

ESSENTIALS

OF FIRE FIGHTING





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Key Terms

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NFPA® Job Performance Requirements

This chapter provides information that addresses the following job performance requirements of NFPA® 1001, *Standard for Fire Fighter Professional Qualifications* (2013).

Firefighter I	Firefighter II
5.3.17	6.4.1
	6.4.2
	6.5.4

Firefighter I Chapter Objectives

1. Identify types of emergency scene lighting equipment. (5.3.17)

Firefighter II Chapter Objectives

1. Explain considerations for maintenance of electric generators and lighting equipment. (6.4.2, 6.5.4)
2. Describe the types of rescue tools and equipment. (6.4.2, 6.5.4)
3. Explain the uses and limitations of each type of rescue tool. (6.4.1, 6.4.2, 6.5.4)
4. Identify the role of a fire department during vehicle extrication. (6.4.1)
5. Describe safety considerations that must be identified and mitigated during vehicle extrication. (6.4.1)
6. Explain the use of cribbing material during vehicle extrication. (6.4.1)
7. Describe the methods used for gaining access to victims during vehicle extrication. (6.4.1)
8. Explain the role a Firefighter II will play in technical rescue operations. (6.4.2)
9. Describe the various types of technical rescue operations. (6.4.2)
10. Explain the unique hazards associated with each type of technical rescue operation. (6.4.2)
11. Demonstrate the steps for inspecting, servicing, and maintaining a portable generator and lighting equipment. (Skill Sheet 10-II-1, 6.5.4)
12. Prevent horizontal movement of a vehicle using wheel chocks. (Skill Sheet 10-II-2, 6.4.1)
13. Stabilize a vehicle using cribbing. (Skill Sheet 10-II-3, 6.4.1)
14. Stabilize a vehicle using lifting jacks. (Skill Sheet 10-II-4, 6.4.1)
15. Stabilize a vehicle using a system of ropes and webbing. (Skill Sheet 10-II-5, 6.4.1)
16. Stabilize a side-resting vehicle using a buttress tension system. (Skill Sheet 10-II-6, 6.4.1)
17. Remove a windshield in an older model vehicle. (Skill Sheet 10-II-7, 6.4.1)
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19. Remove a roof from an upright vehicle. (Skill Sheet 10-II-9, 6.4.1)
20. Remove a roof from a vehicle on its side. (Skill Sheet 10-II-10, 6.4.1)
21. Displace the dashboard. (Skill Sheet 10-II-11, 6.4.1)

Chapter 10

Scene Lighting, Rescue Tools, Vehicle Extrication, and Technical Rescue



Case History

Fire department units responded to a vehicle accident on an icy highway. The incident required extrication of victims from the vehicle. The highway was closed by law enforcement personnel in the direction of travel in which the vehicle accident occurred. However, there were no physical barriers between the incident scene and the opposing direction of travel. A tour bus approaching from the opposing direction lost control, crossed the median, and entered the immediate accident scene. Fortunately, the bus did not strike any vehicles or personnel.

Emergency responders at the scene felt safe and became complacent because the traffic behind them was blocked. No consideration was given to the traffic coming from the opposing direction. In fact, traffic should have been stopped on both sides of the highway.

Source: National Fire Fighter Near-Miss Reporting System.

Emergency incidents will often require supplemental lighting provided by apparatus mounted lights or portable lighting systems. Firefighter I firefighters must be able to operate this equipment, and Firefighter II firefighters must also be able to maintain it. Rescues from structure fires are just one of many type of rescues that fire departments perform. Some of these rescues, such as confined-space, ice/water, and structural collapse, require specialized training and tools. As a Firefighter I you must be able to use emergency scene lighting equipment under the direction of your supervisor or the Incident Commander (IC). As a Firefighter II, you must be able to use emergency scene lighting equipment and manual and power-operated rescue tools. You must also perform vehicle **extrications** and assist specialized technical rescue personnel. This chapter provides you with the basic knowledge needed to perform these tasks based on the requirements found in NFPA® 1001.

Extrication — Incident in which a trapped victim must be removed from a vehicle or other type of machinery.

I Emergency Scene Lighting Equipment

Emergency scene lighting is required at all incidents that occur at night, in low-light conditions, or inside structures where normal lighting is not available. This equipment includes lights, electrical generators, and auxiliary electrical equipment (**Figure 10.1, p. 480**).



Figure 10.1 Full-scene lighting equipment includes a portable generator, cord, and the lights themselves. *Courtesy of Shad Cooper/Wyoming State Fire Marshal's Office.*



Figure 10.2 Portable electric generators provide electricity to scene lighting and other rescue equipment.

Generator — Portable device for generating auxiliary electrical power; generators are powered by gasoline or diesel engines and typically have 110- and/or 220-volt capacity outlets.

Power Take-Off (PTO) System — Mechanism that allows a vehicle engine to power equipment such as a pump, winch, or portable tool; it is typically attached to the transmission.

Electric Generators

Emergency scene lighting and portable rescue equipment are powered by portable electric **generators**, apparatus-mounted generators, or the apparatus electrical system. Generators are the most common power source used by emergency services personnel (**Figure 10.2**).

Portable electric generators are powered by small gasoline or diesel engines and have 110- and/or 220-volt capacity outlets. Most are light enough to be carried by two people. They are useful when vehicle-mounted electrical systems are not available.

Vehicle-mounted generators produce more power than portable units (**Figure 10.3**). They can be powered by gasoline, diesel, propane gas engines, or by hydraulic or **power take-off (PTO) systems**. They typically have 110- and 220-volt outlets and produce more than 50 kW of power. Vehicle-mounted generators with a separate engine have the disadvantage of being noisy, making communication near them difficult. In addition, the exhaust fumes from the generator can contaminate the scene if the vehicle is not positioned downwind.



Hearing Protection Is Required When Using Generators

Electric generators produce high levels of noise. Always wear hearing protection when using this equipment.



Figure 10.4 An apparatus may be equipped with external outlets that are capable of supplying small amounts of electrical power.

Figure 10.3 Vehicle mounted electric generators provide large quantities of power.

Portable lights and equipment may also be powered directly from the apparatus electrical system. If small amounts of power are needed to operate lights and tools, an **inverter** is used to convert the vehicle's 12- or 24-volt direct current (DC) into 110- or 220-volt alternating current (AC) (**Figure 10.4**). The advantages of this method include fuel efficiency and minimal noise. Disadvantages include constant apparatus exhaust, limited power supply, and limited mobility.

Inverter — Step-up transformer that converts a vehicle's 12- or 24-volt DC current into 110- or 220-volt AC current.

Lighting Equipment

Lighting equipment can be divided into two categories: portable and fixed (**Figures 10.5a and b, p. 482**). Portable lights are used in building interiors or remote areas of the scene. They range from 300 to 1,000 watts and typically have carrying handles and large bases for stability. Some are mounted on telescoping stands, which allow them to be raised and directed more effectively.

Fixed lights are mounted on a vehicle and wired directly to the vehicle-mounted generator or apparatus electrical system. They are used to provide overall lighting of the emergency scene. These lights are usually mounted on telescoping poles so they can be raised, lowered, or rotated. Some units consist of large banks of lights mounted on hydraulically operated booms. These light banks generally have a capacity of 500 to 1,500 watts per light. The number of fixed light units mounted on an apparatus is limited by the amount of power the vehicle-mounted generator or apparatus electrical system can produce.

CAUTION

Never connect more lights than the power source can support. Overtaxing the power source results in poor lighting and possible damage to the lights, generator, or electrical system. It may also restrict the operation of other tools using the same power source.

Figure 10.5a Portable lighting can be positioned from the ground.



Figure 10.5b Apparatus-mounted lights provide lighting to an overall emergency scene. *Courtesy of Ron Moore and McKinney (TX) FD.*



Lighting Units Can Cause Injuries

All lighting units produce extreme heat and can cause burns. Be careful when moving lights or turning them off. Bulbs can also explode if they come in contact with water. Never direct lights toward moving traffic because this can blind other drivers.

Auxiliary Electrical Equipment

Auxiliary electrical equipment consists of the following (Figures 10.6a-d):

- Electrical cables
- Extension cords
- Receptacles

- Connectors
- Junction boxes
- Adapters
- Ground fault circuit interrupter (GFCI) devices

All auxiliary equipment must be waterproof, **intrinsically safe**, and designed for the amount of electrical current it is intended to carry. Electrical cables and extension cords can only carry a limited amount of electricity. Do not use them with equipment whose power demands exceed the cords' capacity. This creates an electrical hazard and can damage the equipment. Cords may be stored in coils, on portable cord reels, or on apparatus-mounted automatic rewind reels.

Intrinsically Safe — Describes equipment that is approved for use in flammable atmospheres; must be incapable of releasing enough electrical energy to ignite the flammable atmosphere.



Figure 10.6a Electrical cables come in several lengths and purposes. *Courtesy of Shad Cooper/Wyoming State Fire Marshal's Office.*



Figure 10.6b Extension cords may be stored on apparatus-mounted reels. *Courtesy of Ted Boothroyd.*



Figure 10.6c An electrical receptacle must be used responsibly and within the rated limits. *Courtesy of Shad Cooper/Wyoming State Fire Marshal's Office.*



Figure 10.6d A GFI device is used as a safety feature on a generator. *Courtesy of Shad Cooper/Wyoming State Fire Marshal's Office.*

Ground Fault Circuit Interrupter (GFCI) — Device designed to protect against electrical shock; when grounding occurs, the device opens a circuit to shut off the flow of electricity. Also known as Ground Fault Indicator (GFI) Receptacle.

In addition to being waterproof and intrinsically safe, electrical cables and extension cords should have adequate insulation and no exposed wires. Twist-lock receptacles and connectors equipped with grounding wires provide secure, safe connections as long as they are not immersed in water (**Figure 10.7**).

Junction boxes provide multiple outlets or connections and are supplied through one inlet from the power source (**Figure 10.8**). All outlets must be equipped with **ground fault circuit interrupter (GFCI)** devices and meet the requirements outlined in NFPA® 70E, *Standard for Electrical Safety in the Workplace*®.

Adapter connections are used to permit different types of plugs and receptacles to be connected. Adapters allow mutual aid departments to operate electrical lights and tools off each other's generators and power sources. Using adapters, fire department lights and tools may also be plugged into standard electrical outlets in structures.



Figure 10.7 Twist-lock fittings prevent a cord from accidentally becoming unplugged during operations.



Figure 10.8 Junction boxes allow electrical equipment of different connection types to be used at some distance from the initial power source.

I Maintenance of Electric Generators and Lighting Equipment

Firefighters must regularly inspect and maintain all portable generators and lighting equipment. Inspections and maintenance must follow manufacturer's instructions and your department's standard operating procedures (SOPs). To meet this obligation, you must:

- Inspect generators, lighting units, and lighting accessories periodically and after each use.
- Review the manufacturer's service manual for specific directions.
- Carefully inspect spark plugs for damage, visible corrosion, carbon accumulation, or cracks in the porcelain (**Figure 10.9**). Make sure the spark plug wire is tight.
- Replace the spark plug if it is damaged or if the service manual recommends replacement. Ensure proper gap prior to installing. Replace any plug with signs of **arcing**, indicated by the presence of carbon soot around the ground electrode (**Figure 10.10**).

Arc — High-temperature luminous electric discharge across a gap or through a medium such as charred insulation.



Figure 10.9 Damaged spark plugs create an electrical hazard.



Figure 10.10 Carbon soot that has built up around a ground electrode will prevent a secure connection and lend itself to arcing which creates a hazard.

- Check the generator carburetor and identify any signs of fuel leaks.
- Check fuel level and refill as needed.
- Visually inspect the fuel in the tank to ensure that it is not contaminated. Discard contaminated fuel in an approved manner.
- Check oil level and refill as needed.
- Start the generator and run any tests required in the service manual. If a problem is found with the generator, consult the manual to determine the proper action. Only qualified service personnel or a licensed electrician should perform repair work on the generator.
- Avoid starting a generator while under a load (lighting or other equipment turned on and plugged in). Starting a generator while under a load can damage the electrical system.
- Do not run the generator for a long period of time without a load. This action will overheat and damage the generator.
- Inspect all electrical cords for damaged insulation, exposed wiring, or missing or bent prongs (**Figure 10.11**).
- Test the operation of the lighting equipment. Connect each light to the generator one light at a time to prevent overloading. Avoid looking directly into the lights when they are powered.
- Replace lightbulbs as necessary. Shut off the power and allow the bulb to cool before replacing. If the bulb must be replaced immediately, wear leather gloves to prevent being burned. Discard faulty bulbs in an approved manner.
- Clean the work area and return all tools and equipment to the proper storage areas.
- Document the maintenance on the appropriate forms or records.

Skill Sheet 10-II-1 describes the steps for inspecting, servicing, and maintaining a portable generator and lighting equipment.



Figure 10.11 This high-voltage wire shows the component pieces that should NOT be exposed during standard operation.



Some types of equipment and some kinds of maintenance are not your responsibility. The driver/operator typically inspects and maintains apparatus electrical systems and apparatus-mounted lights and generators. Detailed maintenance and modification of any lighting equipment must be performed by qualified technicians.

Rescue Tools

Rescue tools can be classified based on two criteria: their power source and use. Their power source can be either manual or power-operated (**Figures 10.12a and b**). They may be used for:

- **Cutting** — Removing materials or debris to free a victim
- **Stabilizing** — Ensuring that a vehicle or structural member will not move during a rescue
- **Lifting** — Raising a vehicle, vehicle component, or structural member off a victim or raising the victim out of a space
- **Pulling** — Dragging away materials to free a victim
- **Other Activities** — Securing materials in place or breaking up materials to free a victim

This chapter describes power-operated and manual tools used for any purpose during vehicle extrication or technical rescue. Manual forcible entry tools that may also be used for rescue are explained in Chapter 11.



Vision and Hearing Protection Required

Eye and hearing protection must be worn when operating all types of rescue tools.

Power Sources

The power source for power-operated rescue tools may be electric, hydraulic, or pneumatic. Some tools combine both hydraulic and electric power. Criteria for powered rescue tools are established in NFPA® 1936, *Standard on Powered Rescue Tools*. Tools produced by different manufacturers may have very different capabilities, and the same is true of tools that use different power sources. For example, a power saw produced by one manufacturer may be able to perform tasks that a saw produced by another manufacturer cannot. Similarly, a hydraulic extrication tool may be unable to perform tasks handled by a pneumatic extrication tool.

Electric

Rescue saws and other tools can be powered by rechargeable batteries, apparatus electrical systems, and portable or vehicle-mounted generators. The main advantage of this power source is that electricity is readily available at the incident scene. Electric

tools are lightweight, and battery powered tools are especially portable because they do not require an electric power cord or cable (**Figure 10.13**). One disadvantage of battery-powered tools is that they may be less powerful than other tool types.

Always follow manufacturer's recommendations for maintaining rechargeable batteries. Keep them fully charged and dispose of them if they are damaged or unable to hold a charge. Some batteries must be completely discharged periodically to ensure they can maintain a full charge.



Figure 10.12a Manual tools are indispensable for the uses they are able to perform at an incident.



Figure 10.12b Power-operated tools provide greater force and speed during rescue operations.



Figure 10.13 Battery-powered tools are almost as portable as nonpowered tools.

Hydraulic

Most powered rescue tools are powered by hydraulic pumps. Pumps may be operated by hand, an electric motor, or a gasoline engine. They may be portable and carried with the tool, or mounted on the vehicle and connected through a hose reel line (Figure 10.14).

Inspect pumps regularly for damage. Make sure that hoses and connections do not leak and that connections are clean and work properly. Leave all maintenance to qualified personnel.



Danger of Hydraulic Injuries

Due to the high pressures produced by power-operated hydraulic pumps, you must be aware of the extreme danger of hydraulic injuries. A hydraulic injury can occur when you come in contact with a pinhole leak of pressurized hydraulic fluid on the hoses. The pressurized hydraulic fluid can penetrate your PPE and your skin and enter your bloodstream. Your skin will swell while your body attempts to fight what it thinks is an infection. To treat this injury, your skin must be opened to remove the fluid and relieve the pressure and swelling.



Figure 10.14 Hydraulic pumps may be portable for ease of use at an incident scene. *Courtesy of Owasso (OK) Fire Department.*

Pneumatic

Pneumatic tools are powered by pressurized air from compressed air cylinders, such as SCBA cylinders, vehicle-mounted cascade systems, or portable or vehicle-mounted air compressors (Figure 10.15). If SCBA cylinders are used to supply the tools, an adequate quantity of cylinders must be on hand to meet the tool's high demand for air.

Follow the manufacturer's recommendations for general care and inspection. All maintenance must be performed by qualified personnel.



Figure 10.15 Pneumatic tools connected to SCBA cylinders use a high quantity of compressed air but are very portable.

Powered Rescue Tools

There are four basic types of hydraulic and electric powered rescue tools: spreaders, shears, combination spreader/shears, and extension rams.

Spreaders. Powered hydraulic spreaders were the first powered hydraulic tools used in the fire service. When combined with chains and adapters, they are used for pushing and pulling. Spreaders produce tremendous force at their tips, which may spread as much as 32 inches (800 mm) apart (**Figure 10.16**).

Shears. Hydraulic shears or cutters can cut almost any metal object that fits between the blades. They are also used to cut plastics, wood, and other materials. The blades typically have an opening spread of approximately 7 inches (175 mm) (**Figure 10.17**).

Combination spreader/shears. This tool has removable spreader tips that can be replaced with a set of shears. It is excellent for a small rapid-intervention vehicle or for departments with limited resources. The combination tool is less expensive than individual shears and spreaders, but it cannot cut or spread as forcefully as the individual units (**Figure 10.18**).



Figure 10.16 Powered hydraulic spreaders serve many rescue functions.



Figure 10.17 Hydraulic shears can cut almost anything that will fit between the blades.



Figure 10.18 Spreaders, combination spreader/shears, and shears are commonly used at an incident scene. *Courtesy of Shad Cooper/Wyoming State Fire Marshal's Office.*

Cutting Tools

Cutting tools are used to cut material away from a trapped victim. Most cutting tools are power saws, which are faster and easier to handle than powered shears. Saws are also more powerful, and there are some exotic metals that only a saw can cut through. Power saws can be gasoline, electric, or battery powered. The most common types are reciprocating, rotary, circular, and whizzer saws.

CAUTION

Always wear full PPE including eye and hearing protection when operating any power saw. Do not force the saw beyond its design limits; you may be injured and/or the saw may be damaged. Follow manufacturer's safety recommendations and departmental SOPs.

WARNING

Never use a power saw in a flammable atmosphere. The saw's motor or sparks from the cutting can ignite flammable gasses or vapors causing an explosion or fire.

Reciprocating Saw

The reciprocating saw is a powerful, versatile, and highly controllable saw. It has a short, straight blade that moves in and out, like a handsaw. It can use a variety of blades for cutting different materials. When equipped with a metal-cutting blade, it is ideal for cutting sheet metal body panels and structural components on vehicles (Figure 10.22).

Rotary Saw

Rotary saws used in the fire service are typically gasoline powered, with different blades for cutting wood, metal, or masonry (Figure 10.23). Large-toothed blades are used to make quick, rough cuts, while fine-toothed blades are used for precision cutting. Blades with carbide-tipped teeth are superior to standard blades because they are less prone to dulling. Rotary saw blades can spin at up to 6,000 revolutions per minute (rpm).



Figure 10.22 A reciprocating saw can cut straight lines in small spaces.

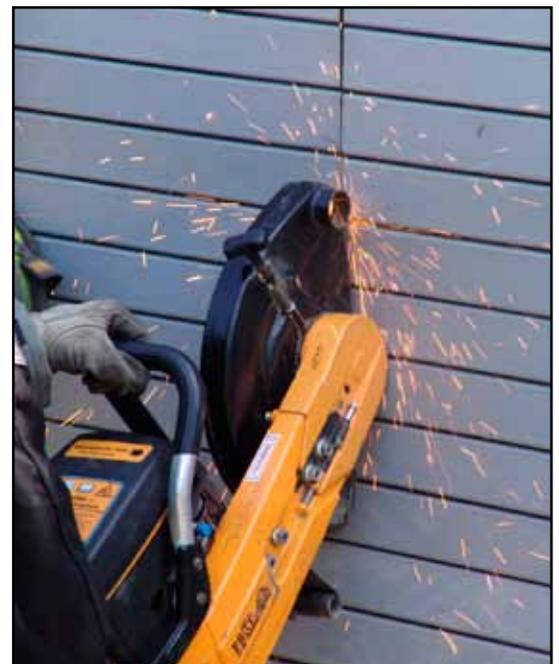


Figure 10.23 Rotary saws may be equipped with customized blades to accomplish a range of tasks.



Figure 10.24 Circular saws are commonly available and easy to handle.

CAUTION

Always have a charged hoseline or portable fire extinguisher available when cutting metal with a rotary saw. Sparks produced by the cutting can ignite flammable gases, vapors, or materials.

WARNING

Never use a rotary saw to cut the shell of a flammable liquid or gas storage tank. Sparks can ignite flammable vapors.

CAUTION

Blade guards on some rotary saws are not designed for use with carbide tipped blades. Always make sure that the saw is designed for the blades you intend to use.



Figure 10.25 A whizzer saw may run for 3 minutes on an SCBA cylinder.

Circular Saw

Electric circular saws are versatile, lightweight, and easy to handle (**Figure 10.24**). Small battery-powered circular saws are also available.

Whizzer Saw

The whizzer saw weighs about one-tenth as much as a circular saw (2 lbs. or 0.9 kg). It is quiet, highly portable, and very easy to handle. It is often used for delicate cutting operations, such as removing rings from swollen fingers.

The saw's 3-inch (75 mm) Carborundum® blade cuts through case-hardened locks and up to ¾-inch (20 mm) of steel. It also has a clear Lexan® blade guard to protect both operator and victim. It is driven by compressed air at 90 psi (630 kPa) from an SCBA cylinder with a regulator and will run approximately 3 minutes on a full air cylinder (**Figure 10.25**).

Air Chisel

These pneumatic-powered tools operate at air pressures between 90 and 250 psi (630 and 1 750 kPa). In addition to cutting bits, special bits are also available for operations such as breaking locks or driving in plugs (**Figure 10.26**). Air chisels are used to cut medium- to heavy-gauge sheet metal and remove rivets and bolts. A tool with more air at higher pressures is required to cut heavier-gauge or exotic metals. Follow manufacturer's recommendations for general maintenance and keeping cutting tips sharp.

Stabilizing Tools

Before you begin a rescue or an extrication, you must ensure that the scene is stabilized. The vehicle, object, structural component, or trench wall must not be able to move, as this can injure the victim or a rescuer. **Stabilization** tools include jacks, buttress tension systems, wheel chocks, and cribbing.

Jacks used in stabilization can also be used for lifting. Jacks should always be placed on a flat, level surface, such as a roadway. If a jack must be positioned on a soft surface, place a solid base of cribbing, a flat board, or a steel bearing plate under the jack to prevent it from sinking into the surface (**Figure 10.27**).

Hydraulic Jack

Hydraulic jacks are designed for heavy lifting, but when used in conjunction with cribbing, they can also be used for stabilization (**Figure 10.28, p. 494**). Read the manufacturer's manual to determine the jack's weight capacity.

Nonhydraulic Jack

Nonhydraulic jacks are much less powerful than hydraulic jacks. There are two main types: screw jacks and ratchet-lever jacks.

Screw jack. Screw jacks can be extended or retracted by turning the threaded shaft. Two commonly used types of screw jacks are the bar screw jack and the trench screw jack. Both jacks have a male-threaded stem (similar to a bolt) and a female-threaded component (**Figure 10.29, p. 494**).

Bar screw jacks are typically used to support collapsed structural members. These heavy-duty devices are not normally used for lifting; their primary use is to hold an object in place. The shaft is turned with a long bar that is inserted through a hole in the top of the shaft.

Stabilization — Preventing unwanted movement; accomplished by supporting key places between an object and the ground (or other solid anchor points).



Figure 10.27 A jack requires solid footing for stability during lifting operations.

Figure 10.26 Air chisels may be customized with tips for a range of specific uses.



Figure 10.28 Hydraulic jacks are used in extrication functions and should be supplemented with cribbing.



Figure 10.29 Screw jacks can be adjusted to the necessary length by turning the threaded shaft.



Figure 10.30 Ratchet-lever jacks lift items on the carriage in a straight line.

Trench screw jacks often replace wooden cross braces during trench rescue. They are durable, inexpensive, and easy to use. Each jack has two swivel footplates. The first has a stem that is inserted into a section of a 2-inch (50 mm) steel pipe up to 6 feet (2 m) long. The second has a threaded stem that is inserted into the other end of the pipe. An adjusting nut (with handles) on the threaded stem is turned to vary the length of the jack and to tighten it between opposing members in a shoring or stabilizing system.

Ratchet-lever jack. Ratchet-lever jacks are also known as *high-lift jacks*. These medium-duty jacks are used primarily for stabilization and lifting, but they can be modified for use in pushing or pulling operations during vehicle extrication. They are the least stable of all types of jacks. If their load shifts, ratchet-lever jacks can fall over, allowing the load to suddenly drop to its original position. They are also prone to failure under heavy loads and sometimes release if less than 100 pounds (45.36 kilograms) is resting on the tongue.

Ratchet-lever jacks consist of a rigid I-beam with perforations along the side and a jacking carriage that fits around the I-beam (**Figure 10.30**). The geared side of the I-beam has two ratchets; one holds the carriage in position while the other works with a lever to move the carriage up or down.

WARNING

Never work under a load supported only by a jack. If the load shifts or the jack fails, you can be severely injured, or even killed. Loads should always be supported by properly placed cribbing. Live by the saying, “Lift an inch, crib an inch.” As the jack lifts the load 1 inch (25 mm), add one 1 inch (25 mm) of cribbing.

Buttress Tension System

A buttress tension system is used to stabilize a vehicle that is resting on its side or top. It may consist of a minimum of three 4 x 4 inch (101 by 101 mm) posts wedged between the ground and the vehicle, or it may be a commercial system composed of metal rods and straps. Two posts are placed on the bottom of the vehicle and one is placed on the top. Their exact placement is determined by the condition and weight of the vehicle, the stability of the soil, and the condition of the victims. The purpose of the system is to provide a larger footprint for the vehicle and prevent it from moving or tipping over during extrication (**Figures 10.31a and b**). See the Vehicle Extrication section for more information about this device.

Wheel Chocks

Wheel chocks prevent emergency vehicles from moving when they are parked. When placed against the downhill side of the rear tires, they can hold a vehicle in place on a 10 to 15 percent grade. During extrication, they can be also used to stabilize vehicles that have been involved in an accident.

Wheel chocks are constructed of aluminum, hard rubber, wood, or urethane plastic (**Figure 10.32**). They are designed to resist corrosion from oils, fuels, and solvents. Chocks typically have a pad or traction cleat on the bottom, as well as handles, ropes,

or grab holds to make them easier to carry. Chocks carried on fire apparatus must comply with NFPA® 1901, *Standard for Automotive Fire Apparatus*; NFPA® 1906, *Standard for Wildland Fire Apparatus*; and the Society of Automotive Engineers standard SAE-J348.



Figure 10.32 Wheel chocks prevent unanticipated movement by an apparatus or other vehicle.



Figure 10.31a A buttress system consists of rods and ties that support the balance of a vehicle while it is in an unstable position.



Figure 10.31b The placement of a support system is determined by the condition of the vehicle and its other supports.

Wheel Chock — Block placed against the outer curve of a tire to prevent the apparatus from rolling; can be wooden, plastic, or metal. Also known as Wheel Block.

Cribbing — Wooden or plastic blocks used to stabilize a vehicle during vehicle extrication or debris following a structural collapse; typically 4 x 4 (100 mm) inches or larger and between 16 to 26 inches (400 mm by 650 mm) long.

Cribbing Materials

Cribbing is used to stabilize a vehicle during extrication or to stabilize debris following a structural collapse. It consists of wooden or plastic blocks 16 to 36 inches (400 mm to 900 mm) long, which typically measure 2 x 4 inches (50 mm by 100 mm), 4 x 4 inches (100 mm by 100 mm), and 6 x 6 inches (150 mm by 150 mm). Block ends may be painted with different colors indicating different lengths. However, the flat surface of the block is never painted because paint can hide defects and cause the surface to be slippery when wet. Individual blocks may have a rope or webbing handle stapled to the end so that they can be easily carried or safely removed from under objects. Wooden blocks can be locally constructed or commercially purchased.

Wooden cribbing is made from construction grade lumber. However, plastic cribbing is often preferred because it is lighter and lasts many times longer (**Figure 10.33**). It also cannot be contaminated by absorbing fuel, oil, or other substances. One disadvantage of plastic cribbing is that it may slip under wet conditions.

Lifting Tools

Lifting tools are used to lower rescuers, remove an object from a trapped victim, or lift a victim out of a hole or confined space. Commonly used rescue tools include tripods and pneumatic lifting bags.

Tripods

Rescue tripods are used to create an anchor point above a manhole or other opening. This allows rescuers to be safely lowered into confined spaces and rescuers and victims to be hoisted out of them (**Figure 10.34**).

Pneumatic Lifting Bags

Pneumatic lifting bags are air-pressurized devices that give rescuers the ability to lift or displace objects that cannot be lifted with other rescue equipment. There are three basic types of lifting bags: high-pressure, medium-pressure, and low-pressure (**Figure 10.35**).

High-pressure bags. High-pressure bags are constructed from a tough, neoprene rubber exterior reinforced with steel wire or Kevlar™ Aramid fiber. When deflated, the bags lie completely flat and are about 1 inch (25 mm) thick. Their surface area ranges from 6 x 6 inches (150 mm by 150 mm) to 36 x 36 inches (900 mm by 900 mm), and they inflate to a height of 20 inches (500 mm). As it inflates, it loses both stability and lifting power.

Low- and medium-pressure bags. Low- and medium-pressure bags are considerably larger than high-pressure bags, and can inflate to a greater height, up to 6 feet (2 m). They are used to lift and stabilize large vehicles or objects. They are most stable when fully inflated.

Lifting bag safety rules. Operators should follow these safety rules when using pneumatic lifting bags:

- Always plan the lifting operation before you begin. Make sure you have an adequate air supply and sufficient cribbing materials.
- Be familiar with the equipment's operating principles, methods, capabilities, and limitations.
- Follow the manufacturer's recommendations for the specific system used.

- Keep all components in good operating condition.
- Make sure all safety seals are in place.
- Position the bag on or against a solid surface.
- Keep sharp objects away from the bag as it inflates.
- Never inflate a bag without a load.
- Inflate slowly and continually monitor the load for signs of shifting.
- Never work underneath a load supported only by air bags.
- Use enough cribbing to support the load in case of bag failure.



Figure 10.33 Wood cribbing has some design limitations that are overcome in plastic cribbing and vice versa.



Figure 10.34 Rescue tripods allow a rescuer in a harness to enter and exit a confined space below ground.



Figure 10.35 Air bag lifting capacities should be visibly marked on each bag.

Figure 10.36 Air bags and cribbing work together to create a safe void space under a heavy item.



- Use at least three pieces of cribbing per layer, and make sure the top layer is solid. Openings in the center of the cribbing may cause the bag to shift or rupture (**Figure 10.36**).
- Never let the bag contact materials hotter than 220°F (104°C).
- When stacking bags, inflate the bottom bag first and put the smaller bag on top. Never stack more than two bags. Single, multicell bags are more effective.
- Fuel and other petroleum products can weaken the bags and shorten their working life. Never store, use, or place a bag in an area where contact may occur.

CAUTION

Test and inspect bags regularly. If there are any signs of damage or deterioration, remove them from service immediately.

WARNING

If you place anything between the bag and the lifted object, it must be made of pliable material, such as a folded salvage cover. Plywood or other rigid material can be forcefully ejected if the bag distorts under pressure.

Pulling Tools

Pulling tools are used to pull vehicles apart, pull an object away from a trapped victim, or stabilize a vehicle that is resting over an edge. Typical pulling tools include winches, chains, and come-alongs. The powered rescue tools mentioned earlier can also be used to pull apart vehicle components.

Winches

Winches are typically mounted on the front, rear, or side of a vehicle. Compared to other pulling devices, they are stronger, faster to deploy, and have a greater travel or pulling distance. They are typically powered by an electric or hydraulic motor, or a PTO system (**Figures 10.37a-c**). They are used in conjunction with chains and/or cables.



Figure 10.37a Electric winches may be mounted on the front of a vehicle.

Figure 10.37b A hydraulic winch combines a hydraulic hauling system with a vehicle chassis and engine to provide mobility and pulling power.

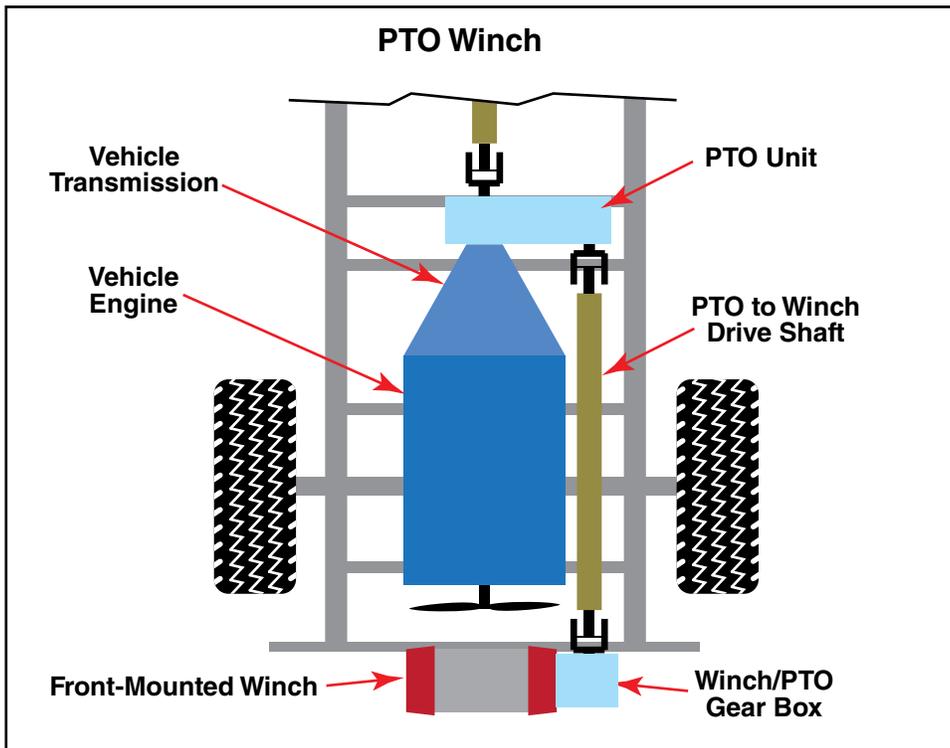
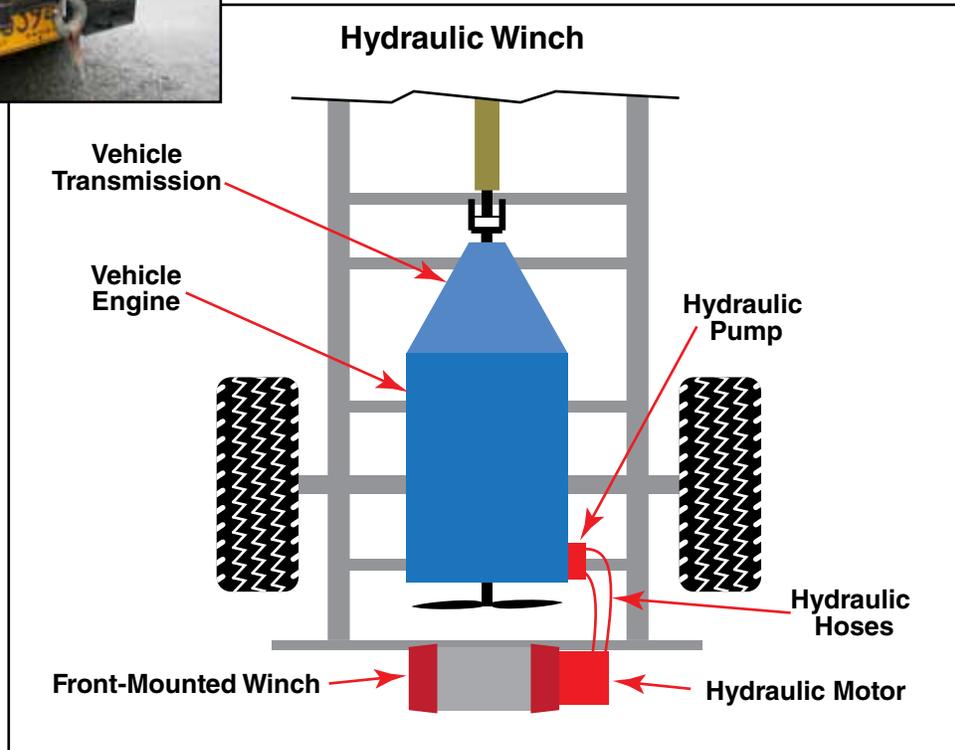


Figure 10.37c A PTO-driven winch rig is bulkier than a hydraulic winch.



Figure 10.38 Winch cable may be composed of synthetic fibers or strands of steel wire.

Winch cables are made from steel or synthetic fiber (**Figure 10.38**). Steel cable is made from thin strands of steel wire wound together. It is durable and long lasting, but also extremely heavy and rigid, making it difficult to handle. Synthetic fiber cable is lighter and stronger than steel. It floats in water, resists ultraviolet light, and is not affected by temperature variations. If it breaks, it does not recoil or whip like steel cable, making it safer to use.

Handheld remote-control devices allow the winch operator to stand outside the danger zone. The danger zone is the area on either side of the winch cable where the cable can whip around if it breaks (**Figure 10.39**). Position the winch as close as possible to the object being pulled, so that if the cable breaks, there is less cable to recoil. Winch cables should be regularly inspected because they develop memory on the coil, returning to the coiled form it had on the winch after it is stretched out. Vehicle vibrations can also cause the cable to fray over time.

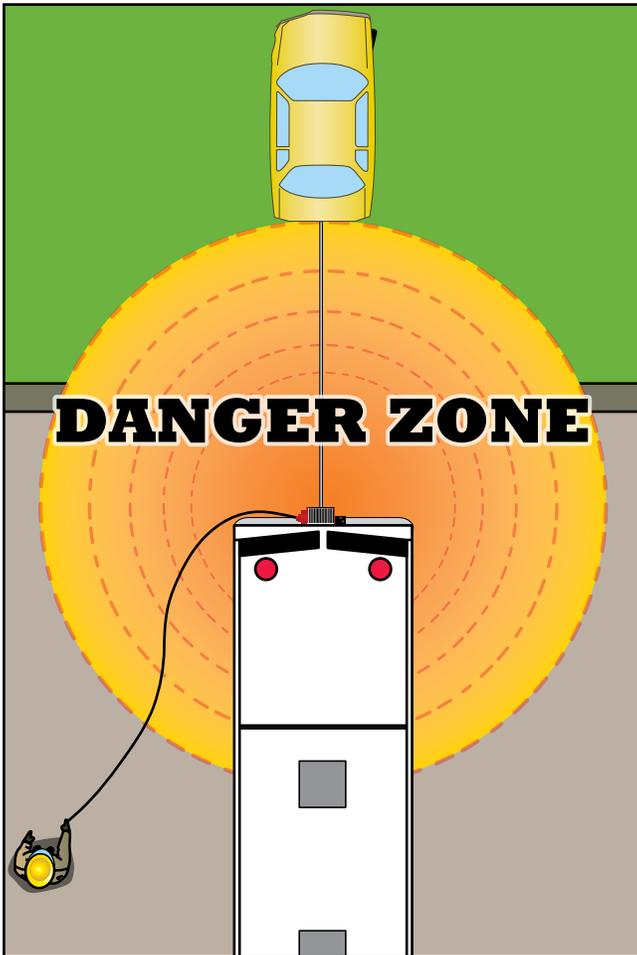


Figure 10.39 A winch cable under pressure can break at any point along its length, and if it does so it will whip back toward the winch box.



Reducing Danger During Winch Operations

There is a danger of injury or death if the cable, hooks, or straps fail while the winch and cable are under tension. To reduce the chance of injury, you should:

- Always follow the winch/cable manufacturer's operating instructions.
- Inspect the winch/cable regularly and prior to each use. Replace any frayed, kinked, or damaged cable immediately.
- Inspect winch mounting and ensure that mounting bolts are tight before every use (**Figures 10.40a and b**).
- Never exceed the rated load capacity of the winch/cable.
- Never operate the winch when there are less than five wraps of cable around the winch drum.
- Always use a pulley block or snatch block to reduce the load on the cable when pulling objects at or near the rated capacity of the winch (**Figure 10.41**).
- Shock loads can exceed the load capacity of the winch/cable. Use the remote control switch to take up slack intermittently.
- Never wrap the cable around an object and hook it back onto itself. This will damage the cable.
- Always place the hook so its back is either facing the ground or facing away from the winch operator. In the event of a hook failure under a load, the broken hook will move in the direction of the back of the hook.



Continued

- Keep the duration of winching pulls as short as possible. Do not pull for more than one minute when operating at or near the rated load capacity of the winch/cable.
- Never step over or stand near a cable that is under tension.
- Keep yourself and others a safe distance to the side of the cable under tension. Ensure that no one is standing in front of or behind the winch or the anchor point.
- Use heavy-duty gloves to protect your hands when handling the cable. Never let the cable slide through your hands.
- Drape a blanket, coat, or tarp over the cable approximately 5 to 6 feet (1.5 to 1.8 m) from the hook. This makes the cable more visible to nearby personnel and reduces the recoil force of the cable if it breaks (**Figure 10.42**).
- Operate the remote control from the cab of the winch-mounted vehicle. Open the vehicle hood for added protection against recoil.
- Stay farther away from the winch than the length of the cable from the winch to the load.
- Never use a winch to pull a living person.



Figure 10.40a Damaged cable cannot be expected to hold the same amount weight as nondamaged cable, and must therefore be retired.



Figure 10.40b Loose winch mounting bolts may require simple tightening before use.



Figure 10.41 A pulley block helps reduce the load on a high tension cable.



Figure 10.42 Draping a flexible weight over a tensioned cable improves the safety of operations.

Come-Alongs

Come-alongs are portable cable winches operated by a manual ratchet lever (**Figure 10.43**). A come-along must be attached to a secure anchor point, after which its cable is attached to the object that must be pulled. The ratchet lever is then used to rewind the cable, pulling the object back toward the anchor point. Come-alongs typically have a load capacity ranging from 1 to 10 tons (0.9 t to 9.1 t).

WARNING

Use only the operating handles provided by the come-along's manufacturer. These handles are designed to fail before the cable. Never use a prybar or other tool instead.

Chains

Chains are used in conjunction with both winches and come-alongs. The two main chain types are alloy steel chain and proof coil chain, also known as *common* or *hardware chain* (**Figure 10.44**). Only alloy steel chain should be used in rescue operations. It is designed to resist abrasion, corrosion, and effects of hazardous atmospheres.

Tools Used in Other Activities

Power tools can also be used for other activities associated with rescue operations. Pneumatic nailers and impact wrenches can be very handy in a variety of situations (**Figures 10.45a and b**).

Pneumatic Nailers

Pneumatic nailers are used to drive nails or heavy-duty staples into wood. They are especially useful for nailing wedges and other wooden components of cribbing systems into place or securing canvas or vinyl covers over roof openings.



Figure 10.43 A come-along is operated manually to move an object toward a fixed anchor point.



Figure 10.44 Alloy steel chain is the only approved type of chain in a rescue operation.



Figure 10.45a A pneumatic nailer attached to an SCBA cylinder is portable and maneuverable in tight places.

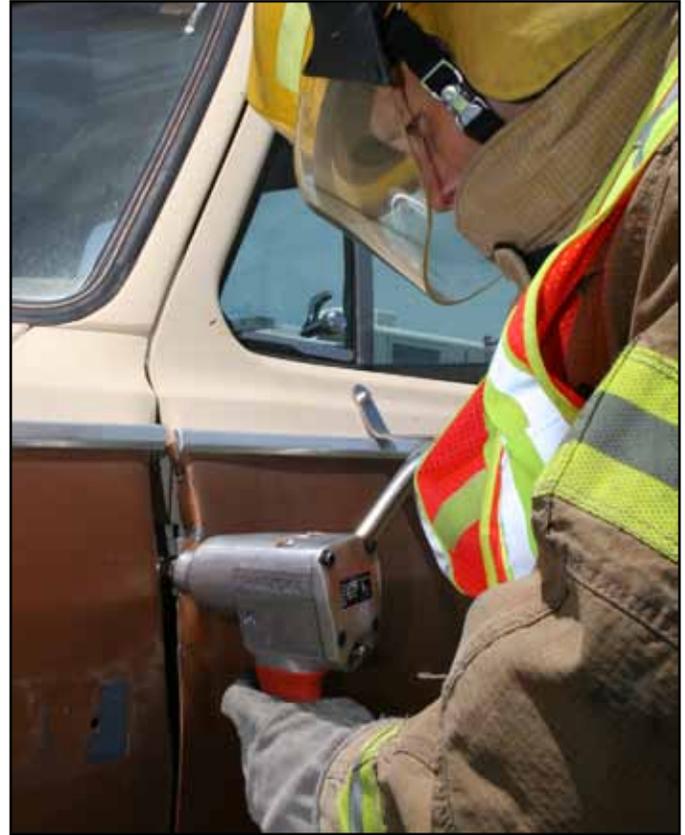


Figure 10.45b An impact wrench can be used to forcibly separate metal panels. *Courtesy of Owasso (OK) Fire Department.*

Impact Tools

Pneumatic impact tools or wrenches have a square drive onto which a socket is attached. The socket can then be applied to a nut or bolt head of the same size to tighten or loosen it quickly. These tools are ideal for disassembling machinery in which a victim is entangled.

Rescue Tool Maintenance

For inspection, care, and maintenance, always follow the manufacturer's recommendations and departmental SOPs. Follow these general guidelines:

- Check all fluid levels.
- Use only the recommended types of lubricants, hydraulic fluids, and fuel grades.
- Keep battery packs fully charged.
- Inspect power tools at the beginning of each work shift and make sure that they start.
- Inspect saw, chisel, and cutter blades regularly. Replace blades that are worn or damaged (**Figure 10.46**, p. 504).
- Check all electrical components, such as cords and portable receptacles, for cuts or other damage.



Figure 10.46 A damaged saw chain link creates preventable hazards.

- Make sure that all protective guards are functional and in place.
- Make sure that fuel is fresh. A fuel mixture may separate or degrade over time.
- Inspect hydraulic and fuel supply hoses for damage.
- Inspect hydraulic hose couplings (quick disconnect fittings) to ensure that they are clean and functional.
- Make sure that all parts and support items are easily accessible.

Vehicle Extrication

Most rescues involve extricating a trapped victim after a motor vehicle accident (**Figure 10.47**). To perform a safe, effective extrication, you must be able to:

- Perform scene size-up
- Assess the need for extrication
- Stabilize the vehicle
- Secure the vehicle's electrical system
- Recognize different types of passenger safety systems
- Determine the best way to gain access to victims
- Perform the correct type of extrication based on the vehicle type and condition

Scene Size-Up

The first step of an extrication is to size up the incident scene. Size-up begins during dispatch and continues throughout the incident. A careful assessment of the scene is necessary to:

- Prevent injury to rescuers
- Prevent further injuries to victims
- Identify potential hazards
- Clarify required tasks
- Identify needed resources

As you approach the scene, be observant and try to answer the following questions:

- What are the traffic hazards, and what types of traffic control devices are needed?
- How many and what types of vehicles are involved?
- What type of fuel or power system (hybrid or electric) do the vehicles use?
- Where and how are the vehicles positioned?
- Are the vehicles located on the roadway?
- How many victims are there, and what is their status?
- Is there a fire or potential for a fire?
- Is there a fuel or fluid leak? What control methods need to be implemented?
- Are there any hazardous materials involved?
- Are there any utilities, such as water, gas, electricity or downed power lines, that may have been damaged? If so, do they pose a hazard to victims or rescuers?
- Is there a need for additional resources?

Controlling Hazards

Traffic is the primary hazard at any motor vehicle accident, but additional dangers are created by fire, bloodborne pathogens, sharp objects, and environmental conditions. Reduce your risk of injury by always following proper safety procedures.

Apparatus should be parked so that they form a protective barrier between the scene and ongoing traffic from all directions (**Figure 10.48**). Signs and cones should be deployed to detour traffic around the scene, and law enforcement officers can provide additional traffic control assistance. You can also protect yourself from traffic hazards by maintaining constant situational awareness. Keep an eye on traffic flow and always stay within the protective barrier provided by the apparatus. Wear your retroreflective vest at all times unless you are directly involved in fire fighting or extrication.



Figure 10.47 During extrication operations, contingencies, such as a sudden fire in the engine compartment, should be planned for.



Figure 10.48 Apparatus responding to an incident should stage in a way that protects victims down-lane. *Courtesy of Jennifer Ayers/Sonrise Photography.*

Fire is another potential hazard (**Figure 10.49**). If open flames are present, extinguish them immediately. Isolate spilled fuels and other ignition sources before addressing other operational concerns. Other sources include vehicle batteries, undeployed air bags, downed power lines, and energy-absorbing struts. To isolate these hazards, you must:

- Disconnect vehicle batteries
- Deactivate undeployed air bags
- Cordon off downed power lines or ground level transformers
- Protect shock absorbers and struts from excessive heat and/or physical damage
- Avoid pyrotechnic seat belt **pretensioners**

Pretensioner — Device that takes up slack in a seat belt; prevents the passenger from being thrown forward in the event of a crash.

NOTE: Pyrotechnic seat belt pretensioners are described later in this chapter.



Disabling Air Bags

Although some air bags can be disabled by removing the ignition key, disabling is usually done by disconnecting the battery. However, the air bag may still be dangerous for up to 60 minutes because of the capacitors in the electrical activation system.

Additional hazards may be found in the vehicle's trunk and interior. Flammable adhesives, pressurized solvents, or flammable liquids (such as gasoline) are commonly encountered hazards. Illegal substances used to produce methamphetamine (meth) are also highly flammable. In extreme cases, vehicles have been found to contain entire mobile meth laboratories.



Figure 10.49 Vehicle fires may occur during other emergency response activities. *Courtesy of Bob Esposito.*

Vehicle wheels and tires, either on the vehicle or in the trunk, may also create a hazard. When exposed to fire, alloy wheels made with magnesium (also known as *mag wheels*) can burn with intense heat. Wheels made from pure magnesium are no longer produced, but may still be encountered. High-pressure tires can also create an explosion hazard when punctured or exposed to fire.

Other vehicle components made with magnesium can also cause high heat fires (**Figure 10.50**). These components include:

- Valve covers
- Steering columns
- Mounting brackets on antilock braking systems
- Transmission casings
- Engine blocks
- Frame supports
- Exterior body components

Bodily fluids resulting from patient injuries can contaminate the interior and exterior of the vehicle. Follow bloodborne pathogen procedures and wear appropriate protective clothing and equipment to avoid exposure. Your boots and the cuff of your protective trousers can become contaminated from standing in blood and other bodily fluids. Be careful to avoid possible contaminants when removing your boots and protective trousers, and follow your department's SOPs for decontaminating this protective equipment.

Broken glass and sharp metal edges can create a hazard during and after the incident. Cover sharp edges with short sections of used fire hose, clear broken pieces of glass away from the door sills and windshield edges, and wear full personal protective clothing while performing vehicle extrication (**Figure 10.51**). Also, carefully remove any glass or metal shards embedded in your boots following the incident.



Figure 10.50 Magnesium components in older vehicles are now known to generate high heat fires that cannot be safely extinguished with water.



Figure 10.51 Full protective gear is essential while breaking glass windows to prevent injury from flying shards.

Environmental conditions can also create hazards. If roads are icy, be extra careful when dismantling the apparatus. Protect other incoming responders by spreading absorbent on the ice until you are able to use sand or salt.

Vehicle Fuel Types

During the size-up, you must determine the type of fuel system in the vehicles you are approaching. The most common conventional fuels are gasoline and diesel, but alternative fuels include:

- Methanol
- Ethanol
- Reformulated gasoline
- Reformulated diesel (for trucks only)
- Natural gas
- Propane
- Hydrogen
- Electricity (including total electric and hybrid electric vehicles)
- Biofuels
- Coal-derived liquid fuels
- Alcohol blended with other fuels

Both conventional and alternative fuels are easily ignitable. Leaks from the fuel lines and tanks must be controlled and fire protection must be established to prevent the ignition of fuel vapors. Minimal fire protection could be a single firefighter standing by with a portable extinguisher, but it may be necessary to activate foam-generating systems and deploy several fully charged hoselines (**Figure 10.52**). Follow your department's SOPs, but at least one 1½-inch (38 mm) hoseline should typically be charged and ready for use.

By the end of 2010, over sixty vehicle manufacturers were designing or building electrically powered vehicles. Electrically powered vehicles may be classified as either total electric vehicles (EV) or hybrid electric vehicles (HEV) (**Figures 10.53a and b**). Total electric vehicles have a relatively short driving range. They are powered by a bank of batteries, which must be plugged into a charging station to recharge. Hybrid electric vehicles are powered by multiple propulsion systems, such as gasoline-electric hybrids that have internal combustion engines and electric motors.

Vehicle Electrical Systems

The electrical system of conventional fuel vehicles is designed to store and deliver the electricity needed to start the engine and to power and operate the various electrical components such as air conditioning, radios, power windows, and power seats. A typical vehicle electrical system is composed of a battery that stores the electricity; an alternator that produces the electricity; wiring; fuses that protect the electrical system; and lights, fans, and other ancillary equipment (**Figure 10.54, p. 510**).

Most vehicle electrical systems are either 12- or 24-volt systems. Passenger vehicles and light trucks usually have 12-volt systems while larger trucks, recreational vehicles, and military vehicles operate on 24-volt systems.

The danger associated with electric and hybrid vehicles is the high voltage stored within the batteries and running through wiring connected to the vehicle's electric motor. These wires can carry as much as 650 volts of DC. Hybrid electric vehicles



Figure 10.52 A standby team should be available while working on a vehicle that may have a compromised electrical system.

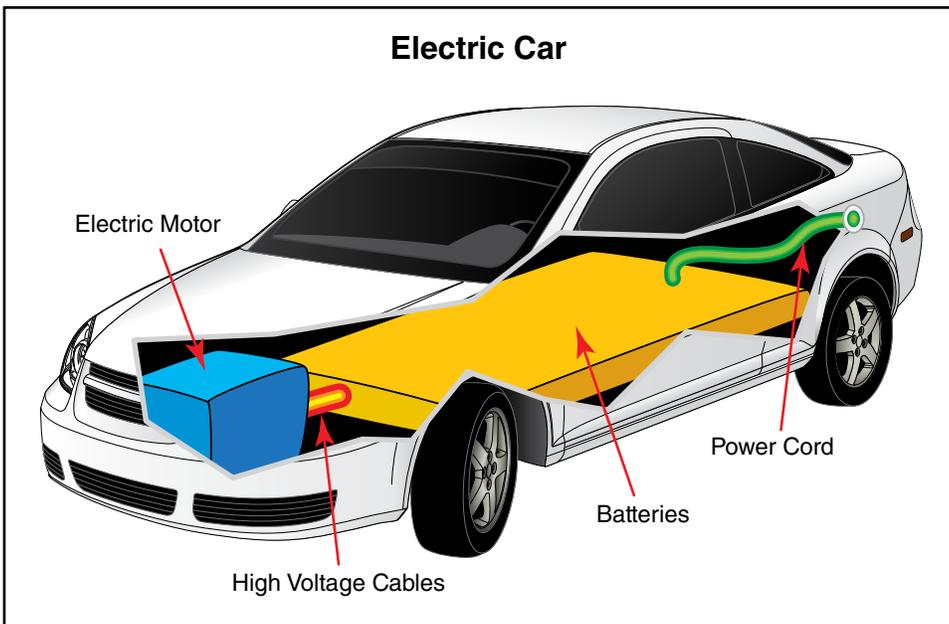


Figure 10.53a An electric vehicle (EV) may have a shorter drive range than a traditional vehicle due to the battery life span.

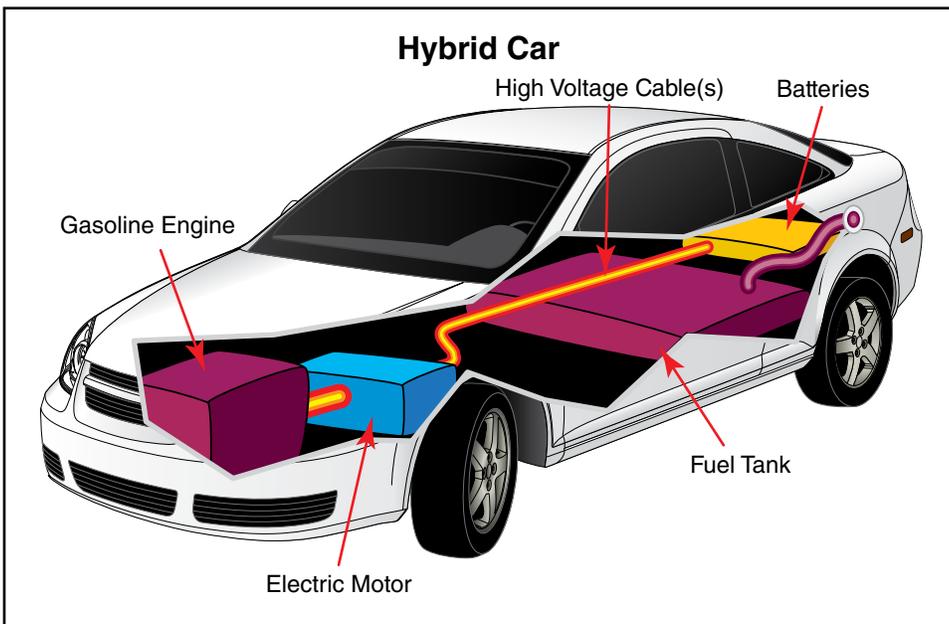


Figure 10.53b Hybrid vehicles (HEV) contain hazards common to both electric and traditional vehicles.

may be identified by a nameplate or logo. Rescue personnel attempting to isolate the electrical power system and batteries are exposed to the danger of electrical shock. To assist emergency responders in recognizing the high voltage power wires and cables, most hybrid vehicles have wiring that is color-coded orange and covered with orange shielding or orange tape (**Figure 10.55**). The 36-volt system on the Saturn, however, is color-coded blue. General Motors classifies the 36-volt system as intermediate voltage.

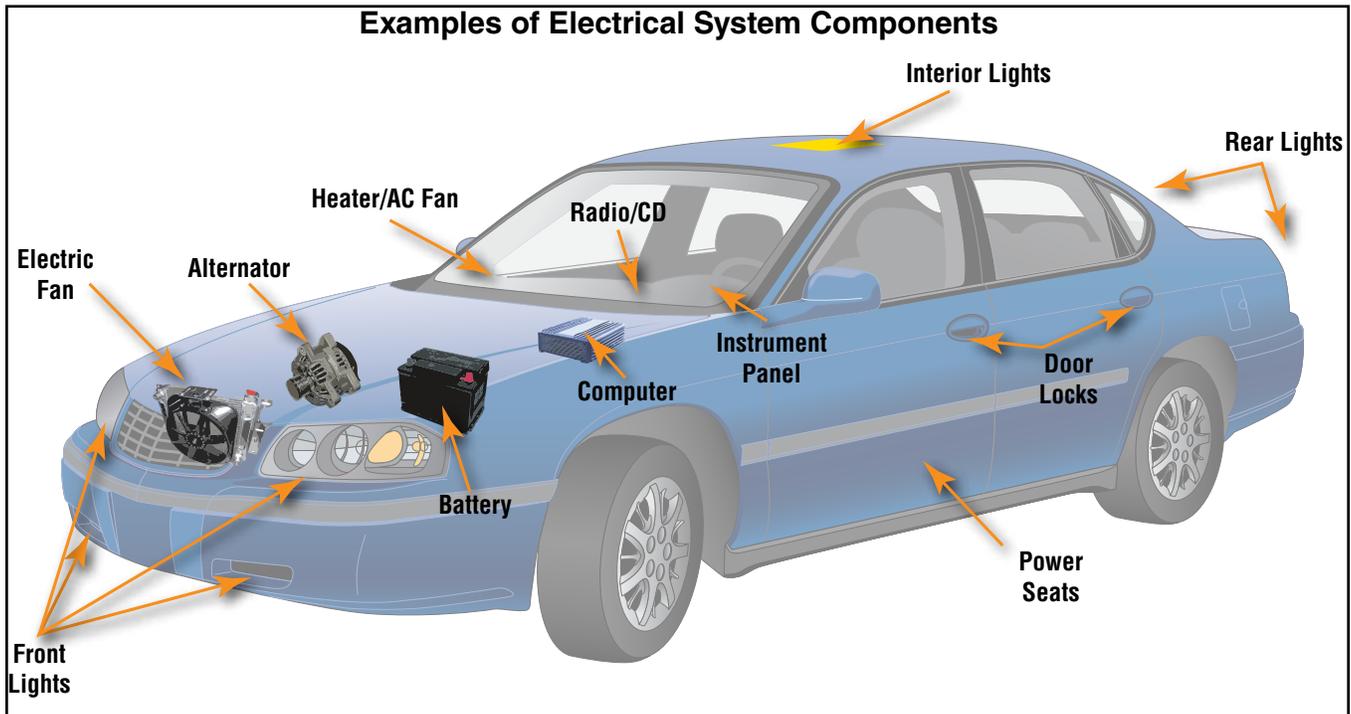


Figure 10.54 Electrical systems include generating and storing devices, as well as devices that use energy during the operation of the vehicle.

Figure 10.55 Most hybrid vehicles use orange wiring and shielding to indicate the presence of high voltage power wires.





Vehicle Voltage Chart

The following are the voltages found in electrical systems of a variety of vehicles:

12 Volt – ALL vehicles

36 Volts – Saturn Vue

42 Volt – Some conventional and hybrid models

72 Volt – Neighborhood Electric Vehicles (NEV)

144 Volt – All Honda hybrids

300 Volt – Toyota first generation Prius hybrids

500 Volt – Toyota second generation Prius

650 Volt – Toyota Highlander SUV, Lexus RX 400h and GS 450h hybrid

Assessing the Need for Extrication

Before beginning an extrication, the entire scene must be thoroughly assessed. In the immediate area around the vehicles, one crew member must:

- Assess the condition and position of the vehicles
- Determine extrication tasks that may be required
- Note any hazardous conditions

Meanwhile, another crew member surveys the entire scene, checking for:

- Other involved vehicles that may not be visible (over an embankment, for example)
- Victims who might have been ejected from the vehicles
- Damage to structures or utilities that may present a hazard
- Other circumstances that require special attention

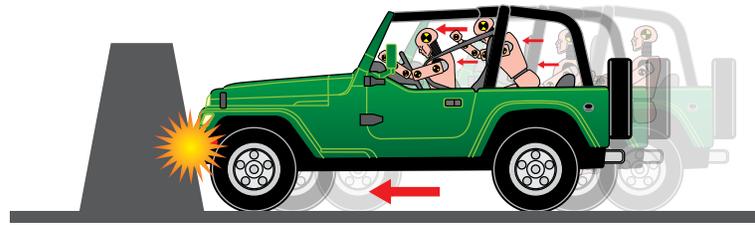
At night or in low light, a thermal imager (TI) can be helpful in locating victims who have been ejected.

A firefighter who is trained in emergency medical care will:

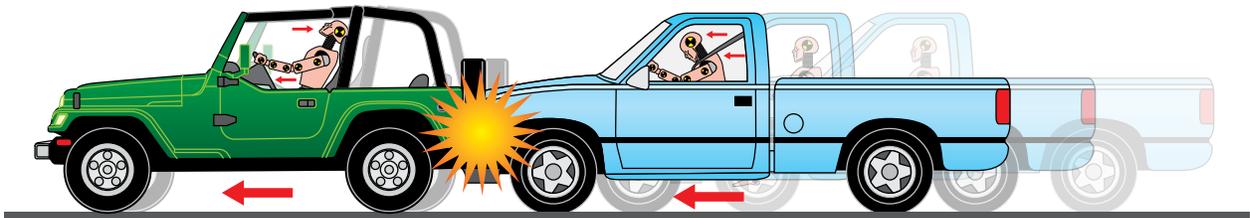
- Determine the number of victims
- Assess their injuries
- Assess the extent of their entrapment

All of this information helps the Incident Commander (IC) determine the resources needed to stabilize the incident and the order in which victims should be extricated. Seriously injured victims must receive higher priority than those with minor injuries. Victims who are not trapped should be removed first to make more working room for rescuers who are trying to remove those who are entrapped. As each assessment is completed, crew members should report the information to the IC. This report should also include the type of accident, such as rollover, head-on, side impact, and so on. The report should also include other identifiers (engine intruding into passenger compartment, unrestrained passengers, deformed steering wheel) that are helpful for hospital emergency room staff when determining likely injuries (**Figure 10.56, p. 512**).

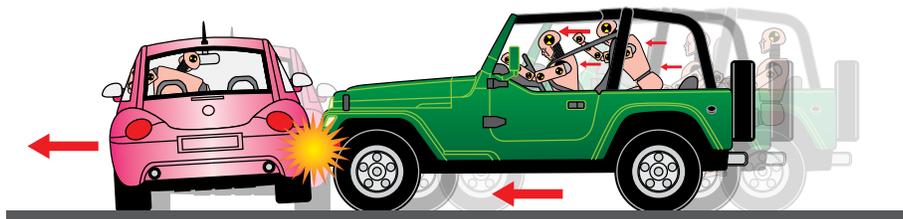
Types of Accidents



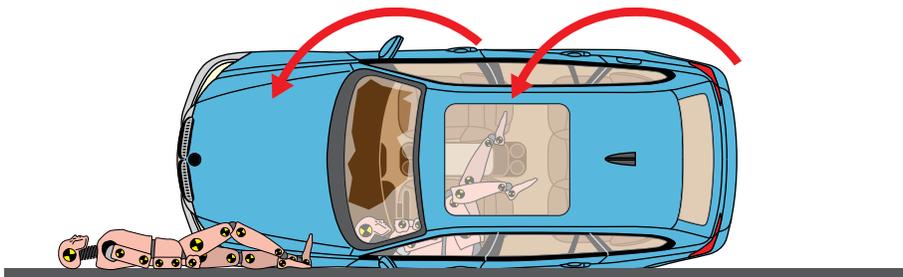
Front Impact



Rear Impact



Side Impact



Rollover

Figure 10.56 Knowledge of common types of vehicle impact injuries helps emergency responders to determine the correct response.

Stabilizing the Vehicle

Once the scene has been assessed, the vehicle must be stabilized. Use cribbing, wheel chocks, lifting devices, and buttress tension systems to support key points between the vehicle and the ground (**Figure 10.57**). The goal of stabilization is to prevent the vehicle from moving unexpectedly because movement can cause severe injury to both victims and rescuers.

Never move the vehicle or attempt extrication until the vehicle has been fully stabilized. This is particularly true if the vehicle is on its side, upside down, or in danger of falling over a cliff, bridge, overpass, or embankment (**Figures 10.58a–c**). Never place any part of your body under the vehicle while putting the stabilizing devices in place.



Figure 10.57 Several common resources, including cribbing, wheel chocks, and lifting devices should be used in tandem to support a vehicle before operations begin.



Figure 10.58a A vehicle that has been subject to a front-end collision may end with its wheels on the ground, but it may still require some stabilization to prevent sudden movement during extrication operations. *Courtesy of Bob Esposito.*



Figure 10.58b A vehicle on its side must be buttressed for stability at the least.



Figure 10.58c Unique configurations of vehicles require specialty tools and skills to create a stable environment for rescue activities.

Using Wheel Chocks

Even a vehicle with all wheels on the ground must be stabilized. One simple approach is to deflate the tires. But if deflating the tires is insufficient or impossible, chocking can accomplish the same result. Chocking can be accomplished with standard apparatus wheel chocks, pieces of cribbing, or other similar-sized objects such as bricks or rocks (**Figure 10.59**). **Skill Sheet 10-II-2** describes the steps for preventing horizontal movement of a vehicle using wheel chocks.

General wheel chock guidelines:

- Place chocks in front of and behind tires.
- Place chocks on the downhill side of a vehicle on an incline.
- Place chocks on both sides of the tires if the ground is level or the direction of the grade is undetermined.
- Test and apply the parking brake before placing chocks.
- Center chocks snugly and squarely against the tread of each tire.

If the vehicle's mechanical systems are operable, they can be used to supplement the wheel chocks. If possible, shift automatic transmission to park, or put manual transmission in first gear. Turn the ignition off, and engage the vehicle's parking or emergency brake.



Figure 10.59 Chocking is a non-damaging method of stabilizing and immobilizing a vehicle's wheels. *Courtesy of Jennifer Ayers/Sonrise Photography.*



Using Cribbing Materials

Cribbing is typically used in a box formation (**Figure 10.60**). Cribbing pieces are typically pushed into position with a mallet or with another piece of cribbing. Wedges may be necessary to ensure solid contact between the cribbing and the vehicle. Cribbing can also be placed under the sides of a vehicle to prevent lateral movement. **Skill Sheet 10-II-3** describes the proper method for stabilizing a vehicle using cribbing.

Using Lifting Devices

Lifting jacks and pneumatic lifting bags are used to:

- Raise a vehicle that is on its roof or side
- Support the frame of the vehicle
- Gain access to the interior by lifting an object that is resting on the vehicle

An advantage of using lifting jacks is that they can be adjusted to the required height and may be inserted into a tight space. Disadvantages include the following:

- They are time-consuming to place.
- They may limit access to the vehicle.
- They may shift, allowing the vehicle to move.

Pneumatic lifting bags can also be used to temporarily stabilize the vehicle. To be effective, at least two pneumatic lifting bags are needed. They may be positioned with one on each side of the vehicle, or with one in the front and one in the rear (**Figures 10.61a and b**).

Because jacks and lifting bags can be damaged or jarred loose, solid cribbing must be used to supplement them (**Figure 10.62, p. 516**). **Skill Sheet 10-II-4** describes the proper method for stabilizing a vehicle using lifting jacks.



Figure 10.60 Cribbing may be used in a variety of applications including vehicle stabilization.



Figure 10.61a Pneumatic lifting bags should be used in pairs at opposing sides of an unstable vehicle.



Figure 10.61b Pneumatic bags may be placed on adjacent sides of a vehicle while checking to ensure the stability of the load.

Figure 10.62 Solid cribbing supplements the work of a jack.



Figure 10.63 The choice of an anchor may have implications during the evolution of stabilization tactics.

Using Struts and Buttress Tension Systems

When vehicles are found upside down, on their side, or on a slope, rescuers should use whatever means are available to stabilize the vehicle. Traditional methods or buttress tension systems can be used to accomplish this.

Traditionally, a combination of cribbing, ropes, webbing, chains, and winch cables can be used to accomplish these types of stabilization tasks. Secure the ropes, webbing, or chains between the frame of the vehicle and a secure object such as a tree, railing, or other substantial object (**Figure 10.63**). You can also use the cable and winch on a fire apparatus or tow truck to secure the vehicle. Be aware that winch cables under tension can be dangerous if they break. Ensure that cables, chains, webbing, ropes, and winches have a safety margin in excess of the weight being secured. Ropes and webbing need to have a sufficient load capacity. **Skill Sheet 10-II-5** describes the method for stabilizing a vehicle using a system of ropes and webbing.

Adjustable struts can be used to stabilize a vehicle that is on its side. Struts typically consist of a square tube attached to a base plate, which spreads the vehicle load. The lower end of the tube houses another tube that telescopes out. A series of holes runs down the sides of both tubes, and a pin can be inserted through the holes to hold the tubes at the desired length. Any space remaining between the top of the tube and the bottom of the vehicle can be taken up with a screw jack in the end of the tube. A 4 x 4 inch (100 by 100 mm) wood post may also be used in place of the adjustable struts to support the vehicle.

The strut system has led to the buttress tension system, which is used to stabilize vehicles that are upside down or lying on their sides. Use a minimum of three buttress tension posts. Start by placing two on the least stable side of the vehicle. The longest side of the unit extends at a 50 to 70 degree angle from the ground to a high point on the vehicle. The two tension straps extend from the base of the long leg to points on the vehicle (**Figure 10.64**). **Skill Sheet 10-II-6** describes the method for stabilizing a vehicle using a buttress tension system.

Securing the Electrical System

The vehicle's electrical system must be shut down to eliminate a potential source of ignition. In newer vehicles, cutting power is especially important because electrical power can activate the vehicle's restraint systems, further injuring the victim and creating an additional risk of ignition (see the next section of this chapter for details).

Before shutting off the electrical power, lower power windows and unlock power doors. Move power seats back only if the victim's medical condition has been evaluated and it is safe to do so.

The simplest method of shutting down electrical power is to turn off the ignition and remove the key. This method will work on any type of car, both electric and nonelectric. However, if the ignition is not accessible, there are different procedures for shutting down power in electric and nonelectric vehicles.

Nonelectric Vehicles

Nonelectric vehicles include those powered by conventional fuels (gasoline, diesel) and alternative fuels (such as biofuels, ethanol, or natural gas). If the ignition is not accessible, disconnect or isolate the negative cables to the vehicle's 12-volt battery (**Figure 10.65**). **Cut the negative cable first, then the positive.** Remove approximately 2 inches (50 mm) of each cable.



Figure 10.64 Buttress tension straps and posts stabilize a vehicle that has come to rest on its side.



Figure 10.65 Disconnect the battery's negative cable before interacting with the positive cable.

Electric Vehicles

This includes both fully electric and hybrid electric vehicles. General safety guidelines for extrication include:

- Always assume that the vehicle is powered up despite the lack of engine noise.
- Place wheel chocks in front and behind tires to prevent unexpected vehicle acceleration.

- Place the transmission in park, turn off ignition, and remove key to disable the high voltage system.
- Disconnect the 12-volt electrical system in the same way you disconnect the battery in a conventional vehicle. Cutting the 12-volt negative and positive cables will isolate the high-voltage system.
- Because the vehicle can hold a charge from capacitors that can cause it to start, remove the key to a safe distance of 25 feet (7.62 m) from the vehicle.
- Stabilize the vehicle to prevent unexpected air bag deployments.
- Never touch, cut, or open any orange cables or components protected by orange shields. Orange cables and components contain high-voltage charges.
- Never touch, cut, or open any blue cables. Blue cables contain intermediate voltage charges.
- Remain a safe distance from the vehicle if it is on fire.
- Always wear an SCBA during and after fire suppression. A fire in the high-voltage battery pack of an electric car will produce toxic fumes.
- Be aware that metal tools, metal buckles on personal protective equipment, and metal jewelry can cause electrical shock if they come in contact with an energized portion of the vehicle.
- Consider the electrical system unsafe for at least 10 minutes after the ignition has been shut down, and be aware that it may hold a charge for up to 24 hours.
- Contact local auto dealerships for more information about their electric and hybrid electric vehicles.
- Review the Manufacturer Specific Emergency Response Guidelines of common electric vehicles in your response area.



Voltage Can Kill

If you are standing in water or your skin is wet, an electric charge of 20 volts can be deadly. If water is not present, a charge of 60 volts is deadly.

Passenger Safety Systems

Seat belts and more advanced passenger safety systems pose an immediate danger to both victims and rescuers (**Figure 10.66**). These systems include:

- Supplemental Passenger Restraint Systems (SPRS)
- Side-Impact Protection Systems (SIPS)
- Head Protection Systems (HPS)
- Extendable Roll Over Protection Systems (ROPS)

As discussed in the previous section, shutting down the electrical system can cut the power to these safety devices. But some can be activated in other ways, so you must know how to disable them individually.

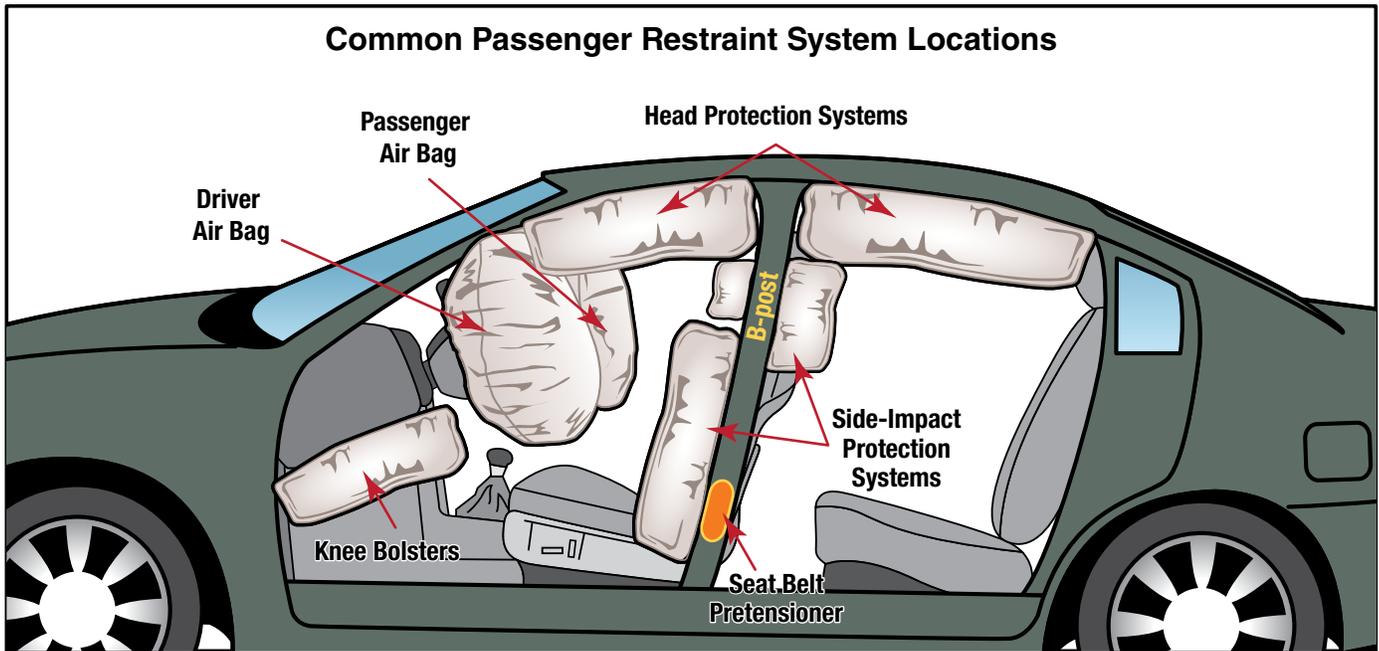


Figure 10.66 Passenger restraint systems may deploy without warning.

Seat Belts

Modern seat belts include devices called pretensioners that lock the belt during a crash to prevent further travel of the belt and the person wearing it. These devices are pyrotechnic, so if they are not disabled they present a significant ignition hazard. Pretensioners are hidden inside the **B-posts** or the center console (Figure 10.67). They can be accessed by removing B-posts' interior trim. Side-impact protection systems (SIPS) (also known as *side curtain air bags*) control modules may also be located in the B-post area. Because the pretensioners and SIPS control modules are hazardous, you should never cut into these units during extrication. Techniques to disable seat belts and seat belt pretensioners include cutting the seat belt webbing, unbuckling, and retracting the seat belts.

B-Post — Post between the front and rear doors on a four-door vehicle, or the door-handle-end post on a two-door car.

WARNING

Never cut a cable or touch a component with yellow/black or orange tapes, insulation, or tags. Doing so may cause electrocution or activate undeployed air bags.

Supplemental Passenger Restraint Systems (SPRS) and Side-Impact Protection Systems (SIPS)

Modern technology has added increased collision protection for vehicle occupants by means of Supplemental Passenger Restraint Systems (SPRS) and Side-Impact Protection Systems (SIPS), commonly called air bags or side curtain air bags (Figure 10.68, p. 520). These air bag systems may be triggered by extrication or fire fight-

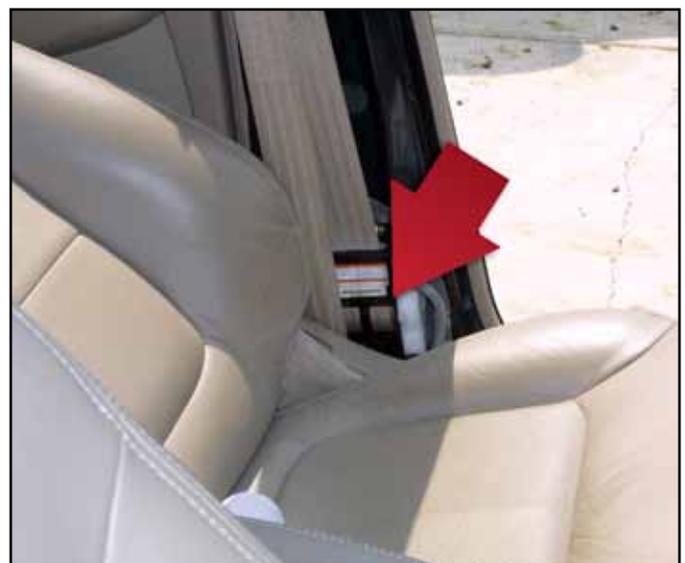


Figure 10.67 Pretensioners are pyrotechnic and should be avoided or protected during extrication evolutions.



Figure 10.68 Side curtain air bags deploy with enough force to cause injury or worse in situations they were not designed to mitigate.

ing operations. They deploy at up to 200 mph (322 km/h), generating potentially lethal force. In some cases, rescuers have been ejected from the vehicle after its air bags deployed. Always wear your protective equipment and be extremely careful when working in and around vehicles with air bag systems.

Although electric restraint systems are powered by the vehicle's battery, they can still deploy the air bags after the battery has been disconnected. The systems' reserve energy supply lasts anywhere from 2 to 60 minutes, depending on the vehicle's make and model. For this reason, some vehicles have a key-operated switch that drains reserve power.



Safety Zone Distances

Use the 5-10-12-18-20 rule to maintain safe working distances during extrication. Stay at least:

- 5 inches (127 mm) away from side-impact air bags and knee bolsters
- 10 inches (254 mm) away from driver frontal air bags
- 12-18 inches (304 to 457 mm) away from side-impact curtains (which deploy down from the headline)
- 20 inches (508 mm) away from passenger frontal air bags

These distances are general guidelines only. Actual safety zone distances will vary depending on make and model (**Figure 10.69**).

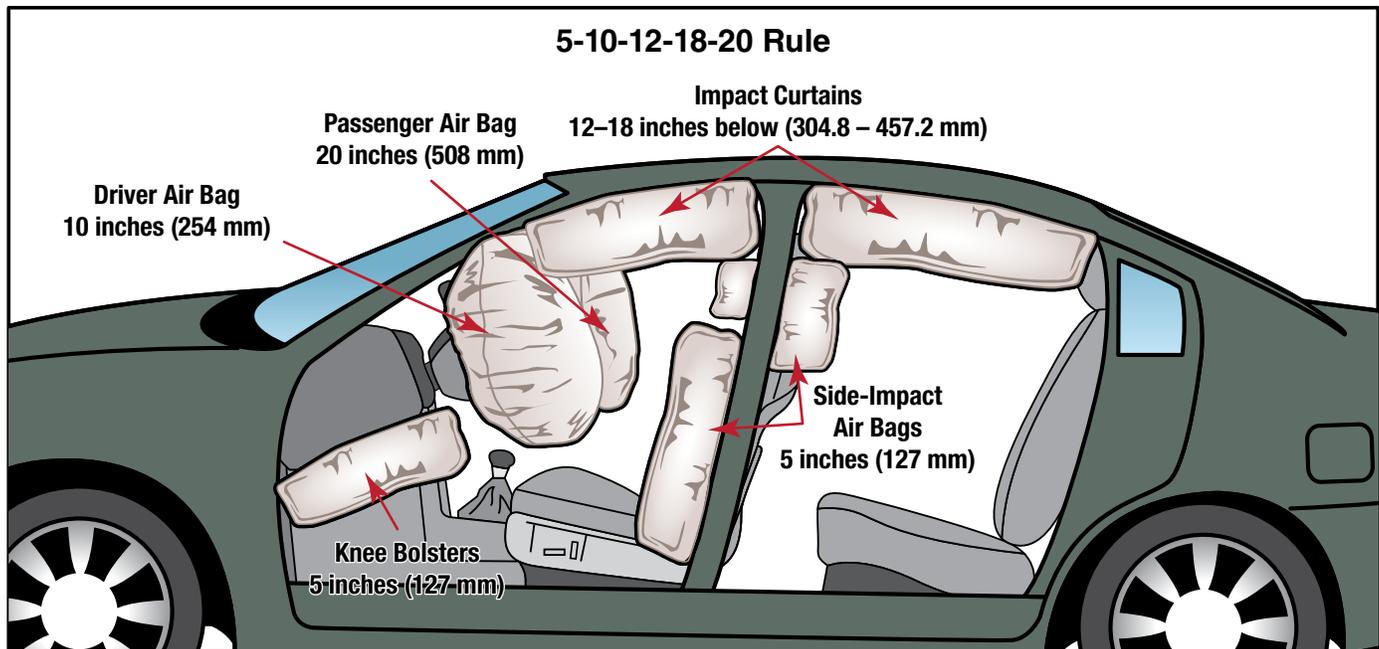


Figure 10.69 In addition to the locations, knowledge of the size of each type of restraint device will help responders access areas strategically.

SIPS restraints are often mechanically operated, so you cannot disable them by disconnecting the battery. If you accidentally apply pressure to the system's mechanical sensors, the air bags may deploy. To prevent accidental deployment, you must cut the connection between the sensors and the control unit, which is usually under the dashboard or in the center console. Disconnection procedures vary depending on the vehicle's make and model.

Head Protection Systems (HPS)

During a side-impact collision, HPS deploy air bags from just above the top of the door frame (**Figure 10.70**). There are two main types, window curtains and inflatable tubes. Window curtains automatically deflate shortly after deployment, but inflatable tubes do not. A knife or sharp tool is typically used to puncture and deflate the tube.



Figure 10.70 Head protection systems deploy automatically in case of side impact.

Rescuers working through a window opening may be directly in the deployment path of HPS air bags. This danger can be mitigated by removing the roof, but be careful not to cut into high-pressure cylinders and other devices used in conjunction with the HPS.

Extendable Roll Over Protection Systems (ROPS)

Extendable ROPS are designed to deploy automatically if the vehicle rolls over. They are found behind the front seat of small sports cars and in the rear window deck of convertibles (**Figure 10.71**). If you are working in a vehicle with an undeployed ROPS, you must stay in a safe working position (**Figure 10.72, p. 522**). Accidental deployment can cause serious injury.

These safety devices can deploy rapidly when the vehicle's inclinometer senses that the vehicle is approaching an angle of 62 degrees laterally or 72 degrees longitudinally, if the vehicle experiences a 3G acceleration force, or becomes airborne

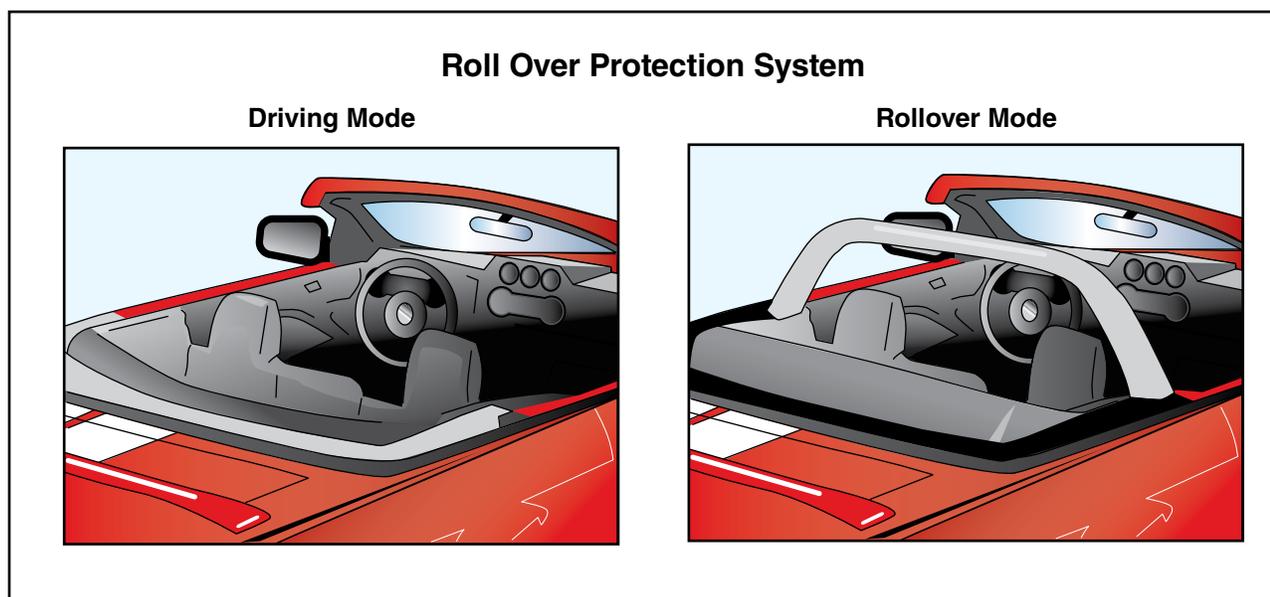


Figure 10.71 An active rollover protection system disengages while the vehicle is in driving mode.

Roll Over Protection System

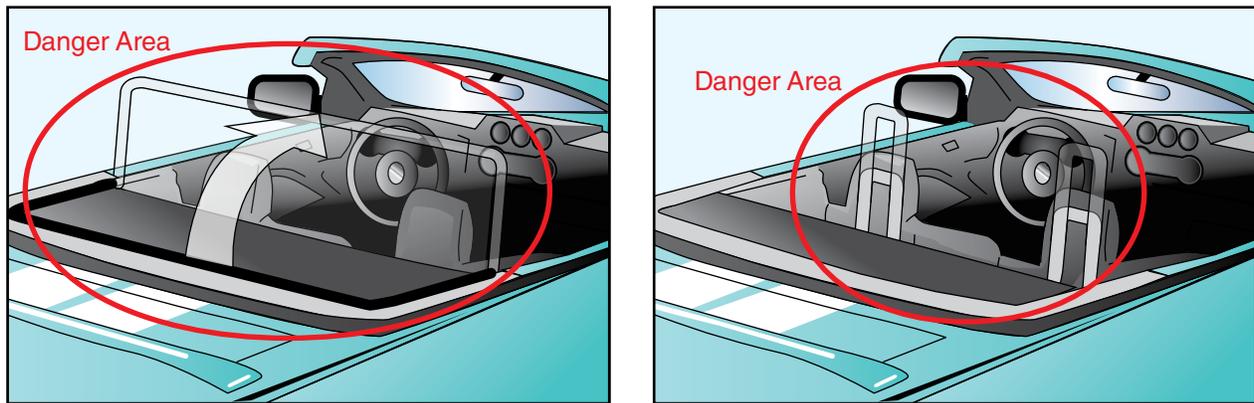


Figure 10.72 Safe working positions are clear of the area where a roll over protection system could engage without notice.

achieving weightlessness for at least 80 milliseconds (such as during a lifting operation) (**Figure 10.73**). To disable these devices power down the vehicle as soon as possible. In some cases you may have to deploy them intentionally to prevent them from being a hazard during extrication.

Gaining Access to Victims

Once the vehicle is stable and its electrical system is secure, rescuers must gain access to the victims. The four basic methods are (**Figures 10.74a-d**):

- Opening a normally operating door
- Removing a window
- Prying open a door
- Removing the roof

The best available method is the one that is simplest and fastest. Lengthier methods of access prolong victims' suffering and are more dangerous for both victims and rescuers. Seriously injured victims are also more likely to survive if they receive medical treatment quickly.

Opening a Normally Operating Door

Examine the door closest to the victim and try to open it normally. If you cannot, try the vehicle's other doors. If none of the doors open normally, use a tool to release one of the locks.

Removing a Window

Windows are removed to gain access to victims or reduce the danger posed by remaining fragments of broken glass. To protect yourself against loose or flying glass, always wear full protective equipment, including eye protection. Protect the vehicle's occupants by covering them with a salvage cover or protective blanket. Vehicle windows can be made from **safety glass** or **tempered glass**. Procedures for removing both types are detailed below.

Safety Glass — Two sheets of glass laminated to a sheet of plastic sandwiched between them; the plastic layer makes the glass stronger and more shatter resistant. Most commonly used in windshields and rear windows. *Also known as Laminated Glass.*

Tempered Glass — Treated glass that is stronger than plate glass or a single sheet of laminated glass; safer than regular glass because it crumbles into chunks when broken, instead of splintering into jagged shards. Most commonly used in a vehicle's side and rear windows.

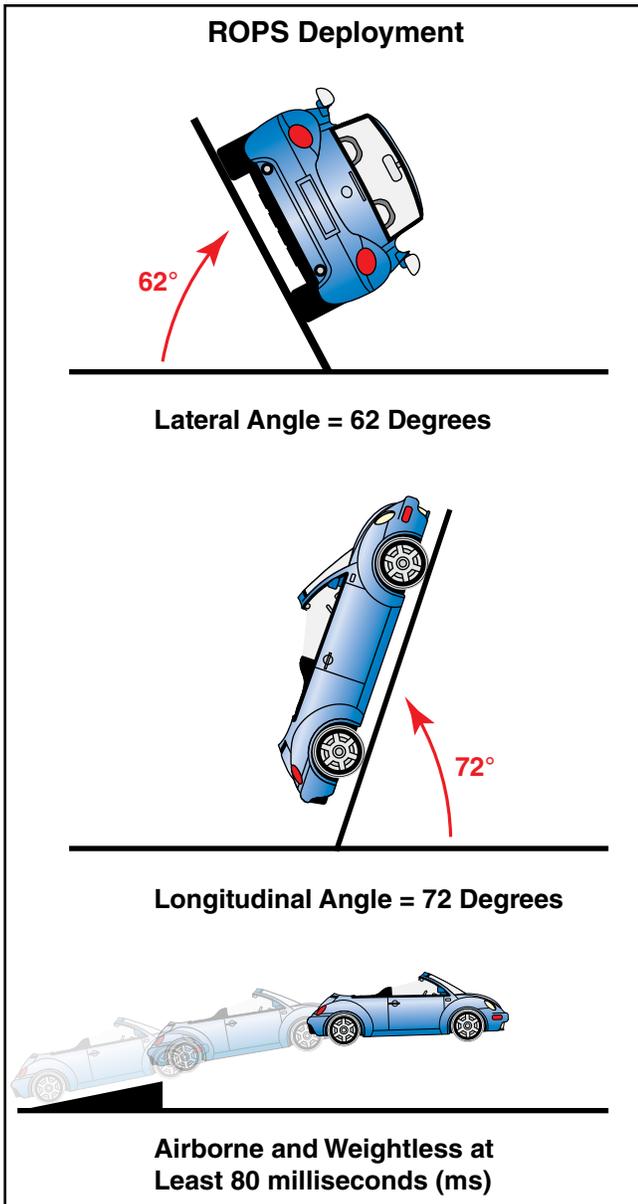


Figure 10.73 Roll over protection systems safeguard against passenger injury by engaging under a specific set of circumstances.

Figure 10.74a As in buildings, the first attempted entry into a vehicle should include checking the functionality of the doors. *Courtesy of Alan Braun/ Missouri Fire Rescue Training.*



Figure 10.74b Removing a window is the second logical step in gaining entry into a vehicle.



Figure 10.74c If a door doesn't open normally and a window is not feasible, prying open a door may then be attempted.



Figure 10.74d Removing a roof should only be attempted after exhausting the other alternatives.

Removing safety glass. Safety glass consists of two glass sheets bonded to a sheet of clear plastic sandwiched between them (**Figure 10.75**). It is most commonly used for windshields and rear windows. It breaks into long, pointed shards on impact, but the plastic laminate keeps most fragments in place. Some manufacturers add an additional layer of laminating plastic on the passenger side of the windshield to protect against lacerations.

Because many automobiles now use the windshield as a structural component, removing windshields is no longer standard practice during extrication. Removing the windshield seriously weakens the vehicle body and may cause it to collapse. Because it is difficult to tell which vehicles include this design feature, some departments no longer remove windshields. Whenever possible, leave the windshield intact.

Removing safety glass is more complicated and time-consuming than removing tempered glass. Safety glass does not disintegrate and fall out the way tempered glass does, and the extra layer of laminate on newer windshields makes them harder to chop through. Saws are the most effective tool for removing doubly laminated glass, but any of the following tools may be used to remove standard safety glass:

- Axe
- Air chisel
- Hay hook
- Reciprocating saw
- Coarse blade handsaw
- Windshield cutter or glass saw

Skill sheet 10-II-7 describes the method for removing a windshield in an older model vehicle. This method requires one firefighter on each side of the vehicle plus two additional firefighters to hold a blanket or cover over anyone inside the vehicle (**Figure 10.76**).



Figure 10.75 Safety glass is a required feature of automotive windshields.

Removing tempered glass. Tempered glass is most commonly used in side and rear windows. On impact, small fractures spread throughout the glass, which separates into many small pieces. This eliminates the long, pointed shards produced by shattered safety glass, but the small pieces can create nuisance lacerations and enter eyes or open wounds.

Removing tempered glass is relatively simple. The lower corner of the window breaks easily when struck with a sharp, pointed object, or when a spring-loaded center punch is pressed into it. Always use your opposite hand to support the hand holding the center punch (**Figure 10.77**). This prevents you from putting your hands through the glass when it breaks and prevents the center punch from hitting a victim who is close to the window. A non-spring-loaded center punch or Phillips screwdriver can also be driven into the window with a hammer or mallet (**Figure 10.78**). If nothing else is available, a Halligan tool or the pick end of a pick-head axe can also be used to break the glass. **Skill sheet 10-II-8** describes the method for removing a tempered glass side window.

CAUTION
Do not allow the tool to penetrate far enough to injure victims inside the vehicle.



Figure 10.76 Removal of a windshield presents implications that will require the assistance of four firefighters to accomplish safely. *Courtesy of Jennifer Ayers/Sonrise Photography.*



Figure 10.77 Maintaining vehicle stability while using a spring-loaded center punch is essential in safely breaking a tempered glass window.



Figure 10.78 A center punch achieves the purpose of knocking out a window by concentrating force on a small point.

Most broken glass will drop straight down onto the floor or seat, so always break the window that is farthest away from the victim. Make sure the victim is covered with a blanket or salvage cover before you break the glass.

Simple materials can also be used to contain the tempered glass during removal. If contact paper is applied to a window, most of the pieces will stick to the paper, allowing the window to be removed as a unit. The same effect is produced by applying duct tape, then spraying the glass surface with an aerosol adhesive. Within seconds this creates a coating layer, binding the glass together and allowing it to be removed in one piece. Rescuers can also use duct tape to form handles that help them carry or control the broken glass (**Figure 10.79**). All of these methods require more time, so use them only if time and patient care are not critical.



Figure 10.79 Duct tape is a simple resource that can be used in some tempered glass removal applications.

Rear windows can be made from tempered or safety glass. If the rear window does not respond to techniques for removing tempered glass, it is probably safety glass.



Defrost Films on Windshields and Rear Windows

Electric vehicles use high-voltage films to defrost windshields and rear windows. These films can cause electric shock.

Prying a Door Open

In some older cars, a lockout tool (also known as a *Slim Jim*) can be used to disengage the door lock. This tool is a strip of metal approximately 24 inches (600 mm) long and $\frac{3}{4}$ to $1\frac{1}{2}$ inches (20 mm to 40 mm) wide, with notches cut into the sides at one end. Insert the tool into the door between the window and the sill, then engage and release the lock.

A spreader can be used to open or completely remove a stuck door by inserting it into the crack on the hinge side. If the outer door panel is plastic, you may have to remove this panel in order to reach the metal door frame. If the interior molding is also plastic, remove the molding and check for curtain bag initiators or composite metal frames (**Figure 10.80**). Other techniques for opening doors include cutting hinges, breaking the latch mechanism (**Nader pin**), or compromising the door locks (**Figure 10.81**). For more information on these techniques, see the IFSTA **Principles of Vehicle Extrication** manual.

Nader Pin — Bolt on a vehicle's door frame that the door latches onto in order to close.

NOTE: Not all shears or cutters are capable of cutting the Nader pin.



Figure 10.80 Pulling out the interior trim allows a spreader to have unimpeded access to the steel frame of a vehicle door.



Figure 10.81 Component pieces of a door may need to be broken or disengaged to open the door.

Removing the Vehicle Roof

Removing the doors and roof from a **unibody construction** vehicle can seriously compromise its structural integrity (**Figure 10.82, p. 528**). Always place a step chock or other support under the B-post of these vehicles before removing the roof. Windshields, A-posts, and the forward edge of the roof also contribute to structural integrity. Leave these intact and cut the roof just behind the A-posts. The roof can then be removed by cutting the remaining door posts and lifting the entire roof off as a unit. Cut just below the roof level to avoid cutting into the seat belt pretensioners (commonly found in the B-posts) or side air bag gas cylinders. **Skill Sheet 10-II-9** describes two approaches to removing the roof from an upright vehicle.

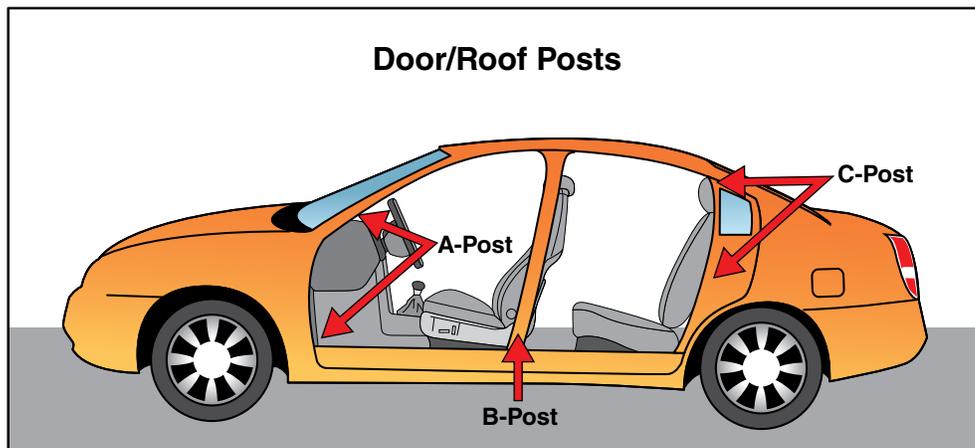
Unibody Construction — Method of automobile construction in which the frame and body form one integral unit; used on most modern cars. *Also known as* Bird Cage Construction, Integral Frame Construction, or Unitized Construction.



Cover Sharp Edges with Old Fire Hose

Cut posts leave behind very sharp edges. Use short sections of 3-inch (75 mm) fire hose to cover these hazards.

Figure 10.82 Door/roof posts are identified by letter starting with the A-post at the front of the passenger compartment.



If the vehicle is on its side, gaining access through the roof is particularly effective. Use an air chisel or reciprocating saw to make a vertical cut in the roof panel, starting about 6 inches (152 mm) from the edge of the windshield and moving down toward the ground. Make a similar vertical cut starting about 6 inches (152 mm) away from the edge of the rear window. Make a horizontal cut to connect the top ends of these vertical cuts, then flap down the roof panel to expose the headliner (**Figures 10.83 a-d**). Cut the headliner support struts with shears or bolt cutters. If you need to remove the headliner, use a knife to cut the same pattern you made in the roof panel. **Skill Sheet 10-II-10** describes the procedures for flapping a roof when the vehicle is on its side.

Cutting Posts

Case-Hardened Steel — Steel used in vehicle construction whose exterior has been heat treated, making it much harder than the interior metal.

Many modern vehicle components are made from **case-hardened steel** or exotic metals, such as boron, magnesium, titanium, and martensite. These metals are lighter, stronger, and result in greater fuel efficiency, but their strength makes them very difficult to cut through. Hand tools cannot cut through any posts made from exotic metals. Reciprocating and rotary saws may cut through boron metal posts, but the cutting does permanent damage to the saw blade (**Figure 10.84, p. 530**). In many cases, only specially designed shears can cut through roof support posts made from these materials.



Roof support posts typically house seat belt pretensioners or side curtain air bags. Make sure you do not activate these safety devices while cutting the posts. Removing the interior trim before cutting is recommended.

Displacing the Dashboard

This extrication technique is common after front-end collisions, in which victims are often pinned under the steering wheel or wedged under the dashboard. To extricate victims in the front seat, you must roll or displace the entire dashboard away from



Figure 10.83a The first cut through a vehicle roof should be vertical and about 6 inches (152 mm) from the windshield.



Figure 10.83b The second cut is parallel to the first cut and about 6 inches (152 mm) from the rear window.



Figure 10.83c The third cut connects the previous two cuts across the top.

Figure 10.83d After the cuts are completed, the roof can be pulled outward.





Figure 10.84 Power saws are the most effective on-site tools against exotic metal posts.

them. The most appropriate method for accomplishing this task depends on available tools, local SOPs, and the vehicle's condition. But the following method is generally accepted in almost all situations.

After removing the door, make a relief cut in the lower part of the A-post. Position an extension ram or hi-lift jack in the doorway, between the base of the B-post and the side of the dashboard. Insert cribbing or other supports under the base of the A-post on unibody vehicles, or between the frame and the body on full-frame vehicles. This prevents the dashboard from returning to its original position after the ram or jack rolls the dashboard forward (**Figure 10.85**). Once the victims have been extricated, these rescue tools can be retracted and removed.

This procedure may be accomplished without removing the windshield or flapping the roof and often by removing only one door. **Skill Sheet 10-II-11** describes this method for displacing (also known as rolling) the dashboard.

In some situations, rolling the dashboard may be unnecessary or impossible. In those cases, it may be necessary to cut the steering wheel post to extricate the driver. If it is accessible, the steering wheel post can be cut to remove the entire assembly. The steering column may also be lifted off

the victim by removing the windshield, placing a hook or chain around the column, and using a power lifting tool to raise it straight up (**Figure 10.86**).

Cutting the steering wheel ring can be hazardous to the victim and to responders. There are two primary hazards associated with cutting the steering wheel ring: accidental deployment of the air bag and the resulting spring action of the wheel when cut.



Figure 10.85 Hydraulic rams may be used to roll back a dash after vehicle's structure has been damaged.



Figure 10.86 Firefighters may use lifting tools to pull a steering column away from a victim.

Technical Rescue Incidents

Technical rescuers must meet the requirements of NFPA® 1006, *Standard for Technical Rescuer Professional Qualifications*. As a Firefighter II, you may have to assist technical rescuers in a variety of rescue types (**Figure 10.87**). Your assistance takes two forms: initial actions that are performed at any rescue scene and tasks related to specific incident types. These specific tasks include:

- Rope rescue
- Structural collapse
- Confined space
- Vehicle extrication
- Water rescue
 - Ice
 - Surface
 - Dive
 - Swiftwater
 - Surf
- Wilderness rescue
- Trench and excavation rescue
- Machinery rescue
 - Industrial
 - Agricultural
 - Elevators and escalators
- Cave, mine, and tunnel rescue



Figure 10.87 First responders may be tasked to assist technical rescuers.

Initial Actions

The first responders to reach the scene must perform the following critical tasks:

- Size up the situation.
- Communicate information.
- Stabilize the situation.
- Stabilize the victim.
- Establish scene security.

If you are a member of a unit, your supervisor will assign you tasks from this list. However, it is still important for you to know each of them. Never attempt to perform any rescue tasks for which you are not qualified or equipped.

Size-Up

Just as you would with any other emergency, you must size up the scene of any rescue. Size-up is an ongoing evaluation of:

- What has happened?
- What is happening?
- What is likely to happen?
- What resources will be needed to resolve the situation?



Figure 10.88 The dispatch report should be verified immediately upon arrival on the scene.

Size-up begins during the initial dispatch. The dispatcher should tell you generally what has happened, including the location, type of rescue, weather conditions, units dispatched, and possibly the number of victims. Some information may be inaccurate because it comes from witnesses or victims, not emergency responders. You may not know that a rescue is required until you reach the scene.

Upon arrival, verify the accuracy of the dispatch report by observing the scene yourself (**Figure 10.88**). Note any hazards that will affect victims or the rescue team. Assess what is likely to occur if no action is taken, and determine the priority of actions that should be taken. For instance, it may be necessary to extinguish a fire before rescue operations can begin. Determine whether additional resources must be dispatched to the scene, such as heavy equipment to move debris, an aerial device to access victims, or a heavy-duty wrecker to move a vehicle.

Communicate the Information

Your next task is to communicate the information you have gathered to the dispatch center and all responding units. The arrival report (sometimes called a situation report) for technical rescue incidents should contain the following:

- Unit arriving on scene
- Correct address of the incident if different from the dispatch report
- Description of conditions found at the scene
- Special considerations
- Intended initial actions

- Water supply if needed
- Establishment of Command
- Any additional resources needed, including medical units

Describe conditions clearly so that other fire crews know what to expect when they reach the scene. Provide details about barriers to access and victims in need of assistance. Include a command statement, which indicates who is in initial command of the incident. State the location of the Command Post and give a description of initial actions. If the operation will be managed over a specific radio frequency, the communications center will tell responding units to switch to that frequency during dispatch.

When a superior officer arrives, you officially transfer Command to that officer. Provide a description of what you have observed and your initial actions.

Stabilize the Situation

Stabilizing the situation means preventing it from getting worse. This involves activities such as blocking traffic, shutting off utilities, or suppressing fires that can affect rescue operations (**Figure 10.89**). Incidents involving machinery may require that the equipment remain on until an expert determines that it is safe to shut it down.

Stabilize the Victim

After the scene has stabilized, the next priority is to provide basic patient care to any accessible victims (**Figure 10.90**). However, you must not put yourself at risk in an attempt to access a victim that will require the skills of a qualified technical rescue firefighter.



Figure 10.89 Stabilization tactics include lockout and tagout of utilities that may be involved in or potentially contribute to the hazard of the incident.



Figure 10.90 Basic care to victims must wait until stabilization procedures are completed. *Courtesy of Alan Braun/Missouri Fire Rescue Training.*

Establish Scene Security

The Incident Command System requires that any scene have a well-maintained perimeter or barrier around the incident. This is intended to:

- Provide a controlled work space
- Protect bystanders from hazards at the incident
- Ensure the use of the personnel accountability system
- Ensure that victims are accounted for
- Protect evidence in the event of a suspicious incident
- Prevent further collapse of a structure or trench due to vehicle vibrations

The Incident Commander determines the location of the outer perimeter, which you may be assigned to mark. Stretch utility rope or barrier tape between any available objects, such as signs, trees, utility poles, or parking meters. Leave a controlled opening near the Command Post. The Accountability Officer will monitor this entry point. Another opening may be necessary to provide access for ambulances and other emergency equipment.

An incident scene is typically divided into three control zones labeled hot, warm, and cold (**Figure 10.91**). Their size, shape, and distance from the hazard depends on weather conditions, general topography, the amount of room needed by working personnel, and the nature of the hazard.

The hot zone is the most critical area of the scene and includes site of the actual emergency. To limit crowds and confusion, only personnel who are directly involved in resolving the emergency are allowed within the hot zone. Personnel in the hot zone must:

- Sign in to the personnel accountability system
- Wear personal protective equipment (PPE) designed for the specific hazard
- Be trained to manage the situation

The warm zone is immediately outside the hot zone. Access is limited to personnel who are directly supporting the work being performed in the hot zone. All personnel must be in full PPE and ready to enter the hot zone. At hazardous materials incidents, a decontamination station is usually assembled in this zone.

The cold zone is the furthest away from the incident. Access is limited to working personnel, and the outer boundary forms the crowd-control line for the general public.

Incident Specific Tasks

Each type of technical rescue incident has its own requirements for equipment, procedures, and personal protective clothing. To assist the technical rescue team when they arrive, you must be able to recognize, locate, and sometimes operate their equipment. You must also be able to recognize the hazards associated with each type of incident and methods for mitigating it.

Rope Rescue Operations

Rope rescue operations involve the use of life safety rope, harnesses, tripods, and accessories to access and remove victims. You may be assigned to retrieve this equipment. In general, rope rescue is divided into high angle urban/structural and

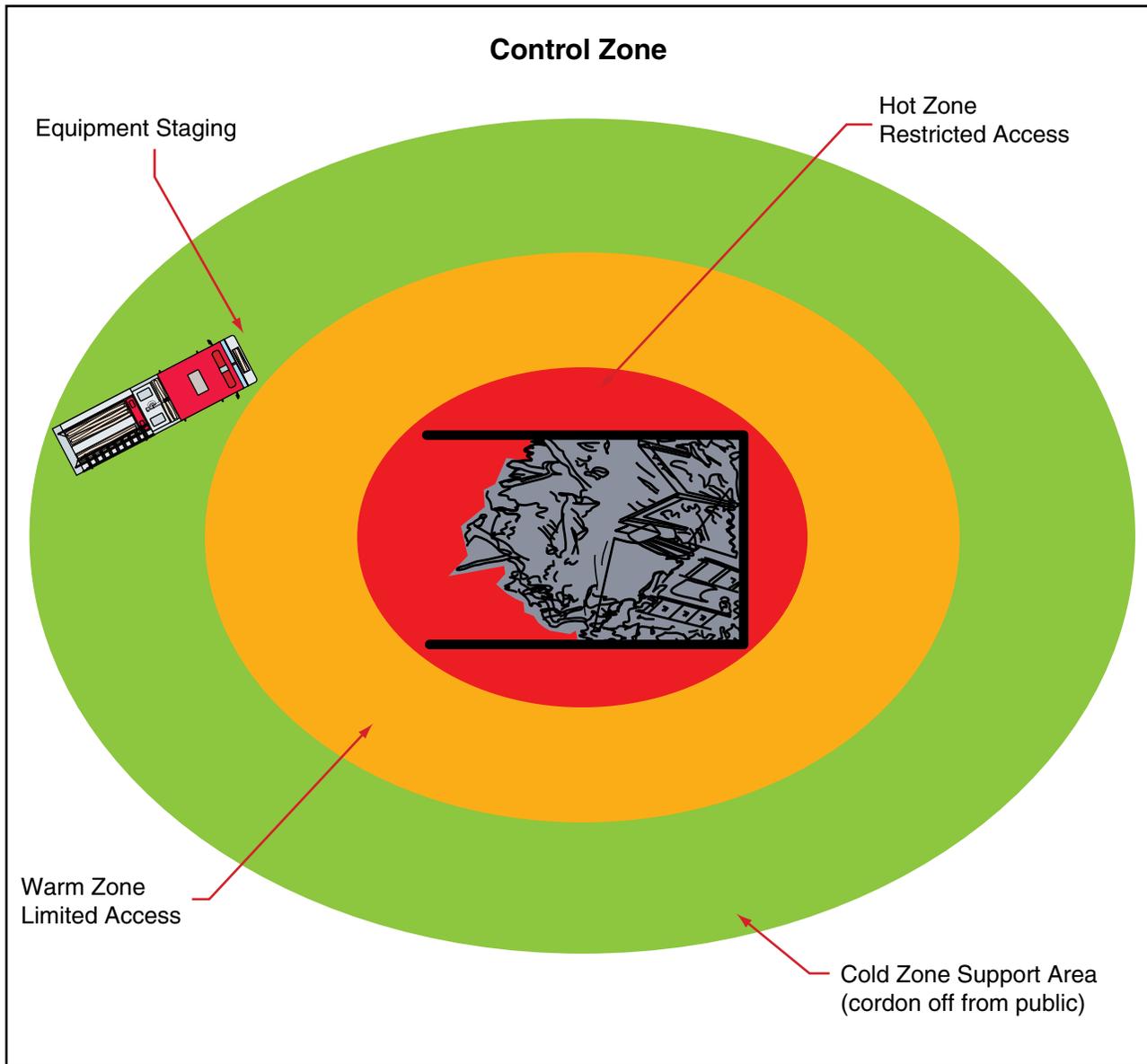


Figure 10.91 Control zones divide an incident scene into hazard and activity level areas.

wilderness/mountain rescue (**Figures 10.92a and b, p. 536**). An example of a high-angle rescue would be rescuing injured workers from a scaffolding on the side of a structure. Wilderness/mountain rescue may involve removing a victim from the base of a cliff or steep slope. The main hazard posed to rescuers is that they are working without a safety net in the same environment as the victims.

Structural Collapse Rescue Operations

Structural collapse may be caused by fire, extreme weather, earthquakes, explosions, or the deteriorated condition of an aging structure. The first priority at the scene is to help get untrapped victims to a safe area. The next priority is to extricate victims who are lightly trapped by collapse debris. After these victims are taken care of, technical rescue teams attempt to rescue victims who are trapped deep within the rubble.



Figure 10.92a Urban high angle rope rescue can be practiced on purpose built structures.



Figure 10.92b Wilderness and mountain rescue is made possible by the strategic use of ropes.

To assist the rescue team, you must be able to recognize different collapse patterns. Structures collapse in predictable patterns, allowing you to predict the location of trapped victims. The five patterns of structural collapse are (**Figures 10.93a-e**):

- Pancake
- V-shaped
- Lean-to
- A-frame
- Cantilever

Pancake collapse. This pattern can occur when exterior walls collapse simultaneously, causing the roof and upper floors to collapse on top of each other (like a stack of pancakes). The collapse of the World Trade Center in 2001 was one example. This pattern is the least likely to contain voids in which live victims may be found. However, always assume that there are survivors until it is proven otherwise.

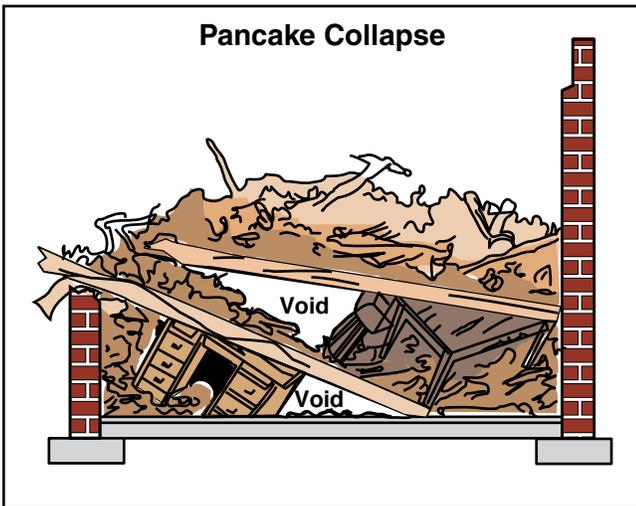


Figure 10.93a A pancake collapse is defined by near-parallel floor structures with debris between that may hold void spaces.

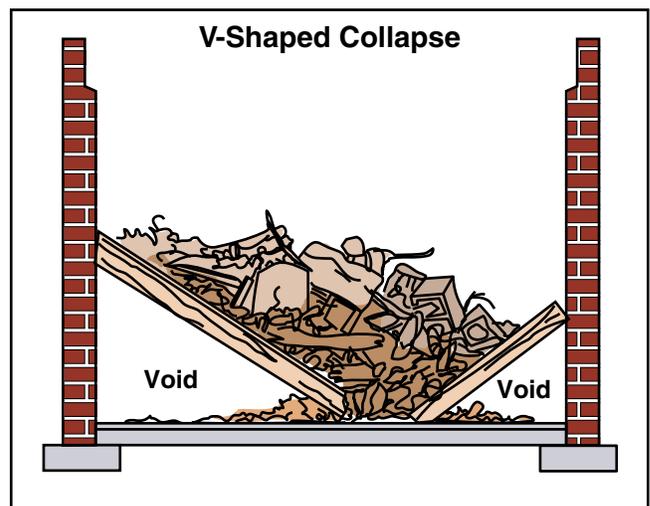


Figure 10.93b A V-shaped collapse creates void spaces on either side of a cave-in at the center of the structure.

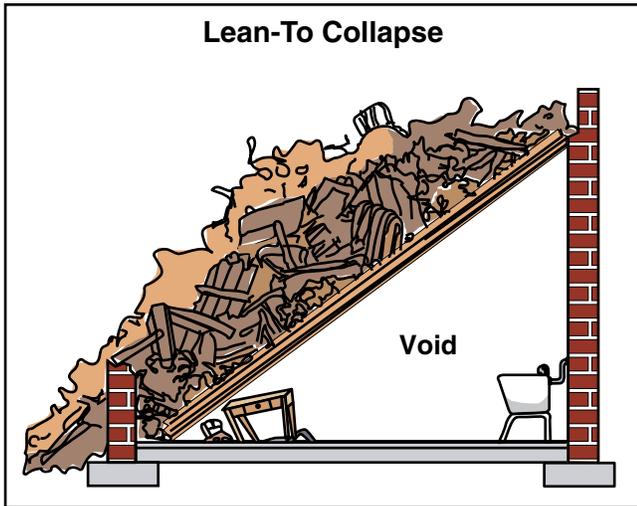


Figure 10.93c A lean-to collapse is characterized by sections of the wall holding their original position while other sections of the wall fall in toward the definitive event.

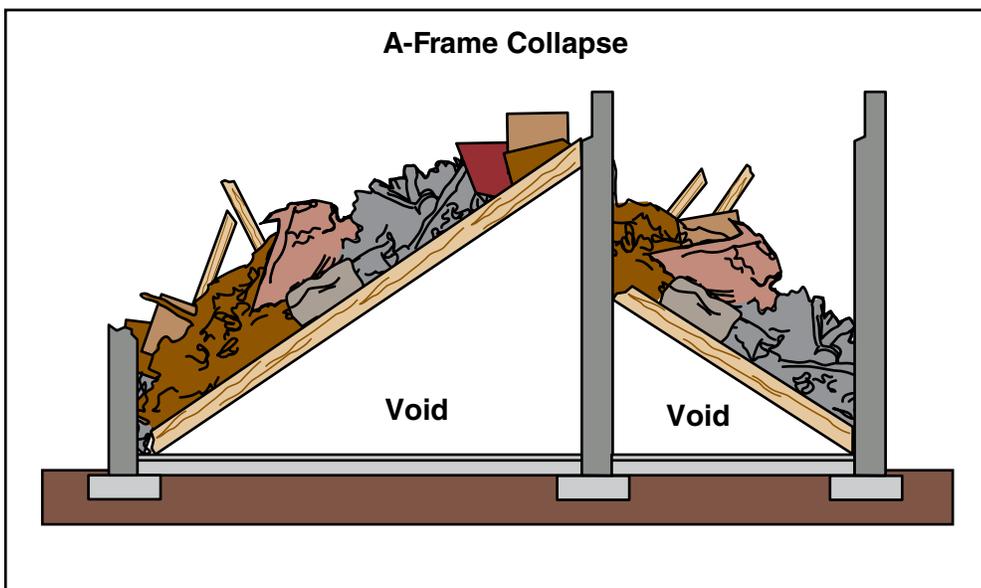


Figure 10.93d An A-frame collapse is characterized by fallen walls near the outside of the structure and intact void spaces along an interior structural wall.



Figure 10.93e The Murrah Building in Oklahoma City demonstrated a cantilever collapse.

V-shaped collapse. This collapse pattern occurs when the outer walls remain intact and the upper floors and/or roof structure fail in the middle. This pattern offers a good chance of habitable void spaces being created along the outer walls.

Lean-to collapse. This collapse pattern occurs when one outer wall fails while the opposite wall remains intact. The side of the floor or roof assembly that was supported by the failed wall drops to the floor, forming a triangular void in which victims are likely to survive.

A-frame collapse. This pattern occurs when the floor and/or roof assemblies on both sides of a load-bearing center wall collapse. This creates a pair of lean-to collapses on opposite sides of the load-bearing wall. Victims have a good chance of surviving within the void spaces on both sides of the wall.

Cantilever collapse. This collapse pattern occurs when one or more walls of a multistory building collapse, leaving the floors attached to and supported by the remaining walls. One example of this pattern was the Oklahoma City Murrah Federal Building following the 1995 explosion. This pattern offers a good chance of habitable voids, but it is the most vulnerable to **secondary collapse**.

Physical hazards. Primary physical hazards include:

- Debris that is sharp, jagged, or unstable (**Figure 10.94**)
- Exposed wiring and rebar
- Broken glass
- Confined spaces
- Unprotected openings
- Heights
- Secondary collapse

Environmental hazards. Potential environmental hazards include:

- Fire
- Noise
- Darkness
- Temperature extremes
- Adverse weather conditions
- Damaged and leaking utilities
- Atmospheric contamination
- Hazardous materials contamination

Confined-Space Rescue Operations

The Occupational Safety and Health Administration (OSHA) defines a *confined space* as one that:

- Is large enough to enter
- Has limited means of entry and exit
- Is not designed for continuous occupancy

Confined spaces in which firefighters must perform rescues include (**Figure 10.95**):

- Tanks/vessels
- Silos/grain elevators

Secondary Collapse — Collapse that occurs after the initial collapse of a structure; common causes include aftershock (earthquake), weather conditions, and the movement of structural members.



Figure 10.94 Debris from a demolition event presents several physical hazards.

- Storage bins/hoppers
- Utility vaults/pits
- Aqueducts/sewers
- Cisterns/wells
- Cofferdams
- Storage tanks

Firefighters without confined-space rescue training are limited to performing non entry rescues and support functions outside of the space. Trained personnel can perform rescues inside the space, but are limited to operations within the scope of their specific qualifications.

Atmospheric hazards in confined spaces include:

- Oxygen deficiency due to inadequate ventilation
- Flammable gases and vapors
- Toxic gases
- Extreme temperatures
- Explosive dusts

Physical hazards include:

- Limited means of entry and egress
- Tight constricted spaces
- Cave-ins or unstable support members
- Standing water or other liquids
- Utility hazards, such as gas, sewage, and electricity

Valuable sources of information include preincident plans and knowledgeable people at the scene. Preincident plans should describe lighting, ventilation, and communication at the scene. They should also have details relevant to protecting victims and rescuers and controlling utilities and other hazards. Plant or building supervisors may be able to tell you the number of victims, their probable location, and potential hazards.



Figure 10.95 Confined spaces contain a range of challenges that can include dangers typical of other types of technical rescues.



Figure 10.96 When the supplied air respirator system is functional and ready for operations, the firefighter monitoring the system should signal the team.

Rescuers may not be able to wear SCBA because of space limitations. Supplied air respirators (SAR) are typically used, especially in extended rescue operations. Hoses up to 300 feet (91 m) long connect rescuers' facepieces to an air cylinder or breathing-air compressor outside the entrance. You may be assigned the task of setting up and monitoring the SAR system for rescue personnel (**Figure 10.96**).

All rescuers have a search line attached to their rescue harness. This line must be constantly monitored at the entrance, and a communication system between inside and outside personnel must be prearranged. Portable radios may not work within the space, so hard-wired telephones are usually preferred.

One basic method of signaling with the search line is the *O-A-T-H* method. One tug on the search line represents the letter *O* which stands for *OK*. Two tugs represent the letter *A*, which stands for *Advance*. Three tugs represent the letter *T*, which stands for *Take-up* (eliminate slack). Four tugs represent the letter *H*, which stands for *Help*. This system must be practiced often to be effective.

Electrical equipment such as flashlights, portable fans, portable lights, and radios must be intrinsically safe for use in flammable atmospheres. A rapid intervention crew or team (RIC/RIT) qualified for confined-space operations must be standing by while rescuers are working inside the confined space.

Vehicle Rescue Operations

Depending on the local policy and procedures, vehicle extrication may be assigned to a technical rescue team or to an engine or truck company trained and equipped to perform this type of task. If you are not a member of a unit that is trained to perform vehicle extrication, you will assist the rescue team members in setting up their equipment, providing care to the victims, standing by with a charged hoseline, and providing a security barrier around the incident. Remember that you must wear the correct PPE when working near the damaged vehicle and you must wear an approved retroreflective vest if you are not engaged in fire suppression or extrication.

Water Rescue Operations

Water rescue operations include the following conditions:

- Ice
- Surface
- Dive
- Swiftwater
- Surf

Locations where water rescue may be required include:

- Swimming pools
- Ponds
- Lakes
- Rivers
- Streams
- Coastal shorelines
- Swamps
- Drainage canals

- Low-head or low-water dams
- Water treatment facilities

The first task during size-up is to determine whether the incident requires rescue or recovery operations. Rescues are incidents where the victim may be saved, typically if they are stranded or floundering. Recoveries are incidents where the victim has been submerged for a long period of time and is likely dead. The operation's main goal is to recover the body.

Personal flotation devices (PFDs) are mandatory for all personnel entering the water, working within 10 feet (3 m) of the water's edge, or riding in waterborne craft. PFDs must be approved by the U. S. Coast Guard or Transport Canada. Firefighters assisting the rescue team may wear structural PPE for warmth, but they should not approach the water's edge (**Figure 10.97**). If you fall into the water, structural PPE can quickly become water-logged and pull you underwater.



Water rescue hazards that you should describe in the situation report include:

- Undercurrents
- Unstable or slippery soil at water's edge
- Debris
- Sink holes
- Quicksand
- Sharp rocks
- Extreme temperatures
- Chemical or biological contamination
- Poisonous or dangerous reptiles

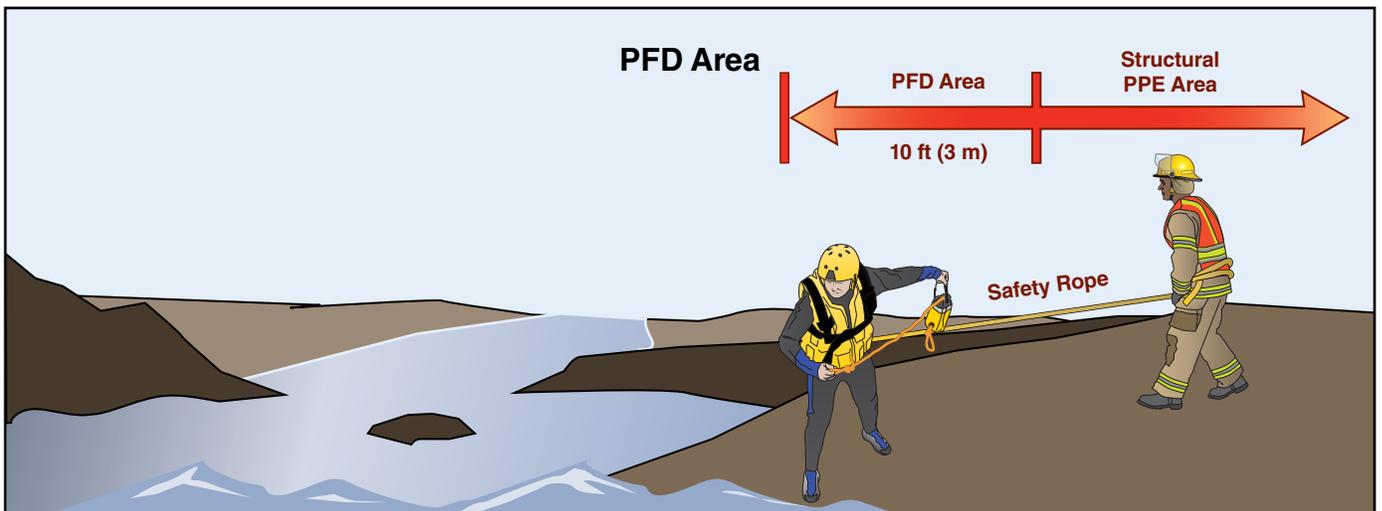


Figure 10.97 Water operations must be approached with the correct gear to prevent injuries to rescuers and victims.

Additional hazards are specific to ice rescues, such as thin and unpredictable ice. Just because ice appears thick does not mean that it is strong; the fact that there is a victim in the water is proof that the ice is weak. Victims are also unlikely to be able to help with their own rescue. Their hands are extremely cold and possibly frozen, making it difficult to grasp a rope or other aid. Their heavy, wet clothing also makes it difficult to keep their heads above water.

Hypothermia — Abnormally low body temperature.

Low-Head Dam — Wall-like concrete structure across a river or stream that is designed to back up water; allows water to flow over the crest and drop into a lower level. *Also known as Low-Water Dam.*

The victim will almost certainly be suffering from **hypothermia**, so it is critical to have an advanced life support unit on scene to start immediate patient care. Immersion in ice water causes the body's core temperature to drop dramatically. Rescuers must remove victims quickly to increase their chance of survival.

Low-head or low-water dams are extremely dangerous for both victims and rescuers. These dams create a pool of standing water in a river or stream. Water recirculates as it passes over the face of the dam, creating powerful undercurrents (**Figures 10.98 a and b**). Debris trapped against the upstream face of the dam poses an additional hazard.



Hazards Created by a Low-Head Dam

Low-head dams are extremely hazardous work areas. Exercise extreme caution when performing any operation nearby.

Figure 10.98a A low-head dam creates a dangerous drowning hazard for anyone who gets caught in the undercurrent. *Courtesy of Jake Zlomie.*

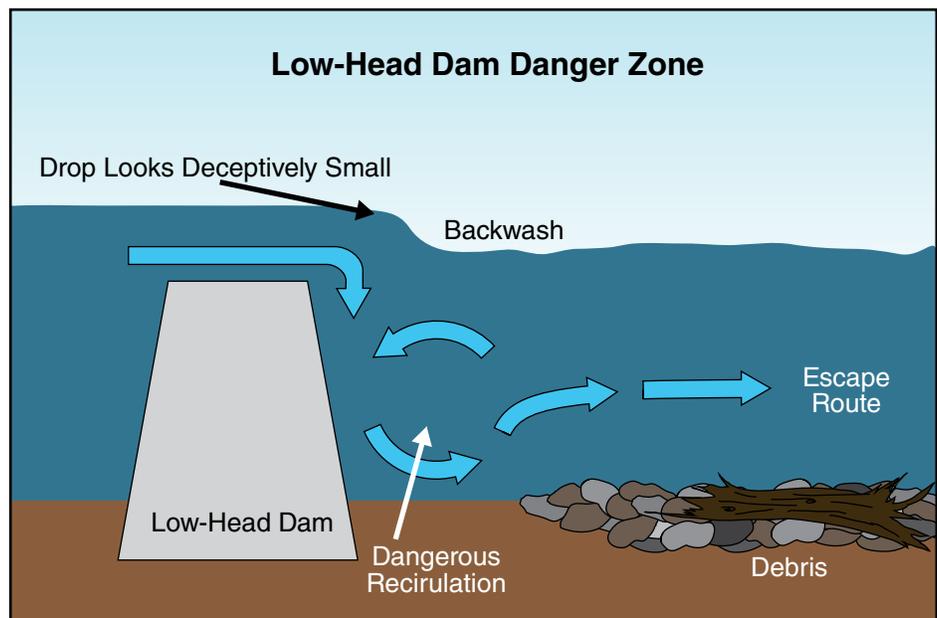


Figure 10.98b A low-head dam poses an entrapment and drowning danger for victims and rescuers.

Wilderness Rescue Operations

Wilderness rescues take place in rugged, inaccessible terrain. Technical rescuers typically use ropes and harnesses to descend to the victim, stabilize any injuries, and remove the victim in a basket or stretcher. Assisting during wilderness rescue includes such tasks as establishing rehab facilities and carrying tools and equipment to a point near the victim.

Hazards include climate extremes and the possibility of a long-term search before the victim is located. Heat stress and dehydration are especially common, so wearing structural PPE is not recommended in hot climates. Structural boots do not protect feet and ankles from the hazard posed by the rough terrain. Large quantities of water should be available, and rehab facilities are mandatory.

Trench Rescue Operations

Trench rescue teams must be skilled in shoring and stabilizing trench walls (**Figure 10.99**). When assisting at a trench rescue, you will most likely be assigned to monitor for hazardous atmospheres or create a safe zone around the trench. Vibrations can cause secondary cave-ins, so all bystanders, nonessential personnel, apparatus, and heavy equipment must be kept well back from the trench lip.

Follow these safety guidelines when assisting with trench rescues:

- Do not enter the trench.
- Cordon off an area 100 feet (30 m) in each direction from the trench.
- Eliminate sources of vibration within 500 feet (150 m) of the trench, such as apparatus and heavy equipment.
- Place exit ladders no more than 50 feet (15.24 m) apart, with the initial ladder near the location of the victim.
- Ladders should extend at least 3 feet (1 m) above the top of the trench (**Figure 10.100**).
- Secure any exposed utilities.
- Be careful when handling tools. Dropped or mishandled tools can injure both rescuers and victims.



Figure 10.99 Trench rescue teams are specially trained to stabilize and shore trench walls.



Figure 10.100 Safe ladder placement contributes to an effective trench rescue operation.

- Be aware of additional hazards, such as underground wiring, water lines, or toxic or flammable gases.
- If the trench is contaminated or oxygen-deficient, set up ventilation fans to allow rescuers to continue working.

Machinery Rescue Operations

Machinery rescues involve a victim who has been caught between parts of a machine. The types of injuries that result make these incidents extremely stressful. Machinery rescues may occur at:

- Machine shops
- Manufacturing facilities
- Agricultural sites (**Figure 10.101**)
- Lumber mills
- Scrap metal recycling facilities
- Construction or demolition sites
- Shipyards
- Railroad yards
- Transportation terminals

When sizing up the situation, note the following:

- Victim's medical condition and degree of entrapment
- Type of machinery
- Number of rescue personnel needed
- Extrication equipment needed
- Presence of fire or hazardous material
- Scene safety issues
- Precautions necessary before securing power to the machinery

Figure 10.101 Make sure ignition switches are clearly labeled while rescue evolutions are underway near agricultural equipment.



WARNING

If the victim is entangled in a machine that is still running, **DO NOT** turn it off until the mechanism has been stabilized. Turning off the machine may cause it to reverse itself or complete its cycle – either of which could harm the victim further. Contact the machinery owner, operator, or plant personnel for guidance in securing the mechanism.

Stabilize the machine with cribbing, chains, or heavy-duty nylon webbing, then shut off the machine's power. Use a **lockout/tagout device** to secure the power switches.

Rescuers may need outside expertise to resolve the situation. Plant personnel who use the machinery are usually good sources of information, but an off-site expert (such as the machinery manufacturer) may be required. Off-site experts should be identified in the department's preincident plan.

Elevator and Escalator Rescue Operations

In some jurisdictions, these rescues are not limited to technical rescue personnel. Firefighters can often extricate victims quickly and safely if they are equipped with ladders, manual and power tools, and forcible entry tools. But more hazardous types of elevator rescues require certified technical rescuers.

Elevator rescue. Elevators are classified based on their primary use. Passenger elevators typically are small, accelerate quickly, and have automatic controls. Freight elevators are slower, with large access doors and either manual or automatic controls. They can carry up to 3 tons (3.05 t) and can be as large as 12 x 14 feet (3.66 by 4.27 m). Construction elevators are similar to freight elevators, but they are temporary installations used during building construction.

Elevator operating systems use either cables or hydraulics. Cable systems are used in structures of any size. They consist of:

- A fully enclosed elevator shaft
- An elevator car
- Cables attached to the car
- Counterweights
- Vertical tracks
- Emergency safety brakes
- An equipment room for the electrical equipment

One variation of the cable elevator is known as an observation elevator. It is mounted on the wall of an atrium, or on the exterior wall of a structure, to provide passengers with a scenic view (**Figure 10.102**).

Lockout/Tagout Device — Device used to secure a machine's power switches in order to prevent accidental re-start of the machine.



Figure 10.102 An observation elevator offers passengers a scenic view while traveling to their destination.

Hydraulic elevators have ram pistons beneath the car that raise and lower it, with hydraulic oil providing the necessary hydraulic pressure. This operating system is used in structures less than six stories high. The mechanical room containing the power unit is usually located on a lower level of the building, within 100 feet (30 m) of the elevator shaft. Some hydraulic systems also have the cables and counterweights used in cable systems.

Elevators may become inoperative because of:

- Physical damage to the elevator shaft caused by earthquakes, explosions, or other events
- Loss of electrical or hydraulic power
- Overheated circuits, switches, or relays
- Jammed or broken cables
- Activation of the emergency stop button
- Short circuit in electrical system
- Elevator car or shaft door left ajar

During size-up, ask building representatives and witnesses for detailed information about the situation. Establish communications with the elevator's occupants, either by telephone, calling out to them from the nearest floor, or establishing an intercom link between the elevator's car and control room. They may be under tremendous stress, so reassure the occupants that you are working to extricate them.

Locate a building maintenance person or call the elevator service company for technical assistance. Next, a firefighter equipped with a portable radio should be sent to the elevator equipment room while the rest of the crew remains at the elevator door on the floor nearest the inoperable elevator car.

If the occupants require immediate medical attention, begin extrication. Avoid forcible entry methods that can damage the elevator and endanger passengers and firefighters. Request assistance from the technical rescue team if necessary.

If the occupants' medical condition is stable, ask them to check the status of the *Emergency Stop Button*. If the elevator is stalled due to a malfunction, such as an overheated relay or loss of power, the *Emergency Stop Button* must be activated before power can be restored. Tell the occupants to press the *Door Open Button*, which may cause the elevator to resume operation.

A member of the building's maintenance staff should check the electrical circuits to see if the elevator has power. If a staff member is not available, the firefighter who was sent to the equipment room can perform this task. Circuits that have tripped due to overheating can occasionally be reset. If the elevator has power, turn the power off for at least thirty seconds, then turn it back on again. This may reset the relays and reactivate the elevator. Once power has been restored, instruct the occupants to press the *Door Open Button*.

Elevators equipped with a recall system can be returned to the ground floor by inserting a key into the control panel on the ground floor. If the doors do not open when the elevator arrives at the ground floor, ask the occupants to press the *Door Open Button*.

Escalator rescue. Also called *moving stairways*, escalators are chain-driven mechanical stairways that move continuously in one direction. The steps are linked together and each step rides a track. The flexible rubber handrails move at the same rate as the stairs. Each escalator in a structure is an individual installation with separate machinery and controls. The drive unit is usually located under the upper

landing and is covered by a landing plate. One variation is the moving walkway/sidewalk, which is similar to a conveyor belt and transports people through large structures, such as airport terminals and pedestrian tunnels (Figure 10.103).

Many escalators have manual stop switches located on a nearby wall or on the handrail support at the top and bottom of the unit (Figure 10.104). Activating the switch slowly stops the stairs and sets an emergency brake. A key-operated switch located in a covered compartment at the bottom of the escalator is used to restart the escalator after the stop button is activated. The stairs should be stopped during rescue operations. As with the elevator, an escalator mechanic should be requested to restart the escalator after the victim is removed. Extrication operations involving moving walkways or sidewalks are similar to escalators.

The majority of escalator rescues result from victims' fingers and toes becoming caught between the step treads and guard plates, or sandals becoming wedged between the treads. To extricate a victim, remove all other passengers from the escalator and use hand pressure to move the treads backward, which allows trapped fingers or toes to be easily freed. Some types of escalators also have a hand crank or wheel that can be operated to move the treads backward. The crank is located under the covered landing plate. After extrication, the escalator is placed out of service until a service technician can work on it.



Figure 10.103 Escalators present unique rescue situations.

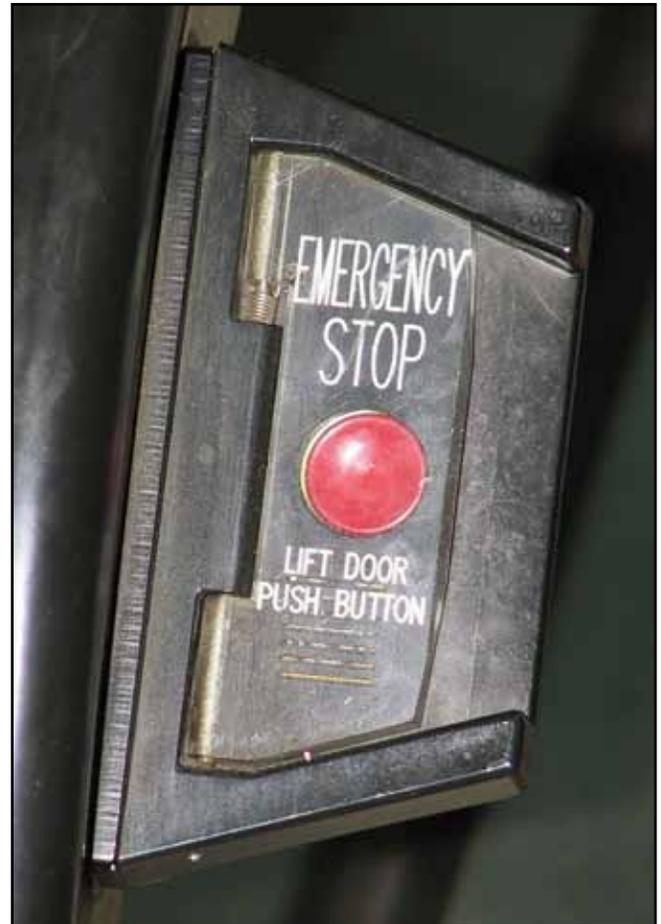


Figure 10.104 An emergency stop button allows passengers to have some control over a malfunctioning escalator.

Cave, Mine, and Tunnel Rescue Operations

Rescues in caves, mines, and tunnels require specialized rescue training and equipment similar to that required for confined-space operations. As a Firefighter II, you should be prepared to assist by monitoring communication channels and search lines, operating SAR systems, and assisting victims once they have been removed from the hot zone. Hazards of these sites include:

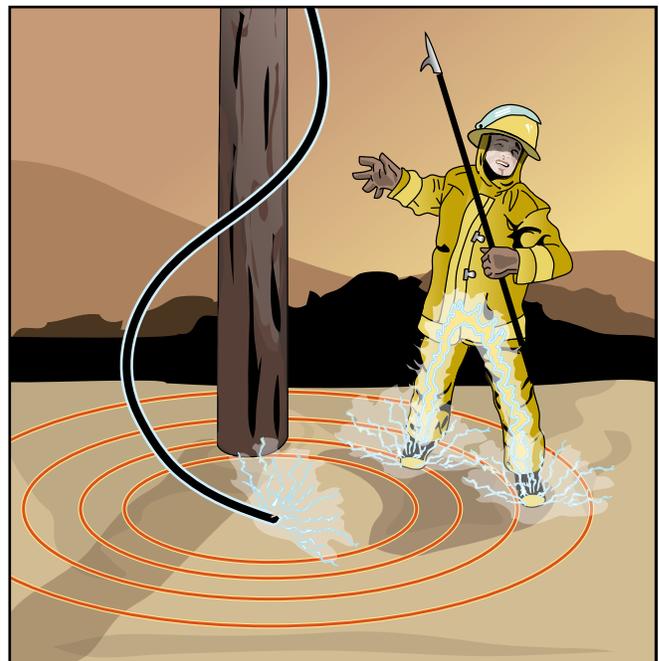
- **Caves** — Toxic gases, oxygen deficiency, tight spaces, sharp rocks, potential for cave-ins, lack of available light, standing or swift running water
- **Mines** — Toxic gases, oxygen deficiency, explosive atmospheres, cave-ins, abandoned tools and equipment, lack of available light, standing water
- **Tunnels** — Toxic gases, oxygen deficiency, smoke, fire, tangled debris, electrified rails or wires, lack of available light, standing water or other fluids, biological waste in sewers

Electrical Rescue Operations

In some jurisdictions, incidents involving electricity are not considered technical rescue situations. However, rescues involving energized power lines or equipment are some of the most common and dangerous situations to which firefighters are called. Improper actions can injure or kill you instantly. Whenever you respond to any situation involving electricity, you should **always** do the following:

- Assume that electrical lines or equipment are energized. A power line in contact with a telephone line or a wire fence (out of sight of rescuers) can energize the entire length of the line or fence.
- Establish scene security and deny unauthorized entry.
- Call for the electric company to respond.
- Stand by until the electric company arrives.
- Allow only electric company personnel to cut electrical wires.

Figure 10.105 It may be difficult to estimate the radius of the ground gradient without the correct tools for the job, so it is important to maintain a safe distance.



Electrical wires on the ground can be dangerous without even being touched. Downed lines can energize wire fences or other metal objects with which they come in contact. When an energized electrical wire comes in contact with the ground, current flows outward in all directions from the point of contact. As the current flows away from the point of contact, the voltage drops progressively. This energized area is called the **ground gradient**. Depending on voltage and other variables, such as ground moisture, it can extend for several yards (meters) from the point of contact (**Figure 10.105**). To avoid this hazard, estimate the distance between two nearby power poles, and stay that distance away from the downed line until you are sure the power has been shut off.

Ground Gradient — Electrical field that radiates outward from where the current enters the ground; its intensity dissipates rapidly as distance increases from the point of entry.

One type of electrical rescue involves a vehicle striking a power pole, severing a high-voltage line that falls onto the vehicle. The first priority is to contact the electric company to shut off the power. Once that is done, the incident becomes a vehicle extrication incident.

Electrified subway or train tracks also pose a hazard to firefighters. Passengers may fall onto or between the rails. Firefighters may also have to enter tunnels to assist passengers from stalled trains or subway cars. Never work around these tracks unless it is proven that the power has been shut off.

WARNING

When you approach a downed power line, a tingling in your feet indicates that the ground beneath you is electrified. If you feel this, keep your feet together and hop away from the line.



Chapter Summary

Your duties as a firefighter include using and maintaining rescue tools and lighting equipment. You must also know how to work as part of a team while performing vehicle extrications and assisting technical rescuers. This chapter provides only basic information; you must practice these duties to make sure that you can accomplish these tasks quickly and effectively.

Review Questions

Firefighter I

1. What types of emergency scene lighting equipment can be used for rescue incidents?

Firefighter II

1. What types of tasks may be required to maintain electric generators and lighting equipment?
2. What are the main uses of rescue tools?
3. What are some common limitations of rescue tools?
4. What role does the fire department play in size-up and assessing the need for extrication after a motor vehicle accident?
5. What safety considerations must be identified and mitigated during vehicle extrication operations?
6. How can cribbing material be used during vehicle extrication?
7. What methods can be used to gain access to victims during vehicle extrication?
8. What role does a Firefighter II play during technical rescue operations?
9. What are the different rescue practices and goals used during technical rescue?
10. How do the hazards for structural collapse rescue operations compare to hazards of rope rescue operations?

10-II-1

Demonstrate the steps for inspecting, servicing, and maintaining a portable generator and lighting equipment.



Step 1: Review the manufacturer's service manual for specific directions.

Step 2: Carefully inspect spark plugs for damage, visible corrosion, carbon accumulation or cracks in the porcelain, and ensure the spark plug wire is tight. Replace spark plug if it is damaged or if service manual recommends.

Step 3: Check carburetor and identify signs of fuel leaks.



Step 5: Check oil level and refill as needed.



Step 4: Check fuel level and refill as needed.



Step 6: Start generator and run tests as required by service manual.



Step 7: Inspect all electrical cords for damaged insulation, exposed wiring, or missing or bent prongs.

Step 8: Test operation of lighting equipment by connecting each light to the generator one light at a time. Replace lightbulbs as necessary, discard faulty bulbs in an approved manner.

Step 9: Clean work area and return all tools and equipment to the proper storage areas.

Step 10: Document maintenance on the appropriate forms or records.



Step 1: Determine vehicle's orientation and need for stabilization.

Step 2: Determine vehicle's construction, condition, and integrity.



Step 3: Place chocks in front of and behind tires.



Step 4: Place chocks on the downhill side of a vehicle on an incline.

Step 5: Place chocks on both sides of the tires if the ground is level or the direction of the grade is undetermined.

Step 6: Test and apply the parking brake before placing chocks.

Step 7: Center chocks snugly and squarely against the tread of each tire.



Step 1: Determine vehicle's orientation and need for stabilization.

Step 2: Determine vehicle's construction, condition, and integrity.

Step 3: Determine whether to use a four-point or six-point support.

Step 4: Identify support locations on the vehicle.

Step 5: Determine whether the ground under these support locations will support the vehicle's/equipment's weight.

Step 6: Position sufficient cribbing material at each support location.

Step 7: Construct a crib base appropriate for conditions.

Step 8: Add the next layer of cribbing allowing the ends of the cribbing pieces to extend 3 or 4 inches (75 mm to 100 mm) beyond the individual pieces of the base.

Step 9: Add additional layers as needed, overlapping the crib corners as described above.



Step 10: Use wedges and shims to provide the maximum amount of contact between the crib and the vehicle.

Step 11: Repeat the process until at least four cribs are supporting the vehicle.

Step 12: Evaluate and maintain the integrity of the cribbing.



Step 1: Determine vehicle's orientation and need for stabilization.

Step 2: Determine construction, condition, and integrity of the vehicle.

Step 3: Determine whether to use a four-point or six-point support.

Step 4: Identify support locations on the vehicle.

Step 5: Determine whether the ground under these support locations will support the weight of the vehicle and equipment.



Step 6: Ensure that the opposite side or end of the object to be lifted is resting on cribbing.



Step 7: Select the lifting device to be used.

Step 8: Position the jack so that it is directly beneath a solid portion of the vehicle frame, yet can be operated without rescuers needing to lie beneath the vehicle.



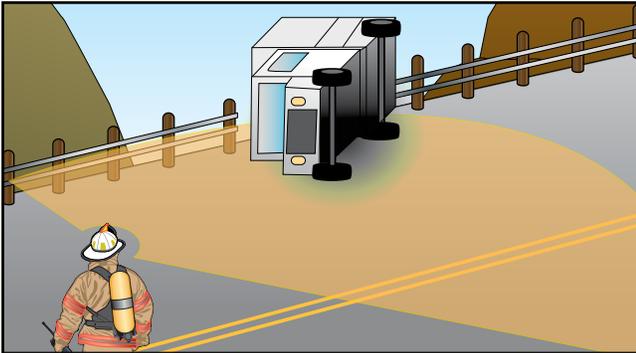
Step 9: As the vehicle starts to lift, construct at least one box crib or insert at least one step chock in the area of the lifting.



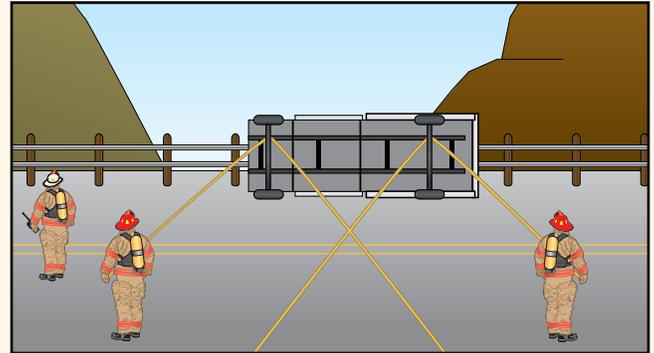
Step 10: Once the jack has reached its maximum travel distance and sufficient cribbing is in place, lower the jack until the vehicle is resting firmly on the cribbing.

Step 11: Retract the jack and add additional cribbing beneath it to raise the vehicle further, if necessary.

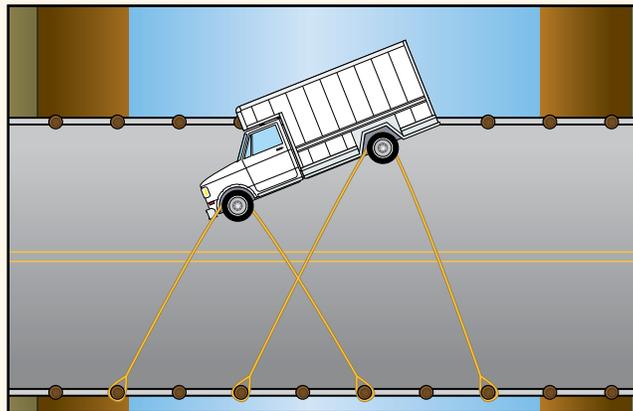
Step 12: Evaluate and maintain the integrity of the cribbing.



- Step 1:** Determine vehicle's orientation and need for stabilization.
- Step 2:** Determine vehicle's construction, condition, and integrity.
- Step 3:** Determine whether to use a four-point or six-point support.
- Step 4:** Identify support locations on the vehicle.
- Step 5:** Ensure that equipment is rated for the anticipated load plus a safety factor.



- Step 6:** Attach webbing, ropes, or chains to anchor points on the vehicle.
- Step 7:** Secure the webbing, ropes, or chains to anchor points.
- Step 8:** Remove slack from the webbing, ropes, or chains.



- Step 9:** Evaluate and maintain the tension of the stabilization equipment used.



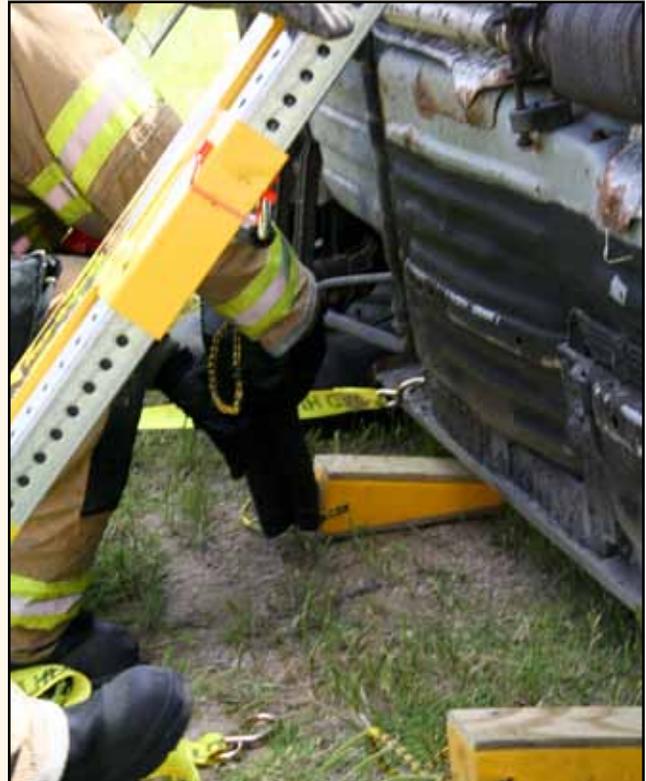
Step 1: Determine vehicle's orientation and need for stabilization.

Step 2: Determine construction, condition, and integrity of the vehicle.

Step 3: Determine whether to use a four-point or six-point support.

Step 4: Identify support locations on the vehicle.

Step 5: Determine whether the ground under these support locations will support the weight of the vehicle and equipment.



Step 6: Manually stabilize and/or place wedges to control vehicle while setting up buttress system.



Check that straps and tip engagements are tight. Adjust if necessary.

Step 7: Based on situation, location of patient, type and condition of vehicle, and any obstructions, determine which side of vehicle to place the single jack stand, and which side to place the two adjustable stands if using a 3-point setup.

Step 8: With a minimum of two people, adjust and set stands while maintaining situational awareness.

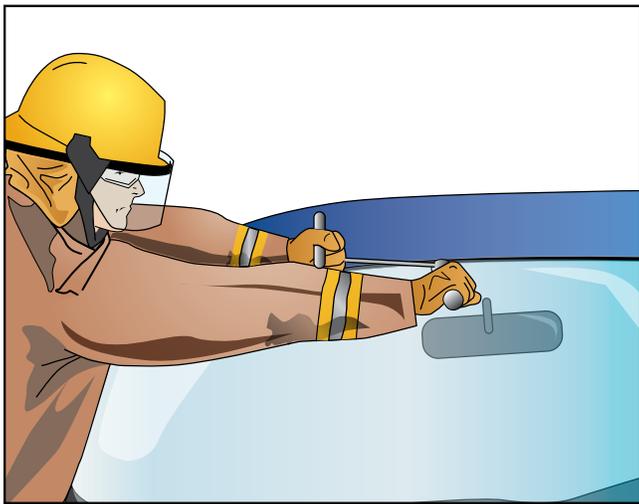
NOTE: Monitor equipment throughout the operation and make adjustments as needed.

Step 9: Set stand(s) on least stable side of vehicle first, then work on opposite side.

Step 10: Engage vehicle with tips as high as possible. Attach base strapping as low as possible. Stands should lean at an angle between 50 to 70 degrees.

Step 11: Once all stands are placed, tighten system up.

Removing the Windshield Seal

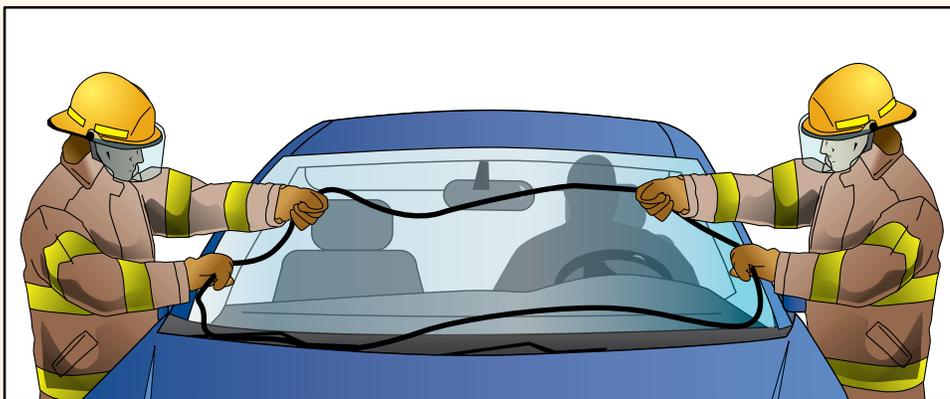


Step 1: Cover patients with a blanket, tarp, or fire resistant material to protect them from glass fragments.

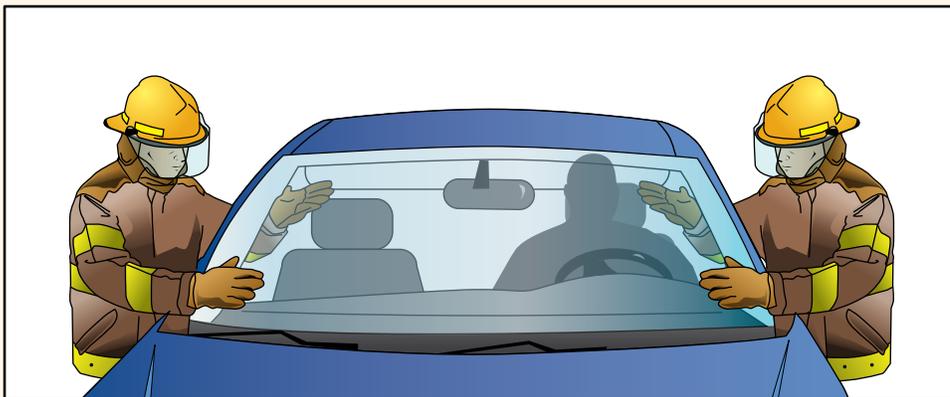
Step 2: Identify the method to be used to remove the windshield based upon windshield type, windshield condition, and equipment available.

Step 3: Place the blade of a commercial windshield removal tool under the windshield seal.

Step 4: Hold and stabilize the seal removal tool with one hand, place the other hand on the attached cable and handle and begin to pull toward oneself, ensuring that the blade of the tool remains against the windshield and under the seal at all times.



Step 5: Continue until the entire seal has been cut. Upon completion, remove the outer portion of the seal from the windshield.



Step 6: Push the windshield outward from the interior of the vehicle. An alternative option of the removal is to place duct tape handles or suction cups onto the outer portion of the windshield and remove.

Step 7: Upon removal of the windshield, position it away from the rescue scene to ensure safety of personnel.

Cutting the Windshield

Step 1: Cover patients with a blanket, tarp, or fire resistant material to protect them from glass fragments.

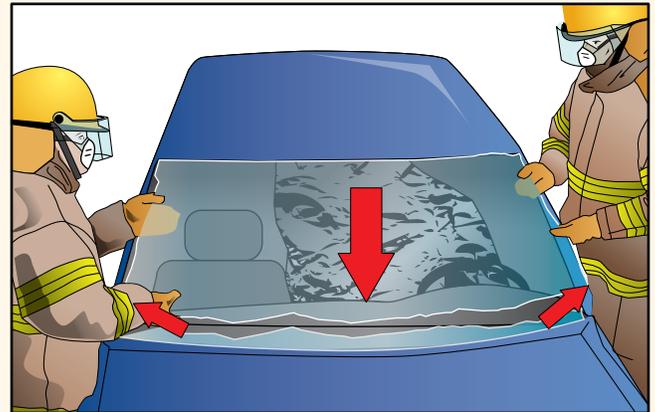
Step 2: Identify the method to be used to remove the windshield based upon windshield type, windshield condition, and equipment available.

Step 3: Saw operator cuts two slits in the glass to be removed using reciprocating saw, handsaw, air chisel, or other tool.

NOTE: Ensure appropriate respiratory protection for responders and victims is used.



Step 4: Operator then cuts the lower portion of the window connecting each side cut near the bottom of window.



Step 5: Saw operator and other glass-removal team members position themselves on opposite sides of the window.

Step 6: Each team member grasps the glass near bottom cut.

Step 7: Raise the glass moving bottom outward, using care not to break the glass.

Step 8: Remove the glass, pulling down to dislodge from frame and folding back over roof.



Step 9: Place the glass out of the way of operations per local protocol.



Step 1: Select the tool that will be used to break the glass.

Step 2: Ensure patients are protected from glass fragments.



Step 3: Place a center punch or other tool in the lower corner of the window.

Step 4: Brace the hand holding the center punch with the opposite hand to prevent the rescuer from pushing the hand with the punch through the broken glass.



Step 5: Break the window with the punch or other tool.

Step 6: Clear the remaining glass from the window opening.

Removing Glass Method



Step 1: Cut the first post at the furthest point from the patient.

Step 2: Remove glass.



Step 3: Cut the B- and C-posts without cutting into seat belt pretensioners located in the B-posts and any side air bag inflation cylinders that might be located in the C-posts. Assign personnel to support the roof while the posts are being cut so the roof will not fall into the passenger compartment.

Step 4: Cut post closest to the patient last.



Step 5: Remove the roof.

Cutting Across Roof Method



Step 1: Peel back the plastic interior finish and peek inside looking for potential hazards, such as airbags, retractors before cutting.

Step 2: Cut the roof supports/door jams just behind the windshield frame.



Step 4: Remove the rear window.

Step 5: Cut the B- and C-posts without cutting into seat belt pretensioners located in the B-posts and any side air bag inflation cylinders that might be located in the C-posts. Assign personnel to support the roof while the posts are being cut so the roof will not fall into the passenger compartment.



Step 3: Continue the cut across the front of the roof behind the windshield frame.



Step 6: Once all the posts have been cut, lift the roof clear and set it aside.

Flapping the Roof Method



Step 1: Peel back the plastic interior finish and peek inside looking for potential hazards, such as air bags and retractors, before cutting.

Step 2: Cut seat belts and appropriate posts.



Step 4: Flapped roofs should be secured with ropes, chains, straps, or other appropriate material.



Step 3: Use a pike pole or other long object to push the sheet metal down at the bending point and to push the roof up at the front.



Step 1: Peel back the plastic interior finish and peek inside looking for potential hazards, such as air bags and retractors before cutting.

CAUTION: Ensure that the vehicle is stabilized appropriately and monitor stability throughout operation.

Step 2: Cut the roof posts that are easily accessible and lay the roof down in a manner similar to that used on upright vehicles.



Step 3: Push or pull the roof down to provide access to the passenger compartment. Pad any rough edges.

Step 4: If desired, the roof can be removed entirely by cutting the remaining posts. Again, after the cuts are complete, cover any rough edges.



Step 5: Cut the B- and C-posts without cutting into seat belt pretensioners located in the B-posts and any side air bag inflation cylinders that might be located in the C-posts. Assign personnel to support the roof while the posts are being cut so the roof will not fall into the passenger compartment.

Step 6: Once all the posts have been cut, lift the roof clear and set it aside.

NOTE: This skill is also known as *rolling the dashboard*.



Step 1: Remove the front door.



Step 2: Make relief cuts behind the strut mounts to eliminate movement of the front end of the vehicle during this operation.



Step 3: Peel back the plastic interior finish and peek inside looking for potential hazards such as air bags and retractors before cutting.

Step 4: Cut the upper portion of the A-post.



Step 5: Cut the bottom portion of the A-post.



Step 6: Position jacking or ram device between base of the B-post and to an area just above the top hinge on the A-post.

Step 7: Operate the jacking or ram device to move the dashboard.