's waist attachment point.
  - Attaching the belay and main line high-point anchor systems to the rescuers equipment sling.
- Attaches the belay and main line system high-point anchors and change of direction pulleys by—
  - Climbing the structure using the fall-arrest lanyard to a point above the victim.
  - Attaching the belay change of direction pulley to high-point anchor.
  - Attaching the main line change of direction pulley with a high-point anchor system.
- Attaches the belay and main line to the victim's harness by—
  - Climbing down the structure to the victim using the fall-arrest lanyard.
  - Attaching the terminal end of the belay line to the victim's dorsal attachment point.
  - Attaching a Prusik to the main line and to the rescuer's sternal attachment point.
- Guides the victim to the ground (see figure 2-17) by—
  - Directing the team to lower the victim down to the ground.
  - Transferring the victim to medical care.
- Recovers rescuer equipment from the structure by—
  - Climbing up the structure using the fall-arrest lanyard.
  - Disconnecting the belay and main line systems and attach them to the rescuer's equipment sling.
  - Climbing down the structure using the fall-arrest lanyard system.

Figure 2-17. Lower victim

HIGHLINES

2-43. Most rope rescues are accomplished by lowering a rescuer from above, packaging the victim, and either lowering the rescue package down or raising the rescue package back up to an area for transport to a medical facility. These are known as vertical rescues. Vertical rescues will not work and the rescue must be completed in the horizontal realm. Highline systems can provide a solution to this problem.

2-44. Prior to executing the highline operation, the team leader shall select an appropriate site to construct the highline system (figure 2-18), select a gap as narrow as possible, ensure that there are suitable loading and off-loading platforms, and both sides have "bombproof" anchors and at least 10 feet of clearance around all rigging.

- Select an appropriate site to construct the highline system (see figure 2-18). Both sides have "bombproof" anchors and at least 10 feet of clearance around all rigging.
- Instruct a team (minimum of three personnel) to get to the farside of the site with their equipment.
- Run the main line of a highline system to the far side by—
  - Lowering the far side end of the main line to the ground.
  - Directing someone to pull the main line end to the base of the structure on the far side.
  - Instructing the far side team to drop a haul line to the ground.
  - Instructing the rescuer on the ground to tie the two ropes (main line and haul line) together.
  - Instructing the far side team pulls up the haul line with the main line attached.

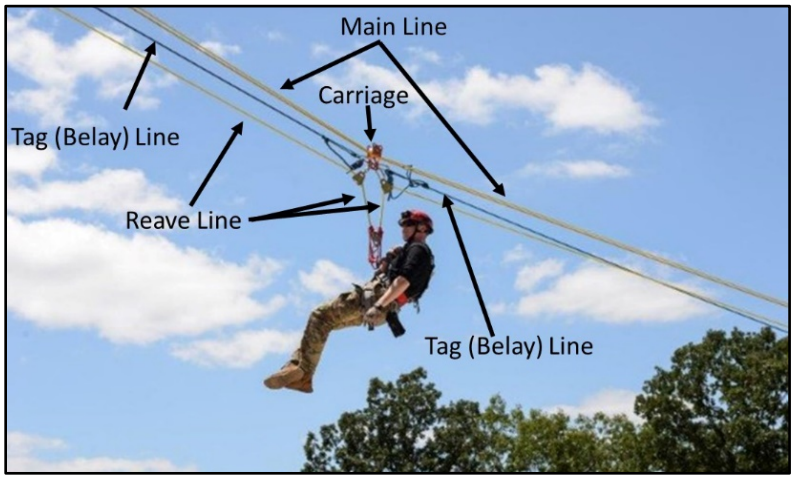


Figure 2-18. Highline rescue

- Run a steep angle main line by—
  - Lowering the far side end of the main line to the ground.
  - Directing someone to pull the end on the main line to the base of the structure.
- Direct the far side personnel to anchor their end of the main line.
- Direct the nearside personnel to anchor their end of the main line.
- Establish an anchor system on the far side for the tag line belay device.
- Run the tag line rope to the far side. The tag line is used to control the horizontal movement of the carriage.
- Direct the far side personnel to construct a belay system and attach it to the anchor system.
- Instruct the far side team to thread the tag line through the belay device.
- Establish an anchor on the nearside for the lowering/belay rope.
- Instruct the nearside personnel to construct a lowering system.
- Attach a lowering system to the anchor on the nearside.
- Attach the carriage to the mainline.
- Attach tag lines to the carriage.

- Conduct a system safety check by—
  - Sending the carriage to the home side.
  - Attaching the rescue load to the carriage.
  - Ensuring that rescue personnel are in place.
  - Ensuring that the brakeman is on the lower/belay line.
  - Ensuring that the belayer is on the farside tag line.
  - Ensuring that he edge tenders secure and monitor edge protection.
- Move the load. The—
  - Rescuer calls *on belay*.
  - Lowering/belay line brakeman calls *belay on*.
  - Far side tag line belayer calls *belay on*.
  - Rescuer calls *prepare to move*.
  - Lowering/belay brakeman begins allowing the rope to move through the brake bar rack.
  - Far side belayer begins taking up slack in the tagline.
- Transfer the load. The—
  - Rescuer calls *stop*.
  - Rescuer calls *off belay*.
  - Lowering/belayer brakeman calls *off belay*.
  - Far side tag line belayer calls *off belay*.
  - Remove rescuer from the carriage. This is done by the offloading team.

Chapter 3

Confined Space

The purpose of this chapter is to give a rescuer basic concepts and methods to conduct a confined space rescue. The techniques utilized in this section are general in nature and can change based upon the current situation.

LEVEL I CONFINED SPACE

3-1. A *confined space* according to OSHA regulation Section 146(b), Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910,146[b]) is a space that—

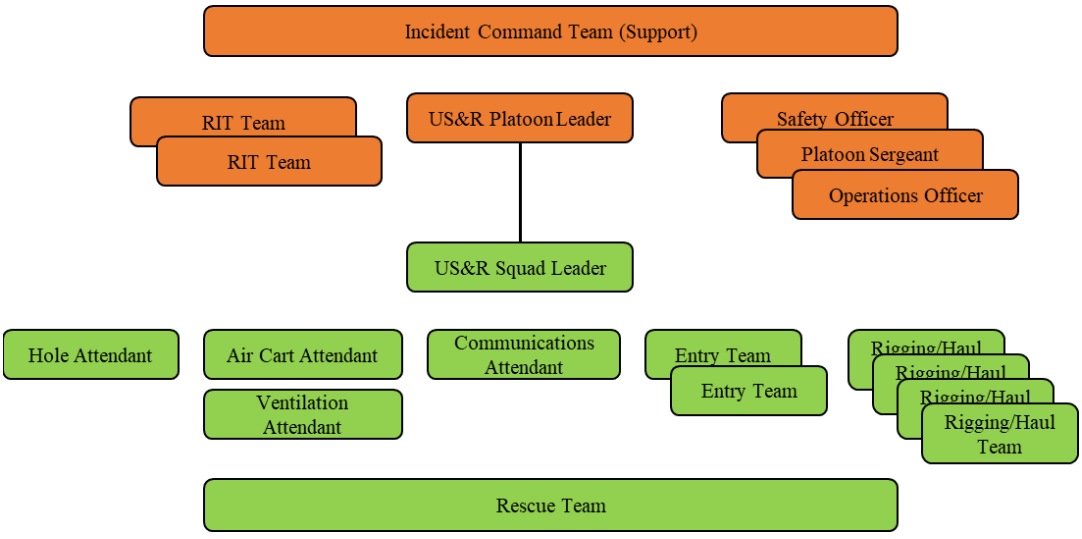
- Is large enough and so configured that an employee can enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.)
- Is not designed for continuous employee occupancy.

3-2. The two kinds of confined spaces are—

- **Nonpermit confined space.** A *nonpermit confined space* (permit space) is a confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.
- **Permit-required confined space.** A *permit-required confined space* is a confined space that contains or has a potential to contain a hazardous atmosphere, contains a material that has the potential for engulfing an entrant, and has an internal configuration such that an entrant could be trapped or asphyxiated.

CONFINED SPACE COMMAND ESTABLISHMENT

3-3. Refer to chapter 1 to conduct site operations. Upon arrival, the US&R team should identify an appropriate location for a base of operations. There are four areas that will need to be setup. The unit (SOP) will dictate the arrangement and layout of the base of operations and determine if more sites are needed. Figure 3-1, page 3-2, is a setup of an US&R confined space site and team concept.



Legend:

RIT	rapid intervention team
US&R	urban search and rescue

Figure 3-1. US&R confined space operation team set up

PREENTRY OPERATIONS

3-4. During rescue operations there will be numerous hazards that the rescuer will encounter. They range from atmospheric conditions, electrical hazards, and other hazards that require lock-out-tag-out, ventilation operations, and establishing the rescue team set up. The paragraphs below are a few items that will assist in the rescue operations prior to entry.

CONDUCT AIR MONITORING

3-5. Air monitoring is the only way to measure chemicals in rescue operations. The rescuer must test the conditions of the space before anyone enters. Best practices during rescue operations is to ensure that there is an air monitor at the rescue, the confined space is monitored while rescue operations are happening, and measuring the air quality outside the operations.

CONDUCT LOCK-OUT-TAG-OUT

3-6. The lock-out-tag-out standard requires the adoption and implementation of practices and procedures to shut down equipment, isolate it from its energy sources, and prevent the release of potentially hazardous energy while performing rescue operations. However, the rescue leader has the flexibility to develop a lock-out-tag-out program that is suitable for their rescue operations.

3-7. These include the following:

- **Electrical switch.** Electrical lockouts keep rescuers safe by locking out equipment and energy sources during a rescue operation. Electrical and circuit lockouts prevent machinery and equipment from being used by locking out electrical outlets and power cords. (See figure 3-2.) The rescuer—
  - Determines the equipment to be deenergized.
  - Switches the electrical switch off.
  - Attaches the lockout device.
  - Places the tag-out tag.
  - Inserts the lock.

Figure 3-2. Electrical switch

- **Electrical circuit breaker.** Circuit breaker lockouts are used to keep the electricity off in a specific circuit by securing the circuit breaker toggle switch in the off position. They consist of a lockable clamp or hasp to immobilize an individual circuit breaker switch. (See figure 3-3.) The rescuer—
  - Determines the equipment to be deenergized.
  - Locates the circuit breaker panel.
  - Switches circuit breaker off.
  - Attaches the lockout device.
  - Places the tag-out tag.
  - Inserts the lock.

Figure 3-3. Circuit breaker

- **Gate valve.** Gate valve lockouts prevent the accidental opening of valves during system repair to protect rescuers from injury in rescue operations. (See figure 3-4, page 3-4.) The rescuer—
  - Determines the distribution systems to be deenergized.
  - Locates the gate valve(s).
  - Turns the gate valve(s) off.
  - Attaches the lockout device.
  - Places the tag-out tag on the lock.
  - Inserts the lock.

Figure 3-4. Gate valve

CONDUCT VENTILATION OPERATIONS

3-8. If there are hazards encountered at the rescue site or within the confined space, rescuers must ventilate the site even if they are in the proper PPE. There are two types of ventilation that a rescuer can use—natural ventilation and mechanical ventilation.

- Natural ventilation relies on the motion of the air currents, without assistance, to ventilate the confined space.
- Mechanical ventilation uses mechanical means either positive or negative ventilation.

MEDICAL MONITORING

3-9. All rescuers must conduct medical monitoring prior to donning an air respirator. Medical monitoring should be executed by a qualified medic or a nurse. Rescuers shall establish a base line 1 hour prior to conducting a rescue operation. The baseline will consist of their blood pressure, temperature, and body weight. Each rescuer must conduct post-entry medical monitoring. No rescuer can conduct a rescue if their heart rate is above 110 or their blood pressure is above 160/100 millimeters of mercury (commonly known as mm Hg).

PRERESCUE OPERATIONS

3-10. It is essential that the rescuers perform both horizontal and vertical entries. The rescue operation should always try and make a vertical entry if possible without the use of retrieval systems. The tripod is a useful high-point anchor that is easy to setup and strong enough to support the rescuer and victim. See figure 3-5. Follow the manufacturer's recommendation on the assembly and maintenance for the particular tripod that is in the US&R cache.

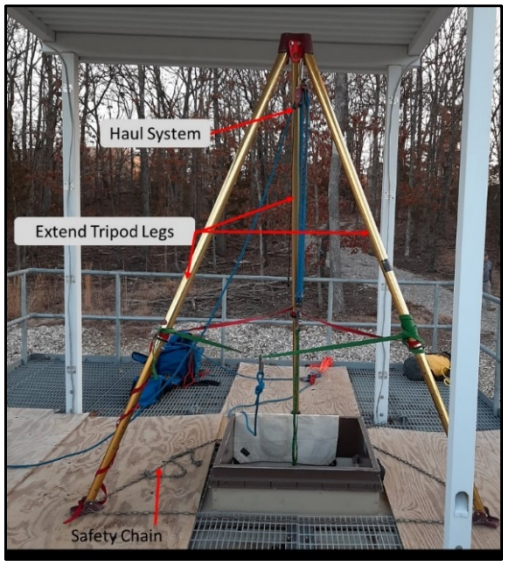


Figure 3-5. Tripod retrieval

LINES OF COMMUNICATIONS

3-11. The basic requirement of confined space rescue communications is to provide rapid and reliable interchange of information. Communications are vital to mission success. Refer to figure 3-6. Follow the manufacturer's recommendation on the assembly and maintenance for the particular communications kit that is in the US&R cache.

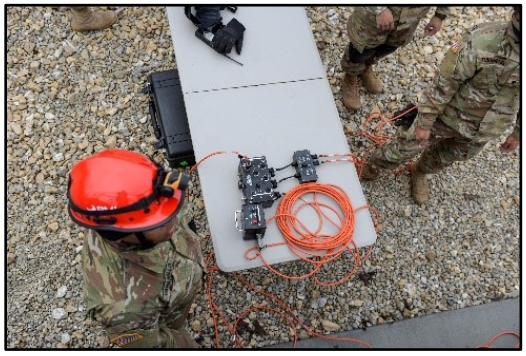


Figure 3-6. Communications box

RESPIRATORY PROTECTION

3-12. The respiratory PPE that are available for an US&R or extraction teams are—SAR, SCBA, PAPR, and N95 mask.

- **SAR.** The SAR is a type of respirator that supplies uncontaminated breathing air to the user from an external source of air connected by a high-pressure hose to the face piece, hood, or helmet. They offer certain advantages over other types of respirators and may be the preferred form of respiratory protection in some applications. All SAR systems should require an emeregency escape cylinder. See figure 3-7 and figure 3-8, page 3-6.
- **SCBA.** The SCBA is a special type of supplied-air respirator that gives the user an independent air supply from a pressurized tank on the wearer's back. Generally, the air supply lasts for 30 to 60 minutes.

Figure 3-7. SAR

Figure 3-8. SAR cart

- **PAPR.** A PAPR has air blowers to pull air through the cartridges and filters. Some PAPRs are available with hoods or other protective headgear for use in specific types of environments.
- **N95 respirators.** The N95 respirator is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. The N95 designation means that when subjected to careful testing, the respirator blocks at least 95 percent of very small (0.3 micron) test particles. If properly fitted, the filtration capabilities of N95 respirators exceed those of face masks. However, even a properly fitted N95 respirator does not completely eliminate the risk of illness or death. This mask is worn mainly in areas of heavy dust and particulates.

LEVEL II CONFINED SPACE

3-13. Certified level two rescuer operations and responsibilities are covered in this section. Each incident is different and may require additional planning. Refer to the unit SOP for additional information.

PREPLAN

3-14. Preplan a confined space incident, given applicable guidelines and regulations and a preplan form, so that a standard approach is used during a confined space rescue emergency. Ensure that—

- Hazards are recognized and documented.
- Isolation methods are identified and documented.

- All accesses to the location of the entry opening are identified and documented.
- All types of entry openings are identified and documented.
- Internal configurations and special resource needs are documented for future rescuer use.

ASSESS THE INCIDENT

3-15. Preparation is the key to effective rescue operations. Even the best US&R teams cannot effectively address a rescue operation without properly assessing the incident. A strong preplan must be in place to support your team. In order to successfully address the safety and operations of the rescue should consider the following:

- Size up information.
- Monitoring equipment.
- PPE required to perform the assessment.
- Specific hazards are identified.
- Bystanders and victims are interviewed.
- The victims' conditions and location are determined.
- Risk-benefit analysis is performed.
- Methods of ingress and egress are identified.
- Rescue systems for victim removal are determined.
- Emergency means of retrieval for rescue entrants is established.

3-16. Procedures to perform a scene assessment in order to determine the magnitude of the problem in terms of life safety can include, but are not limited to, the following:

- Type, size, access, and internal configuration of the confined space.
- Information regarding current and potential hazards that threaten victims and rescuers.
- Risk benefit analysis concerning the threat to rescuers in relation to the viability of victims.

CONTROL HAZARD

3-17. An assortment of hazards may occur at confined space rescue operations. Rescuers must make decisions about what activities will need to be accomplished when they encounter a hazard. Hazard control options include, but are not limited to—

- Wearing proper PPE.
- Establishing safety protocols.
- Establishing monitoring equipment and procedures.
- Conducting ventilation procedures.
- Identifying the types of hazardous materials exposure risks.
- Placing scene control barriers.
- Operating atmospheric monitoring equipment.
- Isolating dangerous forms of energy (lock-out tag-out).
- Mitigating physical and atmospheric hazards.

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Chapter 4

Trench Rescue

Excavation and trenching are among the most hazardous construction operations. The OSHA excavation standards (29 CFR Part 1926, Subpart P) contain requirements for excavation and trenching operations. The excavation standard applies to all open excavations made in the earth's surfaces including trenches, all surface impediments that would create a hazard, and protective systems. OSHA defines an *excavation* as any man-made cut, cavity, trench, or depression in the Earth's surface formed by earth removal. A *trench* is defined as a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth of a trench is greater than its width, but the width of a trench (measured at the bottom) is not greater than 15 feet.

TRENCH ANATOMY

4-1. Before a rescuer can properly apply any rescue procedures to a trench, they must understand the inner and outer components that make up a trench system. Rescuers must be familiar with the regulations of the authority having jurisdiction that governs their response. In some situations, trenches may be excavated in many different configurations including straight wall, "T," "L," and "X."

TRENCH TYPES

4-2. See figure 4-1 and the bullets below for the trench types.

- Straight (Level I).
- L-Trench (Level II).
- T-Trench (Level II).
- X-Trench (Level II).

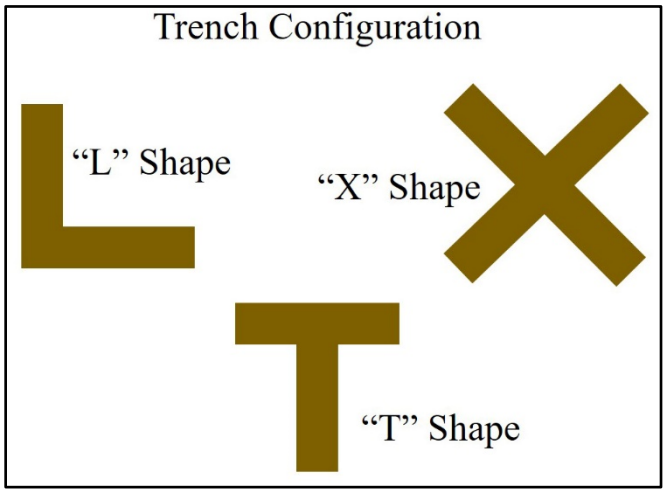

Figure 4-1. Trench types

Note. A professional engineer must design the shoring plans for the protection system that will be built for trench rescues in which the trench is deeper than 15 feet.

TRENCH COMPOSITION

4-3. Trench composition includes the lip, floor, walls, ends, toe, and spoil pile. See figure 4-2.

- **Lip.** The lip is the area 360 degrees around the opening of the trench, 2 feet back from the opening of the trench and extends down the wall of the trench 2 feet.
- **Floor.** The floor is the bottom of the trench.
- **Walls.** Walls are any part of the trench that presents in the vertical or upright position on the long axis.
- **Ends.** The ends of the trench are where the walls end at the short axis.
- **Toe.** The toe is the area where the walls and floor intersect at the bottom of the trench and 2 feet up.
- **Spoil pile.** The spoil pile is the excavated dirt from the trench and must be 2-foot setback from the lip.

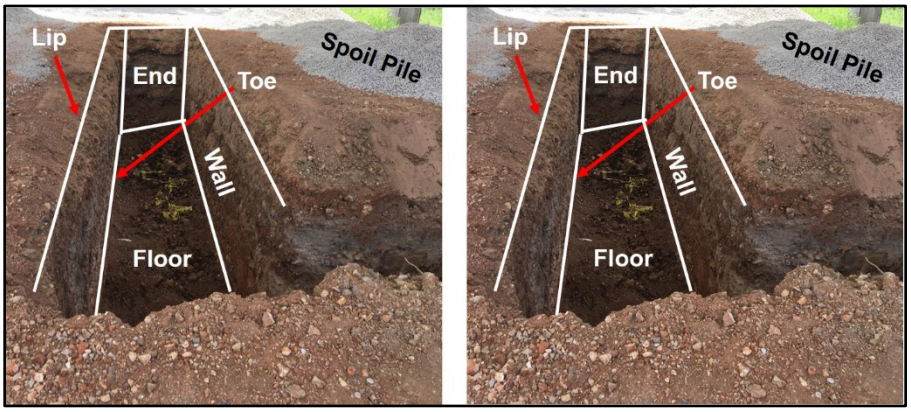

Figure 4-2. Trench composition

COLLAPSE TYPES

4-4. A *trench failure* refers to the movement of soil or rock in a large enough quantity to cause damage or entrapment of a person. Depending upon the type of soil involved, the mechanism of collapse, and other variables, a trench failure can take several forms.

TRENCH FAILURES

4-5. The most common types of trench failures include the following (see figure 4-3):

- **Spoil pile slide.** A spoil pile slide is the result of the excavated earth being placed too close to the lip of the trench.
- **Slough failure.** A slough failure is the loss of a portion of the trench wall, often caused by the forces associated with unconfined hydrostatic pressure that becomes greater than the soil's ability to withstand those pressures.
- **Shear wall collapse.** Shear wall collapse occurs when a section of soil loses its ability to stand and collapses into the trench along a mostly vertical plane.
- **Toe failure.** Toe failure is a slough that occurs at the bottom of the trench where the floor meets the wall.
- **Bell pier condition.** A bell pier condition is caused by the effects of water accumulation in the trench. This type of failure does not occur suddenly, but is a result of long-term toe failure on both sides of the trench floor.
- **Wedge failure.** Wedge failure is a type of failure that normally occurs with intersecting trenches. It is characterized by an angled section of earth falling from the corner of two intersecting trench walls.

Figure 4-3. Trench failures

IDENTIFY HAZARDS

4-6. Most of the hazards associated with trench rescue operations fall into one of these categories—physical hazards, environmental hazards, and atmospheric hazards. When conducting a trench size up it is important to look for hazards in the trench (see figure 4-4). Safe and effective operations at a rescue incident will be possible only if responders are fully aware of the hazards involved and the methods necessary to mitigate or avoid those hazards. During all trench rescue operations it is vital to look for hazards that may contribute to secondary collapses or utilities that may affect the rescue operations. Rescuers should understand all the hazards that will affect their operations.

Figure 4-4. Water hazard

TRENCH RESCUE TEAM

4-7. Trench rescue team composition establishes responsibilities for the personnel who will be assigned to a rescue incident and the functions they will serve. One person or team may serve more than one function. The team leader, squad leader, and safety leader responsibilities remain basically the same in all rescue operations. Below are the unique positions that are needed for trench rescue operations (see figure 4-5, page 4-4).

- Extrication team. The extrication team—
  - Packages the patient.

- Manages the victim.
- Lifts/moves debris from the victim.
- Constructs retrieval methods.

- Panel team. The panel team—
  - Places the ground pads.
  - Prepares and sets panels.
  - Marks the trench danger areas.
- Shoring team. The shoring team measures the shoring and places the shoring.
- Cut/strut team. The cut/strut team—
  - Builds shoring and cribbing.
  - Assembles struts.
- Air monitor team. The air monitor team—
  - Vents the trench.
  - Checks the air inside and outside the trench.

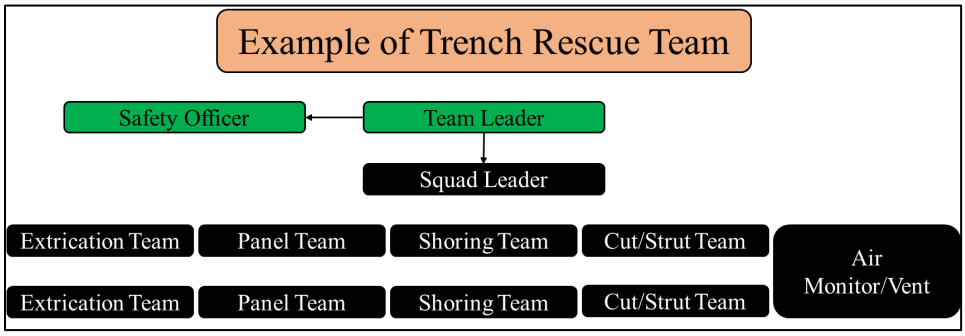

Figure 4-5. Trench rescue team composition

TRENCH RESCUE OPERATIONS

4-8. A phased approach to trench rescue operations must be utilized to safely and effectively mitigate these high-risk and low-frequency rescue operations. Trench rescues have very high injury rates because the forces imposed on the victims through soil weight are unforgiving. The window of opportunity to enter the trench and relieve that pressure is very small. Rescuers must use a phased approach prior to entering a trench.

PREENTRY TRENCH OPERATIONS

4-9. It must be determined if this will be a rescue operation or a recovery operation based on the survivability profile of the victim(s), which include factors such as the location and condition of the victim(s) and the elapsed time since the accident occurred.

General Area Safety

4-10. The rescuers make the general area safe by—

- Establishing a hazard zone perimeter 50 feet from the collapse area.
- Controlling traffic movement.
- Establishing control flow.
- Establishing control points.

Trench Rescue Preparation

4-11. Prepare for a trench rescue by—

- Spray painting the area around the trench to identify hazards. See figure 4-6.
- Clearing at least 2 feet from the lip of the trench.
- Placing ground pads. See figure 4-7.
- Placing ladders in the trench no more than 25 feet apart. The tops of ladders should extend at least 3 feet above the lip of the trench.
- Ventilating the trench.

Figure 4-6. Trench danger area

Figure 4-7. Ground pads

Panel and Shore Placement

4-12. The first set of panels should be placed near the victims head. A straight-wall trench requires the rescuer to use a minimum of three sets of panels.

4-13. Strut placement struts are installed no more than 4 feet apart, with a strut within 2 feet of the top and another strut within 2 feet of the bottom of the trench. See figure 4-8, page 4-6.

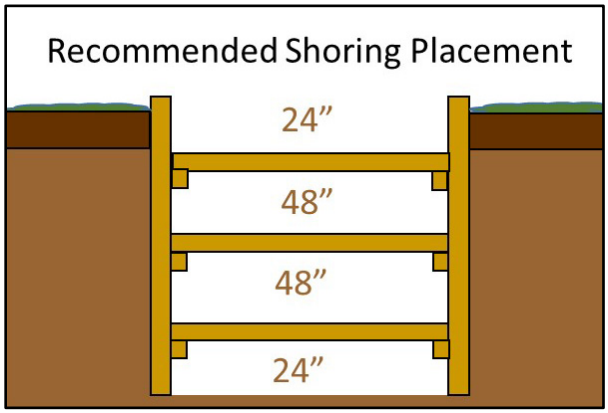

Figure 4-8. Shoring placement

4-14. Timber struts are placed in sequence—top strut, middle strut, and then the bottom strut. Pneumatic struts are placed in sequence—middle strut, bottom strut, and then the top strut. See figure 4-9.

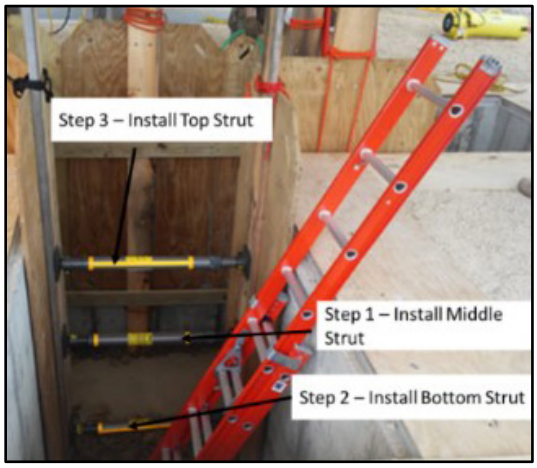

Figure 4-9. Pneumatic struts

Pneumatic Shore Installation

4-15. Pneumatic shore installation is completed by—

- Connecting the air system to the shore.
- Lowering the shore using ropes at each end.
- Positioning the shore—middle, bottom, and top.
- Giving the signal to pressurize and hold.
- Pressurizing and locking the shore.
- Toenailing the shore to the strongback.
- Releasing the air pressure and disconnecting the hose.

Wood Shoring Placement

4-16. Wood shoring placement can be done by—

- Measuring the distance for the top strut. Placing the strut 2 feet from the top edge. The rescuer may descend the ladder far enough to measure the distance for the second strut, never extending more than the rescuer’s waist deep from an emplaced and tightened strut.
- Cutting the second strut and lowering it into place the same as the first. Continuing until all the struts are installed.

- Tightening each strut further once the last of the struts between the fin board panels are in place. Working from the top down to fully compressing the panels against the trench walls.

Outside Waler Placement

4-17. The single-wall slough trench is the collapse of one wall. In this situation, the protective system is designed with outside walers spanning the opening and providing a backing for protective panels. While conducting the shoring operations for a trench rescue, walers are needed. Follow the steps below.

- Ensure that pickets are holding the walers in place prior to panel installation.
- Lower both walers and tie in place.
- Set panels and back fill any voids with dirt and or air bags.

Inside Waler Placement

4-18. Inside walers are used in a trench to span a set of panels to create an open space. The open space may be required to create room for a digging or extrication operation or to accommodate a piece of equipment in the trench that cannot be moved. Place inside walers by—

- Securing two walers to ropes and placing in the bottom of the trench.
- Setting all three sets of panels.
- Tacking a board to the strongbacks to hold them together.
- Installing middle shores on the outside panels.
- Lifting and placing the bottom walers.
- Installing shores on the bottom walers.
- Placing the top walers and securing with shores.

REMOVAL SYSTEM SELECTION AND USE

4-19. The removal system selected to extricate the victim must be designed to cause no further harm. The system cannot be so complicated and elaborate that it takes 2 hours to construct and use. The "Golden Hour" applies to a victim with severe injuries. The removal system must planned from the start of the incident to ensure a timely extrication. A risk benefit analysis is constantly used and adjusted as the rescue is ongoing.

A-FRAME LADDER

4-20. A high-point anchor system can be constructed using an A-frame ladder (see figure 4-10, page 4-8). Construct the system by—

- Identifying the anchor location.

Note. The distance of anchor points should be three times the working height of the ladders.

- Placing the ladders on the beam side and spreading the ladder butts approximately 70 degrees.
- Lashing the top beam tips with round turns using 20 feet of webbing on each side, and interlocking or offsetting beams as needed.
- Locating the center of the rope. Tying two figure eights on a bight. (Each figure eight is 12 inches off center of the rope. Each figure eight bight is 12 inches in length.)
- Attaching a figure eight on a bight to the ladder tips. Between the inverted "V" of the ladders, under the lashed rungs.

Note. Make sure both beam tips are captured by each figure eight on a bight on each side.

- Moving the terminal ends of the rescue rope to the anchor locations. These are now the guy lines.
- Attaching the mechanical advantage and the belay change of direction pulley between the inverted "V" of the ladders

Note. Once vertical the belay system may need a change of direction pulley at the base of the ladder. The belay system also needs a separate anchoring system.

- Prepare the anchors using a picket system or other suitable anchors. Anchoring systems are perpendicular to the ladders and in line with the entrance hole.
- Set up the far side anchoring system to be a raising operation. The nearside anchoring system is set up to be a lowering operation.
- Prepare to raise the A-frame ladder. The base of the ladders must be in line with the entrance hole to ensure that once raised the system is directly over the hole.
- Place one rescuer at the base of each ladder.
- Place one rescuer at the top of the ladders.
- Place a rescuer at each guy line to operate the raising and lowering systems.
- Ensure that there is tension on the guy lines while they are being raised. Make sure the mechanical advantage and belay lines stay within reach of the ground.
- Adjust the A-frame ladder as necessary.
- Stabilize the ladder base with 20 feet of webbing from beam to beam across the A-frame.
- Inspect the A-frame ladder and prepare for rescue operations.

Figure 4-10. A-frame

BIPOD HIGH-POINT ANCHOR

4-21. Use a bipod as a high-point anchor (see figure 4-11) by—

- Rotating the tripod feet so that the pointed ends of the feet are down and supporting the tripod.
- Ensuring that when working on a surface that would allow the feet to slip, tying or securing the feet in such a manner that they cannot slip and allow the system to collapse.

Note. By using any tripod that has swiveling feet in that configuration (bipod) with the feet flat on a hard surface, you will experience uneven pressure on the edges of the feet as it is leaned over the edge.

- Attaching ropes to the two unused anchors that are attached to the head by using carabiners when using the tripod as an A-frame.
- Tying the tripod back in the opposite direction from the load that is being hoisted. This will prevent the tripod from leaning too far over the edge and causing the system to collapse.
- Checking all rigging and attachments for safety prior to lifting any load, especially a human load.

Figure 4-11. Bipod high-point anchor

LADDER SLIDE

4-22. Refer to figure 4-12. The ladder raise rescue can be accomplished in two ways. Once the patient is secure in the Stokes basket, the Stokes basket is then secured to the end of the ladder that extends down into the trench. Once secure, the rescue team outside the trench will pull the entire ladder up out of the trench. A second method, the Stokes basket is not secured to the end of the ladder. The basket is pulled up the ladder with ropes, using the ladder as a rail system. Either method can be used but must be planned before you build your protective shoring system to ensure that the system is not in the way of the extrication method.

Figure 4-12. Ladder slide

LEVEL II TRENCH RESCUE

4-23. The two most common types of intersecting trenches are the “T” trench and the “L” trench. The rescuers involved in the incident involving an intersecting, “T” or “L” trench, must be certified to operate at the technician level.

4-24. A constructed “T” trench protection system requires a minimum of seven panels and two walers to construct. Rescuers should limit the activity on the corners, and set the first two panels of the “T” leg, pressurizing the struts with low pressure or a soft shot. Unnecessary initial pressure on the struts may blow out the corner. (See figure 4-13 and figure 4-14, page 4-10.) Construct by—

- Positioning the walers at the bottom of the trench.
- Placing the remaining five panels.
- Installing the middle strut on the outside set of panels.
- Installing the bottom strut between the waler and the strongback on the outside set of panels.
- Positioning the top waler and then installing the top.

Figure 4-13. Two side panels

Figure 4-14. Panels with walers

4-25. The constructed “L” trench protective system uses a minimum of six panels, four walers, four thrust blocks, and two corner blocks. Two walers are placed in bottom of trench. The first set of panels are installed on the inside L corners with the middle strut.

4-26. Four thrust blocks need to be installed on the inside corner panels, where the strut ends making contact with the strongback. The outside “L” corner panels are set in place. The walers are placed and tied off and the remaining struts are installed on the inside corner panels.

4-27. Two corner blocks can be nailed to the inside corner where the walers meet. Span the distance from the thrust blocks to the corner blocks with two struts to finish off the corner. See figure 4-15.

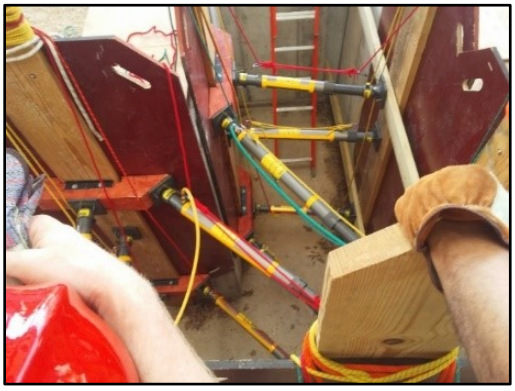

Figure 4-15. Corner blocks

4-28. While pressurizing the pneumatic struts it is essential to follow the advice of the engineer. If there is no engineer on site, pressurize the struts in increments to ensure that the corners are not compromised. Any time a corner is being captured, the amount of air being applied in either a soft or hard shot should be divided by two. The individual pressurizing the struts must be aware of the soil and observe the soils reaction to the strut being pressurized and adjust accordingly.

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Chapter 5

Structural Collapse

Structural collapse rescue is a labor intensive operation that requires multiple techniques to rescue victims.

STRUCTRUAL COLLAPSE OVERVIEW

5-1. Referring to the rescue operation during the tragedy in New York with the twin towers, rescuers will encounter heavy debris removal and stabilization; shoring operations; lifting and moving operations; and torch cutting operations. The initial site operations—size up and search—are basically the same as chapter 1. Below are the skills needed during structural collapse operations.

- Identify the rescue area.
- Understand the control measures at a scene.
- Identify PPE and mission essential equipment needs (see chapter 1 for PPE).
- Identify specialized resources (such as professional engineers, electricians, and heavy equipment operators.

5-2. When orientating rescue operations it is key that all rescuers and the operations cell are communicating in order to draw a sketch of the rescue zone and to ensure accountability of personnel. Rescuers should determine the following:

- **Building sides.** Start on the street side of the building. This is side A. Proceed clockwise with the letters until all sides are lettered. See figure 5-1.
- **Entire block.** When an entire block is hit by a tornado it may not have any doors or house numbers intact. In these cases, rescuers must map the area in order to provide a working blueprint for themselves and other teams of rescuers. The standard system for locating a building on any block is as follows:
  - Use existing numbers and fill in unknowns.
  - If all the numbers are unknown, keep the numbers small and mark odd and even sides of the street.

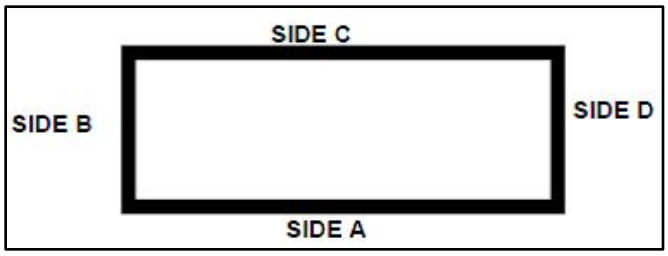


Figure 5-1. Sides of a building

- **Facility quadrants.** Each building is divided into quadrants to help navigate on the inside of the structure and to be able to communicate locations to those not inside. See figure 5-2, page 5-2.

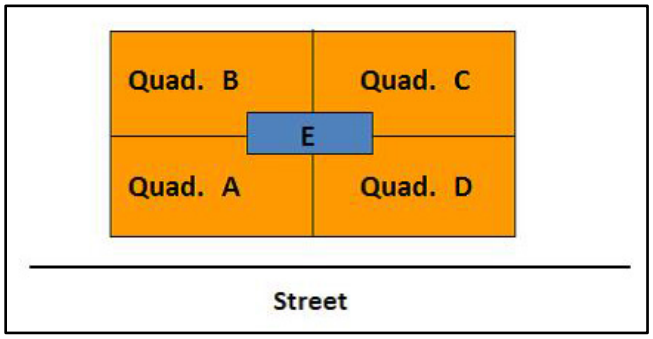


Figure 5-2. Quadrants within a building/structure

- **Facility floors.** When it comes to multistory structures the ground floor is floor 1, the second is floor 2, the third is floor 3, and so forth. The first floor below grade would be B-1, second B-2, third B-3, and so forth.

5-3. Conduct search operations and markings the same as in chapter 1. Refer to the United States Army Corps of Engineers Field Operating Guide for more detailed search markings.

COLLAPSE PATTERNS TYPES

5-4. During the rescuers search operations it is key to understand the different types of collapse patterns, know where the void spaces are, and determine victim survivability. Below are the main collapse patterns. Also refer to the United States Army Corps of Engineers Field Operating Guide for more detailed information. There are several types of collapsed patterns that a rescuer must know and understand the potential hazards associated with each. Below are the collapsed patterns and the dynamics.

- **Lean-to collapse pattern.** The lean-to collapse pattern is often formed when a wall failure causes a floor or roof section to fall completely on one side, while the other end remains supported.
- **V-shape collapse pattern.** The V-shape collapse pattern is created when a floor assembly collapses in the middle due to the failure of the center supports or the overload of the floor.
- **A-frame collapse pattern.** The A-frame collapse pattern is formed when the flooring separates from the exterior bearing walls but still is supported by one or more interior bearing or nonbearing partitions.
- **Pancake collapse pattern.** The pancake collapse pattern is formed when single or multiple floors and/or a roof collapse results in a layering effect. The resulting voids are limited in space and are difficult to access, especially in concrete structures. Victims are often found in the small spaces created where the floors are separated by supporting building contents such as furniture, appliances, or equipment.
- **Cantilever collapse pattern.** The cantilever collapse pattern is formed when a wall collapse results in one end of the floor(s) and/or a roof hanging unsupported and suspended above the other floor(s) on the side where the wall failed. The opposite end of the floor assembly remains attached to the wall at its original connection point.

SHORING OPERATIONS

5-5. Shoring for US&R is the temporary support of only that part of a damaged, collapsed, or partly collapsed structure that is required for conducting search and/or rescue operations at reduced risk to the victims and US&R forces. A shoring system is like a double funnel. It needs to collect the load with headers/sheathing, deliver it into the post/struts, and then to distribute it safely into the supporting structure below.

SHORING OPERATIONS ESTABLISHMENT

5-6. Shoring operations consists of the following teams:

- **Shoring team.** The shoring team—
  - Performs the actual shoring size up.
  - Takes measurements.
  - Constructs the shores.
  - Relays information to the cutting team.
- **The runner.** The runner—
  - Receives the measurements from the shoring team.
  - Relays measurements to the cut team.
  - Carries lumber to the shoring team.
- **The cut team.** The cut team—
  - Establishes the lumber cache.
  - Sets up the cutting station.
  - Cuts all the lumber for the shoring team.

COMMON SHORE COMPONENTS

5-7. Common shore components terminology is used to describe the shore components. Refer to the United States Army Corps of Engineers/Urban Search and Rescue Shoring Operations Guide for more details on components. Components include—

- **Braces.** Braces increase the strength and stability of shores by providing additional support.
- **Cleats.** Cleats are small pieces of wood (typically 2 by 4 inches) used to secure other parts of a shoring system in place.
- **Gusset plates.** Gusset plates are square, rectangular, or triangular pieces of 3/4-inch plywood nailed to secure shoring component junctions or connection points together.
- **Header.** A header is the uppermost element of the shore.
- **Horizontal post or strut.** A horizontal post or strut is the horizontal load-bearing member placed between the header and the floor.
- **Raker.** A raker is the diagonal strut that supports the load from the wall.
- **Shims.** Shims are small, thin wedges, cut from 2- by 12-inch pieces of wood used to snug up a load and fill in voids.
- **Sole plate.** A sole plate is a plate that distributes the weight being transferred from the vertical post to a stable surface.
- **Vertical post.** A vertical post is a post that supports and transfers the weight from the header to the sole plate.

LEVEL I SHORING SYSTEMS

5-8. The authority having jurisdiction can determine other shores to be proficient based upon the cache, personnel, and the validation of the team. Below are four examples of Level I shoring.

- **Timber spot shore (T-post).** The timber spot shore is a temporary shore constructed entirely of wood components that can be installed quickly in unstable areas. See figure 5-3, page 5-4. This shore is used for initial stabilization of dangerous areas where fully braced systems (such as vertical shores) are to be constructed. The following are the steps used to stabilize dangerous areas:
  - Determine where the spot shore should be built in order to reduce risk.
  - Measure the overall height of the shore area.
  - Measure and cut the proper length of the header and sole plate.
  - Measure the overall height to be shored.
  - Deduct the thickness for the header, sole plate, and wedges.

- Measure and cut the vertical post.
- Nail 12- by 12- by 3/4-inch gusset plates on both sides of the header and post.
- Position the shore and sole plate under the load.
- Ensure that the post is plumb.
- Pressurize the spot shore with wedges.
- Tap a duplex nail halfway into the sole plate behind each wedge.
- Nail 6- by 12- by 3/4-inch gusset plates or cleats on both sides of the sole plate to secure it to the vertical post.

Figure 5-3. T-spot

- **Two-post (double post) vertical shore.** The vertical shoring system can be used to support floors and/or roof sections that are in danger of failing. See figure 5-4. The two post vertical shore is considered a Level 1 shore. The following are the steps in order to construct the two post vertical shore:
  - Measure and cut the proper length of header and sole plate.
  - Measure the overall height to be shored.
  - Deduct the thickness for the header, sole plate, and wedges.
  - Measure and cut the two vertical posts.
  - Nail gusset plates to one side of the header.
  - Turn the shore over to the other side.
  - Measure, cut, and install the midpoint brace, if needed.
  - Measure, cut, and install the top diagonal brace to secure the header to the vertical posts.
  - Position the shore and sole plate under the load. Align the ends of the header and sole plate.
  - Ensure that the shore is plumb.
  - Pressurize the posts with wedges.
  - Measure, cut, and install the bottom diagonal brace to secure the sole plate to the vertical posts.
  - Nail gusset plates and/or cleats on both sides of the post joints not covered by a diagonal brace to secure all joint connections.
  - Evaluate the shore and structure.

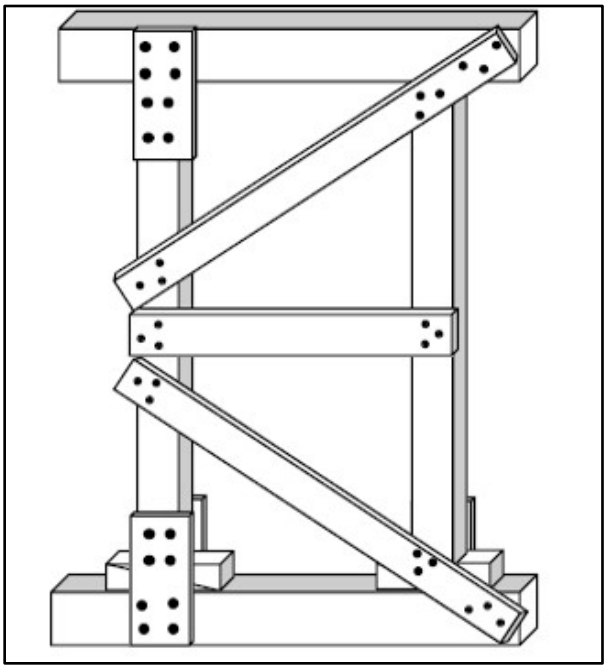


Figure 5-4. Two post

- **Raker shore.** Raker shores are used to stabilize leaning and/or damaged walls. See figure 5-5, page 5-6. Raker shores are diagonal shores used to give stability to walls and sometimes entire structures. Below are the steps the rescuers must do in order to construct a raker shore.
  - Determine the height of the supported wall and the height of the insertion point.

Note. The insertion point is an area located between the top of the floor joist and 2 feet below that point.

  - Determine the raker shore's angle. The two most common angles used are 45 and 60 degrees.
  - Measure and cut the wall plate to length.
  - Install the top cleat.
  - Measure and cut the raker to the rough length.
  - Measure and cut the bottom brace to length.
  - Cut the raker to the desired length.
  - Ensure that the raker has angle cuts with 1 1/2-inch return cuts for full contact with wall plate.
  - Prefabricate the shore.
  - Toenail the raker to the wall plate.
  - Nail a gusset to one side of the joint.
  - Nail one bottom brace to the wall plate, 6 inches from the bottom.
  - Turn the shore over.
  - Repeat the steps on this side of the raker.
  - Assemble the trough and the 18 inch by 18 inch foot (if bearing on soil).
  - Move the prefabricated split sole raker shore in place.
  - Place the trough and foot into position.
  - Place the sole anchor and adjust the trough.
  - Drive wedges.

- Maintain full contact between the wall plate at the insertion point and at the base of the wall plate and the wall.
- Finish nailing the bottom brace and tightening the wedges.
- Anchor the shore to the wall (per the United States Army Corps of Engineers Urban Search and Rescue Program Shoring Operations Guide).
- Place the midbrace (if required by length of the raker).
- Erect horizontal and X-bracing.
- Secure the sole anchor (per United States Army Corps of Engineers Urban Search and Rescue Shoring Operations Guide).

Figure 5-5. Raker shore

- **Door/window shore method.** See figure 5-6. Door and window shores are used to confine and support loose masonry over openings in the walls. They may be used in wood or other buildings where the door or window headers have been damaged. Below are the steps in the building of the door and window.
  - Measure the proper length of the header and sole plate using the shortest length measured if the opening is uneven.
  - Deduct 1 1/2 inches from the length of the header and sole plate.
  - Cut the header and sole plate to the desired length.
  - Measure the overall height to be shored using the shortest length measured if the opening is uneven.
  - Deduct the depth for the header and sole plate.
  - Deduct 1 1/2 inches from the height to allow for pressurization with wedges.
  - Cut the vertical posts to the desired length.
  - Lay out the cut components of the shore on the ground.
  - Place the vertical posts between the header and sole plate.
  - Secure the top and bottom of the vertical posts to the header and sole plate using triangular gusset plates.
  - Turn the shore over to the other side.
  - Secure the top and bottom of the vertical posts to the header and sole plate using triangular gusset plates.
  - Install the shore into the window opening.
  - Pressurize the shore with 1 1/2-inch wedges under the sole plate using two sets of wedges.
  - Pressurize the shore with 1 1/2-inch wedges to the side of one vertical post using three sets of wedges.

- Install diagonal braces if the opening is not used for access or egress.
- Evaluate the shore and structure.

Figure 5-6. Door and window shore

BREACHING AND BREAKING OPERATIONS

5-9. Breaching, cutting, and drilling are labor intensive and time-consuming tasks for rescuers trying to beat the clock to save a victims life. At the same time, rescuers must work at a careful pace so that safety is not compromised. The shape and size of a breached opening will be dependent on the intended use of the hole. The initial hole should be large enough for a rescuer to gain access for search operations and victim care. Before the operation, determine the minimum shapes and sizes to allow access of a rescuer wearing proper PPE.

- **Conduct a clean breach.** A clean breach is used when there is a concern that breached material will fall or cause additional hard to the victim.
  - Mark the location on the concrete to be breached.
  - Drill an inspection hole through the concrete and check for the victim on the other side.
  - Insert an anchor into the inspection hole.
  - Attach webbing to the anchor to prevent the breached area from falling on the victim.
  - Stitch cut the area that was marked.
  - Remove the breached area.
- **Conduct a dirty breach.** A dirty breach is used when there is not a victim or no concern of where the breached material will fall. See figure 5-7, page 5-8.
  - Drill an inspection hole and ensure that there is not a victim on the other side.
  - Mark the area to be breached.
  - Cut the marked area out and remove it from the breach area.

Note. Ensure that the access hole is of adequate size for the rescuer and packaged victim on a stretcher.

Figure 5-7. Dirty breach

- **Cut a rectangle shape.** In a wooden light-framed structure, the initial opening created will be approximately 12 inches wide by 24 inches high based on framing centers. After accessing the adjacent structural members for stability, the initial opening can be expanded by removing one stud, joist, or rafter to provide better access for rescuers and a victim secured to a packaging device. It requires four cuts and is not recommended for masonry walls because it will reduce the strength at the top of the opening.
- **Cut a circular shape.** This shape is acceptable to use with a masonry wall because it will not reduce the strength at the top of the opening. If the concrete has a weakness, such as a crack, break, or space that has been created from the collapse, use these weaknesses to the rescuers advantage to speed the process of gaining entry. The initial opening should be oval in shape, approximately 24-inches wide by 14-inches high. This shape requires the least amount of time to create an opening large enough for rescuer access. The hole can be expanded to meet operational needs. Typical minimum size would be a 24-inch diameter. See figure 5-8.

Figure 5-8. Circular shape

- **Cut a triangular shape.** This shape is most often used to breach masonry products and is desired for masonry walls. It is less likely for the opening to fail based on the configuration of the opening and the forces at play while breaching concrete. An inspection hole is made with stitch holes being made around the perimeter of the triangle. Masonry breakers, drills, and jackhammers are then used to remove the concrete within the triangle. This cut requires three cuts with the minimum size being 36 by 36 by 36 inches. The triangle shape allows for easier access of moving patients that are secured to or on a long spine board or other packaging devices such as a Yates or Stokes basket. See figure 5-9.

Figure 5-9. Triangular shape

LIFTING AND MOVING OPERATIONS

5-10. Simple hand tools can be used to create tremendous mechanical advantage to lift, lower, and move large loads safely. Those same loads can be moved with relative ease by reducing friction between the load and the surface it is to be moved across. Basic methods of building crib beds can be used to stabilize heavy objects. Levers and inclined planes are two types of simple devices that can be used to provide mechanical advantage.

LEVERS

5-11. The simplest of machines is a lever. A lever is a rigid bar, either straight or bent, that is free to move on a fixed contact point called a fulcrum and works by transferring force from one place to another. There are three classifications of levers determined by the location of the fulcrum as it relates to both the load and the force.

- **Class 1 lever.** The Class 1 lever gives the greatest mechanical advantage. A load is located at one end of the lever and the lifting force is placed at the other end, with a fulcrum located between the two. Crowbars and pry bars are examples of Class 1 levers. They are most useful for lifting objects vertically. The Class 1 lever changes the direction of the force. Here the force is applied downward while the load moves up. See figure 5-10.

Figure 5-10. Class 1 levers

- **Class 2 lever.** The Class 2 lever is the next most useful and efficient lever. It consists of a fulcrum at one end of the lever, a load in the middle, and a force on the other end. Wheelbarrows are a type of Class 2. This lever is useful for moving objects horizontally. See figure 5-11, page 5-10.

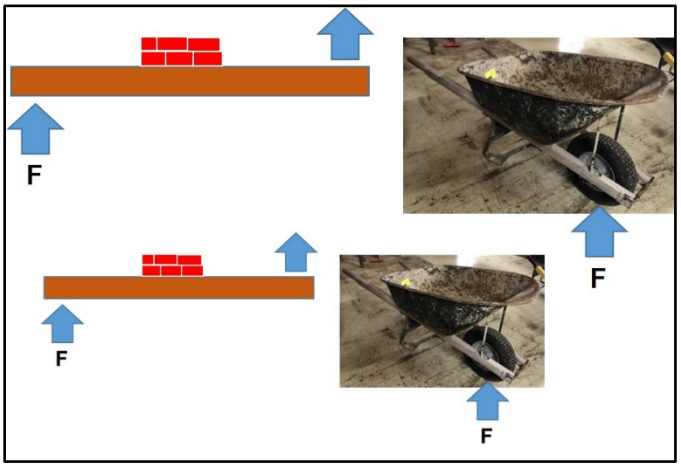


Figure 5-11. Class 2 levers

- **Class 3 lever.** The Class 3 lever is used when force may be sacrificed for distance. It places a load on one end, the fulcrum on the opposite end, and the force in the middle. Shovels and brooms are types of Class 3 commonly used for light debris removal. Class 3 levers are not used for lifting or moving heavy objects.

INCLINED PLANE

5-12. See figure 5-12. An inclined plane is a slanted surface that is used to raise objects. It is a simple device that does not appear to be a machine. It is an instrument designed to transmit or modify the application of power, force, or motion, but is an efficient way to raise a heavy object. Examples of inclined planes are ramps, wooden wedges, and screw threads. Inclined planes gain effectiveness of energy when used on the following principle: *Distance = Mechanical Advantage*

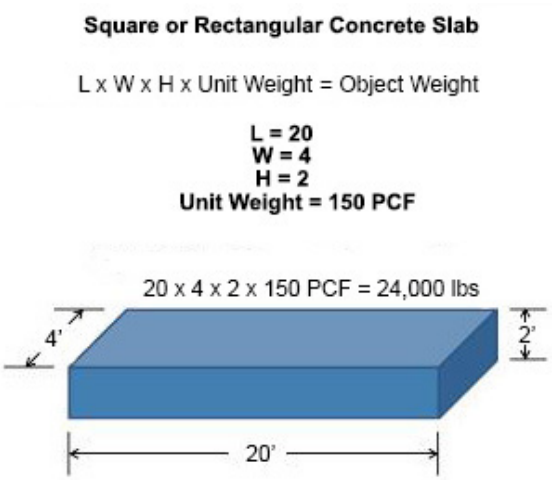
Figure 5-12. Inclined plane

WEIGHT ESTIMATION

5-13. It is important to estimate the weight of an object to be lifted in order to determine if a cribbing will hold it or if the load is within the capabilities of the rescuers equipment. Some of the more common materials involved in structural collapse incidents and their weights are as follows:

- Estimate the weights of common building materials.
  - **Concrete:** 150 pounds per cubic foot
  - **Masonry:** 125 pounds per cubic foot
  - **Wood:** 35 pounds per cubic foot
  - **Steel:** 490 pounds per cubic foot

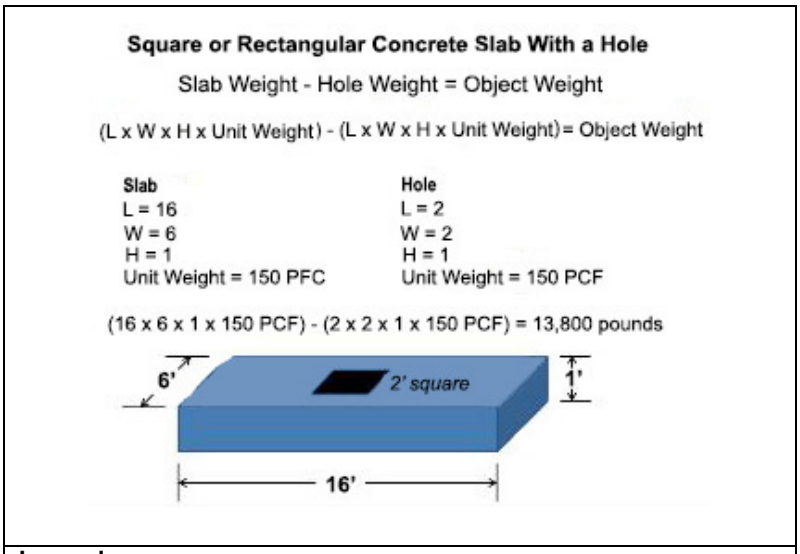
- Calculate the weight of a square or rectangular concrete slab (see figure 5-13).
  - Find the weight of a square or rectangular slab measure the length, width, and height.
  - Multiply the length x width x height x 150 = the answer. (Concrete is 150 pounds per cubic foot.)
- Determine the answer by taking the length of a piece of concrete is 20 feet long x 4 feet wide x 2 feet high. *20 x 4 x 2 = 160 cubic foot*. Take 160 x 150 (weight of concrete) = 24,000 pounds.



Legend:	
H	height
L	length
lbs	pounds
PCF	pounds per cubic foot
W	weight

Figure 5-13. Concrete slab

- Calculate the weight of a square or rectangular concrete slab with a hole. See figure 5-14, page 5-12. If there is a hole in a piece of concrete, the hole has to be calculated as well.
  - Measure the slab: 16 feet long, 6 feet wide, 1 foot high: 16 x 6 x 1 = 96
  - Multiply the square feet x pounds per cubic foot: 96 x 150 = 14,400 pounds
  - Measure the hole: 2 feet long x 2 feet wide x 1 foot high: 3 x 2 x 1 = 4 square feet
  - Multiply the square feet x pounds per cubic foot: 4 x 150 = 600 pounds
  - Subtract the hole weight from the weight of the slab: 14,400 – 600 = 13,800 is the weight of the slab.

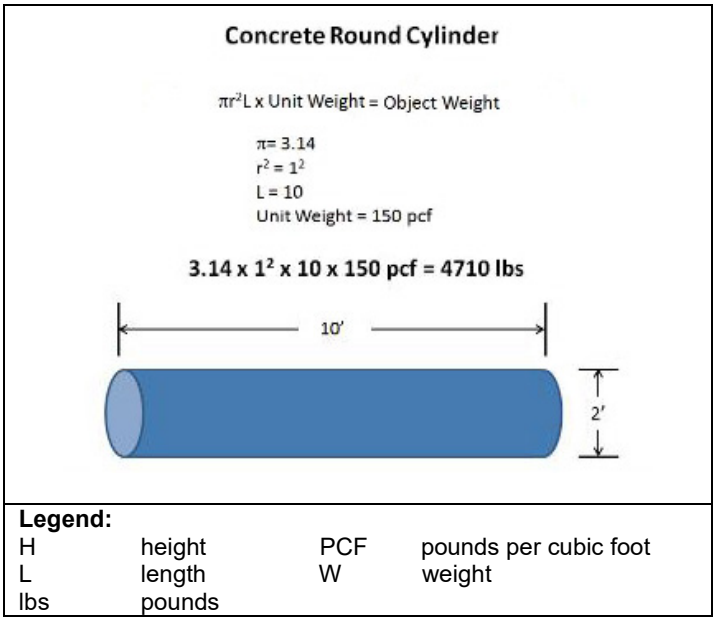


Legend:	
H	height
L	length
lbs	pounds
PCF	pounds per cubic foot
W	weight

Figure 5-14. Slab with hole

- Calculate the weight of a round concrete cylinder. See figure 5-15.
  - When calculating found or cylinder objects, use Pi: 3.14.
  - For the ends use the radius^2 which is half of the diameter multiplied by itself.
  - For example, the figure 5-15 shows that the length of the concrete cylinder is 10 feet. The height of the cylinder at the ends is 2 feet. Half of 2 is 1 which is the radius^2 and 3.14 is the circumference. The weight of the concrete is 150 pounds per cubic foot. The solution is—

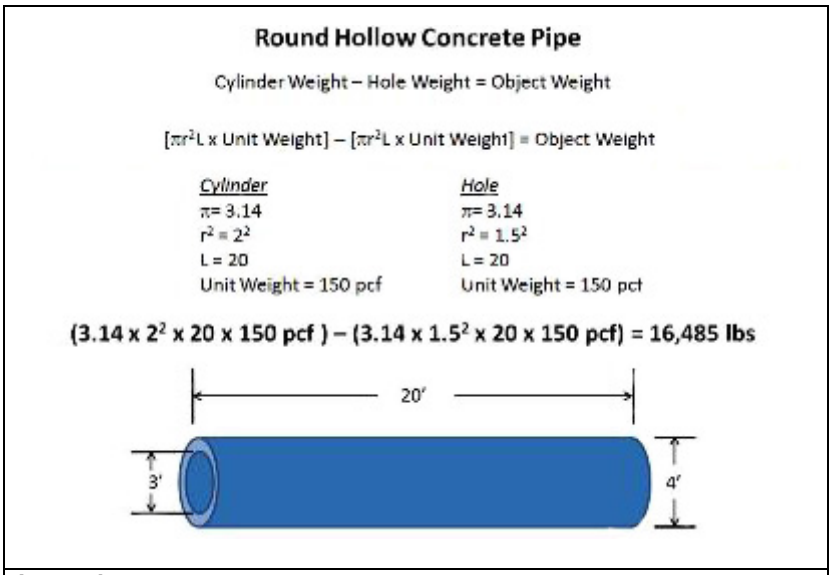
3.14 x 1^2 x 10 x 150 = 4,710 pounds.



Legend:			
H	height	PCF	pounds per cubic foot
L	length	W	weight
lbs	pounds		

Figure 5-15. Round cylinder

- Calculate the weight of a round hollow concrete pipe. See figure 5-16.
  - Calculate the weight of the pipe. (Pi) 3.14 x (r^2) 2^2 x 20 feet long = 251.2
  - Multiply 251.2 x 150 pounds per cubic foot = 37,680
  - Calculate the weight of the hole. (Pi) 3.14 x (r^2) 1.5^2 x 20 feet long = 141.3
  - Multiply 141.3 x 150 pounds per cubic foot = 21,195
  - Subtract 21,195 from 37,680 = 16,485 pounds



Legend:	
L	length
lbs	pounds
PCF	pounds per cubic foot

Figure 5-16. Round hollow concrete

- Calculate the weight of a steel plate. See figure 5-17, page 5-14.
- Convert all measurements to feet. The steel plate is 36 inches long, 12 inches wide, and 3 inches high.

Note. Remember the steel weighs 490 pounds per cubic foot; however, it is very common for 500 pounds per cubic foot to be used for ease of math in the field.

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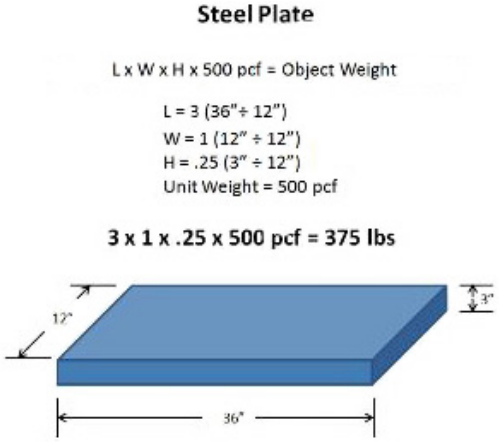
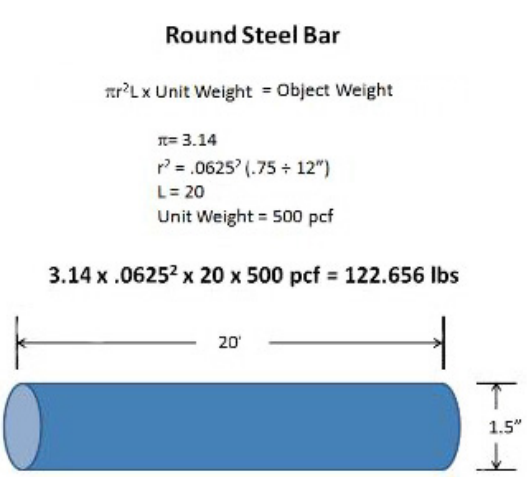
36 divided by 12 = 3 feet
12 divided by 12 = 1 foot
3 divided by 12 = .25
Multiply 3 x 1 x .25 x 500 = 375 pounds



Legend:	
H	height
L	length
lbs	pounds
PCF	pounds per cubic foot
W	weight

Figure 5-17. Steel plate

- Calculate the weight of a round steel bar. See figure 5-18.
- Use 3.14 to find the radius².
- Calculate the r^2; the diameter is 1.5 inches. Half the diameter 1.5 inches divided by 2 = .75 inches, convert inches to feet .75 divided by 12 = $.0625^2$ feet.
- Measure the length of the bar—20 feet.
- Multiply by 500 pounds per cubic foot.
- Calculate the data: 3.14 x $.0625^2$ feet x 20 feet x 500 pounds per cubic foot = 122.656 pounds. Round up to 123 pounds.



Legend:			
L	length	PCF	pounds per cubic foot
lbs	pounds		

Figure 5-18. Steel cylinder

- Calculate the weight of a steel column (see figure 5-19) by using the following information:
  - **Measure side one.** 36 feet long x 36 inches wide x 2 inches thick x 500 (pounds per cubic foot of steel). Convert inches to feet—36 inches divided by 12 = 3 feet; 2 inches divided by 12 =.167. Calculate the measurement—36 feet x 3 feet x .167 feet x 500 pounds per cubic foot = 9,018 pounds.
  - **Measure side two.** 36 feet long x 16 inches wide x 2 inches thick x 500 (pounds per cubic foot of steel).
  - **Determine the thickness of the flange.** Subtract the 2 inch thickness on the bottom and top of the flange: 16 inches – 4 inches = 12 inches in width.

Convert inches to feet
12 inch width divided by 12 = 1 foot width, 2 inch thickness by 12 = .167 feet

Calculate the measurement
36 feet x 1 foot x .167 feet x 500 pounds per cubic foot = 3, 006 pounds

  - **Measure side three.** 36 feet long x 36 inches wide x 2 inches thick x 500 (pounds per cubic foot of steel).

Convert inches to feet
36 inches divided by 12 = 3 feet; 2 inches divided by 12 = .167

Calculate the measurement
36 feet x 3 feet x .167 feet x 500 pounds per cubic foot = 9,018 pounds

  - **Measure side four.** 36 feet long x 16 inches wide x 2 inches thick x 500 (pounds per cubic foot of steel).

Determine the thickness of the flange
Subtract the 2 inch thickness on the bottom and top of the flange: 16 inches – 4 inches = 12 inches in width

Convert inches to feet
12 inch width divided by 12 = 1 foot width, 2 inch thickness by 12 = .167 feet

Calculate the measurement
36 feet x 1 foot x .167 feet x 500 pounds per cubic foot = 3, 006 pounds

- Calculate the weight of the object by using the following: Side 1 + Side 2 + Side 3 + Side 4 = weight of object: 9,018 + 3,006 + 9,018 + 3,006 = 24,048 pounds.
- Convert inches to feet.

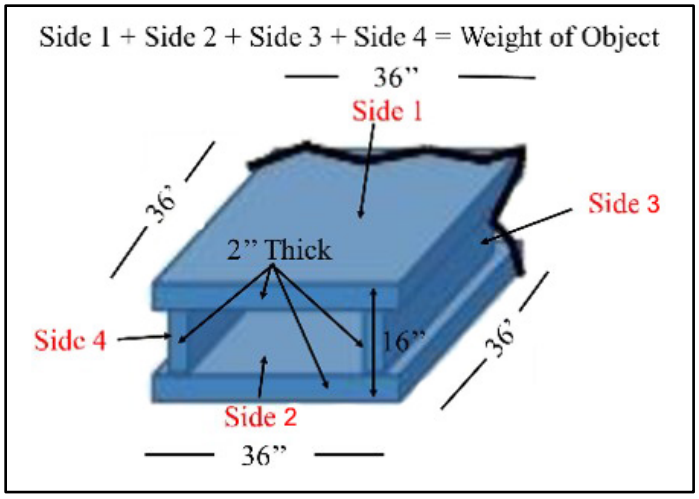


Figure 5-19. Steel beam

LEVEL II STRUCTURAL COLLAPSE

5-14. Level II structural collapse is similar to Level I. Structural collapse Level II can be broken down into four teams—shoring; lifting and moving; breaching and breaking; and torch cutting operations. This training circular will show the difference between Level I and Level II.

5-15. The authority having jurisdiction can determine other shores to be proficient based upon the cache, personnel, and the validation of the team. Below are four examples of Level II shoring.

- **Slope floor shore.** See figure 5-20. To construct a slope floor shore—
  - Determine the height and width of the shore by measuring the opening.
  - Cut the headers and sole plates. The header overhang is a maximum of 12 inches. The sole plate must extend 30 inches from the front of the longer post to allow for the cleats and anchors.
  - Cut the posts to the measured height. The bottom of each post will have 1 1/2-inch return cuts.
  - Attach the posts by toenailing them to the header and sole plates.
  - Attach the cleats to the 30-inch overhang side of the sole plate against the post.
  - Anchor the sole plate to the floor. A minimum of 2 anchors per sole plate.
  - Drill two 1-inch diameter holes through each sole plate on the 30-inch overhang.
  - Insert rebar (minimum 36 inches) through the holes and hammer them in the ground a minimum of 18 inches.
  - Measure for and cut the diagonal braces. Diagonal braces should be long enough to span the entire length and be attached to the header, sole plate, and to each post.
  - Install the diagonal braces by nailing them to the posts, header, and sole plates.
  - Place the half gusset plates to the opposite sides of the post.
  - Measure and cut the horizontal braces. Horizontal braces are placed on both the long and short posts.
  - Nail the horizontal braces into position. Horizontal bracing may be installed on the inside of the shorter posts if access is not possible.
  - Evaluate the shore and structure.

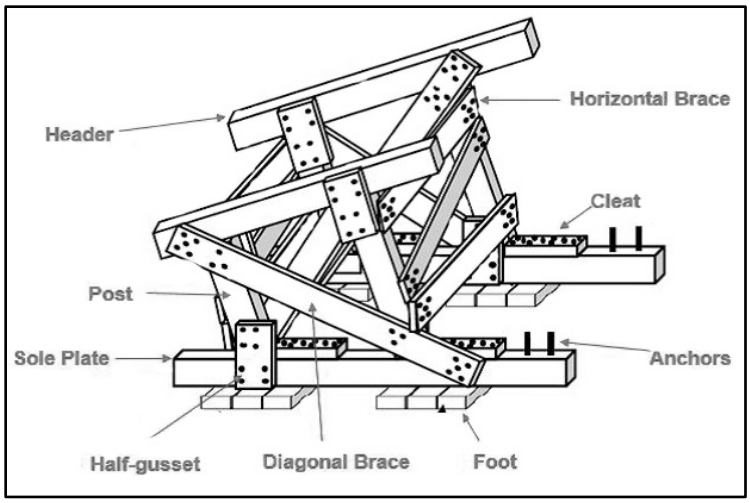


Figure 5-20. Slope floor shore

- **Laced post shore.** See figure 5-21. To construct a laced post shore—
  - Clear the area of debris where the shore will be placed.
  - Measure the opening to determine the height and width of the shore.
  - Construct 2- by 2-post vertical shores.
  - Place both 2-post vertical shores into position.

Note. Maximum spacing for 4-inch by 4-inch posts is 4 feet on the center; Maximum spacing for 6- by 6-inch posts is 5 feet on center.

- Connect (lace) the two sections together.
- Nail the horizontal braces into position.
- Start with the lowest horizontal brace and work up.
- Attach the diagonal braces to the posts. This is a high capacity four-post system that can be used to shore a damaged concrete floor or heavily loaded and damaged wood floor. It is constructed similar to a pair of vertical shores but laced together.

Note. The header, posts, and sole plate should be the same width of diagonal braces to be more effective.

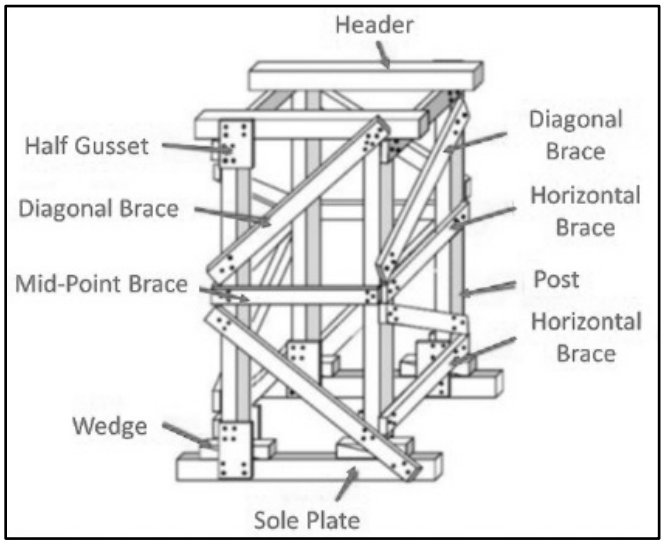


Figure 5-21. Laced post shore

- **Horizontal shore.** This shoring is used for weakened walls (see figure 5-22, page 5-18). To construct a horizontal shore—
  - Measure and cut the proper length of wall plates.
  - Measure the overall width to be shored. Use the shortest length measure if the area is uneven.
  - Deduct the thickness of the wall plates and wedges.
  - Measure and cut the struts.
  - Measure and mark the strut location on the wall plates.
  - Attach the cleats to aid in strut placement, if needed.
  - Position the shore and align the ends of the wall plates.
  - Install and pressurize the top strut.
  - Install and pressurize the bottom strut.
  - Install diagonal braces if the posts are 4 feet or greater, unless access or egress is required.
  - Install midpoint braces if posts are 8 feet or greater.
  - Nail gusset plates and/or cleats on both sides of the post joints not covered by a diagonal brace to secure all joint connections.
  - Evaluate the shore and structure.

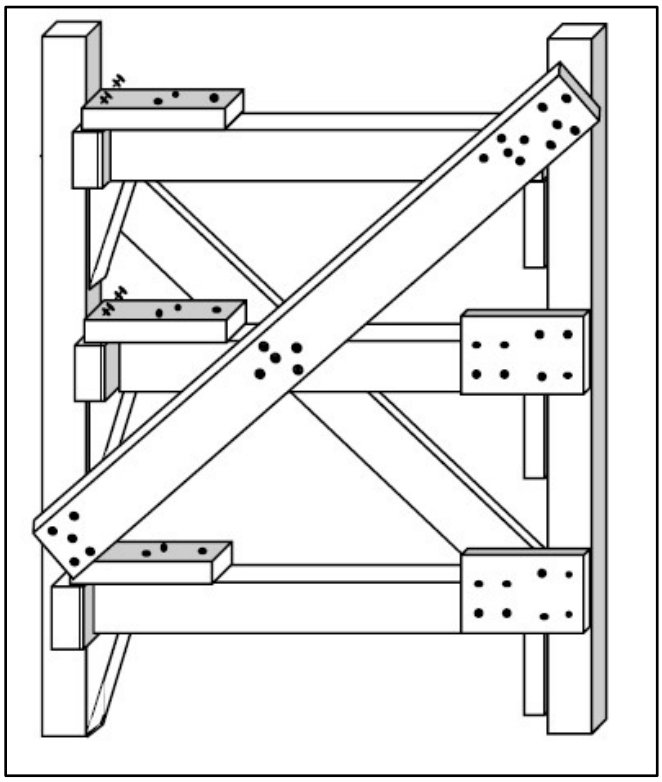


Figure 5-22. Horizontal shore

- **Paratech© raker shoring.** See figure 5-23. Assemble a Paratech raker shoring—
  - Identify the height of the insertion point.
  - Assemble the wall plate.
  - Ensure that the raker wall plate extends 12 inches above the insertion point.
  - Attach the raker rail latch bases onto the assembled raker rails.
  - Place the upper base at the insertion point.
  - Place the bottom base at the bottom hole or one hole higher off the ground.
  - Determine the length of the raker shore. Use the chart attached to the wall plates.
  - Assemble the raker shore and sole shore (using the longshore struts and longshore extensions) and attach to the wall plate.
  - Attach the raker junction base onto the raker and sole shores.
  - Attach the 12- x 12-inch hinged base plates to the bottom of the raker junction.
  - Attach the nailing pads to the approximate locations.
  - Move the assembled system to the wall to be supported.
  - Anchor the raker to the ground with the base plates using pickets or wood cribbing. Pickets are driven in the second hole set to accommodate the raker angle base, if needed.
  - Attach to the wall. Use the predrilled holes in the wall plates.
  - Pressurize the shores and lock into place.
  - Attach the appropriate horizontal and diagonal bracing as needed. (Use the 16d 5-nail pattern.)

Note. Refer to the United States Army Corps of Engineers Urban Search and Rescue Shoring Operations Guide for raker and horizontal shores with pneumatic struts.

Figure 5-23. Raker shore

TORCH CUTTING OPERATIONS

5-16. Torches are well suited for cutting through heavy metal structures. They are used primarily to cut steel reinforcing plates, beams, or cables. There are three torches that may come in the rescuer cache or the extractor cache. The authority having jurisdiction has the responsibility to determine the proper level of what torch is Level I and or Level II.

5-17. Technical rescuers frequently use an oxygen and fuel for torch cutting. A torch with a specially designed tip is connected to a fuel tank, typically acetylene or one of three popular fuel alternatives, and mixes the fuel with oxygen in order to produce a high-temperature flame cone to cut through metals. It is vital that the rescuer know the proper techniques and procedures for the torches discussed below.

OXYGEN ACETYLENE CUTTING TORCHES

5-18. See figure 5-24, page 5-20. Discussed below is the techniques and procedures used to preassemble and shut down an oxy-torch.

- Preassembly instructions. Preassemble by—
  - Ensuring that the regulator pressure adjustment screws are backed out.
  - Ensuring that the torch valves are closed.
  - Standing away from front of the regulator.
  - Separately and slowly opening the oxygen fully and acetylene cylinder valves 1/2 turn.
  - Turning the regulator adjustment screw clockwise to 7 acetylene 40 oxygen.
  - Opening/closing the torch valves separately and fine tuning the pressure settings on the regulators.
  - Separately purging both oxygen and fuel gas lines.
  - Opening the fuel gas valve 1/2 turn.
  - Igniting the flame with the striker.
  - Increasing the fuel gas flow until the flame leaves the end of the tip and no smoke is present.
  - Decreasing until the flame goes back to the tip.
  - Opening the oxygen valve and adjusting to neutral flame.
  - Depressing the oxygen lever and making necessary adjustments.

Note. Never set acetylene above 15-pounds per square inch.

- Shut down an oxygen acetylene torch by—
  - Closing the oxygen torch valve.
  - Closing the fuel gas torch valve.
  - Storing the torch/regulators and gases.
  - Closing the oxygen and fuel gas cylinder valves.
  - Separately purging the oxygen and fuel gas lines.
  - Ensuring that all regulator gauges read 0.
  - Backing out the regulator pressure adjustment screws.
  - Disconnecting the regulators from the oxygen and acetylene.
  - Attaching the steel safety caps to each cylinder.
  - Storing upright in an approved storage area.

Figure 5-24. Oxygen acetylene

EXOTHERMIC TORCH

5-19. An exothermic torch works by feeding oxygen through an exothermic carbon steel cutting rod that is charged by the 12-volt battery. When using the torch, the rod is put in contact with a striker that creates a short circuit arc causing the tip of the rod to heat and spark. Discussed below is the process. See figure 5-25.

Figure 5-25. Exothermic

Preassembly Inspection

5-20. When performing a preassembly inspection—

- Inspect the oxygen hose for damage or wear prior to each use.
- Inspect the ignition power cables and connectors for damage or wear.
- Inspect the torch for damage or wear prior to and immediately following each use.
- Inspect the collet, collet washer, flash arrestor, and heat shield.

- Check the battery for leaks.

Assembly Procedures

5-21. Assemble the torch by—

- Purging the cylinder to remove debris.
- Connecting the oxygen regulator to the oxygen source.
- Connecting the oxygen hose to the regulator.
- Slowly opening the oxygen cylinder valve.
- Adjusting the oxygen regulator to between 90 and 100 pounds per square inch.
- Checking all connections for oxygen leaks.

Battery Connection

5-22. Connect the battery by—

- Connecting the power cable from the torch to the battery by connecting the red battery clamp to the positive terminal.
- Connecting the power cable from the striker plate to the battery by connecting the black battery clamp to the negative terminal of the battery.

Cutting Rod Insertion

5-23. Insert the cutting rod by checking to see that the collet in the torch is the appropriate size to properly fit the rod being used. Replace a collet by—

- Removing the collet nut and collet from the torch.
- Ensuring that the neoprene collet washer is in place.
- Inserting the desired collet and replacing the collet nut.
- Loosening the collet nut 1/2 turn.
- Inserting the end of the rod that has the recessed internal rods into the collet.
- Tightening the collet nut to lock the rod in place.
- Checking for oxygen leaks at the collet nut. If a leak exists—
  - Ensuring that the rod is firmly seated on the collet washer.
  - Inspecting the rod for damage.
  - Inspecting the collet washer for damage and replace if necessary.

CUTTING OPERATIONS

5-24. Conduct cutting operations by—

- Placing the burning tip of the rod against the target material at a 45- to 90-degree angle.
- Increasing the oxygen flow by slowly depressing the oxygen lever.
- Keeping the rod tip in the cut.
- Pulling the rod in the direction of the cut.
- Completing the cut by making sure all the hangers are removed.
- After completing the cut, releasing the oxygen control lever to extinguish the torch.

5-25. Conduct shutdown operations by—

- Closing the oxygen cylinder valve.
- Depressing the oxygen control lever to relieve any pressure from the oxygen hose.
- Turning the oxygen regulator adjustment knob counterclockwise to take the pressure off the diaphragm.
- Disconnecting the regulator and securing the cylinder safety cap on.
- Disconnecting the torch and striker plate power cables from the battery.

- Wiping down the torch assembly and striker plate assembly with a clean oil-free cloth.
- Storing the torch in a clean, dry place.

PETROGEN TORCHES

5-26. See figure 5-26. The paragraphs below discuss the torch operations, and the shutdown of Petrogen torches.

- **Torch operation.** Operate the torch by—
  - Filling the 2.5 gallon fuel tank to the weld line.
  - Pumping the fuel tank to the pressure specified for the system. If the system requires 20 or 50 pounds per square inch, this will be indicated in the manual.
  - Slowly opening the fuel valve all the way making sure the safety valve does not set.
  - Purging the oxygen cylinder to remove debris.
  - Connecting the regulator to the oxygen bottle and snugging the fitting with the adjustable wrench.
  - Loosening the adjustment screw by turning counterclockwise.
  - Opening the cylinder fully standing to the side and ensuring that no one is in front of the regulator.
  - Setting the pressure by turning clockwise.
  - Purging the oxygen at the torch to ensure that the operating pressure is correct.
  - Opening the oxygen valve 1/2 turn.
  - Purging the system 3 to 5 seconds.
  - Opening the fuel valve 1/2 turn.
  - Striking with the tip resting on the material at a 45-degree angle.
  - Rotating every 10 to 15 seconds.
  - Watching for the correct flame.
  - Holding the tip 3/4 inch away from metal, preheating, and waiting for the material to begin to glow and pool.
  - Depressing the oxygen lever all the way to blow the molten metal away from the cut.
  - Keeping the flame angled in the direction of the cut and move slowly.

WARNING

WARM UP. After ignition, rest the tip directly on the steel at a 45-degree angle for 5 to 10 seconds, then rotate to the opposite side. The reflected heat will bring the tip to its operating temperature, allowing the fuel to fully vaporize inside the tip.

- **Shutdown.** Shutdown the torch by—
  - Closing the fuel valve.
  - Purging the system 3 to 5 seconds.
  - Closing the oxygen valve on the torch.
  - Closing the oxygen cylinder.
  - Relieving the pressure in the oxygen line by depressing the oxygen lever.
  - Loosening the adjustment screw.
  - Closing the fuel tank valve.

Figure 5-26. Petrogen torch

CONCRETE ANCHOR SYSTEMS INSTALLATION

5-27. Concrete anchors are torque controlled anchors that come in two types—wedge and sleeve anchors. Wedge anchors are the most commonly used anchor in US&R operations. Wedge anchors have higher tension strength than sleeve anchors of the same size.

5-28. The hole size is the same as the anchor (1/2-inch hole for 1/2-inch anchor). The wedge or sleeve anchors need to be embedded a minimum of five times the diameter of the anchor.

5-29. The wedge or sleeve anchor also needs to be spaced 12 times the diameter of the anchor. For example, if using 1/2-inch diameter anchors, space the anchors at least 6 inches apart. One-half inch wedge anchors have a design strength of about 2,000 pounds. (Follow the manufacturer's recommendation.) See figure 5-27.

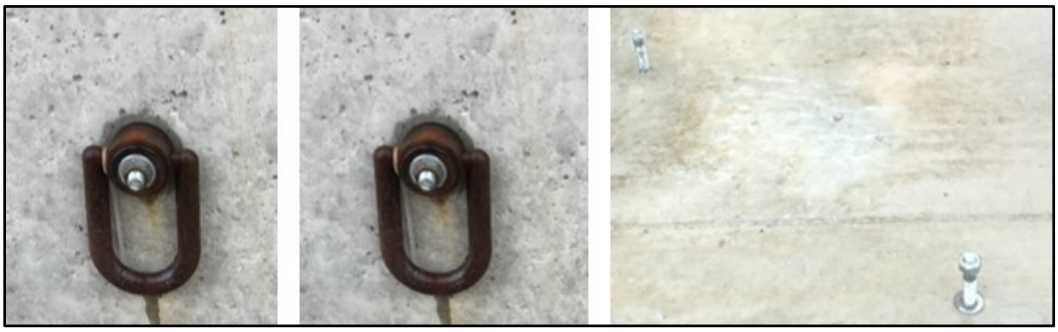


Figure 5-27. Wedge anchors

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Chapter 6

Vehicle Rescue

It is the intent of this training circular to differentiate between vehicle rescue Level I and Level II rescue incidents. Vehicle rescue Level I and Level II will correlate to both the environment in which the rescue is to be conducted and the level or degree of entrapment. Technical rescue units must develop clear SOPs and guidelines for making the determination based on the mission requirements by its higher headquarters.

LEVEL I VEHICLE RESCUE

6-1. There are five operational protocols that rescuers should conduct at a vehicle rescue incident—site operations, size up of the incident, search (refer to chapter 1 for these three tasks), rescue and extraction of victims, and terminate the incident. Before a rescue team can properly apply any extrication procedures, they must understand the components that make up a vehicle system.

6-2. In order to execute a vehicle rescue, it is important that the rescue team determines the vehicle classification, understands vehicle terminology, can identify the fuel types, identify the glass types, and know the supplemental restraint systems.

VEHICLE CLASSIFICATION

6-3. Level I vehicles include subcompacts, midsize, full-size, trucks, and vans. They are designed to carry 10 or less passengers. They typically have two axles and are 10,000 pounds or less. See figure 6-1.

6-4. Level II vehicles include semitrucks, buses, fire apparatuses, military vehicles, and large motor homes. These vehicles are over 10,000 pounds. See figure 6-2, page 6-2.

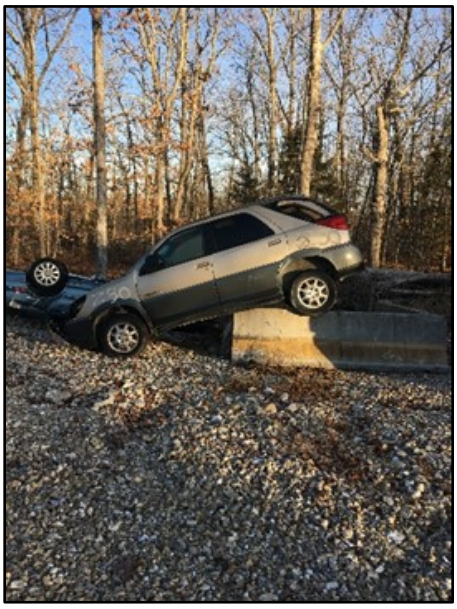

Figure 6-1. Light vehicle

Figure 6-2. Heavy vehicle

VEHICLE TERMINOLOGY

6-5. Most rescuers should know the standard features of a vehicle such as—

- **Driver's side.** The driver's side is the side with the steering wheel.
- **Passenger side.** The passenger side is the side opposite the steering wheel.
- **Posts or pillars (A, B, C, D).** Posts or pillars are the structural member that surround the doors and support the roof. See figure 6-3.
- **Fender.** The fender is the body material surrounding the front tire.
- **Nader pin.** A nader pin is a bolt-like pin in the door frame. See figure 6-4.

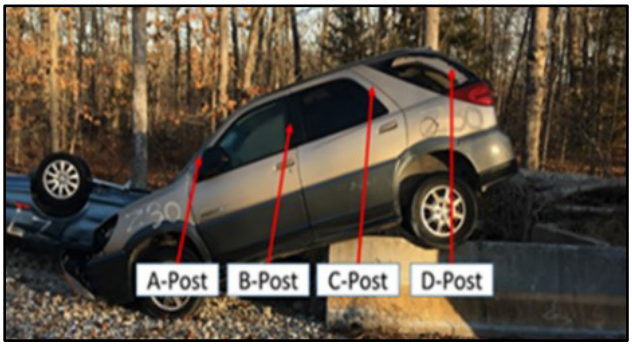

Figure 6-3. Post or pillar

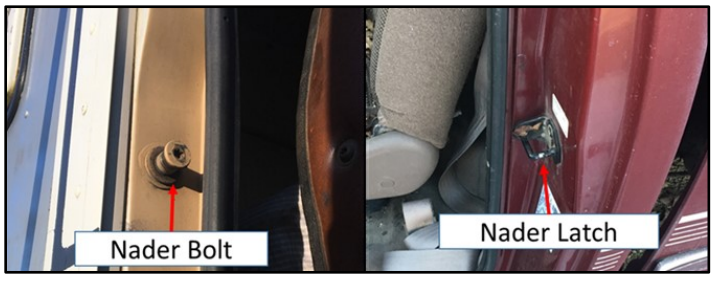

Figure 6-4. Nader pin/latch

FUEL TYPES

6-6. The following are the fuel types:

- **Standard fuel.** Standard fuel uses gasoline (different octanes) and diesel.
- **Flexible fuel.** Flexible fuel is 85-percent ethanol and 15 percent gasoline.

- **Natural gas.** Natural gas is fossil fuel primarily composed of methane used as a compressed natural gas.
- **Liquid petroleum gas**. Liquid petroleum gas is also known as propane.

GLASS

6-7. The following are the four types of glass in a vehicle:

- **Laminated.** Laminated glass is two sheets of glass bonded to a sheet of plastic between them. The windshield of most vehicles and the side windows of a school bus are constructed from laminated glass.
- **Tempered.** Tempered glass spreads small fracture lines throughout the pane when struck.
- **Polycarbonate.** Polycarbonate glass is scratch resistance, has reduced weight, and a variety of shapes.
- **Ballistic glass.** Ballistic glass are sheets of polycarbonate material between sheets of glass.

SUPPLEMENTAL RESTRAINT SYSTEM

6-8. Supplemental restraint systems include seat belts and air bags.

- **Manual seat belts.** Seat belt assemblies are usually housed in posts, columns, under the seats, or in the center console. When cutting through a post at the bottom or top, the molding must be removed to reveal the pretensioning system to avoid cutting the hardened device.
- **Vehicle air bags.** Air bags are a passive restraint device. The occupant does not have to activate the device. The system is automatically activated whenever power to the vehicle is applied.

VEHICLE RESCUE TEAM CONCEPT

6-9. Vehicle rescue operations is the process of removing a vehicle from around a person who has been involved in a motor vehicle collision. This operation is usually accomplished by using stabilization techniques, neutralization techniques, and operating hydraulic and hand tools. Standards and regulations for organizations can be found in NFPA 1670 and for individual members in NFPA 1006.

VEHICLE RESCUE TEAM

6-10. The vehicle rescue team develops its internal organization and identifies roles, responsibilities, and standard operating procedures used to manage emergency operations. See figure 6-5.

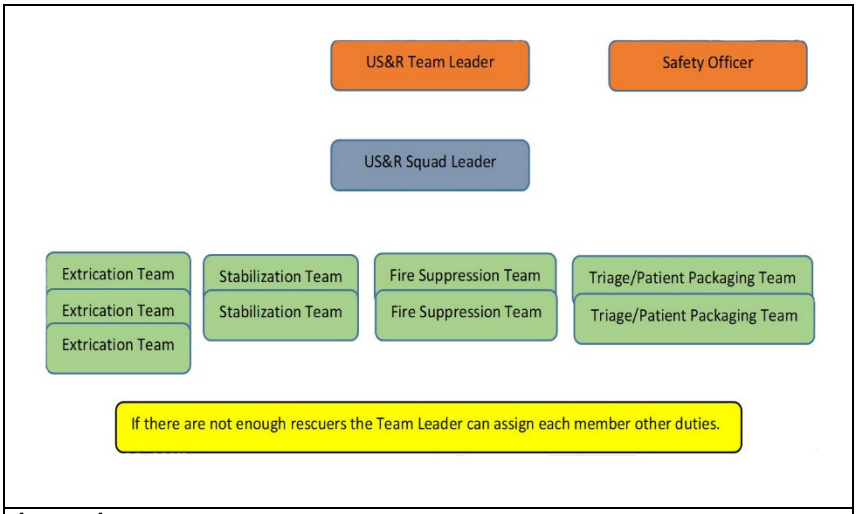

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Figure 6-5. Vehicle rescue team organization

EXTRICATION TEAM

6-11. See figure 6-6. The extrication team—

- Prepares tool layout and organization to the work areas.
- Provides periodic progress reports to the rescue squad leader.
- Establishes access and egress points.

Figure 6-6. Extrication team

STABILIZATION TEAM

6-12. There are two types of stabilization—primary and secondary.

- **Primary stabilization.** Almost all passenger vehicles have a natural lean towards the roof side. Attack the high-risk area of instability first. Place wedges or inverted step chocks on the roof between the ground and fender or the quarter panel.
- **Secondary stabilization.** Struts are key to attaining high-side stabilization. Limiting stabilization efforts to the low side only will never result in a well-stabilized vehicle.

Note. Recheck vehicle stabilization frequently.

TRIAGE/PATIENT PACKAGING TEAM

6-13. The triage/patient packaging team—

- Identifies victim priority.
- Identifies patient packaging devices.
- Identifies victim stabilization devices.

FIRE SUPPRESSION TEAM

6-14. The fire suppression team establishes fire suppression protocols. Protocols include—

- **Water and foam.** Water extinguishers are for Class A fires only.
- **Carbon dioxide.** Carbon dioxide can be used on Class B and C fires.
- **Dry chemical.** Dry chemicals are for multipurpose fire extinguishers used on Class A, B, and C fires.
- **Wet chemical.** Wet chemicals are used on Class K fires. For example, deep fat fryers in cooking operations.
- **Dry powder.** Dry powder is used on Class D fires, such as combustible metal fires only.
- **Water mist.** Water mist extinguishers are primarily for Class A and C fires.

ENERGY SOURCE NEUTRALIZATION

6-15. Vehicle neutralization is a critical component before an extrication can begin. Proper vehicle neutralization provides the rescuers a safe working environment and ensures safety for the rescue personnel, victims, and bystanders. A vehicle's class does not change the neutralization techniques. The following are the steps to remove the energy from the vehicles:

- Remove or cut 1 inch with insulated wire cutters from both battery cables and tape the ends.
- Remove the key fob to at least 250 feet from the incident.
- Turn on the 4-way flashers. This is a good practice to ensure that the power has been neutralized.
- Inspect the air bags. Air bags can still deploy up to 30 minutes after the power has been neutralized.
- Neutralize hybrid batteries in the same manner. Remove the fuses as an additional step for this type of vehicle.
- Absorb leaking fluids. Absorbent material (dry sweep, kitty litter) will reduce slips and fall hazards.

Note. Hazardous materials can be one of the hardest hazards to control at a vehicle incident site. Utilizing placards, the Emergency Response Guidebook, and other references to identify what hazardous materials are present is critically important.

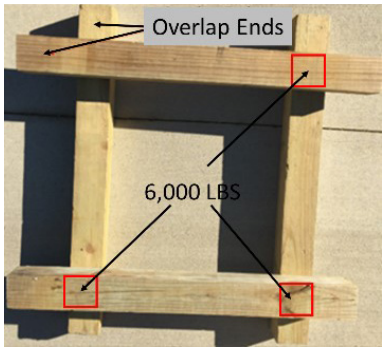
VEHICLE STABILIZATION

6-16. Vehicle stabilization is a critical component of the extrication process. Proper vehicle stabilization provides a solid foundation to work from, and ensures safety for the rescue personnel, victim(s), and bystanders. A vehicle's class does not change the stabilization techniques. Stabilize the vehicle with one of the devices discussed below.

CRIBBING

6-17. Cribbing can be either be 4-by 4-inch or 6- by 6-inch wood or plastics in lengths of 18 to 24 inches. Soft woods are commonly used for cribbing because they are well suited for compression-type loads. Hardwood is very strong but may split easily under certain stresses. Plastics are becoming more popular due to the longer shelf life.

6-18. When building a crib stack, make sure the load is supported through solid wood contact. It might be necessary to widen the crib area with supports if the ground is unstable. Use the 2 by 2 crib stack method with 4- by 4-inch timbers, the weight bearing capacity of the crib stack is, 6,000 pounds per contact point and 24,000 pounds if all four contact points are used. Using 6- by 6-inch timbers and the 2 by 2 construction method, the weight bearing capacity is 60,000 pounds and 15,000 pounds per contact point. See figure 6-7.



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lbs pounds

Figure 6-7. Cribbing

6-19. The ends of the cribbing pieces should overlap the preceding layer by the width of that particular piece. For example, when using 4-inch timber, the ends of each layer should overlap a minimum of 4 inches. To maintain the stability of a crib stack, the height of the cribbing should not exceed 1 1/2 times the length of the cribbing pieces being used. (For example, 24-inch cribbing can be built 36-inches high.) See figure 6-7, page 6-5.

CRIBBING CONFIGURATION TYPES

6-20. NFPA 1006 discusses five types of cribbing configurations—two-piece layer crosstie, three-piece layer crosstie, platform crosstie, triangle crosstie, and the modified crosstie. See figure 6-8.

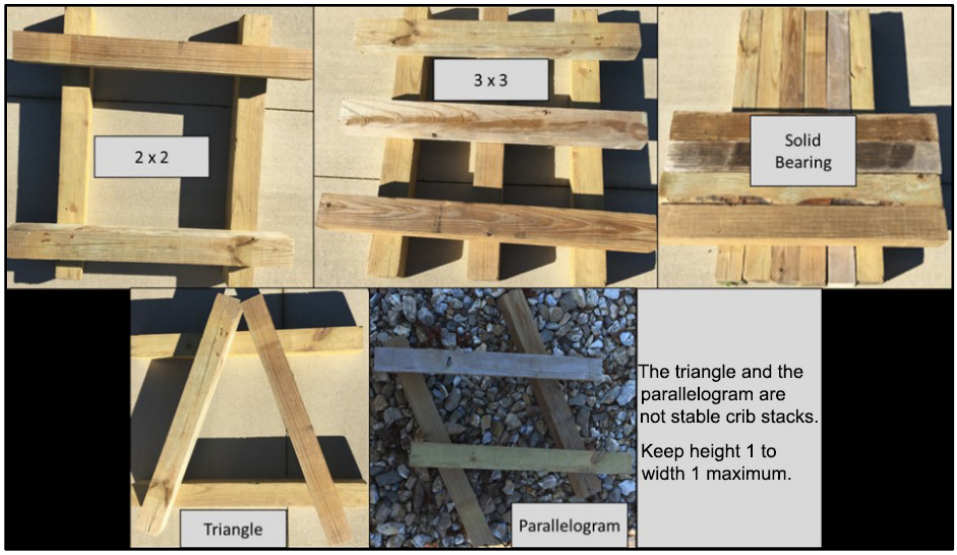

Figure 6-8. Crib stacks

6-21. Use a wedge to fill the void spaces; they should be the same width and preferably the same length as the cribbing pieces. If 4-inch timber cribbing pieces are used, the wedge should be 4 inches in width. The length of a wedge should not exceed 6 times its width. For example, if 4-inch timber cribbing pieces are used, a 24-inch wedge is the maximum size that should be used. See figure 6-9.

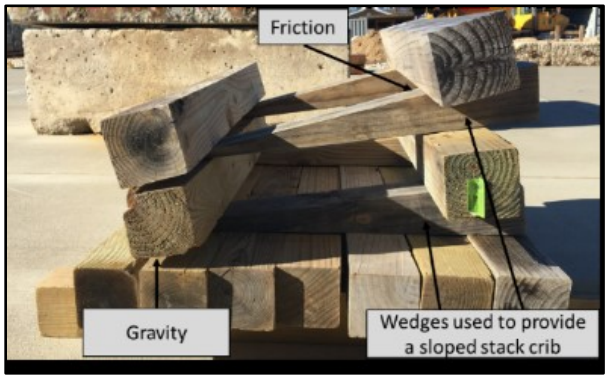

Figure 6-9. Cribbing with wedges

STABILIZATION EQUIPMENT

6-22. There are several methods to stabilize a vehicle. It is the rescue leader's responsibility to ensure what the proper techniques and methods are, based on the size up information.

Struts

6-23. Struts are either pneumatic or wood.

- **Pneumatic.** Pneumatic struts are quicker and easier and has less resources. See figure 6-10.
- **Wood.** Wood struts require the unit to ensure that it carries the proper amount of wood and tools to measure and cut for fit. See figure 6-11.

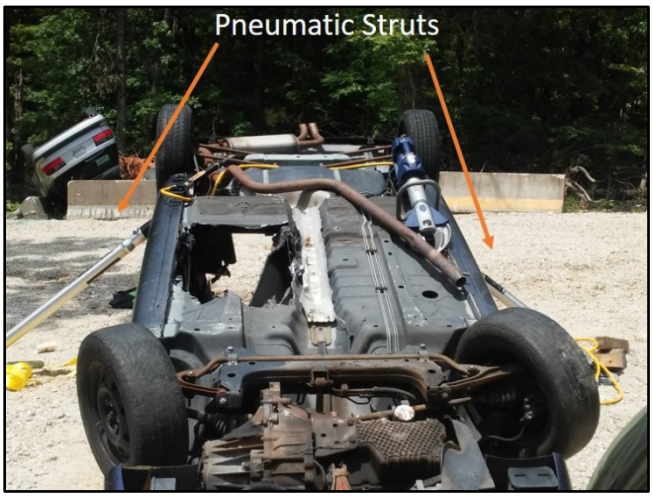

Figure 6-10. Pneumatic struts

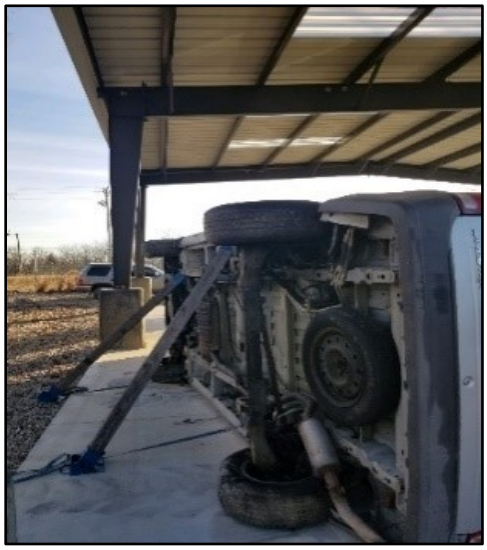

Figure 6-11. Wood struts

Ropes, Webbing, and Chains

6-24. When a vehicle comes to rest on an unstable surface, webbing, ropes, and chains may be used to stabilize the vehicle.

- **Chains.** Use chains that are grade 7 (70 grade), grade 8 (80 grade), or grade 10 (100 grade) (use grade 8 or above when conducting lifting operations). Alloy steel chains are the best to be used and the hook should be of the same rating.
- **Come along.** Use of come alongs are useful during stabilization operations.
- **Utility rope.** Do not use life safety ropes for stabilization.
- **Webbing.** Webbing is used to secure devices and not intended to hold a vehicle in place.

Airbags

6-25. Airbags are used to raise various objects, including light and heavy vehicles. Air bags are a means to lift objects. They are not used to stabilize and always use cribbing when lifting an object. Place support cribbing a minimum of 8 inches from the air bag platform because of the increased space needed when inflated. Use the rule "lift an inch, crib an inch" to provide a safe and stable lift.

VEHICLE POSITIONS

6-26. There are four common vehicle positions that may be encountered during a vehicle rescue operation. They are—

- Upright vehicle.
- Resting on its side.
- Resting on its roof.
- Vehicle on an object or another vehicle.

6-27. These rescue operations will be encountered mainly on the streets in the United States. Rescuers will more than likely be called to a collapsed parking garage rescue where the possibility of mass rescue operations will take place. Regardless of the situation, the neutralization and stability of the vehicle remains the same.

Upright Vehicle

6-28. Techniques for stabilizing vehicles on their wheels are simple and quick. To stabilize an upright vehicle—

- Place the vehicle in park, turning off the engine, and apply the parking brake.
- Place cribbing with wedges under the solid points of the vehicle to stop it from lowering to the ground.
- Chock the wheels to prevent the vehicle from moving forward or backward.

Resting on Its Side

6-29. Vehicles which come to rest on their sides can be the most challenging to stabilize. This type of crash results in specific difficulties that crews must be prepared to address. Some of the things to consider when stabilizing a vehicle on its side are listed below. See figure 6-12.

- Fuel, oil, or coolant should be managed as soon as possible.
- Approach the front of the vehicle, make patient contact, and assess the stability of the vehicle.
- Place initial cribbing under "hard points" such as pillars, bumpers, and the firewall.
- Install struts on both sides of the vehicle. See figure 6-12.
- Do not push a vehicle to assess stability.

Figure 6-12. Vehicle on its side

Resting on Its Roof

6-30. Over 20 percent of traffic collision fatalities are the result of rollovers. The increasing popularity of sport utility vehicles, which have a higher center of gravity, may be partially responsible for these numbers.

- Place the crib stack under the trunk or use struts under the trunk. See figure 6-13.
- Establish four solid points.
- Place cribbing under other hard points until they have been blocked.
- Place cribbing in a manner that will protect the patients from a possible roof collapse.

Figure 6-13. Vehicle on its roof

Vehicle on an Object or Another Vehicle

6-31. A vehicle on an object or another vehicle is first secured together using a ratchet strap to connect the top car to the bottom car. Tighten the vehicle until the shock and springs are fully compressed. This is called "marring" and can help provide a stable platform.

ACCESS OPENINGS

6-32. Once the vehicle has been stabilized, the next step is to gain access to the interior of the vehicle and the victim(s). Each technique provides a general guideline for vehicle extrication. The vehicle, situation, and victim placement will determent the best course of action.

6-33. The common passenger vehicle access and egress points should be determined by—

- Determining the structural and damage characteristics and potential victim location(s) so that the victim location(s) are identified.
- Designating the entry and exit points for victims, rescuers, and equipment.
- Identifying the flow of personnel, victim, and equipment.
- Using the existing entry points.

GLASS REMOVAL

6-34. Refer to figure 6-14, page 6-10. When conducting extrication operations on a vehicle, it is safer to remove all of the vehicle's glass as opposed to leaving some segments intact.

- Cover the victim prior to removing glass.
- Cut two slits in the glass to be removed.
- Cut the lower portion of the window, connecting both sides, and repeat on the upper portion of the window.
- Remove the glass and move out of the way of operations.

Figure 6-14. Glass removal

DOOR REMOVAL

6-35. The set up includes removing glass and providing a purchase point that allows better access for the spreader tips or the cutter blades.

- Create a purchase point with a tool or with a spreader.
- Insert the tips of the spreader slightly above the door lock, and at a downward angle.
- Work the tips at an angle to pop the door open.
- Have a rescuer hold the door before cutting the hinges.
- Cut the hinges and remove the door.

SIDE OUT REMOVAL

6-36. The complete side removal technique is a highly effective technique for four-door side-impact collisions. It pushes the door frame and B-post outward and away from the occupant. Remove the side by—

- Creating a purchase point to access the latch on the rear door.
- Spreading and cutting the rear door away from the latch.
- Cutting the B-post above or below the seat belt pretension.
- Positioning the tool between the rocker panel and the base of the rear door on the hinge side of the door.
- Cutting the top of the B-post at the roofline.
- Operating the spreading device until the base of the B-post separates from the rocker panel.
- Pivoting the entire side on the front door/A-post hinges.
- Cutting both hinges on the A-post and removing the side away from the operations.

ROOF REMOVAL

6-37. When performing a roof removal, position rescuers on both sides of the vehicle to support the roof as the posts are cut. Remove the roof by—

- Cutting the top of both A-posts.
- Cutting the top of both C-posts.
- Cutting the top of both B-posts, prior to making the last cut on the B-post.
- Announcing *final cut* by the rescuer to ensure support rescuers are ready to secure the roof.
- Lifting the roof off and out of the way of operations. See figure 6-15.

Figure 6-15. Roof removal

DASH LIFT TECHNIQUE

6-38. The dash lift technique involves lifting the dash upward with the hydraulic spreader. Precise relief cuts are made in the hood's upper rail and between the hinges of the firewall area, and the dash section is separated from the front end of the vehicle. Lift the dash by—

- Removing the front door.
- Making relief cuts behind the strut mounts to eliminate movement of the front end of the vehicle.
- Cutting the upper portion of the A-post.
- Making two cuts at the bottom of the A-post.
- Using spreaders to pinch the tab between the cuts and folding it towards the front for the vehicle.
- Positioning the cribbing under the base of the A-post between the rocker panel and the surface.
- Inserting the spreader tips into the void made by the removing tab.
- Opening the spreaders to lift the dash until sufficient clearance is achieved.

DASH ROLL TECHNIQUE

6-39. The dash roll technique involves pushing or rolling the entire front end of the vehicle, which encompasses the dashboard, steering wheel, and steering column off of the entrapped occupant. Roll the dash by—

- Removing the front door.
- Making relief cuts behind the strut mounts to eliminate movement of the front end of the vehicle.
- Cutting the upper portion of the A-post.
- Cutting the bottom portion of the A-post.
- Positioning the ram between the base of the B-post and to an area just above the top hinge on the A-post.
- Operating the ram device to roll the dashboard.

LEVEL II HEAVY VEHICLE EXTRICATION

6-40. There are five incident specific operational protocols that rescuers should conduct at a vehicle rescue incident site (refer to chapter 1). They are—

- Conduct site operations.
- Conduct a size up of the incident.
- Conduct a search.
- Conduct the rescue and extraction of victims.
- Terminate the incident.

6-41. Most medium and heavy trucks operate on diesel fuel, rather than gasoline. Look for hazardous material signs on vehicles prior to approaching the scene. For details on stabilizing a heavy vehicle and to create an access see Level I techniques.

HEAVY VEHICLE

6-42. A heavy vehicle is a type of specialty emergency rescue. The data provided below is the information needed to know during a Level II rescue operation. During a Level II rescue operation, the following information must be known:

- A Level II heavy vehicle rescue are vehicles above a gross vehicle weight rating of 10,000 pounds.
- Involves vehicles that may have hazardous chemicals.
- Feature complex rescue such as a vehicle hanging over a bridge or suspended from a utility pole line.
- Includes multiple car pileups that overwhelm a Level I rescuer and exceed their capabilities.

BUS ANATOMY

6-43. See figure 6-16. It is imperative that the rescuer know the anatomy of a bus. It has steel members that support the bus and is very difficult to cut through hindering the rescue operations. A bus consists of—

- **Sidewalls.** Sidewalls are comprised of vertical load-bearing frame members.
- **Collison beam.** Running horizontally along the base of each sidewall is a framing element referred to as a collision beam. The finish panels of 20-gauge steel are typically mounted on the exterior and 22-guage on the interior of the sidewall frame members.
- **Skeletal framework.** The skeletal framework of the school bus roof commonly consists of 11- to 14–gauge steel frame members called roof bows. These members span the roof structure from side to side. Within this frame are 14- to 16-gauge girders running from front to rear, strengthening and spacing the bows.
- **Escape hatch.** Emergency escape hatches are located in the roof structure. See figure 6-17.

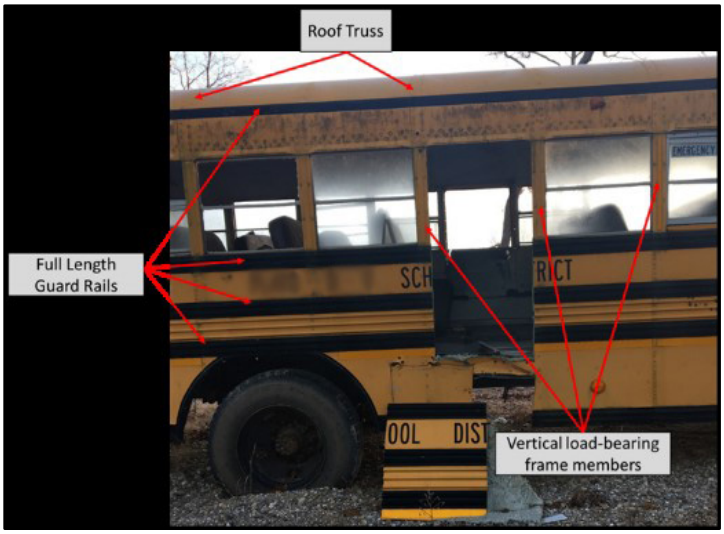

Figure 6-16. Bus anatomy

Figure 6-17. Escape hatch

ENERGY SOURCE NEUTRALIZATION

6-44. Some of the larger trucks are equipped with auxiliary power systems. These may include generators and inverters. Other vehicles are equipped with separate hydraulic systems used to operate specialized equipment on the vehicles.

BRAKE SYSTEMS

6-45. Medium and heavy trucks are equipped with one of the following: air brake systems, air over hydraulics, or hydraulic brakes. The rescuer activates the parking brakes by pulling out one or both of the valves on the dash. (Tractor brakes have a yellow button; trailer brakes have a red button.)

MOVING PARTS

6-46. Rescuers should be aware of all moving parts on heavy vehicles, such as hydraulic pistons, rotating attachments, and hoists to name a few. These moving parts also need to be neutralized prior to extracting a victim.

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Chapter 7
Machinery Rescue

It is the intent of this training circular to differentiate between machinery rescue Level I and Level II rescue incidents. Machinery rescue Level I and Level II will correlate to both the environment in which the rescue is to be conducted and the level or degree of entrapment. Technical rescue units must develop clear SOPs and guidelines for making the determination based on the mission requirements by its higher headquarters.

LEVEL I MACHINERY RESCUE

7-1. Machinery rescue Level I skills are applicable to machinery events that involve simple or small machinery. They—

- Are limited to digital entrapment of the victim.
- Involve environments where rescuer intervention does not constitute a high level of risk to either the victim or rescuers.

MACHINERY INCIDENT PLANNING

7-2. In order to execute a machinery rescue operation, the rescue team must establish site operations, conduct a size up, conduct search operations, and rescue all survivors as rapidly as possible.

OPERATIONAL PROTOCOLS

7-3. Operational protocols are procedures for response implementation and should include, but are not limited to, the following:

- Site operations (see chapter 1).
- Size up (see chapter 1).
- Search techniques (see chapter 1).
- Patient packaging (see chapter 1).
- Terminate the incident (see chapter 1).

MACHINERY RESCUE TEAM

7-4. Refer to chapter 1 for the duties of the US&R team leader, safety officer, and the US&R squad leader. These positions and duties remain the same throughout the rescue operations. The squad leader will normally be the lead member of the machinery rescue operations. (See figure 7-1, page 7-2.)

Extraction Team

7-5. The US&R extraction team—

- Prepares tool layout and organization to the work areas.
- Provides periodic progress reports to the rescue squad leader.
- Establishes access and egress points.

Stabilization Team

7-6. The stabilization team—

- Conducts primary stabilization.
- Attacks the high-risk area of instability first.
- Conducts secondary stabilization.
- Rechecks stabilization frequently.

Triage/Patient Packaging Team

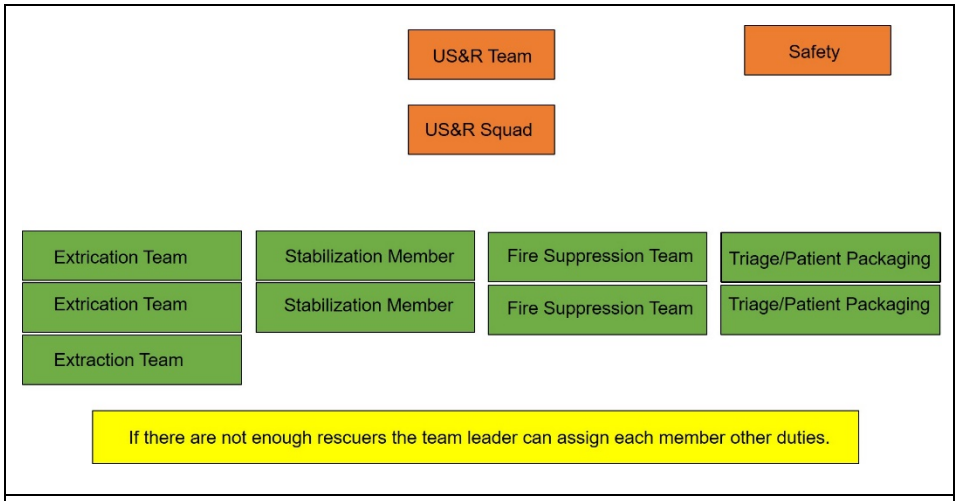
7-7. The triage/patient packaging team—

- Prepares all medical equipment.
- Provides patient protection.
- Performs triage.

Fire Suppression Team

7-8. The fire suppression team—

- Has the appropriate fire extinguisher.
- Knows the Emergency Response Guidebook.
- Knows the procedures to use a fire extinguisher.



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US&R urban search and rescue

Figure 7-1. Machinery rescue concept

MACHINERY TYPES

7-9. The types of machinery (see figure 7-2) (not all inclusive and just a small sample) include—

- Conveyor belts.
- Escalators and elevators.
- Drills and augers.
- Blenders, presses, and robotics.
- Power takeoff shafts.
- Pneumatic, electric, and hydraulic equipment.
- Lathes, presses, and drills.

Figure 7-2. Machinery types

MACHINERY HAZARDS

7-10. Crushed hands and arms, severed fingers, and blindness are some of the possible machinery-related injuries and the list is as long as it is nearly endless. There seems to be as many hazards created by moving machine parts as there are types of machines. Safeguards are essential for protecting workers from needless and preventable injuries. See figure 7-3.

Figure 7-3. Machinery hazards

Mechanical Hazard Areas

7-11. The following are three areas where mechanical hazards occur in machinery with dangerous moving parts that require safeguarding:

- **Point of operation.** The point of operation is where the work is performed on the material, such as cutting, shaping, boring, or forming of stock.
- **Power transmission apparatus.** The power transmission apparatus is all the components which transmit energy to the part of the machine performing the work. These components include flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, and gears.
- **Moving parts.** Moving parts are the parts that move while the machine is working. These can include reciprocating, rotating, and transverse moving parts, as well as feed mechanisms and auxiliary parts of the machine.

Machinery Movement Hazards

7-12. Machinery has seven general categories of hazards that are created through their operation. They include—

- **Pinch points.** Pinch points are found on many types of agricultural machinery (see figure 7-4, page 7-4). They are formed when two or more moving objects run together and at least one of them is rotating. Good examples of exposed pinch points are the feeder rollers on some forage harvesters and the compression rollers on some round hay balers.

Figure 7-4. Pinch points

- **Wrap points.** Warp points are exposed rotating components on a machine, such as a power take off assembly which clothing, hair, or loose items can become entangled.
- **Shear and cutting points.** Shear points are formed when two edges come close enough together to cut what is between them. A cutter head on a forage harvester and a sickle bar mower are examples of machines that have shear points. Cutting points are found where an edge is moved fast enough and forcefully enough to cut material. A rotating mower blade is an example of a machine component with a cutting point. See figure 7-5.

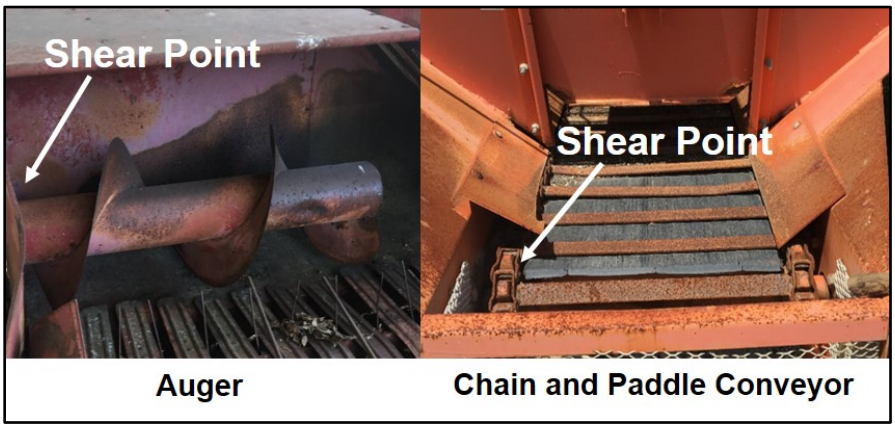

Figure 7-5. Shear and cutting points

- **Crush points.** Crush points are formed when two objects move towards each other or one object moves towards a stationary object. A door and its frame provide a common type of crush point.
- **Pull-in points.** A pull-in point is basically a wrap point or pinch point that is also intended, by design, to pull in or feed material in between running rollers. Two common pull-in points that have resulted in many serious injuries are the snapping rollers and husking rollers on older corn pickers and the compression rollers on some large round balers. See figure 7-6.

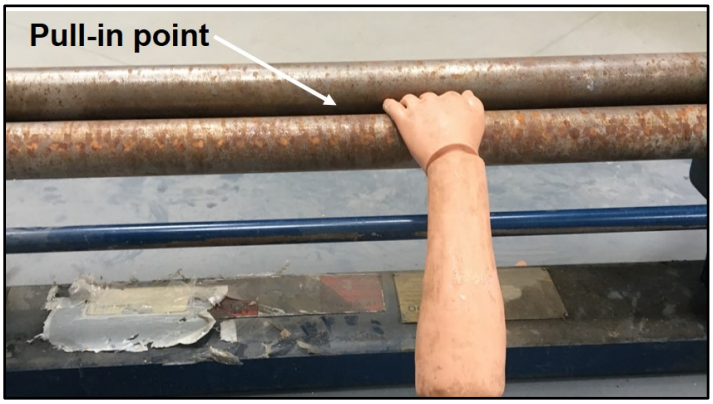

Figure 7-6. Pull-in point

- **Thrown objects.** Any type of agricultural machine that operates at high speed has the potential of throwing an object with enough force to inflict serious injury. Common machines often involved in this type of incident are the home lawn mower, shredders, grinders, forage harvesters, hammer mills, and straw choppers. Avoiding the path of discharge, keeping shields in place, and using eye protection can prevent most serious injuries from occurring. See figure 7-7.

Figure 7-7. Thrown objects

- **Stored energy.** As agricultural machinery has become more complex, the use of components or systems that can store extensive amounts of energy has increased. This includes springs, hydraulics, compressed air, and electricity. If suddenly released, any one of these energy forms can inflict serious physical injury or cause property damage. Since these hazards are generally hidden, the primary form of protection is knowing the recommended service and maintenance procedures and following any safety precautions found on the machine.

MACHINERY CATEGORIES

7-13. There are seven simple machine categories. Categories include—

- **Lever.** A lever is a rigid bar resting on a pivot and is used to help move a heavy or firmly fixed load with one end when pressure is applied to the other end.
- **Wheel and axle.** A typical example is in automobiles, an engine turns a drive shaft and in turn rotates the wheels. All components are locked together so that as one turns the others must turn as well. A longer motion on the edge of one wheel is converted to a shorter motion along the axle, but that motion contains a more powerful rotating force. That force can then be transferred to another wheel causing it to rotate faster.

- **Pulley.** A pulley changes the direction of a force. Pulleys moving with a load create a mechanical advantage, reducing the force required to move the load.
- **Inclined plane.** An inclined plane is a flat supporting surface tilted at an angle (wheel chair ramp), with one end higher than the other and used as an aid for raising or lowering a load.
- **Wedge.** Cutting and lifting machines commonly build wedges into their design. Wedges convert forces acting in line with the wedge to the forces that act at right angles to the blade.
- **Screw/auger.** A screw/auger is a central core with threads or grooves to convert rotary motion into a forward or backward motion. Screw drives are often used to move objects along the threaded core.
- **Chains and belts.** Chains and belts often connect separate wheels so that when one turns, the other turns as well. Depending on how the belt or chain is wound around the wheels, they can turn in the same direction or in opposite directions.

7-14. Compound or complex machinery are more complicated in design. The internal mechanisms often contain several simple machines, allowing the machine to conduct several processes in the same machine. The complexity of the machine increases the dangers to the entrapped victim and requires a technical rescuer to analyze the multiple hazards during the rescue. (See figure 7-8.) Compound or complex machinery have the basic components listed below.

- **Bicycles.** The pedals and wheels of bicycles form cooperating wheel and axle systems, the brakes are levers, and the parts are held together with multiple screws.
- **Wheelbarrows.** Wheelbarrows are compound machines. A combination of a lever, wheel, and axle.
- **Scissors.** Scissors consist of two pivoting levers.

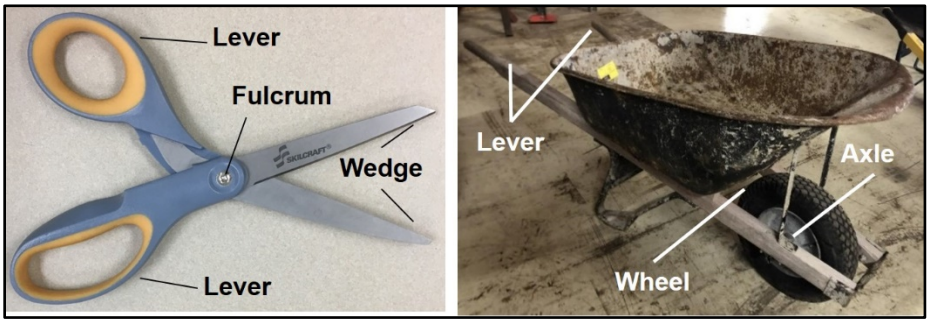

Figure 7-8. Compound and complex machinery

FIRE SUPPRESSION AND SAFETY MEASURES

7-15. There are five classes of fires and five types of fire extinguishing devices. It is imperative that the rescuer determine the type of fire or expected fire type and select the appropriate device. By isolating the materials that can be used to feed the fire, the fire can be controlled and managed. See chapter 6 for more information on the five classifications of fire and the types and uses of extinguishing devices.

CAUTION

Use of the wrong fire suppression device increases the risk of spreading the fire, causing more collateral damage, and drastically increases the risk to rescuers and victims.

SMALL OR SIMPLE MACHINE STABILIZATION

7-16. Machinery stabilization is a critical component of the extrication process. Proper stabilization provides a solid foundation to work from, and ensures safety for the rescue personnel, victim(s), and bystanders. A

machinery's class does not change the stabilization techniques. Stabilize the machine with one of the devices discussed below. Use the following methods to stabilize the devices:

- **Lever.** Use straps and or lashing to secure the lever from movement.
- **Wheel and axle.** Use wedges so the wheel does not spin. Use a chain and straps to secure the wheel to the frame of the machine to prevent movement.
- **Pulley.** Place a wedge inside the pulley to prevent movement. Secure the loaded end by blocking and bracing. Secure the haul end by securing the end so the load is not lowered or raised with webbing or straps.
- **Inclined plane.** Use a wedge to prevent the upward or downward movement on an inclined plane.
- **Wedge.** Use pickets, rebar, or nails to prevent the wedge from moving.
- **Screw/auger.** Insert a wedge or cribbing device to prevent movement of the screw/auger.

ENERGY SOURCES NEUTRALIZATION

7-17. Machinery neutralization is a critical component before an extrication can begin. Proper neutralization provides the rescuers a safe working environment and ensures safety for the rescue personnel, victim(s), and bystanders. A machine's class does not change the neutralization techniques.

ENERGY SOURCE TYPES

7-18. There are numerous types of energy sources rescuers will encounter during machinery rescue operations. All energy sources likely to activate the machinery and equipment and expose people to hazards should be identified prior to beginning work. Such energy sources include—

- Hydraulic.
- Electrical.
- Pneumatic.
- Fuel powered.
- Battery.
- Fuel.

STORED ENERGY REMOVAL

7-19. Any or all of the following steps need to be taken to guard against energy left in the machinery and equipment after it has been isolated from its energy sources:

- Inspect the machinery and equipment to make sure all parts have stopped moving.
- Release the tension on the springs or block the movement of spring-loaded parts.
- Block the parts in the hydraulic and pneumatic systems that could move from pressure loss.
- Bleed the lines and leave the vent valves open.
- Dissipate extreme cold or heat, or provide protective clothing.
- Use an alternating current hot stick to determine potential electrical hazards.
- Use lock-out-tag-out devices to secure potential hazards.
- Ventilate the area if needed.

SYSTEM NEUTRALIZATION METHODS

7-20. System isolation methods ensure that the rescuer and victim(s) are safe. Removing the potential energy source from the machinery will ensure that the rescue operations will be rendered safe. Steps to neutralizing the energy source—

- Identify all energy sources and other hazards.
- Identify all isolation points.
- Isolate all energy sources.
- De-energize all stored energies.

- Lockout all isolation points.
- Tag machinery controls, energy sources, and other hazards.

CREATE ACCESS FOR SIMPLE MACHINES

7-21. Once the machine has been neutralized and stabilized, the next step is gain access to the entrapped victim(s). Each technique provides a general guideline for machinery extrication, anatomy of the machine, and the victim's location will determine the best course of action to create access and egress from a machine. To determine the best of course of action—

- Remove the access panels or covers using a mechanical tool box, torch cutting equipment, or other rescue tools.
- Remove the chains using a chain break kit.
- Remove the pulley belts with general tools to diminish belt tensioner. If time is the factor cut the belts.
- Remove items that have caused the pinch points (rollers, belts, chains).

GUARDING

7-22. Adjustable guarding incorporates movable sections or panels of the guard that allows for material or parts to be fed into the guarded area while still preventing bodily contact. Rescuers will need to familiarize themselves with the different types of guards. Rescuers need to be familiar with the guards that protect rescuers and workers from the following:

- Rotating end drums of belt conveyors.
- Moving augers of auger conveyors.
- Rotating shafts.
- Moving parts that do not require regular adjustment.
- Machine transmissions pulley and belt drives, chain drives, and exposed drive gears.

PROTECTION METHODS

7-23. If possible, cover the victim with material and—

- Provide the victim with PPE, such as a helmet, face shield, or eye protection.
- Secure all impalement objects to prevent further movement.
- Remove all energy sources to the machine.
- Conduct lock-out-tag-out procedures.

LEVEL II MACHINERY RESCUE

7-24. Level II skills apply to those incidents that involve heavy machinery, the application of complex extrication processes, the presence of multiple uncommon concurrent hazards, or situations including more than digital entrapment of a victim. It is the responsibility of the rescue team leader to understand the capabilities and the limitations of the machinery rescue team.

7-25. Stabilization of large, heavy, or complex machines requires more advanced techniques and specialized resources, to include the following:

- Use of commercial heavy wreckers or crane services to assist at incidents involving large machinery.
- Use, care, and maintenance of power winches.
- Establishment of an anchor over the responder's head.
- Use of advanced techniques in shoring.

7-26. All other aspects of Level II rescues remain the same, such as planning and conducting site operations.

Glossary

The glossary lists acronyms and terms with Army or joint definitions. Where Army and joint definitions differ, (Army) precedes the definition. The Army proponent publication for other terms is listed in parentheses after the definition.

SECTION I – ACRONYMS AND ABBREVIATIONS

Acronym	Definition
ADP	Army doctrine publication
ANSI	American National Standards Institute
attn	attention
CBRN	chemical, biological, radiological, and nuclear
CFR	Code of Federal Regulations
DA	Department of the Army
DOD	Department of Defense
DOTD	Directorate of Training and Doctrine
ERG	emergency reponse guide
FM	field manual
ICS	incident command system
IFSTA	International Fire Service Training Association
MCTP	Marine Corps tactical publication
MO	Missouri
MSCoE	Maneuver Support Center of Excellence
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PAPR	powered air purifying respirator
PPE	personal protective equipment
SAR	supplied air respirator
SCBA	self-contained breathing apparatus
SOP	standard operating procedure
SSSF	Static System Safety Factor
TC	training circular
US&R	urban search and rescue

SECTION II – TERMS

term

Definition.

authority having jurisdiction

A person or organization that is in charge of setting the standards for training or procedures.

attendant

An individual that monitors rescuers that enter and exit a confined space.

authorized entrant

A qualified rescuer who is authorized to enter a confined space.

atmospheric monitoring

A method of using a portable chemical detector monitor that is versatile and customizable, while delivering real-time access to instrument readings and alarm status from any location.

confined space rescue preplan

A rescue operation plan on-site that includes equipment, such as retrieval devices, breathing and resuscitating apparatus and is ready for emergency use immediately.

ICS

A management system designed to enable effective and efficient incident management by integrating a combination of equipment, personnel, policies, and procedures within a common organizational structure.

large machinery

This has numerous rescues or hazards associated within the rescue. Normally has more than one energy source, contains hazardous material, multiple rescue disciplines (use of ropes, SAR, shoring operations). The rescue is more than a digit entrapment and the design of the machine is complex.

mechanical advantage

A measure of the force amplification achieved by using a tool, mechanical device, or machine system such as pry bars, inclines, or rope and pulley systems.

rapid intervention team

A reactionary force that is prepared to immediately enter the hot zone to rescue s team member that may have become trapped, injured, or is not responding.

shall

To do something with no exception.

should

A recommendation; during rescue operations it is a good idea but not a must.

shoring team

The group of individuals assigned to build the support system during structural collapse, trench, and vehicle rescue.

technicial rescue

The use of specialized tools and skills for rescue during the US&R operations.

technical rescuer

A person who has been certified by IFSAC or ProBoard in US&R disciplines.

Technical Rescuer Level I

A person who has been certified in rescue operations according to NFPA 1006 at the Level 1 certification per each job performance requirements.

Technical Rescuer Level II

A person who has been certified in rescue operations according to NFPA 1006 at the Level 2 certification per each job performance requirements.

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These documents must be available to intended users of this publication.

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These documents contain relevant supplemental information.

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MULTI-SERVICE PUBLICATIONS

Unless otherwise indicated, Army doctrinal publications are available online: https://armypubs.army.mil/.

FM 6-27/MCTP 11-10C. *The Commander's Handbook on the Law of Land Warfare.* 7 August 2019.

WEBSITES

OSHA Regulations and Standards. Website https://www.osha.gov/laws-regs/regulations/standardnumber/.

PRESCRIBED FORMS

This section contains no entries.

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Unless otherwise indicated, DA Forms are available on the Army Publishing Directorate website: https://armypubs.army.mil. ICS forms are available on the Federal Emergency Management Institute website: https://training.fema.gov/icsresource/icsforms.aspx.

DA Form 2028. *Recommended Changes to Publications and Blank Forms.*

ICS Form 201. *Incident Briefing.*

ICS Form 202. *Incident Objectives.*

ICS Form 204. *Assignment List.*

ICS Form 206. *Medical Plan.*

ICS Form 208. *Safety Message/Plan.*

ICS Form 209. *Incident Status Summary.*

ICS Form 210. *Resource Status Change.*

ICS Form 214. *Activity Log.*

RECOMMENDED READING

American National Standards Institute. Website: www.ansi.org.

NFPA 472. *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents.* 2018.

NFPA 473. *Standard for Competence for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents.* 2018.

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NFPA 1561. *Standard on Emergency Services Incident Management System and Command Safety*. 2020.

Hazardous Materials/Weapons of Mass Destruction Response Handbook, 8th Edition. Website https://catalog.nfpa.org/.

The National Fire Protection Association. Website: https://www.nfpa.org/.

National Institute for Occupational Health Guidelines. Website: https://www.cdc.gov/niosh/index.htm.

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25 August 2020

By Order of the Secretary of the Army:

JAMES C. MCCONVILLE
General, United States Army
Chief of Staff

Official:

KATHLEEN S. MILLER
Administrative Assistant
to the Secretary of the Army
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