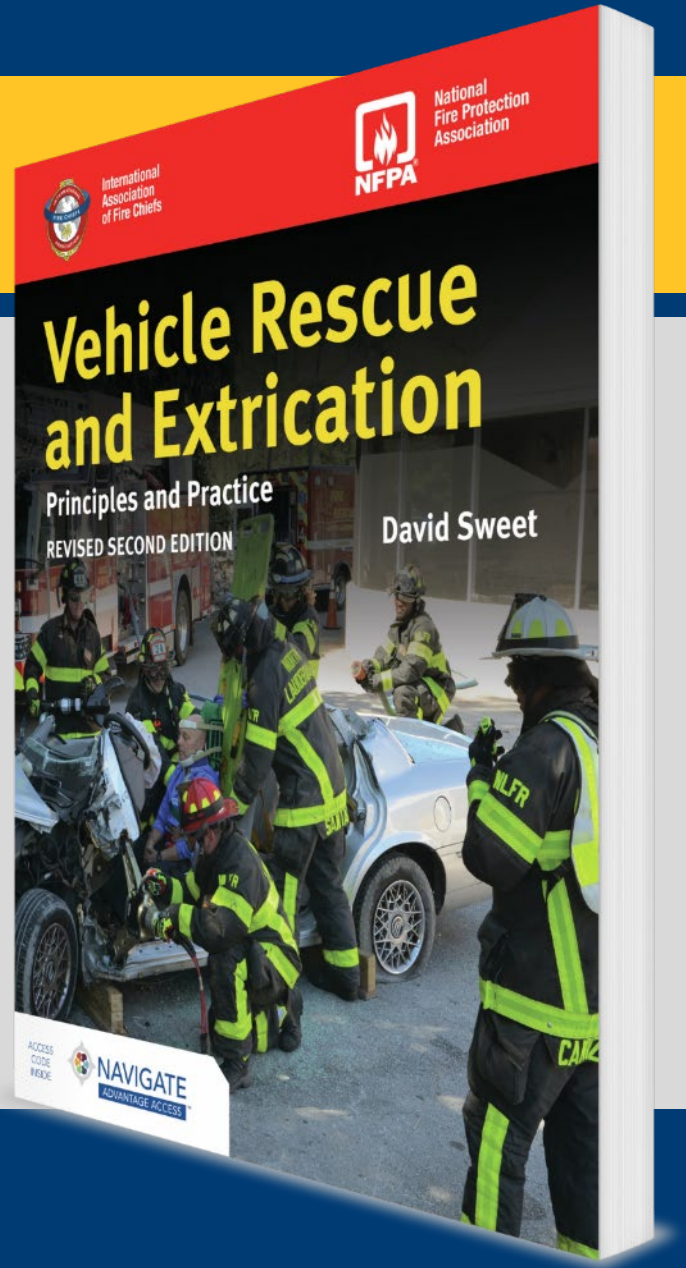
CHAPTER 3

Tools and Equipment



Knowledge Objectives (1 of 3)

- Identify the two standards describing protective ensembles for technical rescuers.
- Indicate the primary differences between active and passive hearing protection.
- Articulate the differences between supplied air respirator/breathing apparatus (SAR/SABA) and self-contained breathing apparatus (SCBA).
- Explain advantages and disadvantages of supplied air respirator/breathing apparatus (SAR/SABA) and self-contained breathing apparatus (SCBA) for a vehicle technical rescue.

Knowledge Objectives (2 of 3)

- Classify hand tools into one of four categories.
- List the types of pneumatic tools and describe their uses at a vehicle rescue incident.
- List the types of air-powered lifting tools and describe their uses at a vehicle rescue incident.
- List the types of electric tools and describe their uses at a vehicle rescue incident.
- List the types of fuel-powered tools and describe their uses at a vehicle rescue incident.

Knowledge Objectives (3 of 3)

- List the types of hydraulic tools and describe their uses at a vehicle rescue incident.
- List the types of stabilization tools and describe their uses at a vehicle rescue incident.
- Describe the benefits of Class B foam at vehicle rescue incidents and identify the required equipment for its production.
- Identify victim packaging and removal equipment.

Introduction (1 of 2)

- A technical rescuer must have extensive knowledge of tools used in the field.
- Rescuer must always be prepared to adapt and overcome obstacles.
- There are many types of tools, some specialized and geared toward vehicle rescue.

Introduction (2 of 2)

- Five basic categories of tools:
  - Hand tools
  - Pneumatic tools
  - Hydraulic tools
  - Electric- or battery-operated tools (nonhydraulic)
  - Fuel-powered tools
- Stabilization tools can be classified as hand, pneumatic, or hydraulic.

Personal Protective Equipment (PPE)

- Technical rescuers must wear full protective equipment before working with tools.
- Protective ensemble includes clothing, helmet, eye protection, gloves, footwear, and interface components that overlap to provide full protection.
  - Respiratory protection may also be necessary in some situations.
- Selection of specific components depends on hazards at the scene, availability of equipment, weather, etc.

Head Protection

- Has a minimum of a three-point suspension system
- Many different types of helmets
  - Traditional fire helmet
  - Lighter urban search and rescue helmet
  - European-style helmet (additional, significant safety features)
- Inspect helmets for signs of damage to the shell, suspension system, liner, etc. before use.
- Keep all head protection clean to facilitate inspection.

Head Protection (2 of 2)

Courtesy of David Sweet

Courtesy of David Sweet

Courtesy of David Sweet

Body Protection (1 of 2)

- Depends on:
  - Hazards present
  - Authority Having Jurisdiction
  - Level of comfort
- Protective coveralls or coats/pants
- Extrication jumpsuits provide easier movement and less fatigue from overheating.
- PPE must be bright to ensure visibility, equipped with reflective material for visibility in darkness
- High-visibility garments should meet ANSI 107.

Body Protection (2 of 2)

Courtesy of David Sweet.

Courtesy of David Sweet.

Eye and Face Protection (1 of 2)

- Protects from risks that can:
  - Cause damage to vision
  - Enable entry for bloodborne pathogens
- Includes respirators, face shields, goggles, safety glasses
- Face shields are not considered a primary eye protection device.
- Safety glasses should include retainer straps and side shields.
- Inspect for scratches/gouges

Eye and Face Protection (2 of 2)

Courtesy of Chris Xiste.

Courtesy of David Sweet.

Hand Protection

- Gloves should protect hands and wrists.
- Consider wearing latex gloves underneath.
- Inspect for damage.
- Clean and decontaminate according to manufacturer's instructions.

Courtesy of David Sweet.

Foot Protection (1 of 2)

- Boots should
  - Contain puncture-resistant materials
  - Have an impact- and compression-resistant toecap
- Most boots are either fire fighter or work safety boots.
- Inspect footwear for wear, tears, or holes in the leather or rubber, as well as damage.
- Waterproof boots in accordance with the manufacturer’s directions.

Foot Protection (2 of 2)

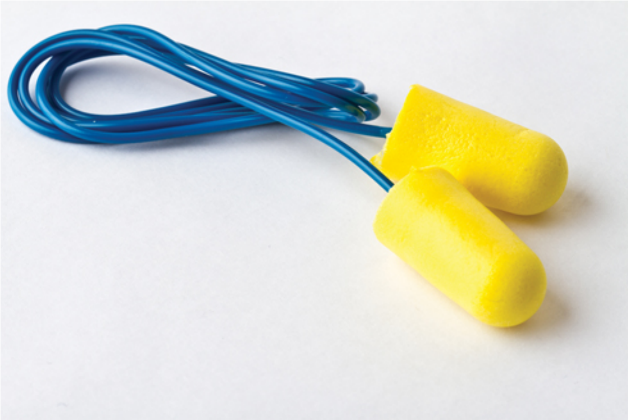
Courtesy of David Sweet.


Courtesy of David Sweet.

Hearing Protection (1 of 2)

- Reduces the decibel (dB) level that enters the ear
- One of the most underutilized safety items
- There are two types of hearing protectors recognized by OSHA:
  - Passive: static noise control that cannot be changed
  - Active: changes attenuation of device based on sound changes

Hearing Protection (2 of 2)



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Courtesy of Bill Larkin

Hearing Protection: Earplugs

- Passive hearing protection
- Manually inserted into the outer ear canal and conform to its shape
- Come in disposable or reusable packs
- Number 1 failure is from not properly seating the device.
- Inexpensive, easy to carry, and some are equipped with a cord

Hearing Protection: Earmuffs

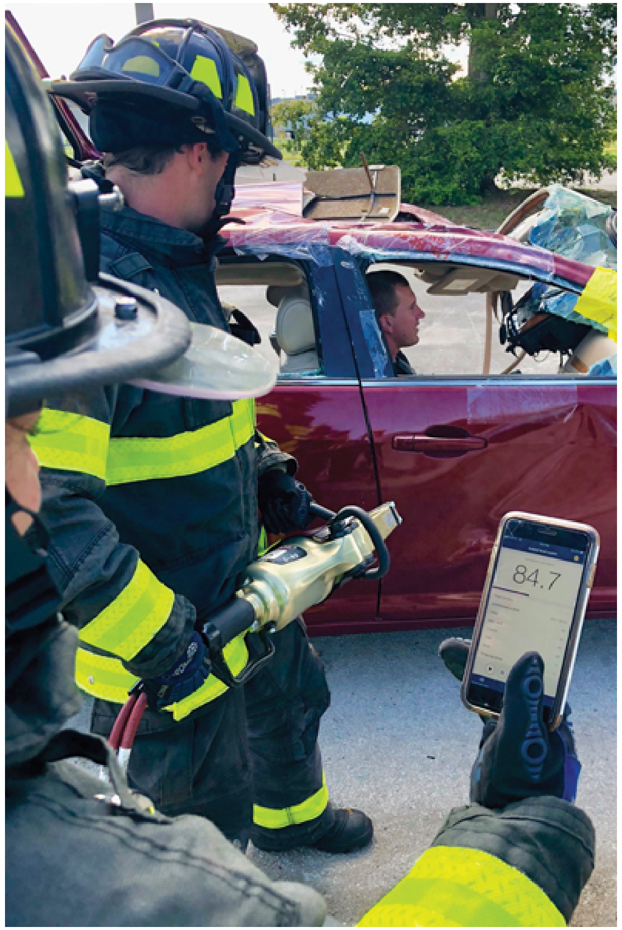
- Passive hearing protection
- Designed to fit over the head and cup the ears
- More comfortable than earplugs
- Some are designed to be mounted or integrated into a helmet

Hearing Protection: Noise-Cancelling Headphones

- Active hearing protection
- Fit over the wearer's head or helmet
- Emit an electronic signal that blocks high-dB frequencies
- Higher cost per unit
- Some features may prevent rescuer from wearing a helmet.

Hearing Protection

- NIOSH offers a free app that provides real-time dB levels.



Courtesy of David Sweet.

Respiratory Protection

- Hazards in the air may take the form of
  - Chemicals
  - Vapors
  - Fumes
  - Dust
  - Glass particulate/dust
  - Bloodborne pathogens
  - Oxygen deficiency

Air-Filtering Face Piece Respirators

- Use electrostatic charges to attract and contain particles
- Use NIOSH-certified masks
  - N: not resistant to oils
  - R: resistant to oils, single use
  - P: resistant to oils, multiple use
- Filtering efficiency numbers are assigned; 95% is the minimum level of protection.
- Hoods and scarves pulled over the mouth do not provide sufficient respiratory protection.

Self-Contained Breathing Apparatus (1 of 2)

- Respirator with an independent air supply
- Protects against almost all airborne contaminants
- Disadvantages:
  - Limited air supply
  - Bulky frame
  - Weight

Self-Contained Breathing Apparatus (2 of 2)

Courtesy of Mike Jackles, BSO Fire Rescue.

Courtesy of Chris Xiste.

Supplied Air Respirator/Breathing Apparatus

- Breathing air is supplied by an air line from either a compressor or a stored air (bottle) system outside the work area.
- Should comply with NFPA 1986 requirements

Respiratory Protection

- Fit testing
  - Ensures the wearer has a proper seal maintained throughout usage
- Inspections should be performed at regular intervals and after each use.
  - Including replacement or refill of air cylinders, inspection of components, cleansing and sanitation
- NFPA 1951 covers procedures for inspecting and maintaining PPE.

Maintenance of PPE

- Proper maintenance of PPE:
  - Always inspect before and after each use.
  - Follow manufacturer's instructions.
  - Document all inspection and maintenance activities.
  - Consider using an independent company to clean and maintain PPE.
  - Report problems immediately.

Hand Tools

- A **hand tool** operates from human power.
    - Basis of all working tools
    - May be more efficient than power tools
    - Categories:
        - Striking tools
        - Leverage/prying/spreading tools
        - Cutting tools
        - Lifting/pushing/pulling tools

Striking Tools

Courtesy of David Sweet.

Leverage/Prying/Spreading Tools

Courtesy of David Sweet.

Cutting Tools

Courtesy of David Sweet.

Lifting/Pushing/Pulling Tools

Courtesy of David Sweet.

Striking Tools

- Apply an impact force to an object
- Hammers, punches, and glass saws

Courtesy of David Sweet.

Spring-Loaded Center Punch

- Glass removal tool used on tempered glass only
- Spring-loaded plunger fires off a steel rod with a sharpened point directly into a pinpoint area of glass, shattering it.
- Spring may fail from rust in the chamber.
- Point of rod can dull.

Courtesy of David Sweet.

Other Punches

- Stationary punch
- Hammer-type punch
- Spring-back-type punch
- All of these follow different operating procedures.

Courtesy of David Sweet.

Glass Handsaw (1 of 2)

- Manually operated striking tool for removing glass
- Extremely versatile;
  has several design applications
- Never attempt to use the point section of the glass tool to break out tempered glass.

Courtesy of David Sweet.

Glass Handsaw (2 of 2)

Courtesy of David Sweet.

Courtesy of Edward Monahan.

Leverage Tools (1 of 2)

Courtesy of Edward Monahan.

Courtesy of Edward Monahan.

Leverage Tools (2 of 2)

- Rotating
  - Turn objects
  - Include wrenches, pliers, and screwdrivers
  - Help gain access, expose concealed areas, or disassemble components
- Prying and spreading
  - Act as a lever
  - Can lift heavy objects
  - Claw bar
  - Crowbar
  - Flat bar
  - Halligan bar
  - Kelly tool

Cutting Tools

- Have a sharp edge for severing an object
- Examples include saws, chopping/snipping shears, trauma scissors or shears, seat belt cutters, knives, and chisels.
- Each type is designed to work on certain types of materials and cut in a different manner.

Handsaws

- Heavy duty hacksaws are the most common.
  - Useful for metal
- Large-tooth saws (bow saw) are effective tools for cutting.

Courtesy of David Sweet.

Chopping Tools

- Flat-head axe
- Pick-head axe
- Can also be used as striking tools

Courtesy of David Sweet.

Snipping Tools (Shears)

- Examples include bolt cutters, cable cutters, insulated wire cutters, sheet metal snips, seat belt cutters, and EMS trauma scissors or shears.
- Operate on a leverage concept; concentration of a cutting force on a small area
- Purchase seat belt cutters with blades that can be easily changed.

Knives

- Should have a retractable or folding blade that locks while open
- Keep knives sharp or replace them with each use.

Courtesy of David Sweet.

Hand-Operated Chisels

- Used to cut wood and metal
- Operated by striking with a hammer or mallet
- Variety of widths and styles
- Should be used only for cleaving the material for which they were designed

Lifting/Pushing/Pulling Tools

- Include mechanical jacks and hand-operated hydraulic jacks
- Mechanical jacks can be of the screw, ratchet-lever, or cam type.
- Jacks are used to lift or push heavy objects.

Courtesy of Edward Monahan.

Winches

- Used for a variety of lifting, pulling, and holding operations
- Chain winches come in two varieties:
  - Integrated cable and drum type (come along)
  - Grip hoist, a pass-through cable type
- When inspecting manual winches and hoists, look for any damage caused by overloading and friction.
  - Be sure to inspect cables and chains.
  - Lubricate moving parts properly.

Grip Hoist

- Manual winching device that can lift, pull, move, and stabilize vehicles
- Can be operated in multiple positions
- When base is attached to an anchor point, a wire rope is fed into the back and through the unit, attaching to the object to be pulled
- Uses a grip-on-grip locking mechanism
- Does not use a ratchet or wire-over-drum mechanism

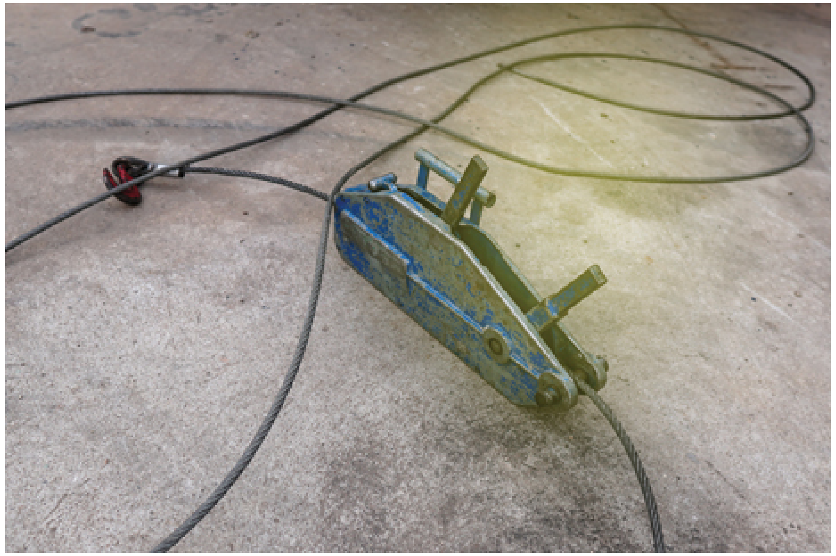
Come Along and Chain Package

- Hand-operated, ratchet lever winching tool that can provide several thousands of pounds of pulling force when used with chains
- Operates by ratcheting a wire cable around a drum

Courtesy of David Sweet.

Come Along and Chain Package (2 of 5)

- Handle is designed to fail and bend long before the tool fails.



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Courtesy of David Sweet.

Come Along and Chain Package

- Can provide just enough lift clearance to release the entrapment, with the benefit of having full control and feel over the entire length of the pull
- Can also be used for stabilization

Courtesy of Edward Monahan.

Come Along and Chain Package (4 of 5)

- Chain package that comes with come along kit is rated for the system only and should not be used with any other system.
- Chains must be marked with a grade (WLL).
- Variety of hook attachments

Courtesy of David Sweet.

Come Along and Chain Package (5 of 5)

- To determine product’s WLL, the manufacturer utilizes the minimum breaking strength of the device and divides this by a safety or design factor that is predetermined by the manufacturer
- The minimum breaking “tensile” strength of a chain: divide the unit of force (Newton) by square millimeter (N/mm^2)

Hooks

- Slide hook allows the chain links to pass freely through the throat of the hook to tighten around an object.
  - Should never be tip loaded
- Grab hook is used by inserting a link of the chain into the slot of the hook.
  - Chain shortener designed to take up slack
- O-ring joins chains together or joins a chain to a come along using a hook.

Pneumatic Tools

- Use air under pressure to operate
  - Supplied from air compressors, SCBA cylinders, or vehicle-mounted systems
  - Most operate at forces between 90 and 250 psi (621 and 1724 kPa) and use adjustable regulators to provide proper operating pressure.

Air Compressors

- Provide power to pneumatic tools or breathing air
- Portable or fixed
- Maintenance tasks include draining water and filter replacement.
- Oil levels and engine fluid levels should be checked after each use.

Courtesy of David Sweet.

Pneumatic Cut-Off Tool

- Uses a small carbide disc to cut through metals
- Throws off a lot of sparks
- Has many applications
- Can be stowed almost anywhere because it is small

Courtesy of David Sweet.

Pneumatic Chisel

- Cuts sheet metal or hardened steel
- Requires extensive training
- A variety of chisels are available; use one capable of heavy-duty rescue work.

Courtesy of David Sweet.

Pneumatic Rotating Tool

- Used to remove nuts and bolts of various sizes
- Always use the sockets that come with the tool set.
- Comes in several sizes.
  - ½-inch drive model should be adequate to handle most vehicle applications.

Courtesy of David Sweet.

Pneumatic Lifting Tools: Shoring

- Used where vertical distances are too great to use cribbing, or the load must be supported horizontally
- Temporary support of a structure
- Can also be used with unstable vehicles
- Air shoring

Courtesy of Rescue 42, Inc.

Pneumatic Lifting Tools: Air-Lift Bags (1 of 2)

- Pneumatic-filled bladders used to lift an object or spread one or more objects away from each other
- Can move a tremendous amount of weight
- Variety of shapes and sizes

Courtesy of David Sweet.

Pneumatic Lifting Tools: Air-Lift Bags (2 of 2)

- Lifting capacity is measured in metric tonnage.
- Ensure correct operating pressure is applied and entire contact area of the bag is achieved.
- Flat-form bags are designed to maintain a flat profile.
- Cribbing is also used.

Courtesy of Genesis Rescue Systems.

Rules for Air-Lift Bags

- Never stack more than two bags on top of one another.
- Always ensure valves and hoses are facing outward.
- Never place objects on top of or between the bags.
- Do not use to pull a steering column.
- Do not use as sole means of stabilizing a vehicle.
- Stacking bags will not increase the lifting capacity.

Low-Pressure Air-Lift Bags

- Provide a very high lift with a maximum air pressure of about 7 psi (48 kPa)
- Most commonly found on big tow units because they can upright heavy vehicles
- Disadvantages include lower lifting capacity

Courtesy of David Sweet.

Medium-Pressure Air-Lift Bags

- More rugged design
- Working pressure of 15 psi (103 kPa)
- Commonly have two to three cells and are suitable for aircraft, medium or heavy trucks, and bus rescues

Courtesy of Savatech Corp.

High-Pressure Air-Lift Bags

- Most commonly used by rescue agencies
- Air pressure of 100–150 psi (689–1034 kPa)
- Come with hoses, regulators, a master control module, and other attachments
- Usually require multiple personnel


Courtesy of David Sweet.

High-Pressure Flat-Form Air-Lift Bags

- Designed to retain flat profile in the center during inflation
- Can stack up to three bags on top of each other
- Come in a variety of operating pressures, sizes, and lifting capacities

Multi-Cell High-Pressure Air-Lift Bags

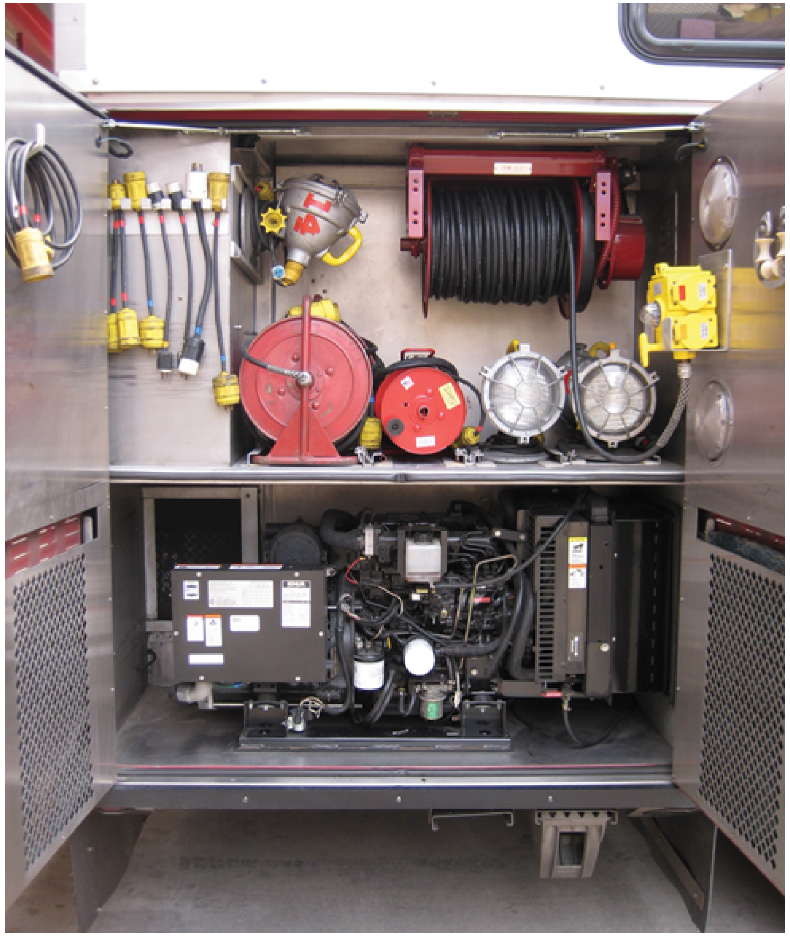
- Distinct height advantage and unique lifting system
- Air pressure is approximately 150–174 psi (1034–1200 kPa)
- Always assess the bags to ensure they are properly threaded and locked together.

Electric Tools (1 of 4)

- Operate on household current or generator
- Electric generators are portable or fixed.
- Some tools can use a battery as an electrical power source.
  - Batteries can sustain only a certain energy and can drain with continuous use.
- Three types of batteries have been used in cordless tools
  - Nickel–cadmium
  - Nickel–metal hydride
  - Lithium–ion (mostly widely used)

Electric Tools (2 of 4)

Courtesy of American Honda Motor Co., Inc.



Courtesy of the Berwyn Heights Volunteer Fire Department & Rescue Squad, Berwyn Heights, Maryland.

Electric Tools (3 of 4)

- Amperes per hour holds the capacity or how fast a battery discharges.
  - Duration also depends on efficiency, heat release, design, and user.
  - Higher voltage can generate more torque, but a high AH allows high-power operation for longer.
- Adapters can convert a battery-powered tool to a general-current tool.
  - Good backup accessory

Electric Tools (4 of 4)

Courtesy of David Sweet.

Courtesy of Edward Monahan.

Electric Cutting Tools: Plasma Cutter

- Has a nozzle from which inert gas or compressed air is blown at a high speed
- Electric arc forms within the gas, turning some of the gas to plasma, which is hot enough to cut through metal.

Electric Cutting Tools: Electric Reciprocating Saw

- Cutting action uses a back-and-forth motion, or a push and pull of the blade.
- When choosing a blade, consider:
  - Type and thickness of blade
  - TPI rating
  - Type of metal

Courtesy of David Sweet.

Electric Cutting Tools: Electric Circular Saw

- Used primarily for cutting wood
- Excellent for cutting fence post and rebar material
- Battery-powered option offers versatility to access tight spaces.
- Disadvantage: weight
- Advantage: clean cuts

Electric Lifting/Pulling Tool: Winches (1 of 3)

- Two common types of power-driven winches:
  - Electrically operated: draws power from vehicle system
  - Hydraulically operated: uses a power take-off system
- The winch uses a wire or synthetic rope at a minimum of 75 feet (22.9 m).
  - Pulling capacities range from 2,000 to 12,000 lb (907 to 5443 kg).
  - A winch should be remotely operated with at least 12 ft (3.7 m) between the winch and the object in an enclosed area.

Electric Lifting/Pulling Tool: Winches (2 of 3)

- Any winch is only as strong as what it is attached to (normally the frame of the vehicle)
- Bumper-type winches versus tow hitch-type winches

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Electric Lifting/Pulling Tool: Winches (3 of 3)

- Pulling capacity should be 1.5 times the gross vehicle weight of the vehicle to be pulled.
- Easy to set up on a vehicle using universal mounting kits
- Disadvantages: Prone to overheating

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Electric Lighting

- Variety of styles
- Ranges from 300 to 1,000 watts per light
- Make sure lights do not exceed rated capacity of generator
- Keep stock of replacement light bulbs
- LEDs are the future of lighting

Portable Lights

- Provide light where fixed lights cannot
- Adjustable for elevation
- Broad base prevents from tipping.
- Useful for providing large-area or higher-height lighting

Courtesy of Akron Brass Company.

Fixed Lights

- Mounted on the rescue vehicle
- Come in a variety of sizes and styles
  - Mounted in the vehicle
  - Mounted so they can be adjusted
  - Light towers

© Glen E. Ellman.

Fuel-Powered Cutting Tools

- Include chain saws, rotary saws, cutting torches, and exothermic torches
- Advantage of fuel-powered tools is the high power they generate.
- Disadvantages:
  - Heavy to carry
  - Some require a mixture of fuel and gas.
  - Some can be difficult to start cold.
- A periodic maintenance schedule and thorough inspection are crucial.

Chain Saws

- Capable of cutting wood, concrete, and light-gauge steel
- Good for working on vehicles that have hit trees
- Use proper safety procedures when cutting tree branches that might be under tension to avoid spring-back injuries.
  - Chainsaw should be equipped with chain brake
  - Appropriate PPE should be worn.

Rotary Saws

- Capable of cutting wood, concrete, or metal
- Two types of blades:
  - Round metal blade with teeth
  - Abrasive disc made to wear down
- Important to match the appropriate saw blade and saw disc to the material being cut
- Use of these saws in vehicle extrication is extremely limited because they throw off a lot of sparks.

Cutting Torches (1 of 2)

- Produce extremely high–temperature flame
- Used for cutting through heavy steel objects
- Operators must be specifically trained before using torches.
- Most common type of cutting torch uses oxygen and acetylene to create the flame.
- Many rescue services have begun to use oxygen/gasoline torches, also known as Petrogen.
- An alternative to the Petrogen and acetylene systems is the oxygen/propane torch.

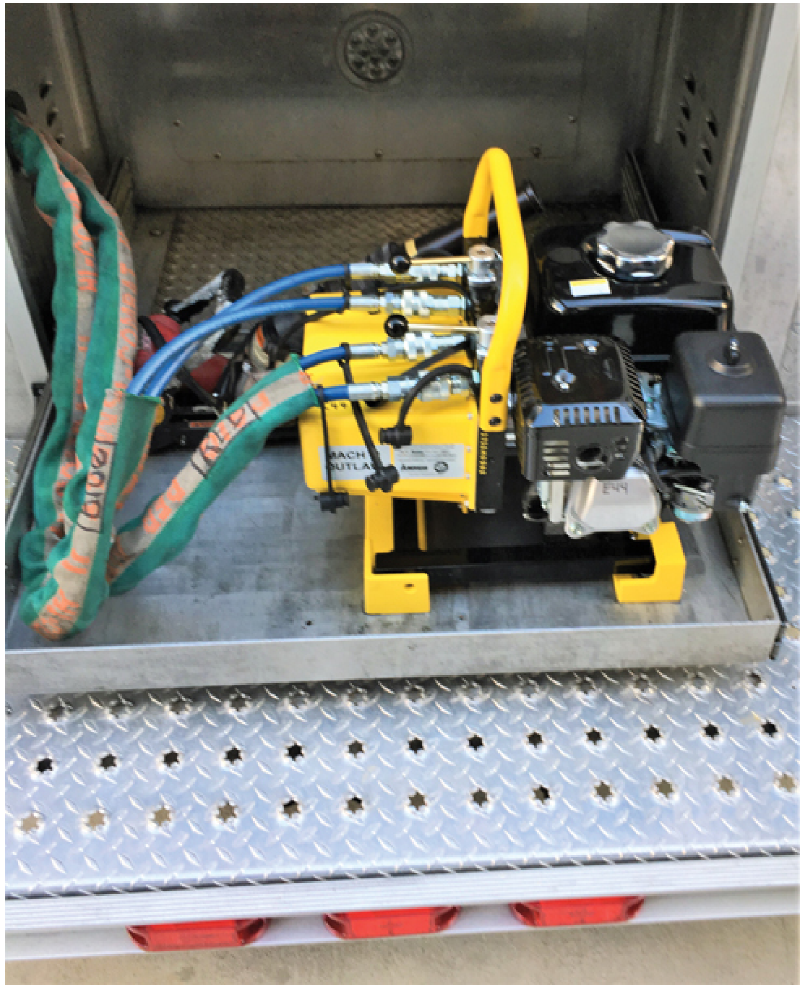
Cutting Torches (2 of 2)

- Another type of cutting torch is the exothermic torch.
- Similar to the exothermic cutting torch is the plasma cutter.
- Always practice the same safety steps before cutting:
  - Review the surroundings, environment, and object to be cut.
  - Check your equipment before operating.
  - Check everyone’s proximity.
  - Full PPE is a priority.

Hydraulic Rescue Tools (1 of 4)

- Operate by transferring energy or force from one area to another by compressing a high-density fluid.
- Can also operate by electric and/or battery, gasoline, or pneumatic power
- Many apparatuses carry hydraulic pumps.

Hydraulic Rescue Tools (2 of 4)



Courtesy of David Sweet.

Courtesy of Edward Monahan.

Hydraulic Rescue Tools (3 of 4)

- Advantages of hydraulic tools are the power and speed of operation.
- Disadvantages are that the tools are heavy and difficult to maneuver in tight spaces.
- Types of hydraulic rescue tools:
  - Spreader
  - Cutter
  - Ram
  - Combination tool (spreader and cutter)

Hydraulic Rescue Tools

Courtesy of Kevin Bellucy.

Hydraulic Rescue Tool Pumps

- Come in a variety of sizes
  - Single-operation pump: only 1 tool can be operated
  - Multiple-operation pumps: several tools can be operated at the same time
  - Two-pump system is more common.
- Ability to switch the flow of both pumps to one side should be used only by trained professionals to avoid harm or injury.

Hydraulic Fluids

- Phosphate ester (predominant until early 2000s): fire-resistant, considered an irritant
- Mineral base oil (common now): easier to work with, less of an irritant, more cost effective; less fire-resistant
- Need to wear full PPE

Courtesy of Genesis Rescue Systems.

Hydraulic Spreader

- Moveable arm opens to move/spread apart or crush/lift material.
- The higher the spreading force, the heavier the tool.

Courtesy of Edward Monahan.

Hydraulic Cutter

- Consists of at least one moveable blade used to cut, shear, or sever material
- Do not necessarily cut metal; they are designed to compress metal until it reaches its breaking point.

Courtesy of Brad Fellers.

Hydraulic Ram

- Powerful, with a piston or other extender that generates extending forces, or both extending and retracting forces
- Variety of length and options, some with interchangeable tips

Courtesy of Edward Monahan.

Hydraulic Combination Tool

- Capable of spreading and cutting
- Advantage of not having to switch tools
- Some also come in hand pump version useful in confined spaces.

Courtesy of Kevin Bellucy.

Battery-Powered Hydraulic Rescue Tools (1 of 2)

- Same force as conventional tools but are void of any hoses and have a separate self-contained pump
- Advantages:
  - Deployed and operated quickly
  - No attached lines that can rupture or leak
- Disadvantages
  - Tool can seem bulky or off-balanced
  - Battery loses power faster
  - No option to double the flow rate of hydraulic fluid

Battery-Powered Hydraulic Rescue Tools

Courtesy of Genesis Rescue Systems.

Courtesy of Power Hawk Technologies, Inc.

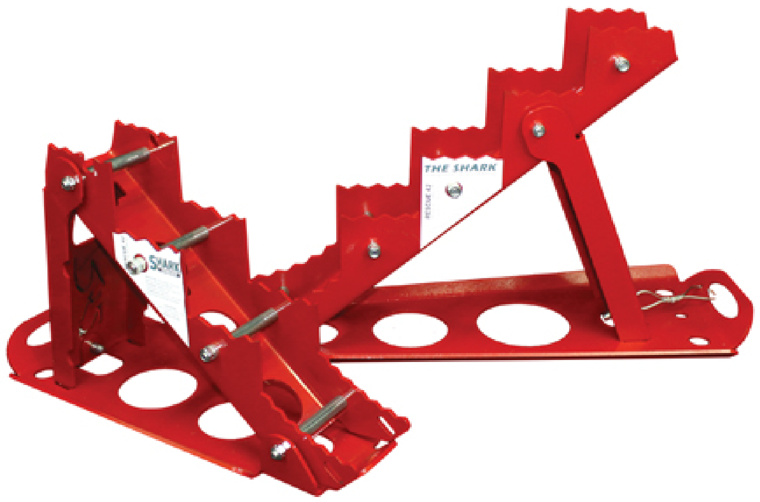
Stabilization Tools

- Main objective is to gain balance by expanding the vehicle’s base and lowering its center of mass.
- The goal of vehicle stabilization is to achieve balance.
  - The vehicle is either stable or unstable.
- An object is stable when the center of mass is lowest to the support base and the base is horizontally wider.
- There are a multitude of tools used to stabilize or shore up a vehicle.

Cribbing

- Consists of short lengths of sturdy timber or composite material to stabilize loads
- Several designs used for extrication
- Wood cribbing is most economical and easy to construct.
    - Consider the strength and behavior of wood when constructing cribbing.
    - Composite plastic is another option to use for cribbing.
    - Metal collapsible step chocks are another option.

Step Chocks



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Courtesy of Edward Monahan.

Wedges

Courtesy of David Sweet.

Shims

Courtesy of David Sweet.

Struts (1 of 3)

- Structural supports or shores used as a “buttress” to stabilize and reinforce an object
- Can be made of steel, aluminum, wood, and/or composite
    - Operated pneumatically or hydraulically
- Non-wood struts are normally telescopic devices that slide to various lengths.
- Can generally support 4,000 to 18,000 lb (1814 to 8165 kg)

Struts (2 of 3)

Courtesy of Edward Monahan.

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Struts (3 of 3)

- Most systems use tension buttress stabilization.
- Each manufacturer adds various features
  to enhance its system.
  - Interchangeable heads
  - Jacking device
  - Try before you buy.

Courtesy of David Sweet.

Jacks (1 of 2)

- Mechanical jacks are most commonly used.
  - Ratchet lever type (FRJ)
  - Scissor/screw jack
- Safety:
  - Operate the tool without any load to understand the mechanism.
  - Never exceed the WLL of the tool.
  - Make sure the load being carried by the jack does not shift.
  - Always stand to the side when jacking or ratcheting.
  - Always lock the safety latch.

Jacks (2 of 2)

Courtesy of David Sweet.

Courtesy of Edward Monahan.

Ratchet Strap

- Uses a manual gear–ratcheting drum to put tension on an object using webbing material
- Not designed to lift
- Used to marry vehicles together
- Several attachment options available

Courtesy of Edward Monahan.

Organization of Equipment (1 of 2)

- Includes tool staging at an incident and proper setup and staging of tools on the apparatus
- May involve organizing tools on a tarp at the edge of a secure work area

Courtesy of David Sweet.

Organization of Equipment (2 of 2)

- Should ultimately begin at the planning stages for the building and design of the apparatus itself
  - A simple redesign can make a big difference.
- The proper organization of equipment will be different for each agency based on the type of apparatus and preference of the users.

Special Equipment: Foam (1 of 3)

- All foams are not created equal.
- Unignited events, such as fuel spills at motor vehicle accidents, are over 85% of the nation’s Class B flammable liquid events.
- Film-forming foam (AR-AFFF) that is UL listed for flammable liquids (not combustibles) should be used.
- PFAS and PFOA chemicals in the foam have been found to be cancer causing. AFFF foam is slowly being phased out in the service with replacement products without these cancer-causing chemicals

Special Equipment: Foam

- All unignited fuel spills should be managed as a polar solvent fuel.
  - The blended fuels are polar and scene security cannot be guaranteed when utilizing a regular Class B AFFF.
  - Class A foam shall not be used for vapor suppression on polar solvents and/or blended gasoline.

Special Equipment: Foam (3 of 3)

- Mil-spec AFFF is the specification of the U.S. Navy and is also used per the FAA at airport authorities in the United States.
  - Does not have any vapor suppression characteristics on polar solvent or blended fuels
  - Use of an ARFF apparatus possibly could overwhelm and extinguish an ignited fuel fire, but there is no scene security after extinguishment.

Foam Equipment

- The default foam proportioner for UL is a foam eductor.
  - Requires 200 psi (1379 kPa) at the inlet of the eductor to operate accurately
  - Can be connected to a 2.5-in (64-mm) discharge
  - Installing the eductor behind the pump panel typically results in failure.
- Using a low-pressure combination nozzle or foam nozzle will allow for more length after the foam eductor.
  - Also, using a larger diameter hose will allow for a longer hose lay.

Foam Equipment (2 of 3)

- More than 130 psi (896 kPa) back pressure applied to the foam eductor will result in a proportioning failure.
- There are also onboard foam systems, which are behind the pump panel of a fire apparatus.
  - Mechanically operated or run by an electronic system
- There are options to have a Class A or a Class B foam used, the choice of which needs to be specified in the purchase of the apparatus.

Foam Equipment (3 of 3)

- There are also quick-attack foam systems available in a portable package designed for fast deployment and operation.

Courtesy of David Sweet.

Signaling Devices

- Portable or fixed communication devices
- Marking kits (paint, chalk, pens/pencils/crayons)
- Pickets or stakes used to close off perimeters
- Preplans or maps
- Traffic control devices
- Visual devices

Specialized Cameras

- Thermal imaging cameras (TICs) detect hot spots and are helpful in finding victims.
- Useful on late night calls where visibility is limited

Courtesy of Edward Monahan.

Power Detection (1 of 2)

- Every rescue organization should have an AC power locator such as a hot stick.
- Detects frequencies below 100 Hz
- Does not detect DC power or AC power contained in solid metal enclosures

Courtesy of HotStick USA, Inc.

Power Detection (2 of 2)

- If a wire is suspected to be down and resting on the vehicle or in close proximity, ensure that the power utility company is notified and proper action is taken.
- Never attempt to see whether a wire is hot by using a hot stick or pole.

Courtesy of Brad Myers.

Victim Packaging and Removal Equipment

- Avoid causing further injury to the victim.
- Immobilization devices
- Stretchers and litters
  - Collapsible and basket stretchers
  - Scoop stretchers

Immobilization Devices

- Full and half (short) backboards are often used in conjunction with stretchers.
- Ensure that there are no cracks, splinters, gouges, worn straps, damaged buckles, or missing pieces.

Courtesy of Edward Monahan.

Stretchers and Litters

- Collapsible and basket stretchers
  - Allow for incorporation of a backboard and may be rigged for vertical lifting
  - Basket stretchers are also useful for water rescues because flotation devices can be attached.
- Scoop stretcher
  - Designed to be split into two or four pieces to be fitted around a patient.
  - Not designed to be used by itself for immobilization

Research Tools

- Internet is always a good tool to use for searching for information.
- Greatest research tool a technical rescuer has is his or her mind.
  - Learn as much as you can about the equipment you use and share your knowledge with others.

Summary (1 of 6)

- A technical rescuer must be proficient with all tools used in the field to adapt and overcome challenges of tool failure that can often arise on an incident or during training.
- There are five basic categories of tools used for vehicle rescue and extrication purposes: hand tools, pneumatic tools, hydraulic tools, electric or battery-powered tools, and fuel-powered tools.
- The technical rescuer must be fully protected before using any tools. To be compliant with NFPA 1951, the protective ensemble must provide protection from exposure to physical, thermal, liquid, and body fluid–borne pathogen hazards.
- The components of PPE include protection of the head, body, eye and face, hands, feet, hearing, and the respiratory system.

Summary (2 of 6)

- A departmental SOP should be implemented for the proper maintenance of all PPE. Setting periodic inspections for all gear, along with inspections after each incident, can help ensure the safety of the individual user.
- A hand tool is any tool or equipment that operates solely from the physical manipulation of human power. There are four basic types of hand tools: striking tools, leverage/prying/spreading tools, cutting tools, and lifting/pushing/pulling tools.
- Working load limit (WLL) is the maximum force that can be applied before failure occurs to an assembly or a component of a device or rope/line/cable in straight tension.

Summary (3 of 6)

- To determine a product's WLL, the manufacturer utilizes the minimum breaking strength of the device and divides this by a safety or design factor that is predetermined by the manufacturer. The minimum breaking "tensile" strength of a chain is determined by using a formula of dividing the unit of force (Newton) by square millimeter (N/mm^2). For example, the grade 80 chain equals 800 Newton per square millimeters. A manufacturer will determine the minimum breaking strength of their 5/8 grade 80 chain at 72,400 lb with a 4:1 safety factor, giving the chain a WWL of 18,100 lb. This WWL is the maximum load determined by the manufacturer that can be applied safely without failure.

Summary

- Pneumatic tools utilize air under pressure to operate and include air chisels, air impact wrenches, air shores, cut-off tools, and rescue air-lift bags. Pneumatic tools can be further categorized into cutting tools, rotating tools, and lifting tools.
- Electric-powered tools use standard household current or a generator to operate. Some tools, such as reciprocating saws, circular saws, drills, and glass cutters, use a battery as an electrical power source.
- Fuel-powered cutting tools such as chain saws, rotary saws, cutting torches, and exothermic torches can generate high power. However, they can be heavy to carry, and some require a mixture of gas and oil. Regular inspections before and after use, along with periodic maintenance schedules, are important for reliable operation of these tools.

Summary

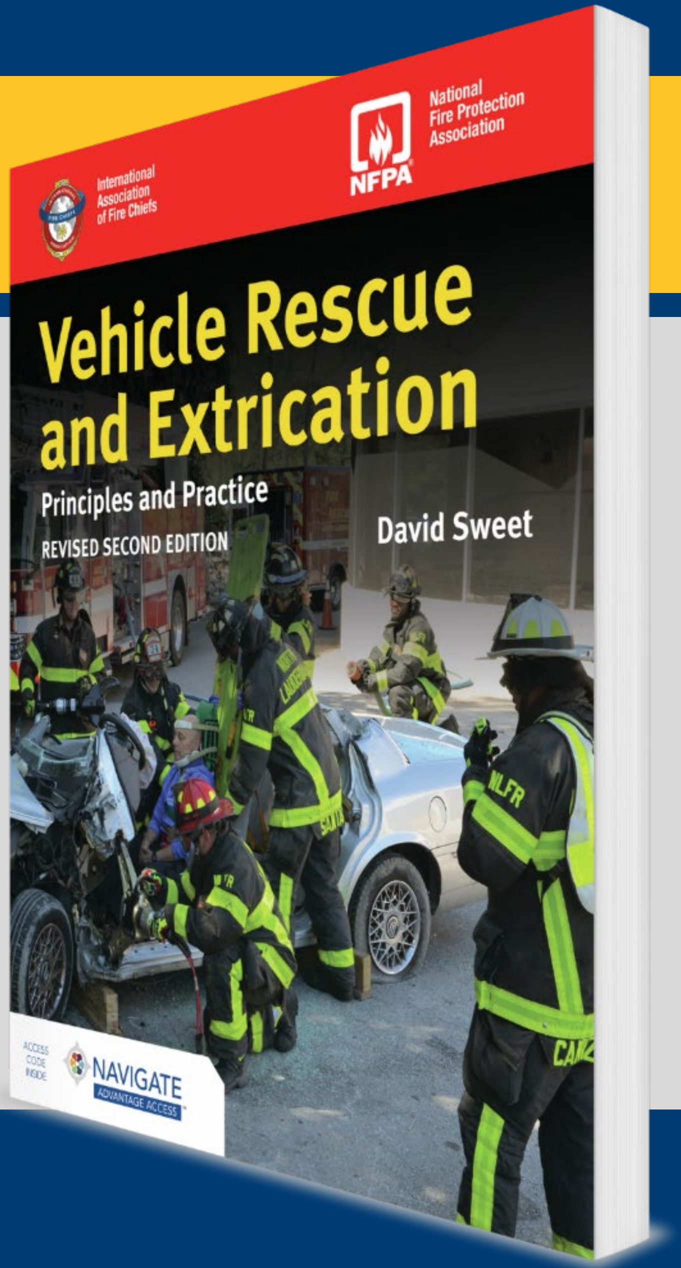
- Hydraulic rescue tools transfer energy or force from one area to another. They can be operated by electric and/or battery, gasoline, or pneumatic power. The major advantage of hydraulic tools over any other tool is the power and speed of operation. The disadvantages are their weight and the limited maneuverability in tight spaces.
- There are four types of hydraulic rescue tools currently used: hydraulic spreader, hydraulic cutter, hydraulic ram, and a hydraulic combination tool (spreader and cutter).
- There are many tools for stabilizing or shoring up a vehicle, including cribbing, struts, jacks, pneumatic shores, and ratchet straps.

Summary (6 of 6)

- The proper staging of tools on the scene and on the apparatus is highly beneficial to completing the operational tasks more expediently and efficiently.
- Special equipment used at the scene of vehicle extrication includes Class A and Class B foams, signaling devices, and specialized cameras.
- A thermal imaging camera is one of the most common specialized cameras, detecting body heat in victims not easily seen or detecting hidden fire or hot spots at the scene.
- Victim packaging and removal equipment is used to protect victims from further injury using stretchers and immobilization devices.

CHAPTER 4

Site Operations



Knowledge Objectives (1 of 2)

- Describe the three stages of vehicle extrication.
- Explain the importance of documentation for vehicle extrication incidents.
- Communicate fire hazards and rescue objectives to the fire support team.
- Compare and contrast vehicle extrication inner and outer surveys.
- Compare and contrast formal and informal postincident analysis.

Knowledge Objectives (2 of 2)

- Identify hazards to rescuer(s) and victim(s) at vehicle extrication incidents.
- Identify fire suppression and safety measures.
- List key elements of landing zone safety.

Introduction (1 of 2)

- There is a three-phase process that should be followed at every extrication incident.
  - The first step is site operations.

Courtesy of David Sweet.

Introduction (2 of 2)


Courtesy of David Sweet.

Courtesy of David Sweet.

Safety

- SOPs outlining universal safety procedures and best practices must be followed.
- Be aware of any situation where safety can and will be jeopardized.
- Know how to adjust, adapt, and conform to the best practice model in order to avoid and eliminate injuries.

Personnel Rehabilitation

- Establishing a rehabilitation group is critical in any prolonged incident.
- Refer to NFPA 1584 for information on
  - Weather and shelter guidance
  - Active and passive cooling and warming techniques
  - Rehydration
  - Medical monitoring and base readings
  - Personnel accountability
  - Transport capabilities

Equipment Resources

- Know what specialized equipment is available.
- Adds another layer of safety concerns
- Establish relationships with other agencies.
  - Coordinate training or “meet and greet”
- Included in agency’s SOPs/SOGs

Courtesy of David Sweet.

Communication and Documentation

- Adoption of NIMS will lead to use of plain language and a structured IAP.
- Use of tactical worksheets at large-scale incidents can be the difference between successful outcomes vs. disastrous outcomes.
- Proper documentation:
  - Pays dividends for an agency when legal issues occur
  - Provides justification of service
  - Provides an avenue to improve the agency

Scene Size-Up (1 of 3)

- **Scene size-up** is the evaluation of information presented in visual or audible form.
  - Begins at the time the incident is dispatched
    - Rescuer should start strategizing while en route.
- First company officer will size up the scene and establish command.
  - Rapid and visual size-up

Scene Size-Up (2 of 3)

TABLE 4-1 Elements of a Rescue Operation

Scene Size-Up	Ongoing Size-Up	Gaining Access to Victims
Appropriately placing apparatus	Controlling associated hazards by stabilizing the scene	Stabilizing the victims by treating and packaging victims
Assessing environmental concerns	Stabilizing the vehicle	Extricating victims
Ensuring appropriate PPE	Creating entry and exit plans: Plan A, Plan B, and emergency escape	Transporting victims
Protecting rescuers with a charged hose line	Dismantling/inspecting equipment	Terminating the incident

Scene Size-Up (3 of 3)

- IDLH hazards
- Exposure to traffic
- Incident scope and magnitude
- Risk–benefit analysis
- Number, size, and type of vehicles involved
- Number of known or potential victims
- Identification of witnesses/bystanders
- Stability of vehicles involved
- Access to the scene
- Necessary resources and their availability

Scene Size-Up Report (1 of 2)

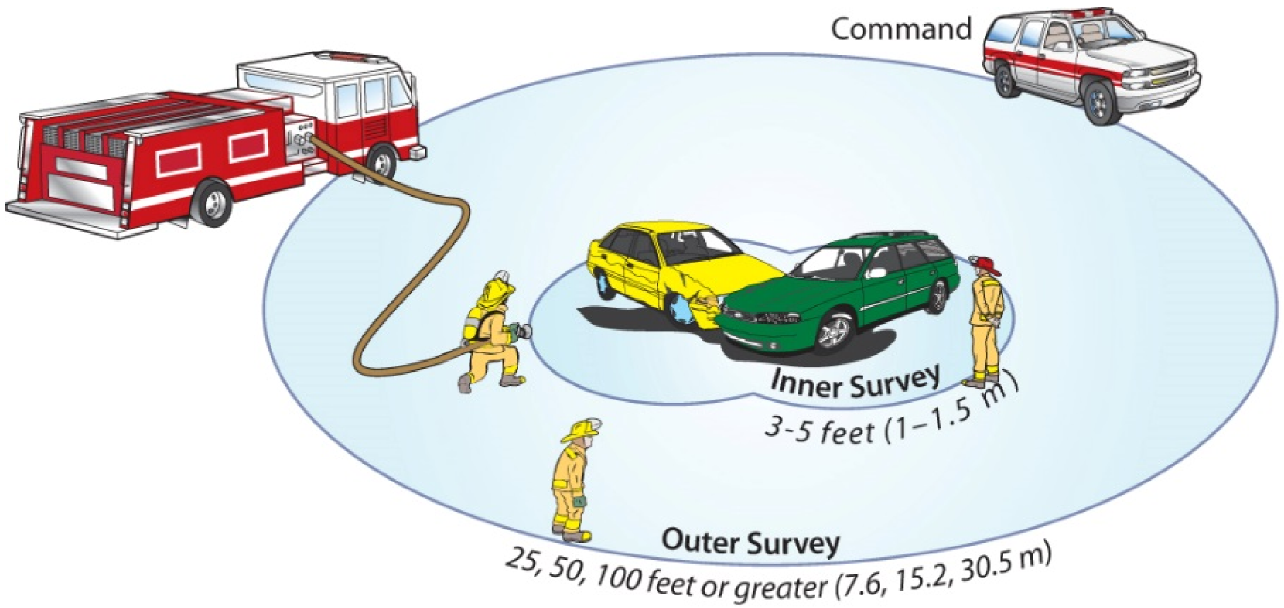
- As the apparatus arrives on scene, the company officer will need to give a size-up report to dispatch.
- The units responding should tailor their response to what the report states:
  - Number of vehicles involved
  - Type of vehicles
  - Position of vehicles
  - Extent of damage
  - Victim status and level of entrapment

Scene Size-Up Report (2 of 2)

- If extrication/special ops are needed, the company officer establishes command and requests a tactical channel.
- After the initial report is given and a closer evaluation of the scene has been accomplished, an update report can be conveyed.
- Once decided upon, entrapment classifications should be considered to be incorporated in departmental response protocols or SOPs.

Inner and Outer Surveys (1 of 2)

- 360-degree inspections completed by two personnel
- Every area in the hot zone should be investigated.



Inner and Outer Surveys (2 of 2)

- Provide the officer and crew with information about
  - Hazards
  - Types of vehicles
  - The number of victims
  - Possible ejections or entrapment
  - Need for additional resources
  - Information for IAP or incident strategy
- If any IDLH hazards are found, rescue team members need to be ordered to freeze until the hazard has been mitigated.

Inner Survey (1 of 5)

- Four-point inspection including top and undercarriage
- Conducted by first arriving company officer, identifying
  - Entry and exit points
  - Victim locations
  - Victim entrapment type and level
  - Vehicle stability

Inner Survey (2 of 5)

- Avoid touching the vehicle.
- Remain 3–5 feet (1–1.5 m) away from the vehicle.
- Approach from the front driver's side corner of the hood.
- Establish immediate verbal contact with victim.
- 45 seconds

Courtesy of David Sweet.

Inner Survey (3 of 5)

- Collect this information:
  - IDLH hazards
  - Type and status of vehicle
  - Number of patients
  - Entrapment classification
  - Obvious trauma to the victim(s)
  - Position and stability of the vehicle
  - Activated SRS air bag system
  - Primary and secondary vehicle access points

Inner Survey (4 of 5)

- **Primary access (Plan A)** consists of the existing openings and/or doors.
- **Secondary access (Plan B)** consists of openings created by rescuers.
- **Emergency escape plan** is for immediate unexpected hazards that affect the rescuers and/or victim.
  - Temporary refuge that the team can retreat to if an immediate danger to life and health is experienced, such as another vehicle entering the hot zone.

Inner Survey (5 of 5)

- **Emergency escape plan**
  - Officer in charge to confirm that all personnel are aware of the designated safe zone area.
  - Emergency evacuation signals should be agreed upon. Signals may be audio (such as an air horn) or visual (such as hand signals).
  - Decision for a rapid extrication is a judgment call.

Outer Survey

- Conducted simultaneously with the inner survey
    - Rescuer moves in opposite direction.
- Start 25–50 feet (7.6–15.2 m) from the position of the inner survey.
- Best to approach from the front side, opposite the officer conducting the inner survey
- Check for IDLH hazards, ejections, walking wounded, additional vehicles, car seats.

Inner and Outer Surveys

- Once inner and outer surveys are complete, the rescuers will meet to discuss their findings, compile the information, and formulate an IAP.
- A rapid **triage** of the victims can be implemented (sorting patients based on the severity of each patient's condition).
- Once victims have been triaged, rescuers establish treatment and transport priorities so resources can be allocated.

Incident Action Plan (1 of 4)

- Can be developed formally for large-scale or major incidents or informally for smaller incidents
- Basic steps
  - Conduct an initial incident size-up.
  - Establish the incident objectives and strategy.
  - Develop the plan.
  - Prepare and disseminate the plan.
  - Evaluate and revise the plan.

Incident Action Plan (2 of 4)

The city of Clearwater Florida

INCIDENT ACTION PLAN

November 1, 2017
Operational period-0700 to 1900

The national extrication competition

Action plan contents

1) Incident objectives
2) Organizational chart
3) Division assignments
4) Safety message
5) Communications plan
6) Transportation plan
7) Medical plan

Courtesy of Carlos Eguiluz.

Incident Action Plan (3 of 4)

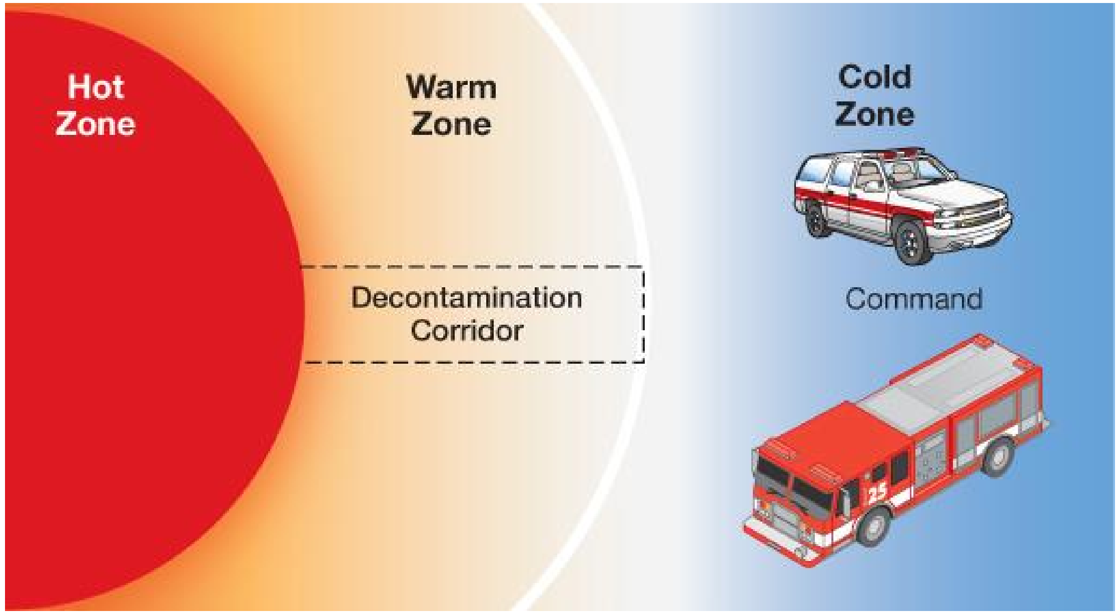
- Regardless of incident size, the IAP encompasses a complete risk–benefit analysis, including
  - Hazard mitigation
  - Resource activation and staging
  - Incident strategy and tactics
  - Establishing and assigning operational and support tasks
- Other possible components include air operations, traffic management, decontamination/waste disposal plans, and evidence recovery plans.

Incident Action Plan (4 of 4)

- Vehicle rescue and extrication in itself is a technical process that requires a plan consisting of structured successive steps to produce favorable results.
  - If steps are skipped, then a poor product will be the end result.
  - A detailed plan of action makes the rescuer better prepared to mitigate unforeseen situations.

Establishing Scene Safety Zones

- Once the entire area has been surveyed, hazard control zones need to be established and maintained until the incident has been terminated.



Establishing Scene Safety Zones (2 of 2)

- Zones are designated by the IC and strictly enforced by the incident safety officer.
- Boundaries should be established in a manner that ensures the safety of the crews operating within the zones and limits the exposure of personnel outside the zone.
  - If there are changes, these must be acknowledged by all on-scene personnel.

Zones (1 of 2)

- Hot zone: for entry teams and rescue teams only
- Warm zone: for properly trained and equipped personnel only
  - Personnel and equipment decontamination
- Cold zone: for staging vehicles and equipment
  - Contains the command post
- No-entry zone: nobody is permitted to enter because of an IDLH or need to preserve the scene
  - May or may not be needed

Zones (2 of 2)

- Most common methods of establishing zones involve
  - Law enforcement
  - Fire line tape
  - Barriers
- Size of each zone will vary by incident.
  - Anyone entering the warm or hot zone must be wearing full PPE, without exception.

Lockout/Tagout Systems

- Ensures that systems and equipment have been shut down and cannot be turned on at the incident scene
- Most often used at hazardous material incidents, machinery entrapment situations, and/or confined space incidents

Courtesy of Edward Monahan.

Fire Hazards (1 of 2)

- Crashes that pose large fire hazards may require additional fire suppression resources.
- Small spills can be handled by using absorbent or adsorbent material to isolate the spill from the area around the vehicle.

Courtesy of Houston Holcomb.

Fire Hazards (2 of 2)

- A post-crash fire or hazard can occur for many reasons, so it is important to be prepared.
  - Short in the electrical system
  - Sparks created during the crash
  - SRS components/associated propellants may rupture
  - Lift struts and bumper assemblies may expand and rupture
- Personnel should possess the necessary skills, training, and qualifications before attempting to extinguish a fire.

Electrical Hazards (1 of 2)

- Down electrical lines present a serious hazard.
- Recognize signs when dealing with power outages.
- Contact the utility, provide and isolate the hazard with traffic cones or barrier tape

Courtesy of Bill McGrath.

Electrical Hazards (2 of 2)

- Never assume a downed power line is dead.
- Never throw anything over a down line to contain or move it.
- Buried electrical supply lines and electrical transformers present the same hazards as suspended lines.


Courtesy of Brad Myers.

Fuel Sources (1 of 2)

- The most common fuel sources today are gasoline and diesel fuels, but alternative fuels are becoming more popular.
  - Gas explosions and leaks normally involve natural gas and propane gas.
  - Natural gas incidents usually involve a ruptured or failed supply line.
- Rescuers should evaluate any gas releases with gas and air monitoring devices to determine the actual release point.

Fuel Sources (2 of 2)

- Once the release point has been located, all buildings in the immediate area should be monitored before the area is considered safe.
- Odorant may or may not have been added to propane, making it difficult to identify.
- BLEVE is one concern.

Fuel Runoff

- Concerns:
  - Ignition sources
  - Environmental concerns
  - Reactions of fuels mixing together
- Methods used to control it:
  - Damming
  - Diverting
  - Diluting
  - Absorbing

Ignition Sources

- Atmospheric monitoring should be established.
- All ignition sources should be eliminated.
- May be necessary for apparatus and vehicles to remain in a staging area upwind beyond the isolation zone
- No apparatus or portable equipment is to be started until hazards are identified/mitigated.

Hazardous Materials (1 of 2)

- Responders must be aware of the complexity, impact, and potential harm that different types of hazardous materials can present so they can avoid exposure.
- Most intelligent course of action is to contact appropriately trained and equipped personnel.
- Responders must also be trained to recognize indicators of potential terrorist incidents.
  - Vehicles are being widely used as weapons.

Hazardous Materials (2 of 2)

- Occasionally involves vehicles that carry flammable and nonflammable gases
- Or solid materials:
  - Explosives and flammable solids
  - Oxidizers and organic peroxides
  - Poisons and corrosives

Courtesy of Mike Jachles.

Other Hazards (1 of 2)

- Environmental conditions
  - Weather
  - Topography
- Infectious bodily substances
  - Do not let bodily fluids come in contact with skin.
  - Wear gloves that will protect from contaminated fluids and sharp objects.
  - Report, document, and clean contamination.

Other Hazards (2 of 2)

- Threats of violence
  - Intoxicated persons
  - Weapons
- Animals
  - Protective pets
  - Livestock or horses

© FOTOKERSCHI.AT/AFP/Getty Images.

Air Medical Operations (1 of 2)

- Medevacs are generally performed by two types of helicopters:
  - Fixed-wing aircraft are used for interhospital patient transfers over distances greater than 100 miles.
  - Rotary-wing aircraft are more efficient for transport over shorter distances.
- Most air ambulances fly in excess of 100 mi/h without delays or traffic hazards.
- Departmental SOPs or medical protocols for air rescue should be established.

Air Medical Operations (2 of 2)

© Ralph IDuenas/Jetwash mages

Courtesy of Ed Edahl/FEMA.

Establishing a Landing Zone (1 of 3)

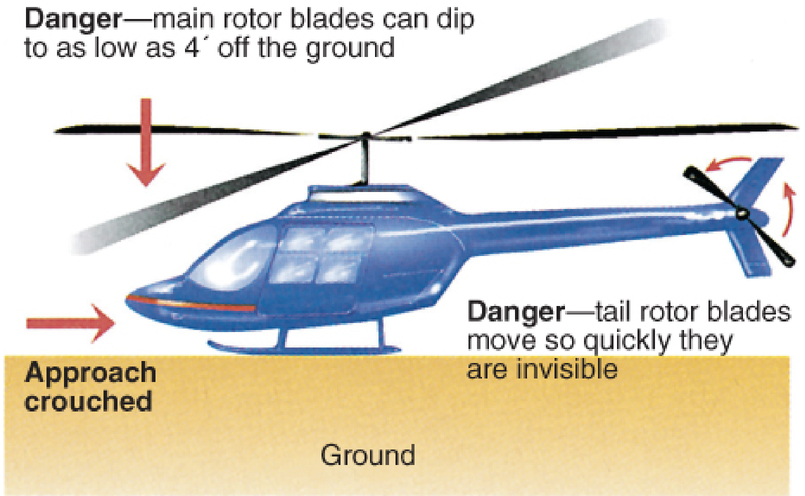
- Responsibility of the ground crew with the coordinated effort of the flight crew
  - Must be agreed upon by both parties
- Ground crew must make certain the flight crew is able to land and take off safely.
- Request for a medevac response should include
  - Ground contact radio channel
  - Call sign that the helicopter medivac should make contact with
- Some agencies preestablish landing zones.

Establishing a Landing Zone (2 of 3)

- Make sure the area is a hard or grassy level surface that measures 100 feet x 100 feet (30 m x 30 m).
- Notify the flight crew if the site is not level.
- Clear the area of any loose debris.
- Survey the immediate area for any overhead hazards.
- Mark the landing site with weighted cones or place lights under these cones for illumination.
- Make sure all nonessential persons and vehicles are moved to a safe distance outside the landing zone.

Establishing a Landing Zone

Courtesy of Devon Sweet.

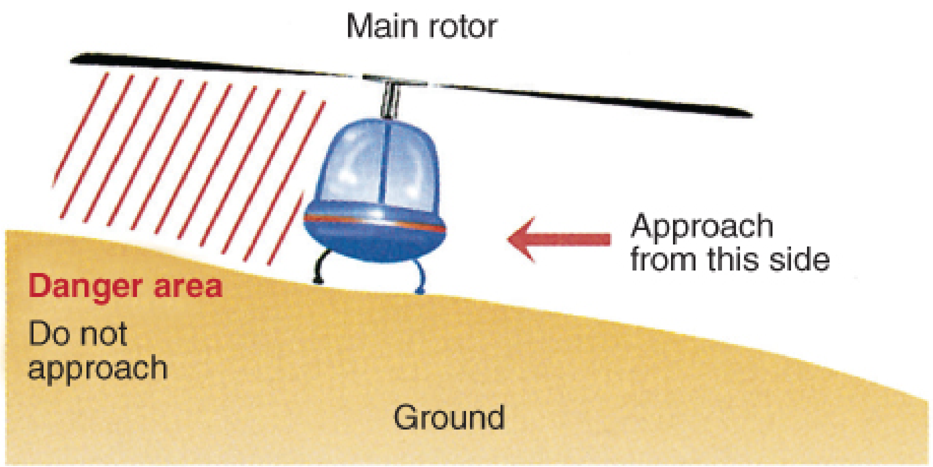


Landing Zone Safety (1 of 2)

- Go only where pilot or crew members direct you.
- Keep a safe distance from the aircraft whenever it is on the ground and hot, which means the helicopter blades are spinning.
- Stay out of the landing zone perimeter unless directed.
- Stay away from the tail rotor; the tips of the blades move so rapidly they cannot be seen.
- Never approach the helicopter from the rear.
- Never go where the pilot cannot see you.

Landing Zone Safety (2 of 2)

- The height of the main rotor blade can dip as low as 4 feet (1.2 m) from the ground.
- On approach, crouch when you walk.
- Hats and loose equipment can be blown off.



Summary

- Ensuring that proper safety procedures are followed in any operation, whether it is responding to an emergency incident, working on an emergency incident, conducting training, or simply checking out or inspecting equipment, is paramount for any organization.
- A properly equipped rehabilitation unit providing shelter and thermal control options should be established early during prolonged extrication incidents.
- When responding to vehicle rescue and extrication incidents, it is vital to know what additional specialized equipment is available to assist in managing an incident.

Summary (2 of 4)

- Proper documentation always pays dividends for an agency when legal issues, such as lawsuits, occur.
- Size-up begins at the time the incident is dispatched, not at the time the unit arrives at the scene.
- A size-up report gives an update to the units responding so they can organize their response.

Summary (3 of 4)

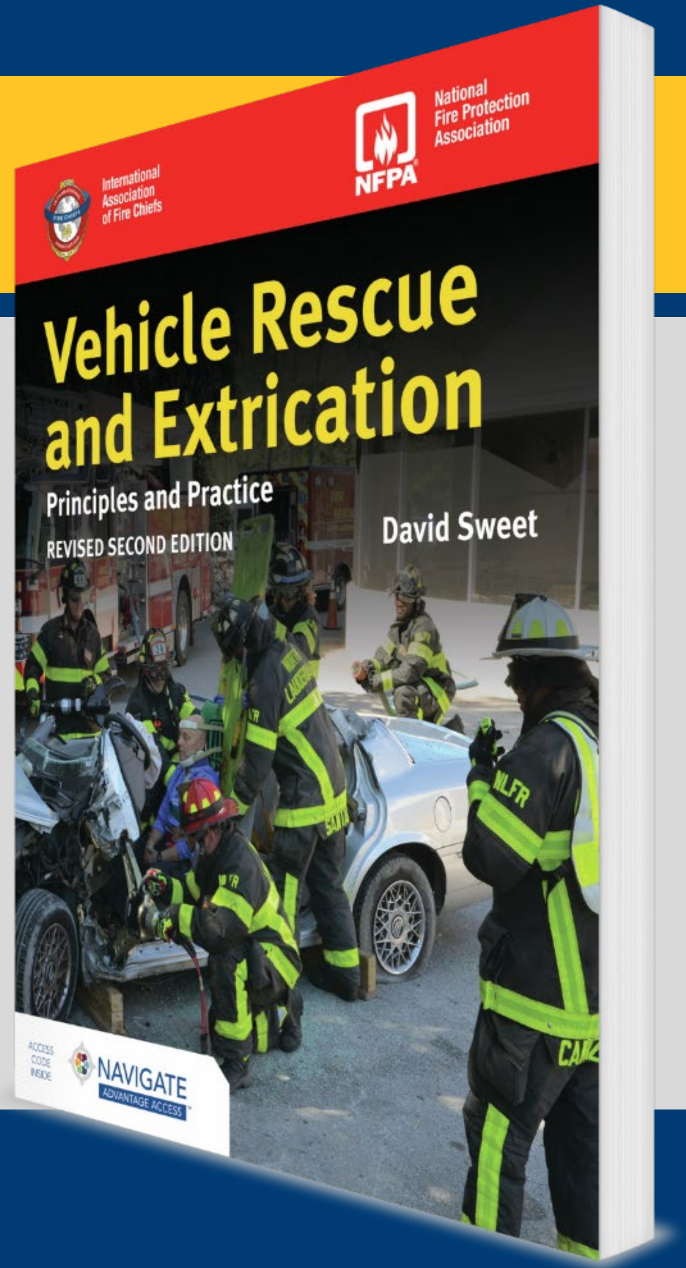
- There are generally three categories of entrapment: minor, moderate, and heavy.
- The inner and outer surveys are 360-degree inspections of the scene that are completed by two or more personnel.
- An IAP may be formal or informal.
- Scene safety zones or operational zones are divided into hot, warm, and cold zones with a fourth, no-entry, zone established if needed. These zones are strictly enforced by a designated incident safety officer.

Summary

- Hazards at vehicle rescue and extrication incidents may include fire hazards, electrical hazards, fuel hazards, ignition sources, and hazardous materials. Personnel should possess the necessary skills, training, and qualifications before attempting to mitigate any of these hazards.
- You should be familiar with the capabilities, protocols, and methods for accessing and landing helicopters in your area.

CHAPTER 5

Mechanical Energy and Vehicle Anatomy



Knowledge Objectives

- Define the following terms and use the terms correctly in discussing vehicle rescue incidents: energy, kinetic energy, potential energy, and work.
- Discuss the application of the law of conservation of energy to vehicle crashes.
- Define mechanism of injury (MOI) and discuss the correlation of MOI and injury to the human body.
- Identify air bag deployment and occupant seat belt use at a vehicle crash.

Knowledge Objectives (2 of 4)

- Explain the five general classifications of vehicle collisions.
- Identify common passenger vehicle anatomy and composition.
- Describe the implications for vehicle rescue of materials used in vehicle construction, including:
  - Metal
  - Carbon
  - Carbon fiber–reinforced polymer
  - Magnesium alloy

Knowledge Objectives (3 of 4)

- Define the following terms and describe their effect on vehicle rescue:
  - High-strength steel (HSS)
  - Advanced high-strength steel (AHSS)
- Identify the major vehicle frame/construction systems.
- Identify common passenger vehicle structural components.

Knowledge Objectives

- Describe two common types of striker plate assemblies in passenger vehicle door construction.
- Identify A-, B-, and C-posts in passenger vehicles.
- Discuss the common types of safety glass used in passenger vehicles.
- Identify primary vehicle propulsion systems in passenger vehicles.

Introduction

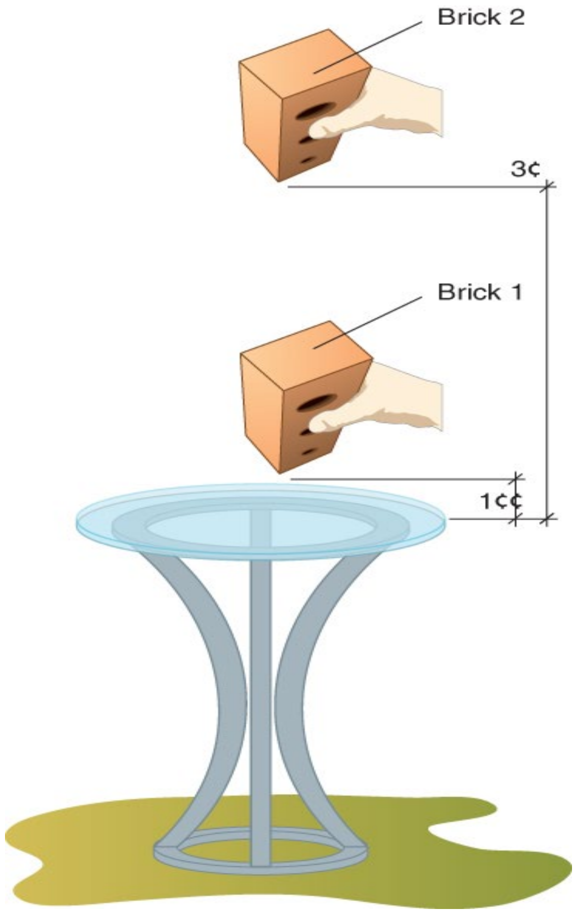
- This chapter explores the application of energy in relation to a motor vehicle collision, including
  - The law of conservation of energy
  - The mechanism of injury
  - The sequence of events
- And the anatomy of a vehicle system:
  - Electrical components
  - Frame systems
  - Vehicle classifications
  - Vehicle propulsion systems

Energy (1 of 5)

- **Energy** is transferred between parts of a system.
  - Capacity for doing work
- **Law of Conservation of Energy**: energy can be neither created nor destroyed.
- Mechanical energy is the force behind vehicle collisions.
  - Two types of mechanical energy: kinetic and potential
  - When combined with work, a system is produced.

Energy (2 of 5)

- **Kinetic energy**: energy of motion
  - Based on weight and velocity
  - Kinetic energy =
    mass/2 × velocity^2
- **Potential energy**: the energy of position or stored energy



Energy (3 of 5)

- **Work** is a mechanism for the transfer of energy.
  - Energy is transferred to an object and the object is displaced.
  - Applied in two ways:
    - Positive: in the direction of travel
    - Negative: against the direction of travel

Energy (4 of 5)

- Work can be extreme or lessened by stored potential energy
  - Speed of travel
  - Weight of vehicles
  - Whether brakes are used
  - Vehicle construction

Courtesy of David Sweet.

Energy (5 of 5)

- Newton's First Law of Motion:
  - Objects at rest stay at rest.
  - Objects in motion stay in motion unless acted upon by an outside force.
- Traumatic injury occurs when the body's tissues are exposed to energy levels beyond their tolerance.
- Mechanism of injury (MOI) describes the forces acting on the human body that cause injury.
  - The same release of energy that occurs during a vehicle collision occurs in the human body.

Sequence of Event in a Motor Vehicle Collision

- Sequence of events typically consists of three separate collisions.
- Understanding this sequence will help you be alert for certain types of injury patterns.
- Your general impression of the victim and evaluation of the MOI can help direct life-saving care and provide critical information to the appropriate medical facility.

Event 1: Vehicle Impact with Object

- Damage to the vehicle is the most dramatic part of the collision.
- Damage can provide information about the severity of the collision and occupant injuries.

Courtesy of Bill McGrath.

Event 2: Occupant Impact with Vehicle (1 of 2)

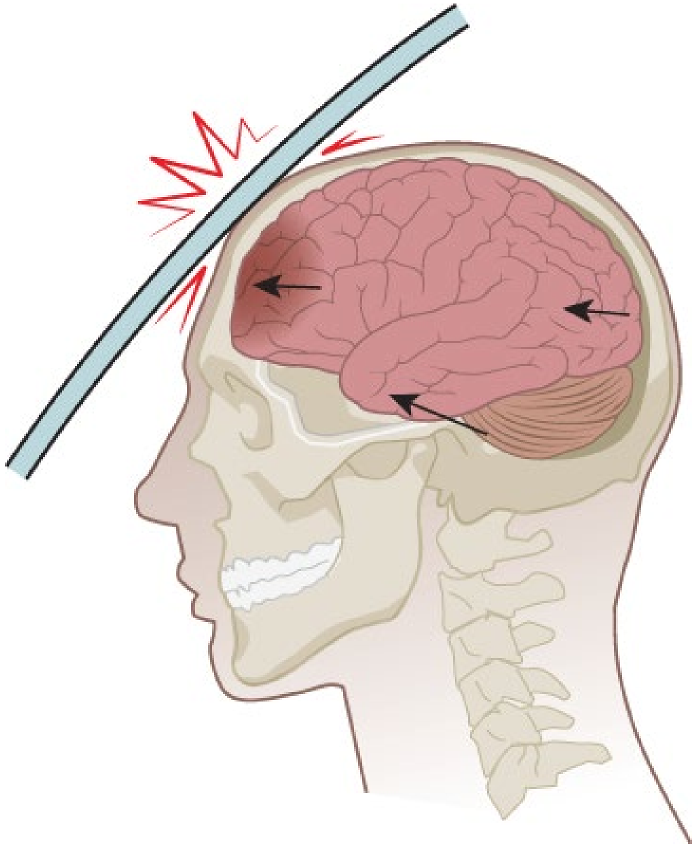
- The kinetic energy of the passenger's mass and velocity is converted into the work of stopping his/her body.
  - Can be extreme or lessened depending on whether seat belts are worn or an air bag is deployed
  - Some injuries will be immediately apparent during the scene size-up.

Event 2: Occupant Impact with Vehicle (2 of 2)

- Common passenger injuries include
  - Lower extremity fractures
  - Flail chest
  - Head trauma
- These are more frequent and severe if the passenger is not restrained.

Event 3: Occupant Organs Impact Solid Structures of the Body

- Organs can impact back and forth several times.
- These injuries may not be obvious, but they can be life-threatening.



Vehicular Collision Classifications

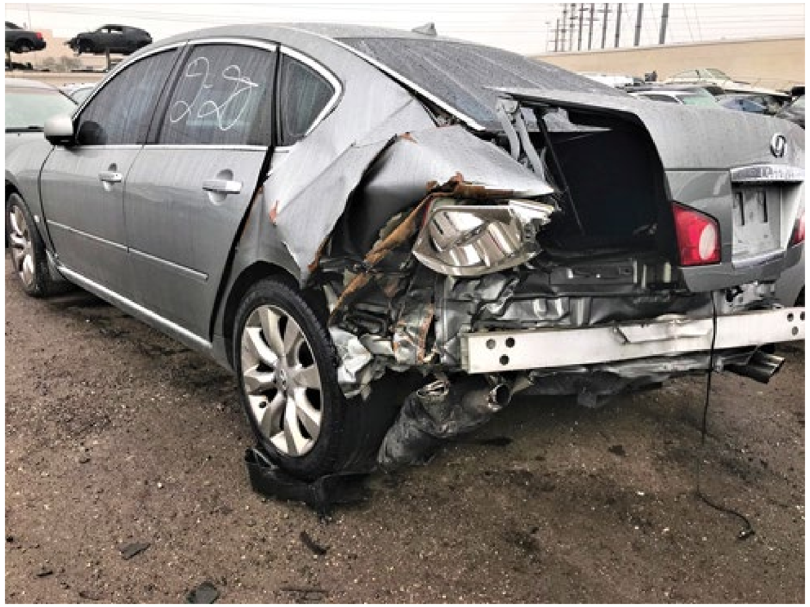
- Collisions are classified by initial impact.
  - Front impact
  - Lateral impact
  - Rear-end
  - Rollovers
  - Rotational (spins)

Front Impact Collisions

- Vehicle strikes an object head-on.
  - Vehicle travels under object.
  - Vehicle travels over object.
- Understanding MOI first involves evaluation of restraint systems: seat belts, seat backs, and air bags.
  - Determine whether passengers were restrained
  - Determine whether air bag impacted the occupant
  - Look for bent steering wheels, broken windshields

Rear-End Collisions

- Known for causing whiplash; cervical spine may be injured
  - Headrests reduce injury.
  - Other parts of the spine and pelvis may be at risk.
- Patient may also sustain an acceleration-type injury to the brain.



Courtesy of David Sweet.

Lateral (Side-Impact) Collisions

- T-bone collisions
- Limited protection for occupants; common cause of fatalities
- Passenger can sustain a lateral whiplash injury.
- May thrust upper body against the doorpost or window.

Courtesy of David Sweet.

Rollovers

- Large trucks and SUVs most prone
- Injuries vary depending on use of restraints.
  - Ejection is common, life-threatening injury.

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Rotational Collisions (Spins)

- Conceptually similar to rollovers
- Rotation may cause secondary impacts.

Vehicle Anatomy and Composition

- The rescuer should
  - Understand the inner and outer components of a vehicle system
  - Know the basic parts that make up various vehicles
  - Not improvise!

Electricity (1 of 2)

- Most ICEs use a basic 12-volt lead acid battery for starting and powering electrical components.
- Hybrids, fuel cells, and electric vehicles also use a 12-volt lead acid battery.
  - Advanced electrical design
- Some vehicles use more than one 12-volt battery:
  - Vehicles operating in cold climates
  - Vehicles with heavy towing assignments
  - Vehicles with additional electrical components

Electricity (2 of 2)

- Larger commercial trucks and military vehicles use a 24-volt power electrical system, where two 12-volt batteries are wired in series.
- A 12-volt lead acid battery system consists of six cells in an electrolyte solution.
  - Chemical reaction with lead plates
    - Produces electrons that flow through conductors
  - When overcharged without proper venting, an explosive by-product can be generated.

Battery Designs

- Wet cell: contains an active electrolyte solution
  - Must be maintained upright
- Absorbed glass mat: prevents electrolyte from moving
  - Can be stored under pressure in multiple positions
- Gel cell: silica base additive firms up the electrolyte
  - Can be stored in multiple positions
- Spiral wound-type: uses tightly wound lead plates
  - Can be mounted in multiple positions

Other Sources of Power

- Alternator
  - Belt-driven generator
  - Produces current used to operate electrical components
- Voltage regulator
  - Regulates the flow of electricity from the alternator

Metal, Carbon, and Composites (1 of 5)

- Metals are group of elements that possess positive ions.
  - Ferrous or nonferrous
  - Good conductor of heat
  - Generally malleable
  - Generally alloyed
- Alloying metal and nonmetal produces products that can be hardened; are lighter, stronger, and resistant to corrosion; and maintain some elasticity.

Metal, Carbon, and Composites

- Carbon: extremely common nonmetallic element
  - Ability to bond with multiple elements, making it the foundation of over 95% of known chemical compounds
  - Carbon steel was once the standard for all structural framing and vehicle components.
- High-strength steels are being discovered and developed to replace conventional steels.
- CAFE standards: sole purpose is to reduce energy consumption by increasing fuel economy

Metal, Carbon, and Composites (3 of 5)

- Manufacturers are always working to make their vehicles more fuel efficient, lighter, stronger, and crash-resistant.
    - Ideas come from the racecar industry.
        - "Safety cage"protects occupants from rollovers and other impacts
    - Conventional vehicle designs are becoming obsolete.

Metal, Carbon, and Composites (4 of 5)

- CFRP can be 5–10 times stronger than some steel alloys and significantly lighter.
- Cutting into CFRP can produce fine particular matter, so respiratory protection is necessary.

Courtesy of Edward Monahan.

Metal, Carbon, and Composites (5 of 5)

- Aluminum alloyed metal is used to strengthen and lighten the vehicle.
- Magnesium alloy is gaining popularity because of its highly sought after high strength-to-weight ratio (helps meet CAFE standards).
  - Danger of fire is a major concern.
  - Implicated vehicle components are engine block, wheels, steering columns, seats, front consoles, strut cradles, door frames, and hoods.

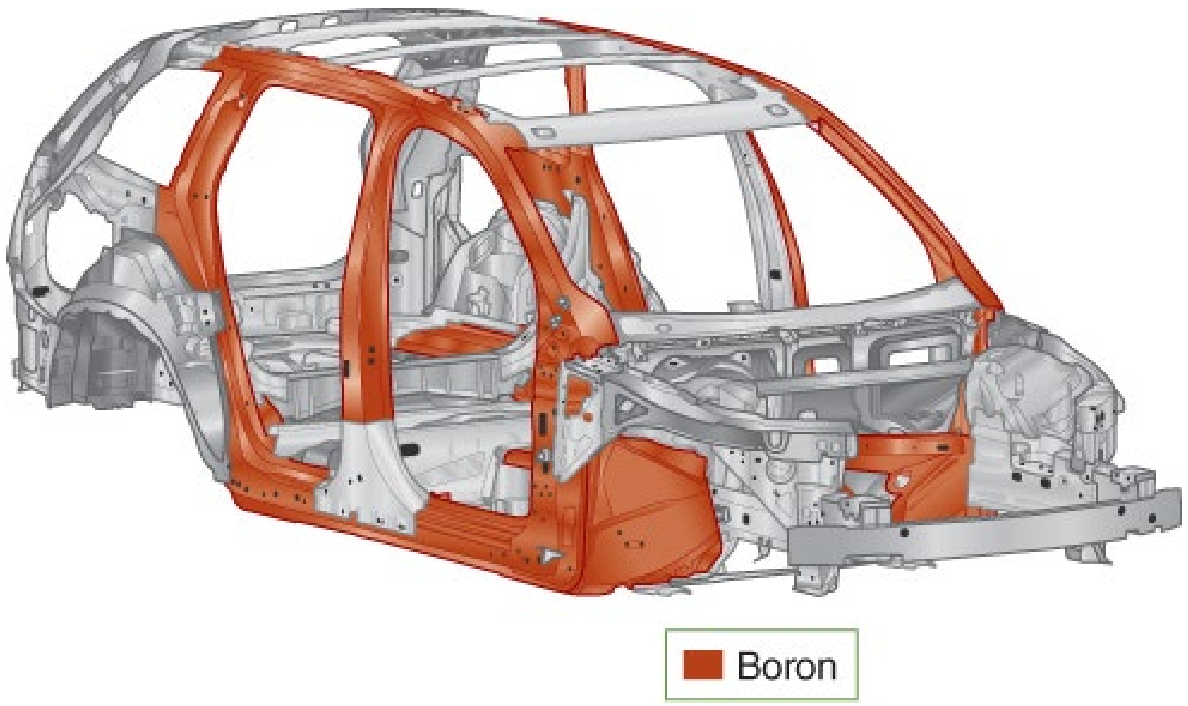
Steel

- More than 3,000 types
- Measured by
  - **Tensile strength:** measures the amount of strength required to tear a section of steel apart
  - **Yield strength:** the amount of force or stress that a section of steel can stand before permanent deformation occurs

Alloyed Steels (1 of 3)

- Mixture of metals and elements classified by
  - Strength range (MPa)
  - Metallurgical type designation
- World Steel Association classifications:
  - High-strength steel: ultimate tensile strength between 39 and 102 ksi
  - Advanced high-strength steel: ultimate tensile strength of 63 to 145 ksi (e.g., Boron-alloyed steel)

Alloyed Steels (2 of 3)



Alloyed Steels (3 of 3)

- Third-generation steels are being developed with a better balance of strengthening versus elongation properties.
- The world of technical rescue must replace processes and procedures to keep pace with advancing technology.
- Becoming adaptive and fluid with technique and fully understanding the capabilities and limitations of modern metallurgical elements are imperative for successful operations.

Frame Systems: Body–Over–Frame Construction

- Body is placed onto a frame skeleton.
  - **Ladder frame**
- Used for heavier vehicles
- Force distribution is greater on the occupants.

Courtesy of David Sweet.

Frame Systems: Unibody Construction (1 of 3)

- One piece
- No formal frame structure
- Body is merged with **chassis**.
- Subframe systems: two short beams attached to the occupant compartment to house vehicle components

Courtesy of David Sweet.

Frame Systems: Unibody Construction (2 of 3)

- Potential to be split in half in a severe collision
- Incorporates **crumple zones** to direct energy away from the passenger compartment

Courtesy of Jim Dobson.

Frame Systems: Unibody Construction (3 of 3)

Courtesy of David Sweet.

Courtesy of Devon Sweet.

Frame Systems: Space Frame Construction (1 of 2)

- Designed for the auto racing industry
- Lighter weight and rigid structure
- Traditional body design is made of multiple lengths and angles of tubing welded into a rigid, but lighter, web or truss-like structure.

Courtesy of David Sweet.

Frame Systems: Space Frame Construction (2 of 2)

- The vehicle’s outer panels are attached independently to the frame after its completion.
- Can be driven in its skeleton form, void of any body panels

Structural Components (1 of 21)

- **Bumper system**
  - Helps vehicle withstand impact of a collision
    - Federal regulations require that a bumper be able to withstand front or rear impact collision at 2.5 mph.
  - Several different types of bumper systems
    - Gas strut telescoping-type design
    - Crate-like design made of polypropylene foam or plastic material

Structural Components (2 of 21)

- **Core support (radiator support)** is a key component of the front end of the vehicle.
  - Designed to secure the radiator to the engine assembly frame
  - Ties the upper and lower rails together
  - Also houses the lights, horn, and other components
  - Maintains alignment of the hood and hood latch

Structural Components (3 of 21)

- **Upper rail**
  - Located on front top section of the vehicle
  - Two beams hold the hood in place and attach the front wheel strut system to the chassis.

Courtesy of Edward Monahan.

Structural Components (4 of 21)

- **Strut tower** is a component of the suspension system.
  - Critical relief cut area associated with the dash-lift technique
- **Engine cradle** is attached to the frame rails and houses the engine.
  - Bolt heads are designed to shear off on impact to drop the engine under the vehicle instead of into the passenger compartment.

Structural Components (5 of 21)

- **Passenger compartment**
  - Cowl section is the upper area of the front passenger compartment directly in front of the windshield.
  - Below the cowl section is the firewall, or bulkhead, which separates the engine compartment from the passenger compartment.
  - On the outer sections of the bulkhead that bookend the firewall are the hinge pillars where the front doors are attached.

Structural Components

- **Dash bar**
  - Runs the entire width of the car
  - Two steel brackets (known as dash brackets) are located in the center console to lock the dash in place.

Courtesy of Edward Monahan.

Courtesy of Edward Monahan.

Structural Components (7 of 21)

- **Rocker panel**
  - Channel that runs along the outermost sections of the floorboard where the doors rest
  - Hollow section of metal
  - Little structural support

Courtesy of David Sweet.

Structural Components (8 of 21)

- **Doors** are constructed of five sections:
  - Inner panel
  - Outer panel
  - Hinge and hinge reinforcements
  - Impact beam
  - Latch and locking assembly

Structural Components (9 of 21)

- **Door hinges** allow doors to swing.
  - **Hinges** come in various types
    - Leaf system
    - Full body hinge

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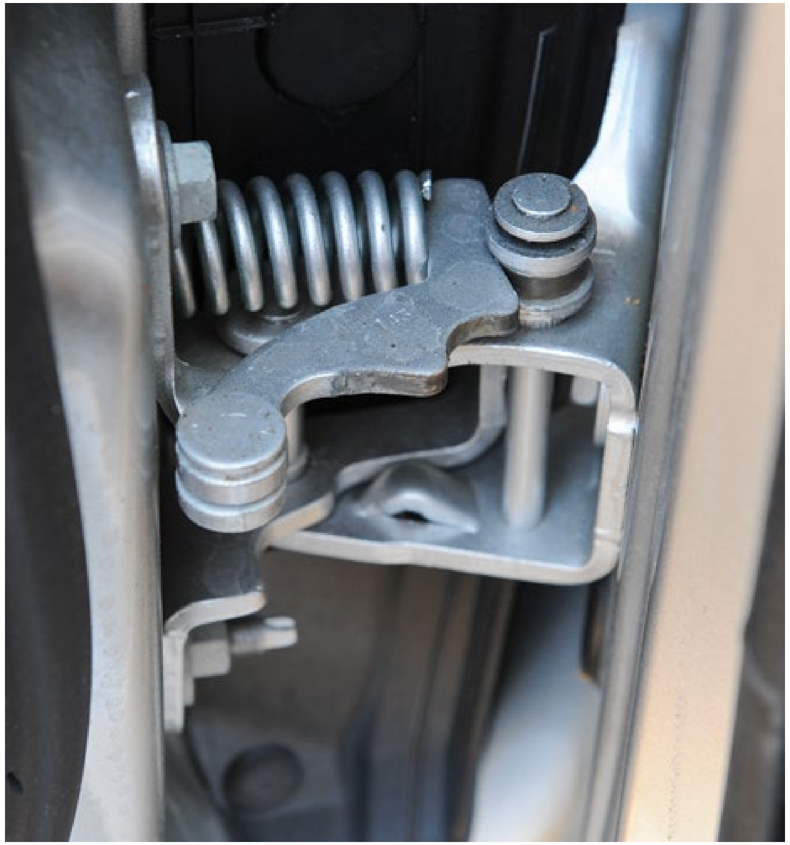

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Structural Components

- **Door hinges**
  - Some hinges have a spring attachment that can come off violently without warning under extreme force.

Courtesy of David Sweet.

Structural Components

- **Swing bar** assists the door in opening and closing.
- Designed to stop the motion of the door and prevent the door from overextending
- Can be very difficult to cut through but easily detached

Courtesy of David Sweet.

Structural Components (12 of 21)

- **Latching mechanisms**
  - **Nader bolt:** difficult to cut through
  - **U-bolt:** easier to cut through

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Courtesy of David Sweet.

Structural Components

- **Impact beam**
  - Entire length of the door
  - Absorbs impact energy of another vehicle or object
  - Very difficult to cut through
- **Outer panels** can be removed with hand tools.

Courtesy of David Sweet.

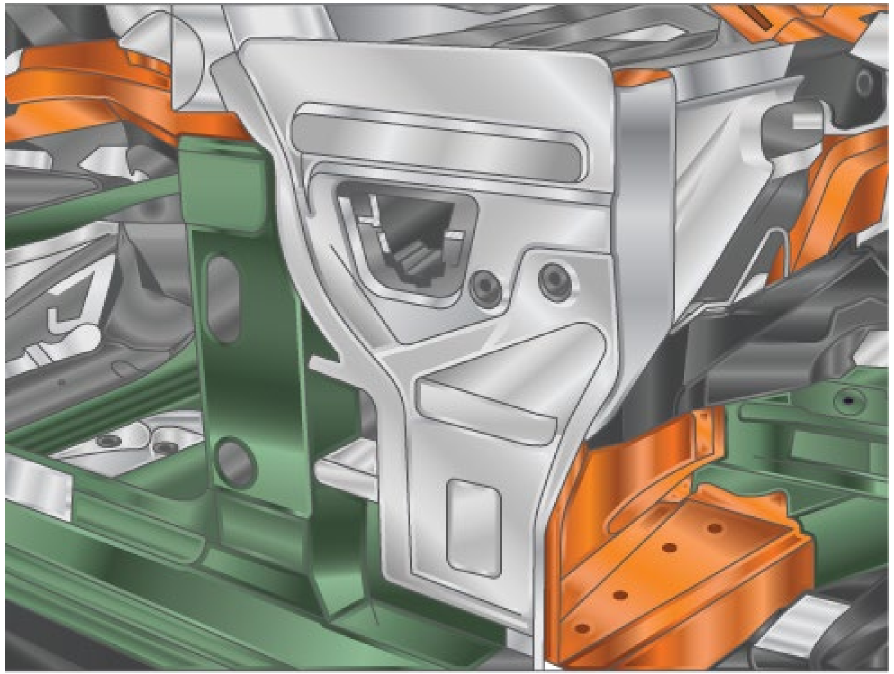
Structural Components

- **Roof posts** add vertical support to the roof.
- Posts are labeled alphanumerically.

Courtesy of David Sweet.

Structural Components (15 of 21)

- **A-post**
  - Closest to windshield
  - Layers of steel or aluminum
  - Reinforced area makes dash lift difficult
  - Expose and examine for SRS



Structural Components (16 of 21)

- **B-post**
  - Located between front and rear doors
  - Several types of seat belt systems
    - **Standard seat belt harness** includes a shoulder and lap belt.
    - **Pretensioner belt system** pulls back and tightens when activated by a collision.
    - Automatic seat belt system has a shoulder harness that slides into place automatically.

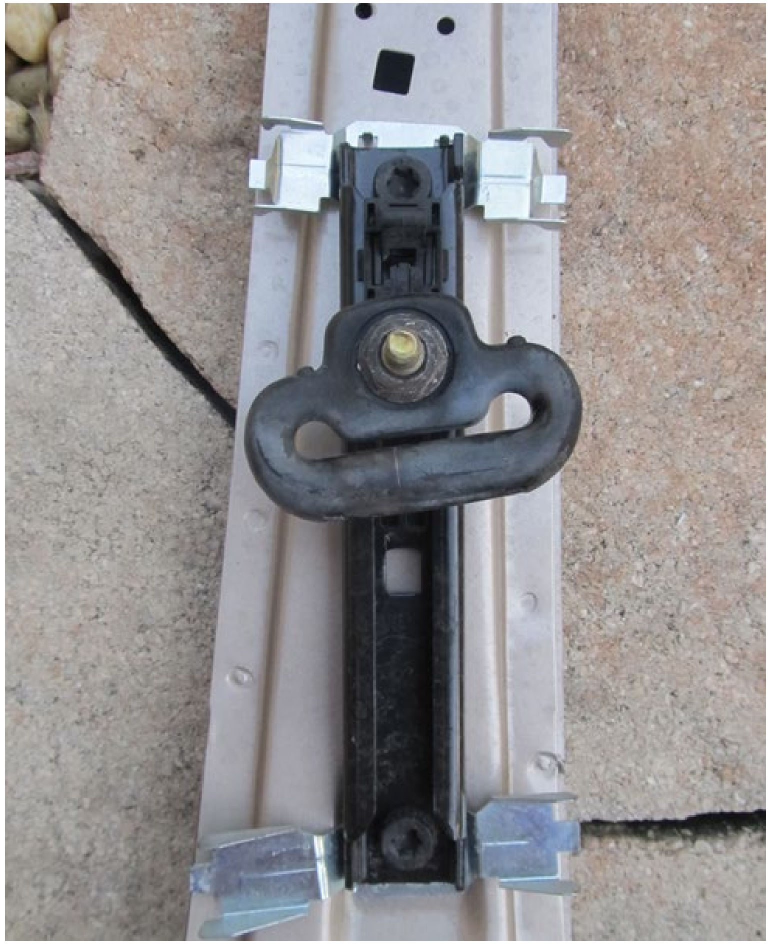
Structural Components

- **B-post**
  - Areas may be reinforced with HSS.

Courtesy of David Sweet.

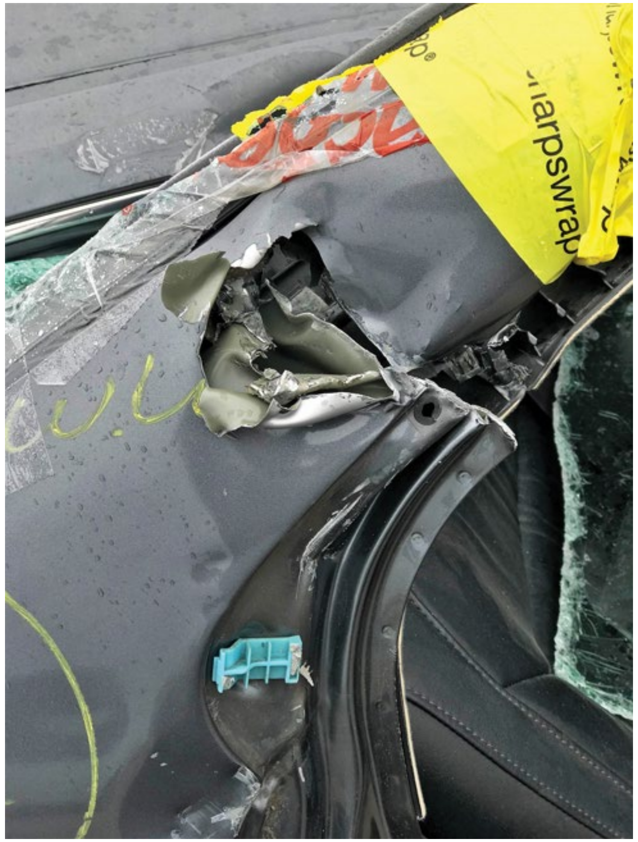
Structural Components (18 of 21)

- **B-post**
  - Height-adjusting anchor at the upper section is also reinforced.



Courtesy of David Sweet.

- **C-post**
  - Rear post in most vehicles
  - Can be wide or narrow
  - Air bag cylinders may be present.



Courtesy of David Sweet.

Structural Components

- **Rear end of the vehicle**
  - Trunk/hatchback
  - Rear suspension
  - Rear quarter panels
  - Rear deck/shelf (package tray)

Structural Components

- **Piston struts**
  - Assist in lifting and support of vehicle components
  - Cutting the cylinder section can cause a rapid release of pressure or hydraulic fluid.
  - Vehicle fires are a concern.

Courtesy of Edward Monahan.

Federal Safety Standards and Regulations

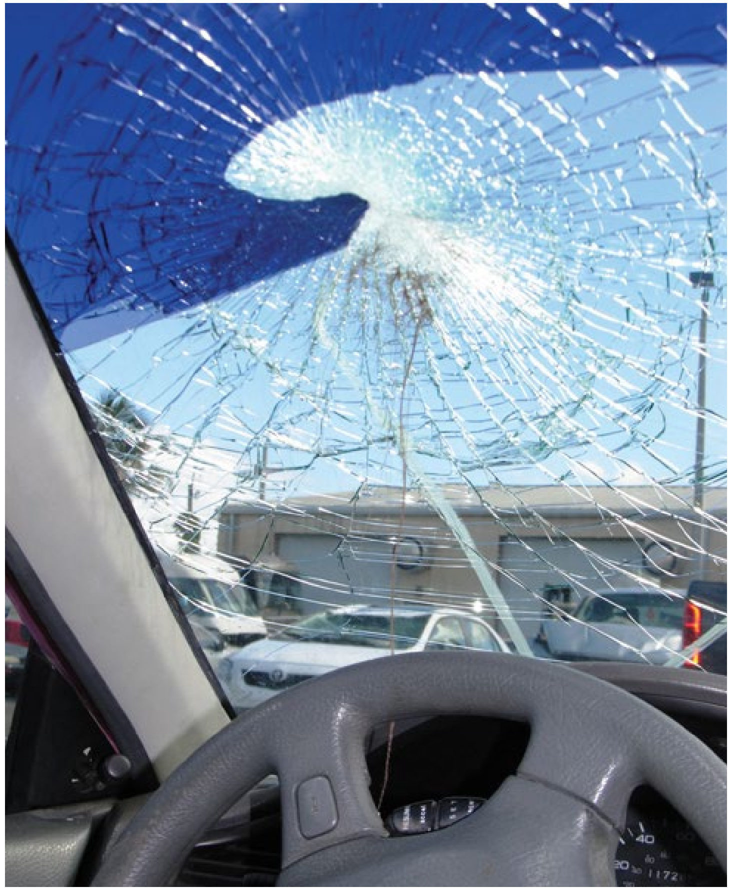
- Federal safety compliance regulations that outline the minimum safety performance requirements for motor vehicles or equipment.
- Manufacturers design and redesign vehicle frames, structures, and components based on these regulations.
- Issued by NHTSA; first standard was issued in 1967

Vehicle Glass and Glazing (1 of 5)

- Glass management is the process of controlling the voluntary or involuntary fragmentation of glass by applying proper removal techniques and/or securing the glass in place.
  - Properly managing glass from the onset of the rescue increases proficiency, speed, and overall safety for the rescuer and victims.
  - There are several types of glass and glazing that the technical rescuer can encounter in a vehicle.

Vehicle Glass and Glazing (2 of 5)

- **Laminated safety glass**
  - Created by heating a layer of clear plastic film between two layers of plate glass.
  - Prevents the glass from flying in on the occupant
  - **Window spidering**
    - Designed to resist small projectiles



Courtesy of David Sweet.

Vehicle Glass and Glazing

- **Gorilla Glass**
  - Uses a three-layer fusion process to make laminate glass compatible with vehicle use
  - Lighter than transitional laminates
  - Surface is more resistant to fractures.
- **Tempered safety glass**
  - Glass is heated and then quickly cooled.
  - Breaks into small pieces with no long shards (**dicing)**

Vehicle Glass and Glazing

- **Polycarbonate**
  - Clear plastic material that can endure impacts
  - Pliable on impact
  - More and more manufacturers now use it
  - Difficult access problems for the rescuer
- **Ballistic glass**
  - Bullet-resistant glass
  - Weight and thickness depends on level of protection.
  - Not advised to remove or cut into this material

Vehicle Glass and Glazing (5 of 5)

- Smart technology is the driving force for new techniques that allow enhanced features:
  - Electrochromic, suspended-particle heads-up display
  - Self-tinting
  - Self-cleaning
  - Side and rear view monitor viewing
  - Auto-temperature adjustments
  - Curved/extended/panoramic-type windows and rooflines

Vehicle Classifications

- DOT classifies vehicles based on whether the vehicle transports passengers or commodities.
  - **Passenger vehicles**: manufactured for the purpose of transporting passengers
- DOE classifies vehicles by size in cubic feet (passenger and cargo) and gross weight.

Vehicle Identification Numbers

- 17-character sequence of letters and numbers
- All vehicles manufactured in the United States and many other countries are required to have them.
- Normally etched on a plate
- Listed on vehicle documents and records
- Each alphanumeric designation has a specific meaning.

Vehicle Propulsion Systems (1 of 3)

- **Conventional vehicles**
  - Majority of vehicles on the road
  - Use **internal combustion engines (ICE)** for power
    - Burn petroleum-based fuels and alternative fuels
  - Fuel tanks are constructed of steel or aluminum.
  - **Pounds per square inch (psi)** describes pressure.
    - Amount of pressure exerted over an area of equaling 1 square inch

Vehicle Propulsion Systems (2 of 3)

- **Hybrid electric vehicles**
  - Combine two or more power sources for propulsion
    - Usually a high-voltage electrical system and an internal combustion engine
- **Hydrogen fuel cell vehicles**
  - Electrochemical devices that use hydrogen and oxygen to create electricity

Vehicle Propulsion Systems (3 of 3)

- **Electric-powered vehicles**
  - Use an electric motor for propulsion
  - Powered by batteries in a rechargeable battery pack
  - Recharge through dedicated charging station or plug-in house current

Summary (1 of 4)

- Three concepts of energy are typically associated with injury: potential energy, kinetic energy, and work.
- Motor vehicle collisions are classified traditionally by the area of initial impact: front impact (head-on), lateral impact (T-bone or side impact), rear end, rotational (spins), and rollover.
- In every crash, three collisions occur:
  - The collision of the vehicle against an object
  - The collision of the passenger against the interior of the vehicle
  - The collision of the passenger’s internal organs against the solid structures of the body

Summary (2 of 4)

- Before a rescuer can properly apply any vehicle rescue and extrication procedures to a vehicle, he or she must understand the inner and outer components that make up a vehicle system.
- The DOT classifies vehicles based on whether the vehicle transports passengers or commodities, with a non-passenger vehicle being further classified by the number of axles and unit attachments it has.
- The DOE classifies vehicles by size using a cubic-foot system (passenger and cargo volume) and gross weight system.

Summary

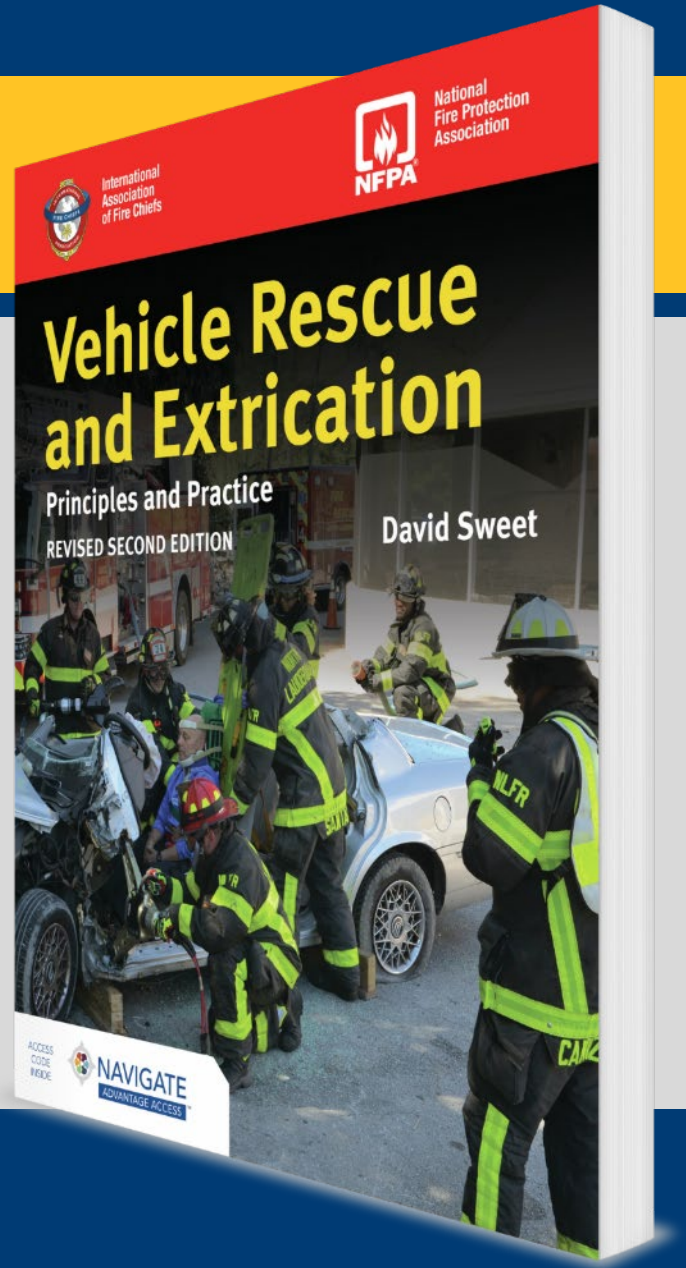
- Most vehicles on the road today are conventional-type vehicles; these types of vehicles utilize ICEs for power. Other types of vehicles include hybrid electric vehicles, hydrogen fuel cell vehicles, and electric-powered vehicles.
- Electrical power in conventional-type vehicles with ICEs is supplied by a basic 12-volt lead acid battery system. In hybrids, fuel cell vehicles, and electric vehicles, a different, advanced electrical design is used.

Summary (4 of 4)

- The development of strong, crash-resistant vehicles requires engineers and the steel industry to develop stronger and lighter steels to meet demands.
- There are two frame systems that are most common in today's vehicles: body-over-frame construction and unitized, or unibody, construction. These frames can be composed of steel (most common), aluminum, or carbon fiber/composite. Another type of frame system that is less common today is the space frame.
- Several key components make up the body portion of the vehicle.
- The technical rescuer can encounter several types of glass in a vehicle, including LSG, TSG, polycarbonate, and ballistic glass.

CHAPTER 6

Supplemental Restraint Systems



Knowledge Objectives (1 of 2)

- Define the following terms and explain their role in vehicle rescue incidents:
  - Accelerometer
  - Air bag control unit (ACU)
  - Deployment zone
  - Distancing
  - Electronic control unit (ECU)
  - Initiator
- Identify the differences between active and passive vehicle restraint systems.

Knowledge Objectives

- List the steps in the air bag deployment process.
- Identify the basic components of an air bag system.
- List the types and locations of air bags present in passenger vehicles.
- Explain the importance of expose and cut.
- Describe seat belt pretensioning systems and explain their activation.
- Explain safety precautions to protect rescuers in extrication from vehicles with air bag systems.

Introduction

- In 1967, the NHTSA issued **Federal Motor Vehicle Safety Standards (FMVSSs)**.
  - To protect the public from risks of injury or death resulting from poor design, construction, or performance of a motor vehicle
    - FMVSS 209, Seat Belt Assemblies
    - FMVSS 208, Occupant Crash Protection
    - FMVSS 214, Side Impact Protection
    - FMVSS 226, Ejection Mitigation

Air Bags (1 of 7)

- Fatalities from motor vehicle accidents increased dramatically in the 1970s because occupants did not wear seat belts while driving.
- Automobile industry introduced an air cushion restraint system to counter this trend.
    - At the time, it was considered to be a replacement to the seat belt.
    - More accident fatalities occurred.
    - As time went by, the air cushion restraint system faded away, and seat belt education and enforcement started to increase.

Air Bags (2 of 7)

- In the 1980s, a system similar to the air cushion restraint (the air bag) emerged as a supplement to the seat belt.
- Became known as a supplemental restraint system (SRS)

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Air Bags (3 of 7)

- Manual seat belts are **active restraint devices**.
- Air bags are **passive restraint devices**.
- In 1984, FMVSS 208 was amended to mandate that motor vehicles must be equipped with a passive restraint system.
  - Included air bags and automatic seat belts
  - Most vehicles offered only a single-stage air bag system.

Air Bags (4 of 7)

- First-generation air bags would fire at a preset discharge rate and pressure fitted only for average-sized males.
  - Children, women, or smaller-statured individuals were not factored in.
  - Out-of-position occupants or unbelted occupants would be subject to a crushing force.
- Caused FMVSS 208 to be amended to accommodate different-sized individuals
  - Mandated that air bags be depowered and a deactivation switch be added to passenger-side air bags (second-generation air bags)

Air Bags (5 of 7)

- Smart air bag systems automatically adjust the pressure in the air bag by using **inflators**.
  - Deployment force is based on
    - Crash severity
    - Occupant’s weight
    - Proximity to the air bag
    - Seat belt usage
    - Seat position

Air Bags (6 of 7)

- 14 mph was determined to be the minimum cutoff speed for air bag inflation.

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Air Bags (7 of 7)

- Features to protect occupants from air bag injuries:
  - Dual-stage or multistage inflation process
  - **Suppression system** shuts down air bag if occupant classification system detects a child.

Air Bag Deployment Process (1 of 2)

- Crash itself
- Crash sensor (**accelerometer**) detecting deceleration
- Air bag deploying and inflating
- Occupant moving forward and striking the bag as deflation occurs

Air Bag Deployment Process (2 of 2)

- Certain factors can change some of these crash sequence dynamics:
  - Seat belt system
  - Size and seated distance of the occupant
  - Severity of the crash
- The entire crash process takes approximately 100 to 125 milliseconds.
- The gas inside the air bag must be precisely set with the correct volume to prevent the occupant from striking the steering wheel or dash.

Air Bag Components (1 of 2)

Courtesy of David Sweet.

Air Bag Components (2 of 2)

- Consists of strong, durable nylon or blended material
- Coated with a powdered substance, normally consisting of talcum, chalk, or cornstarch
- Comes equipped with several tethers designed to manage the speed of deployment
- Air bag cover is a plastic material designed to tear apart and separate when the air bag inflates.
- Size of the bag will vary.
- Driver and front passenger air bags are mandatory in all vehicles.

Types of Air Bags: Side-Impact Air bags

- Protect the head, chest/upper torso
- Designed to activate immediately upon impact
- Can be found in the door, seat backs, roof posts, or roof rails
- Designed to maintain inflation to protect from secondary impacts or rollovers

Courtesy of David Sweet.

Types of Air Bags: Center Air Bag

- Designed to protect from secondary impacts
- Also protects from side impacts that occur on the opposite side of the vehicle
- Deploys in an upward and forward position between the front and rear seats

Types of Air Bags: Knee Air Bags

- Protect the occupant's abdomen, pelvis, and lower extremities
- Plastic molding makes contact with the occupant rather than tearing away at a seam.
- Designed to prevent the occupant from being pulled under the dash

Courtesy of David Sweet.

Types of Air Bags: Other (1 of 2)

- Seat belt air bags
  - Protect torso and pelvic area
  - Work in conjunction with the seat belt pretensioning system to reduce the "clothesline effect"
- Seat cushion air bag
  - Positioned just under the front section of seat
  - Raises the hip and knee area of the occupant, in turn reducing the forward movement of the chest and abdomen

Types of Air Bags: Other (2 of 2)

- Rear seat deployment air bag systems
  - Deployed from the center roof area, seat belt, door, or roof post
- Outside pedestrian protection system
  - May be an air bag positioned in the front bumper/hood area
- No standardized locations for air bags or inflation cylinders

Air Bag Components

- An **initiator** device, such as a **squib**, ignites the propellant that produces the gas that fills the air bag.

Courtesy of David Sweet.

Air Bag Control Unit (1 of 2)

- Computerized component of the overall ECU
- Generally located in center of vehicle and/or between the seats
- Calculates deployment level
  - No deployment
  - Low deployment
  - Full deployment

Courtesy of David Sweet.

Air Bag Control Unit (2 of 2)

- Designed to eliminate unnecessary deployments
- Works in conjunction with other sensors
- ECU contains an energy capacitor that acts as a back-up system in any power disruption (30 s to 30 min).
- Can also simultaneously activate a seat belt pretension system for added protection
- Some ECUs record and store information from accidents that have occurred.

Inflator/Propellant

- Fills up air bag instantaneously
- Critical consideration of the technical rescuer; generally positioned in the cut zone areas
  - Always inspect before you dissect.

Stored Compressed Gas System

- Uses an inert gas stored in a steel or aluminum cylinder
- The igniter sets off a burst or rupture disc; the disc breaks open, releasing the gas, which expands and fills the bag.
- A vehicle may have multiple cylinders.

Courtesy of David Sweet.

Multistage Inflators

- Cylinders that can comprise two separate chambers of compressed gas
  - One with a large amount of product
  - Another with a small amount of product
- Can fire independently or together
- If the ECU determines that a full deployment is needed, both chambers will fire simultaneously.

Gas Generation System (1 of 2)

- Uses a chemical reaction that rapidly produces the gas (commonly nitrogen) that fills the bag.
- Sodium azide is most common (very volatile).
- Common driver-side air bag housing units contain approximately 2 ounces of sodium azide.
  - Used in pellet form for easier product containment
- Passenger-side air bag housing unit can contain approximately 7 ounces of sodium azide.
  - Must fill the passenger-side area

Gas Generation System (2 of 2)

- Air bag may fracture the windshield.
- Some manufacturers use non-azide propellants such as ammonium nitrate.
  - These are under a national recall because of documented containment failures and degradation over time.

Courtesy of David Sweet.

Hybrid Type Inflator

- Consists of both a gas-generation pyrotechnic propellant and a compressed gas
- Two chambers; first chamber uses gas-producing propellant, second uses compressed gas
- Common to side-impact air bags
- Designed to react and deploy at a much faster rate (10–15 ms) because of the proximity of the occupant to the impact

Sensors (1 of 2)

- Send information to the ECU
- Determine whether or not to deploy air bags
- Detect a rapid deceleration of the vehicle
- Several different types can be located in a vehicle.

Courtesy of David Sweet.

Sensors (2 of 2)

- **Occupant classification system**
  - Seat position sensor (proximity of the occupant to the air bag)
  - Seat belt sensor (engagement of seat belt)
  - Occupant weight sensor (determines whether the occupant has met a preset weight)
    - Will also measure rescuer’s weight

Rollover Protection System (1 of 2)

- Initially designed for convertible vehicles
- Concealed until activated
- Activated by an **inclinometer sensor** or tilt sensor
- **G-sensor** detects a vehicle's weightlessness.

Courtesy of Bill Larkin.

Rollover Protection System (2 of 2)

- To activate, sensors must detect a significant vehicle tilt with lateral acceleration.
- Exercise caution when operating around a vehicle containing an undeployed roll bar.
  - Avoid placing any parts of the body over an undeployed roll bar.
- Technical rescuer must follow the same safety guidelines and electrical disconnection procedures that are established for vehicle air bag systems.

Seat Belt Systems

- Active restraint systems designed to maintain the position of the occupant when a force from a sudden acceleration or deceleration is applied
- By design, the seat belt webbing material stretches and absorbs the force of the occupant's body weight controlling against the potential interior impact.
- Have a tensile strength of over 6000 lb
- Can be anchored in two-, three-, or four-point systems

Seat Belt Types (1 of 2)

- Retractable
  - Has the webbing wound up in a gear housing under a tensioned spring mechanism
  - Automatically takes up slack when the belt is released
  - Has a locking mechanism web clamp that prevents any further release of the webbing.
- Nonretractable
  - Remains static, with slack being taken up manually

Seat Belt Types (2 of 2)

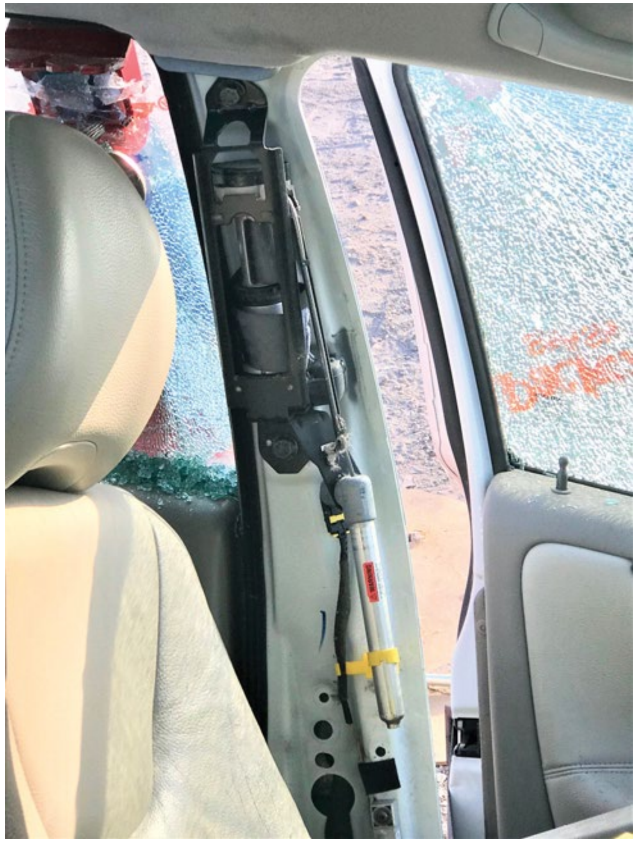
- Load-limiting device
  - Reduces the force applied by the seat belt when it locks in place after sudden force
  - Can be incorporated into the webbing material or into a torsion bar attached to the retractor gear
  - A fold is stitched into the belt that is set to tear when a present amount of force is applied, preventing the belt from locking up
  - Gradually releases the tension that can cause injury

Seat Belt Pretensioning System (1 of 3)

- Can be activated in conjunction with air bags or act independently
- Can be set up to operate at the belt buckle attachment or at the anchor attachment
  - The belt buckle will operate by pulling down and/or back on the buckle itself by means of a cable attachment or piston rod.
  - Commonly activated by a small pyrotechnic charge or firing mechanism, which draws back on the cable or piston attachment

Seat Belt Pretensioning System (2 of 3)

- The pretensioning system that activates at the retractor spool also uses a pyrotechnic charge and gas-generation system where it forces a rack gear to engage the pinion gear connected to the retractor spool mechanism, winding up the webbing.



Courtesy of David Sweet.

Seat Belt Pretensioning System

- Mechanical pretensioning systems use a torsion spring that is pretensioned and operates by means of a pendulum.
  - When the pendulum is offset by a crash, the spring is released and draws back on the retractor that rapidly spools the webbing.
- Other types of pretensioning systems use a series of steel balls in a chamber tube that are forced through a cog wheel–type mechanism that engages the retractor that spools the webbing and locks the retractor once the slack is removed from the belt.

Dissection

- Seat belt assemblies can be housed in any post or column, under the seats, or in the center console.
  - If cutting through a post, the molding must be removed to reveal the pretensioning system in order to cut around the device.
- Do not rip or tear the vehicle apart; comprehend the action taken.
- One must dissect the vehicle section by section.
- This step-by-step technical process requires continuous training.

Emergency Procedures

- Never assume the air bag is dead.
  - Energy capacitor can store power for 30 minutes.
  - Air bag inflators are “live” until deployed.
  - Attempting to disable the inflator can cause the air bag to deploy.
- Licensed technicians must install, repair, or remove air bags.

Disconnecting Power

- Several things can be done to ensure that power is disconnected.
  - Remember there is a backup energy system with storage capacitors.
  - Remember it may be difficult to adjust seats if electrical **beneficial systems** are installed in the vehicle.

Recognizing and Identifying Air Bags (1 of 2)

- Common acronyms generally located in proximity to the inflator:
  - SRS
  - SIR
  - HPS
  - IC
  - SIPS
  - ROI

Courtesy of David Sweet.

Recognizing and Identifying Air Bags (2 of 2)

- Acronyms/letters may be embossed, raised, or sewn into the material.
- Starting in 1998, all vehicles must contain a driver- and passenger-side air bag.
  - All other air bags will have to be located by the rescuer.
- One of the assignments for the rescuer positioned in the vehicle is to scan the entire interior for air bag locations.

Distancing

- Once an air bag location has been identified, the next precaution is to maintain proper distance from the deployment zone.
- Proper distancing:
  - 10 inches (25 cm) for driver side
  - 20–25 inches (51–64 cm) for passenger side
  - 5–15 inches (13–38 cm) for side-impact bags
- Only recommendations; each manufacturer differs

Extrication Precautions

- Never place anything between occupant and an undeployed air bag.
- Never try to contain the air bag.
- Inspect before you dissect!
- Consider the ECU.
- Be aware of side-impact sensors.

Courtesy of Edward Monahan.

Summary (1 of 3)

- In 1967, the NHTSA issued a federal mandate titled FMVSS 209, Seat Belt Assemblies. This was the first of many subsequent regulations that outlined minimum safety requirements for motor vehicles mandating compliance from vehicle manufacturers.
- In the 1980s, the air bag became known as an SRS by working in conjunction with the seat belt.
- A four-stage process occurs when an air bag deploys in a crash sequence: the crash itself, the crash sensor detecting deceleration, the air bag deploying and inflating, and the occupant moving forward and striking the bag as deflation occurs.
- Several components make up an air bag, including the air bag, initiator, ECU, propellant, inflator, and sensors.

Summary (2 of 3)

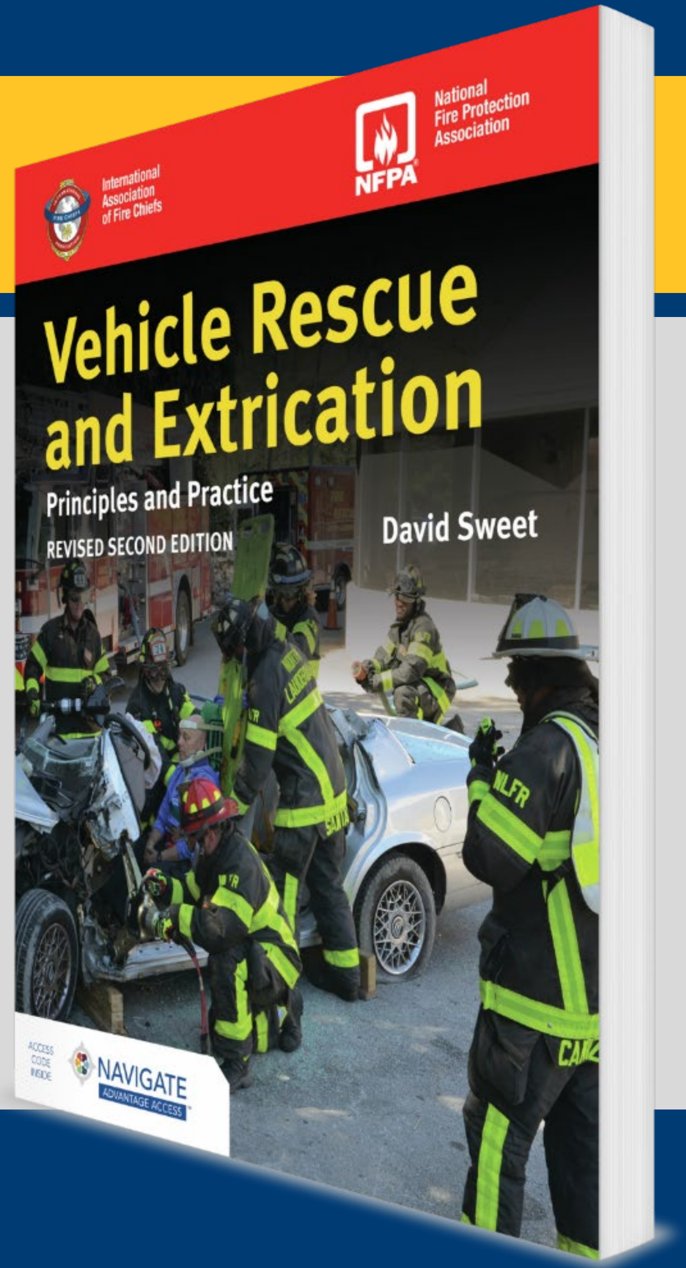
- ROPS were initially designed for convertible vehicles to protect occupants in vehicle rollover incidents. Roll bars are concealed until activated by sensors.
- Seat belts, also known as safety belts, are active restraint systems designed to maintain the position of the occupant when a force from a sudden acceleration or deceleration is applied.
- Seat belts can be retractable or nonretractable. The retractable type has the webbing wound up in a gear housing under a tensioned spring mechanism that automatically takes up slack when the belt is released. The nonretractable type remains static, with slack being taken up manually.

Summary (3 of 3)

- Pretensioning systems are designed to retract automatically through a mechanical or electrical/pyrotechnical mechanism. They can be activated in conjunction with the vehicle air bags from the ECU or act independently.
- Never assume that an air bag is dead just because the power has been disconnected; a vehicle air bag system comes equipped with an energy capacitor, which can store power for up to 30 minutes in some models.
- Eliminating potential hazards of SRS systems may include disconnecting power, recognizing and identifying air bags, distancing, and taking additional extrication precautions.

CHAPTER 7

Advanced Vehicle Technology: Alternative-Fuel Vehicles



Knowledge Objectives (1 of 3)

- Describe these alternative-fuel sources and explain the unique extrication hazards they present:
  - Flexible fuel
  - Hybrid electric
  - Electric
  - Natural gas
  - Liquefied petroleum gas
  - Biodiesel
  - Hydrogen fuel cell

Knowledge Objectives (2 of 3)

- Define the following terms and explain their importance in vehicle rescue incidents:
  - *Emergency Response Guide (ERG)*
  - Pressure relief device
  - Vehicle identification badge
  - Temperature relief device
- Identify dangers common to all alternative-fuel vehicle extrication operations.
- List standard safety precautions for alternative vehicle extrication.

Knowledge Objectives (3 of 3)

- Describe the benefits of using the *Emergency Response Guide (ERG)* for alternative-fuel vehicle extrication.
- List classes of hybrid vehicles and explain unique dangers associated with each.
- Identify typical voltage cable color coding for electric and hybrid vehicles.
- Identify fire suppression and safety measures at an alternative-fuel vehicle extrication incident.
- Explain the reasons for using atmospheric monitoring equipment at an alternative-fuel vehicle incident.

Introduction (1 of 5)

- There are many alternative fuels in use today.
  - Rescue personnel must be familiar with these.
  - Hazards include:
    - Multiple batteries
    - High-voltage power cables
    - Advanced air bag protection systems
    - Alloyed metals
    - Reinforced passenger compartments
    - Advanced energy management systems

Introduction (2 of 5)

- Upon conducting a size-up, the officer must immediately recognize the various types of alternative fuels present and establish safety/hazard control zones.
- Difficult to keep up with advances in vehicle technology.
  - Dealers of alternative vehicles can provide information.
  - **Emergency response guides** and the Internet are also good sources of information.

Introduction (3 of 5)

- Using the same emergency procedures on every incident is impractical and dangerous.
  - Each vehicle system will have some unique steps.
    - Some emergency steps are universal.
- The best practice model is to preplan by studying and training.

Introduction (4 of 5)

- If a known IDLH hazard is presented with an alternative-fuel vehicle:
  - Set the hazard control zones appropriate to the hazard.
  - Look for visible vapor clouds.
  - Listen for a loud hissing noise, which may indicate product release.
- Incidents requiring fire suppression may require a large-diameter hose and master stream device in defensive mode.

Introduction (5 of 5)

- Safety procedures can be very specific to the type of fuel encountered and must be strictly adhered to.
  - However, some safety procedures are universal.
  - Be aware that various vehicles will have additional or unique emergency procedures specific to that vehicle.
  - Not all steps are completed in succession; some are simultaneous.

Safety

- Consider atmospheric monitoring when dealing with alternative vehicles and fuel cell vehicles.
- Multi-gas meter detects hazards in the air, although not always accurately.
- Should be reviewed and decided upon by the AHJ

Courtesy of Mike Smith.

Alternative Fuels (1 of 5)

- Alternative-fuel vehicles use fuels other than gasoline or diesel.
  - Ethanol
  - Methanol
  - Natural gas
  - LPG
  - Biodiesel
  - Hydrogen
  - Electricity

Alternative Fuels (2 of 5)

- Vehicle identification badges identify the vehicle type or the fuel type.
- Be aware that labeling is not uniform.
- Technical rescuer should check for labels before working on the vehicle.

Courtesy of David Sweet.

Alternative Fuels (3 of 5)

- **Ethanol**
  - An alcohol-based fuel processed from crops
  - Can be blended in different percentages
  - Used to fuel **flexible fuel vehicles (FFVs**)
- **Methanol**
  - Processed from wood sources
  - Also used as a flex fuel
  - Widely used outside the United States

Alternative Fuels (4 of 5)

- Most manufacturers offering FFVs, label vehicle with flex fuel badge.
- May use yellow gas caps to indicate distinction

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Alternative Fuels (5 of 5)

- Ethanol and methanol require alcohol-resistant foam to extinguish fires.
  - Vapor suppression and diking procedures may be needed to contain runoff.
  - Both fuels separate from the gasoline when water is applied.
  - With the exception of a vehicle fire, emergency procedures will be the same as a standard conventional vehicle.

Alternative Fuels: Natural Gas

- Fossil fuel composed of methane that is used as compressed natural gas or liquefied natural gas
- Not widely produced in the United States
- Liquefied natural gas (LNG) is a colorless, odorless, nontoxic gas that floats on water.
  - Changes to gas when released
  - Using water on LNG will cause rapid boil-off.
  - Fuel tanks must be double-walled and well-insulated.

Alternative Fuels: Compressed Natural Gas (1 of 3)

- More practical than LNG
- Used for many fleet vehicles
- Storage tanks are steel, aluminum, or carbon/fiber composite.
    - Normally located behind the rear passenger seat

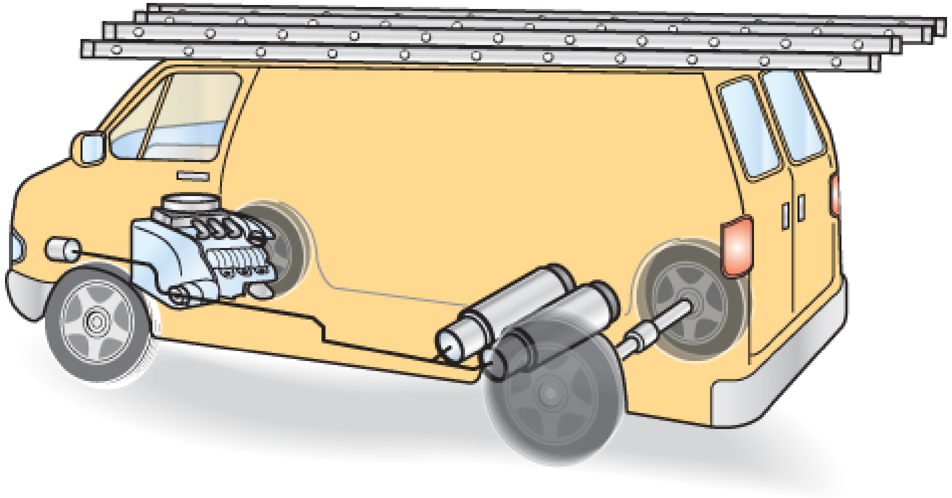
Courtesy of David Sweet.

Alternative Fuels: Compressed Natural Gas (2 of 3)

- Compressed to 3000 to 3600 psi (20,684 to 24,821 kPa)
- May need to be stored in several onboard tanks
- Stainless steel high-pressure lines run under the vehicle.

Courtesy of David Sweet.

Alternative Fuels: Compressed Natural Gas

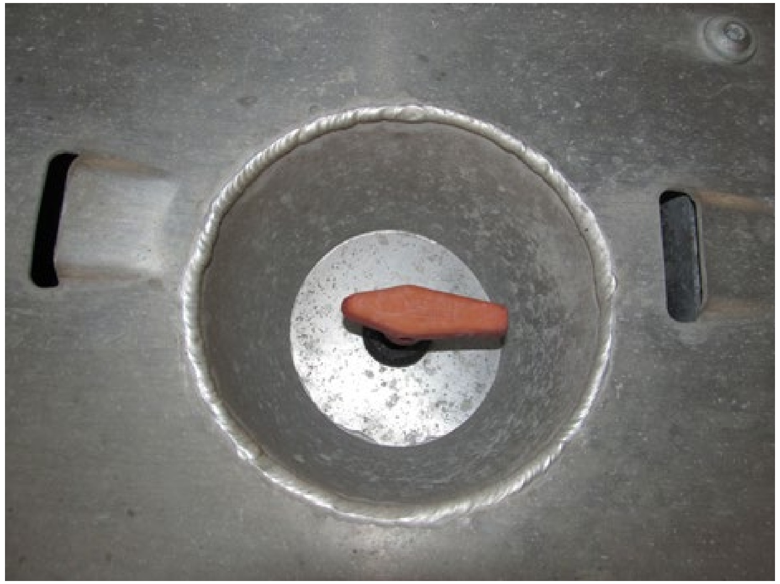


Courtesy of Culver Company.

Courtesy of Heil Company.

Alternative Fuels (1 of 2)

- Safety features vary by manufacturer.
- Sensing unit turns off fuel when ignition is off.
- Most have manual shut-off valves.
- PRD rapidly releases gas when exposed to high temperature.
- Chemical odorant is added.



Courtesy of David Sweet.

Alternative Fuels (2 of 2)

- Vehicles that use CNG and LNG must have an identification label.
  - Diamond shape
  - CNG or LNG in reflective lettering

Courtesy of David Sweet.

Natural Gas Emergency Procedures (1 of 5)

GUIDE 115 — GASES - FLAMMABLE (INCLUDING REFRIGERATED LIQUIDS) — ERG2008

POTENTIAL HAZARDS

FIRE OR EXPLOSION

- **EXTREMELY FLAMMABLE.**
- Will be easily ignited by heat, sparks or flames.
- Will form explosive mixtures with air.
- Vapors from liquefied gas are initially heavier than air and spread along ground.

CAUTION: Hydrogen (UN1049), Deuterium (UN1957), Hydrogen, refrigerated liquid (UN1966) and Methane (UN1971) are lighter than air and will rise. Hydrogen and Deuterium fires are difficult to detect since they burn with an invisible flame. Use an alternate method of detection (thermal camera, broom handle, etc.)

- Vapors may travel to source of ignition and flash back.
- Cylinders exposed to fire may vent and release flammable gas through pressure relief devices.
- Containers may explode when heated.
- Ruptured cylinders may rocket.

HEALTH

- Vapors may cause dizziness or asphyxiation without warning.
- Some may be irritating if inhaled at high concentrations.
- Contact with gas or liquefied gas may cause burns, severe injury and/or frostbite.
- Fire may produce irritating and/or toxic gases.

PUBLIC SAFETY

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks).
- Keep out of low areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing will only provide limited protection.
- Always wear thermal protective clothing when handling refrigerated/cryogenic liquids.

EVACUATION

Large Spill

- Consider initial downwind evacuation for at least 800 meters (1/2 mile).

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions.

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ERG2008 — GASES - FLAMMABLE (INCLUDING REFRIGERATED LIQUIDS) — GUIDE 115

EMERGENCY RESPONSE

FIRE

- **DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED.**

CAUTION: Hydrogen (UN1049), Deuterium (UN1957) and Hydrogen, refrigerated liquid (UN1966) burn with an invisible flame. Hydrogen and Methane mixture, compressed (UN2034) may burn with an invisible flame.

Small Fire

- Dry chemical or CO_2.

Large Fire

- Water spray or fog.
- Move containers from fire area if you can do it without risk.

Fire involving Tanks

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- Do not direct water at source of leak or safety devices; icing may occur.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.
- For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipment used when handling the product must be grounded.
- Do not touch or walk through spilled material.
- Stop leak if you can do it without risk.
- If possible, turn leaking containers so that gas escapes rather than liquid.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Do not direct water at spill or source of leak.
- Prevent spreading of vapors through sewers, ventilation systems and confined areas.
- Isolate area until gas has dispersed.

CAUTION: When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning.

FIRST AID

- Move victim to fresh air.
- Call 911 or emergency medical service.
- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- Clothing frozen to the skin should be thawed before being removed.
- In case of contact with liquefied gas, thaw frosted parts with lukewarm water.
- In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing if adhering to skin.
- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

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Courtesy of the U.S. Department of Transportation.

Natural Gas Emergency Procedures (2 of 5)

- Don appropriate PPE and clear area of bystanders and hazards.
- Establish hazard control zones.
- Conduct inner and outer surveys: approach from upwind and uphill.
- Use a multi-gas meter.
- Look for vehicle identification badge.
- Deploy two 1¾-in. (44-mm) charged hose lines to protect personnel.

Natural Gas Emergency Procedures (3 of 5)

- Ensure the vehicle's ignition is turned off, the keys are out of the ignition, and the vehicle is placed in park.
- Stabilize the vehicle from movement with cribbing.
- Attempt necessary component adjustments before disabling power to the vehicle.
- Disconnect the 12-volt DC battery starting with the negative line first.
- Manually turn off the gas at the tanks by shutting off the valves.

Natural Gas Emergency Procedures

- If AHJ decides to, remove main fuse from the vehicle to ensure the electrical system is disabled.
- For CNG to be combustible, it must fall within its flammability range (5–15 percent).
- For PRDs that are releasing product with visible flame, cool the tank or eliminate flame impingement rather than attempt to extinguish the flame.
    - Until the leak can be isolated and eliminated, it is safer to let the product burn itself out.

Natural Gas Emergency Procedures

- Before attempting extrication, examine the vehicle carefully for fuel line locations before attempting any cutting.
- Take extra precaution with
  - Dash displacement techniques
  - Cutting and dropping the floorboard under the brake and gas pedals

Alternative Fuels: LPG (1 of 2)

- Fossil fuel produced from natural gas
- 1.5 times heavier than air
- Fuel tanks are built according to the standards set by the American Society of Mechanical Engineers.
  - Constructed from carbon steel
  - Cannot exceed 200 gal (757 L)
  - Mandatory 20 percent reduction in product
  - Chemical odorant is added.
  - Equipped with PRD

Alternative Fuels: LPG (2 of 2)

- Identification label must contain:
  - Water capacity
  - Working pressure
  - Serial number
  - Manufacturer
- Vehicle with permanently installed LPG container must be marked.

LPG Emergency Procedures (1 of 4)

- Remember, propane disperses well beyond its vapor cloud and will seek out ignition sources, which can cause a flashback to the leak.
- Don appropriate PPE, including SCBA, and clear area of bystanders and hazards.
- Establish hazard control zones.
- Conduct inner and outer surveys; propane will accumulate in lower areas.
- Use a combustible gas meter.

LPG Emergency Procedures (2 of 4)

- Look for vehicle identification badge.
- Deploy two 1¾-in. (44-mm) charged hose lines.
- Ensure ignition is off, the keys are out of the ignition, and the vehicle is placed in park.
- Stabilize the vehicle.
- Attempt necessary adjustments.
- Disconnect the 12-volt DC battery.
- Turn off the gas at the tanks.
- Remove main fuse from the vehicle.

LPG Emergency Procedures (3 of 4)

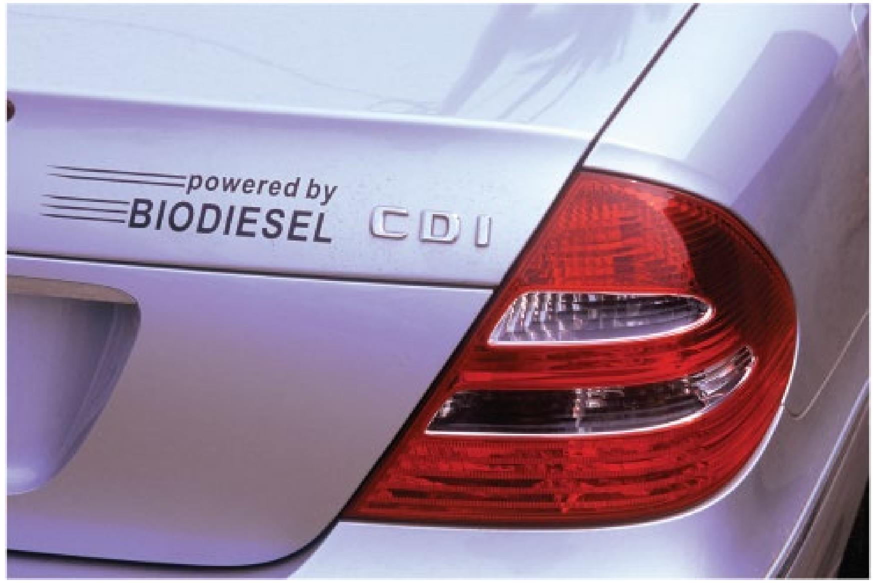
- Propane can present unique challenges.
  - Continuous flame impingement will cause overpressurization and eventual failure, resulting in a BLEVE.
  - Hose streams must be directed toward the vapor space of the tank.
  - Fire must not be extinguished until
    - Tank is cooled.
    - Leak is stopped.
    - Main shut-off valve is turned off.

LPG Emergency Procedures (4 of 4)

- When attempting extrication, same precautions for CNG vehicles should be used.
  - Examine fuel line locations before cutting.
  - Techniques that involve cutting and dropping the floorboard area under the brake and gas pedal should not be attempted.

Alternative Fuels: Biodiesel

- Used solely for diesel engines
- Processed from domestic renewable resources
- Not recommended for use in low temperatures
- Safe, nontoxic, and biodegradable
- Not classified as flammable
- Biodiesel-blended fuels act as a hydrocarbon-type fuel or a polar solvent.
  - Use AFFF on fires.
  - Use same procedures as for conventional vehicles.



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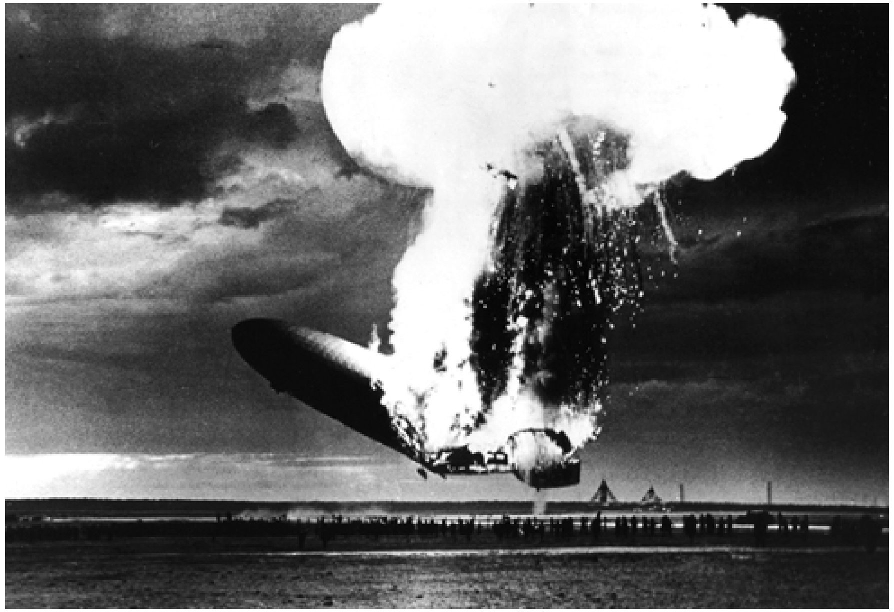
Biodiesel Emergency Procedures

- Look for identification badge.
- Similar to those for a conventional vehicle
- Can still burn
- Use a foam blanket with AR-AFFF.
- Implement diking procedures

Hydrogen (1 of 2)

- Abundant element
- Odorless, colorless, flammable, and nontoxic gas
- Combines easily with other elements
- Hindenburg (1937)
- 14 times lighter than air
- Wide flammability range



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Hydrogen (2 of 2)

- Fast dispersion rate
- Produced from multiple sources
- Can be used directly on a modified ICE or as a catalyst in a fuel cell
- Vehicles are required to be clearly marked.

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Hydrogen Storage Tanks

- Stored as a liquid; must be cooled to –423°F (–253°C) or it will boil off as a gas.
- Compressed and stored in high-pressure storage tanks with pressures of 3600 psi, 5000 psi, and 10,000 psi (24,821, 34,474, and 68,948 kPa)
- Chemically combined in hydride form with certain metals; stored more compactly and efficiently than in gas form
- Stored in microscopic pores of carbon nanotubes
- Must meet federal government's Federal Motor Vehicle Safety Standard 304

Types of Fuel Tanks

- Type 1: composed of steel; most common
- Type 2: composed of steel or aluminum with a partial hoop wrap that goes around the cylinder
- Type 3: same as Type 2 except that wrapping encompasses the entire tank
- Type 4: nonmetallic liner (usually plastic)

Hydrogen

- As of early 2018, only 40 commercial hydrogen fueling stations in the United States
- New standards and codes for hydrogen gas vehicles are being developed.
- Numerous training resources are provided through the DOE H2 Tools website.

Photo courtesy of Michael Penev/NREL.

Hydrogen Emergency Procedures (1 of 2)

- Don appropriate PPE and clear area.
- Establish control zones.
- Conduct inner and outer surveys.
- Use a hydrogen-specific gas meter.
- Look for identification badge.
- Deploy two charged hose lines.
- Ensure ignition is off, keys are out, and vehicle is parked.
- Stabilize the vehicle.

Hydrogen Emergency Procedures (2 of 2)

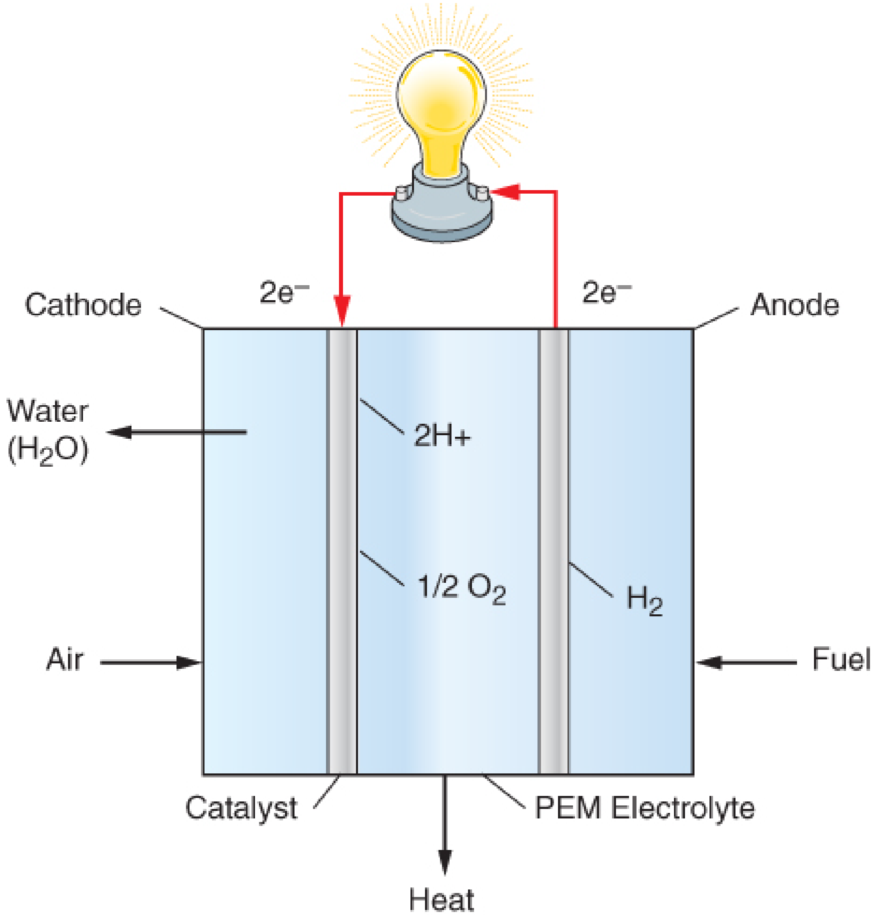
- Attempt necessary adjustments before disabling power.
- Disconnect the 12-volt DC battery.
- Turn off the gas at the tanks.
- Remove main fuse from the vehicle.
- Use service disconnects.
- Thermal imaging camera can identify hydrogen fire.
- Isolate and eliminate the leak or shut down the fuel tank before extinguishing the fire.
  - Often safer to let the product burn itself out

Hydrogen Fuel Cell Vehicles (1 of 2)

- Uses hydrogen stored in an onboard tank combined with outside oxygen to produce electricity
- By-products are water and heat.
- Two to three times more efficient than conventional vehicles
  - Little or no greenhouse gas emissions
  - The space industry has used this technology for many years.

Hydrogen Fuel Cell Vehicles

- Four basic elements of a fuel cell:
  - Anode
  - Cathode
  - Electrolyte
  - Catalyst



Polymer Exchange Membrane

- PEM is placed between anode and cathode; it exchanges positive electrons.
- Positive ions pass through the PEM and combine with the cathode.
- Water is created and is used for cooling or emitted from the tailpipe.
- Negative ions provide electrical current to the vehicle.
- Heat is also created, which requires coolant.
- This process encompasses just one fuel cell.

Hydrogen Fuel-Cell Vehicle Electrical Design

- Hybrid system separated by two sources of power
- Basic components of a fuel-cell vehicle:
  - Fuel cell module pack/stack
  - Electric motor
  - Generator
  - Hydrogen storage system
  - Battery pack
- Fuel cell consists of over 300–400 cells.
- Most come equipped with regenerative braking system.

Hydrogen Storage System (1 of 2)

- Fuel cell design normally uses a compressed hydrogen gas system.
  - Regulated to a nominal pressure
  - Reinforced framing
  - Hydrogen lines are underneath the vehicle.


Courtesy of David Sweet.

Hydrogen Storage System (2 of 2)

- All hydrogen storage tanks come with a PRD or **temperature relief device (TRD)**.
  - Rapidly releases product when overheated
  - Can take up to several minutes
- Do not direct a water stream into liquid hydrogen.
  - May freeze the PRD and block product release
  - May cause a rapid boil-off

Hydrogen Storage System Safety Features

- Hydrogen leak detectors
- ECUs
- Crash detection systems
- Deactivation of system/shut down of gas lines when the hood release is pulled, ignition is off, and/or key is removed
- Manual shut-off valves
- ID badges

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Hydrogen Fuel Cell Emergency Procedures (1 of 4)

- Don appropriate PPE and clear area.
- Establish control zones.
- Conduct inner and outer surveys.
- Use a hydrogen-specific gas meter.
- Look for identification badge.
- Deploy two charged hose lines.
- Never assume the ignition is turned off.
- Stabilize the vehicle.

Hydrogen Fuel Cell Emergency Procedures (2 of 4)

- Manually engage the hood release device.
- Attempt necessary adjustments.
- Disconnect the 12-volt DC battery.
- Remove main fuse from the vehicle.
- Manually shut off the cylinder tank valve.
- Use service disconnects as indicated.

Hydrogen Fuel Cell Emergency Procedures (3 of 4)

- Medium- to high-voltage wires run along the undercarriage of the vehicle on the opposite side of the hydrogen gas lines.
  - Can vary with different models
  - Protected by framing and/or protective casing
  - Have ground-fault and short-circuit protection
  - Fully discharging the voltage can take 5 to 10 minutes.
- Precautions must be observed when the vehicle is overturned on its roof.

Hydrogen Fuel Cell Emergency Procedures

- Tunneling technique: remember that the battery packs are normally placed under the rear seat or trunk area.
- Dash displacement technique: remember that medium- to high-voltage wires run along the undercarriage.
- Disconnect any power before attempting extrication.
- Do not cut into any medium- to high-voltage wire or hydrogen gas lines.
- Floorboard drop technique: do not attempt regardless of fuel system type or power supply status.

Hybrid Electric Vehicles (1 of 3)

- Two or more power sources; one is electric
  - Several types of vehicles on the roadway today are designed with a HEV propulsion system.
  - Hybrid technology has existed for over a century.
  - Economical and produce lower emissions
  - Power from nickel-metal hydride or lithium battery

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Hybrid Electric Vehicles

- **Full hybrids** use electric motor, ICE, or a combination of both.
- **Mild hybrids** use electric power in conjunction with the ICE.
  - **Start/stop mild hybrid**
    - Motor/generator is not used to propel the vehicle.
  - **Integrated motor assist (IMA) mild hybrid**
    - Motor/generator will assist ICE with acceleration.

Hybrid Electric Vehicles (3 of 3)

- Some have additional batteries in the trunk.
- Works off a low-to-medium-voltage range (36–42 volts DC).
- Regenerative energy braking system
- Standard 12-volt lead acid battery

Courtesy of Mike Smith.

PHEV

- Ability to recharge the battery system by using a plug-in cord
  - Can run off general house current
  - Can run solely on electric power over short distances
- A rescuer responding to a fire must disconnect the power from the vehicle or the residence.

EREV (1 of 2)

- Series-type propulsion allows the vehicle to run on all battery or all electric power.
- On-board gasoline engine extends mile range.
- Can be plugged into a power grid to recharge
- High-voltage wiring configurations can be problematic for dash displacement.
    - Ensure system is disabled.

EREV (2 of 2)

Courtesy of David Sweet.

Courtesy of David Sweet.

Voltage Color Coding

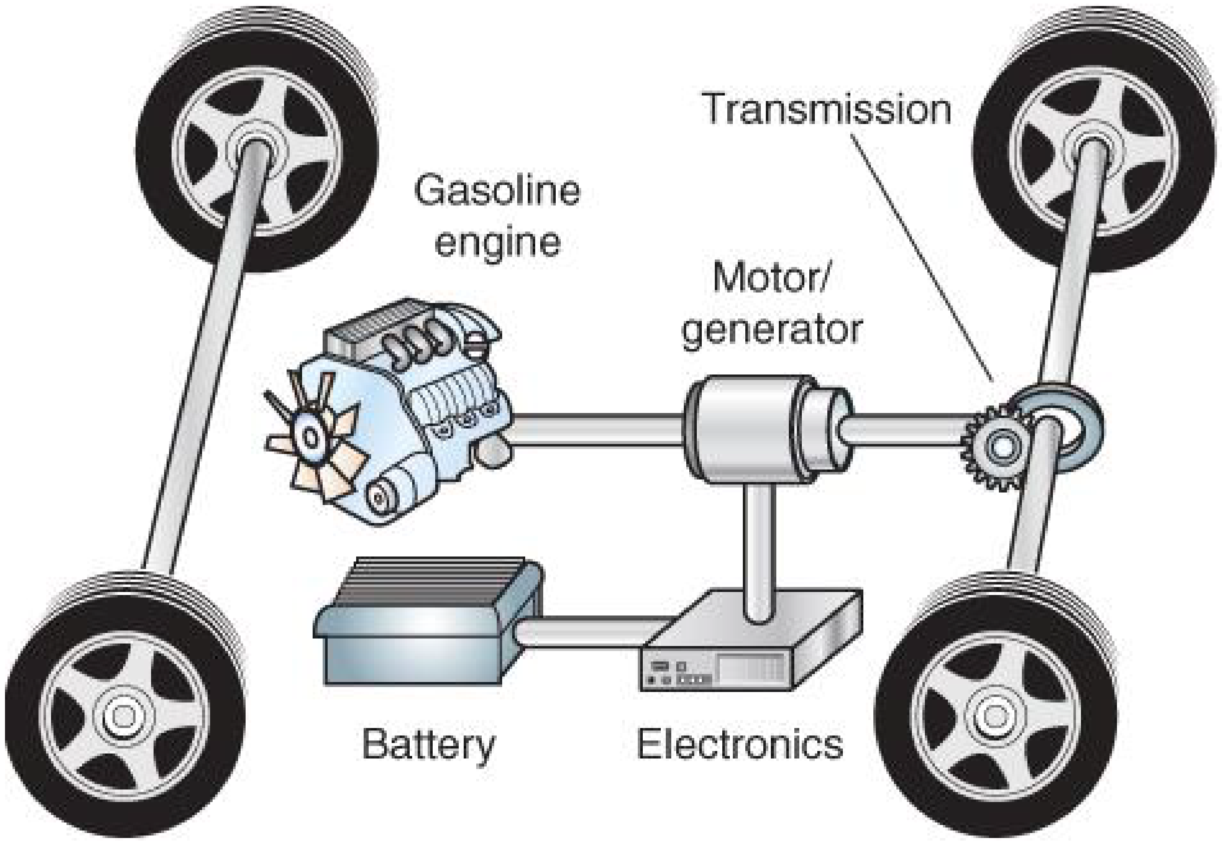
- Low or medium voltage cable: blue
- High voltage cable: orange
- No standard for medium-voltage cables
- All cables must be evaluated and respected for their voltage capacity.

HEV Drive Systems (1 of 2)

- **Series drive system**
  - Electric motor turns the vehicle′s transmission to provide propulsion.
  - ICE does not provide propulsion.
    - Only supplies power to the electric motor

HEV Drive Systems (2 of 2)

- **Parallel drive system**
  - More common
  - Uses vehicle's ICE and/or electric motor to power the vehicle's transmission
  - Which propulsion system is used is dependent on the speed of the vehicle.



Hybrid Electric Vehicles

- HEVs are usually recognizable through vehicle identification badge.
- Green leaf logo
- “Hybrid” or letter H
- No standardization

Courtesy of David Sweet.

HEV Emergency Procedures (1 of 6)

- All hybrid vehicles have built-in safety features that shut down high- and medium-voltage lines in different situations.
  - Always assume the vehicle is still energized.
- Inertia relays open when detecting a collision and disable system.
- Ground faults will detect leaks, line breaches, or short circuits and disable the high-voltage system.
- Thermal detection devices will shut down the high-voltage system if the temperature rises.

HEV Emergency Procedures (2 of 6)

- Medium- to high-voltage wires are protected by framing or protective casing.
  - If there is a break in the line, a relay will kick in, isolating and disabling the voltage.
  - Fully discharging the voltage can take 5–30 minutes.
- Ways to disable the high-voltage system:
  - Turn the main engine key off and remove.
  - Pull the main fuse or all fuses.
  - Do not try to manually disconnect the battery pack.

HEV Emergency Procedures (3 of 6)

- Don appropriate PPE and clear area.
- Establish control zones.
- Conduct inner and outer surveys.
- Look for identification badge.
- Deploy one charged hose line.
- Never assume the vehicle is turned off.
- Turn engine key off and remove the keys.
- Stabilize the vehicle.

HEV Emergency Procedures (4 of 6)

Courtesy of David Sweet.

Courtesy of David Sweet.

HEV Emergency Procedures (5 of 6)

- Attempt necessary adjustments.
- Disconnect the 12-volt DC battery.
- Energy capacitors can hold power for 5–10 minutes after power is disengaged.
- Remove main fuse from the vehicle.
- Use service disconnects as indicated.

HEV Emergency Procedures (6 of 6)

- Precautions must be observed when vehicle is overturned on its roof.
  - Battery packs are normally placed under the rear seat or trunk area.
  - Medium- to high-voltage wires run along the undercarriage.
  - Disconnect any power before extrication.
  - Floorboard drop technique: do not attempt regardless of fuel system type or whether the power supply has been secured.

All-Electric Vehicles (1 of 3)

- 100 percent electric
- Energy efficient and environmentally friendly
- No air pollutants
- Propelled by one or more electric motors
- No tailpipe
- Nissan LEAD was followed by Tesla

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All-Electric Vehicles (2 of 3)

- Use regenerative braking to recharge the laminated lithium ion battery (24 kWh)
- Can be plugged in to be recharged
- Commonly charged from conventional power outlets or charging stations
- Fully recharging a battery pack can take up to 20 hours.
- Battery is encased in steel in the undercarriage.

All-Electric Vehicles (3 of 3)

- A 12-volt DC battery is located under the hood to supply power to low-voltage devices.
- Many can travel 100–200 miles without charging.
  - Range may be affected by temperature, speed, topography, driving style, and cargo.
- EVs can be recognized through vehicle identification badging.

NEV

- Battery-operated, low-speed vehicles.
- Top speed of 25 mph
- Generally travel 35 miles on full charge
- Uses Level 1 charging system

© Jim West/Alamy Stock Photo.

EV Emergency Procedures (1 of 2)

- Don appropriate PPE and clear area.
- Establish control zones.
- Conduct inner and outer surveys.
- Look for identification badge.
- Deploy one charged hose line.
- Never assume the ignition is turned off.
- Turn engine key off and remove the keys.

EV Emergency Procedures (2 of 2)

- Ensure remote heating/air conditioner is deactivated.
- Ensure that the charging is disconnected.
- Stabilize the vehicle.
- Attempt necessary adjustments.
- Disconnect the 12-volt battery.
- Remove the main fuse.
- Use service disconnects as indicated.

Ongoing Education

- Technical rescuer must adapt and change with advancing vehicle technology.
  - Alternative-fueled vehicles will become dominant.
  - SOPs should be developed.
  - Everyone should be trained to the basic level of competency in dealing with this technology.
- Stay current on new developments.
  - Continual training and education
  - Download manufacturer emergency response guides.

Summary (1 of 5)

- Alternative-fuel vehicles are vehicles that use fuels other than petroleum or a combination of petroleum and another fuel for power.
- The Energy Policy Act of 1992 outlines a list of fuels that can be classified as alternative fuels for vehicles.
- Most vehicle manufacturers identify the vehicle or fuel type through a label known as a vehicle identification badge. Currently, no standardized labeling system is used to identify hydrogen fuel-cell vehicles.

Summary (2 of 5)

- Flexible fuel vehicles can run on gasoline alone or use the E85 blend of up to 85 percent ethanol and 15 percent gasoline.
- Natural gas is a fossil fuel primarily composed of methane that can be used as a CNG or LNG.
- A safety feature for high-pressure cylinders is the PRD, which is designed to rapidly release all the gas when exposed to high temperatures, such as during a fire.
- LPG, also known as propane, is produced from the processing of natural gas and is also produced as part of the refining process of crude oil. Propane is the third most common engine fuel today, after gasoline and diesel.

Summary (3 of 5)

- Biodiesel is a fuel used solely for diesel engines that is processed from domestic renewable resources, such as plant oils; grease; animal fats; used cooking oil; and, more recently, algae. Biodiesel can be used by itself as a diesel fuel or blended with petroleum diesel.
- Hydrogen is one of the most abundant elements on Earth. As a fuel, hydrogen can be compressed and stored in high-pressure storage tanks with pressures of 3600, 5000, and 10,000 psi (24,821, 34,474, and 68,948 kPa).
- Hydrogen can be chemically combined in hydride form with certain metals, which can store it more compactly and efficiently than in a gas form.

Summary (4 of 5)

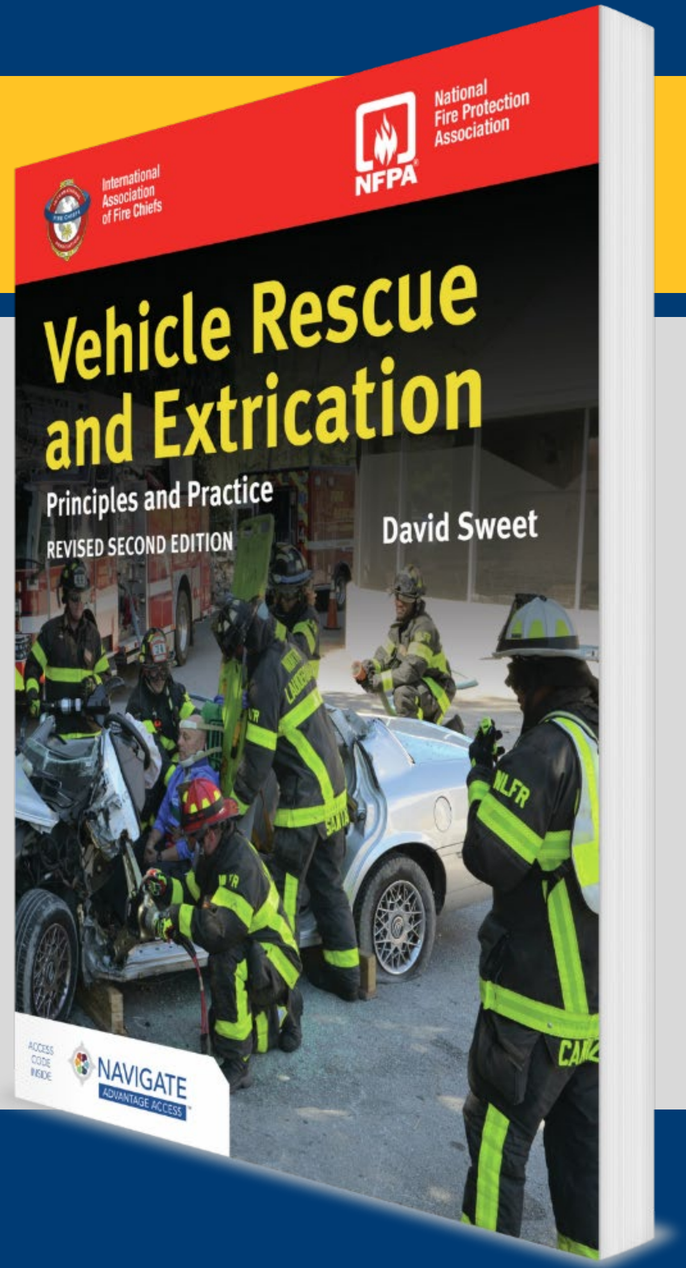
- A fuel cell is an electrochemical device that uses a catalyst-facilitated chemical reaction of hydrogen and oxygen to create electricity, which is then used to power an electric motor.
- The basic components of a fuel-cell vehicle system are a fuel-cell module pack/stack, electric motor, generator, hydrogen storage system, and battery pack.
- An HEV is a vehicle that combines two or more power sources for propulsion, one of which is electric power. A full hybrid vehicle can use its electric motor or its ICE or both to propel itself.

Summary (5 of 5)

- In contrast to the full hybrid, the mild hybrid vehicle cannot propel itself on electric power alone; it must use electric power and the ICE.
- The EV, or BEV, is 100 percent electric and propelled by one or more electric motors, which are powered by rechargeable battery packs. The EV does not have a tailpipe because it does not emit exhaust.

CHAPTER 8

Vehicle Stabilization



Knowledge Objectives

- Explain how to craft an incident action plan to address the safe removal of victims from a common passenger vehicle.
- Create an incident action plan for an incident where a common passenger vehicle has come to rest on its side.
- Define the following terms and explain their role in vehicle rescue incidents:
  - Contact point
  - Tunneling

Knowledge Objectives

- Explain position and condition effect on a vehicle’s equilibrium and stabilization.
- Describe the types and capacities of stabilization devices.
- List the five box-cribbing configurations.
- Identify the five directional movements of a vehicle.
- Describe methods for stabilizing vehicles in upright, side, or inverted positions.

Knowledge Objectives (3 of 3)

- Explain the purpose for marrying vehicles together.
- Select and use stabilization devices in accordance with agency policies and procedures to stabilize a common passenger vehicle.

Introduction (1 of 5)

- Vehicle extrication is a three-phase process.
  - The second step is vehicle stabilization.

Courtesy of Edward Monahan.

Courtesy of Edward Monahan.

Introduction (2 of 5)

- Unstable vehicles are threats to rescuers and to those injured in an MVA.
- The shape, size, and resting positions of vehicles after a collision can have a profound effect on the complexity and time spent on an incident.

Courtesy of Edward Monahan.

Introduction (3 of 5)

- Proper vehicle stabilization provides a solid foundation from which to work, ensuring safety for personnel and rescuers.
- Balance goes hand in hand with stabilization.

Courtesy of Jeff Lopez.

Introduction (4 of 5)

- The main objective in stabilization is to gain a balanced footprint by expanding the vehicle's base and lowering its center of mass.
- Equilibrium can be stable or unstable.
- Mass is what makes up the matter or substance of an object.

Courtesy of Jeff Lopez.

Introduction

- Weight, by definition, is equal to the force exerted on an object by gravity.
- The center of mass of an object is the point where the downward force of gravity is at its greatest.
- The force of gravity is measured through an imaginary straight line passing through the center of mass of an object to a ground base of support.
- An object is stable when the center of mass is lowest to the support base and the base is horizontally wider.
- The goal is to lower its center of mass to the support or base level to achieve a state of stable equilibrium.

Cribbing

- Cribbing is the most basic physical tool used for vehicle stabilization.
  - Available as wood, composite, or steel
  - Several different types of designs
    - Step chocks
    - Wedges
    - Shims
    - 4 × 4 timber cut at various lengths

Wood Characteristics (1 of 3)

- Understanding the basic characteristics of wood used for cribbing is essential.
- Heterogeneous: composed of a mixture of different materials
- Anisotropic: the properties of each wood species are different.
- Not all wood types are suitable for cribbing or shoring.
  - Soft woods are well suited to compression.

Wood Characteristics (2 of 3)

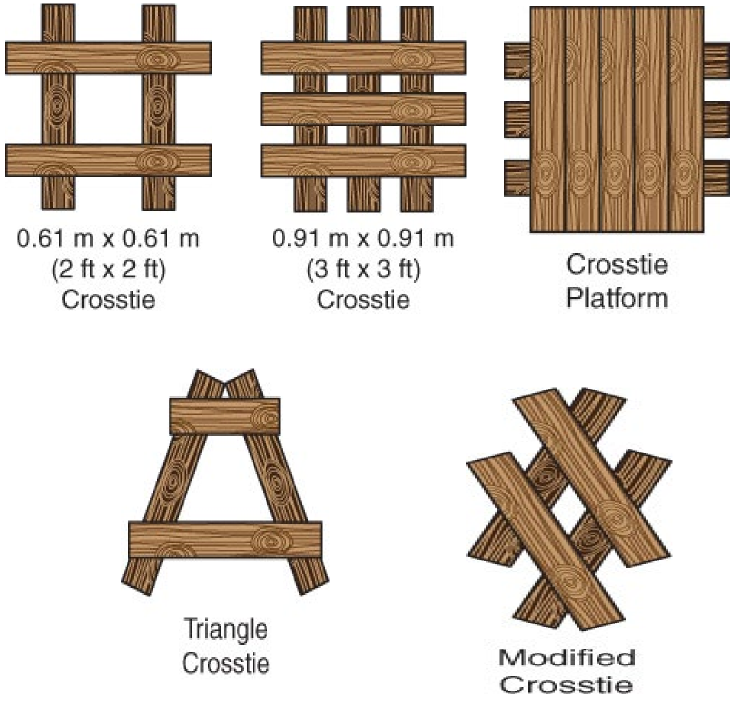
- When choosing wood, consider:
  - Measurement of applied stress (compression, tension, or shear)
  - Wood bends when a force is applied to it (elastic performance).
  - Stress and strain are proportional.
    - Wood is considered elastic up to its proportional limit; failure occurs beyond that limit.

Wood Characteristics (3 of 3)

- ATSM has adopted standardized testing guidelines for measuring the relative stress resistance or strength value of a particular species of wood.
- The maximum stress a board can be subjected to without exceeding the elastic range or proportional limit is known as its FSPL rating.
- The dimension of the surface area at the **contact point** (weight-bearing section of the cribbing) is multiplied by the FSPL rating of that species of wood.

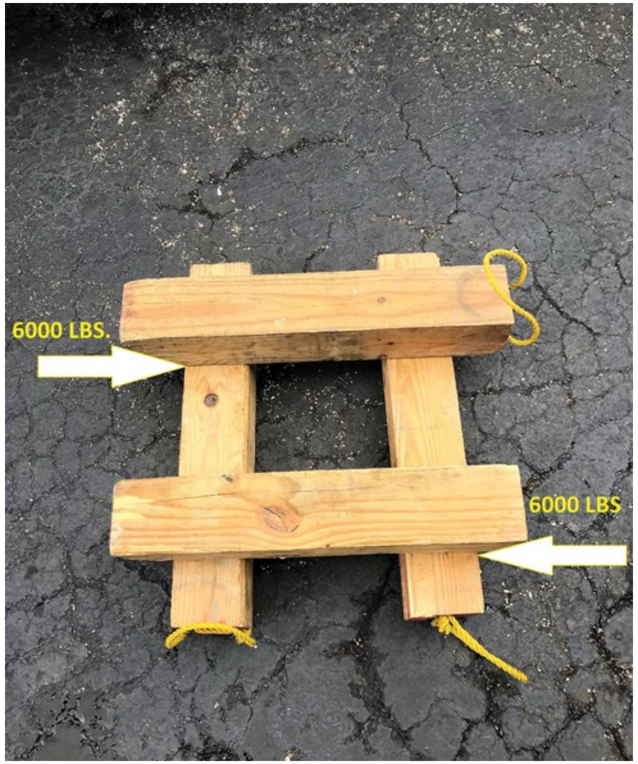
Wood Box Cribbing (1 of 2)

- Five wood box cribbing configurations
  - Two-piece layer crosstie
  - Three-piece layer crosstie
  - Crosstie platform
  - Triangle crosstie
  - Modified crosstie



Wood Box Cribbing (2 of 2)

- When using two- or three-piece crosstie configurations, make sure all sections are uniform, with one on top of the other.
  - Avoid placing the contact points at the ends.



Courtesy of David Sweet.

Vehicle Positioning (1 of 2)

- Five directional movements
  - Horizontal: forward or rearward on longitudinal axis or horizontally on lateral axis
  - Vertical: up and down in relation to the ground
  - Roll: rocks from side to side
  - Pitch: up and down on its lateral axis
  - Yaw: twists and turns on its vertical axis

Vehicle Positioning (2 of 2)

- Four common post-collision vehicle positions:
  - The vehicle may be in a regular or normal upright position resting on all four tires.
  - The vehicle may be resting on its side.
  - The vehicle may be resting on its roof.
  - The vehicle may be on top of another vehicle or some other object, or an object may be on top of the vehicle.
- There are numerous additional complexities that can accompany each of these positions (e.g., mountainous terrain).

Vehicle in Normal Position (1 of 6)

- Main objective is to gain control of vehicle movement by minimizing the vehicle's suspension system and create a solid base to work from.
- A vehicle's suspension system can cause the vehicle to move up and down, risking further injury to the victim.

Courtesy of David Sweet.

Vehicle in Normal Position (2 of 6)

- Crib the sides that you have access to, preferably all four sides.
- Place cribbing at the front and rear tires to eliminate forward or backward movement of the vehicle.
- Place cribbing in solid areas, such as directly under the dash section or just in front of the rear tires.
- Avoid areas that can potentially block the extrication process.
- Place cribbing strategically.

Vehicle in Normal Position (3 of 6)

- Determining the height distance from the ground to the bottom frame will vary.
- Use step chocks to save the guesswork.
- Consider the use of adjustable step cribbing or a scissor jack.
- The goal is to make the contact area from the ground to the undercarriage tight.

Vehicle in Normal Position (4 of 6)

Courtesy of Edward Monahan.

Courtesy of Edward Monahan.

Vehicle in Normal Position (5 of 6)

- Use wedges or shims to fill any void spaces.
  - Tap the wedge section in using the butt end of a 4 × 4 or a rubber mallet.

Courtesy of Edward Monahan.

Vehicle in Normal Position (6 of 6)

- Not advisable to attempt to lift part of the vehicle to place cribbing
- Proper technique includes
  - Positioning your back against the body of the vehicle near the wheel well
  - Lifting with your legs and not your back
  - Lifting the suspension and not the vehicle itself
- The decision rests upon the officer in charge.

Deflating the Tires (1 of 4)

- One benefit of deflating the tires on the vehicle after cribbing has been inserted is that it forces the vehicle to rest on the cribbing, regardless of pieces being removed from the vehicle.
  - The drawback is that the stability of the vehicle may shift.
  - Some design features impede inflation.
- Not advocated by some agencies because it can interfere with law enforcement’s investigation

Deflating the Tires (2 of 4)

- Four tools can be used:
  - Those than depress the valve core
  - Those that remove the core from the valve stem
  - Those that remove the entire valve assemble
  - A portable drill and step bit for puncturing the sidewall

Courtesy of David Sweet.

Deflating the Tires (3 of 4)

- If the decision is to deflate a tire by removing the entire valve stem assembly, then
  - If the stem is flexible and not a metal clamp-in type and the valve is not recessed into the tire rim, use simple channel lock wrench.
  - Grab hold of the tire stem and rotate the tool so that the head of the wrench rests on the tire rim.
  - Using the rim as a leverage point, move the tool downward, causing the stem to dislodge from its housing.

Deflating the Tires (4 of 4)

- One of the fastest ways to deflate a tire is a battery-powered drill with a step-bit attachment.
- Another option for tire deflation is to use the forked end of a Halligan bar.
  - Never use the spiked end.

Vehicle Resting on Its Side (1 of 5)

- Very dangerous and requires the officer to develop an incident action plan (IAP)
- The IAP for a vehicle resting on its side should be developed using the following items:
  - Scene size-up
  - Risk assessment
  - Resource availability and capability
  - Witness information
  - Reference materials
- Company officer develops IAP using base procedures outlined in the organization's SOPs.

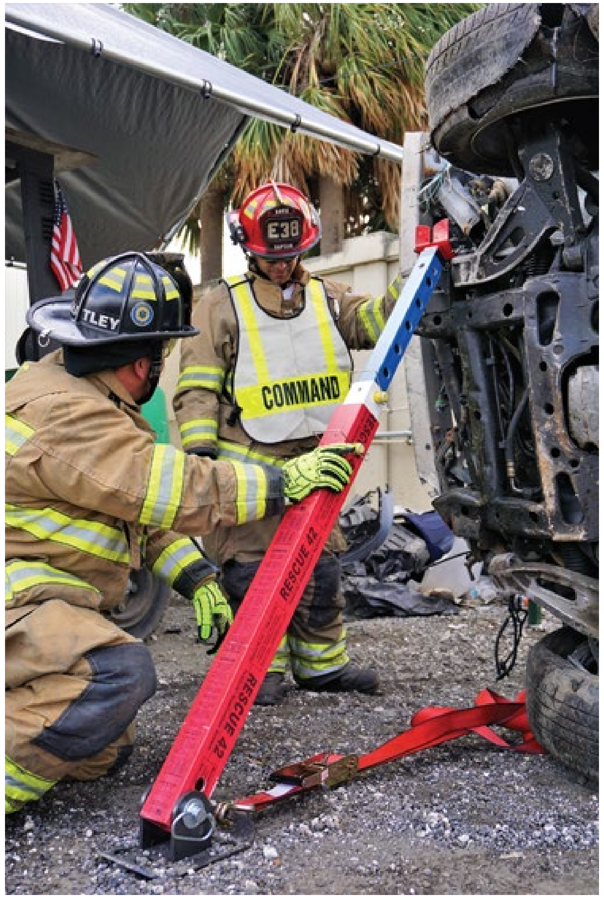
Courtesy of David Sweet.

Vehicle Resting on Its Side (1 of 5)

- Stabilization involves cribbing and tensioned buttress struts.
- The process should take no more than 5 minutes
- Keep techniques basic.

Vehicle Resting on Its Side

- Buttress stabilization struts with a tensioning attachment have simplified the stabilization process tremendously and make it much safer to conduct emergency operations on a vehicle.



Courtesy of Edward Monahan.

Vehicle Resting on Its Side (3 of 5)

- Vehicle resting on its side has a high center of gravity and a narrow track/base.
  - Can topple easily
- Goal is to lower the center of gravity by expanding the vehicle's footprint.
  - Accomplished with strategically placed struts, cribbing, and ratchet strapping
  - Position the struts to form an A-frame configuration.

Vehicle Resting on Its Side (4 of 5)

- Determine whether the vehicle is leaning.
- Tendency is for car to fall on its roof.
- The person in charge will feel for shifting.
- Rescuers should work from a semi-kneeling stance.

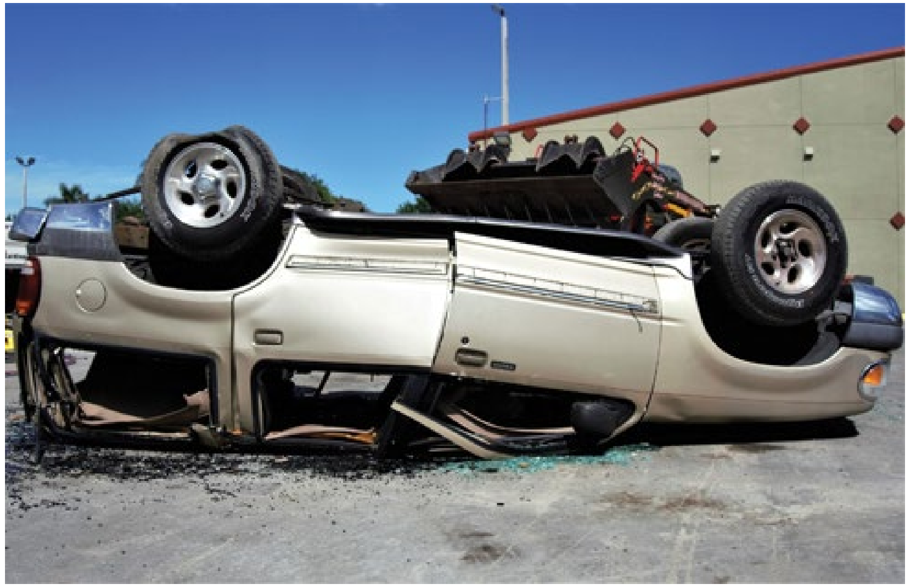
Courtesy of Edward Monahan.

Vehicle Resting on Its Side (5 of 5)

- Initial crib placement will focus on the most unstable area.
- Generally, one set of struts is sufficient.
- The main advantage of using an A-frame technique is that an uncomplicated roof removal can be accomplished if called for by the officer in charge.
- Other techniques require cribbing to be inserted under the roof line in the area of the A-, B-, C-, or greater posts, which can impede a roof-removal operation.

The Vehicle Upside Down or Resting on Its Roof (1 of 3)

- Roof posts can be compromised, making vehicle unstable.
- FVMSS establishes minimum roof strength, but this does not apply to post-crash roof supports.
- Stabilization involves struts and cribbing.



Courtesy of Edward Monahan.

The Vehicle Upside Down or Resting on Its Roof (2 of 3)

- The weight of the engine will usually drive the front area of the vehicle lower to the ground.
- Stabilization should always be set up to keep three entry points open.
- Initial crib placement should focus on the most unstable area, which is usually the trunk area.
- The objective is to set up an A-frame configuration at the rear of the vehicle by building up cribbing under the rear roof and hood/dash areas.

The Vehicle Upside Down or Resting on Its Roof (3 of 3)

- It is also possible to use crosstie box-cribbing configurations stacked on top of one another and placed under the trunk area on both sides.
  - Eliminates the trunk as a point of entry.
- **Tunneling** is the process of gaining entry through the rear trunk area.
- Rescuers should have a full complement of cribbing sections and struts to work with.

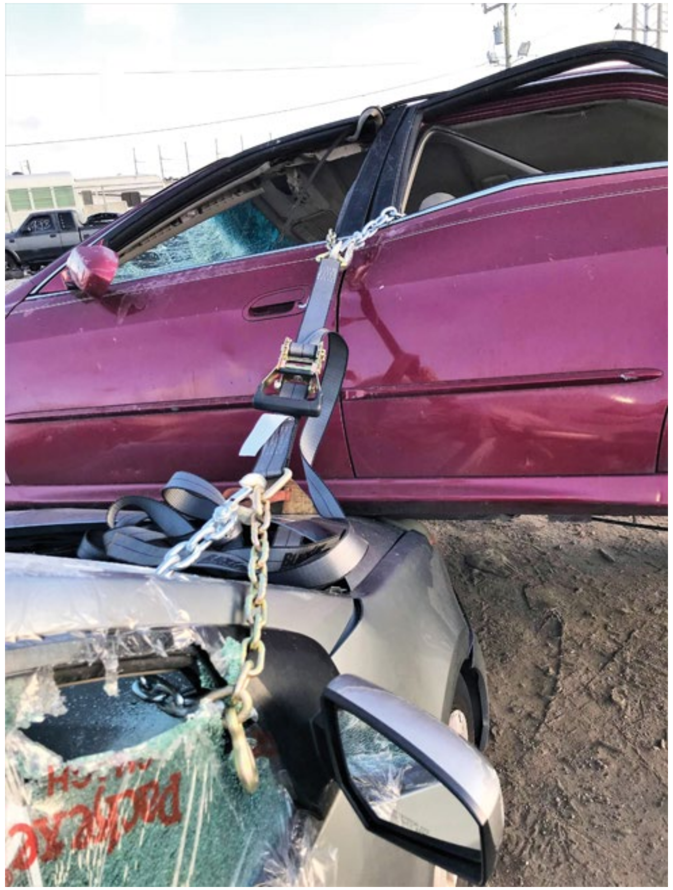
Vehicle on Vehicle or Multiple Concurrent Hazards (1 of 7)

- Two objects may be independently unstable.
- Two objects will need to be married before operations are conducted to prevent independent movement.
- Industrial-grade ratchet strapping

Courtesy of David Sweet.

Vehicle on Vehicle or Multiple Concurrent Hazards

Courtesy of David Sweet.



Courtesy of David Sweet.

Vehicle on Vehicle or Multiple Concurrent Hazards

- Stabilize the bottom vehicle first.
- Never crawl under the top vehicle.
- If you need to pass a strap under to the other side, hook the strap to a pike pole and pass it to the other side.

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Vehicle on Vehicle or Multiple Concurrent Hazards (4 of 7)

- Guidelines for marrying vehicles with ratchet straps:
  - Always look at the top vehicle and determine where it wants to move. Strap it in the opposite direction.
  - Try to wrap the ratchet strap around the object and hook it back onto itself.

Vehicle on Vehicle or Multiple Concurrent Hazards

- Considerations
  - How is the top vehicle resting on the bottom vehicle?
  - Is any section of the top vehicle touching the ground?
  - Where are the victims in relation to the top vehicle?
  - Are there any victims inside either vehicle?
  - Where are the access points to both vehicles?
  - Will marrying the vehicles compromise the access points?

Vehicle on Vehicle or Multiple Concurrent Hazards (6 of 7)

- This marrying configuration gives you access to the victim through the entire door and roof area.

Courtesy of David Sweet.

Vehicle on Vehicle or Multiple Concurrent Hazards (7 of 7)

- Keep in mind that there are additional cribbing options to prevent potential sliding as the bottom vehicle is being stabilized.

Courtesy of David Sweet.

Monitoring Stabilization

- Stabilization of vehicle requires continuous monitoring.
- Requires a designated member to walk around the vehicle and ensure cribbing has not shifted and is tight and in place
- Shifting may occur after every major application of a tool.
- Should be reassessed after application to confirm stabilization

Hidden Dangers and Energy Sources (1 of 5)

- Once the vehicle has been stabilized, the proactive technical rescuer can mitigate hidden potential hazards.

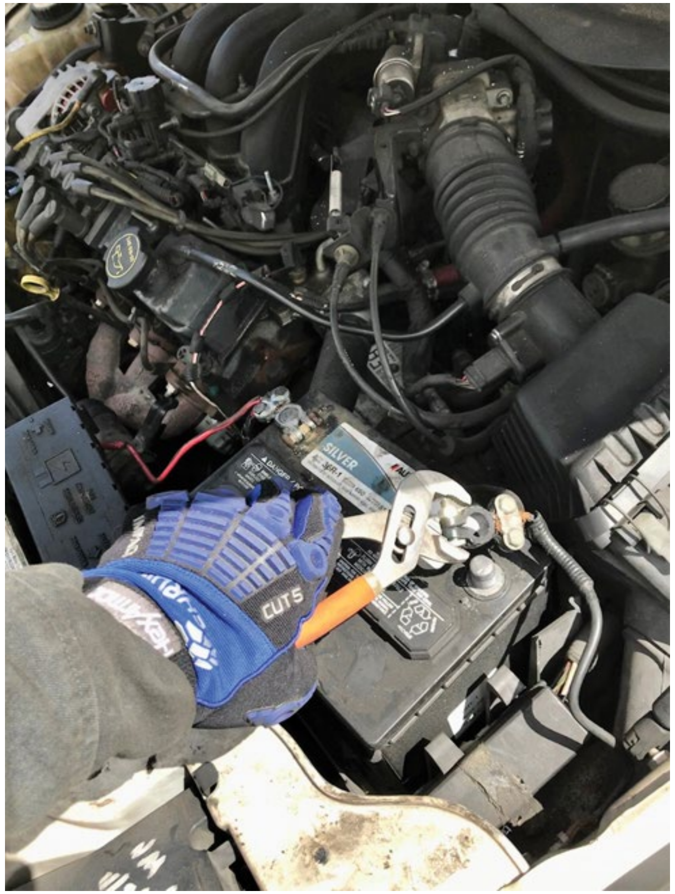
Courtesy of David Sweet.

Hidden Dangers and Energy Sources

- Unless there is an immediate danger to life or health (IDLH), the vehicle should be stabilized before opening the hood or trunk of the vehicle to eliminate the power.
- Alternatively fueled vehicles require specialized procedures before stabilizing the electrical systems.
- The sequence of actions is a judgment call made by the officer in charge depending on the type of incident.

Hidden Dangers and Energy Sources (3 of 5)

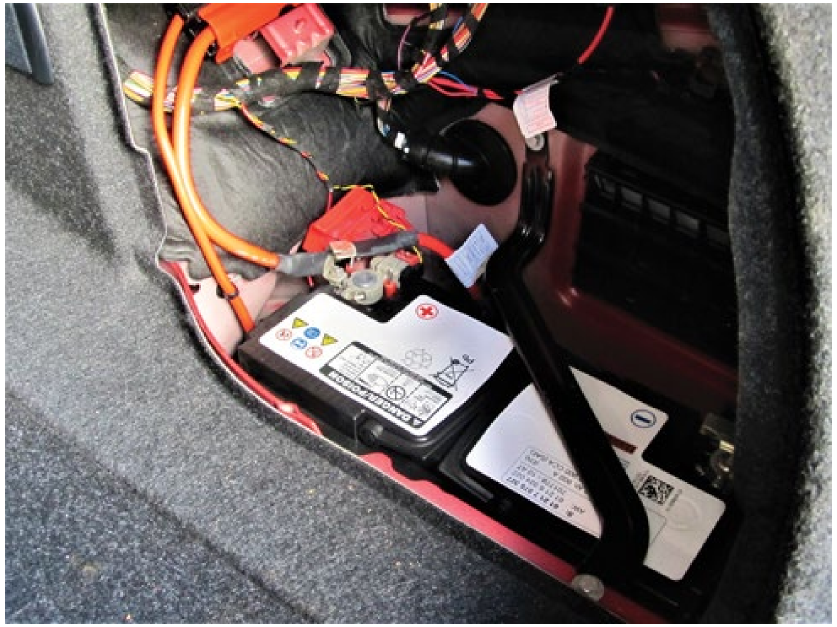
- Eliminating a vehicle's electrical system:
  - Disable 12-volt DC battery
  - Remove fuses from fuse box
  - Remove smart keys



Courtesy of David Sweet.

Hidden Dangers and Energy Sources

- Some vehicles have multiple batteries, and they may be located throughout the vehicle.
- Some manufacturers provide access only to the negative battery cable for purposes of disconnecting the electrical system.



Courtesy of David Sweet.

Hidden Dangers and Energy Sources (5 of 5)

- Be aware that supplemental restraint system air bag control units come equipped with an energy capacitor.
  - Can keep the system live after power has been disconnected

Summary (1 of 6)

- Vehicle stabilization is a critical component of the extrication process.
- Proper vehicle stabilization provides a solid foundation to work from, which ensures safety for the emergency personnel as well as the victim and bystanders.
- Cribbing is the most basic physical tool used in vehicle stabilization.

Summary (2 of 6)

- Soft woods are commonly used for cribbing because they are well suited for compression-type loads. Hard wood is very strong but may split easily under certain stresses.
- NFPA 1006 discusses five types of wood box-cribbing configurations:
  - Two-piece layer crosstie
  - Three-piece layer crosstie
  - Platform crosstie
  - Triangle crosstie
  - Modified crosstie

Summary (3 of 6)

- There are five directional movements to consider during the process of vehicle stabilization: horizontal movement, vertical movement, roll movement, pitch movement, and yaw movement.
- There are four common post-collision vehicle positions that can be encountered at a collision scene:
  - The vehicle may be upright.
  - The vehicle may be resting on its side.
  - The vehicle may be resting on its roof.
  - The vehicle may be on top of another object.

Summary (4 of 6)

- The basic or simple forms of internally stabilizing a vehicle include placing the vehicle in park, turning off the engine, and applying the parking brake.
- The main purpose for stabilizing a vehicle in its normal position is to gain control of all vehicle movement by minimizing the vehicle's suspension system and creating a solid and safe base to work from.
- When placing the cribbing, choose areas that are solid; areas such as the rocker panel just under the firewall/dash section or the area just in front of the rear tires are generally very solid points to work from.
- When using cribbing, the goal is to make the contact area from the ground to the undercarriage tight, filling up any void spaces.

Summary (5 of 6)

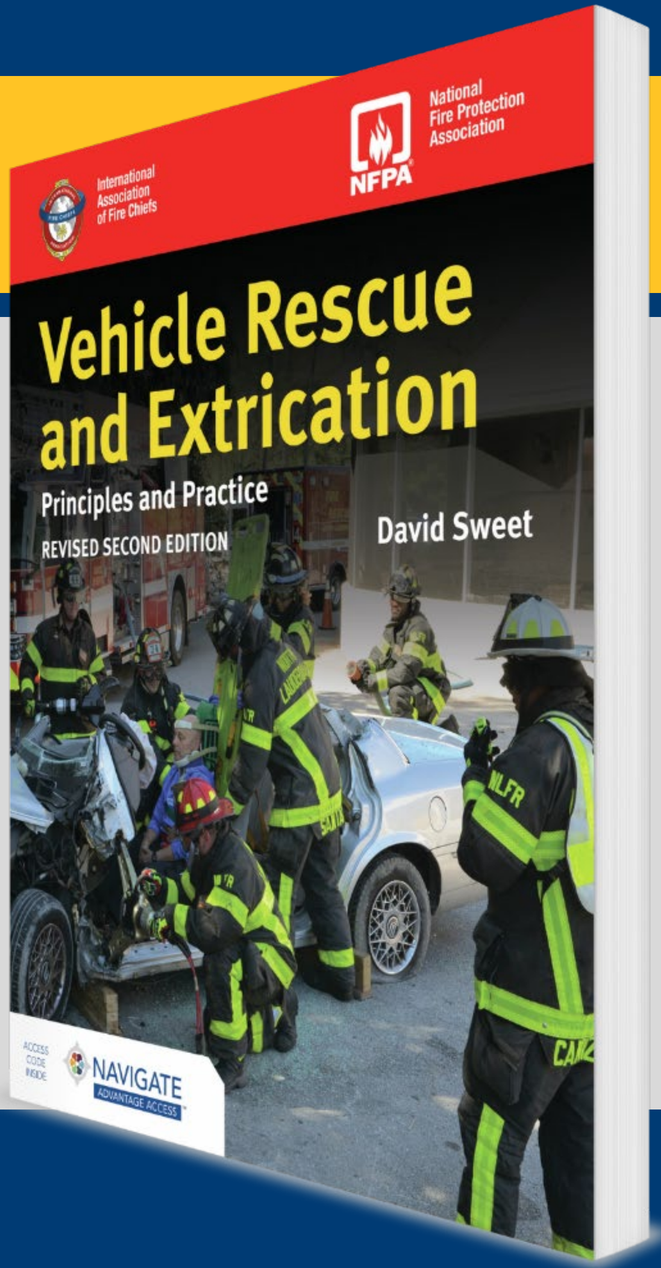
- The purpose of deflating the tires is to have the frame of the vehicle settle down onto the cribbing, creating a balanced platform to work from and minimizing the suspension system.
- The goal of stabilizing a vehicle on its side is to lower its center of mass by expanding the vehicle's footprint, or base, such as seen with utilizing the outriggers on an aerial platform apparatus.
- When a vehicle is involved in a rollover, the roof posts will be compromised by the impact and weight of the vehicle, making the vehicle unstable.
- The objective is to set up an A-frame configuration at the rear of the vehicle using struts by building up cribbing under the rear roof rail section and hood/dash areas to maintain balance.

Summary (6 of 6)

- When the technical rescuer encounters a vehicle on top of another vehicle or an object on top of a vehicle, he or she is presented with two objects that are independently unstable. These objects need to be joined together, or married, to eliminate any independent movement.
- Once the vehicle has been stabilized, the technical rescuer should mitigate any potential post-crash vehicle electrical hazards that can occur, which may require disabling the vehicle's electrical system.

CHAPTER 9

Victim Access and Management



Knowledge Objectives

- Define the following terms and discuss their role in vehicle rescue incidents:
  - Glass management
  - Expose and cut
- Detail the steps in victim access and removal.
- Explain the differences between primary and secondary access.

Knowledge Objectives (2 of 3)

- Identify automotive window materials, and explain the challenges these materials pose to rescuers.
- List dangers encountered in cutting vehicle components.
- Describe the steps in roof removal.
- Compare and contrast the dash roll and the dash lift.

Knowledge Objectives (3 of 3)

- Describe the techniques available to rescuers for steering wheel relocation.
- List the steps in addressing life-threatening injuries in vehicle crash victims.
- Identify and use appropriate immobilization, packaging and transfer devices, and techniques to safely remove a victim from a vehicle.

Introduction

- Vehicle extrication is a three-phase process.
  - The third step is victim access and management.

Courtesy of Edward Monahan.

Courtesy of Edward Monahan.

Introduction (2 of 2)

- Managing the victim involves
  - Victim access
  - Care
  - Packaging
  - Removal
  - Transport
- Main objective is to remove the vehicle from the victim.

Courtesy of Edward Monahan.

Access Points (1 of 2)

- After stabilizing the vehicle, the rescuer must gain access to the passenger compartment to assist the patient.
  - Plan A: primary access refers to the existing openings of doors and windows.
  - Plan b: secondary access refers to openings created by rescuers.
- Basis for the IAP
  - Access types may be combined as the plan evolves

Access Points (2 of 2)

- Important to add an emergency escape plan with Plan A and Plan B
- The emergency escape plan is a designated area of temporary refuge that the team can immediately enter if an immediate danger to life and health is experienced.

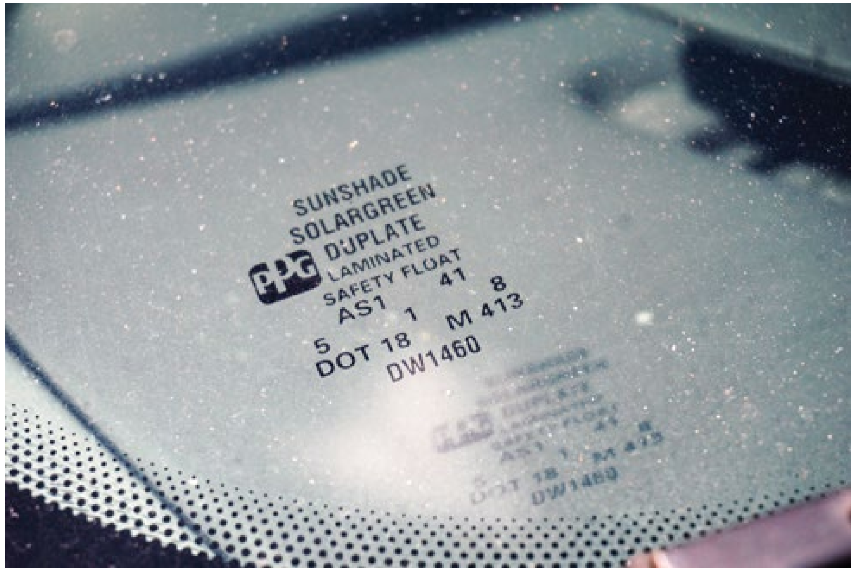
Access Through Doors

- Manually try the doors first.
- Attempt to unlock and open the least damaged door.
  - Ensure locking mechanism is released.
- Consider breaking a window in order to unlock the door.

Courtesy of David Sweet.

Access Through Windows

- Side and rear windows can be made of tempered, laminated, or polycarbonate glass.
- Look for embossed marking or use center punch technique.
- Entering through the windshield is uncommon.



Courtesy of Edward Monahan.

Courtesy of Edward Monahan.

Glass Management

- The controlled removal of glass or maintaining the glass intact
  - Consider using a self-adhesive film.
- Removing a roof requires all glass to be removed.
- When breaking glass, ensure that all personnel and victim(s) are aware.
- Make sure rescuers and victim are covered.
- Attempt to break the glass at the farthest point from the victim.
- All glass should be placed in a designated debris pile.

The Backboard Slide Technique

- Used to gain access to the patient as quickly as possible to render care
- If doors are inaccessible, slide the backboard through a window.
  - May be difficult to maneuver
- Rescuer may have to slide headfirst.
  - Wear PPE.
  - Protect against head/neck injury.
  - Make sure there is no harmful debris or biohazards.

Tempered Safety Glass (1 of 4)

- Using a spring–loaded center punch:
  - Place a hand against the corner of the window to be broken.
  - With free hand, rest the tool on the outer ridge of hand.
  - Place the tip of the tool at a 90-degree angle to the window.

Courtesy of David Sweet.

Tempered Safety Glass (2 of 4)

- Using a spring–loaded center punch (*continued*):
  - Plunge the tool into the window.
  - Tinting film will usually hold glass together.
  - Chip out a small section of glass.
  - Pull the entire section of glass up and out of the frame.

Courtesy of Edward Monahan.

Tempered Safety Glass (3 of 4)

- Using a glass handsaw
  - Manually operated glass removal tool
  - Can break tempered or laminated glass
  - A center punch is set inside the hollow slot in the middle of the tool.
  - The tool is rolled forward, plunging the center punch into the glass.

Tempered Safety Glass (4 of 4)

- Using a glass shearing tool
  - Battery-powered
  - Designed to quickly cut laminated glass
  - Gives rescuer full directional control
  - Minimal fragments
  - Laminated glass only
  - Purchase point requires other tool

Courtesy of David Sweet.

Laminated Safety Glass (1 of 3)

- Created by applying a layer of clear thermoplastic film or binding agent between two layers of plate or sheet glass
  - Federally regulated to use for windshields but may also be found in rear and side windows
- Film prevents large shards of glass from flying.
- Sealed with a mastic adhesive that requires a cutting action for removal
- All rescuers in the area must wear respiratory protection!

Laminated Safety Glass (2 of 3)

- Accessing the victim through the windshield is uncommon; must remove entire windshield
- Requires two rescuers on opposite sides of the vehicle
- Apply safety film
- Cover the victim

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Laminated Safety Glass (3 of 3)

- Very fast process; leaves a straight edge
- Cut through A-posts and the windshield.
- Choose TPI rating.
- Beware of the potential for an air bag cylinder to be located in the A-post.
- Support the windshield.

Courtesy of David Sweet.

Polycarbonate Windows and Ballistic Glass (1 of 2)

- Lighter, durable plastic
- 250x stronger than glass
- Best to remove it in one piece
  - May use a hydraulic spreader to pry the window out of the frame casing
  - Use any openings created by the crash, or
  - Make a purchase point by crushing a section of the roof rail or section of accessible metal

Polycarbonate Windows and Ballistic Glass (2 of 2)

- Use of saws is not effective because the heat will cause the window to reseal itself.
- Use a powered rotary saw (K-12 saw) and reverse the carbide tip blade.
  - Impractical and time-consuming
- Ballistic (bullet proof) glass uses multiple layers of tempered glass, laminated material, and polycarbonate thermoplastics.
  - Treat it like polycarbonate, removing the entire section as one piece.

Removing the Windshield from a Partially Ejected Victim

- Occupants who are not wearing seat belts can be easily ejected.
- A victim in a vehicle is traveling at the same speed as the vehicle unless stopped by an object.
- In some cases, the victim is only partially ejected from the vehicle.
  - It is a challenge to free and render medical care to these victims.

Using Hydraulic Rescue Tools to Gain Door and Roof Access (1 of 3)

- Technical rescuers may need to use heavy tools.
- Advances in technology have led to faster and more powerful tools designed to make vehicle rescue less complicated and cumbersome.
  - Today’s rescuer must be less like a mechanic and more like a surgeon.
- Making a purchase point is the process of inserting and positioning a tool for operation.
  - Expose and cut

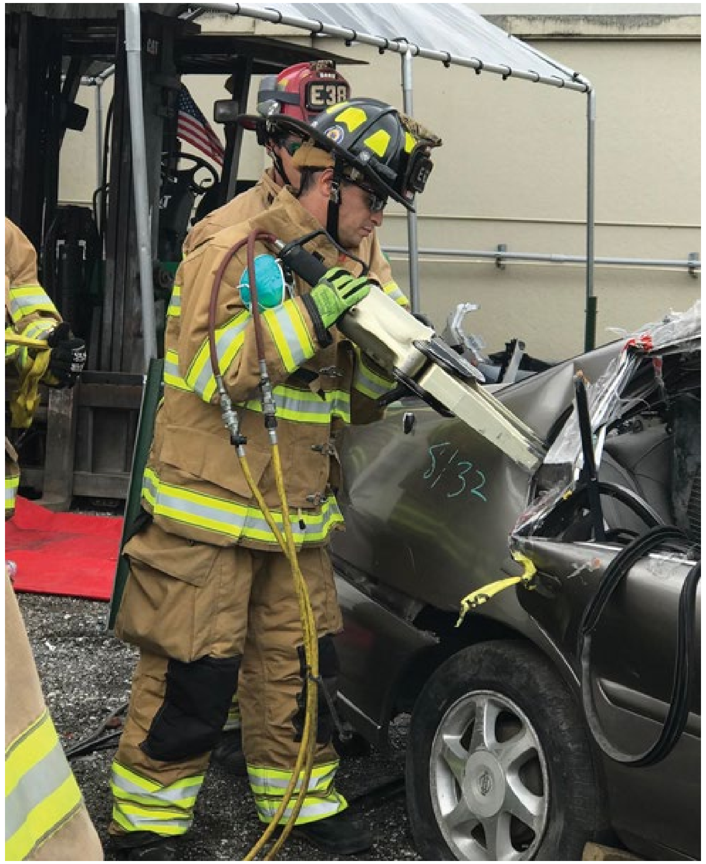
Using Hydraulic Rescue Tools to Gain Door and Roof Access (2 of 3)

- A hydraulic spreader is the best hydraulic tool used for making a purchase point.
- Most hydraulic cutters are rated to cut through hinges and locking/latching mechanisms located in vehicles.

Courtesy of Edward Monahan.

Using Hydraulic Rescue Tools to Gain Door and Roof Access (3 of 3)

- Anyone can rip a door off of a vehicle.
- A true professional applies force with technique and control.
- Goal is to increase efficiency through proper approach.



Courtesy of David Sweet.

Door Access from Latch Side: The Vertical Spread (1 of 4)

- Older method required two rescuers using a striking and prying tool.
  - Not good time or personnel management
- Hydraulic tools can cause problems when inserted into purchase points.
  - Metal collapsing around the tool blocks the possibility of inserting a hydraulic cutter to cut the latching mechanism.

Door Access from Latch Side: The Vertical Spread (2 of 4)

Courtesy of David Sweet.

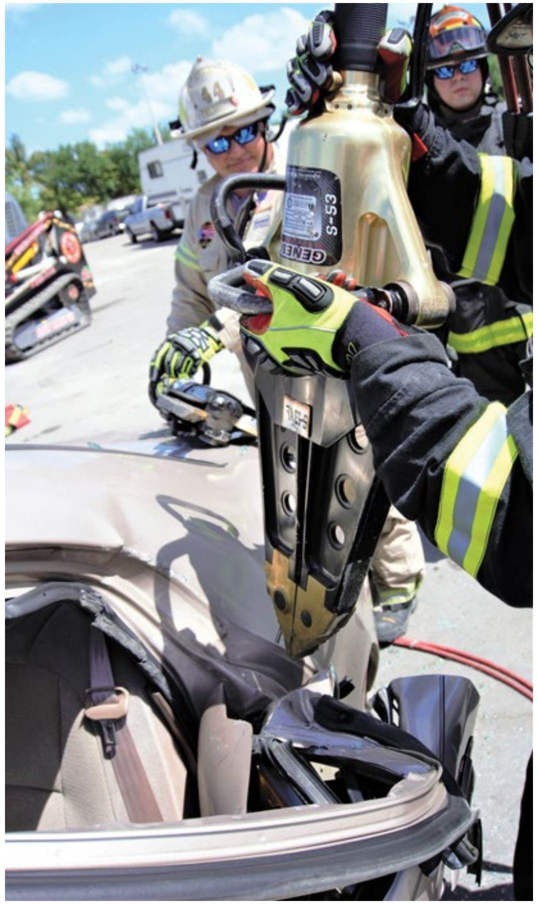
Courtesy of Edward Monahan

Door Access from Latch Side: The Vertical Spread (3 of 4)

- Suggested procedure:
  - Expose the latch with a vertical spread.
  - Insert the cutter and cut the latch.
- If hydraulic tools are not available, hand and power tools can accomplish the same objective.

Courtesy of Edward Monahan

Door Access from Latch Side: The Vertical Spread (4 of 4)



Courtesy of Edward Monahan

Courtesy of Edward Monahan

Door Access from Hinge Side: Front Wheel Well Crush

- Not a common procedure; needed in some scenarios
- One possible solution to front-end impact is to enter the door from the hinge side, cut the hinges, and pull door away and back.
- Best option is to enter by removing the roof.

Courtesy of Edward Monahan

Wheel Well Crush Technique

- Method of gaining access to door hinges from the outside using a hydraulic spreader and cutter
- Use the hydraulic spreader to crush the wheel well and create a purchase point at the door’s seam, allowing the spreader to get in and expose the hinges.
- Hydraulic cutter can then be inserted to cut the hinge.

Complete Side Removal Technique (1 of 4)

- Side-out technique is designed for four-door vehicles involved in side-impact collisions.
- Allows rescuers to remove front and rear doors as one unit
- Dramatically reduces the time it takes to gain access through the doors
- Understanding what occurs to the body of a vehicle after it has been involved in a side-impact collision is important: both doors and B-post move inward toward occupants.

Complete Side Removal Technique (2 of 4)

- Attempting to spread the driver's side door at the latching mechanism would only cause the B-post to continue to collapse.
- The correct action is to push the doors and B-post out and away.

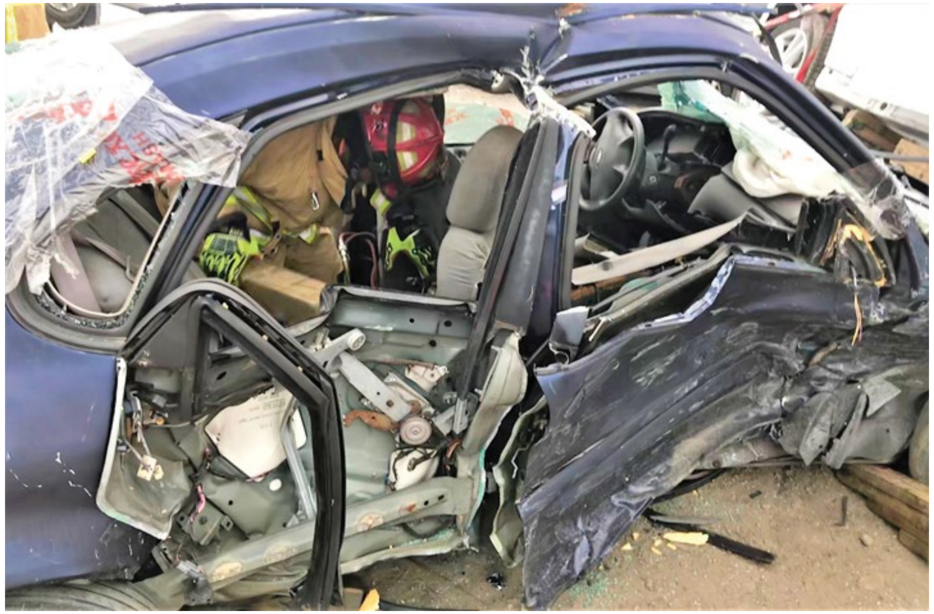
Courtesy of David Sweet.

Complete Side Removal Technique (3 of 4)

- Best accomplished with two rescuers working in tandem
- Begins at rear door and progresses forward
- Cut through the top of the B-post and place the spreader inside the vehicle to push the B-post and frame back into position.
- Then proceed with the all-door side-out technique.

Complete Side Removal Technique (4 of 4)

- Adding or changing out tools expends valuable time.



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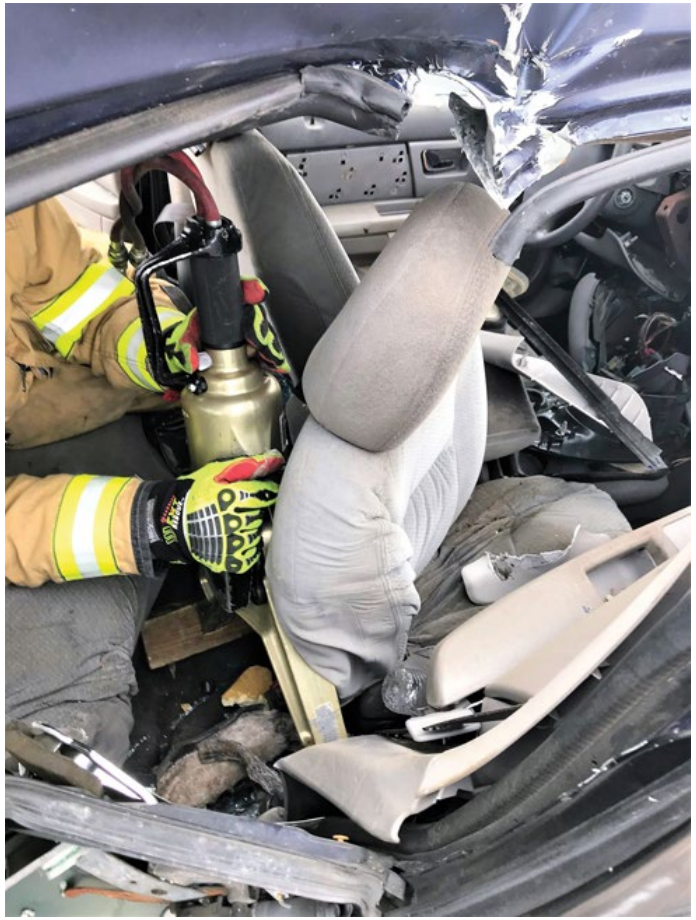
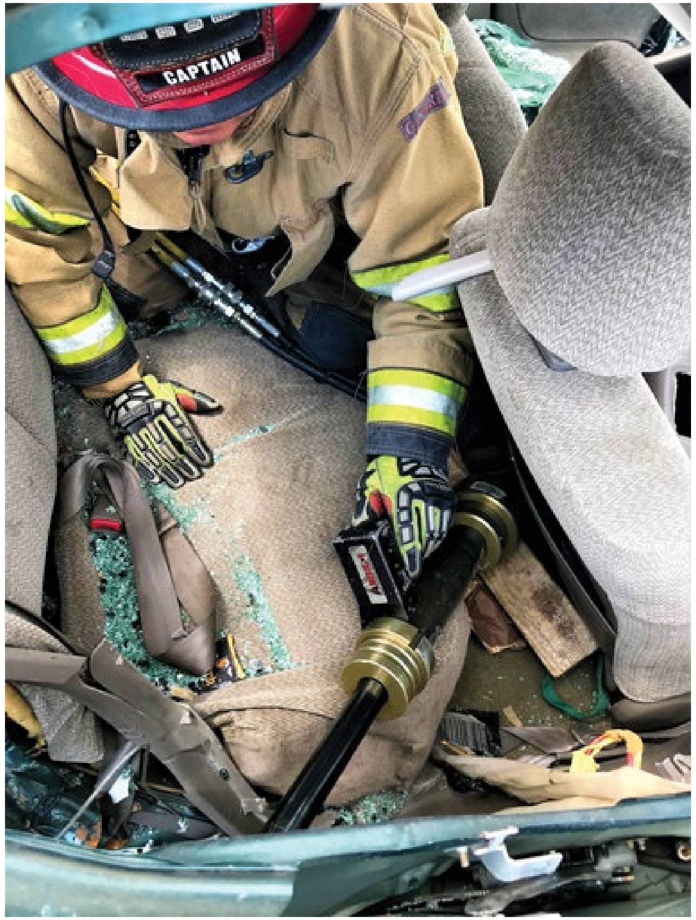


Courtesy of David Sweet.

Removing the Vehicle from the Victim

- In an entrapment situation, a solution is to push the B-post or door section off the victim using a hydraulic ram.
- Need to create enough room for tools
- Several options and techniques



Courtesy of David Sweet.

Roof Removal (1 of 3)

- Allows for victims to be kept in-line as they are packaged and removed.
  - Properly packaging victims using an immobilization device provides the best care.
- The rescuer must expose the interior of each post and the roof rail prior to cutting.
  - Cut above or below object or area of concern.
  - The blade of the hydraulic cutter should be perpendicular to the object being cut.

Roof Removal (2 of 3)

Courtesy of David Sweet.

Courtesy of David Sweet.

Roof Removal (3 of 3)

- Tool movement is common when cutting a post.
  - Caused by the blades of the tool trying to fracture and cut in the path of least resistance
- Be prepared to respond to the first instance of movement.
  - Push or pull forcefully in the opposite direction.
  - Engage the throttle.

Cutting C-Posts

- Wide C-posts may require several cuts.
  - Make cuts on both sides of the post.
  - Position the tips of the tool in the cut sections.
  - Close the tool on the cuts.
  - Make certain that the tips of the spreader carry past the inside wall of the post.

Relocating the Dashboard Section and/or Steering Wheel Assembly

- There are several techniques to remove or lift the dash section that is entrapping the victim.
  - Using the wrong technique can complicate the situation.
  - Knowing when to use one technique over another can greatly reduce time spent.
  - Combining techniques may improve the outcome.

Dash Roll Technique (1 of 2)

- Standard technique for displacing the dash and steering wheel assembly for many years
- Process involves rolling the vehicle's front end off the entrapped occupant using hydraulic rams.
  - Begins by removing the roof and gaining access to the front doors
  - Telescoping ram is most effective.
- The front end will lift up and forward, hinging on the relief cuts on both sides.

Dash Roll Technique (2 of 2)

- If the vehicle is a two-door model, use an L-bracket, which is made of steel and fits over the rocker panel and preferably up against the back of the door frame.
- Considerations if the B-post has been removed:
  - Another option is to stagger the height of the cribbing under the rocker panel.
  - Less desirable option is to drive the spiked end of a Halligan bar into the rocker panel, creating an artificial push point.

Dash Lift Technique (1 of 5)

- The dash roll technique will not be effective in scenarios where the weight and position of objects are locking and holding down the dash area.
  - Creates tenting effect
- Dash lift is good for these situations.

Courtesy of Bill McGrath.

Dash Lift Technique (2 of 5)

- The goal is to release the strut tower from the dash/firewall section and create a hinge point for the dash to rise up and away.
- Two relief cuts are made: upper rail section and firewall area.
- When done correctly, section of dash will lift straight up and off occupant, leaving the front section of the vehicle.
- Steps will need to be repeated on opposite side.

Dash Lift Technique

- Prior to making any relief cuts, the area must be examined for possible hydraulic or gas-filled piston struts installed to lift the vehicle hood
- If it is in the way, will need to be disabled or detached

Courtesy of Edward Monahan.

Dash Lift Technique (4 of 5)

- To disable the strut:
    - Insert hydraulic cutter and cut section of the piston where it attaches to the vehicle.
    - Do not cut into the cylinder body.

Courtesy of Edward Monahan.

Dash Lift Technique (5 of 5)

- Advanced technique with multiple steps that must be strictly carried out
- Dash brackets can complicate this technique.
  - Majority of the time, these brackets will break off.

Courtesy of David Sweet

Steering Wheel Assembly Relocation

- Option when other techniques are not possible
- Controversial because there is fear that the steering column will come apart under force
- There is a misperception about the amount of pull needed to release the steering column.
- When the come along and the chain package have been properly applied, the rescuer has complete control of the movement.
- Do not use hydraulic tools along with a rated chain package.

Providing Initial Medical Care (1 of 4)

- Any technique, procedures, and/or tools applied to extrication are futile without a solid medical plan.
- The medical position requires trained personnel to
  - Make the best medical decisions in chaotic conditions
  - Rapidly evaluate the incident
  - Develop a medical plan of action
  - Integrate that plan into the IAP
  - Reassess for effectiveness
  - Be prepared to adjust

Providing Initial Medical Care (2 of 4)

- Upon arrival, the medical position will immediately engage in the operational process as the inner and outer survey crews complete the initial scene stabilization.
  - Move in the direction of the first identified victim.
  - Establish verbal but not physical contact.
    - Provides immediate information on airway and neurologic function, as well as establishing a relationship with the victim.

Providing Initial Medical Care (3 of 4)

- Primary assessment can be made outside of the vehicle, but preferable to enter the vehicle
- Ensure the all-clear has been given.
- While medical provider makes entry, another rescuer can maintain victim's airway.

Courtesy of David Sweet.

Providing Initial Medical Care (4 of 4)

- XABCDE mnemonic format
- The components are taught and displayed in a sequential manner but can be performed simultaneously.
  - Any life-threatening conditions identified can immediately be addressed before completing the entire primary survey.
- The goal is to prevent the onset of shock by maintaining delivery of oxygen to the tissues via an intact circulatory and respiratory system.

Exsanguinating Hemorrhage

- Must be immediately controlled
- Can be internal, external, or both
  - Apply direct pressure or use a tourniquet.
- Quickly assess the victim's color and temperature.

Courtesy of David Sweet.

Airway

- Immediately assess for patent airway.
- Apply standard trauma jaw thrust maneuver/chin lift.
- Grasp victim's head, put one hand on chin, one hand on back of the head, and raise head to a neutral position.

Courtesy of David Sweet

Breathing

- If the victim is conscious, assess the rate and quality of breathing.
- If the victim is unconscious, check for breathing by placing the side of your face next to the victim’s nose and mouth.
- If the victim is having difficulty breathing or you hear unusual sounds, check for any object(s) in the victim’s mouth and remove it.
- If breathing is absent, take immediate steps to open the victim’s airway and perform rescue breathing.

Circulation (1 of 2)

- If victim is unconscious, check the carotid pulse.
  - Place your index and middle fingers together, and touch the larynx.
  - Slide your two fingers off the larynx toward the victim’s ear until you feel a slight notch.
  - If you cannot feel a pulse with your fingers in 5 to 10 seconds, begin CPR.
- If the victim is conscious, assess the radial pulse.
  - Place your index and middle fingers on the victim’s wrist at the thumb side.

Circulation (2 of 2)

Courtesy of David Sweet

Courtesy of David Sweet

Disability

- Assess the cognitive reaction of the victim.
- Determine the victim's GCS score to determine the severity of traumatic brain injury.
  - Three parameters measure the victim's best motor response, verbal response, and eye response.
  - Factors such as alcohol and drug use and low blood sugar can alter the scoring.

Expose

- Expose areas of the body that require the removal of clothing.
  - Protect the integrity of the victim.
  - Maintain the body’s temperature and prevent hypothermia.
- If the victim is conscious and alert, the provider must explain all actions taken and obtain consent.
- Use a systematic approach when exposing areas of the body, beginning at the head.

Compartment Syndrome (1 of 2)

- Compartment syndrome occurs when compressive forces are applied to the body and blood is shunted away for a prolonged period of time from a tissue or organ.
- Occur from crushing and traumatic injuries
- Immediate recognition and treatment of compartment syndrome is critical for patient survival.

Compartment Syndrome (2 of 2)

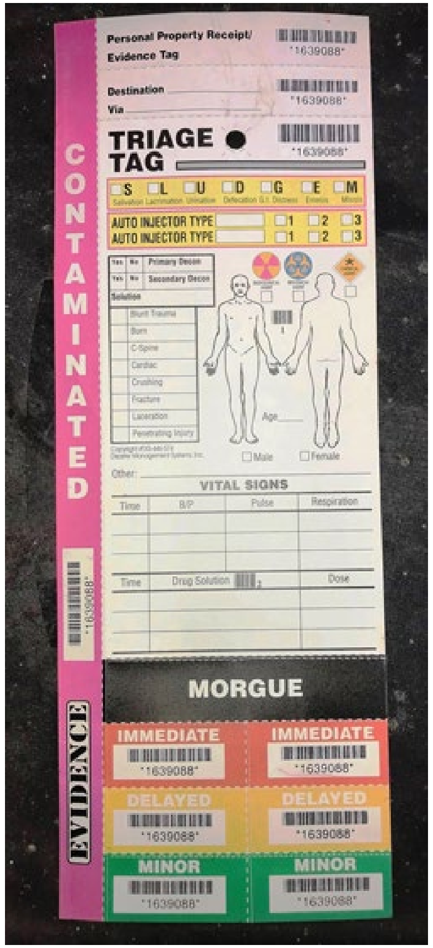
- Signs and symptoms:
  - Severe pain
  - Lack of a pulse in the extremity
  - Obvious bone fractures
  - Loss of color to the extremity or area
- Vital for the medical team to rapidly assess the patient before the patient is extricated.
- Compartment syndrome is an advanced life support emergency.
- Intravenous fluids and medications may need to be administered to the patient before the patient is extricated from the vehicle.

Triage (1 of 2)

- Four common categories:
  - Immediate (red)
  - Delayed (yellow)
  - Minor or minimal (green)
  - Expectant (black)
- Each patient should have a tag or label indicating his or her condition.
  - Easy to read
  - Color coded

Triage (2 of 2)

- This is a rapid initial assessment; more detailed and thorough examinations will follow.
- On secondary survey, a labeling triage tag system should be attached to each victim.
  - Weatherproof and easy to read
  - Tear-off receipt may help with tracking.



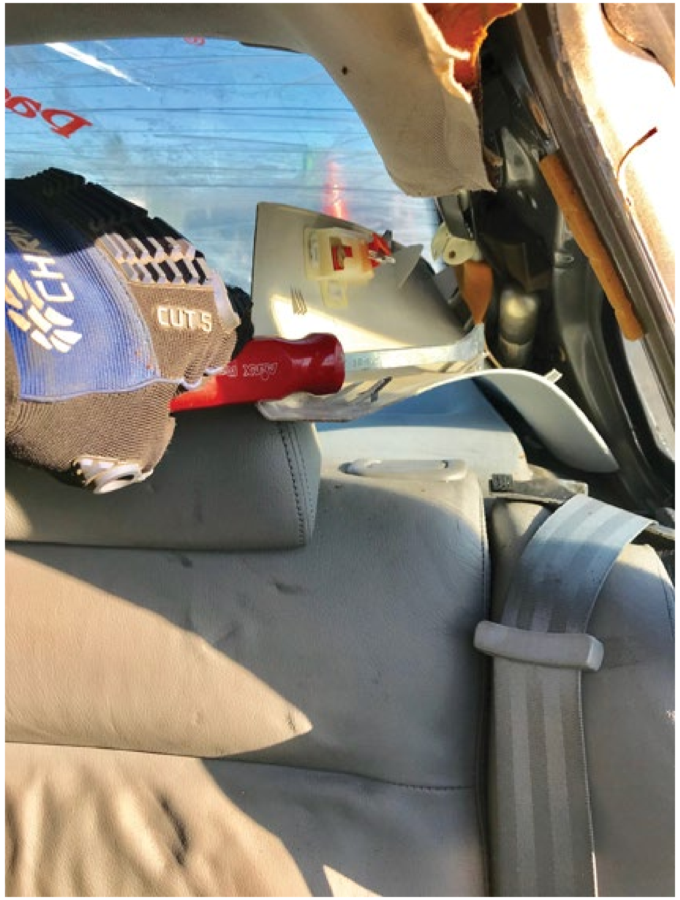
Courtesy of David Sweet

START

- **S**imple **T**riage **A**nd **R**apid **T**reatment
  - Rapid limited assessment of patients based on their ability to walk, respiratory status, hemodynamic status, and neurologic status
- JumpSTART is a similar strategy for assessing pediatric patients.
- SALT triage system is another all-hazard national guideline (sort, assess, life-saving interventions, and treatment/transport).

Other Steps

- Cutting all the seat belts to assist in roof removal
- Identifying undetected air bag or SRS components
- Determining whether beneficial systems are operational
- Providing soft and hard protection for the victim
- Continuous communication


Courtesy of David Sweet

Victim Packaging and Removal

- Maintaining alignment is a main objective when removing a victim from a vehicle.
- Use a victim immobilization tool, such as a KED.
- Several rescue personnel will be needed.

Courtesy of Edward Monahan.

Transport

- Once the victim has been removed from the vehicle, transfer all medical information to EMS personnel who will transport the patient to a medical facility.
- Documentation:
  - Serves as a record that appropriate care was delivered
  - Guarantees the proper transfer of responsibility
  - Ensures continuity of patient care
- The type of transport used to deliver the victim to the emergency department will vary.

Summary

- Victim management involves vehicle entry, victim packaging, and victim removal.
- The main objective is not to remove the victim from the vehicle but to remove the vehicle from the victim by creating a large opening with systematic and precise techniques.
- Primary access points are the existing openings into the vehicle, and secondary access points are openings created by rescuers.
- One of the simplest ways to access a victim is to open a vehicle door. It is important to manually try all the doors before other methods are used, even if the doors appear to be badly damaged.

Summary

- Polycarbonate glass is a light and durable thermoplastic that is up to 250 times stronger than glass; it is naturally designed to resist direct impacts by any striking tool carried on the apparatus.
- Making a purchase point/access opening is the process of gaining an access area to insert and better position a tool for operation.
- Once a purchase point has been established, the goal is to create a wide enough opening with the hydraulic spreader to expose the locking/latching mechanism or hinges and to insert a hydraulic cutter; this technique is known as expose and cut.

Summary (3 of 6)

- For gaining door access, a vertical spread technique gives the technical rescuer the best vantage point from which to expose the latch and create enough room for the cutter blades to get in and cut the latching mechanism.
- A wheel well crush technique is utilized to gain access to door hinges from the outside using the hydraulic spreader.
- The complete side removal technique (side-out) is a highly effective technique for four-door side-impact collisions; it pushes the door frame and B-post outward, separating them from the rocker panel, away from the occupant, utilizing the door’s natural directional movement.

Summary (4 of 6)

- When performing a roof removal, position rescuers on both sides of the vehicle to support the roof as the posts are cut.
- The dash roll technique involves pushing or rolling the entire front end of the vehicle, which encompasses the dashboard and steering wheel assembly, off of the entrapped occupant utilizing hydraulic rams.
- The dash lift technique involves lifting the dash upward with the hydraulic spreader by making precise relief cuts in the hood's upper rail and between the hinges of the firewall area, thus separating the dash section from the front end of the vehicle.
- Metal brackets attached to the dash can at times resist the upward movement of the dash lift technique, halting any progress.

Summary (5 of 6)

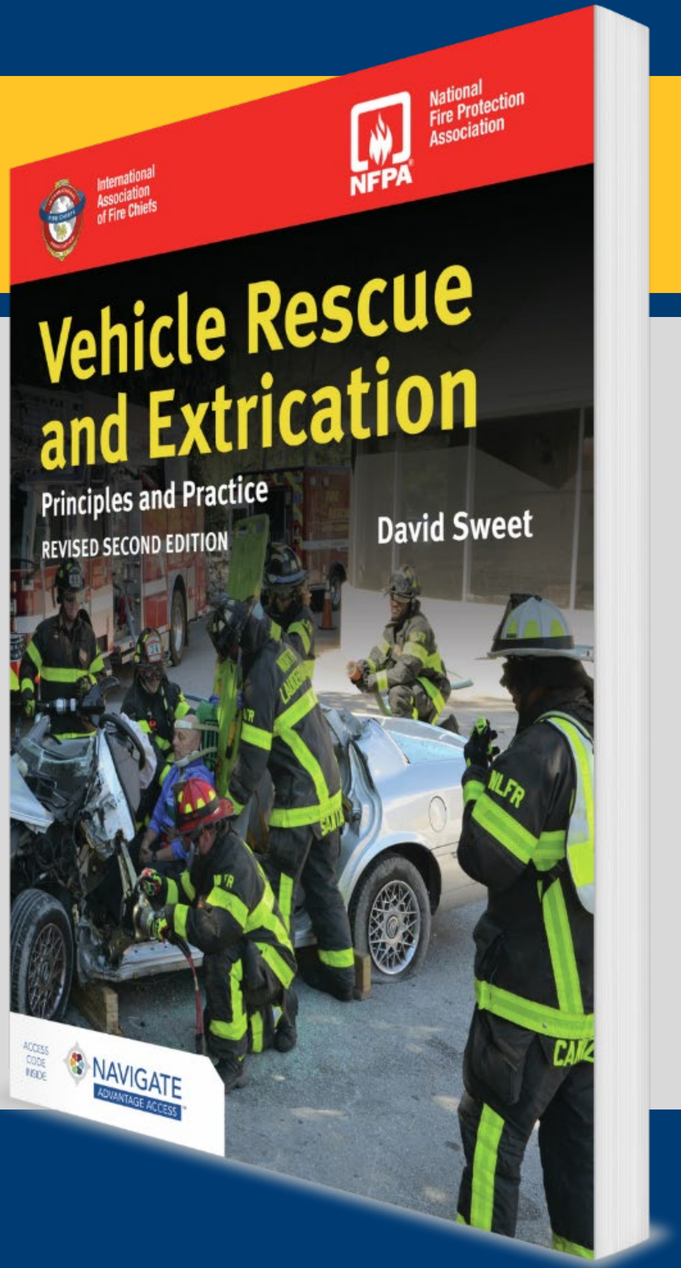
- Relocating a steering wheel assembly utilizing an FRJ or rated come along may be a reliable option when other dash displacement techniques, such as a dash lift or dash roll technique, are not an option or a hydraulic tool fails.
- Once inside the vehicle, the EMS care provider must assess the condition of the victim and render care, such as managing airway, breathing, and circulation.
- Because trauma is suspected after a motor vehicle collision, protect the cervical spine by keeping the victim's head in a neutral position and using the jaw thrust maneuver to open the airway. Maintain cervical stabilization until the head and neck are immobilized.
- Some incidents may involve multiple victims. Triage simply means to sort victims based on the severity of their injuries.

Summary (6 of 6)

- There are four common triage categories. They can be remembered using the mnemonic IDME, which stands for immediate (red), delayed (yellow), minor or minimal (green; hold), and expectant (black; injuries incompatible with life or deceased).
- Once the victim has been removed from the vehicle, transfer all pertinent medical information to the EMS personnel who will transport the victim to the appropriate medical facility.
- Skilled verbal communication and written documentation will enable you to effectively coordinate the transfer of care.

CHAPTER 10

Alternative Extrication Techniques



Knowledge Objectives

- Describe the process of tunneling through a vehicle to gain access to victim(s).
- Explain the dangers associated with tunneling and strategies to mitigate risks.
- Identify when it is appropriate to remove front seats or seat-backs in alternative extrication operations.
- Identify tools that can be utilized to replace or augment traditional extrication tools.
- Provide and explain alternate extrication strategies when traditional methods are inappropriate or unsuccessful.

Introduction

- Well–rounded technical rescuers have a diverse repertoire of alternative techniques that they can apply to any incident.
- It is best to be prepared with as many options as possible.
- The technical rescuer should be able to
  - Utilize various tools
  - Transition between hand, electric, and hydraulic tools

Tunneling (1 of 3)

- Tunneling is the process of gaining entry through the rear trunk area.
- Commonly performed on a vehicle on its roof
- With practice, it can be accomplished very quickly and enable in-line removal of the victim.

Courtesy of Edward Monahan.

Tunneling (2 of 3)

- Use caution with hybrid, fuel cell, and alternative fuel vehicles.
- Several tools need to be set up.
  - Air chisel
  - Electric-powered reciprocating saw
  - Hydraulic spreader/cutter

Courtesy of Edward Monahan.

Tunneling (3 of 3)

- When the vehicle is stabilized, remove the trunk.
    - Expose and cut the latching mechanism to release the trunk cover.
    - Tools depend on
        - Type of vehicle
        - Body design
        - Presentation of vehicle

Jacking the Trunk (1 of 3)

- An extreme technique
- Entails cracking the undercarriage and lifting the rear end of the vehicle.
- May be required when a tunneling operation reveals a large fuel tank or battery in the trunk blocking entry attempts

Courtesy of David Sweet.

Jacking the Trunk (2 of 3)

- Make relief cuts at precise areas on opposite sides of the rocker panel/floorboard closest to the rear tires.
- Release rear doors from their latch mechanisms to allow the rear of the vehicle to separate and lift.
- Attach chains spanning from front to rear of the vehicle.
- Position an FRJ upright in the middle of the undercarriage.

Jacking the Trunk (3 of 3)

- Lay the chain over the tongue of the FRJ and engage the lever until the chain is taut.
- Engage the FRJ, which will tighten the chain and jack up the rear of the vehicle.
- The battery systems in some electric vehicles comprise the entire floor plan and thus negate the use of this technique.
- This technique is extreme and very technical.

Seat Removal

- Once the rescuer is inside the vehicle, he/she may find different entrapment scenarios.
  - Two rescuers should be in the passenger compartment.
    - One rescuer will perform patient disentanglement.
    - Other rescuer will perform patient care.
  - Evaluate what is impinging the victim and use the correct tools to release the victim.

Front Seat-Back Removal

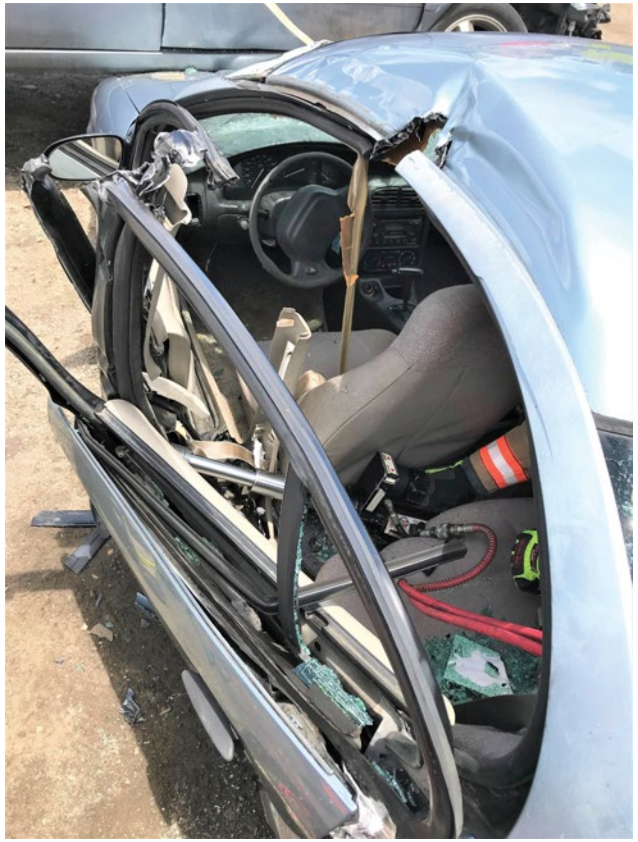
- May be difficult because of advanced designs
- Seats are attached to the floorboards in at least four places.
  - Attachments can be simple or complicated.
- The back seat hinges are normally the best area of access.
- The material covering the seats may have to be removed to expose hinges.
- If removal is not an option, consider making relief cuts on both sides of the lower seat-back.

Front Seat-Back Relocation

- Another technique to help gain better access to the victim.
- Relocates the seat-back using an FRJ.
- Fast technique
- Forcefully pushes the seat-back down

Impingement and Penetrating Objects (1 of 4)

- If the B-post was pushed into the occupant compartment and is impinging on and entrapping the victim, the B-post will have to be pushed back or relocated.
- Any force applied to remove the door will cause the B-post to move farther inward.



Courtesy of David Sweet.

Impingement and Penetrating Objects

- One possible solution is to push or relocate the B-post from the inside.
- The main factor is accessibility, which cannot be predicted.
- The key is to cut the top of the B-post completely away from the roof rail and locate an effective base to push from the inside of the vehicle.
  - The transmission hump
  - Another area that can be used is the opposite side B-post by applying a cross-ramming technique with a telescopic hydraulic ram.

Impingement and Penetrating Objects (3 of 4)

- If you have gained access to the center transmission hump area:
  - The next step will be to position the base of the ram or the arm of the spreader against the hump of the transmission to push from.
  - When using the hydraulic ram, maneuver the tip of the tool to meet the area on the B-post that will best push the metal off of the victim.

Impingement and Penetrating Objects (4 of 4)

- When using the hydraulic spreader, place one or more cribbing sections inside the vehicle against the transmission hump, and position one arm of the spreader against this cribbing and the opposite arm angled upward against the inside of the B-post.
- Once enough room has been established, the side-out or door-removal technique can be initiated.
- If hydraulic tools are not available or access or positioning inside the vehicle is not possible, then an FRJ and chain package can be applied, and the B-post can be pulled away from the victim.

Cross-Ramming Technique

- Used when impingement on the victim requires mechanism that cannot be completed with a hydraulic spreader
- The hydraulic telescoping ram can maneuver the tool's arm to push out on multiple areas, relieving the pressure on the victim.

Courtesy of Edward Monahan.

Impingement (1 of 2)

- A crushed roof with impingement on the victim needs to be raised using a hydraulic tool before any cuts.
- Have several sections of cribbing, wedges, and shims available to insert.

Courtesy of Edward Monahan.

Impingement (2 of 2)

- Be aware of the potential for tool slippage.
  - Can be prevented by recognizing the signs and repositioning the tool
  - It is not recommended to add a 4x4 between the B-post and the tip of the hydraulic ram.
- Tools needed include
  - Large hydraulic ram, preferably telescopic
  - Assorted cribbing sections
  - Backboard

Roof Lift

- If the roof is impinging on the victim, the roof will need to be lifted before any technique can be applied.
  - Any cutting action on the roof can potentially continue the deflection of the roof into the passenger component.
  - Lifting the roof up with a hydraulic spreader or ram or an FRJ changes the force direction of the metal to move upward away from the victim.

Roof Lift Using a Hydraulic Spreader

- The placement of the tool depends on the location of the victim, area that needs lifting, and the amount of intrusion.
- A simple lift requires placing the spreader in the rear window area using the rear deck as a base.
- The bottom arm of the spreader pushes off the 4x4s, and the top arm aims for the roof line.
- Slowly work the tool upward until the top arm creates a tenting effect and the entire rear roof section lifts upward.

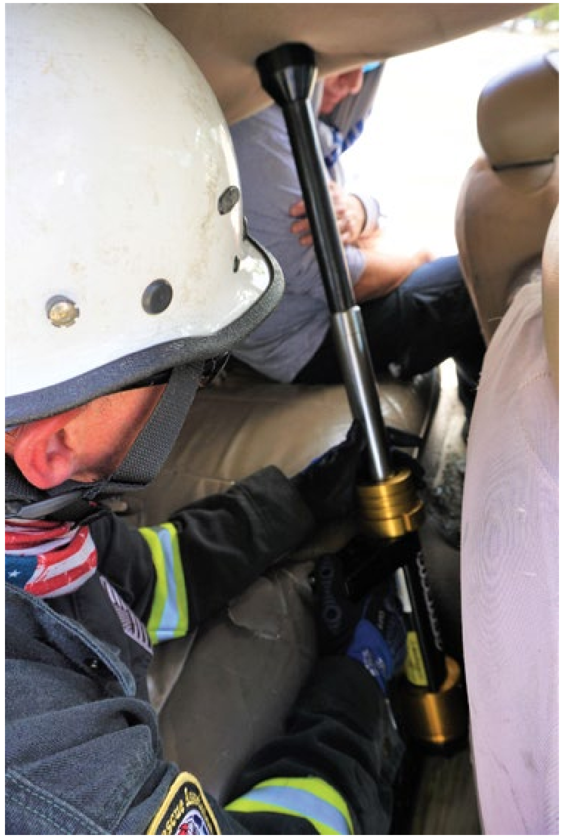
Roof Lift Using an FRJ (1 of 2)

- Place two 4x4s parallel on the rear deck of the vehicle.
- Place the base of the FRJ on the 4x4s for support.
- Slide the tongue of the FRJ to sit just under the roof line, and engage the lever until a tenting effect occurs and the entire rear roof lifts.
- Last, a hydraulic ram can be inserted inside the vehicle and the roof systematically pushed upward away from the victim.

Roof Lift Using an FRJ (2 of 2)

Courtesy of Edward Monahan.

Courtesy of Edward Monahan.



Courtesy of Edward Monahan.

Penetrating Objects

- The main objective is to stabilize the object at the entry and exit points.
- Tools needed include
  - Metal-cutting circular saw
  - Pneumatic cut-off tool
  - Portable bandsaw
  - Basic apparatus toolbox
- Using a hydraulic cutter, reciprocating saw, or handsaw will cause too much movement or torqueing of the impaled object.

Roof Removal (1 of 3)

- When cutting a roof, examine for any tensioning or torsion deformities.
  - This will help you find the best angle for cutting.
- Remove plastic molding on posts and roof rail.
- Keep half of the tip of the chisel blade showing through the entire cut.

Roof Removal (2 of 3)

- When a post is under tension or has a torsional bend to it, it is under a lot of pressure.
  - Always cut away from the bend or torsion.
  - Cut at the base of the post or at the roof line area.

Roof Removal (3 of 3)

- Watch the reaction of the post through the entire cut.
- When cutting through a large or wide post, make an inspection cut to reveal the inside panel.
- When using a reciprocating saw, try to cut at a semi-downward angle.
- If an area in the post is very difficult to cut through, there's probably an impact or reinforcement bar located in the post; cut lower.
- Use hard protection.

Roof Removal Using the Air Chisel

- Requires continual training
- Air cutter only goes through one layer of metal at a time.
- Multiple blades come with most tool kits.
- Success is based on maintaining control.

Courtesy of David Sweet.

Roof Removal Using the Reciprocating Saw

- Fast and efficient
- A power output of 11–15 amps will cut through a wide range of steels.
- Use a 9-inch (23-cm) bi-metal cutting blade with a TPI rating of 9–14.
- Speed setting should be moderate.

Courtesy of David Sweet.

Rapid Roof Removal: Vehicle on Its Side

- Rapid entry technique
- Involves a reciprocating saw
- Two reciprocating saws can increase speed.
  - As the bottom line is cut midway through the roof, another rescuer can start cutting the top line.
  - Can remove roof in 2–3 minutes
  - An advantage is that a section of the roof is actually removed.

Door Removal on the Hinge Side

- Using an air chisel to cut through door hinges can be a challenging task.
- With training, it is an effective technique that is easily mastered.

Side Removal: Vehicle Upside Down or Resting on Its Roof

- Gaining entry through the side of a vehicle that is resting on its roof can require
  - Basic procedure
    - Forcing a door open
  - Involved process with multiple steps

Pedal Displacement and Removal

- Acceleration and brake pedals can trap and entangle occupant's feet.
  - Some manufacturers have designed a special air bag component that pushes the foot out of the way using the piston rod in conjunction with a rapidly inflating small air bag.
- Properly supporting a foot that is trapped must be accomplished before trying to remove the pedal.
  - The foot may be fractured or dislocated.

Pedal Displacement and Removal

- The pedal arm can be cut and/or relocated using
  - Hydraulic cutter, reciprocating saw, air chisel or pneumatic cutoff tool
  - Come along and chain set
  - Webbing or rope

© Jones & Bartlett Learning.

Pedal Displacement and Removal

- Which tools to use will be decided at the time of extrication
- Variables include
  - Type of entrapment
  - Position of foot
  - Type of injury and condition of patient
  - Involvement of air bags or SRS components
  - Other interventions to release the occupant
  - Model of pedal

Removal of a Victim Under a Vehicle Using an FRJ

- One of the fastest tools
- Minimal set up time
- Stable tool
- Quick application
- Requires multiple personnel and cribbing support
- The position of the victim, entrapment, and position of the vehicle will affect tool placement and personnel assignment.

Removal of a Victim Under a Vehicle Using an FRJ (2 of 2)

- One person should be positioned at the head of the victim, two on either side to insert cribbing as the lift is established, one to operate the FRJ, and one to monitor the opposite side.
- Initial support cribbing has to be placed on the opposite side of the vehicle.
- If there are suspected crushing injuries, medical support should be initiated immediately.
- Engage the FRJ until sufficient lift has been established to remove the victim.

Summary (1 of 5)

- Tunneling is the process of gaining entry through the rear trunk area of a vehicle.
- It is most commonly performed for a vehicle that is resting on its roof, but it can be performed for a vehicle in any resting position.
- Jacking the trunk, or cracking the undercarriage and lifting the rear end of a vehicle, is an extreme technique that should be included in the technical rescue arsenal.
- While attempting a tunneling operation, a scenario can present itself in which entry through the trunk area is blocked due to a large fuel tank or a battery pack stored in the trunk of a hybrid or electric system vehicle.

Summary (2 of 5)

- There are multiple variations of the types of seat frames.
- Seats are attached to the floorboards of the vehicle in four or more places, with positional adjustments on slide tracks that are either fully automatic/motorized or manually operated.
- The material covering the seats may have to be removed using a knife or trauma shears to expose the area of attachment located on the floor or to expose the steel hinges where the seat-back is attached to the seat-bottom section.
- The cross-ramming technique is used when the impingement of metal on the victim requires a unique mechanism of movement.

Summary (3 of 5)

- When an object impales a vehicle occupant, the main objective is to stabilize the penetrating object at the entry and exit points if an exit point exists.
- The pneumatic air chisel is a powerful tool with multiple blades.
- The two most widely used blades are the panel cutter, or T-blade, and the flat/curved blade.
- The panel cutter is used for cutting shallow straight cuts on small-gauge sheet metal, and the flat/curved blade is used for cutting through medium- to heavy-gauge steel.
- A reciprocating saw is an excellent tool to use for removing a vehicle's roof, especially on vehicles with large C-posts.

Summary

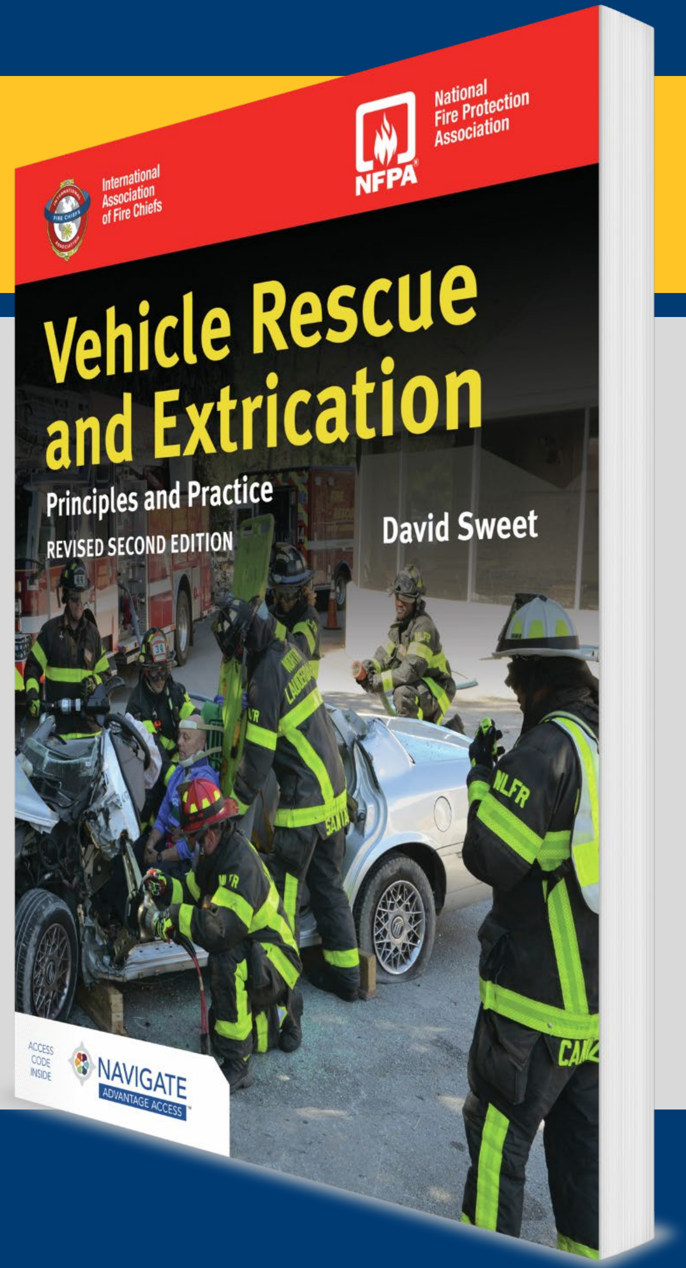
- The technique of removing a door on the hinge side can be completed using a combination of a hydraulic spreader and hydraulic cutter, or it can be accomplished using an air chisel.
- Gaining entry through the side of a vehicle that has rolled over and is resting on its roof can require either a very basic procedure, such as forcing a door open, or it can be a very involved process requiring multiple steps.
- Acceleration and brake pedals are notorious for trapping or entangling occupants' foot extremities. The pedal arm can be cut and/or relocated using mechanical tools, such as a hydraulic cutter, reciprocating saw, air chisel, or pneumatic cut-off tool (whizzer saw); a come along and chain set; or a very simple tool such as a section of webbing or rope.

Summary (5 of 5)

- Removing a person who is trapped underneath a vehicle can be accomplished using various tools: air-lift bags, hydraulic spreaders, or an FRJ. An FRJ is the fastest tool to accomplish this task, having minimal setup time, stability, and quick application.

CHAPTER 11

Terminating the Incident



Knowledge Objectives

- Determine statutory requirements for responsible party notification.
- Record and document notification reporting methods based on statutory requirements.
- Determine and communicate potential or existing risks to responsible party.
- Recognize postincident stress indicators, and appropriately intervene or refer to protect emergency responders.
- Identify information to include in a postincident analysis.

Introduction (1 of 2)

- The victim management phase ends when the victim is extricated, packaged, and transported to the medical facility.
  - The incident is far from over.
- Personnel, equipment, and the scene must be secured before the unit is ready to respond to another incident.

Introduction (2 of 2)

- Terminating an incident includes
  - Securing the scene by removing the damaged vehicle and equipment
  - Ensuring the scene is left in a safe condition
  - Transferring the scene to a responsible party
  - Notifying dispatch that the scene has been transferred and that the units are in service
  - Completing documentation, reports, and debriefing
  - Fully inventorying, cleaning, servicing, and maintaining all the equipment

Securing the Scene (1 of 4)

- The proper transfer of a scene to a responsible party must be established; this is usually law enforcement.
  - Law enforcement will conduct their on-scene investigation.
  - Any potential crime scene should be managed by law enforcement.
- A tow agency will coordinate removal of the vehicles once law enforcement has released the scene.
  - Stand by with a charged hose line.

Securing the Scene (2 of 4)

- Unique cases:
  - Roadway transit authority takes responsibility of a scene to ensure traffic flow is restored or roadway debris removed.
  - Utility companies may need to restore traffic signals, restore power to a transformer, or remove power lines.

Securing the Scene (3 of 4)

- All medical waste must be properly disposed of.
- Remaining body fluids will need to be neutralized with the appropriate solution.
- Any fluid hazards from the vehicle will be removed by the towing agency.

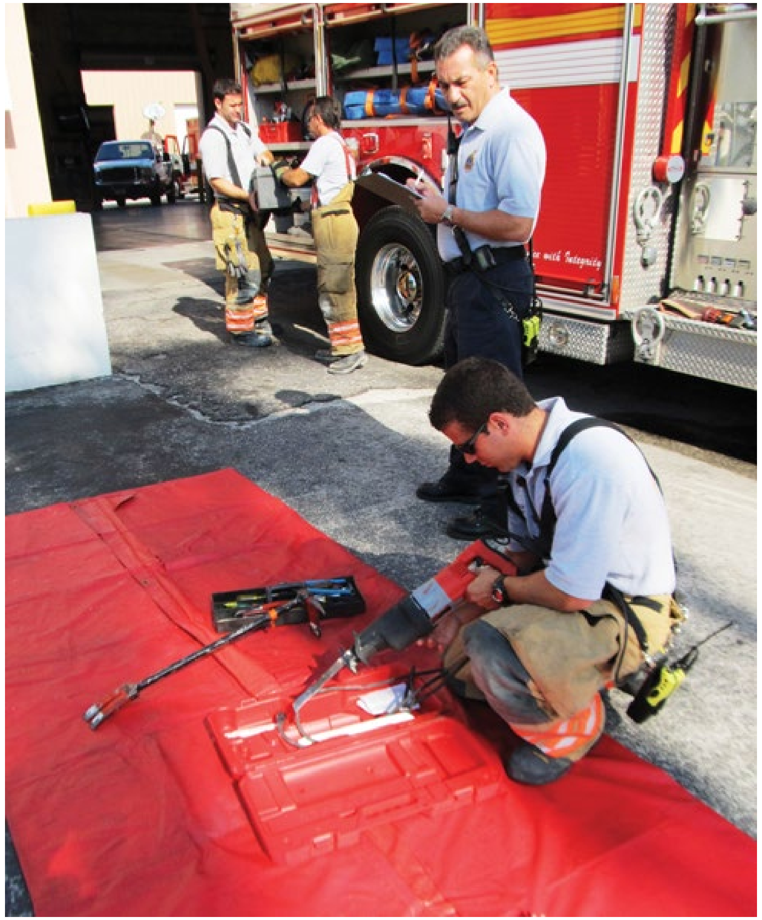
Courtesy of David Sweet.

Securing the Scene (4 of 4)

- Place any vehicle parts back in a heavily damaged vehicle to assist the towing agency.
  - Ask the tow agency whether they need assistance.
  - Maintain a good working relationship.
- Carry a contact list of various resources that can offer a particular resource that can be utilized on the incident.
- Incidents involving fatalities have special requirements.
  - You may be called back to the scene later.

Securing Equipment (1 of 2)

- Accountability and maintenance of equipment after the incident are critical components for proper termination.
- Allot enough time to gather the equipment properly.
- Put one person in charge.



Courtesy of David Sweet.

Securing Equipment (2 of 2)

- Any equipment that is contaminated must be properly isolated and/or cleaned following your agency's decontamination procedures.
- Exposure to any biologic or chemical contaminants must be reported immediately and documented.
- Contaminated PPE must be initially deconned/washed down and placed in a secure containment system.
- Refer to your departmental SOPs.

Checklist for Securing Equipment (1 of 4)

- Ensure that all gas-powered units are topped off.
- Ensure hydraulic fluid levels for all power units are full.
- Conduct an inspection of the hydraulic hoses.
- Check that the couplings are in good working condition.
- Conduct an inspection of the hydraulic tools.
- Engage the hydraulic spreader and relieve the pressure before storing it away on the apparatus.

Checklist for Securing Equipment (2 of 4)

- For all battery-operated tools, replace batteries.
- Examine the teeth of the reciprocating saw blade.
- Examine the electrical cord of the reciprocating saw.
- Examine the air chisel blade for any damage.
- Examine the regulator gauge for any damage.
- Lubricate pneumatic tools.
- Change out any used air cylinders.

Checklist for Securing Equipment (3 of 4)

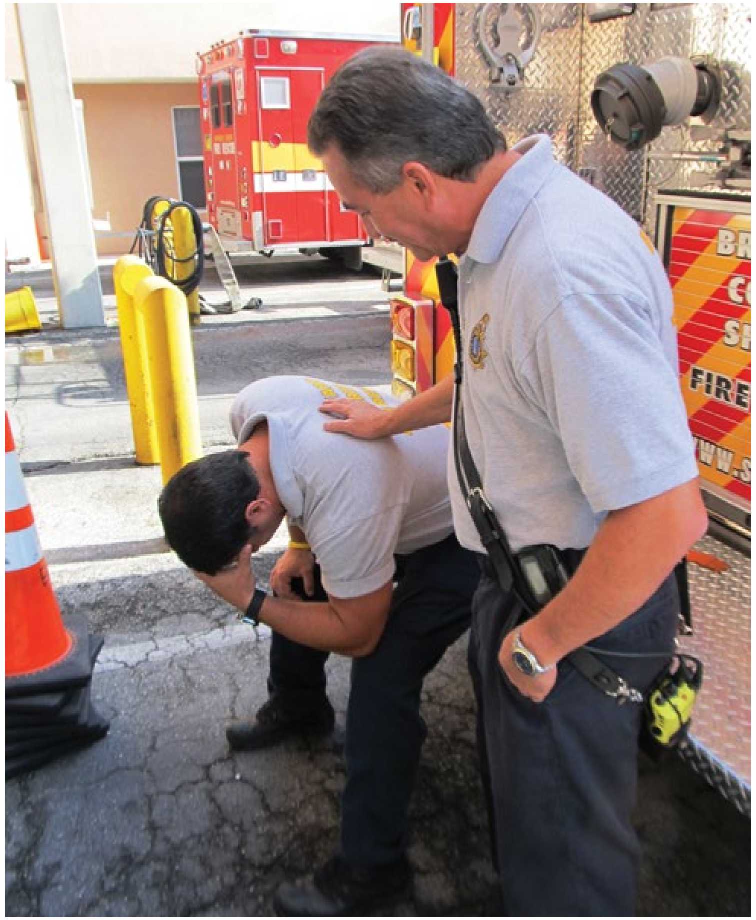
- Examine all wood cribbing.
- Examine all strut stabilization systems and account for all securing pins and any other attachments.
- Examine all cargo straps.
- Examine chains and come along cables.
- Examine the handle of the come along.
- Examine all rescue lift air bags, hoses, and regulators.

Checklist for Securing Equipment (4 of 4)

- This checklist should be modified to accommodate the agency's needs and equipment types.
  - At first glance, this checklist may appear extreme or time consuming.
  - Remember that it can be completed fairly quickly.
  - Heavy maintenance can be completed back at the station.
- Take the time while still on scene to properly account for all of the equipment.

Securing Personnel (1 of 2)

- At one time, it was a badge of honor not to show emotions.
- Great strides in research and treatment protocols have reduced debilitating effects.
- Programs managing stress are now considered a priority.



Courtesy of David Sweet.

Securing Personnel (2 of 2)

- Stress is a normal response to a stimulus that manifests itself in cognitive, physical, emotional, or behavioral signs.
  - Not necessarily a bad thing
  - Eustress produces a positive response.
  - Distress produces a negative response.
    - Exposure to a critical incident
    - Can lead to PTSD
  - PTSD is a delayed stress reaction to a prior incident.

Critical Incident Stress

- Critical incident stress is a type of stress emergency personnel are exposed to.
- A critical incident is an event that has the potential to create significant human distress that can overwhelm the body's normal coping mechanisms.
  - Describes almost every emergency incident a rescuer responds to
  - Everyone reacts differently to a stressor.
  - Reactions can occur immediately, several hours after the event, or several days later.

Types of Reactions to Stress

- Cognitive reactions: attention deficit, nightmares, confusion, lack of concentration, flashbacks
- Behavioral reactions: withdrawal, emotional outbursts, extreme changes in behavior, drunkenness, insomnia, absenteeism
- Emotional reactions: depression, guilt, anger, fear, anxiety, grief
- Physical reactions: headaches, muscle twitching/tremors, dry mouth, elevated blood pressure or heart rate, nausea, rapid breathing, sweating, chest pains

Critical Incident Stress Management

- A multifaceted system of crisis intervention specifically designed to help emergency personnel who have been exposed to a traumatic event
- Geared toward enhancing natural coping mechanisms and facilitating a natural resiliency and recovery
    - Emergency psychological first aid

Critical Incident Stress Debriefing

- Structured and confidential group discussion
- Goals: defuse psychological impact, assist in recovery, identify individuals who need help
- Within 12–72 hours
- Lasts 45–60 minutes

Courtesy of David Sweet.

Peer Support Groups

- Trusted members of the organization with similar experiences provide emotional support through nonclinical conversation and guidance.
  - Builds trust and encourages communication
  - Can open the door for further professional counselling
- Chaplain positions provide nondenominational spiritual and personal counseling to personnel.
- The IAFF Center of Excellence for Behavioral Health Treatment and Recovery is an inpatient residential facility for the treatment of behavioral health injuries.

Postincident Analysis

- A review of an incident that identifies opportunities for improvement
  - Formal: structured agenda
  - Informal: simple discussion
  - Key is transparency
  - Conducted after every incident

Courtesy of Carlos Eguiluz.

Documentation and Record Management

- Serves several purposes:
  - Tracking equipment
  - Training
  - Needs assessment
  - Response times
  - Preincident planning
  - Continuity of care
  - Transfer of responsibility
  - Administrative needs

After Action Report

- A brief summary that analyzes the overall operations and effectiveness of the agency at a particular incident through real-time on-scene evaluations
- Goes hand in hand with needs assessment
- Should be a formalized document discussing compliance to SOPs, medical protocols, staffing requirements, mutual aid, equipment, and training
- AHJ may request an AAR for significant incidents.

Summary (1 of 4)

- Before units are ready to respond to the next incident, personnel, equipment, and the scene must be secured and placed in a readiness state.
- A potential crime scene shall be managed by law enforcement to preserve and secure any evidence.
- Accountability and maintenance of the equipment after the incident has concluded are critical. There should be one person (normally the driver or engineer/chauffer of the apparatus) in charge of inventorying and overseeing that all the equipment that was used on scene is accounted for.
- A basic equipment checklist can be completed fairly quickly as the equipment is being loaded back onto the apparatus. Any heavy maintenance, such as washing, degreasing, and repairing, can be completed back at the station.

Summary (2 of 4)

- Making sure that you and your personnel are physically, psychologically, and emotionally sound after the incident is vital not only to being able to properly function at the next incident, but also to maintaining longevity in emergency services.
- Stress is something that a rescuer experiences every day.
- Great strides in research with immediate recognition and treatment protocols have greatly reduced the negative side effects and debilitating emotional scars that can linger and impair normal everyday functions.

Summary (3 of 4)

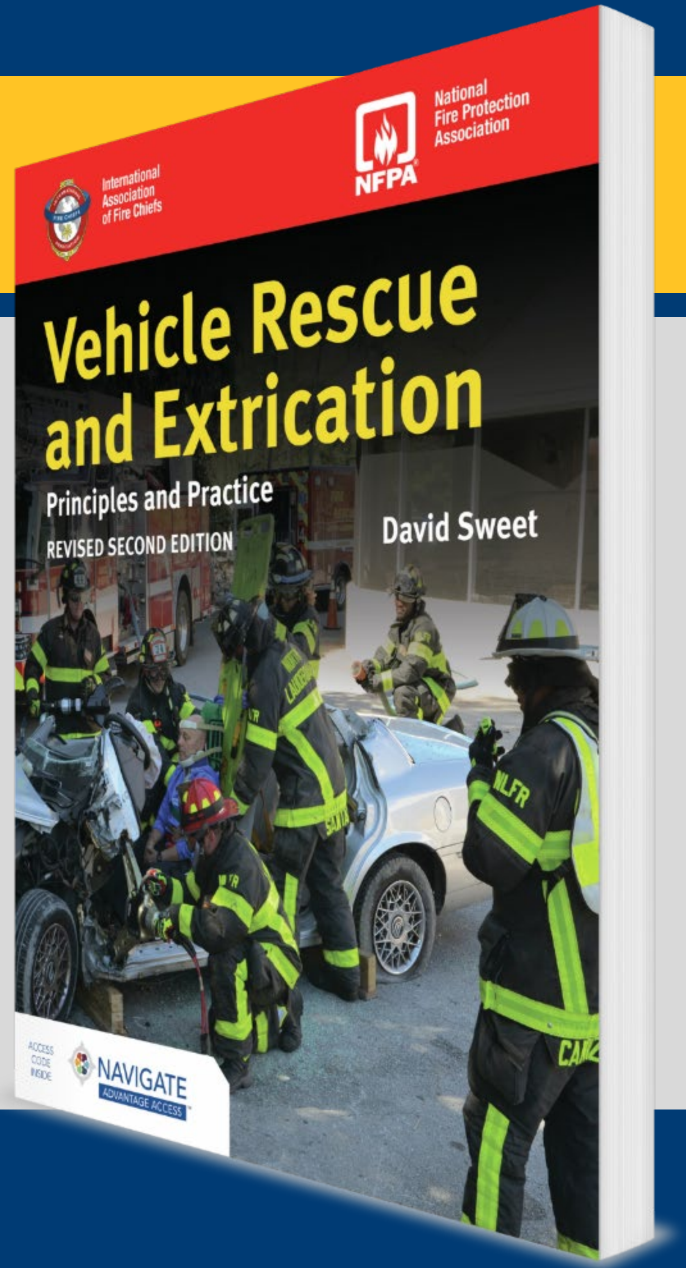
- CISM is a type of behavioral health mechanism for crisis intervention specifically designed to help emergency personnel who have been exposed to a traumatic event process their response to the incident in a way that validates the normal stress reactions and stabilizes the potential negative results of the individual's response.
- Peer support groups are formed to help alleviate work-related stressors by using trusted members of the organization who have had similar experiences to provide emotional support through nonclinical conversation and guidance.

Summary (4 of 4)

- A PIA is a review of the positive and negative aspects of an incident that identifies opportunities for improvement and any necessary corrective actions to improve the organization as a whole. An AAR may be completed following this analysis.
- Documentation, or record keeping, aids in keeping track of equipment inventory, training, needs assessment, response times, and preincident planning.

CHAPTER 12

Commercial Vehicles



Knowledge Objectives (1 of 3)

- Define the following terms and explain their role in vehicle rescue incidents:
  - Commercial motor vehicle (CMV)
  - Semi-truck
  - Semi-trailer
- Identify the criteria for classifying a vehicle as a commercial vehicle.
- Discuss the anatomy of a commercial vehicle.

Knowledge Objectives (2 of 3)

- Discuss the braking systems found in commercial vehicles.
- Match the type of commercial vehicle with the hazardous materials it may be carrying.
- Identify hazards present at commercial/heavy-vehicle extrication incidents.
- Determine commercial/heavy-vehicle access and egress points.

Knowledge Objectives (3 of 3)

- Describe the role of placarding and shipping papers in heavy-vehicle extrication.
- Cite types of commercial vehicles common in the AHJ response area.
- Describe common commercial vehicle construction components.

Introduction (1 of 2)

- Commercial motor vehicle (CMV): a motor vehicle or combination of motor vehicles used in commerce to transport passengers or property
  - Gross vehicle weight rating (GVWR) of 26,001 lb (11,794 kg) or more
  - Transports 16 or more passengers
  - Any size; used to transport hazardous materials
  - Designed to transport more than 8 passengers for compensation

Introduction (2 of 2)

- CMVs are further classified as passenger or nonpassenger.
- Many are designed for a special purpose.

Commercial Trucks (1 of 2)

- Encountering this type of collision is inevitable.
- CMVs that require extrication will involve special techniques, heavy equipment, and tools.
- Proper qualified training is an absolute requirement.

Courtesy of Darren Wells.

Commercial Trucks (2 of 2)

- CMVs are classified in eight categories.
  - Classes 1–8
- Measured by:
  - GVWR system
  - Work duty of the engine as it relates to emissions
- Other classifications to determine weights:
  - GAWR (gross axle weight rating)
  - GCWR (gross combined weight rating)
  - GTWR (gross trailer weight rating)

Commercial Truck Anatomy

- Most commercial trucks have similar construction features.
  - Cab
  - Chassis
  - Cargo area
  - Drive train (power train): a system that transfers rotational power from the engine to the wheels, which makes the vehicle move

Commercial Truck Anatomy (2 of 3)

- Semi-truck is capable of towing a separate trailer that has wheels only at one end.
  - When combined with a trailer, it is known as a semi-tractor trailer (semi-trailer).
- Designed with three axles
  - One in the front for steering
  - Two tandem axles in the rear

Commercial Truck Anatomy (3 of 3)

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Cabs

- Enclosed space where the driver and passengers sit
- Usually made of steel, aluminum, and fiberglass

Cab-Over-Engine

- Cab is lifted up over the engine to gain access to the engine itself; the driver seat is positioned over the engine and the front axle.
  - Maximizes truck cargo space

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Conventional Cab

- The driver's seat is positioned behind the engine and front axle.
  - More common in United States and Canada
  - Fuel tanks tend to be larger than COEs.

Cab-Beside-Engine

- The driver sits next to the engine.
    - Mostly found in airports and seaports

Sleeper

- A compartment attached to the cab that allows the driver to rest while making stops during a long transport
  - Designed with steel or aluminum ribs or framing with an outer shell of fiberglass or plastic injection molding
  - Between the layers are insulation and wires.
  - Cutting can require multiple tools.
- The roof sections of the cab/sleeper can contain an air-conditioning unit as well as a wind deflector.
  - Adds considerable weight

Cabs

- Overall height of cabs can range from 13.6 to 14.6 ft (4.2 to 4.5 m)
  - Requires the technical rescuer to build several platforms that surround the cab to gain height and stability
  - Working from a ladder placed against the cab is not safe.

Courtesy of David Sweet.

Windshield Glass

- Composed of standard laminated safety glass and is set in a rubber gasket
- Can be removed with a prying tool
- Can be removed without breaking or cutting
- Side windows are composed of tempered safety glass.

Chassis

- Makes up the main structural framework
- Includes braking, steering, and suspension system
- Constructed of heavy-gauge steel
- Two parallel rails or beams held together with crossbeams

Suspension System (1 of 3)

- Designed to protect the cargo and frame system
- Comes in the form of
  - Large steel leaf springs
  - Spiral springs in addition to air bellows (**air ride system**)

Suspension System (2 of 3)

- Weight of these vehicles will vary greatly and must be calculated into any technique or procedure.
  - The U.S. national weight standards allow for a maximum of 80,000 lb (36,287 kg) for transport on the interstate highway system.
- Tools used to stabilize trailer's suspension unit include:
  - Large 50/60-ton rotating tow unit with an articulating boom
  - Tension stabilization struts
  - Rescue-lift air bags

Suspension System (3 of 3)

Courtesy of Houston Holcombe.

Courtesy of Houston Holcombe.

Cargo Area (1 of 4)

- The cargo area can be attached to the same frame as the cab or there can be a separate frame from the trailer.
  - **Gross combined weight rating (GCWR)** is used to determine the cargo capacity limitations.
  - The cargo trailer is connected to the tractor by a large locking pin (**kingpin**).
    - Sits in a flat horseshoe-shaped quick-release coupling device (**fifth wheel**) or a turntable hitch mounted at the rear of the towing truck

Cargo Area (2 of 4)

Cargo Area

- Semi-trailers come equipped with a stabilizing device known as **landing gear**.
  - Located at the front of the unit
  - Can be lowered to support the trailer
  - Commonly operated by hand crank

Cargo Area (4 of 4)

- Some CMVs are equipped with a **dromedary**.
  - Separate box, deck, or plate, mounted behind the cab and in front of the fifth wheel
  - Can be used to store products that should be kept away from cargo

Axle

- A structural component or shaft that is designed for wheel rotation.
  - **Live axles** cause the wheels to turn.
  - A **dead axle** is used for load support.
  - A **lift axle** can be raised or lowered to increase weight capacity.

Doors (1 of 2)

- Heavier construction than conventional vehicles
- Hinges:
  - Piano-type hinges
  - Two-piece full/solid hinges
  - Strap hinges
- The latching mechanism will usually consist of a latch pin and a latching device.
- Gaining access through the hinge side of the door will depend on the type of hinge.

Doors (2 of 2)

Braking Systems (1 of 4)

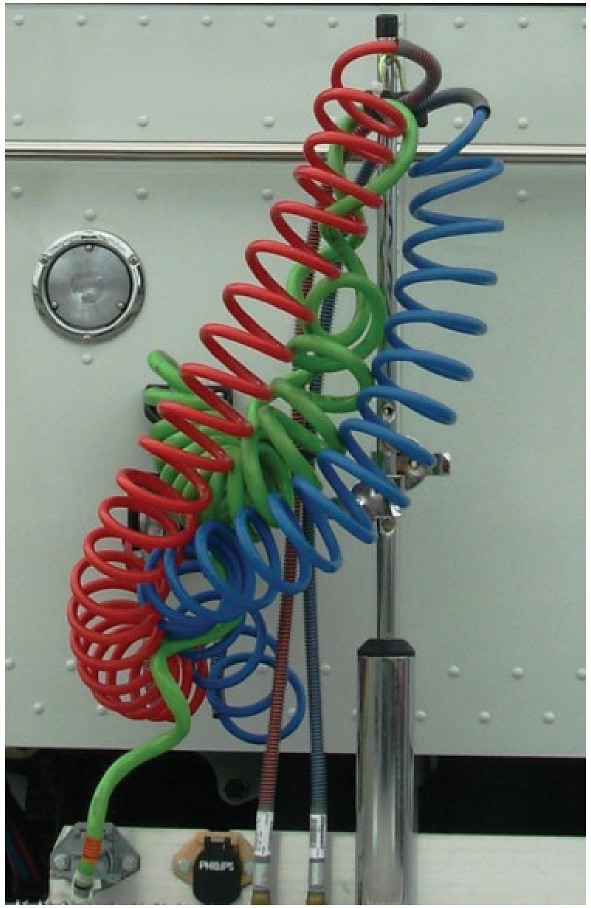
- Uses compressed air to actuate the system
- Three types:
  - Service brake
  - Air brake (parking brake)
  - Emergency brakes
- An added safety feature is an antilock braking system.
  - Power cables are color coded in lime green.

Braking Systems (2 of 4)

Braking Systems (3 of 4)

- Two air lines:
  - **Service air line** (normally blue)
  - **Emergency air line (supply line)** (normally red) controls the air brake for the trailer and is used to fill the air reservoir tanks.
- The couplers that are used to connect the tractor to the trailer are known as **glad hands**.

Braking Systems (4 of 4)



Battery Systems

- Can consist of four or more 12-volt DC batteries hooked together
- Can be located in several areas throughout the vehicle
- Generally located underneath the step-up to make entry into the vehicle easier

Fuel Tanks (1 of 2)

- Usually constructed of aluminum
- May be a single tank or two tanks
- Independently siphoned from the fuel pump
- May be equipped with a shut-off valve

Fuel Tanks (2 of 2)

- Hybrid CMVs are also beginning to be manufactured.
- **Hybrid-electric commercial motor vehicle (HECMV)** uses internal combustion engine or electric motor.

Hazardous Materials

- According to the DOT's PHMSA, there are more than 400,000 CMVs dedicated to the transportation of hazardous materials.
- Federal Hazardous Materials Transportation Law
  - Defines a hazardous material as a substance or material including explosive; radioactive material; infectious substance; flammable or combustible liquid, solid, or gas; toxic, oxidizing, or corrosive material; and compressed gas
  - And the Secretary of Transportation has determined it is capable of posing a risk

Hazardous Materials Regulations

- Refer to the regulations listed in 49 CFR, parts 171 through 180, and 49 CFR, parts 100 through 185.
- Apply to the transportation of hazardous materials in interstate, intrastate, and foreign commerce.
- Issued by DOT's PHMSA

Hazardous Materials Classification (1 of 2)

- Class 1: explosives
- Class 2: gases
- Class 3: flammable liquids
- Class 4: flammable solids, spontaneously combustible materials, and dangerous-when-wet materials or water-reactive substances

Hazardous Materials Classification (2 of 2)

- Class 5: oxidizing substances and organic peroxides
- Class 6: toxic substances and infectious substances
- Class 7: radioactive materials
- Class 8: corrosive substances
- Class 9: miscellaneous hazardous materials

Cargo Tank

- Bulk packaging either permanently attached to or not permanently attached to a motor vehicle
- Loaded or unloaded without being removed from the motor vehicle
- Not tube trailers (which consist of several individual cylinders banded together)

MC-306/DOT 406 Flammable Liquid Tankers

- Frequently carry liquid food-grade products, gasoline, or other flammable/combustible liquids
- Nonpressurized; made of aluminum, stainless steel
- Safety features include roll-over protection and remote emergency shut-off valves.

Courtesy of Polar Tank Trailer L.L.C.

MC-307/DOT 407 Chemical Hauler

- Transports flammable liquids, including mild corrosives and poisons
- Round or horseshoe-shaped tank capable of holding 6000 to 7000 gal (22,712 to 37,854 L)
- May have a rubber lining to prevent tank corrosion

Courtesy of Polar Tank Trailer L.L.C.

MC-312/DOT 412 Corrosives Tanker

- Carry corrosives
- Identifiable by several heavy-duty reinforcing rings
- Substantial rollover protection
- Operates at 15 to 25 psi (103 to 172 kPa)

Courtesy of National Tank Truck Carriers Association.

MC-331 Pressure Cargo Tanker

- Carry materials such as ammonia, propane, Freon, and butane
- Steel or stainless steel, single tank compartment
- Threat of explosion exists; use great caution

Courtesy of Rob Schnepp.

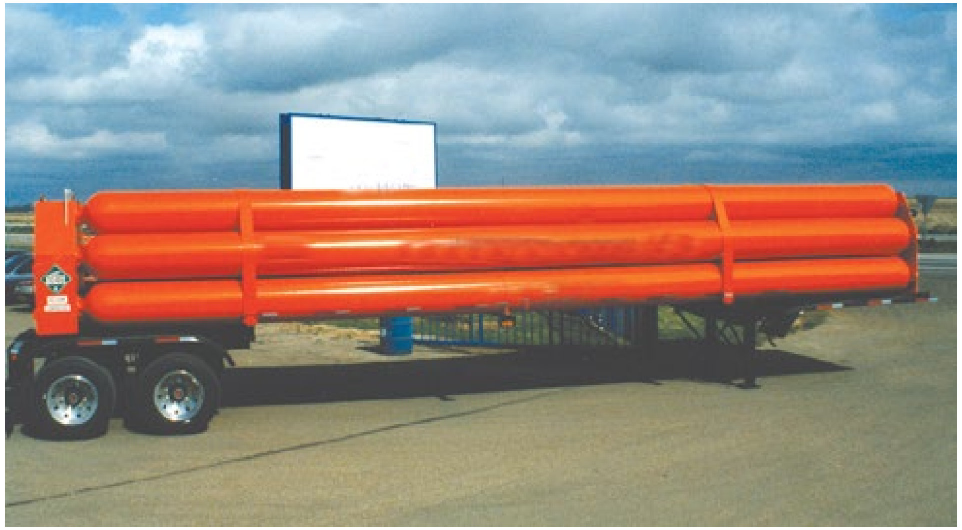
MC-338 Cryogenic Tanker

- Maintains high thermal protective qualities
- Low-pressure tanker relies on insulation to maintain low temperatures
- Special training is required to operate valves

Courtesy of Jack B. Kelly, Inc.

Tube Trailers

- High-volume vehicles made up of several cylinders banded together and affixed to a trailer
- May carry several different gases
- Valve control box found toward the rear of the trailer



Courtesy of Jack B. Kelly, Inc.

Dry Bulk Cargo Tanks

- Carry dry bulk goods
- Not pressurized, but may use pressure to off-load product
- Generally V-shaped with rounded sides to funnel contents to the bottom-mounted valves

Courtesy of Polar Tank Trailer L.L.C.

Placards (1 of 2)

- Federal law requires placards to be clearly displayed on each side and end of the vehicle.
  - The **gross weight** measurement is the weight of the single item package plus its contents.
  - The **aggregate weight** measurement combines all the packages to determine the total weight the hazards.
- A vehicle is required to post warning placards when the gross weight of a single hazard or the aggregate weight totals 1001 lb (454 kg) or more.

Placards (2 of 2)

- Placards must be displayed for each product.
- Placards are required for any explosives, poisonous gases, or radioactive materials.
- ORM-D materials do not require placards.

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UN/NA Identification Numbers

- When large quantities of a single hazardous material are transported in non-bulk packages, the vehicle must be marked on each side and each end.
- The number must be displayed on an orange label or on the placard itself.
- Each package is marked with proper shipping name and identification number.
  - Aggregate gross weight of hazardous material is 8820 lb (4000 kg) or more.
  - All of the hazardous material is loaded at one facility.
  - The vehicle contains no other material.

Shipping Papers

- Identification of the shipper and receiver
- Hazard class or division
- UN/NA identification number
- Packing group number
- Product quantity and weight
- Emergency contact number
- Certification statement
- Signature of shipper

Site Operations: Commercial Motor Vehicle (1 of 2)

- Survey the area and identify hazardous transport cargo through placard/UN number recognition.
- Dispatch additional resources.
- Locate the driver of the CMV and if possible confirm shipping cargo and location of shipping papers.
- Deploy at a minimum two 1.75-in. (44-mm) hose lines and consider foam application for any significant fuel leaks

Site Operations: Commercial Motor Vehicle (2 of 2)

- Conduct the inner and outer surveys to clear all hazards within the operational area.
- Create hazard zones: hot, warm, cold
- Try to locate the shipping papers to confirm cargo before opening the cargo vessel/trailer.
- Stabilize all vehicles involved in the collision.
- Locate and disconnect the 12-volt DC battery system.
- Disentangle and extricate the victim(s).

Victim Access: Commercial Motor Vehicle (1 of 5)

- One of the challenges is calculating the increased height of the cab; the rescuer must be elevated.
- When conducting an inner survey, the officer will have to
  - Make a complete 360-degree ground-level search
  - Clear visual hazards
  - Ensure vehicle stability

Victim Access: Commercial Motor Vehicle (2 of 5)

- Once the victim has been located, the officer will
  - Call for additional resources
  - Formulate the IAP
  - Set up hazard control zones
  - Determine appropriate stabilization

Courtesy of David Sweet.

Victim Access: Commercial Motor Vehicle (3 of 5)

- Conventional vehicles often underride semi-trailers.
  - A 50/60-ton tow truck with an articulating boom can be used to lift the semi-trailer; tow operator controls it with a remote controller.
  - A second, smaller tow truck should be positioned to pull the smaller vehicle out.
  - The larger tow unit can also perform both functions by adding a snatch block and tackle.
  - The larger unit must be positioned at a specific angle for this to work.

Victim Access: Commercial Motor Vehicle (4 of 5)

Victim Access: Commercial Motor Vehicle (5 of 5)

- Most states have their own rating system to classify the size or towing capacity of a tow unit.
  - There are licensing standards and requirements that must be met to operate a towing unit.
  - The TRAA offers driver certification depending on the type or classification.

Summary (1 of 3)

- The U.S. DOT defines a CMV as a motor vehicle or combination of motor vehicles used in commerce to transport passengers or property if the motor vehicle has a gross vehicle weight rating (GVWR) of 26,001 lb (11,794 kg) or more inclusive of a towed unit(s) with a GVWR of more than 10,000 lb (4536 kg); or a GVWR of 26,001 lb (11,794 kg) or more; or is designed to transport 16 or more passengers, including the driver; or is of any size and is used in the transportation of hazardous materials.
- CMVs also include box trucks, semi-tractor trailers, concrete mixers, vehicle transporters, buses, and cranes.

Summary (2 of 3)

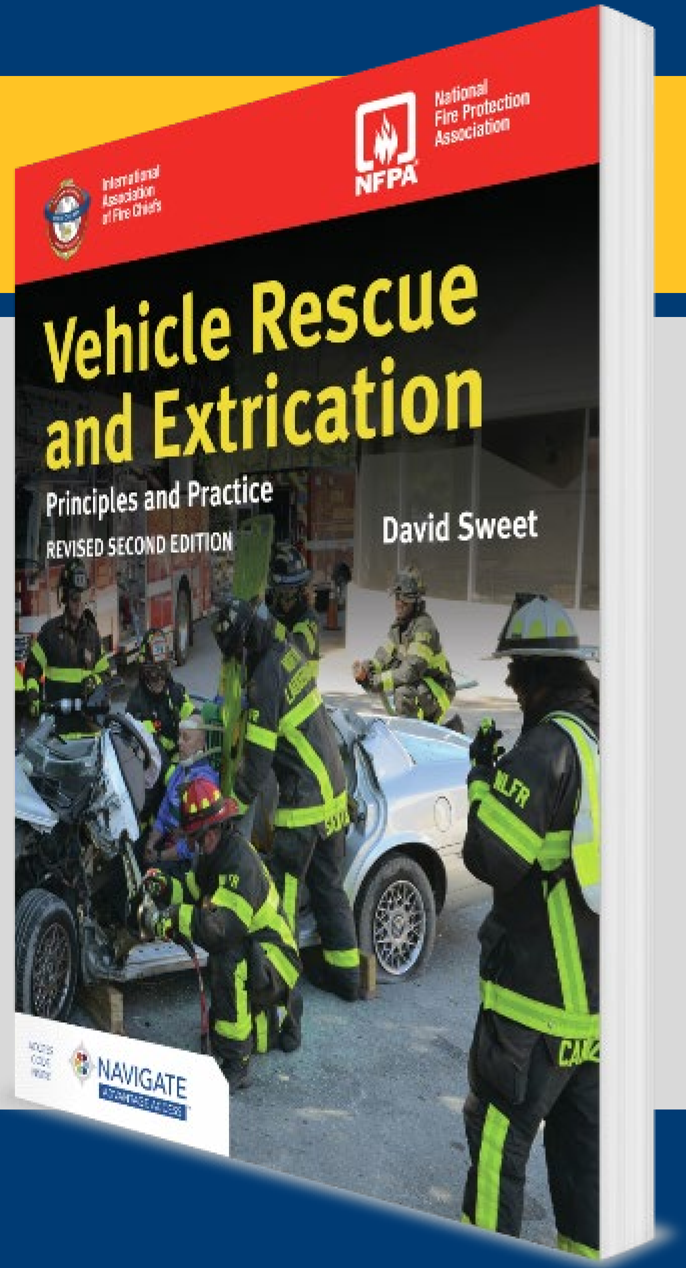
- Within the United States, the rules and regulations that are placed on CMVs are implemented through the DOT, which limits the amount of weight a CMV can transport, including the type of cargo being hauled with these vehicles.
- CMVs are classified into eight weight categories.
- One of the greatest concerns for the technical rescuer responding to a motor vehicle accident involving a CMV is the potential for that CMV to be transporting hazardous materials and for that cargo's or vessel's integrity to be compromised.

Summary (3 of 3)

- Federal law requires placards to be clearly displayed on each side and end of the vehicle. UN/NA identification numbers are another way to identify the hazardous material that is being transported.
- There are five types or classifications of tow units to assist in a CMV extrication.

CHAPTER 13

School Buses



Knowledge Objectives

- Define body-over-frame construction and explain its role in vehicle rescue incidents.
- Describe the four types of buses and four types of school buses and their subcategories.
- Describe the anatomy and structure of a school bus.
- List access points and emergency exits present in school buses.

Knowledge Objectives (2 of 4)

- Identify fire suppression and safety measures.
- Evaluate school bus stabilization needs.
- Consider isolation methods and scene safety at school bus incidents.
- Identify and document resource needs for future use.
- Factor in time constraints for a school bus extrication incident.

Knowledge Objectives (3 of 4)

- Establish emergency escape routes for rescuers at school bus incidents.
- Enforce agency safety and emergency procedures in school bus incidents.
- Identify the mechanisms of heavy vehicle movement and AHJ policies and procedures.
- Identify the types of stabilization devices, stabilization points, and vehicle construction.

Knowledge Objectives

- Manage commercial/heavy-vehicle systems and evaluate their beneficial use.
- Isolate and manage potential harmful energy sources.
- Disentangle victims from a school bus.
- Prevent victim injury.

Introduction

- School buses are detailed in this chapter
  - As an example of a CMV
  - To help demonstrate the concepts of vehicle rescue and extrication for MCIs involving CMVs
- There is great diversity in the types of buses on the roadways today; accurately describing or classifying a bus can be difficult at best.
  - The FMCSA categorizes buses into carrier types or by function or purpose.

School Bus

- Any public or private school or district, or contracted carrier, providing transportation for K–12 students

© Photodisc/Getty Images.

Transit Bus

- An entity providing passenger transportation over fixed, scheduled routes, within primarily urban areas

Courtesy of David Sweet.

Intercity Bus

- A company providing for-hire, long-distance passenger transportation between cities over fixed routes with regular schedules

Courtesy of David Sweet.

Charter/Tour Bus

- A company providing transportation on a for-hire basis

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Other Buses

- Private companies provide transportation to their own employees, nongovernmental organizations such as churches or nonprofit groups, noneducational units of government such as departments of corrections, and private individuals.

© Henryk Sadura/Alamy Stock Photo.

School Buses

- Buses are one of the safest forms of transportation.
  - Still important to be prepared and know the makeup, structural components, and different types of school buses
- “School bus” is a vehicle that is designed for carrying a driver and more than 10 passengers and likely to be “used significantly” to transport “pre-primary, primary, and secondary” students
  - Small: GVWR of less than 10,000 lb (4536 kg)
  - Large: GVWR equal to or greater than 10,000 lb (4536 kg)

Type A School Bus

- A conversion type or bus constructed using a cutaway front section vehicle and a left side driver's door
- Type A-1: GVWR of 14,500 lb or less
- Type A-2: GVWR greater than 14,500 lb and less than or equal to 21,500 lb

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Type B School Bus

- Constructed using a stripped chassis
- Entrance door is behind the front wheels.
- Type B-1: GVWR of 10,000 lb (4536 kg) or less
- Type B-2: GVWR greater than 10,000 lb (4536 kg)

© Matt/Fotolia.

Type C School Bus

- Also known as a *conventional school bus*. Constructed using a chassis with a hood and a front fender assembly
- The entrance door is behind the front wheels.
- GVWR greater than 21,500 lb (9752 kg)

© Hemera/Thinkstock.

Type D School Bus

- Constructed using a stripped chassis where the outer body of the bus is mounted to the bare chassis
- The entrance door is ahead of the front wheels, and the face or front section of the bus is flat
- Capacity of 80–90 people

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School Bus Anatomy

- A school bus is designed with a body-over-frame construction composed of a full skeletal frame system.
- Consists of steel trusses and studs, which are attached to and reinforced by steel cross members
- Encapsulated by inner and outer sheet metal panels with fiberglass insulation

FVMSS Requirements

- Length of the bus is no greater than 45 feet (14 m).
- Width of the bus is no greater than 102 inches (2.6 m).
- Inside body height of the bus shall measure 72 inches (1.9 m) or more.
- Width of the aisles will be at least 12 inches (30 cm).
- Aisle clearance for wheelchair accessibility will be at least 30 inches (76 cm) to the closest emergency door or lift area.
- School buses equipped with a power lift or ramp shall have aisles of at least 30 inches (76 cm) wide.

Chassis Frame

- Two long steel channel beams that has steel crossmembers of 14-gauge steel.
- Crossmembers are normally spaced up to 12 inches (30 cm) apart.
- Attempting to gain entry through the floor generally should not be attempted unless there are no alternatives.

Floor Deck

- Composed of 14-gauge sheet metal panels that are attached to the chassis frame.
- Plywood is fastened over the steel deck and covered with a thick corrugated rubber or vinyl matting.
- Attempting any entry into the bus through the floor area is not recommended.

Bow Frame Trusses (1 of 2)

- Run continuously from below the floor level on one side of the bus, vertically raising/bowing over to form the roof structure
  - Normally composed of heavier 12-gauge steel
- Each roof pillar or side window frame makes up one of these structural members and has the crash and rub rails attached to it along with exterior and interior sheet metal panels.
  - Locations are easy to determine because of the exterior rivets.

Bow Frame Trusses (2 of 2)

Courtesy of David Sweet.

Rub Rails

- Visible exterior steel attachments that consist of 16-gauge corrugated metal
- 4 inches (10 cm) or more in width
- Attached to the bow trusses
- Run the entire length of the bus
- They look like black stripes running the length of the vehicle.
- Strategically placed bottom, middle, and top rails

Crash Rail

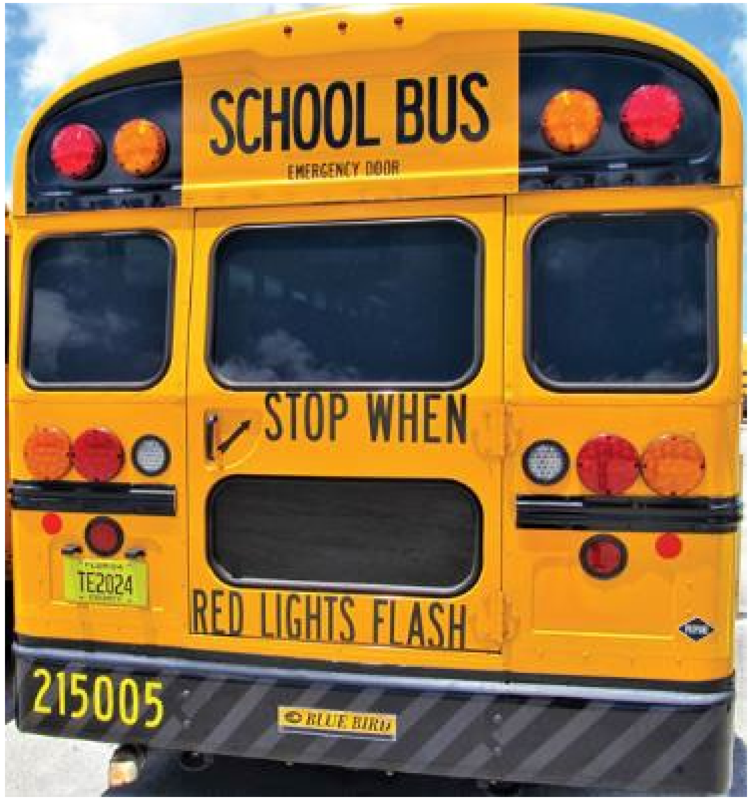
- Composed of 14-gauge steel
- Extends the entire length of the school bus
- Extends above the floor area and seat rub rail
- Designed to protect the students from impact intrusions

Entrance Door

- Usually designed in a two-section, split-type style; opens outward
- The front door can be manually operated with a lever bar that the driver controls.
    - May also have an air-actuated mechanism
    - Has a clearly marked emergency release valve
- All entrance door glass is composed of tempered safety or laminate glass and is held in place by a gasket seal.
    - Can be manually removed and the glass panels pushed in to release the frame

Emergency Exits

- Designed to open or swing outward from left to right, with the hinges being on the right side
- The rear door on the bus is a main access or egress point depending on the location of the victims and bus position.
- Transit-style school buses do not have a rear door.



Courtesy of David Sweet.

Side Window Exits

- Composed of either tempered safety or laminate-type glass
- Each window has an opening between 9 to 13 inches (23 to 33 cm) and at least 22 inches (56 cm) wide.
- Windows are designed to slide down to open.
- Emergency windows are designed to release the entire frame.

Emergency Roof Hatches

- Hinged on the front or forward side
- Operable from both inside and outside the vehicle
- The total opening is 16.5 inches (41 cm), too narrow for a backboard.

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Bench Seats

- Designed to have a 1-inch (2.5-cm) tubular frame and two outer leg posts attached to the floor by bolts and screws
- The inside of the bench seat is screwed or bolted to a lip that extends from the interior "skin."
- Exception to this are seats located in the emergency egress; the seat section of the bench lifts up to make room

Driver Seat

- Usually a single high-back chair with a fully integrated three-point seat belt harness
- Normally designed with an air-actuated suspension-type system, which is manually operated by the driver

Battery Compartment

- A pull-out sliding tray that is positioned inside the vehicle body
- Located near the front of the vehicle on the driver's side
- Normally two or more 12-volt DC batteries connected in parallel

Exhaust After-Treatment Device

- Replaced the standard muffler after the EPA called for a 90% reduction of particulate matter and a 55% reduction of nitrogen oxide
- Converts soot to carbon dioxide and water through a process called regeneration
  - Passive, active, manual regeneration
  - All three regeneration processes engage automatically by the computer system, independent of the driver’s actions.

Site Operations: School Buses (1 of 2)

- Proper scene management is critical and can mean the difference between a successful, controlled operation and an operation where chaos and freelancing occur.
- Any vehicle rescue and extrication incident with multiple victims (especially children) can be overwhelming
- Ensure proper preplanning for managing a technical incident such as necessary for a large CMV.
    - Local school authorities should be included in the planning.

Site Operations: School Buses (2 of 2)

- The first 10–15 minutes set the tone.
- Priorities:
  - Size-up (safety)
  - Scene stabilization
  - Resources available and needed
  - Vehicle stabilization
  - Victim access and management
  - Removal/extrication of victims
  - Terminating the incident

Size-Up: Stabilize the Scene (1 of 2)

- Begins with the initial dispatch
- Ascertain the number of occupants so the proper resources are dispatched.
- Consider factors such as the time of day, weather, and topography.
- Upon arrival, visually assess the scene for notable hazards.
- As a safety measure, two hose lines should be laid out and charged at every school bus incident.

Size-Up: Stabilize the Scene (2 of 2)

- Recognizing the type of school bus involved can give an indication of the potential number of victims and the position of the school bus.
- Initial report must include
  - Damage assessment
  - Additional resources requested or canceled
- Inner and outer surveys are then initiated to garner information needed to formulate the IAP.

Stabilize the Vehicle

- Once the scene has been deemed safe, evaluate the stability of the vehicle and ensure the vehicle is safe to operate on.
- Can be as simple as
  - Engaging the parking brake
  - Turning off the engine
  - Chocking the wheels
- However, can be very complex and require heavy equipment and additional resources

Stabilize the Victim(s)

- Optimal setting is to use the existing front entry and side or rear exit to maintain operational flow.
- Physical interventions such as removing seats or cutting and opening will require precise planning and coordination.
- To conduct these procedures, personnel must be qualified to a technician level.

Planning

- A needs assessment study covers a wide range of topics.
  - Answers the question of where the organization wants to be in relation to providing the necessary level of emergency services for the community it serves
  - Incorporates both long- and short-range goals

SWOT Analysis

- Used in corporate business environments
- A self-examination model that can be adjusted, adapted, and applied to any situation
  - **S**trengths
  - **W**eaknesses
  - **O**pportunities
  - **T**hreats
- To be effective, must be complete, honest, and objective.

MCI Protocols

- Progressive agencies have preplanned and trained heavily for such an event and already have protocols in place.
- If you do not have a pre-established plan, assign a resource/staging officer and add a separate response channel for all incoming units.
- Consider two or more channels to make things more manageable.
- Some agencies carry MCI kits on their apparatus.

Scene Stabilization

- The need to maintain situational awareness should be a priority.
- Be proactive and call for additional units to respond.
- Put air rescue on standby.
- Preassignments should be directed to your crew while en route.
- A thorough visual scan should be conducted prior to stepping off of the apparatus.

Scene Stabilization: Inner and Outer Surveys

- What type of bus are you dealing with?
- What is the damage level?
- Is the school bus still running?
- What is its resting position?
- How many occupants are there?
- What are the additional resources needed?
- Do you have an established MCI plan?
- Items customized to your agency's needs and capabilities

Stabilization: School Buses (1 of 3)

- Four positions in which the school bus will present: upright, on its side, on its roof, or on another vehicle
- Main goal is to create a solid foundation to work from.
  - Lower the bus’s center of gravity
  - Prevent unnecessary movement
- Stabilizing an upright school bus that uses an air bladder is important.
  - If there is a rupture or a leak, the bus will lean heavily to the side.

Stabilization: School Buses (2 of 3)

- Because of the shape and design, it is rare that a school will come to rest on its roof.
- The elongated box shape of the bus is designed to prevent a bus from resting on top of another vehicle.
    - Not always effective

© Jess Roberson/AP Photos.

Stabilization: School Buses (3 of 3)

- Such accidents are extremely rare and would challenge even the best prepared agency.
  - However, breaking the incident down into manageable segments mean it can be handled and controlled with a high percentage of success.
  - Multiple stabilization tools and resources are required to properly stabilize a vehicle of this size.

Victim Access: School Buses (1 of 7)

- Gaining or creating access will depend on the vehicle's resting position.
- The goal is to create a main entry and exit area so the flow of rescuers and victims is controlled.
  - The cage-like structure can make cutting into a school bus difficult.

Courtesy of David Sweet.

Victim Access: School Buses (2 of 7)

- Front windows are composed of laminate safety glass.
- When removed, can provide the rescuer with a large enough opening to pass equipment and remove victims on backboards
- Two settings for installing the laminate glass:
  - Gasket push-out type
  - Beaded mastic type

Victim Access: School Buses (3 of 7)

- Removing a bench seat can be fairly easy.
  - For speed of operation, the combination of the hydraulic spreader and cutter is the tool of choice for this task.
- Removing a section of the sidewall can produce a large opening for patient removal.
  - Multiple tools will be needed.
- Accessing the roof of a bus requires cutting through several structural members of heavy-gauge steel.

Victim Access: School Buses (4 of 7)

- Several techniques are available for gaining entry through the rear emergency door.
- Upright position: remove the two safety glass panels located in the rear door prior to forcing entry
  - A vertical spread technique can be performed to create a purchase point opening.
  - The goal is to create a large opening near the latching mechanism.
- Cutting out the entire rear section of a school bus is great practice, but it wastes valuable time.

Victim Access: School Buses (5 of 7)

- Entry through the front door of a school bus will depend on the operability of the door itself.
  - Always try to open the door manually.
  - May only require removing one of the glass panels in the door
  - May also require cutting the door out completely

Victim Access: School Buses

© Jones & Bartlett Learning. Photographed by Glen E. Ellman

Courtesy of David Sweet.

Victim Access: School Buses (7 of 7)

- There are multiple tools that can be used to safely and effectively lift and extricate a victim who has become trapped under a school bus.
  - An appropriately sized tow truck unit
  - Two FRJs
  - Two heavy-lifting struts
  - Rescue air-lift bags
- Again, preplanning and training for incidents such as this cannot be stressed enough.

Extricating Ejected and Trapped Victims

- The first technique involves two FRJs (fastest).
- Second technique is a jacking operation.
- Rescue: lift air bag operation may be needed.
  - The key is to always lift evenly and from areas with structural support such as roof bow trusses.
  - “Lift an inch, crib an inch”
  - Unstable terrain can sink a bag when inflated.

Relocating a Steering Wheel Assembly

- Can be quickly accomplished using a small tow-truck unit that is equipped with a stationary boom
- Back the tow unit to the front of the bus.
- Pull the wire rope from the top of the boom.
- Wrap the rope securely around the steering wheel and column.
- Can also use a come along and chain package
  - Can only be applied to a type C bus

Lifting a School Bus Off of an Underride (1 of 3)

- A vehicle that has impacted the rear of a school bus and has projected far under the rear chassis, entrapping the passengers, presents unique challenges to the rescuers.
  - Requires multiple operations to be conducted simultaneously
  - The goal is to properly stabilize the school bus and determine whether the underride is accessible to conduct rescue and extrication operations while still wedged.

Lifting a School Bus Off of an Underride (2 of 3)

- If access is blocked, the main objective will be to lift the school bus and remove the underride far enough out to allow for full access to entrapped victims.
  - If access to a large-capacity tow unit is available, the operation will be fairly routine.
- The operator attaches a strapping and chain system under the bus, and the tow unit lifts with its boom extended.
- A smaller tow unit positioned at the rear slowly pulls the underride out from under the bus.

Lifting a School Bus Off of an Underride (3 of 3)

- When the tow unit is not available, the operation will focus on alternative options.
  - Involves additional equipment with multiple personnel in a highly coordinated evolution
- Any shift from noncoordinated and/or uneven jacking, tool failure, or heavy winds can potentially cause catastrophic consequences.
  - The strictest discipline must be adhered to with all personnel.

Alternative Fuels (1 of 2)

- Becoming more prevalent
- Other systems such as bi-fuel or dual-fuel engines are designed to run on two different types of fuels by switching from one tank to another.
- There are also newer and cleaner petroleum-based fuels.
- Propane is one of the more prevalent alternative fuels used in school buses.

Alternative Fuels (2 of 2)

Courtesy of David Sweet.

Courtesy of David Sweet.

Hybrid Technology

- Uses the same concept design as conventional vehicles
- Parallel (more common) or series propulsion systems are combined with a diesel- or gasoline-powered ICE.
- The propulsion of the bus can either be operated from the onboard electric generator or through the diesel-operated ICE.
  - The hybrid system is placed behind the transmission.

Hybrid Technology (2 of 4)

- A hybrid school bus uses two or more 12-volt DC batteries located on a slide-out tray.
  - Normally positioned outside at the front of the bus on the driver's side area
- Two types of parallel hybrid systems are in use for types C and D school buses.
  - Charge-depleting hybrid system
  - Charge-sustaining hybrid system

Hybrid Technology (3 of 4)

- Battery pack comes in a sealed unit; two designs
- Single battery pack is set in undercarriage on driver's side.
  - Counterbalance weight on opposite side
- Two battery packs are set opposite from each other on both sides of the undercarriage, eliminating the need for a counterweight.
- Battery packs also have a service disconnect switch.
  - Mounted on the outside of the pack and in plain view

Hybrid Technology (4 of 4)

- A series-operated propulsion system (uncommon) uses the electric motor to propel the school bus.
  - Combustion engine is only used to regenerate the battery pack.
  - May be found on type A school buses
- Emergency procedures for the hybrid bus
  - Directed at the current parallel system
  - It is the responsibility of the technical rescuer to stay current with the latest technology and research developments.

Summary (1 of 3)

- The Federal Motor Carrier Safety Administration categorizes buses into carrier types or by function or purpose, such as school bus, transit bus, intercity bus, and charter/tour bus.
- As an emergency responder, you may never come across a school bus accident, but it is vital to be prepared and know the makeup, structural components, and different types of school buses that are on the roadways today.

Summary (2 of 3)

- The school bus industry has designated four categories of school buses: types A, B, C, and D.
- The overall design features of the bus, such as metal thickness and spacing of channel beams, may vary among manufacturers, but all must meet the FMVSS for school buses.
- Many of the design features of a school bus integrate safety.

Summary (3 of 3)

- The greatest concern for the officer in charge at a school bus extrication incident is gaining and maintaining control of the incident through proper scene management.
- Progressive agencies have preplanned and trained heavily for such an event and have pre-established MCI protocols and/or an emergency response plan in place. Upon your arrival at the scene of a school bus extrication, give a clear and accurate account of what is presented, and conduct inner and outer surveys of the scene to formulate your IAP.
- As with most vehicles, there are basically four positions in which a school bus will present that the technical rescuer will have to stabilize: upright, on its side, on its roof, or on another vehicle.