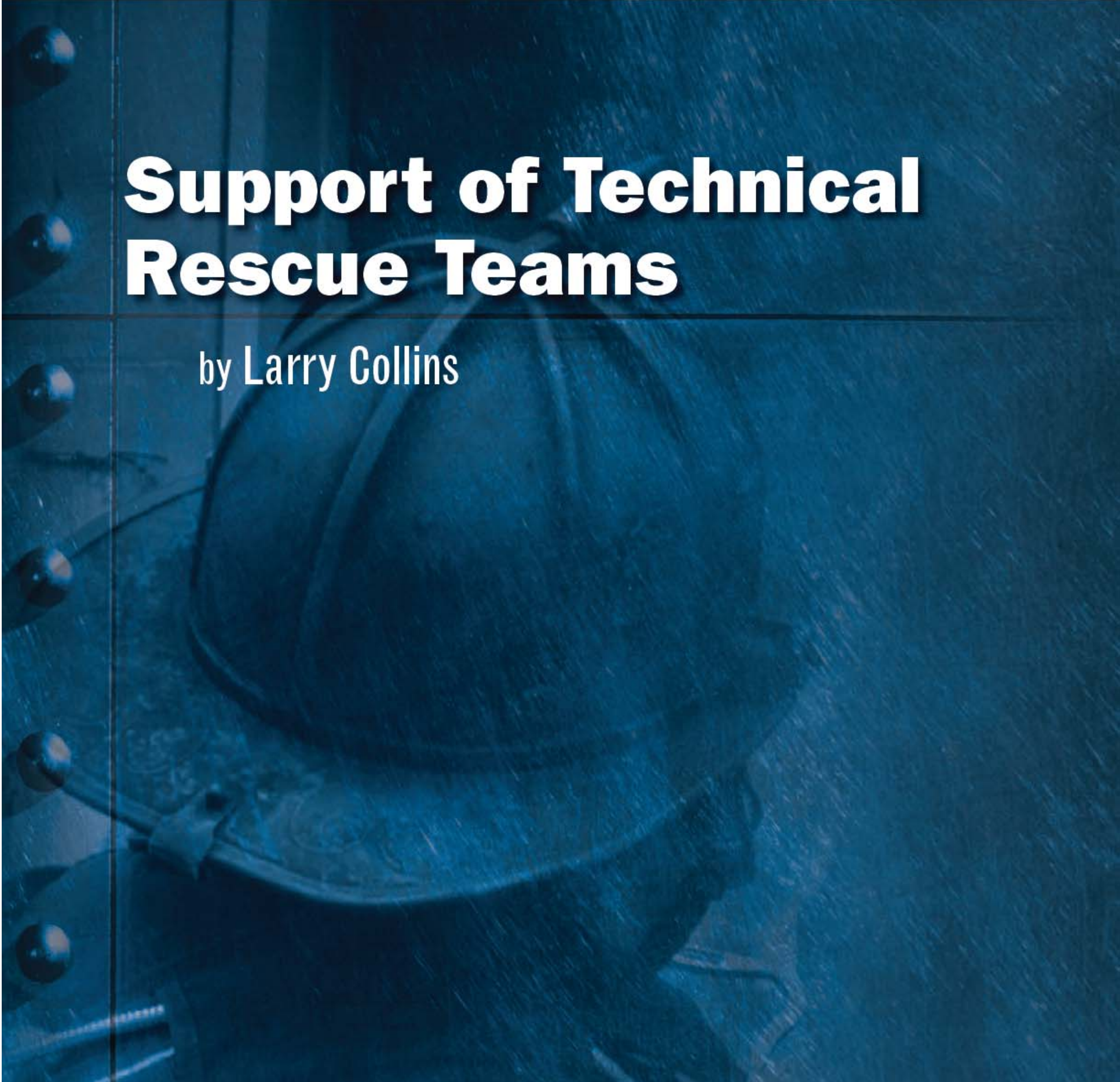


Support of Technical Rescue Teams

by Larry Collins

This chapter provides required knowledge items for the following NFPA Standard 1001 Job Performance Requirements:

FFII 6.4.2

This chapter contains Skill Drills. When you see this icon, refer to your Skill Drill book for step-by-step instructions.

Fig. 35–1 Supporting technical rescue teams is an important responsibility for the Firefighter II.

OBJECTIVES

Upon completion of this chapter, you should be able to do the following:

- Describe the role of the Firefighter II in supporting technical rescue teams and the need to operate within the Firefighter II's level of training
- List and describe the proper procedures to be used during water rescue operations
- List and describe the proper procedures to be used during ice rescue operations
- List and describe the proper procedures to be used during mud and debris flow rescue operations
- List and describe the proper procedures to be used during structural collapse rescue operations
- Describe the placement considerations during structural collapse operations for fire service apparatus
- Describe the importance of proper staging of resources during technical rescue operations

- Identify the "victim search markings" approved by FEMA that are used during technical rescue operations
- List and describe the proper procedures to be used during void space rescue operations
- List and describe the proper procedures to be used during high-angle rescue operations
- List and describe the proper procedures to be used during trench and excavation collapse rescue operations
- Identify factors to consider for rescue operations during marine emergencies
- List and describe the proper procedures to be used during confined space rescue operations
- List and describe the proper procedures to be used during industrial machine operations
- List and describe the proper procedures to be used during elevator and escalator rescue operations
- Describe medical considerations that can impact rescue operations
- List and describe the proper procedures to be used during cave and tunnel rescue operations
- Describe what factors need to be considered during electrical emergencies

INTRODUCTION

According to National Fire Protection Association (NFPA) 1001, the Firefighter II should be prepared to help rescue companies and technical rescue teams safely manage water rescues, structural collapse rescue operations, trench and excavation collapse rescue, rescues in caves and tunnels, elevator and escalator emergencies, energized electrical line emergencies, high-angle rescues, motor vehicle entrapments, and industrial accidents.

In the sort of multitiered response system common in many progressive fire departments, the first-arriving engines, ladder/truck companies, and other first-responder units are tasked with sizing up the emergency and recognizing if it is a technical rescue. They then ascertain if there are immediate personnel safety hazards and react to them by establishing command; requesting additional resources as needed; stabilizing the scene (including isolating and denying entry to the public in the operational area); attempting immediate life-saving rescue within the limitations of their training and equipment; and coordinating with the responding rescue company or technical rescue team to define, establish, and implement a definitive solution (rescue of the victim with safety measures for personnel). In this type of system, the first-due firefighters are responsible for supporting the rescue company or technical rescue team (see fig. 35–1).

FFII 6.4.2 Based on those goals, the Firefighter II should be capable of supporting rescue companies and technical rescue teams: establishing barriers, recognizing and retrieving rescue tools, understanding the hazards of rescue operations, and assisting as a member of the rescue team as needed and according to their SOPs.

Ropes and knots, vehicle extrication, and forcible entry are covered in other chapters this of textbook. This chapter concentrates on the remaining skills, knowledge, and abilities for the Firefighter II to support rescue companies and technical rescue teams. In all cases it's recommended that every Firefighter II supplement this information with formal didactic and manipulative training to develop and hone their skills and knowledge.

A final word about rescue: This chapter cannot describe every possible situation the Firefighter I and II may encounter. A sample of training requirements for some rescue companies is included in Appendix B to help illustrate the wide variety of rescue knowledge and skills that may be required for modern firefighters to get the job done. And even with this level of sophistication in the modern fire service, there are some situations for which a clear solution with designated protocols, procedures, and equipment may not be evident.

What would you do to resolve a similar rescue situation? Would you have the ability to adapt equipment, methods, and protocols from other disciplines into a seamless rescue operation? In addition to the basic skills covered in this chapter, it is the ability to innovate and take the best practices and use them to save lives in unusual emergencies that distinguishes top-grade firefighters and fire/rescue organizations. Starting with the skills and knowledge covered here, you will have an opportunity to take it to the next level of preparedness to manage the ever-expanding risks confronting modern firefighters.

LESSON FROM THE FIREGROUND

One example of this occurred as this chapter was written, when three men backed a truck up to the edge of a 70-ft-high (20-m) mountain of sand and began digging at the base to load their truck in a city next to this author's fire department jurisdiction. The men were buried when an entire slope of the mountain collapsed in an avalanche of sand.

The local fire department arrived to find one man buried to his chest, two others missing, and a 70-ft (20-m) high cornice of packed sand towering over their heads. They knew that the rest of the cliff could collapse at any moment, yet they also had a live victim trapped and talking to them in the collapse zone, with two other victims buried nearby.

Clearly, there was no way to erect protective shoring to stabilize the entire cliff in a timely manner, and entering the collapse zone would certainly place the lives of firefighters in jeopardy. It might be possible to bring in a trench box and employ an air knife and other trench/excavation rescue methods to this situation, and that's pretty much how the rescue was conducted, using lookouts, communication, escape routes, and safe zone (LCES) protocols adapted from wildland firefighting, using aerial ladders for lookouts and for moving equipment and personnel over the collapse zone (a method adapted from the New York City Fire Department [FDNY] structure collapse protocols), and other practices adapted from other rescue disciplines.

WATER RESCUE

Understanding conditions and hazards

A Firefighter II should have a clear understanding of the hazards of **moving water** and be able to recognize the conditions that occur during water rescue emergencies (fig. 35–2). When discussing directions with regard to rivers and other waterways, four basic terms are used:

1. **Upstream**
2. **Downstream**
3. **River right** (the right side of the river as one is looking downstream)
4. **River left** (the left side of the river as one is looking downstream)

Fig. 35–2. Water presents a wide array of hazards to firefighters and should be treated with great caution. (Win Henderson/FEMA)

Water rescue comes with one big advantage: The forces of moving water are governed by natural laws, which allows properly trained firefighters to predict what the water will do under specific conditions like gradients, obstacles, different water levels, and so forth. For example, water along the shore is slowed by friction with the sides, and water in the center typically moves faster. The deepest water is slowed by friction with the bottom, whereas the fastest water is often found near the surface, riding over the top of the slower current below. These are examples of **laminar flow** (fig. 35–3).

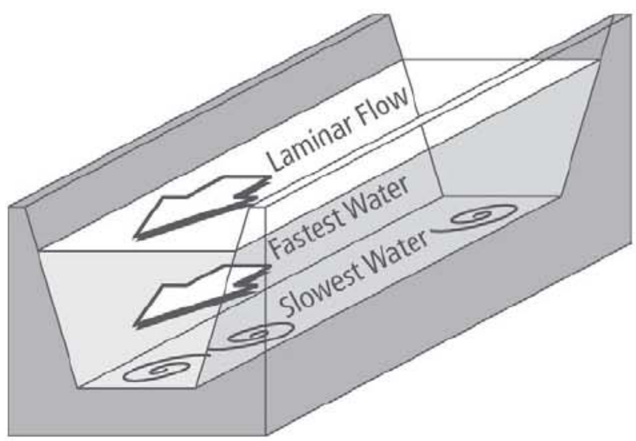


Fig. 35–3. The fastest water is usually found midstream just below the surface.

The slower moving water along the shore often circulates with water in the middle in a spiral motion, which we call a **helical flow**. The water along the shore is pulled to the middle and dives down, returning to shore along the bottom and then returning to the surface in a corkscrew motion.

When a river encounters a curve and strikes the shore at the outside of the curve, the water tends to carry away material and undermine the banks (unless they are lined with concrete or riprap). The water deflects off the outside bank and moves downhill once again in a straight line. Even if the current appears to make a graceful arcing change of direction, it's actually trying to move in a straight line until it's deflected by another curve or some sort of obstacle (fig. 35–4).

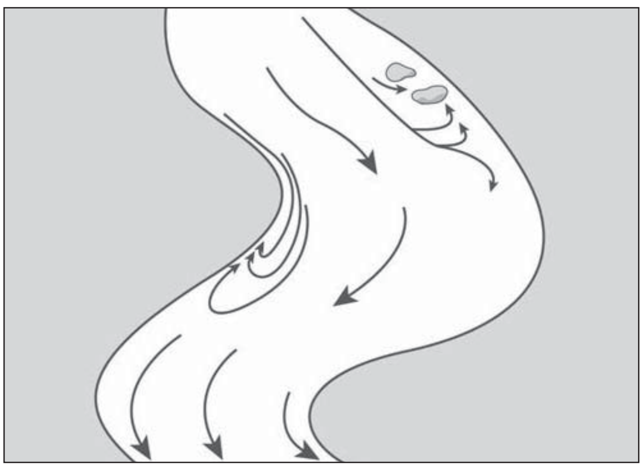


Fig. 35–4. Current flow and shore eddies on a curving stretch of waterway

The fastest moving water is found moving from the middle of the stream to the outside of the curve, then back to the middle (if the river straightens out). If there is a series of turns, the fastest water is found moving from the outside bank of the first turn to the outside bank of each subsequent turn. Conversely, the slowest water is found at the inside of the turn, just downstream of the bend. The difference between the fast and slow currents often creates an eddy effect in this area, known as a **shore eddy**. This can be used to escape the current, and it can also serve as a preplanned rescue point.

Eddies are calm areas separated from the main current flowing downstream. As the obstacle upstream of the eddy breaks the current, a gentle reversing current is often the result. This is an area where large amounts of floating debris (and victims) may be found and where tired rescuers may find a break from the main current.

The current water level has perhaps the greatest influence on the hydrology (and the look) of a waterway. Many small riffles indicate shallow water. This is particularly true where the current passes over gravel bars. As the water gets deeper, the surface tends to look smoother.

Submerged obstructions, such as rocks, cause a characteristic swelling on the surface just downstream of the obstacle. These bulges are an indication of objects below the surface (fig. 35–5).

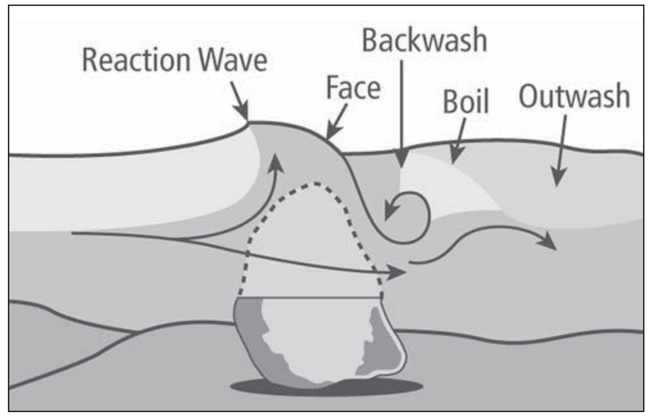


Fig. 35–5. How water level and its relationship to submerged objects affects the appearance of the surface of moving water.

The protruding object also causes the water to part into a V pointing upstream. We call this an **upstream V**. Swimmers approaching from upstream will see a V pointing upstream at them, indicating an obstruction to avoid. The downstream point of the eddy lines, where the main current resumes, is called the **eddy tail**. Where two eddy tails meet, or where the channel narrows and pushes the current together from both sides, a V pointing downstream forms. This is called a **downstream V**, and it's a good indicator of deeper, faster water with few obstacles (fig. 35–6).

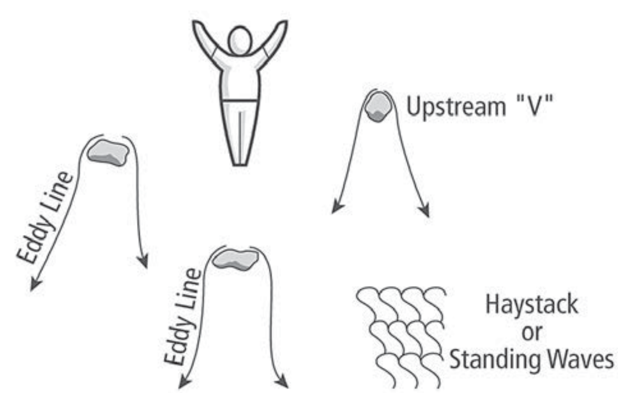


Fig. 35–6. Upstream Vs and downstream Vs

When water flows over a steep vertical drop, the force of the water creates a depression just downstream of the drop. The depression can get so deep that water normally flowing downstream is forced to move back upstream to fill the hole. Gravity has overcome the force of the current. This sets up a continuous recycling of the water we call a **hydraulic**, or **hole**.

The line where the recycling water is separated from the main downstream current is called the **boil line**, recognized for its constant white turbulent water that wells up from below and moves back upstream toward the drop. The turbulent white water found in a hydraulic is approximately 60% air. Even otherwise buoyant objects may not float well in white water. Hydraulics can be powerful enough to hold people and even boats for seconds, minutes, or hours. The configuration or shape of the drop has an effect on the holding power of a hole.

Low-head dams are artificial vertical or near-vertical drop structures that stretch across a waterway, resulting in a hydraulic from shore to shore with no downstream Vs, eddies, or other river features normally used to escape from fast moving water. People caught in the hydraulic of a low-head dam are forced down to the base of the dam, often through debris along the bottom, until they reach the boil line, where they may surface momentarily while being pulled back upstream to the face of the dam, where it happens all over again. Victims lucky enough to get to the side are often confronted with a high vertical sidewall. There is usually no escape unless rescue is available from shore (fig. 35–7).

The utmost caution is required any time firefighters are working near a low-head dam. Personnel should not enter the water upstream of low-head dams unless they are fully trained swiftwater rescue team members using precisely controlled means to prevent them from being swept over the falls (e.g., the use of helicopters, **inflatable rescue boats (IRB)** controlled by high-line systems, **live bait rescues**, or other positively controlled systems).

Fig. 35–7. Low-head dams should be treated with great caution as they can be potentially dangerous to responders.

A **strainer** is found where bridge abutments, trees, fencing, and other conditions that *strain out* floating objects (including people) from water moving past it. Naturally, strainers are dangerous because rescuers may become pinned against them in moving water.

Shallow, rocky areas are dangerous in fast-moving water, because rescuers trying to stand or walk across them may find an ankle wedged between submerged rocks (fig. 35–8). If the water is powerful enough, the victim may be forced under the water. The strength of the current and lack of adequate footing may prevent rescuers from reaching the victim in time. In these areas, it is best to crawl toward shore until the water is no longer deep enough to cause a problem, or unit an eddy is reached.

Mountainous areas, drainages, desert areas affected by intense monsoon storms, and regions affected by hurricanes are especially prone to flooding caused by heavy or excessive rainfall in a short period of time, or **flash flooding**.

Fig. 35–8. Water rescue responders must maintain a situational awareness to prevent being caught by debris or obstacles.

Water rescue equipment

Firefighters operating near moving water should use a minimum level of protection (fig. 35–9). **Personal flotation devices (PFDs)** used by fire departments typically are type III/V U.S. Coast Guard approved for use in rough water conditions. They are designed to keep an unconscious person upright and tilted slightly back in the water to maintain an open airway. A foam collar keeps the wearer's head out of the water. PFDs also provide limited torso protection. A whistle and rescue knife should be attached to a PFD. The whistle is for improved communication and warning. The knife is used if a victim or rescuer becomes tangled in rope or other debris and has a special blade for cutting rope safely and quickly.

Fig. 35–9. When working around moving water, responders must don appropriate personal protective equipment.

Structural firefighting helmets are generally not designed for use in water rescue situations. Although they provide excellent head protection from falling objects, they can cause more problems than they prevent when worn in moving water. The bill on the rear of structural firefighting helmets tends to catch water and create sufficient drag to rip the helmet off the wearer's head and tangle the chin strap around his neck. Rescue helmets provide full head protection and do not impair the wearer's head movement and vision. Rescue helmets differ from structure firefighting helmets in that they are lighter and do not have a rear bill.

Most fire department activities require safety shoes with steel toes. Water rescue incidents clearly have different footwear requirements. The use of heavy boots can be a hazard because they provide little traction on wet river banks. If firefighters fall into the water wearing boots, they are at a disadvantage from the start.

Firefighters typically have a pair of running shoes at their work site for participation in physical fitness programs. Running shoes are much more effective than work boots or turnout boots when working near moving water. They are the recommended footwear for many water rescue incidents if the alternative is turnout boots or work boots, which are slippery on wet shorelines and can impede the firefighter's ability to swim if water immersion occurs. There are also a wide variety of specialized rescue and outdoor recreation and water rescue footwear items available.

Fire and rescue agencies use a variety of devices as life floats. Some are commercially made, whereas others are as simple as inner tubes wrapped with **bungee cord** netting (fig. 35–10).

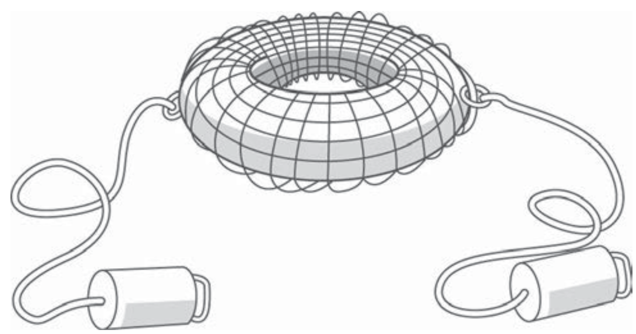


Fig. 35–10. Improvised flotation device with two throwbags for control

Hose inflators allow engine companies to inflate 2½-inch fire hose with air from SCBA bottles. The inflated hose is used in rescues from bridges, low-head dams, and other water rescue situations.

There is a great temptation for rescuers to tie themselves into rope systems when working in moving water. This may be inviting tragedy. If the line becomes tangled in debris, or if the rescuer is unable to get free of a static line, the rescuer can be forced to the bottom and drown. The effect is similar to a water skier who falls off his skis and attempts to hold onto the tow rope.

The Firefighter II should be prepared to support or conduct water rescues without actually entering the water. Throw bags are considered the single most versatile tool used for water rescue. They are similar in size and construction to the drop bags used for firefighting operations. One difference is the foam **flotation ring** sewn into the bottom of the bag (fig. 35–11). Rope stuffed into the float bags is a blend of nylon and polypropylene, which allows it to float on the surface.

Fig. 35–11. Throw bags for water rescue include a foam flotation ring at the bottom of the bag (shown inside the metal grommet).

This rope is strong enough to haul victims to shore, but it is not generally rated as lifeline rope. When a victim is swept downstream, the quickest method of rescue is to toss the throwbag.

The average rescuer can normally toss the bag from 40 to 60 ft (12.2 to 18.3 m) using an underhand, overhand, or side arm throw. Once the victim grabs the floating drop bag, the rescuer begins to pull in the line. The victim moves toward shore in an arcing motion that resembles the swing of a pendulum. This is known as the **pendulum technique**, and it has a variety of other applications. Moving downstream as the rescuer pulls in the line helps keep the victim upstream of the rescuer, accentuating the pendulum effect.

Submerged victim rescues

When a victim is missing and presumed to be submerged in the ocean, lake, pond, or other body of water, the incident commander should immediately request a dive rescue team in addition to other units that may be responding. Helicopters are another good asset because helicopter crews viewing the scene from above can sometimes see submerged victims who are not visible to personnel working on the surface of the water. If conditions are reasonably safe, first responders may initiate a preliminary search. The following provides some guidelines to begin search operations until the arrival of a dive rescue team.

Search

Fire and rescue agencies are frequently called on to search for swimmers, boaters, fishermen, and others who have disappeared in lakes, ponds, the ocean, and other bodies of deep water. Searches under these conditions are usually hampered by lack of visibility caused by murky water or depth.

When a victim cannot be immediately spotted in deep water, the incident commander should ensure that the following objectives are met:

- Request one or more dive rescue teams and get their **estimated time of arrival (ETA)**
- Get a history of the victim's activities prior to disappearance
- Establish a **point last seen (PLS)**
- Request appropriate watercraft and helicopter resources for search

The PLS is commonly used as the basis for establishing a search perimeter. When responding to a search rescue in calm water, your only source of information about the victim's location may be witnesses on the shore. In some cases, firefighters or other rescuers approaching the victim may actually see the injured party go under water. In this event, your last visual contact with the victim is the PLS. When dive rescue teams arrive, give as much information as possible to assist them in locating the victim.

When you get to the PLS, begin a quick visual surface search to make sure you are in the proper location and the victim has not **popped up**. Attempt to get bearings from prominent geographical structures such as cliffs, points, mountains, or objects near the shore such as trees, buildings, and so on. Try to line up a couple of these points to *triangulate* the position.

Submerged vehicles

Firefighters responding to vehicles submerged in water are faced with several special problems ranging from the need for self-contained underwater breathing apparatus (SCUBA) or snorkeling gear, to powerful currents, to poor visibility in murky water. Add to that the inherent problems of vehicular damage resulting from collisions, the tendency of many automobiles to **turtle** (that is, turn upside down as they submerge and bury themselves in mud), air/water pressure differentials, failure of electrical systems, and other complications.

Fortunately, many passenger vehicles tend to float for several minutes (if there isn't severe damage) before submerging. Electrical windows and door unlocking systems tend to work long enough for conscious victims to make an escape before the auto goes below the surface. Many buses, however, tend to sink almost immediately.

One of the most important factors is the amount of impact a vehicle experienced before and after it entered the water. Regardless of the type and size of the vehicle, the amount of air trapped within is related to the amount of damage sustained as it hit the water (as well as whether or not the windows were down).

Low-speed crashes into water may present a greater chance for rescue than a high-speed crash off a bridge or cliff. It may be possible to make a surface before the vehicle sinks. The vehicle tends to tilt somewhat depending on where the center of gravity is. A front-engine car tends to tilt forward, exposing the rear window. This is ideal if the windows are rolled up because the tempered glass of the rear window shatters with a blow from a sharp object like an axe. A blow to one corner of the glass is most effective. Victims can then be pulled out through the rear window before the car goes down.

Rescue can be made from the side windows if the occupants are able to roll them down (or if they were down to begin with). Electric windows may still operate for a time even when a vehicle submerges. If the windows are inoperable or the victims are unconscious, the side windows (also tempered) can be shattered just like the rear window.

Windshields are notoriously difficult to break because of the lamination process that protects them from accidental breakage. Therefore, firefighters should avoid wasting valuable time trying to break a windshield unless there are no other options.

Note that the vehicle can suddenly tilt vertically and plunge to the bottom, and rescuers don't want to be climbing through a window (or in the car) when this happens. In fact, rescuers should move far away from the car if it appears to be ready to submerge. Rescuers do not want to be near such a large moving object in the water. Rescue efforts can continue once the vehicle has come to rest below the surface.

In deep or murky water, rescuers may have difficulty finding the vehicle. If it appears that the vehicle will submerge before victims can be removed, it may be possible to tie a rope to the bumper to guide rescuers to the vehicle after it goes to the bottom. A submerged vehicle leaves clues to its location. They may include a continuing trail of escaping air bubbles, an oil or gasoline slick, or articles floating to the surface. At night, headlights may be seen shining up from below.

In some cases it may be necessary to stabilize a submerged vehicle before rescue can proceed. The guide rope can be used for this purpose in calm water. Tying it to a bridge, tree, or other strong anchor at least lessens the chance of the vehicle moving and pinning a rescuer or victim. A winch, tow truck cable, or crane can follow the rope to provide additional stabilization. Other measures may be necessary under some conditions.

In some cases, the position of the vehicle can hinder rescue operations (i.e., a vehicle on its side with the exposed doors inoperable because of impact damage). Firefighters may need to move the vehicle to proceed with rescue operations. A tow truck, A-frame with a winch, or crane should be used when possible. If these devices are available, it may be possible to lift the vehicle to the surface. A heavy-duty crane may be able to pick the vehicle out of the water and set it on the shore. Obviously, this creates a much safer work environment for rescuers.

Under limited conditions, a rope hauling system could be used to move a vehicle in a life-and-death emergency. The human-powered pull raising system with a brake is one alternative. Mechanical advantage systems may also be used to move limited loads.

Doors may be difficult to open because of the pressure differential between the inside of the vehicle and the water. In some cases they may be opened when the vehicle fills with water, which equalizes the pressure. Doors may be difficult to open even when the vehicle is filled. Consider the possibility that the vehicle may have struck an object prior to going into the water. Previous impact, or even mud, may have jammed the doors.

ICE RESCUE

Ice rescues are complicated and dangerous because we have three main hazards to deal with:

1. Water is inherently dangerous to humans because it's a foreign environment in which we can't breath, and it robs the heat from our bodies.

2. Ice is a hard surface over the water that hides any danger below, and if broken through it may prevent us from getting back to the surface where the air is.

3. Cold is a rapid killer that gives victims just minutes and maybe only seconds to escape before their bodies fail and prevent them from climbing out.

The rules for ice rescue are much the same as for water rescue, emphasizing shore-based rescue first and contact rescue only if the shore-based rescue methods are not working (or not going to work because the victim is unconscious or out of reach). But they also take into account the other two main hazards: the hard ice over the water, which is subject to fracturing under the weight of rescuers, and the cold.

Firefighters responding to a potential ice rescue naturally want to be suiting up en route with appropriate gear to protect them from the cold. For many tailboard firefighters this still consists of bunker gear with an outer layer, such as a jacket, and should always include a PFD. Still, even with the cold, firefighters should try to avoid wearing turnouts near the water and when on the ice that might break under their weight. If you do fall in from the shoreline or go through the ice, you want to make a very quick escape, and bunker gear full of water only impedes that escape.

Ice rescue, dive, and some technical rescue teams responding to ice rescues typically wear thermal rescue suits built to maintain body temperature even during full immersion in ice water, and they train in that environment on a regular basis. Typically, other responding firefighters do not have that level of protection, so their tasks are limited to shore-based operations.

Thus, the order of the day for most firefighters includes tactics such as the following:

- Talking the victim through self-rescue
- Attempting to reach the victim with pike poles, rubbish hooks, or other reaching tools
- Tossing a rope or throw bag (or other tossing devices) to the victim in hopes of pulling the injured party out and over the ice

For specially trained firefighters with the proper equipment, the options expand further. The following are all tasks outside the realm of Firefighter II skills, so formal ice rescue training and the right equipment are required:

- Move across the ice using a commercial ice rescue platform and tools like ice picks (for traction) to attempt a contact rescue, with ropes attached for retrieval by personnel on the shoreline
- Attempt the same type of maneuver using plywood to spread the weight, a ladder with fire hose weaved through the rungs and inflated with air, a large rescue board, or some other weight-spreading device, also with ropes for retrieval by shore-based personnel
- Attempt to plow and chop through the ice using an IRB with oars and/or with a motor, to reach the victim, also with retrieval lines attached for rapid return to shore
- Attempt a helicopter pick off with a firefighter lowered on a hoist cable or a short-haul system to capture and extract the victim
- For submerged victims, properly equipped dive rescue teams enter the icy water to search for and rescue the victim
- Other options that are beyond the Firefighter II level of skills, knowledge, and abilities

LESSON FROM THE FIREGROUND

We all know ice floats on water, and typically in the colder climates of North America it forms seasonally on lakes, ponds, and even some rivers. Ice rescues also happen in places you wouldn't normally expect. For example, during the writing of this chapter, a man died attempting to rescue children who broke through the ice in a lake in the 11,000-ft-high (3,352.8 m) San Gabriel Mountains right above Los Angeles (the lake is at approximately 6,500 ft [1981.2 m] elevation). According to witnesses, the children fell through the ice, and a desperate rescue effort was launched by citizens while the Los Angeles County Fire and Sheriff departments were called to respond. The would-be rescuer disappeared beneath the ice while helping the children, and he was never seen alive again. A specially equipped dive rescue team was required to locate and remove him.

MUD AND DEBRIS FLOW RESCUE OPERATIONS

Mud and debris flows are among the most hazardous emergencies because they combine some of the most dangerous characteristics of swiftwater, flash floods, and mud slides (fig. 35–12). They have been known to wipe out entire cities, kill thousands of people, and give little warning before leaving large areas buried under dozens of feet of mud and rocks. They are extremely dangerous because, unlike water, swimming in a mud and debris flow is generally not an option because of the load carried in the flow, which tends to batter victims and leave their bodies with severe physical trauma in addition to the drowning mechanism.

Fig. 35–12. Significant mud slides are rare events, but present a complex variety of hazards to emergency responders.

Mud and debris flows are common where steep mountains are affected by extreme erosion, earthquakes, volcanic action, fires, and other **debris flow producers**. Also, mud and debris flows and mud slides can sometimes create natural dams in canyons that are not visible (because of location, rain, darkness) to personnel working downstream. The only warning might be signs like water flow interruption. Failure of these natural dams can create a flash flood of mud, debris, trees, boulders, and vehicles with devastating consequences.

Wildfires are a particularly important trigger in some regions (especially the Western ranges), because after fire season come the winter rains (fig. 35–13). As the rain strikes, rocks and soil begin sliding off the mountain sides and falling into the canyon bottoms. Then, when intense downpours occur, tremendous amounts of debris can be quickly turned to a slurry and mobilized into a large flood of mud, rock, and water. The winters following major wildfires require extra vigilance and planning to prepare for the possibility of damaging mud and debris flows.

Fig. 35–13. The winter season following a major wildfire is an opportune time for mud slides.

The Firefighter II should understand that mud and debris flows often arrive in multiple waves or surges. Firefighters attempting to rescue people from a mud and debris flow should assume they are in imminent danger of being affected by larger waves or surges of mud, water, and debris that can strike with little warning (fig. 35–14). Important considerations when arriving on the scene of a mud and debris flow include the following:

- Assess the condition of the incident site, including the stability of slopes, hazards like deep or moving mud and debris, shifting structures, and so forth. Is it a recently burned area? If so, an extra measure of precaution is required because the likelihood of multiple mud and debris flows is greatly increased.
- Establish upstream lookouts for *secondary* mud and debris flows or mud slides.
- Establish the following zones:
  - Exclusion zone: Within 100 ft (30.5 m) of the mud and debris flow and the debris field. Consider an exclusion zone of 500 to 1,000 ft (152.4 to 304.8 m) from debris flows on slopes 26° or greater.
  - Operational zone: To within 100 ft (30.5 m) from the edge of the flow
  - Support zone: At least 100 ft (30.5 m) from the outside edge of each side and the base of debris flow

- Strongly consider evacuation of all threatened areas to get people out of the potential path of secondary flows.
- Determine the potential number and location of victims (trapped and missing).

Fig. 35–14. Mud slides can occur in several "waves" and so emergency responders must be ever vigilant when operating in these conditions.

- Strategically stage resources in preparation for rescue operations in affected areas.
- Ensure all firefighters are wearing swiftwater personal protective equipment (PPE) or other gear appropriate for the conditions (personal flotation devices and other swiftwater gear is appropriate while active flows are occurring).
- Begin rescue operations (see the following text).
- Coordinate prehospital care and transportation.

Firefighters attempting rescue operations after a mud and debris flow should consider the following options to address common situations. Some tasks may exceed Firefighter I and II training. Others are in a gray area because they're nontraditional tasks, but they have been proven effective under mud and debris flow conditions, and they're mentioned here for context (fig. 35–15):

- Use front end loaders, bulldozers, helicopters, and other alternate-terrain units to transport personnel, equipment, and victims in and out of the incident site where fire apparatus generally cannot go.
- Breach the roofs and sides of buildings, and tunnel through debris to reach victims. Consider using trench shoring material and techniques to help secure areas around trapped/missing victims from further encroachment of mud and debris. It may be necessary to use sandbags or other options to divert mud, debris, and water flow away from rescue sites.
- Create access over mud and quicksand-like conditions by placing plywood as ground pads or using air-inflated fire hose weaved through ladder rungs as a floating structure or inflatable rescue boats attached to rope systems to spread the weight of rescuers and equipment.
- Use helicopter hoist operations or heavy equipment to remove stranded victims.
- Lift and move heavy objects like trees or others pinning victims.

Fig. 35–15. Firefighters must be prepared to use conventional and unconventional methods to retrieve victims of mud slides.

- Pull victims out of mud by considering the following options:
  - Break the suction using reel lines blasting water into the mud (after harnessing the victim to gradually pull up the victim as suction is broken). Also use compressed air (air compressor lines from the **urban search and rescue [USAR]** apparatus, heavy lift rescue unit, or self-contained breathing apparatus [SCBA] bottles with lines) blasted into the mud with water.
  - Build an island of plywood around the victim on which an A-frame or tripod device can be established as a lifting system to slowly raise victim from the mud as suction is broken

STRUCTURE COLLAPSE OPERATIONS

Firefighters arriving at the scene of a structure collapse, regardless of the cause, typically need to complete the following tasks simultaneously: search for missing victims, prevent secondary collapse through shoring, rescue trapped victims, knock down fires from gas leaks and other causes, identify and react to possible hazardous material releases, and treat casualties (fig. 35–16). These are among the most challenging emergencies to which firefighters respond.

If the collapse is caused by a terrorist attack, **secondary devices** are a primary consideration. If it's a large earthquake, these simultaneous challenges may be multiplied many times over, across an entire city, county, or region. First-due firefighters may be on their own for an extended period of time before help arrives in the form of rescue companies, technical rescue teams, or regional/state/federal urban search and rescue task forces. So it's important to understand the basics of collapse emergencies and be prepared to take immediate action *and* assist rescue companies or technical rescue teams when they arrive.

Fig. 35–16. Managing structural collapse incidents involves a wide variety of tasks.

The modern fire and rescue service has developed a systematic approach to structure collapse emergencies. This approach is based on consensus of the most experienced fire departments and rescue organizations, and now it is recognized and used by international urban search and rescue teams in disasters around the world. The basis of this approach is the *five stages of collapse operations*. Regardless of the size or scope of a collapse emergency or disaster, each particular collapse site can be effectively managed by conducting the five stages.

Stage 1: Response, size-up, and reconnaissance

When responding to a reported structure collapse, consider the possible causes and their associated hazards. Typical causes are fires, natural gas explosions, vehicles striking structures, construction accidents, mud slides, floods, avalanches, earthquakes, or bombs and other terrorist attacks. Each cause is often associated with particular hazards. Always consider the potential for explosion(s) caused by postcollapse gas leaks, secondary devices, and so on.

Size-up is critical on arrival (fig. 35–17). What is the extent of the affected area? Is it a single building or an entire neighborhood or city? Conduct an *eight-sided* size-up of the involved building(s) and the surrounding area. Check the top, bottom (basement), and four sides of the building; also check the air space around the building for falling hazards from adjacent structures and other aerial hazards. Finally, conduct a rotary sweep of the ground around the structure, looking for hazards like ruptured gas mains, broken water mains, railroad tracks, and other potential ground-level problems.

Fig. 35–17. When responding to structural collapse incidents, firefighters must consider how the collapse occurred and conduct a thorough size-up accordingly.

Consider factors that indicate how many victims might be trapped, and where they might be (fig. 35–18):

- What time of day was the collapse event?
- What day of the week?
- Is it a holiday?
- What is the building's occupancy type (e.g., offices and commercial versus residential or schools and hospitals)?
- What is the overall situation in the immediate area of the collapse?
- What is the condition of the area surrounding the actual collapse?
- What construction materials are involved?
- What is the pattern of collapse (pancake, lean-to floor collapse, lean-to cantilever, V-shape void, etc.) (fig. 35–19)?
- Are there basements or subterranean passageways?
- Are there heavy water tanks, air conditioning units, heating plants, communications, equipment, fuel tanks, or generators on the roof, upper levels, or in the basement?
- Is there heavy stock that can absorb water and cause secondary collapse after a fire?
- Are there vertical shafts for elevators and stairways?
- Is there a potential for secondary devices (possible terrorist attack)?
- Is there a hazardous materials (hazmat) problem?
- How many victims are missing or trapped?
- How many victims have been rescued and removed? From which locations?
- Is there an inventory of the occupants? Is there a seating chart for offices and schools?
- Is there an accounting of which occupants are missing, which ones have been accounted for, and which ones have left the area?
- Is there a need for additional resources?
- After finishing the size-up, the first-due unit typically names the incident, requests additional resources as needed, establishes command, and prepares to establish unified command when necessary.

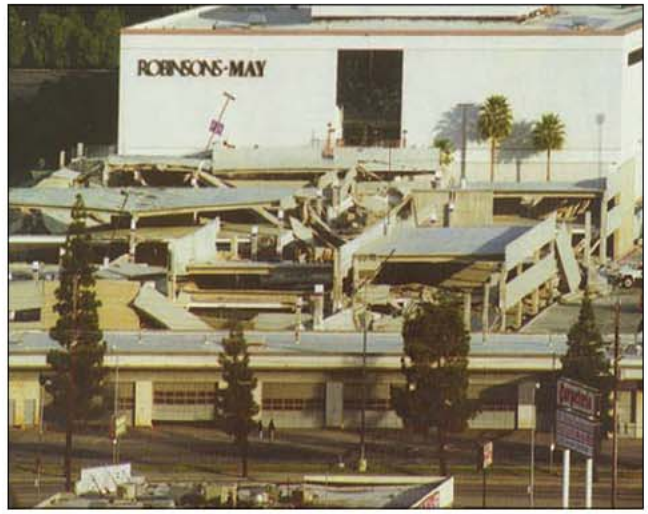


Fig. 35–18. As always, life safety is the number one priority at structural collapse incidents.

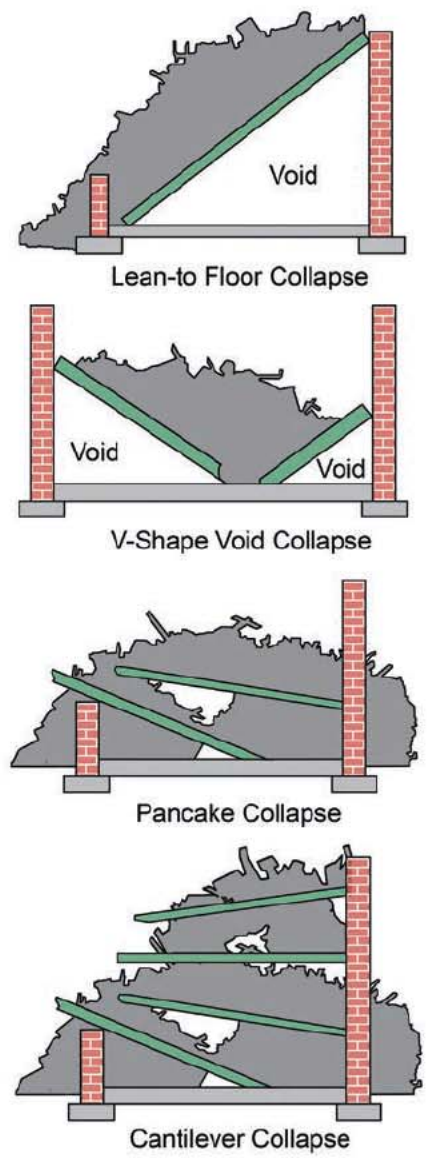


Fig. 35–19. Patterns of collapse

Apparatus placement. Just as in normal fireground operations, the placement of apparatus and vehicles is important for effectiveness of long-term operations. Parking heavy fire apparatus and bulky rescue vehicles in the wrong locations can complicate the situation by blocking access, placing personnel in the collapse zone, exposing units to the radiated heat of fires, preventing the deployment of supply hoselines and hand lines, preventing the proper placement of aerial ladders, and blocking egress and ingress for rescue companies, heavy equipment, and other critical resources. Some agencies have developed standard operating guidelines (SOGs) for collapse operations, including the placement of apparatus and personnel. The first-arriving officers must quickly develop a strategy for the incident, and the placement of apparatus should reflect and support those strategic decisions.

Aerial ladders/towers. Following the lead of FDNY, the SOGs for many progressive fire departments at structure collapse emergencies include the assignment of at least one tower ladder (aerial platform) at or near the front of the affected building(s). The ladder or platform is raised to an elevation from which a firefighter can observe the entire collapse zone and surrounding areas. This provides a constant lookout over the operational area, with particular emphasis on shifting walls, smoke or water appearing from cracks in walls, sagging roofs, and other signs of impending secondary collapse. The firefighter assigned as lookout should have the means to immediately notify everyone on the scene when signs of impending collapse or explosion are noted. This may include a handheld radio, an air horn, a whistle, or some other signaling device.

Firefighters should consider assigning tower ladders (aerial platforms) to different sides of the collapse zone to maximize the observation capabilities for lookouts (fig. 35–20).

Engine companies. To deal with the potential for fire and explosions occurring during collapse rescue operations, at least two sources of water should be secured for firefighting and protection of trapped victims and firefighters working to rescue them (fig. 35–21). Additional engines may be positioned to support effective water supply operations (relay pumping, shuttling water, etc.). Engine companies can also be used for personnel, cutting teams, medical teams, litter teams, and many other functions.

Fig. 35–20. Aerial ladders can be used at technical rescue incidents as observation towers.

Fig. 35–21. Engine companies will be responsible for fire suppression activities and supporting technical rescuers at structural collapse incidents.

Rescue companies and technical rescue teams. Rescue company and technical rescue team apparatus should be placed close to the collapse (but out of the collapse zone) where the heavy tools they carry can be put to the best use (fig. 35–22). Typically, this is directly in front of the collapse near an equipment pool.

Paramedic/advanced life support units and ambulances. Advanced life support and paramedic units and ambulances may be positioned in a **medical group** configuration, in a mass victim configuration, or somewhere else away from the collapse zone that allows victims to be triaged, treated, and transported in a timely manner.

Chief officers. If a chief officer vehicle is to be used as the command post, maintain a two-sided view of the incident, if possible, while remaining outside the collapse zone (fig. 35–23).

Fig. 35–22. Technical rescue apparatus should be placed as close to the collapsed structure as can safely be arranged to aid in tool accessibility.

Fig. 35–23. Incident commanders should establish a command space in a conspicuous location where good visibility of the incident can be obtained.

Helicopters. Helicopters are useful for aerial assessments as well as transporting personnel, equipment, and victims in a collapse emergency. However, when personnel are working in an unstable collapse zone, helicopters should also be kept at a safe distance to reduce the noise at the scene, the chance of the rotor wash blowing loose material, blowing concrete dust and dirt, and other complications.

Specialized companies/units. The placement of lighting units, generator units, air compressor units, commercial vacuum trucks, and other specialized units is incident-specific (fig. 35–24).

Heavy equipment. Likewise, the placement of cranes, skip loaders, track hoes, bulldozers, dump trucks, and other heavy equipment is incident-specific (fig. 35–25). However, it's a good idea to leave room for these units to approach the collapse and potentially make direct access to the affected structure(s).

Staged resources. Staging areas should take into consideration such factors as ground vibration, debris-filled streets, the distance that equipment must be carried, and so forth.

Fig. 35–24. Numerous specialized apparatus are common at technical rescue incidents.

Fig. 35–25. Although not normally considered emergency response equipment, heavy machinery is common at structural collapse and other technical rescue incidents.

Stage 2: Surface search and rescue

Stage 2 includes searching for victims while working from the exterior of the collapse, using whatever search means are available, and rescuing all victims trapped at or near the surface beneath *nonstructural* elements (desks, beds, bookcases, etc.). This includes firefighters pulling people from beneath bricks, walls, and roofing materials that are readily removable by hand, using hand tools, buckets, and other methods that don't require collapse rescue technical expertise and heavy equipment (fig. 35–26).

Victims found on top of the debris or lightly buried should be removed first. Initial rescue efforts should be directed at removing victims who can be seen or heard by firefighters combing the pile and calling out for victims (**hail searching**). The next efforts should be directed at reaching victims whose locations are known even if they cannot be *seen* or *heard*. It may be necessary for firefighters to use hand tools like saws, pike poles, pry bars, hammers, axes, and hydraulic jacks to lift or move debris off lightly trapped victims without cutting through or moving structural elements that might cause secondary collapse without proper shoring.

During stage 2 operations there is constant danger of causing secondary collapse or further crushing of trapped victims. Basic and advanced shoring systems may be necessary to prevent secondary collapse, and the Firefighter II may be requested to gather and assist with items such as hydraulic or pneumatic shoring; timbers and lumber for wood shoring; rescue air bags and jacks to lift, spread, and move items; and saws, coring tools, chain saws, and rescue saws with special blades to breach walls or cut through structural members and reinforced concrete slabs (fig. 35–27). The Firefighter II may be requested to help cut lumber for shoring, make wooden wedges, and associated tasks.

Fig. 35–26. Surface rescue is attempted on the outside of a structural collapse incident and involves rescue victims trapped beneath nonstructural elements.

Fig. 35–27. A chainsaw can assist rescuers in gaining access to victims trapped beneath collapse structures.

Firefighters should not allow passersby and relatives to scamper over the rubble pile (risking secondary collapse or the crushing of victims beneath), pick away indiscriminately at structural members (whose removal may precipitate secondary collapse), or use torches and other spark-generating tools without appropriate fire protection (because an out-of-control fire might render the victims **unsalvageable** and endanger the lives of firefighters and other rescuers).

Generally, during stage 1, 2, and 3 operations, firefighters should not allow heavy equipment to operate where surface rescue and void space search has yet to be conducted. Special caution and discipline are required whenever the use of heavy equipment is contemplated, especially when people may be trapped directly beneath the surface. Seek guidance from the rescue company or technical rescue team before putting heavy equipment to work in these areas.

Firefighters should avoid actions atop the collapse pile that could precipitate a secondary collapse event (fig. 35–28). Every move should be thought out by each person, because one wrong move could have devastating effects on people trapped beneath your feet, or adjacent to where you're standing and operating (including your coworkers).

Fig. 35–28. Firefighters operating on the surface of a structural collapse must be careful not to disturb the pile, as a secondary collapse can have deadly ramifications for victims.

Firefighters may be assigned to establish bucket brigades to remove debris from atop the collapse pile. If so, make use of designated open spaces to deposit debris where it is out of the way of emergency operations or where dump trucks, front-end loaders, and other equipment can later be used to move it to another site.

As the last readily accessible victims are removed, and as signs of additional victims trapped near the surface diminish, it's time to consider transitioning into stage 3 operations, or combining stage 2 and 3 operations. The incident commander typically makes this determination based on the conditions at hand, after considering reports from those doing the work and the recommendations of the most experienced rescuers.

Firefighters should use the nationally approved search marking system to identify buildings being searched as well as those where search has been completed (fig. 35–29). This helps prevent redundant searches by clearly identifying buildings and areas that have already been searched, and the results of those searches. It also includes a marking to indicate the stability of the structure itself and any special dangers, based on the assessment of the unit or team that searched it.

Fig. 35–29. Using a standardized marking system is important since it prevents duplication of effort and helps subsequent crews determine where further searching should continue.

This is critical information at a major collapse emergency, and even more important in a widespread collapse disaster where there may be many sites requiring search and rescue operations. These markings need to be readily identifiable from a distance, and typically they are made using fluorescent orange paint sprayed directly on the building, at the front or address side. Some newer systems use large stickers that can be applied to structure surfaces and marked appropriately.

The nationally approved search marking system is periodically updated by consensus by the major fire service and rescue agencies, including Federal Emergency Management Administration (FEMA) and state offices of emergency services, which have jurisdiction over disaster operations. It's recommended that firefighters consult their **field operations guides (FOG)** and updates from FEMA and their state offices of emergency services for updates (fig. 35–30 to fig. 35–33).

Fig. 35–30. Place these search markings at the main entrance when you enter.

Fig. 35–31. Place these search markings at the main entrance when you exit.

Structure/Hazards Markings

Make a large (2' x 2') square box with orange spray paint on the outside of the main entrance to the structure. Put the date, time, hazardous material conditions and team or company identifier outside the box on the right hand side. This information can be made with a lumber marking device.

Structure is accessible and safe for search and rescue operations. Damage is minor with little danger of further collapse.

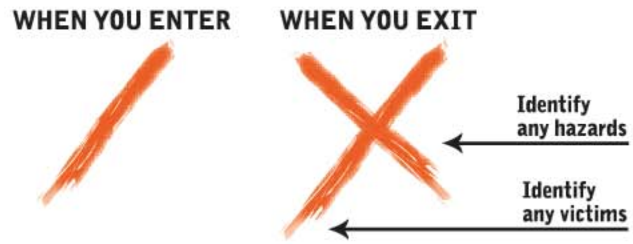
Structure is significantly damaged. Some areas are relatively safe, but other areas may need shoring, bracing, or removal of falling and collapse hazards.

Structure is not safe for search or rescue operations. May be subject to sudden additional collapse. Remote search ops may proceed at significant risk. If rescue ops are undertaken, safe haven areas and rapid evacuation routes should be created.

Arrow located next to a marking box indicates the direction to a safe entrance into the structure, should the marking box need to be made remote from the indicated entrance.

Fig. 35–32. Make these markings on the exterior of a structure so other firefighters will know the status of the building.

Interior Search Markings
-Each Room or Area



Make a large (2' x 2') "V" with orange spray paint near the location of a potential victim. Mark the name of the search team or crew identifier in the top part of the "V" with paint or a lumber marker type device.

Paint a circle around the "V" when a potential victim is confirmed to be alive either visually, vocally, or hearing specific sounds that would indicate a high probability of a live victim. If more than one confirmed live victim, mark the total number of victims under the "V".

Paint a horizontal line through the middle of the "V" when a confirmed victim is determined to be deceased. If more than one confirmed deceased victim, mark the total number of victims under the "V". Use both the live and deceased victim marking symbols when a combination of live and deceased victims are determined to be in the same location.

Paint an "X" through the confirmed victim symbol after all the victim(s) have been removed from the specific location identified by the marking.

Arrow located next to a marking box indicates the direction to a safe entrance into the structure, should the marking box need to be made remote from the indicated entrance.

Fig. 35–33. Make these markings in each room or interior area as you search.

Stage 3: Void space search operations

After firefighters have removed all victims who are visible, lightly trapped, and readily reachable, the next step is to begin searching every potential **survivable void** space for victims, typically by breaching, shoring, creating, and crawling into void spaces, or using technical search devices or search dogs to check the voids (fig. 35–34).

Void space search is among the most dangerous tasks in collapse rescue operations and generally exceeds the Firefighter I and II skill level, because it requires physical entry into confined areas, establishing shoring, using search cameras and other technical search equipment, and other advanced skills. Firefighters voluntarily place themselves in harm's way to find victims. They break their way into, create, shore up, and crawl through confined areas that may be unstable. Typically, these tasks are conducted by firefighters and rescuers who have completed formal advanced rescue courses including confined-space rescue, shoring, rescue systems, and so forth. They are assigned to organize rescue companies or technical rescue teams. Nevertheless, first-due firefighters must be ready to assist rescue companies and technical rescue teams by providing shoring material, moving debris, providing lighting and other support, and so on (fig. 35–35).

Fig. 35–34. Searching for victims in void spaces occurs after all visible victims have been identified and removed.

In a large disaster, first-due firefighters may not have the luxury of rescue companies and technical rescue teams to assist them for many hours or even days. They may have to take extraordinary measures to attempt saving lives by performing tasks normally delegated to rescue specialists (fig. 35–36). So it's instructive to review these steps, with the caveat that they should be conducted with close supervision of experienced and properly trained officers, even in a disaster.

Under normal (nondisaster) conditions, the main role of the Firefighter II is to support these operations by gathering and delivering shoring materials and tools, cutting, breaching and lifting equipment, acting as litter teams and bucket brigades, and other associated tasks.

Fig. 35–35. Firefighters must be prepared to assist technical rescuers with gathering equipment and shoring materials for complex structural collapse incidents.

Fig. 35–36. Although it is preferred to have highly trained technical rescuers conduct structural collapse searches, under extraordinary circumstances firefighters may have to undertake these responsibilities.

In void space search we look for victims in void spaces and other places that could have afforded a reasonable chance of survival when the collapse occurred. The following places should be considered among the priorities for physical search:

- Between pancaked slabs
- In sheltered parts of structures with higher likelihood of surviving the collapse
- Beneath fallen walls
- In basements and other underground locations
- In voids beneath collapsed floors
- Beneath stairs and in stairwells
- Next to chimneys
- In spaces around sturdy furniture, safes, washing machines, desks, and so forth
- Rooms where access is difficult but where rooms have not yet collapsed
- Beneath other victims

It may be necessary for firefighters to assist rescue companies and technical rescue teams breaching walls, floors, roofs, and other structural elements, taking care not to further compromise the stability of the structure by cutting through **weight-bearing beams and columns**, and taking care to avoid cutting tensioned cables within concrete slabs (fig. 35–37).

Fig. 35–37. Assisting technical rescue teams by supporting breaching, breaking, and forcible entry operations is a common task for the firefighter.

Rescue companies and technical rescue teams often avoid breaching walls, as it may undermine the structural integrity of the building. They are trained to understand that it's generally safer to cut holes in floors and use the **vertical shaft** approach than to breach walls. If they must breach a wall or cut a floor, it's safer to cut a small hole first to ensure that they are not entering a hazardous area.

Rescue companies should understand that shoring should be used to support weakening walls or floors in the position they are found, *not* to restore structural elements to their original positions. Attempts to force beams or walls into place may cause secondary collapse. They should try to keep timber shoring as short as possible (the longer the timbers, the less weight they support and the more unstable the shoring system). Generally, any shoring that's been installed should *not* be removed once it is placed in an unstable building, because doing so may precipitate a secondary collapse from loss of support (fig. 35–38).

Fig. 35–38. Once supplemental shoring is placed in a building, it should not be removed, as it may cause secondary collapse.

In some situations, **engineered shoring**, designed and supervised by structural engineers (including FEMA USAR Task Force Structures Specialists), may be required. This was the case in the aftermath of the 1993 World Trade Center bombing, the Oklahoma City bombing, and the 9/11 attacks at the World Trade Center and the Pentagon.

Rescue company and technical rescue team (urban search and task forces, etc.) members probe all accessible void spaces and follow them when possible, looking for signs of trapped victims within the collapse zone. In some cases this is akin to following an earthquake fault or a narrow cave through the earth, exploiting existing weaknesses and openings in a journey that takes the searchers wherever the voids and cracks and faults lead.

As debris filling the cracks and voids is encountered, it is removed to allow forward movement, and shoring is placed where necessary to maintain stability for ingress and egress. Typically, the first-due firefighters in this system are positioned at the entrance to the opening to remove debris as it's passed out and hand requested materials to rescue companies or technical rescue team members working inside the voids.

Stage 4: Selected debris removal

After all known survivable void spaces are searched, **selective debris removal** begins. During this phase, rescue companies and technical rescue teams work with heavy equipment operators, structural engineers, construction and demolition contractors, and others to *delayer* the collapse zone (typically from top to bottom). As upper layers of the buildings are peeled away, additional void space search operations are generally conducted to check newly accessible parts of the building for potential survivors.

The role of first-due firefighters during stage 4 operations is similar to stage 3: Assist with moving equipment, debris, and victims as they are encountered, and providing support like hoselines for fire protection, cutting lumber for shoring, and so forth (fig. 35–39). It should be noted that sometimes the strategy of void space searches (stage 3) is alternated with selective debris removal (stage 4) until the entire collapse zone is dismantled and all victims are located and extracted (fig. 35–40).

Fig. 35–39. Removing debris from a collapsed structure to a safe area is a difficult task, but one common for the firefighter.

Fig. 35–40. Dismantling the collapse zone through selective debris removal is part of stage 4 operations.

Stage 5: General debris removal

Stage 5 generally signals the end of search and rescue operations and a transition to the **recovery phase**. These operations should be undertaken only after all other potential life-sustaining voids have been physically or technically explored for signs of victims, and after there is reasonable assurance that no survivors remain inside the collapse.

Even when stage 5 operations are proceeding, firefighters and other rescuers must remain alert to the possibility that some hidden parts of the collapse may reveal some sign of life (or life-sustaining conditions) that may require further exploration before the area is demolished and the rubble removed. They must also remain vigilant for human remains and potential evidence of the cause of the collapse, which helps identify and repatriate the deceased with their families and may assist in investigations into the factors that led to structural failure.

Stage 5 operations typically include the use of heavy equipment to bulldoze, demolish, and remove large sections of building as well as the debris piles left behind. This may involve hundreds of firefighters participating in the hand removal of tons of debris not accessible to heavy equipment. If victims are known or suspected to be missing, the search for deceased victims in the rubble continues through stage 5. It may be necessary to sift all the debris for evidence if the event is an act of terrorism, arson, or some other crime.

High-angle rescue operations

SKILL DRILL

You've already learned about ropes and basic knots and how they're used in lowering and raising systems and for other purposes like maneuvering firefighting equipment (fig. 35–41). Now it's time to consider how you actually deal with **high-angle** rescues as a first-arriving firefighter, until the arrival of a rescue company or technical rescue team (at which point your responsibility is typically to assist these more highly trained rescuers).

Fig. 35–41. High-angle rescue operations can occur in a variety of locations including buildings, mountains and bridges.

Size-up. The following factors must be known about the incident, and this is information the first-arriving unit typically determines and communicates to the dispatch center and other incoming units:

- What is the exact location of the incident and the best access for ground units and helicopters?
- What is the victim's predicament (e.g., trapped or stranded on cliff, fallen to bottom, etc.)?
- Is victim able to assist in his or her rescue (e.g., injuries, age, frozen in place, etc.)?
- Is this a situation best handled by a helicopter hoist or short-haul operation, a high-angle rope rescue, or a combination of both?
- For vehicles over the side of a mountain road (possibly down a cliff or in a deep ravine), is there a vehicle extrication problem?
- What equipment is needed (battery-powered hydraulic rescue tools, battery-powered reciprocating saws, etc.)?

Rescue operations are as follows:

- Until the victim is rescued, rescue companies and technical rescue teams typically should not be canceled. Doing so may delay the rescue of the victim and may create unnecessary risks to firefighters.
- After ensuring firefighter safety, the next priority is to secure victims in danger of falling from their current position and securing vehicles in danger of rolling or falling. Typically, this is accomplished by having a first-responder firefighter rappel or be lowered over the side (by firefighters with appropriate training) to either place a harness and safety line on the victim, connect a rope or cable to the vehicle to prevent it from moving, or take some other stabilizing action that can quickly be accomplished. Sometimes this is done by specially trained firefighters lowered from a helicopter, with ground support by first-responder firefighters (fig. 35–42).

Fig. 35–42. An example of a situation where Firefighter IIs can assist rescue companies and teams

- The next priority is to treat the victim immediately for life-threatening conditions while waiting for the rescue company or technical rescue team to arrive, or for first-responding units to establish and insert a litter team and prepare to raise the victim and rescuers.
- If it has been determined that a rope system will be used, establish **bomb proof anchors** (fig. 35–43). If vehicles are used as an anchor, chalk the wheels and *remove the keys from the ignition*.

Fig. 35–43. Using vehicles as anchors for rope rescue systems is a common practice.

Fig. 35–44. For safety purposes, two ropes should be used when possible, especially when raising victims and/or rescuers.

- Any point where a rope passes, a stationary object must be padded with edge protection to prevent damage to the rope.
- Gloves, helmets, and other PPE should be worn by all firefighters engaged in the operation. At night, headlamps are recommended, and all members should carry at least one (preferably two) backup source of light. Goggles are mandatory around helicopters. Only NFPA-compliant harnesses or other approved rescue harnesses should be permitted for rescue operations.
- A helmet and goggles should also be provided for the victim and can be taken to the victim by the first rescuer or by the litter team.
- Whenever possible, two ropes should be used to lower the first rescuer over the side, and always when raising victims and rescuers (fig. 35–44). The second rope is the safety line. But single-line rappels are a common Firefighter II tactic, typically with some form of fall protection (prussic, bottom belay, etc.).
- In some cases (e.g., vertical cliffs where the rescuer is out of sight and requires split-second control to reach the victim), some fire departments allow the rescuer to **rappel** on the main line with a **safety line** attached to his sit harness and chest harness for fall protection.
- Non-rescue-rated cable winches are not recognized as appropriate raising systems.
- Even rescue-rated cable winches should be used judiciously. Caution is advised whenever the cable winch operator does not have *direct line-of-sight visual contact* with the rescuers (fig. 35–45). In the event of communication delay, it is possible for the powerful cable winch to pull rescuers through brush and rocks before the operator realizes it.

Fig. 35–45. Winch systems must be operated with care, especially when the operator does not have direct visual contact with the other rescuers.

- **Capstans**, machined that rotate to apply force to another used in conjunction with ropes or cabled winches, are often used in combination with winch systems to provide safety/belay capabilities for rescue loads, and so on (fig. 35–46).

Fig. 35–46. Capstans are used in combination with winch systems and offer additional rescue options.

- Injured victims should be securely packaged in a rescue litter bag before any raising or lowering operations.
- Solid rescue litters generally should be avoided for helicopter hoist or short haul operations because of their aerodynamic properties beneath Rotorwash®.

Potential jumper rescues. A twist on high-angle and rope rescues is in response to potential **jumpers** and hostage or crisis negotiation situations in high-risk environments like high rooftops, bridges, towers, and so forth. In many places, the primary responsibility of the fire department in these emergencies is to establish unified command with local law enforcement, provide safety support for the crisis negotiators, establish fall protection for the subject and potential rescuers, and be prepared to attempt a tactical rescue if conditions warrant.

Typically, law enforcement agencies are charged with primary responsibility for crisis negotiations and scene security. Fire department resources may be requested to be prepared to conduct or assist with tactical rescue operations of crisis negotiators, subjects, hostages, or even bystanders (fig. 35–47). Additionally, firefighters are frequently requested to stand by in case of injury to subjects, negotiators, law enforcement officers, or bystanders, or in case a fire erupts during the course of negotiations and/or tactical actions. Following are some considerations and actions that the Firefighter I and II should be aware of and capable of handling.

En route. Gather critical information from the dispatcher and mobile data terminal text descriptions that might indicate the nature of the incident (e.g., a possible jumper perched on a tower, whether the subject appears to be armed, and so forth.)

Fig. 35–47. During jumper rescuers, the fire department should work with the police department under unified command to establish a common incident action plan.

- If available and appropriate for the situation, request a rescue fall cushion unit (e.g., stunt fall bags, carried by many U.S. fire department units) to respond to provide fall protection (fig. 35–48).
- Ensure law enforcement and crisis negotiators have been notified.
- Coordinate with the responding rescue company or technical rescue team via radio for any other needs.

Fig. 35–48. If available, a fall rescue cushion can be a valuable resource at jumper incidents.

Fig. 35–49. A thorough size-up will determine the number of potential victims and other hazards that may exist to the victim or jumper.

Size-up. On arrival, firefighters should assess and report the following (fig. 35–49):

- The exact location of the incident and the best access and staging of fire department units and ambulances to maintain a secure perimeter around the operational area.
- The nature of the subject's predicament:
  - Is the subject injured?
  - If the subject falls or is dislodged from his present position, can the victim be injured?
  - Is the subject physically able to help exit to a safe location if compelled to do so?
  - Can the subject be convinced to move to a safer location/position until help arrives?
  - Are there hostages?
  - Are there obvious weapons?
  - Are there signs of explosive devices (including secondary devices), booby traps, or other unexpected factors that can cause injury or death to firefighters and negotiators?
  - What are the plans and needs of the crisis negotiators (fig. 35–50)?
  - Is there a need for fall bags or other special equipment like an aerial platform (fig. 35–51)?
  - Is there a need to provide physical protection (e.g., belay systems, harnesses, helmets) to crisis negotiators, the subject, and other involved parties?
  - Are negotiators in contact with the subject?

Fig. 35–50. Working with crisis negotiators is an essential requirement of firefighters operating at jumper incidents.

Fig. 35–51. Aerial platforms can be used to aid in gaining access to the jumper and providing for an added level of safety.

Operations.

- Until arrival of the rescue company or technical rescue team, firefighters can coordinate with law enforcement to develop the basic strategy (e.g., fall protection provided by the fire department, scene security provided by law enforcement, crisis negotiators make approach to the subject, fire department be prepared to attempt tactical rescue if necessary).
- It should be noted that some law enforcement crisis negotiations teams use a two-negotiator approach whereby one is the *talker* (to engage with the subject) and the other is the *shooter* in case the subject produces a weapon or takes action that threatens negotiators, firefighters, or the public. And other law enforcement officers on the scene may be compelled to take action if the subject becomes a threat. Firefighters should be aware of all these issues so they can stay out of the potential line of fire.
- If crisis negotiators aren't present when firefighters encounter a jumper, the incident commander should confer with law enforcement to determine how contact will be established, by whom, and under what parameters. Law enforcement typically has jurisdiction over crisis negotiations, although the fire department sometimes arrives first and must make a judgement about the situation (fig. 35–52). It's generally advisable to secure the scene, begin preparations for fall protection and tactical rescue, but wait for law enforcement to take the lead in negotiations. There are obviously exceptions, such as when it's obvious that the subject is serious about jumping, or if the subject is intent on doing harm to another person (such as holding a child). But before taking action, these questions must always be asked: If we take action, why are we doing it, and why now? What is the likely reaction of the subject if we take action? In most cases, the best solution is to wait, allow law enforcement to establish a presence, get crisis negotiators involved, and be prepared to provide fall protection and to conduct tactical rescue in a coordinated manner with law enforcement.
- Departments with rescue air cushion units can coordinate with law enforcement and crisis negotiators to establish fall protection.

Fig. 35–52. If crisis negotiators aren't present when firefighters contact a jumper, contact should still be established.

- Tactical rescue is generally assigned to the rescue company or technical rescue team, with support of the other firefighters (fig. 35–53). However, first-arriving firefighters should consider the potential need to initiate tactical rescue if conditions warrant.

Fig. 35–53. Tactical rescue is typically conducted by seasoned technical rescue personnel.

Marine emergencies. Marine emergencies refer to incidents in which victims are in need of rescue on the open sea, lakes, or wide rivers resulting from airplane crashes, capsized boats, boat collisions, boat fires, or other mishaps (fig. 35–54). In many areas where marine disasters are a hazard, progressive agencies have developed a coordinated response of all affected agencies (fire department, U.S. Coast Guard, law enforcement rescue, lifeguards, etc.) to get marine-based, air-based, and land-based fire/rescue/EMS units in place in a timely manner (fig. 35–55).

Fig. 35–54. Marine emergencies involve rescuing victims in the sea, lake, or other bodies of water.

Fig. 35–55. Using inflatable boats is a common practice for marine emergencies.

The goal of marine response is to deal with fires aboard ship or on the water, effect timely rescue and recovery, and provide rapid transportation to shore.

The role of firefighters may be to respond via fire boats, helicopters, engines, truck companies, paramedic squads, and other land-based units to provide medical care for injured victims transported to shore to assist in firefighting or hazmat operations or other tasks. Some tasks are outside the scope of Firefighter I and II, but it's worthy of consideration for firefighters who might respond to marine disasters to ensure they understand the plan, where they fit in, and what might be required of them.

Although the fire department often responds to off-shore search and rescue operations along the coast of the United States, ultimate responsibility is typically assigned to the local U.S. Coast Guard district as the Federal Search and Rescue Coordinator (SMC). However, the first on-scene agency (including fire departments) typically establishes incident command and then transfers command to the Coast Guard when they arrive. In some areas it has already been decided that unified command will be the order of the day for marine emergencies.

Trench and excavation collapse rescue. A common industrial accident resulting in fatalities is the collapse of trenches and excavations, generally at construction sites (fig. 35–56). These emergencies usually require rescue companies or technical rescue teams to provide specialized equipment, training, and rescuers to get the job done. However, first-arriving firefighters are a critical element; and they face dynamic and dangerous conditions requiring basic scene stabilization to prevent additional injuries or death as well as provide protection for trapped victims. Even as a tailboard firefighter without formal trench rescue training, it's important to understand the hazards of trench and excavation collapse and to perform basic scene stabilization. So let's review basic considerations for first-arriving firefighters.

Fig. 35–56. Trench and excavation emergencies involve rescuing victims from below grade earth cave-ins.

En route:

- Consider special information from the dispatchers (e.g., location is at a construction site, number of victims, special hazards) and potentially any preplanning that was done for the site in anticipation of potential collapse emergencies there.
- Consider the need for additional resources (shoring trailers, units equipped with **rescue vacuums**,

hydrovac trucks, additional rescue companies, lighting, and utility companies are common requests for additional resources).

- Request law enforcement response to assist in traffic control and other vibration-elimination and crowd-control measures required for working trench collapse incidents.

On arrival:

- Park apparatus at a safe distance from the collapse to reduce potential of vibration causing secondary collapse. No vehicles should be within 50 ft (15 m) of the trench, except possibly the hydrovacs or aerial ladder if required for soil removal and as a high point for vertical extraction (fig. 35–57). Instruct other units to do the same.

Fig. 35–57. Emergency vehicles should be staged at least 50 ft away from trenches.

- Isolate and deny entry into unshored collapse areas and unshored trenches. Generally, rescuers should not enter unshored trenches and excavations more than 5 ft deep, even for rescue. Alternatives are to work from outside the collapse area: using reaching tools; lowering in breathing apparatus masks and other supplies to trapped victims; reaching in with shovels to remove soil; and using rescue vacuums, which have long handles designed to allow rescuers to work from outside the collapse. Once shoring is in place, rescuers can start working their way in.

- If construction workers, police, or others are digging in unshored areas to attempt rescue, they should be instructed to exit to a safe zone until adequate shoring can be placed. Failing to remove would-be rescuers from unshored areas risks additional victims if there is a secondary collapse, further complicating efforts. One alternative is to convince them to help you begin the process of stabilizing the scene using plywood and/or timbers as edge protection around the trench or excavation, and moving **spoil piles** (excavated dirt) at least 2 ft (0.6 m) away from the edges.

- Remember that there is a greater than 50% chance of secondary trench excavation collapse following the original collapse. Isolating and denying entry until shoring is in place helps prevent additional victims if secondary collapse occurs.

- Eliminate vehicle traffic, heavy equipment, and other causes of vibrations. Shut them all down except critical items like hydrovac trucks. Don't forget to shut down nearby rail lines.

- Locate the site supervisor to determine potential number of victims, their last known locations, and site-specific hazards like utilities, pipelines, water mains, and so on. Keep the site supervisor with the incident commander; do not allow the site supervisor to venture off.

Rescue operations. Until the arrival of the rescue company or technical rescue team, first-arriving firefighters can begin performing the following tasks that keep them outside the unshored collapse zone.

- Place edge protection in the form of wooden planks, plywood sheeting, or even backboards around all edges of trench/excavation (figs. 35–58 and 35–59). This helps distribute weight of rescuers and eliminate secondary collapse.

- Consider options for helping to stabilize the area directly around the victim from secondary collapse. Examples can include the placement of ladders and plywood to prevent wall failure. Trench rescue operations eventually require the trench walls to be pressurized in the shoring process, and these skills and equipment are generally outside the realm of the Firefighter I and II.

- If the spoil pile is right on the edge of the trench, begin hand digging the pile back at least 2 ft (0.6 m) from the edge. Consider requesting an additional alarm for personnel for this labor-intensive work.

- If possible, lower a helmet and SCBA mask to the victim with instructions to don both to provide head and airway protection in the event of a secondary collapse.

Fig. 35–58. Edge protection along the sides of the trench can help distribute weight and prevent secondary collapse.

Fig. 35–59. Cutting and assembling lumber at a trench rescue incident will require several firefighters.

- If possible, lower a rope to the victim with instructions to tie it around the victim's body. This allows firefighters to trace the rope back to the victim in case of secondary collapse.
- *Do not* allow the use of backhoes or other heavy digging equipment to free victims.
- Ensure that water mains, electrical, and other utilities and pipelines are shut down in the collapse area.
- Develop an **equipment pool**, including buckets and rope, shovels, rope rescue equipment, and so forth.
- Assign companies to help the rescue company or technical rescue team unloading equipment on their arrival, and transport tools to the equipment pool.
- Develop a materials pool to store plywood, planks, and other shoring material.
- Consider potential high-angle rescue options in case rope systems are needed to *pick* the victim straight from the trench once the victim is freed (fig. 35–60).

Fig. 35–60. High-angle rescue techniques may have to be combined with the trench rescue operation in order to provide for safety and expedite victim removal.

- Approach trenches from the ends to avoid secondary collapse, and insert a ladder in each end. A ladder should be placed every 20 ft in the trench, for emergency escape by rescuers once they are working in the collapse zone with shoring in place.
- Be prepared for unanticipated release of water or other substances in the collapse zone, caused by rupturing pipes, ground movement, etc. (fig. 35–61). Have sump pumps and eductors positioned to insert at a moment's notice. A new device called the rescue vacuum (in combination with a Vactor or hydrovac truck) can rapidly remove water and mud flooding a collapsed trench. Also be prepared to quickly lower SCBA mask, dive mask, or some other source of emergency breathing air before the victim goes under water.
- When hazmat or rescue companies arrive, monitor the atmosphere in the collapse zone. Be mindful that apparatus still running may create carbon monoxide (CO) that could find its way into the trench or excavation.

Fig. 35–61. Controlling utilities, especially water service, is of extreme importance during trench operations.

- Precautionary ventilation into the trench and other collapse zones is advised under most circumstances to maintain a fresh atmosphere clear of contaminants. Consider the possible effects of dust from ventilation fans.
- Radio your findings to the incoming rescue company or technical rescue team.
- Identify the incident commander, operations section chief, rescue group supervisor, safety officer, shoring officer, cutting team, logistics, medical group, and other standard positions for these incidents based on your agency's standard protocols.
- For long-term entrapment with potential for crush syndrome, compartment syndrome, and trauma complications, consider requesting a medical director or physician to advise paramedics on treatment, and a helicopter to expedite patient transportation to trauma center after the victim is rescued.

Confined-space rescue. Confined-space rescue is one of the most difficult and dangerous duties, and most firefighters never encounter a true confined-space rescue in their careers. However, firefighters in some regions prone to confined-space conditions may respond to multiple rescues in this environment (fig. 35–62). Firefighters assigned to active rescue companies and technical rescue teams may see multiple confined-space emergencies practically every year.

Fig. 35–62. Confined-space rescue can occur in industrial settings, transportation vessels, and a variety of other situations.

There is a relatively high incidence of mortality among would-be rescuers during confined-space emergencies. There are strict federal and state laws regulating who can attempt rescue in confined spaces, what equipment they require, and the level of rapid intervention that's necessary. Entry into confined spaces is typically beyond the scope of the Firefighter I and II, but it's important for all firefighters to understand the hazards and basic first-responder operations.

There are two major classifications of confined space: nonpermit spaces and permit spaces. A **nonpermit confined space** is any area that:

- Is large enough for an employee to bodily enter to perform work
- Has limited or restricted means of entry and egress, and
- Is not designed for continuous human occupancy

A **permit confined space** is any area meeting the aforementioned conditions, *and* the following additional hazards:

- Contains, or has a known potential to contain, a hazardous atmosphere
- Contains material with the potential for engulfment
- Has an internal configuration that may cause an occupant to become trapped or asphyxiated

by inwardly converging walls, a floor that slopes and tapers to a smaller cross section, or other similar hazards

- Contains any other recognized serious safety or health hazard

Most firefighters recognize the following examples of confined spaces: storage tanks, pump wet wells, degreasers, sewers, manholes, tunnels, pits, tank trucks, underground vaults, boilers, silos, vessels, grain elevators, mixers, collapsed structures, storm drains, wastewater towers, railcar tanks, trenches, and excavations (fig. 35–63).

Fig. 35–63. Underground vaults are merely one example of confined spaces.

A 1985 Occupational Safety and Health Administration (OSHA) study revealed that of 173 confined-space fatalities, 67 were in untested, oxygen-deficient atmospheres (fig. 35–64).[1] Even a small reduction of the oxygen percentage in a space indicates that some process is actively reducing it. It may be the result of consumption by fermentation, bacterial, or chemical reactions; absorption of hazardous substances into the lining of the shaft; displacement by other gases formed within the space or introduced from the outside; purging operations; oxidation from rusting steel casings or curing concrete shaft casings; or even as a result of respirations from a trapped victim, which can reduce the oxygen level to dangerous or lethal levels.

Combustible atmospheres may ignite or explode if a source of ignition is present or introduced. Combustible agents may include naturally occurring gases, vapors from liquids such as fuels or solvents, or dusts of combustible materials.

Fig. 35–64. Rescue company member making a confined space entry

Combustibles are considered hazardous when they reach 10% of their lower explosive limits (LELs). Some flammable gases may flow into deep shafts naturally or be introduced by workers into the space accidentally. An oxygen-enriched atmosphere (23.5%+) increases the potential for ignition. Different gases, heavier or lighter than air, seek lower or higher levels (stratification) in a deep confined space such as a vertical shaft. **Desorption** of chemicals from the walls of the confined space may cause a combustible atmosphere. Dusts may become combustible in certain concentrations. Generally, dusts are considered possibly combustible when particulates reduce visibility to less than 5 ft, but some materials may reach dangerous concentrations long before that.

The atmosphere of a confined space might contain either immediate or delayed asphyxiates and irritants that can cause disease, illness, injury, or death. CO may be found where there has been incomplete combustion of fuels containing carbon and in decomposition of organic matter. CO is odorless, colorless, and may quickly reach lethal levels in a confined space and give little to no warning before a victim or rescuer is overcome. **Hydrogen sulfide** gas is produced from the natural decomposition of sulfur-bearing organic matter. Raw sewage can produce extremely high concentrations of hydrogen sulfide. Exposure to even very low concentrations may cause pulmonary complications, and exposure to higher concentrations rapidly cause unconsciousness and death. The rotten egg odor may not seem present at higher concentrations because it causes paralysis of the olfactory nerve, a double-whammy for rescuers and victims alike.

Mechanical hazards are another potential hazard, especially in industrial facilities. In these cases, power machines must be isolated and locked out/tagged out and a guard posted, if necessary, to prevent reactivation. Restrictive entry and egress openings often contribute to the dangers of confined space rescues (fig. 35–65).

Fig. 35–65. Restrictive ingress and egress openings in confined spaces present a large risk to rescuers.

Darkness is a key hazard in confined spaces. Getting lost in a shaft or tunnel without light is obviously something to be avoided. Consequently, three separate and intrinsically safe light sources are carried by each entry team member who enters a confined space. One option is for first-arriving firefighters to establish flood lighting and other high-intensity lighting outside a safe distance away to illuminate the confined space portal.

Engulfment and collapse is yet another potential hazard in confined spaces. Until proven otherwise, all confined space environments should be considered immediately dangerous to life and health (IDLH). As we have seen, the biggest danger is likely to be atmospheric. In every case it should be assumed that IDLH hazards exist throughout the duration of the entry.

In some cases, a dangerous situation might even be created by performing actual rescue work in a confined space. Certain cutting, shoring, and lifting operations carry a level of inherent danger in any environment. The danger is multiplied if these tasks must be performed in a confined space. For example, cutting metal with torches is accompanied by toxic by-product gases that might normally dissipate in open air. If this task is required to free a trapped worker in a confined space, it may lead to a concentration of gases which, combined with other atmospheric hazards, may quickly reach IDLH levels.

OSHA regulations require all employees (including fire and rescue personnel) who are expected to conduct or assist confined-space rescue to be protected from all existing and potential hazards through proper equipment, training, and procedures. Although only certified personnel typically enter confined spaces to attempt rescue, there are several actions that first-arriving firefighters can take before the rescue company or technical rescue team arrives to improve survivability for the victim(s) and rescuers.

En route. Consider special information from the dispatchers, as well as preplans for target hazards like refineries, industrial complexes, and other places prone to confined-space rescues.

The first-arriving firefighters set the stage for a successful operation if they can quickly determine what has happened, the potential number of victims, the probability of victim survival, and potential hazards to rescuers (fig. 35–66). Interview witnesses, the reporting party, and the site supervisor to obtain this information. If work was being conducted in the confined space, request the entry permit that contains information about the space, entrants, and potential hazards. Obtain material safety data sheets (MSDSs) if available. Victim information should include the number of entrants, their location, age, sex, general health, special health conditions, what they were doing in the space, and what protective clothing and equipment was being used.

Consider factors that indicate whether the situation is a potential rescue or a probable body recovery, based on the events that took place, the IDLH nature of the environment, the length of exposure, and other pertinent factors. The incident commanders and rescue company/technical team officers must use a realistic risk-versus-benefit calculation when developing the incident action plan and rescue plan.

Fig. 35–66. First-arriving firefighters must gather as much information as possible from pre-incident surveys and on-site facility representatives.

Now first-responding firefighters can begin accomplishing the following goals that help the rescue company or technical rescue team when they arrive:

- Establish an **exclusion zone** (the danger zone into which no personnel should enter without suitable safety equipment). Typically, the exclusion zone is 50 ft (15 m) around the space opening at a minimum, but it is also based on the configuration of the incident site (fig 35–67).
- Establish an **operational zone** (a 100-ft [30.5-m] perimeter around the exclusion zone), in which primary and backup entry team operations and support operations are conducted (fig. 35–68). Outside the operational zone, establish an equipment pool, logistics, rehab, and entry control. Outside the perimeter of the incident, establish a zone for media, bystanders, and public officials who often gravitate toward extended deep shaft operations. Use fire line tape and other barriers. It may be necessary to request law enforcement to help secure the site and keep bystanders at a safe distance.

The initial efforts of first-arriving firefighters should generally be focused on preventing additional victims, establishing an effective incident command structure, and considering ways for rescuers to safely initiate *indirect* rescue operations without entering the confined space themselves, until arrival of the rescue company or technical rescue team.

Fig. 35–67. An exclusion zone around the opening of a confined space is typically 50 ft (15.2 m), but may be modified based upon the specific situation.

Fig. 35–68. Equipment should be assembled and staged in the operational zone.

Indirect support for the victim may include tasks like lowering harnesses, wristlets, ropes, or even ladders to the victim for assisted self rescue, lowering SCBA to the victim to provide respiratory protection if he or she is conscious, lowering air hoses and fresh air blowers to ventilate the space and provide fresh air ventilation, and other tasks that assist the victim without placing rescuers inside the danger zone (figs. 35–69 and 35–70).

When a hazmat unit or other unit equipped with atmospheric monitoring equipment arrives, initial air sampling/monitoring can begin, conducted by personnel in the appropriate PPE (fig. 35–71).

Initial ventilation can also be conducted, which might make the atmosphere in the confined space more tenable for the victim until he can be rescued (fig. 35–72).

Fig. 35–69. Firefighters may assist victims in self rescue by lowering ladders into a vertical confined space.

Fig. 35–70. Webbing can be lowered through a confined space opening, tied around the victim's hands and used to hoist them to safety.

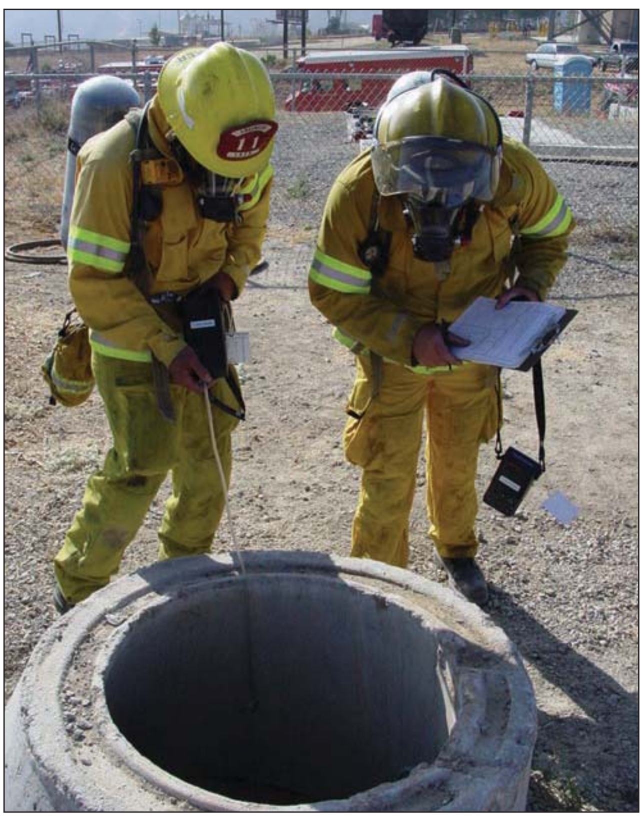


Fig. 35–71. Monitoring of hazardous materials must occur in confined space rescue.

Fig. 35–72. Ventilation of the confined space can help alleviate a hazardous atmosphere and can make the space more tenable for the victim.

If there is machinery involved, or industrial processes that might introduce contaminants into the confined space, or electrical or other utility hazards, first responding firefighters can conduct **lockout/tagout** procedures as follows:

- All electrical, mechanical, or other forms of energy must be shut down and de-energized prior to entry. Post a firefighter to guard against someone turning the switches back on during the operation.
- All valves, switches, gates, or other control devices must be locked out with a keyed padlock and tag that reads, "DO NOT REMOVE. DO NOT TOUCH." Again, post a guard to make sure no one circumvents these safety measures.
- Hydraulic lines and pipelines must be blanked or blinded by disconnecting or using a provided steel plate blank out system. The system should then be bled to assure deactivation.
- The key should stay with the person who places the lock or be given to a responsible person, such as the safety officer, attendant, or incident commander.
- Locate a responsible party who is familiar with the systems to assist with this process and give any necessary technical advice about the facility and equipment.

As soon as a unit with atmospheric monitors arrives, at least a cursory assessment of the atmosphere around the opening can be attempted by personnel who are properly protected (SCBA, etc.) from potential hazardous atmosphere emanating from the confined space.

Entering a confined space with known or suspected IDLH hazards is generally not permissible unless personnel are trained in confined-space entry with appropriate recurrence. This is beyond the scope of the Firefighter I and II.

So, unless your department has a specific training program and policies that allow first-arriving firefighters to make limited confined-space entries, the next steps are to maintain a secure scene, continue ventilating and performing other tasks, maintain a medical group or team ready to treat victims (and any rescuers who get exposed by accident), and await the arrival of the rescue company or technical rescue team. Support them from that point forward.

All firefighters and rescuers operating near the opening to a vertical confined space (such as a shaft) should be properly harnessed and tied off (belayed) to prevent accidentally falling into the hole. Plywood or other decking material should be placed around dirt of soft edges to prevent collapse from point loading and to prevent objects and debris from being knocked into the space (fig. 35–73).

If it's technically a confined space that allows firefighters to operate safely from the outside to extract the victim (e.g., a person trapped in a chimney), firefighters can take actions within the scope of their training to safeguard and stabilize the victim and begin the process of extraction while operating from the outside (figs. 35–74 and 35–75). Even in some of the most basic of these rescues, however, specialized tools and training from the rescue company or technical rescue team may be required.

Fig. 35–73. Plywood or other decking material should be placed around the edges of the entrance.

Industrial and person-in-the-machine rescues.

Industrial rescue includes such a wide range of machinery, processes, and potential entrapment situations that they cannot all be covered here (fig. 35–76). For the purposes of this book we also include farming machines in this category, because the entrapment of people in machines has similarities regardless of whether it occurs in a factory or on a farm. There are some basic guiding principles that allow firefighters to effectively manage industrial entrapments of practically every shade.

Many progressive fire departments have developed **person-in-machine** tool kits on truck companies (and even some engine companies) that include items frequently used to extricate people from machines

Figs. 35–74 and 35–75. Even a person trapped inside a chimney constitutes a confined space rescue and may require specialized equipment.

(fig. 35–77). These kits may include cutting torches, whizzer saws, Dremel tools, small rescue air bags, fiber optic scopes, reciprocating saws, pneumatic rivet removers, assorted hand tools, and other items helpful in freeing people trapped in machinery.

Fig. 35–76. Industrial and machinery rescue involves extricating patients from heavy-duty machinery and processes.

Fig. 35–77. Specialized tools kits may be assembled by departments to assist in extricating victims from known machinery hazards in their response area.

It should be reasonable to assume that your local rescue company or technical rescue team also has such a kit and/or an assortment of other tools that would be helpful in extricating victims from machinery (see Appendix A for a sample equipment inventory for rescue companies), but it's never a bad idea to make contact with them to familiarize yourself with their capabilities, limitations, operational guidelines, and expectations.

Let's consider actions that can be taken by first-arriving firefighters at the scene of industrial entrapment emergencies.

Conduct lockout/tagout procedures as follows:

- All electrical, mechanical, or other forms of energy must be shut down and de-energized prior to committing personnel to situations where machinery might suddenly move or become energized. Post a firefighter to guard against someone energizing machinery, switching the *on* button, or performing other acts that might endanger rescuers and the victim.
- All valves, switches, gates, or other control devices must be locked out with a keyed padlock and tag that indicates, "DO NOT REMOVE" or "DO NOT TOUCH." Again, post a guard to make sure no one circumvents these safety measures.
- Hydraulic lines and pipelines must be *blanked* or *blinded* by disconnecting piping or using a steel plate blank out system (usually provided). The system should then be bled to ensure deactivation.
- The key should stay with the person who places the lock or be given to a responsible person, such as the safety officer, attendant, or incident commander.
- Locate a responsible party familiar with the systems to assist with this process and to give any necessary technical advice about the facility and equipment.

First-arriving firefighters can also expedite the process of rescue by answering the following questions:

- What is the mechanism of entrapment? What was the person doing when trapped? What kind of machinery is it (what drives it, what does it do, how did it *grab* or trap the victim)?
- Has a similar mishap happened before, and how was it resolved?
- Can the mechanism be reversed safely in a way that will cause the least amount of pain, injury, and damage to the victim?
- Can the victim be freed by torching or cutting a chain, cutting a belt or band, disassembling a gear, and so forth (after securing the device from unwanted movement)?
- Can the machinery be carefully disassembled around the victim to free him?
- Can other elements of the machinery be torched, sliced, pried, peeled, moved, lifted, lowered, or otherwise manipulated to free the victim (fig. 35–78)?

Fig. 35–78. A cutting torch can prove to be an effective way to extricate a victim trapped in heavy machinery.

- Is there someone at the site who knows how the machinery works, understands what happened, and might know what can be done to reverse it? If offsite, can this person be contacted and respond to the scene (with Code R escort by law enforcement if necessary)? As another alternative, is there some machinery or process expert available from another source (the manufacturer or another similar facility with the same machines), or even an instruction manual?

- Caution: Is there still **stored energy** in the mechanism (electrical, pneumatic, hydraulic, gravity, water, etc.) that could cause unwanted movement? If so, it's important to find a way to block or stop unwanted movement, such as chocking or wedging; or other alternatives such as securing with rope mechanical advantage systems, winch cables, chains, come-alongs, or heavily weighted devices or objects (fig. 35–79). For chocking and wedging, consider the possible need for materials heavier than normal wood cribbing and wedges, because some machines generate sufficient pressures to crush wood. If the mishap occurred in the middle of a machinery cycle, it may be necessary to prevent unwanted movement *in both directions.*

- What is the viability of the victim? Is the victim already pronounceable as dead on arrival (evisceration of the brain, lungs, or heart; incineration; decapitation; massive crushing; etc.)? Is the victim bleeding out quickly, being suffocated, in need of CPR but in a position that won't allow it, or in some other situation requiring rapid and drastic action? Or is the victim trapped by one part of an appendage causing pain but not an immediately life-threatening situation as long as rescue is reasonably fast?

- Does the victim require immediate pain medication introduced by paramedics or a physician at the scene?

- Are advanced treatments such as surgery required for impending crush syndrome and other medical/trauma problems?

- Are other specialized tools and equipment required for extrication?

- Will vegetable oil, liquid soap, or some other nontoxic agent allow the victim's entrapped part to slip out of the machinery?

- Is field amputation possibly going to be required to free the victim? (If the answer is yes, immediately request the appropriate resources.)

- What are plans B and C if plan A doesn't work? (fig. 35–80).

Most questions can be answered by an experienced rescue firefighter in a matter of moments with the initial size-up, rapid patient assessment, and discussion with bystanders, the on-site supervisor, and of course the victim himself (fig. 35–81).

Fig. 35–79. Stabilizing and securing belts, pulleys, and other moving parts are essential since some machines may have trapped a victim during the middle of a cycle, thus presenting a further hazard as the person is freed.

Fig. 35–80. Firefighters must develop a back-up plan when dealing with complex machinery disentanglement situations.

Fig. 35–81. Conducting a proper scene size-up is always essential to a successful rescue incident.

First-arriving firefighters, however, do well to answer these questions while initiating basic stabilization operations (lockout/tagout, eliminating unwanted movement, dissipating stored energy, determining victim vitals and beginning appropriate medical treatment, requesting additional resources as needed, etc.).

It's also advisable to report conditions to dispatch and the other responding units to paint a picture of the victim's predicament and to dialogue with the on-scene expert and the responding rescue company or technical rescue team (via radio, cell phone, mobile data terminal [MDT], etc.) to determine the best course of action and consider other options.

Other initial efforts can include the following:

1. Establish an equipment pool close to the rescue site (with an equipment pool manager) to expedite the use of equipment and supplies likely to be needed off the responding apparatus.
2. Provide adequate lighting and ventilation.
3. Establish a medical group including immediate transportation to a trauma center or appropriate hospital once the victim is freed.
4. Begin basic efforts to free the person, constantly checking to see if the actions are improving the situation or making it worse and keeping alert for unexpected complications.

If the mechanism cannot be safely reversed without causing more damage or otherwise jeopardizing the victim and rescuers, it's typically necessary to begin disassembling the machinery in a strategic way or cutting it from around the victim. Be sure to employ basic precautions like fire extinguishers or protective hoselines for tactics like torching and cutting, providing spark and fire protection for the trapped victim (including, if necessary, a particulate mask, SCBA, or supplied air breathing apparatus), being careful of the use of oxygen in the presence of petroleum products and sparks.

Since firefighters respond to practically every rescue scenario imaginable, it's not unheard of for firefighters to be called on to enter hospital emergency rooms or surgery suites to attempt removal of items like stainless steel rings, case-hardened manacles, various types of rings, and practically anything else. This may require battery-powered tools or electric tools (instead of gas-powered tools that would obviously contaminate hospital atmospheres) and non-sparking tools that could be a hazard in close proximity to medical oxygen, and so on.

These cases may also require firefighters to scrub up and drape like doctors and nurses when conducting extrication operations in surgical suites, sometimes with victims under anesthesia. These are obviously unusual situations that typically require the rescue company or technical rescue team. But first-arriving firefighters may be the first to size up the situation and begin the process of setting up equipment pools, coordinating with hospital staff, communicating with the responding rescue company or technical rescue team, and so forth.

If the job is as simple as using a standard ring cutter to free a finger, typically the first-responding firefighters can complete that task. More complicated removal might require special tools or blades carried by truck companies, rescue companies, or technical rescue teams.

Elevator rescues. Many urban firefighters are accustomed to managing situations where victims are trapped in elevators, and increasing suburban and even rural areas are seeing multistory buildings outfitted with elevators, so it's no longer just an inner-city issue. The most common scenario is passengers in an elevator that stopped between floors caused by failure of power to the building or the elevator circuits or some sort of mechanical malfunction.

Other elevator emergencies involve repair technicians, building maintenance personnel, or kids engaged in the dangerous game known as **elevator hopping** who have become physically trapped and perhaps badly injured by an elevator.

Still other elevator rescues occur during the middle of larger incidents or disasters like high-rise fires, earthquakes, floods, hurricanes, or terrorist attacks, presenting firefighters with additional complications in already hectic situations. In the 1993 World Trade Center bombing, many elevator mechanics were required to help the FDNY locate and free people trapped in elevators at various elevations. Some mechanics were flown to the roof via helicopter and others were given SCBA that allowed them to operate in the smoky conditions within the building.

When terrorists attacked the World Trade Center on 9/11, dozens of people were trapped in elevators in the north tower (in some cases likely because of door restrictions—described below). In at least one case, firefighters reported they had to chop their way out of an elevator that became stuck between floors.

Even though elevator emergencies often end up being somewhat routine, they can be complicated and dangerous, and it's good for firefighters to be prepared to handle both.

When responding to a report of the most common type of elevator call (an occupied car stuck between floors), the first action is to ensure that dispatchers have requested the response of an elevator service mechanic (if it's known which company services that building). This information is ideally kept in fire department preattack plans for the building, and if that information is accessible to dispatchers, they can make that contact. If the information is unknown ahead of time, firefighters may have to arrive on scene and request the building manager or maintenance authorities to get the appropriate elevator repair company on the way. In any case, firefighters can never go wrong if they request and use the expertise of certified elevator mechanics.

On arrival, determine the general situation, the ETA of an elevator mechanic, and the type of elevator involved. Generally, there are two types of elevators: **traction elevators** (which use an electric motor and cable or "rope" to raise and lower the car) and **hydraulic elevators** (which use a piston under hydraulic pressure to raise and lower the car). Very tall buildings may have multiple sets of elevators staggered within. The control for traction elevators is found in the elevator **equipment room** at the top of the **hoistway** (fig. 35–82). Elevator cars travel within these hoistways (typically shafts), which contain hoistway doors at each floor level. The elevator cars themselves contain their own **car doors**.

Fig. 35–82. Motors for elevators are typically located in a designated elevator machinery room inside the building.

Buildings with up to five floors may have hydraulic elevator systems that rely on hydraulic pistons to lift and lower the cars, which are perched on the pistons. The power unit for hydraulic elevators is typically found at or near the lowest level.

Next, determine if there is any immediate life safety issue. For example, is there any sort of medical emergency among occupants of the elevator car? Is the lighting on with adequate ventilation, heating, or air conditioning? You can best determine that by making contact with the occupants using the elevator phone or intercom. To help determine the exact location of the car, this is a good time to ask what floor the indicator shows or what floor they recall the car passing (up or down) before it malfunctioned.

If there's no intercom or if it's out of service, firefighters can generally contact the occupants with direct voice contact talking through the elevator doors. Often, building maintenance or occupants have determined where the car is before firefighters arrive, having heard people calling for help within. Once contact is established, determine the condition of the occupants, reassure and calm them, and then act according to the urgency of the situation. You can also ask if occupants have cell phones that are getting service, and either call them directly with your cell phone, or have them call another specified phone that will allow you to talk with them.

If there is no contact, it is necessary to determine the car's location. Send firefighters to the **elevator pit** (to look up) or to the elevator equipment room (usually at roof level) to look down and determine the car's position (fig. 35–83). The location can then be confirmed by firefighters sent to the closest floor to visually check the car's position.

Fig. 35–83. Firefighters can determine the location of an elevator through the top or bottom of the elevator shaft.

This is also a good time to lockout/tagout the elevator system to prevent unwanted movement during the ensuing operations. A firefighter (preferably with a building maintenance person) can be assigned to go to the electrical panel (typically in the elevator equipment room) to de-energize the elevator. Just as in industrial rescues, post the lockout/tagout sign and use the kit's locks or assign the firefighter or a police officer, security guard, or a maintenance person to remain at the panel to ensure it's not energized until directed by the incident commander (fig. 35–84).

Fig. 35–84. Securing the electrical service to the elevator can be done by a trained firefighter or by a building maintenance person.

Some elevators can be freed (after ensuring the elevator banks were clear of personnel) by switching off and on the electrical switch to reset the system, allowing normal operation to proceed. Some elevators in certain buildings are known to have repeated problems with the electrical system that can be resolved in this way.

If your communication with the occupants indicates they are fine, the best action is often to await the arrival of the certified elevator repairman, who might be able to resolve the problem in minutes. Maintain contact with the occupants and continue to monitor their condition until the car can be moved to the appropriate landing for removal. You can reassure them by informing them that you can force doors and take other actions necessary to reach them if an emergency develops, but that under the current conditions the best strategy is to let the expert elevator mechanics free the car.

If information indicates there is some sort of medical or other emergency aboard the car that requires faster access, ascertain the ETA of an elevator mechanic, perform the lockout/tagout, and maintain communication with the occupants.

Work to open the hoistway door on the floor closest to the car. Firefighters can attempt opening these doors using hoistway door keys (sometimes stored in the equipment room, sometimes carried on engines, trucks, and rescue or other companies) (fig. 35–85). This takes some practice, and there are courses that firefighters can take to learn the best methods. Another option is to use a **Slim Jim** or another similar opening device to reach and manipulate the mechanism to open the door. If these options aren't available, yet another method is to force the hoistway door using wedges, irons, rabbit tools, hydraulic spreaders, or even small rescue air bags. Naturally, damage to the hoistway door system by forcing the doors should be weighed against the urgency of the situation in the car.

All firefighters operating in or near open elevator shafts must be secured with a rope and harness to protect against falls, including when removing occupants from a car.

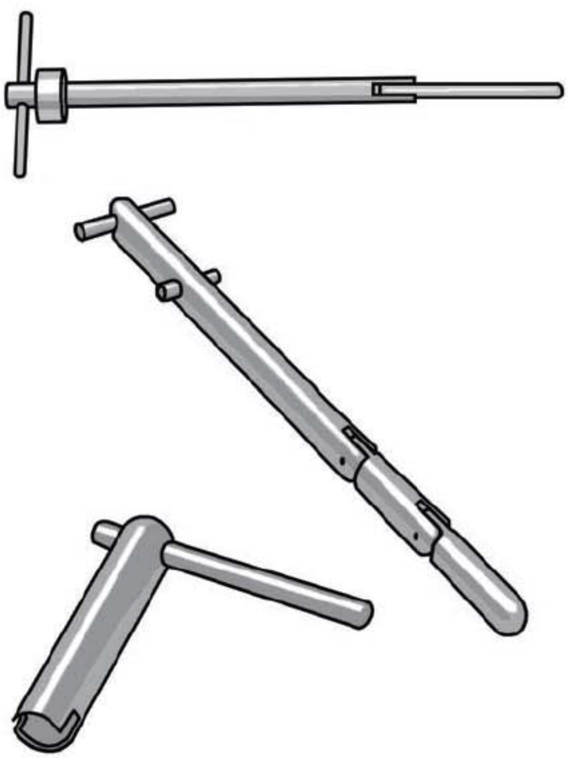


Fig. 35–85. Hoistway keys

Elevator systems are designed so that opening the hoistway doors automatically sets a safety interlock that prevents movement of the car. The switch is operated electrically and is naturally subject to damage or malfunction, and firefighters should not trust it absolutely to prevent movement of the car. Therefore, lockout/tagout is still necessary.

Some elevators use **door restrictors**. Typically these are metal bars that prevent the elevator hoistway door from opening when the car is outside the **landing zone**, 18 in. (45 cm) above or below the floor level of the lobby. Door restrictors are used to prevent people from opening the hoistway door from the inside and accidentally falling down the shaft when they try to exit the car. There are a variety of different types of door restrictors, depending upon the manufacturer of the elevator. Some can be bypassed with tools like a pike pole; others cannot. It is best to preplan the elevators in your response district to determine whether or not they have door restrictors and how you will be able to disable them during a rescue.

With the hoistway door open, block off any large openings (typically when the car is just above the landing, creating a large space near the floor level) by placing ladders or other obstacles across the opening to prevent accidental falls into the hoistway. Now, using appropriate caution to prevent personnel from becoming trapped *if* there is any unexpected movement of the car, and while communicating with the occupants ("stay back away from the doors, we're going to open them," etc.), push the elevator car doors, which should open freely (and also activate the safety interlock to prevent car movement even if the occupants themselves open the elevator car doors).

Alternate access into the elevator car doors can be made through emergency panels in the roof of all elevators, and the sidewalls of multi-elevator hoistways (to allow car-to-car emergency access).

Based on your access to the elevator car, its position in relation to the closest landings, and the condition of occupants, determine the best way to access and remove them. In some cases it might be as simple as a transfer from the car to the landing through the doors if the car is level with the landing. Consider placing a ladder or plank across the gap, and physically assist the occupants across.

If the elevator car is above the landing but reasonably accessible from that floor, block the gap in the hoistway as previously mentioned to prevent accidental falls, and place a ladder from the landing into the car (fig. 35–86). A firefighter can then climb in and determine the best way to move occupants out. Belaying harnessed occupants as they climb down on the ladder is a good method to prevent accidental falls. Occupants who are injured or medically impaired may need to be secured in a rescue litter and transferred down the ladder (using a ladder slide method with belay or another accepted method).

Fig. 35–86. A roof or attic ladder is held across the opening to prevent people from falling down the shaft as they are removed from the elevator car.

If the car is below the landing and enough of it is accessible to allow the movement of occupants, a ladder can be placed from the landing down into the car (fig. 35–87). Have a firefighter climb down into the car to assess the situation and assist occupants up the ladder.

If there is no access to the elevator car because of its position between floors, go to the floor above and open that hoistway door. Now the emergency roof panel should be accessible for a firefighter climbing down a ladder that's been placed from the landing onto the top of the car. The firefighter can lift the panel, assess the situation in the car, and go from there.

If the car is within reach, a ladder can be placed on the floor of the car and occupants can climb (with assistance) directly out to the landing (fig. 35–88). If not, consider using an attic ladder to allow occupants to climb out of the car, where firefighters assist them onto the other ladder to climb to the landing. Another option for multiple-elevator hoistways is to bring another elevator car to the appropriate level and transfer occupants across to that car. Use ladders or planks for a walkway, and consider belaying occupants as necessary.

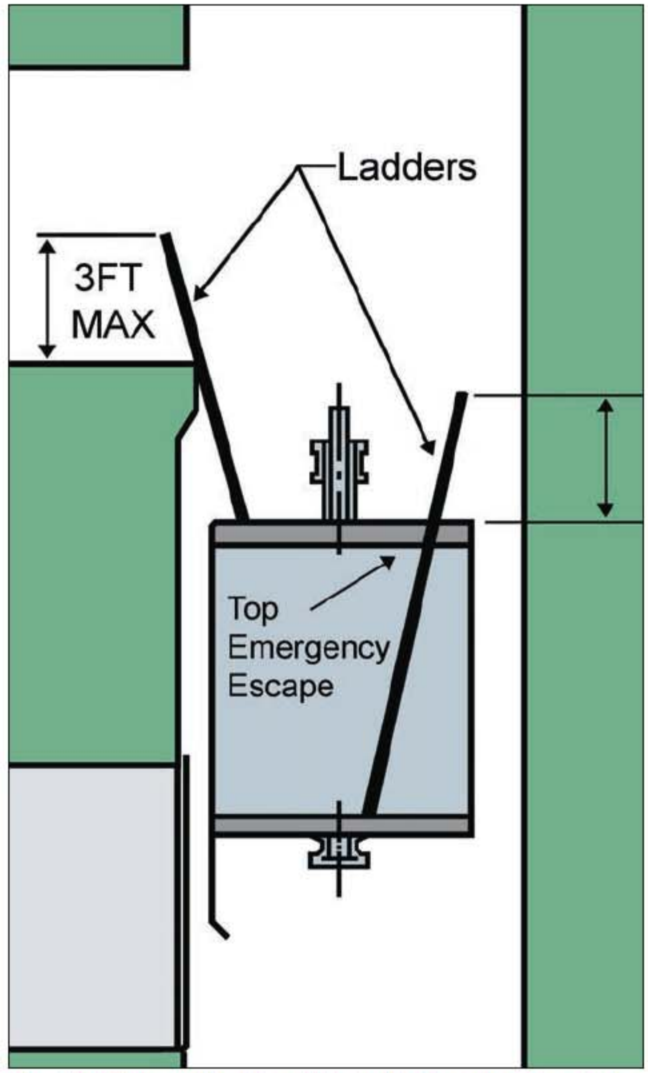


Fig. 35–87. A small ladder (attic ladder) can be placed into the elevator car, allowing victims to climb out to a floor above, if necessary.

Fig. 35–88. Victims using a ladder to evacuate an elevator car should be assisted by firefighters and given direction.

Some "express" elevators that access the upper reaches of a high-rise may travel through **blind shafts**—elevator shafts without hoistway doors since they don't stop on the lower floor. It may be necessary to breach the wall around such a stalled car; be careful when breaching walls as you may encounter electrical wiring and other utilities. Breaching a shaft wall in many cases will be a long, difficult, tedious task, especially in older buildings with a substantial concrete block or poured concrete shaft wall.

If the elevator system is hydraulic, lowering the elevator is a task that should be performed by a certified elevator technician. It is best to shut off the electrical power supply through lockout/tagout and to remove the passengers from the car using techniques described earlier for electric traction elevators (fig. 35–89).

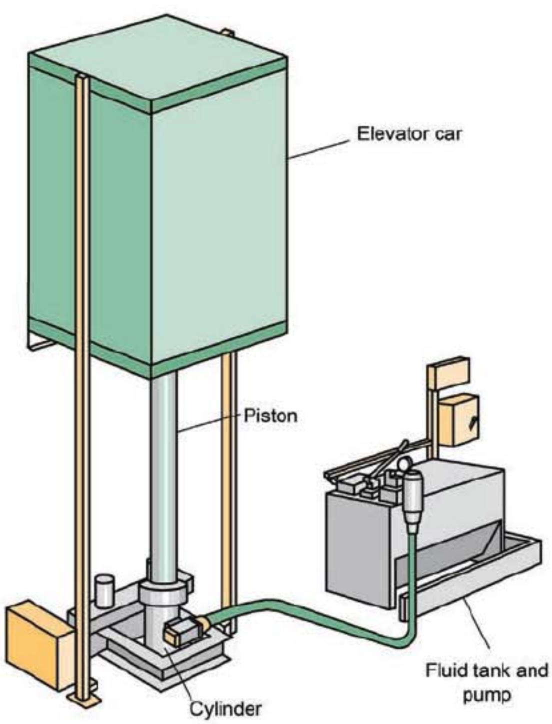


Fig. 35–89. A hydraulic elevator system

If a person is trapped between the car and a landing or bottom, or between cars in multi-elevator systems, lockout/tagout and other precautions must be taken. Then make a game plan for how best to support technical rescue companies/teams to extricate the person. Movement of the elevator is not always the best method of freeing people in these situations, but that also may be required. An elevator mechanic's advice and assistance is critical, and if necessary the mechanic's response can be expedited by a law enforcement escort or even by helicopter transport to the roof. Considerations similar to industrial entrapment are pertinent here, including the use of rescue air bags, cribbing, and possibly even field surgical intervention (amputation). First-arriving firefighters can assist the rescue company or technical rescue team by establishing an equipment pool and performing other stabilization and support tasks.

Escalator rescues. Although less common than elevator emergencies, escalator entrapment presents firefighters with serious hazards and potential complications. The first task is to ensure that the escalator is shut down (using the emergency shut down button or switch). Then ensure that an escalator mechanic has been requested, and provide a law enforcement escort if necessary to expedite his response (fig. 35–90).

Fig. 35–90. Escalator emergencies require the immediate response of a repair technician.

On arrival, assess the predicament and establish lockout/tagout. Typically, escalator electric power is provided through a motor located beneath the upper landing, inside a protective **landing plate**. There should also be an emergency stop switch at the top and bottom of the escalator, or on a nearby wall (which can also come in handy when firefighters must use escalators to access other floors with hoselines, etc.). Start by hitting the emergency stop button if it has not already been used by bystanders, and then disconnect power if feasible by lifting the landing plate (fig. 35–91).

Fig. 35–91. If not already done so by bystanders upon your arrival, the emergency stop switch should be activated.

If fingers are caught where the handrail glides into the underside, it may be possible to use a whizzer saw or reciprocating saw to cut the plate and expose the innards for further evaluation and action. Cutting through the handrail (a continuous belt) may allow you to manipulate it just enough to free the fingers. Reversing the escalator's direction of travel is usually not a good option because of multiple safeties that prevent backward movement in case of power loss. Fingers caught beneath the handrails can usually be freed by cutting the handrail belt or by using tools to access and free the fingers (fig. 35–92 a and b). Feet (or feet still in shoes) caught where the escalator stair dives beneath the landing plate, may be freed by lifting the plate to reveal the gears and motor for further evaluation and action.

As with any industrial entrapment, effective medical care including trauma, crush syndrome treatment, and pain management are critical. Equally critical are provisions for rapid transportation to the appropriate medical facility after the victim is freed.

Medical considerations during rescue operations.

Some major rescues take hours to complete, requiring a mix of ingenuity, good patient care, and patience. An informal rule of thumb when estimating the time it will take to extricate a victim is this: If you think it's going to take 1 hour, plan on it taking 2 hours. In other words, double the time you *think* it might take because often that's what actually happens during rescues, which are often slowed by a wide range of unexpected complications (fig. 35–93).

Figs. 35–92 a & b. Cutting through and manipulating belts, as well as moving stairs and other mechanisms can be done to free the victim.

Fig. 35–93. Rescuers should estimate the amount of time an incident should take by doubling what the time they think it will take.

Because of the potentially long time frames for extrication of trapped victims, firefighters must always keep in mind the potential for victims to suffer the effects of **crush syndrome**, **compartment syndrome**, and other maladies related to long-term crushing trauma (effects of which sometimes kill victims long after they are rescued). Another consideration is reducing pain of victims who are severely trapped, when medically feasible.

In addition to basic life support provided by first-arriving firefighters, it's important to allow paramedics to establish advanced life-support treatment when possible so that the victim does not suffer excessive pain or permanent (even deadly) complications that might otherwise be prevented (fig. 35–94). This requires good judgment and cooperation between the first-arriving firefighters, the incident commander, and EMS personnel.

Fig. 35–94. Although it may be difficult, firefighters and technical rescuers should allow advanced life support providers to have access to the patient when possible.

Rapid transportation to a trauma center should be strongly considered, including measures like having life-flight EMS helicopters dispatched to stand by for immediate transport once the victim is freed (fig. 35–95). This is especially true in remote areas like the mountains, where ground transportation is lengthy to begin with.

The time saved by aerial transportation to a trauma center sometimes literally means the difference between life and death for the victim. It certainly may have an effect on the victim's long-term recovery and whether or not the victim suffers permanent disability.

An uncomfortable but important consideration in industrial entrapment is the topic of **surgical field amputation**. Physical entrapment of one or more limbs sometimes compels firefighters to consider the possible need to request a physician and medical team to respond to the scene to be ready to perform field amputation in the following cases:

- *If* the victim may not survive a long-term extrication because of uncontrollable internal or external bleeding, uncontrollable airway, or other uncontrollable medical issue
- *If* successful extrication may be impossible within the survivable limits of the victim's condition

Fig. 35–95. Utilizing helicopters for medical transportation is a good decision for long-duration rescue incidents.

In many regions there are preestablished protocols for requesting field surgical support when industrial entrapment or other difficult rescues present firefighters with conditions indicating a field amputation may be necessary. Protocols include potential helicopter transportation of the field surgical team and the victim to save time.

The key for first-arriving firefighters is to recognize situations that might require these extreme measures, and rapidly initiate the system that gets field surgical teams on the scene. In places without any sort of preestablished plan for this, it's even more important for the incident commander to get this ball rolling as soon as conditions indicate it may be needed.

Rescues in caves and tunnels. NFPA 1001 states that, in addition to other rescue situations, the Firefighter II should be prepared to help rescue companies and technical rescue teams safely manage rescues in caves and tunnels. When it happens, rescues in caves and tunnels are among the most hazardous situations that firefighters ever encounter (fig. 35–96).

Fig. 35–96. Cave and tunnel rescues are rare, but they present a serious risk to rescuers.

Many ingredients for disastrous situations can be found in mines, tunnels, caves, and other underground structures, including remote or restricted access to entrances and portals; tight spaces with minimal natural ventilation; potential for wall and ceiling collapse (possibly secondary collapse following a primary collapse that trapped victims); long horizontal or vertical travel distances to fresh air and the safety of the outdoors; the potential for sudden and massive flooding; the presence of atmospheric hazards like CO, hydrogen sulfide, methane, oxygen deficiency, and harmful dusts; potential for disease-causing organisms; complete darkness in the absence of artificial lighting; and the possibility of fires or explosions, which may create a fiery oven channeling heat and smoke, killing victims and rescuers where they stand.

In short, everything is more difficult underground: ventilation, lighting, communications, logistics, firefighting, physical disentanglement, movement of equipment and personnel, command and control, dewatering, atmospheric monitoring, and dive operations when necessary. Everything is made more complicated when it's happening in a hole in the earth (fig. 35–97).

The fire service has seen its share of underground rescues and disasters in recent times, including mining accidents that killed dozens of workers at a time (approximately 45 miners still die annually in the United States, and the toll is far higher in countries like China); automobile drivers roasted alive when fireballs erupted during collisions involving gasoline tankers in highway tunnels; the 1971 Sylmar (Los Angeles) tunnel explosion that killed 17 construction workers drilling through methane-laden soils and working with muck pocketed in the middle of a mountain near Los Angeles's San Gabriel Fault; a number of subway crashes that required firefighters to spend many hours cutting apart subway cars to extricate trapped passengers; several cavers trapped below the earth; and many other examples.

Mine rescue teams, required for operations in commercial mining mishaps, are mandated to adhere to strict standards, including federal standards of Mine Safety and Health Administration (MSHA) for mine rescue teams (Code of Federal Regulations, title 30, part 49), and in some cases even stricter state standards.

There also are strict rules for workers and for rescue operations in tunneling operations for subways, rail tunnels, automobile tunnels, and water tunnels. The ironic thing about tunneling operations is that once the tunnel is completed and transitions from the *construction phase* to the *revenue phase*, the tunnel rescue rules change or don't seem to apply at all. A fire department or rescue agency responding to an emergency or disaster in an active tunneling operation during the construction phase must meet much stricter requirements than when responding to the very same tunnel after it's completed and is in the revenue phase.

Fig. 9–97. Cave rescues complicate ventilation, atmospheric monitoring, and logistics.

And in some cases there don't seem to be any rules at all. One example is abandoned mines and tunnels, which fall into a great big gray area with seemingly no formal regulation except common sense and adapting the rules of other disciplines like confined-space, high-angle, and tunnel rescue. Abandoned mines and tunnels are a particular problem because they are no longer maintained, they are often poorly marked (or not marked at all), and there is no reliable database that shows all their locations.

Thousands of abandoned mines can be found in the mountains and deserts across the United States (fig. 35–98). New Mexico alone has approximately 20,000 abandoned mines that the state has classified as dangerous because the openings present an attractive hazard to children and adults keen on exploring their depths. Utah also has approximately 20,000 mines, and it's common for snowmobile riders to plunge into the vertical shafts hidden by snow cover. California's inventory of abandoned and working mines easily exceeds 40,000. Every year about half a dozen explorers die in abandoned California mines. Dozens more are injured while climbing and crawling through them. And then there are the other mining states like Pennsylvania, West Virginia, and others.

Fig. 35–98. Abandoned and unmarked mines can attract children and adults, thus presenting a serious risk to responders.

Firefighters should understand that federal and state mine safety regulations were written for working commercial mining operations (fig. 35–99). Active mining, where there is ongoing penetration of the earth, has distinct inherent dangers that must constantly be monitored and dealt with. When disasters occur in working mines, there is the potential for large-scale life loss. Not surprisingly, regulations for mine rescue teams are basically intended to provide for rescue of miners lost or trapped in active commercial mines, including a requirement that team members have at least one year of working mine experience.

Fig. 35–99. Federal standards exist for commercial mine operations and their rescue teams.

So federally certified mine rescue teams are typically made up of miners employed in active commercial mining operations, who are required to have certain equipment, be trained in the use of certain equipment and techniques, and come together when a mining accident occurs to attempt the rescue of their own colleagues or miners who are lost or trapped in accidents in other commercial mining operations. They are required to be familiar with commercial mining equipment, methods, structures, and other information that would typically be known by people who work in the commercial mining environment every day.

This is important because active mines and tunneling operations have specific dangers such as deep vertical shafts, the use of heavy machinery, conveyer belts, explosives storage, the potential for collapse or sudden flooding, the potential for hitting methane pockets, and a long list of others potential hazards. Among other tools, mine rescue teams use devices (e.g., closed circuit SCBA for long-distance entry, long-term helmet lighting, etc.) and the so-called self rescuers (oxygen-generating device) that may be unfamiliar to the typical firefighter or rescuer.

As of this writing, MSHA is undertaking a review of existing policy, equipment, training, and capabilities for mine rescue as well as soliciting comments and recommendations. It is intended to improve the survivability of commercial miners when accidents happen in active commercial mines, as well as improving the speed, safety, and effectiveness of mine rescue operations.

Beyond working mines, what about underground situations is not covered specifically by federal and state mine safety regulations? Today, municipal fire and rescue departments across the United States are responsible for first-due (life-saving) response to fires, explosions, terrorist attacks, collapses, flooding, derailments, and other mishaps deep in the ground, sometimes hundreds of yards (or even several miles, in some cases) from portals (fig. 35–100). They can also be in subways, train tunnels, pedestrian tunnels, water tunnels, vehicular traffic tunnels, and other subsurface structures. This includes during the tunneling process, when an even wider range of mishaps can occur.

Fig. 35–100. Access and the construction of underground tunnels (including those under construction) should be inspected and surveyed by firefighters and rescue teams.

Municipal fire departments and other first responders are responsible for planning and executing life-saving operations in these below-grade structures using whatever equipment, training, and protocols are available, under conditions where far more lives may be at stake than in any commercial mining operation in the world. They are responsible for being prepared to assess conditions, establish incident command, make long-distance entry to fight fire, conduct searches, extract trapped victims, stabilize collapse zones, be aware of potential for secondary events (including, in the case of terrorist attacks, secondary explosive and delivery devices), mitigate hazmat releases, and remove victims to the safety of the surface.

But the existing rules for operations beneath the ground exist in a gray area. Firefighters and other first responders know that they will be the first response to trouble in these places, and they are usually the first and last line of defense for victims who might be trapped, lost, or in need of physical rescue from these places.

The potential for disastrous fires, collapses, explosions, flooding, derailments, and other mishaps has always been known by the first responders. And the potential is even more pronounced in the aftermath of the London subway terrorist bombings, the attacks on Spain's railway systems, the Tokyo subway sarin gas attacks, and the threat of future terrorist attacks on mass transit systems. First-arriving firefighters will be compelled to make risk-versus-gain decisions under life-and-death conditions that are not covered by the federal and state rules (fig. 35–101).

Fig. 35–101. Rescuers must make careful decisions when below-grade rescues are complicated with criminal intentions.

If there's any doubt about the special demands of these operations, try carrying a victim from a train wreck in a tunnel in zero-visibility conditions, with heat and smoke from uncontrolled fire, in a potentially explosive atmosphere, wearing full PPE and SCBA. How long do you think your 30-minute SCBA bottle will last? What about a 45- or 60-minute SCBA bottle? Which units in your area carry closed circuit SCBA, and how long will it take for them to arrive? Factor all this in, and it becomes evident that fire and rescue agencies with tunnels in their jurisdictions have special hazards that require special plans, training, and capabilities (fig. 35–102). Those issues exceed that scope of this text, but it's good food for thought for firefighters who may be called on to assist rescue companies and technical rescue teams when these emergencies occur.

Fig. 35–102. Tunnel and cave rescue operations require significant planning and resources and should not be attempted without training and preparation.

ELECTRICAL EMERGENCIES

So, let's review some basic concepts that will allow firefighters to operate safely at the scene of emergencies where electrical hazards are likely to be present. The first priority is situational awareness: being heads-up about the potential dangers of any emergency scene. Everyone, from the tailboard firefighter to the incident commander (IC), should be scanning the area for possible hazards that can hurt responders and the public. Structure fires, wildland fires, and automobile collisions are notorious for knocking down power lines or even the power poles themselves (fig. 35–103). All electrical lines and conductors should be considered energized until determined "cold." And even then, they should be avoided because power lines often become re-energized as the electrical grid often attempts (automatically) to reroute the power if there is a break in the system. Even guy-wires can become energized under some conditions (auto collisions that damage poles, expose energized wiring, and contact the guy-wires, etc).

Fig. 35–103. Downed power lines

When approaching the scene of a fire or possible electrical emergency, the engineer or driver must be "heads up" to potential electrical hazards. Responding units should not travel beneath or position apparatus below wires that are compromised and/or damaged or suspected to be. Consider positioning apparatus at least one span (the distance between two poles) from any damaged wire or pole, and think about the effects of a large fire on the wires and poles. If possible, avoid parking in or near puddles of water that may become energized if wires fall during the incident. All firefighters should carefully examine the immediate area before stepping off the rig to ensure it has not stopped atop a downed wire. Avoid stepping in puddles of water that may become energized.

Fire trucks and other apparatus provide protection from electrical currents, but they may become energized by live wires if they contact wires (or an object that is in contact with a live wire).

Remember, any metal part of an aerial ladder that touches high-voltage lines energizes the entire apparatus. Don't give the enemy easy access. Don't make your body the "ground" for an electrical contact. If it becomes evident that there is possible contact between the apparatus and an electrical source, stay on the rig (this is also the advice we give to the public in vehicles contacting wires and other electrical sources).

If it becomes necessary to get off the apparatus, do not step off. The way to exit is to carefully jump off as far away as possible, landing with both feet together and without losing your balance. Do not touch the ground with your hand, and don't fall backward or forward. Once on the ground, shuffle your feet as you walk away from the apparatus to maintain contact with the ground and prevent arcing.

Another way firefighters are sometimes injured or killed is when aerial ladders or baskets/snorkels touch or get too close to live wires. The operator should know his apparatus behavior intimately, and should allow for ladder swaying, rocking, and sagging when operating near power lines and cables, and should also take these factors into consideration when positioning apparatus and ladders. Operating, erecting, or handling of tools, machinery equipment, or apparatus over energized high voltage lines is generally prohibited. For wires and components of 600 volts or more, aerial ladders are required to maintain a minimum clearance of 10 ft (3 m).

Alternate methods than aerials for reaching upper stories and roofs must be considered rather than raising aerial ladders near high-voltage lines. Such methods, in addition to wooden ground ladders may call for using fire escapes, interior staircases, or adjacent roofs of buildings. In extreme cases, helicopters may be considered.

The use of ground ladders near electrical overhead wires must be done safely. Even if constructed of wood, ground ladders are still conductive due to metal parts and dirt and debris that may coat the ladder. Care must be taken when moving, raising, and lowering any ladders.

One of the first things your eyes should be drawn to as you approach these scenes is the telltale sign of power lines drooping over fences, dangling across streets and sidewalks, or the free ends of severed wires hanging around the scene. Right there you have a possible electrical emergency, and the IC should be made aware of the situation and should be requesting the jurisdictional power company to respond to the scene.

Windstorms, hurricanes, earthquakes, floods, landslides, and mudflows also cause power lines to go down, often over a large geographical area. Another colleague of the author was electrocuted after the 1987 Whittier earthquake when he stepped into the yard of a home near which a power line had fallen.

Whenever entering areas affected by these events, it should be assumed that power lines are down and other electrical hazards are present, often hidden from sight by debris. This is one reason that nighttime operations are considered high-risk during these types of emergencies or disasters. In some cases where most victims have been accounted for and the risk-versus-gain equation is such that the greatest life loss potential is to rescuers tromping around the scene at night and possibly encountering downed power lines, search operations may be suspended during hours of darkness.

Other electrical hazards are encountered at fires in homes, businesses, refineries, infrastructure, and other locations. They range from internal electrical hazards, such as wiring in walls to external hazards such as drip loops. In some cases, the likely electrical hazard locations are pretty clear (triplex drip loops between homes and power poles, underground electrical vaults, etc.). In other cases, they can be a surprise. How can you determine if electricity is present in any of these situations? In many cases, firefighters follow the practice of eliminating the source: they flip the switches at electrical panels, or carefully cut the drip loops (using proper PPE), or have the local utility company shut down power and confirm it.

Another option is to utilize "hot sticks" and voltage meters that detect the presence of electrical currents and signal you with an audible warning. They are carried on some rescue companies, truck companies, engines, and by some individual firefighters who find them useful. Not only can these devices detect electricity in bare wiring or being transmitted to objects like fences, they can also detect electricity being carried by wiring within walls (something to consider when breaching walls).

In life-threatening situations such as victims in contact with energized wires, victims trapped on high-voltage electrical towers, on billboards, in trees, in electrical vaults, and other places where victims might have been electrocuted and require physical extraction, or "jumpers" on or around electrical facilities, the IC should ensure the fastest response of a power company field team and a supervisor to assist and provide technical expertise. The request should be made for an "immediate/expedite" response, with a Code R (Code 3) escort by law enforcement as necessary to ensure timely response.

Part of the strategy should always include establishing a rapid intervention crew, and ensure that an ambulance and an advanced life support (ALS) unit are in place.

Firefighters attempting to control electrical hazards should wear full turnouts at minimum, to protect against the possibility of electrical arcing, flash fires, and explosions. This includes donning firefighting hood and gloves. Lineman's gloves (properly inspected and maintained) should be used where available (many departments now assign them to units that carry other electrical control tools). Full turnout clothing is not electrical protective clothing, and firefighters must be aware of the limitations. The composite material of SCBA bottles and the metal insoles of turnout boots can conduct electricity. Turnout coats and pants have metal clasps and buttons that are conductive.

One of the most common electricity-related situations you're likely to face is the task of de-energizing a building during an emergency. Consider the two most common methods. The first is to open the main switch or breaker switches at the electrical main panel. This is a practical method for de-energizing a building and reducing the hazard to the firefighter as well as the potential damage to the occupancy. However, responders should be aware of the inherent dangers of discontinuing the current in a high voltage application. Inspect the panel for signs of damage from fire or water. Avoid standing in water, and stand to the side of the electrical panel. Do not reach across your body to disconnect switches. Turn away from the panel when disconnecting switches to protect your upper extremities, and use your SCBA mask or shield to protect your face.

Never de-energize a building by pulling the electrical meter. This can cause arcing and possible explosion.

When turning off breakers, mark or remember any tripped breakers. Turn the main switch off first. If this does not turn the power off, shut off the individual breakers one at a time. If the panel cannot be accessed, contact the local power company.

The second common method is to cut drip loops using an approved mechanical axe and insulated electrical (lineman's) gloves. This method must be confined to low-voltage wires only. In an emergency when there is a need to de-energize a high-voltage line, the local electrical utility company should be requested to respond to the incident. Only qualified electrical workers should handle high-voltage lines. Firefighters should not for any reason attempt to cut high-voltage lines.

Many low-voltage service drops are found in the form of triplex cables. A triplex is three wires wound around each other. Triplexes should not be cut as a whole, because they will cause a short circuit that will damage or destroy the blades of the mechanical axe and may injure the firefighter. They must be cut one at a time. Use the approved mechanical axe and insulated rubber gauntlet gloves. Stand on a dry object. Lock in when working on a ladder.

Do not reach over wires. Cut the closest conductor first. Do not touch another conductor or ground. After cutters are in place, turn your head to protect your eyes from flash and sparks, and make sure all insulated wires leading to service head are cut. When possible, the loops should be cut at the service head. If it's necessary to cut the loop at the pole, cut one wire at a time before it goes into the triplex.

If there are downed wires, visually inspect all other wires in the immediate area and adjacent to downed wires to determine the extent of involvement and possible flow of electricity to the ground. Identify all wires and their termination points. Visually follow all wires to determine if they are contacting fences, structures, trees, brush, etc., or if they are obscured from view. Remember, wires may be contacting metal fences or other conductors, causing them to become energized, creating a very hazardous condition for fire personnel and the public.

Establish a safety perimeter at least 30 ft (9 m) in all directions from the downed wires or objects in contact with them, and deny entry to the scene and control vehicle and pedestrian traffic. Use fireline tape or traffic barriers or assigned law enforcement to limit access, and request the local electrical utility company to respond. All power poles and towers and associated power lines, guy-wires, and/or communication wires should be considered energized until proven otherwise. Electrical utility employees determine whether electrical distribution lines and equipment are de-energized and the scene safe to operate.

Generally speaking, firefighters should avoid moving or cutting high-voltage lines that have not been de-energized. It's safer to allow the professional linemen to conduct these operations. Usually, communication wires located on the same pole as electrical distribution lines can be moved or cut by qualified firefighters with the proper PPE after a thorough inspection of all lines.

In electrical rescues or other circumstances where lives may be endangered but where there initially is no other way to terminate power to low-voltage wires, the local electrical company should be requested and provided with a Code R escort by law enforcement as necessary to ensure timely response for life-threatening electrical emergencies. Here is where the risk-versus-gain decision will apply: to save a life, a qualified and properly equipped firefighter might be assigned to attempt separating the downed wire from the victim, with a rapid intervention crew with ambulance and ALS positioned.

One method is to move the wire away from the victim using a "hot stick" made for that purpose while wearing the proper gloves and other PPE.

If fire is at the base of an electrical pole and it's been determined that the fire was not caused by underground electrical sources or wires down, the pole fire may be considered a Class A and extinguished with water. If fire is near a pole top and/or involves electrical wires and/or equipment, fire should be considered Class C. Do not use water or foam to extinguish. Contact the local electrical utility company to advise them of the situation. Protect exposures, and establish a safety perimeter around poles and wires a distance of 1½ times the height of the pole.

If the situation is a vehicle that has crashed into an electrical pole, the IC should notify the local electrical utility company and law enforcement. If downed wires are contacting vehicle and victims are still inside, there is a decision point: if the person is conscious and no life hazard is present, instruct victim to stay inside vehicle. Provide instructions to the person from a safe distance away (30 ft) using a public address system. Direct your dispatch center to request an "immediate/expedite" response of the local electrical company, with a Code R (Code 3) escort by law enforcement as necessary to ensure timely response. Ensure a rapid intervention crew (with a squad and ambulance) is in place when conducting operations in any immediately dangerous to life and health (IDLH) conditions during electrical emergencies. Have hoselines in place in case a fire breaks out (in which case the priorities may change). Wait for the local power company representative to arrive to de-energize wires and other equipment before making victim contact.

If a fire breaks out and cannot be contained, or the area is flooding, or some other life safety hazard is present (for example, there is interior fire or other immediate life hazard), and the victim is conscious and ambulatory and able to follow your instructions, direct the victim to open the vehicle door, stand on the rocker panel (doorway) of the vehicle and jump to the ground with both feet together at once. Instruct the victim not to touch the ground with hands after jumping (they must remain balanced). Demonstrate the action to the person to make it absolutely clear before allowing them to proceed. This is especially important with children. Once out of the vehicle, victim(s) should be instructed to shuffle (not walk or run) away from the hazard area to a safe zone at least 30 ft from the vehicle and/or downed wire.

If the victim is unconscious but no life hazard is present, wait for the local power company representative to arrive to de-energize wires and other equipment before making victim contact.

If a life safety hazard is present and the victim(s) appear unconscious, the IC must weigh the risk versus gain, considering all the hazards present to firefighters before ordering a rescue attempt. The IC should consider alternative means, such as a deck gun, to knock down fire using a deluge of water, or use another vehicle to push the involved vehicle to attempt to separate it from the power line, or other means.

Generally, one should not attempt to extinguish a vehicle fire with water or foam if wires are in contact or near the vehicle. Consider the fire Class C. Wait for the local power company to de-energize the wires before extinguishing the fire with water. Protect exposures and isolate and deny entry within 30 ft of the affected area.

If, after evaluating the risk-versus-gain equation, the IC determines that cutting the downed wires is prudent to save a life, only qualified personnel should attempt this procedure. Wear full PPEs, including protective goggles or SCBA facepiece. Use an approved mechanical axe and insulated rubber gauntlet gloves. Shuffle step (do not walk) to the best position to more closely assess the hazards and potential for successfully moving or cutting the downed wire. The qualified firefighter, after consulting with the IC and/or the on-scene safety officer, will determine if the best course of action will be to move or cut the downed wire. If the decision is made to cut the wire, stand on a dry object and follow the procedures outlined above.

Fires in electrical vaults, manholes, and pad-mounted equipment are an unusual but potent hazard. In 2008 a Los Angeles City firefighter was killed after several manhole explosions and fire caused the fire department to cut into a utility box. Unfortunately there apparently was an explosive atmosphere in the box, and it ignited/exploded when a circular saw was used to cut into it.

If the incident involves a potential rescue from a vault or manhole, ensure that a confined-space rescue response has been dispatched. Upon arrival, a priority is to determine whether there may have been personnel working in the space who are not yet accounted for.

LESSON FROM THE FIREGROUND

What is more dangerous than an enemy you can't see, can't hear, can't smell, can't taste, and can't feel until it's too late? What if that enemy can move at nearly the speed of light? What if that enemy had the ability to burn your insides, including your muscles, tendons, nerves, bones, brain, and all layers of your skin in an instant? What if that enemy had the ability to blow off the ends of your limbs and kill anyone who touched you while trying to rescue you? How would you protect yourself against such an enemy?

In the past two decades, more than 25 American firefighters have been killed in the line of duty from electrocution. Hundreds of firefighters have suffered electrical injury, and many of those have been career-ending events. When I came on the job in 1980, one of the best mentors was a training captain who had for many years been assigned full-time to light duty. He was a wealth of knowledge, a true firefighter's firefighter.

Wondering why the captain spent all his time in training, this author remembers being stunned to find out that he had barely survived an electrocution that killed another firefighter. They had arrived on the scene of what appeared to be a "typical" traffic collision, with one car having plowed into a fence. Unknown to the firefighters, a power line had been knocked loose and was draped over the chain-link fence beyond their initial vantage point.

When the captain went to help a victim still trapped in the car, he in essence became "the ground" between the now-electrified fence and the earth. Not only did he suffer severe electrical burns to his internal organs and extremities, but he was made nearly deaf and would forevermore rely on a hearing aid to communicate normally.

The enemy was unseen, unheard, and unfelt until it was too late. That's how it goes with electrical mishaps. Another colleague firefighter was once killed by contact with piping that became electrified at a construction site. The list of firefighters killed or injured by electricity is far too long.

Make no attempt to extinguish fires involving underground or pad-mounted electrical equipment. This equipment should be considered Class C until de-energized by the local power company. Never put water or foam into a vault until it is de-energized. Use only nonconducting extinguishers (CO_2, BC, or ABC-type) and only when requested to do so by the local power company representative.

Upon arrival at a manhole fire, care must be taken on apparatus placement. No emergency vehicle should stop over or within close proximity to manholes because they may fill the holes with carbon monoxide. Control traffic, set up a safety perimeter, and keep vehicles and pedestrians away from the area. Manhole covers often weigh 300 lb and have been blown 75 ft vertically into the air and a lateral distance of 125 ft.

If smoke or flames are showing from a manhole cover, do not attempt to remove the cover. A flammable atmosphere may be present which may be toxic or explosive.

Do not enter a vault or manhole until a power company representative confirms that it is safe to enter. Any entry made to rescue a downed worker or victim should be considered a confined-space rescue emergency, and a confined-space rescue response should be requested with confined-space rescue protocols and a rapid intervention crew (with an ambulance and ALS unit) in place.

Fires in electrical substations are high-risk operations, and unless there is an immediate threat to life, it's best to hold back, go slow and deliberately, and don't get tunnel vision on the fire and smoke. Your enemy here is the unseen electrical forces that are present all around. Generally speaking, it's best not to enter electrical substations without approval from the local power utility company, which should be able to guide you about next actions.

Do not fight electrical substation fires from outside the gates.

Protect exposures and isolate and deny entry until a local power company representative arrives. Follow the power company representative's instructions when entering and driving inside a substation. If victims are injured, missing, or trapped within the facility, the IC should determine whether personnel with full PPE including SCBA have a reasonable chance of completing a rescue. The risk-versus-gain decision must also take into account the potential for a successful rapid intervention operation if a mishap occurs. Ensure that a rapid intervention crew (with ambulance and ALS unit) is being assigned if a rescue is attempted.

Fires in electrical substations should be considered Class C until de-energized. Do not attempt to extinguish with water or foam. If fire involves transformers, fire shall be considered Class B once the equipment is de-energized.

Transformers and capacitors contain oil coolants that have a tendency to explode when subjected to intense fire. Older capacitors may contain a liquid substance called polychlorinated biphenyls (PCBs), which is toxic, non-biodegradable, and environmentally hazardous. All capacitors owned by SCE have been converted to mineral oil; however, this assurance cannot be made for those owned by other power companies. If a capacitor has ruptured for any reason, the liquid should be considered a hazardous material until determined otherwise by the local power company representative or a health hazmat officer.

Many wildfires affect electrical power poles and towers, and they can present a significant hazard to firefighters. Maintain a safe distance from electrical power lines, poles, and towers equal to 1½ times their height when involved in wildland firefighting activities. If fire has ignited the base(s) of electrical power pole(s), fire may be considered Class A and should be extinguished with water to prevent the pole from collapsing and causing wires to drop. Extinguish smoldering pole fires (below electrical wires only) to prevent power line failure or dropped lines. Consider all downed or compromised wires and associated poles, towers, and other equipment to be energized.

Fires on electrical poles at or near the level of electrical wires shall be considered Class C. Do not attempt to extinguish using water or foam. Isolate and deny entry until a local power company representative arrives to de-energize lines. Do not use areas below wires as safe zones, escape routes, ICP locations, or for any other use. Avoid ordering aerial water or retardant drops directly over electrical power lines, which can cause arcing, shorting, down-strikes, and explosions. Wires create a hazard for aircraft because they are hard to spot in even normal conditions. Be aware that heavy smoke conditions can cause electrical down-strikes below transmission and distribution power lines.

Another electrical hazard is found where potential jumpers or victims of industrial mishaps are found trapped or stranded on high-voltage towers. This can also include victims trapped in trees with electrical lines, and other high-angle electrical emergencies. The IC should ensure the most appropriate response is dispatched, and then double check that the correct units are coming. Furthermore, he should ensure that the local electrical company has been requested on an expedite/ immediate response, with a Code R escort from law enforcement.

If the situation is a jumper with electrical hazards, ensure that a rescue fall bag and a crisis negotiation team are also dispatched. The responding rescuers can work with these units to coordinate high-angle and negotiation operations.

If the emergency is some sort of entrapment on a power tower, billboard, or other above-ground electrical hazard, consider rescue fall bags and coordinate with the rescue company and other units to establish a rescue plan once the electrical lines have been de-energized, or until it's determined that a rescue can proceed before all the electrical lines are de-energized. Ensure a rapid intervention crew (with ambulance and ALS) is being/has been assigned if a rescue is attempted.

NOTES

1. Atwood, Rich, Tod Mitcham, Wayne Ibers. *County of Los Angeles Fire Department Confined Space Rescue Technician Training Manual*, 1996.

QUESTIONS

1. Water rescuers benefit from understanding laminar flow and helical flow. Explain both terms.
2. Name five water hazards.
3. Name five good devices for water rescue equipment.
4. A submerged vehicle leaves clues to its location. Name at least three.
5. ____________________ are a particularly important trigger for mud and debris slides in some regions.
6. Name the five stages of collapse operations.
7. There is a ___________% chance of secondary trench excavation collapse following the original collapse.
8. You've arrived at a trench collapse before the rescue crew. List five tasks you and your crew could perform outside the unshored collapse zone while waiting for the rescue crew to arrive.
9. List three forms of indirect support for a victim that the first-arriving firefighter can provide while waiting for a rescue company to arrive.
10. At an escalator rescue, what should be the first task?