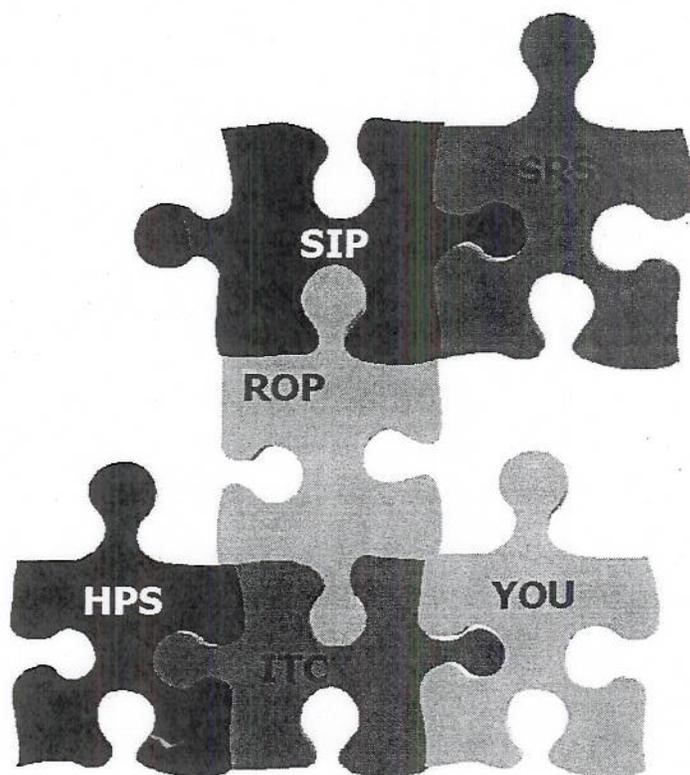


VEHICLE EXTRICATION: New Technology



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VEHICLE EXTRICATION; NEW TECHNOLOGY

Introduction

One of the biggest challenges that the fire service is faced with today is keeping up with the auto industry in regards to vehicle extrication. Not only have the manufacturers of heavy hydraulic rescue equipment tried to keep abreast of the changes that automakers are making to cars, but those that must perform extrications also must keep abreast of the ongoing changes. In order to understand the changes that are being made to cars, one must understand what the goal of the auto industry is.

No longer do we see the heavy gas guzzling cars of past decades. The older cars on the road today are products of an era that was concerned with fuel efficiency. These cars are lighter in weight and present unique challenges to the rescuer who learned how to do vehicle extrications with the original heavy hydraulic equipment.

In the past, due to the emphasis on fuel economy, there was a tremendous push to make cars lighter. This was done by using less metal and more plastic. An example of that is seen where the skin of a car is plastic or fiberglass instead of metal, or the fact that there is no longer metal in the dashboard frame.

The emphasis today is on passenger protection. This is being accomplished by using lighter, yet stronger material in the construction of the automobile. Because some of the structural components in today's cars are stronger, they also pose a problem during extrication attempts. Those problems can be seen not only in the difficulty with cutting these new materials, but also in the lack of strength of some of the older hydraulic equipment.

Because of this difficulty, new techniques and equipment are being devised to make the extrication easier. We can't lose sight of the reason why we are trying to extricate a person from a car in the first place. Remember the golden hour, that time frame that has been determined to provide the patient the greatest chance of recovery due to traumatic injuries. The auto industry is always trying to find better and safer features for the occupant of the car without regard for the difficulty that it may present to rescue personnel. For that reason, vehicle extrication is an ongoing, always changing problem for the fire service.

This program is an attempt to make rescuers aware of the changes that are being made to cars on the road today and how they affect vehicle extrication. It is divided into four sections:

- New Vehicle Construction
- Occupant Protection
- Extrication Problems
- Firefighting Hazards

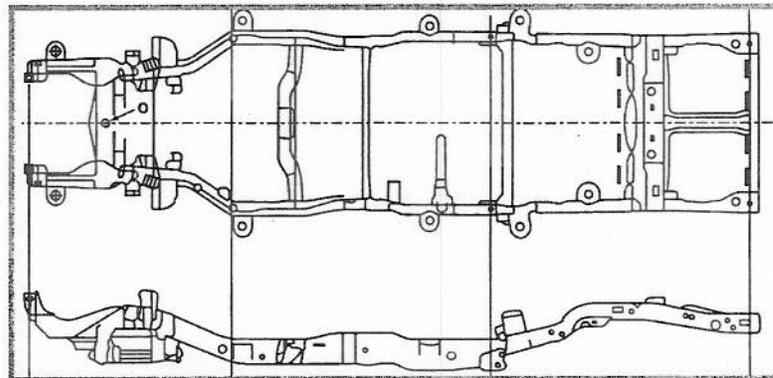
In the 1920s automobile sales were slowing, so General Motors introduced the annual model year change. Automobiles have evolved throughout our lifetimes and will continue to do so. The automobile manufacturers want to produce vehicles that the public will buy. These vehicles must also meet federal and state standards. Standards now include fuel economy, pollution, crash-worthiness, and safety.

Automobile designers must consider fuel efficiency, performance, safety, and cost. This has led to the use of new materials and technologies. Our concern lies primarily with the safety aspects. Since the 1960's, automotive engineers have relied on the "protect in place" theory of survivability. Most of the "new" construction features are designed toward this goal. There are three basic types of collisions designers focus on: frontal impact, side impact, and rollover. In side impacts and rollovers, ejection or partial ejection are a major factor in survivability.

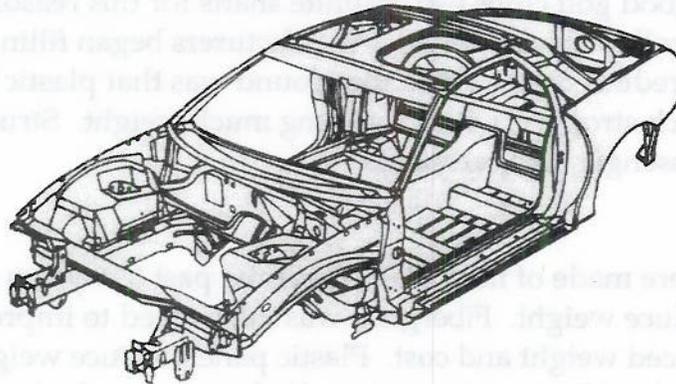
NEW VEHICLE CONSTRUCTION

Frames

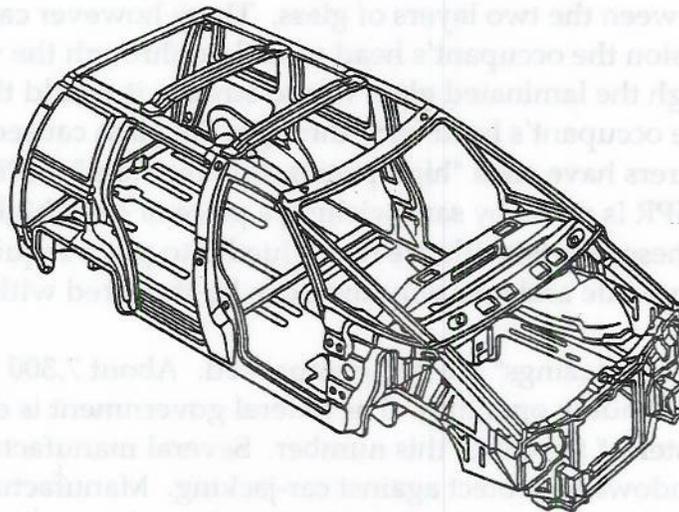
Originally automobiles were built on a frame that provided the strength of the vehicle. The frames consist of two pieces of hardened steel channel with crosspieces for stability. The components and body are mounted to the frame. Full frame construction is still used in trucks, and is found in most sport/ utility vehicles.



The next evolution, in the 1970s, was Chrysler's "unibody" construction. In unibody construction there is no frame for strength. Like a lightweight truss, each part relies on each other for strength. Unibody construction is now found in most passenger cars.



Next, the automobile industry developed the "space frame." These vehicles have a lightweight metal cage with a lighter weight skin attached. Although introduced in small passenger cars, the Pontiac Fiero, it is most often found in Mini-vans.



What is new are the modifications needed to "protect in place." These involve designing crumple zones to absorb impacts and stronger passenger compartments. Designers are also varying the strength of steel within the frames. There are two new approaches. In space frame vehicles like the Chevrolet Corvette a mild steel "hydro-formed" rail system is added. In framed vehicles there is a "sliding-form" frame, where different sections with different strengths are attached together. These allow engineers to let the vehicle crumple to absorb energy in a collision.

In both Unibody and Space Frame construction the passenger compartments are being strengthened to protect the people inside. Much of this is being done through metallurgy. Before World War II the steel industry developed "High Strength Low Alloy" (HSLA) steel for automobiles. Although too expensive at the time, this alloy is now being used in passenger compartments. HSLA steel is up to three times stronger than mild steel. Manufacturers are

now using graphite in vehicles. This is not like the "lead" in a pencil. Graphite is very light and strong. In fact many good golf clubs use graphite shafts for this reason. Aluminum is being used as a lightweight collapsible material. Manufacturers began filling hollow spaces inside vehicles with foam to reduce noise. What they found was that plastic foam inside automobile pillars made them much stronger, without adding much weight. Structural foam is now being used to strengthen passenger compartments.

Bodies

Automobile bodies were made of mild steel. Over the past few years several alternatives have been developed to reduce weight. Fiberglass was introduced to improve performance in sports cars. Aluminum reduced weight and cost. Plastic panels reduce weight and dents. Stainless steel has also been used to eliminate corrosion. Today many vehicles are found with a combination of these materials. See the appendix for an extensive list of composite materials.

Glass

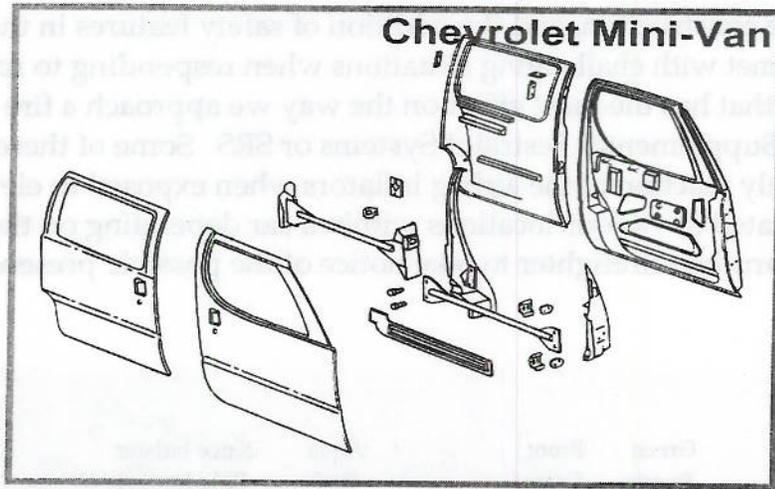
The original automobiles had windscreens made of plate glass. When broken, this glass caused serious wounds. In the 1920s plate glass was replaced by laminated glass in windshields. This glass had adhesive between the two layers of glass. These however caused the "glass necklace effect." During a collision the occupant's head would go through the windshield. While the head was going through the laminated glass would stretch; it would then go back into place. When recoil pulled the occupant's head back through, the glass caused severe neck injuries. Since 1966, manufacturers have used "high penetration resistant" (HPR) windshields of three-ply laminated glass. HPR is made by sandwiching a piece of clear high strength plastic inside two pieces of glass. These windshields are now glued into place requiring us to cut them out. Tempered glass, in most side and rear windows, can be shattered with hand tools.

Automobile windows or "glazings" are being improved. About 7,300 people die each year after being ejected through window openings. The federal government is experimenting with "advanced glazing systems" to reduce this number. Several manufacturers are advertising intrusion resistant windows to protect against car-jacking. Manufacturers are using five-ply laminations. They are also using laminated glass in side and rear windows. The newest development is polycarbonate windows. These are a lightweight form of the "bulletproof" glass found in limousines and armored cars. They cannot be broken with our regular hand tools. They must be drilled or cut. Once this has been done, they can be broken further.

Doors

For many years most automobile doors have been hinged. The hinges are on the front pillar and latch into the next pillar. There are also some sports cars with "gull wing" doors that are hinged at the top. Vans have had an interlocking double door, where a standard door latches to a "suicide" door (opening from the opposite side). We are now seeing this as a means of improved access to rear seats in other vehicles. The other van technology is the sliding door. This is now used extensively in Mini-vans.

Door technology is being improved to improve safety in side impact collisions. There is no room for crumple zones on the sides. Older cars have a mild steel barrier in their doors that resembles a highway guardrail.



Some newer vehicles have replaced this with an "HSLA" or "Micro-alloy" tube. "Micro-alloy" is made of Boron steel, which is very strong and rigid. The disadvantage is that in a severe frontal collision it can be driven into the pillars. When this happens, the tube must be displaced. Many passive seat belt and airbag systems are now contained inside doors.

Bumpers

Federal standards require that vehicles withstand minimal impacts without damage. Because of this almost all cars have energy absorbing bumpers. These bumpers can become jammed or "loaded" by impact and release violently. Traditional bumpers are still found on most trucks.

Batteries

Many automotive batteries are now sealed and "maintenance free." This has allowed designers to put them almost anywhere. Be cautious of any fluid in the vehicle after a collision; it could be acid from a cracked battery. Most batteries are still in the engine compartment. If they are not obvious some can be found by following the wire from the jump-starting terminal. Batteries are also installed in front wheel wells, under rear seats, and in compartments under the floor of the trunk. Consider checking the glove compartment for a manual with the battery location.

Remember that to disconnect power, you must cut all of the wires from the battery. Always cut the ground wires first in case your tool touches another part of the car while you are cutting.

Some experts recommend removing a section of each wire so that the ends cannot touch each other and restore power.

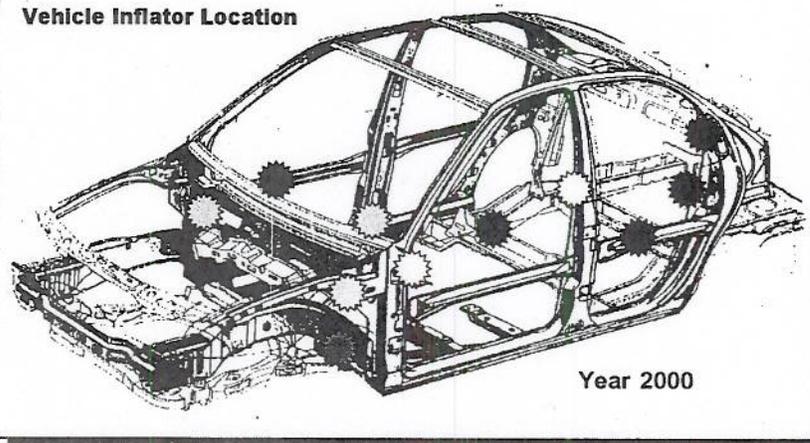
VEHICLE EXTRICATION; NEW TECHNOLOGY FIREFIGHTING HAZARDS

PROBLEMS

Due to changes in the construction, and the addition of safety features in the newer automobile, today's firefighter is met with challenging situations when responding to routine car fires. Probably the feature that has the most effect on the way we approach a fire in automobiles has been the addition of Supplemental Restraint Systems or SRS. Some of these problems are caused by the untimely reaction of the airbag inflators when exposed to elevated temperatures. These devices are located at various locations within a car depending on the make and model and it behooves the prudent firefighter to take notice of the possible presence and location of these devices.

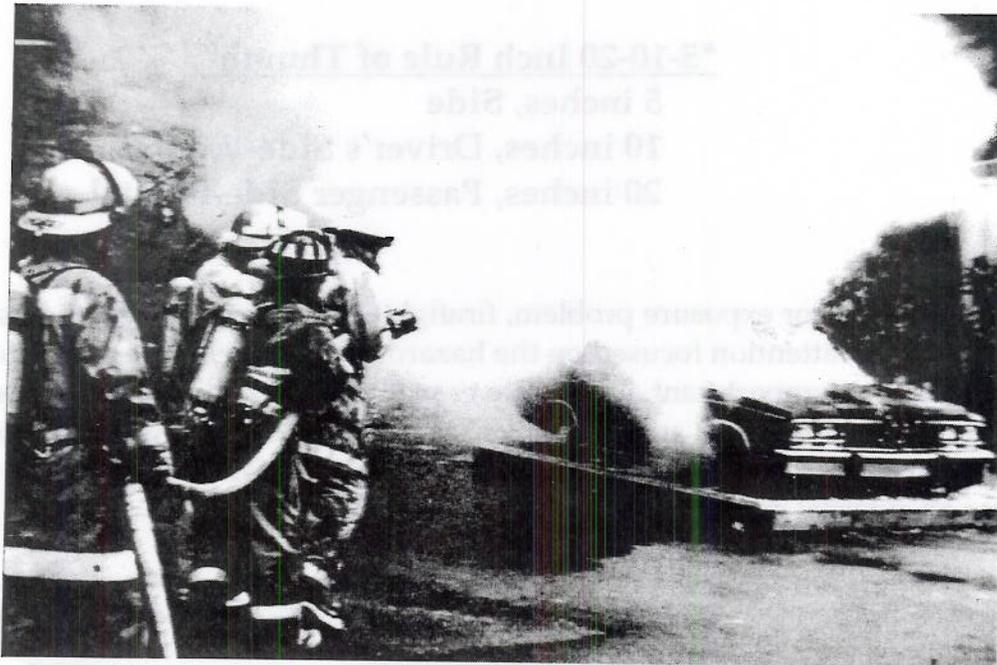
Green	Front	Aqua	Knee bolster
Purple	Carpet	Red	Side Impact
Yellow	Pre-tensioners		

Vehicle Inflator Location



The devices that appear to create the biggest problem in the event of a fire are the airbag initiating devices, or inflators. In recent incidents where it appeared that the fire caused the airbag itself to deploy, it was actually the inflator reacting to exposure to fire. These documented cases show the tremendous force that is produced when, for example, a steering wheel airbag inflator is projected. For this reason it is important that attention be given to the location of these devices and their potential reaction when exposed to fire. When doing so, however, it is important that our attention to traditional exposures such as bumpers, tires, and fuel tanks is not neglected. In order to avoid injuries caused as a result of the reaction of these devices to fire, we must reevaluate our approach to any vehicle that contains these devices that is on fire.

The device that activates or deploys the driver side frontal air bag is located underneath the unit housing the actual airbag in the center of the steering wheel. For this reason when this device is exposed to temperatures as low as 300°F, a detonation occurs that gives the appearance of the airbag itself deploying. What actually takes place is a detonation of the inflator that may subsequently cause the airbag to deploy. In either case, if attention is not given to either of these possibilities, the result may be that somebody gets hurt.



Whenever there is a fire in an automobile that contains any of the SRS's, it is imperative that a hose stream be directed into the passenger compartment at the location of these devices to keep them cool, similar to protecting exposures while fighting a structure fire. This may require the need for multiple hose streams depending on the extent of the fire. Using the John Wayne method of approach to car fires is no longer, nor has it ever been, acceptable to extinguishing a car fire. Remember that the car may be a total loss, especially if the fire has extended from the engine compartment into the passenger compartment. In this case the primary concern is the safety of the firefighters and the protection of exposures. Taking unnecessary chances may result in injury. The best way to avoid injury and protect exposures is to approach the burning vehicle from the side behind the protection of a hose line with the nozzle set on straight stream. This allows reach and penetration from a distance while extinguishing and cooling during approach.

Another initiating device that may be present is that which is used for side impact air bags. In some models this may be a pyrotechnic charge composed of a small amount of gunpowder. There may be an inflator used in the seat belt pre-tensioner that is usually located at the base of the seat belt, and in some models there may be an inflator located in the 'A' post. That is used to deploy head restraint air bags. Although there have been no documented cases of detonation of these devices, it is important to know of their existence and location.

The dangers caused by the effects of elevated temperatures on these SRS's cannot be ignored once a passenger compartment fire has been extinguished. Especially if the fire was extinguished before it involved the entire contents of the compartment. Keep in mind that the temperature which the inflators have reacted to, 300°F, is on the low end of the temperature curve produced by the combustion of plastics. With this in mind, it is recommended that fire fighters keep clear of the path of trajectory from a detonated inflator. As an added safety precaution, you should also observe the 5-10-20 inch buffer zone when working around undeployed air bags.

"5-10-20 Inch Rule of Thumb"

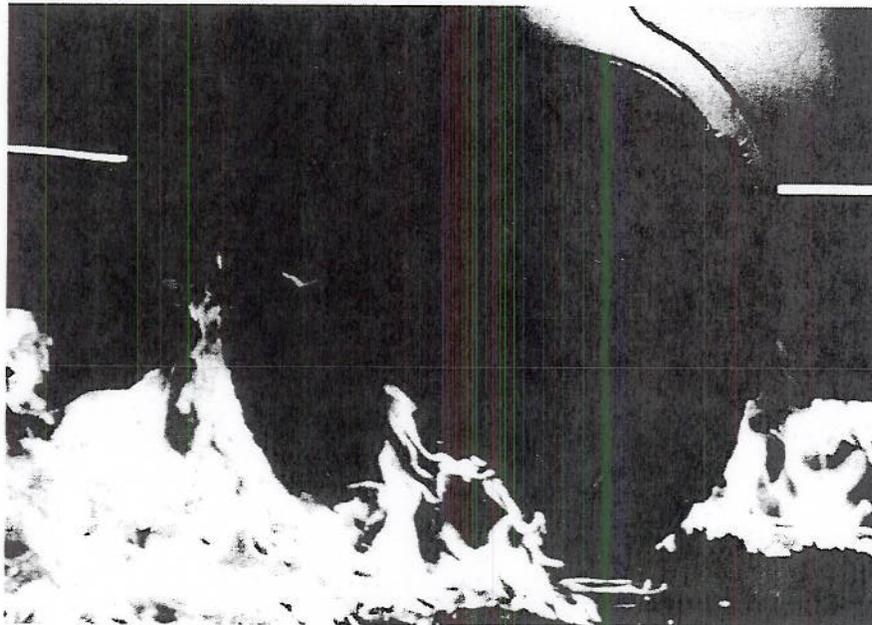
5 inches, Side

10 inches, Driver's Side-Frontal

20 inches, Passenger Side-Frontal

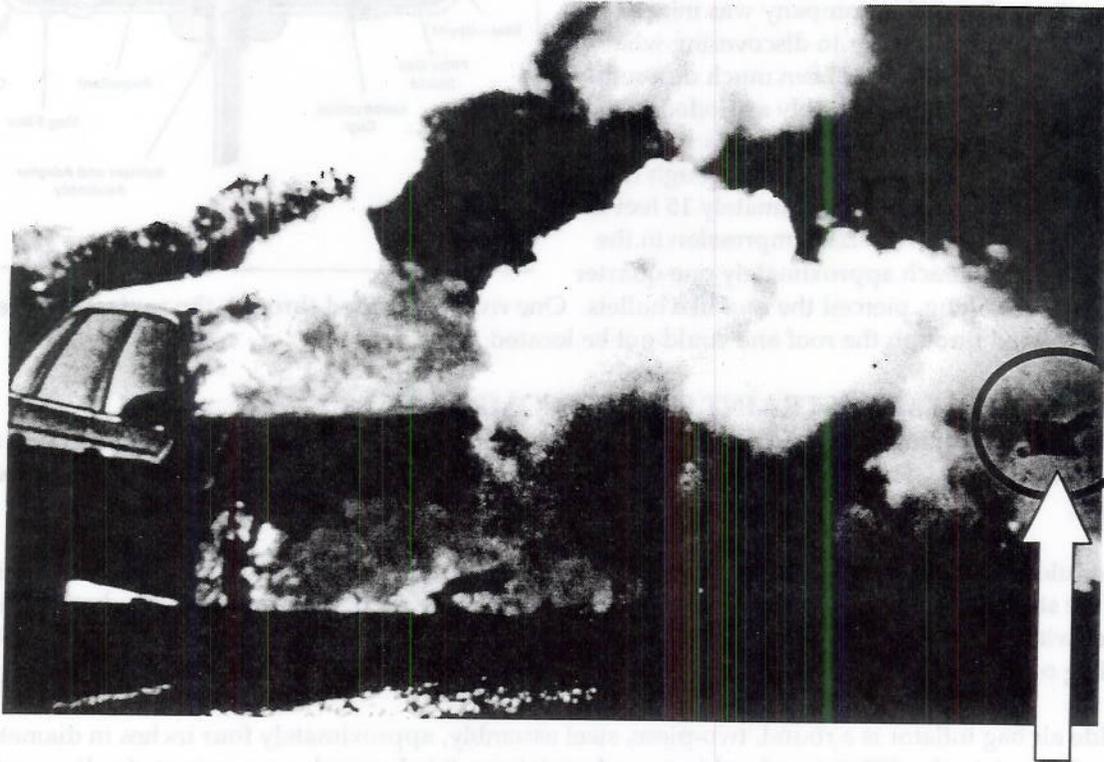
EXPOSURES

In addition to the interior exposure problem, firefighters must not neglect the usual exterior exposures. With our attention focused on the hazards presented by the new safety devices inside the passenger compartment, it becomes easy to overlook the dangers presented by such things as tires, shock absorbers, and fuel tanks. In addition to these, we must now add hood and truck piston struts. Although these struts are located underneath either the hood or trunk, they become an external exposure once the hood or trunk is open.



AIR BAG INFLATOR EXPLOSION

Although tires are not part of what is considered new car technology, they are worth mentioning because of the possibility of being ignored when attention is being focused on the devices that may be located inside the passenger compartment. The same is true with shock absorbers. The possible rupture of the shock absorber piston dictates the normal approach to a car fire from the side. In addition to the shock absorbers, we are now confronted with the possible detonation of the frontal air bag located in the steering wheel which creates a hazard zone to the rear of the vehicle. In the case of a well-involved car fire, two lines must be used, one for the passenger compartment and one for the exterior exposures.

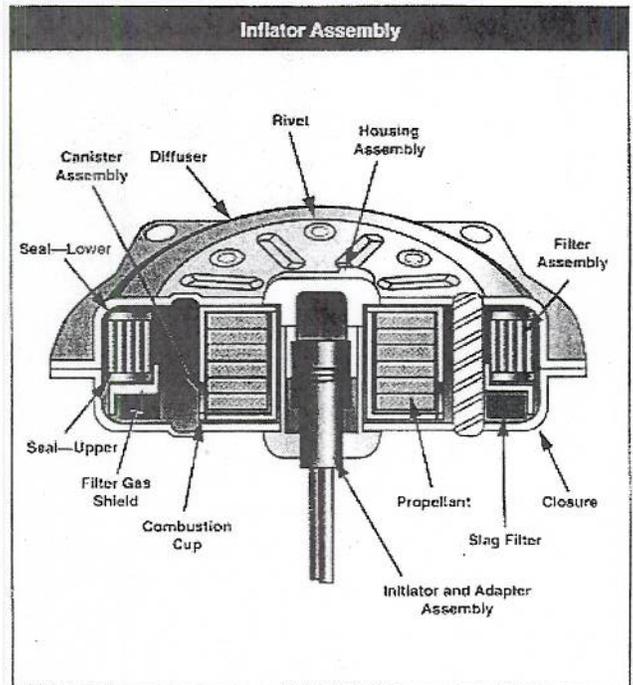


Bumper Shock Absorber

AIR BAG INFLATOR EXPLOSION

On September 19, 1995, Cedar Hammock Fire Department Engine Company No. 211 was dispatched to a vehicle fire that on arrival appeared to be a routine call. The passenger compartment of a 1994 Ford Aspire was heavily involved with fire, which was quickly knocked down with a 1-3/4-inch preconnect. What the engine company found after extinguishing the fire was anything but routine. It may have been the first or the only explosion and fragmentation of the inflator assembly of an air bag supplemental restraint system. This proves once again that there is no such thing as a routine emergency call.

Although no one from the engine company was injured or experienced anything unusual prior to discovering what had occurred, the results could have been much different. The driver's side air bag inflator assembly exploded with such force that the top of the steel assembly was ripped in half. A piece of the assembly was propelled through the air and was found on the ground approximately 15 feet in front of the vehicle. It left a bowl-sized impression in the vehicle's roof. Two rivets, each approximately one-quarter inch wide by two inches long, pierced the roof like bullets. One rivet protruded through the roof, while the other rivet completely passed through the roof and could not be located.



AIR BAG SUPPLEMENTAL RESTRAINT SYSTEM COMPONENTS

Most systems consist of four major components: an air bag module, an electronic diagnostic module, crash sensors, and a backup power supply. The driver's side air bag module is the component that exploded; therefore, we will concentrate on it.

The air bag module consists of three major parts: trim cover, air bag, and inflator assembly. The trim cover is in the middle of the steering wheel hub and covers the folded air bag. The air bag is a woven nylon bag that is folded into a container within the steering wheel hub center. The inflator assembly is mounted in the air bag module, under the air bag container, within the steering wheel hub.

The driver's side air bag inflator is a round, two-piece, steel assembly, approximately four inches in diameter and one inch thick. It consists of a diffuser and a closure and contains solid chemical gas generants (sodium azide and potassium nitrate) in the form of pellets or disks and an oxidizer (such as copper oxide), which are sealed in the assembly to keep moisture out.

When sensors detect a sudden deceleration, they trigger the inflator, igniting the generant. The generant burns rapidly in the assembly, producing nitrogen gas and dust, which are directed into the air bag, splitting the trim cover and inflating the air bag in less than one-twentieth of a second. This is the normal process during a front-end collision.

◆ **LEIGH T. HOLLINS**, a 20-year veteran of the fire service, is training director for Cedar Hammock Fire Control District and Southern Manatee Fire & Rescue District, in Florida, and director of Starfire Training Systems, Inc. of Manatee County, Florida. He is a state-certified firefighter/EMT, fire officer instructor, and inspector instructor.

FIRES IN AIR BAG-EQUIPPED VEHICLES

What happens during a vehicle fire? In the written guidelines from Ford, General Motors, and the U.S. Department of Transportation, there is a common message concerning fires: The air bag should self-deploy when temperatures reach 300 to 350°F.

The following is quoted from the various guidelines:

- Q. Is the sodium azide canister likely to explode during a car fire?
- A. No. The air bag is designed to inflate normally in the event that a vehicle fire causes the canister to be heated above 300°F. Consequently, it is possible that the air bag will deploy in a car fire, but there should be no fragmentation of the inflator.
- Q. If there is a fire in an air bag-equipped car, can water be used to extinguish it?
- A. Yes. Any effective firefighting medium, including water, may be used to extinguish a fire in an air bag-equipped car. ("Emergency Rescue Guidelines for Air Bag-Equipped Cars," USDOT-NHTSA, DOT HS 807 579 Rev. August 1990)

VEHICLE CRASH FIRE PROCEDURES

Use standard fire extinguishing procedures first. Use any type of firefighting agent, including water. The sodium azide is sealed in a watertight container.

While air bag modules may deploy in the rare case of a fire involving an interior occupant compartment, the inflator will operate normally. In an intense fire, the air bag module is designed to self-deploy if its internal temperature reaches approximately 350°F. The gas generant rapidly burns, without fragmentation of the inflator. NOTE: AIR BAGS WILL NOT EXPLODE. ("Rescuer's Guide for Ford Motor Company Air Bag Supplemental Restraint System," Ford Motor Company, October 1990)

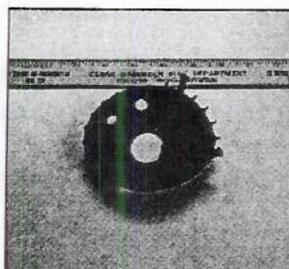
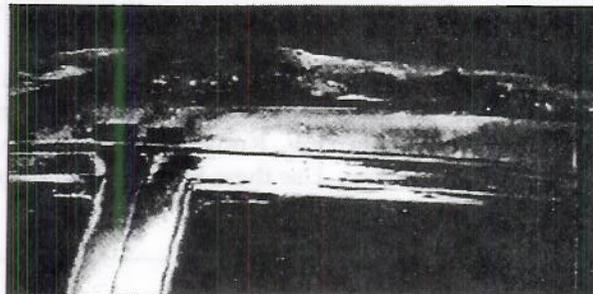
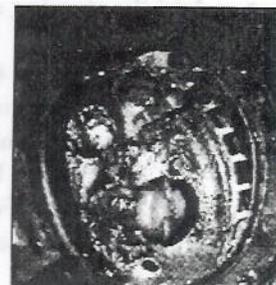
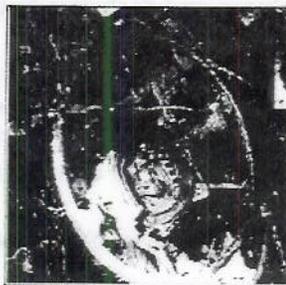
CONCERNS

The concern to firefighters is rather obvious—a vehicle fire with flying shrapnel and large rivets shooting like bullets. Add to this possibility the fact that more and more air bag-equipped new cars are on the road every day and that there are more air bags per car than ever before, and the concern intensifies. Although firefighters should take the new knowledge and use it to their benefit, overreacting would not be prudent. According to safety representatives from General Motors, Ford, and TRW (the manufacturer of the inflator assembly involved), they are not aware of any other explosion incidents. This appears to be an isolated incident or the only incident to date.

RECOMMENDATIONS

Following are my recommendations when fighting vehicle fires:

- Follow accepted vehicle fire tactics.
- Wear full protective gear, including SCBA.
- Look around. Don't get tunnel vision.
- Attack from a 45-degree angle.
- Cool critical components.



(Top left) The steering wheel area of the Ford Aspire involved in the fire. (Top right) Note the remaining portion of the inflator assembly. The explosion ripped the d'flosser in half, propelling it so that it landed on the ground 15 feet in front of the vehicle (bottom left), dented the car roof (middle), and caused a rivet to become lodged in the roof (bottom right). (Photos by author, reproduced from a videotape.)

- Add the steering column and dash area to the critical components to be cooled.
- Continue to cool for several minutes after knockdown.
- Study the following *Fire Engineering* articles:
 - "New Fire Tactics for New-Car Fires," Bill Gustin, April 1996.
 - "Car Engine Fires: Tactics for Quick Knockdowns," Brian G. Anderson, February 1994.
- Notify the vehicle's manufacturer if the assembly explodes.

It does not matter whether your response is to a vehicle fire, a trash fire, an automatic "nothing showing" structure fire; complacency will kill or injure you and your company. Knowledge, education, and experience will afford the best protection. Use them to your advantage. Accept the risks, but be safe.



A complete diffuser assembly. The assembly that exploded tipped at the "windows" of the diffuser—not at the seam of the diffuser/closure.

RESOURCES

The following will provide free information pertaining to fires involving air bag-equipped vehicles and extrication:

- Carl Farris, c/o GM-Atlanta Training Center, (404) 767-2628.
- Ford Motor Co., Colin Earl, (313) 845-8639.
- Chrysler Corporation, (800) 992-1997
- National Highway Traffic Safety Administration, (800) 424-9393.

CHART OF COMPOSITE PARTS AND IDENTIFICATION			
IDENTIFYING SYMBOL	CHEMICAL COMPOSITION	TYPICAL PART USAGE	COMMON AND/OR TRADE NAMES
UP	Polyester/Thermoset	Fender extensions: hoods, roofs, deck lids, instrument housings, ventilation grids, air scoops, air spoilers	SMC, premi-glas, selection, vibrinamat, fiberglass
PE	Polyethylene	Inner fender panels, valances, spoilers, interior trim panels, seatbelt covers, gas tank shields	Dylan, fortiflex, marlex, alathon, hifax, hosaplen, paxon
PS	Polystyrene	Dash panels, door panels	Lustrex, dylan, styron, duration, polystyrol
PPE (PPYO)	Polyphenylene Ether	Chromed plastic parts, headlamp doors, ornaments, bezels	Noryl, Oleflo, PreveX
PP	Polypropylene	Door panels, load floors, kick panels, deflector panels, cowl panels, wheel covers, interior moldings, radiator shrouds, inner fenders, bumper covers	Proflax, oleflo, marlex, azdel, novolen, tenite, daplen, escorene
TPU (TPUR)	Polyurethane, Thermoplastic	Bumper covers, soft filler panels, glass moldings, gravel deflectors	Pellethane, estane, roylar, toxin
PUR	Polyurethane, Thermoset (unsaturated)	Bumper covers, front and rear body panels, filler panels	Castethane, bayflex (commonly referred to as RIM and RRIM)
ABS	Acrylonitrile/Butadine/Styrene and Polycarbonate	Instrument clusters, trim moldings, consoles, armrest supports, steering column brackets and jackets	ABS, Ccyloac, abson, kralastic, lustran, absafil, dyel
ABS & PC	Acrylonitrile/Butadine/Styrene & Polycarbonate	Instrument panels, instrument clusters	Baybland, proloy, cycoldy, KHA
ABS/PVC	ABS/Vinyl (Soft)	Headrest skins, crash pads, trim moldings, trim panels	ABS vinyl
E/P (EPM; TPO)	Ethylene/Propylene (Rubber)	Bumper covers, valence panels, fascias, air dams	TPO, TPR (Thermoplastic Rubber), EPI, EPII
EPDM	Ethylene Propylene Diene Monomer	Bumper impact strips, body panels	EPOM, NORDEL
E/VAC (EVA)	Ethylene/Vinyl Acetate	Headrest skins, crash pads, trim moldings, trim panels	Elvax, microthane
PA-PPE	Polyamide-Polphenylene Ether	Fenders, exterior trim	GTX
PVC	Polyvinyl Chloride (Vinyl)	Interior soft trim, instrument panel skins, roof covers	Geon, vinylite, plipvic, "vinyl", vinoflex, unichem
SA (SAN)	Styrene-Acrylonitrile	Center consoles, glove box doors, interior trim panels	Lustran, tyril, foracryl
PC & PETP	Polycarbonate, Polybutylene, Terephthalate	Bumper covers	Xenoy, valox, macroblend
PA	Polyamide	Headlamp bezels, quarter panel extensions, exterior finish thin parts	Nylon, capron, zytel, ralsan, minlon, vydyne, wellamid
PBTP & EEBC	Polybutylene, Terephthalate & Ether Ester, Block Copolymer	Rocker cover moldings, fascias	Bexloy "M"
PC	Polycarbonate	Interior hard (rigid) trim panels, valance panels	Lexan, merion, calibre
PF	Phenol-Formaldehyde	Ashtrays	Phenolic, bakelite, durez, genal, resinnox, amberol, plyophen

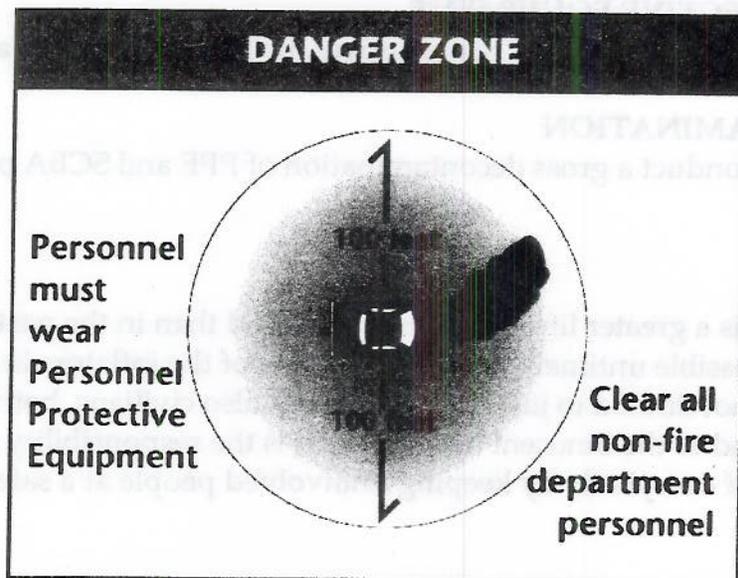
() Old Identifying Symbols

SUGGESTED OPERATING GUIDELINES (SOGs)

Guidelines for responding to and operating at car fires should be established and strictly adhered to. With the addition of SRS in the newer cars found on the road today, the chance of serious injury can not be ignored. There have been documented cases where unusual reactions occurred during a fire. The type of situation should dictate our actions, depending on whether there is a rescue involved or not. If there is no person trapped inside the vehicle and/or the vehicle is well involved in fire, the primary life safety becomes our own. SOGs should include the placement of apparatus, PPE, hose line/gpm flow, exposure protection, and precautions to take with the presence of SRS.

The first thing that should be done on arrival at a car fire is to determine the proper placement of the engine. This should be upwind, preferably uphill, and in such a position as to shield personnel from oncoming traffic if such is the case. The minimum distance as prescribed by the NFPA is 75 feet. This, however, may be too close as it may prompt firefighters to stretch a 100-ft trash line and come up short. By staying at least 100 ft. away, this would force members to use the next shortest length of hose, preferably a 150-ft preconnect. If the fire has extended past a firewall, and has involved both areas, such as from engine to passenger compartment or vice versa, two lines should be stretched. One for extinguishment, and one for exposure protection. We should begin applying water from a distance. This will allow us to approach the vehicle faster behind the protection of the heat-absorbing stream. Just as a side note, we should not overlook the fact that because of the amount of plastics used on the interior of cars and the large amount of BTU's they produce from combustion, we will be hard-pressed to extinguish a full size car that is fully involved using only the booster tank water and one hoseline. By using two hoselines we increase the GPM discharge, allowing the water to absorb more BTU's thereby achieving a faster knockdown with less water. The minimum size hose that is used must be 1- $\frac{1}{2}$, preferably 1- $\frac{3}{4}$. Remember that the size of the hose is of no use, if the proper discharge pressure is not used.

Department SOGs must specify that it be mandatory that members wear full turnout gear, including SCBA, whenever working at any size car fire. Remember that there is a large amount of different plastics used on the interior of cars and that they all produce toxic gases during combustion. Car fires present numerous hazards to the firefighter that require the use of full turnout gear: not just from the previously mentioned hazards, but from hot objects that can easily cause severe burns to the skin, careless movement of fellow firefighters, and the sharp edges of metal after their protective cover has been burned away.



SUGGESTED OPERATING GUIDELINES FOR CAR FIRES

When responding to any report of a vehicle that is on fire, the following guidelines should be followed when the situation allows.

APPARATUS PLACEMENT

1. Position apparatus in a location that is upwind from the burning vehicle
2. Position apparatus in such a location that it protects personnel from traffic
3. Position apparatus to the side of the burning vehicle
4. Position apparatus at least 100 feet from burning vehicle

HOSE/GPM FLOW

1. Personnel will stretch a minimum 150 feet of hose
2. Personnel will stretch a hose with a minimum diameter of 1-1/2-inches

FIREFIGHTER APPROACH

1. All personnel, including company officer, will wear full turnout gear and SCBA
2. Pump operator will don SCBA as soon as possible
3. A minimum of two firefighters will advance hose line
4. Personnel will approach vehicle from upwind
5. Personnel will approach vehicle from a 45-degree angle
6. Personnel will approach vehicle with protection of charged hose line
7. Personnel will begin flowing water a minimum of 30 feet from vehicle

PERSONAL PROTECTIVE EQUIPMENT

All personnel will wear department issued gloves, helmet, coat, pants, and SCBA

GROSS DECONTAMINATION

All personnel will conduct a gross decontamination of PPE and SCBA prior to returning to service

LIFE SAFETY

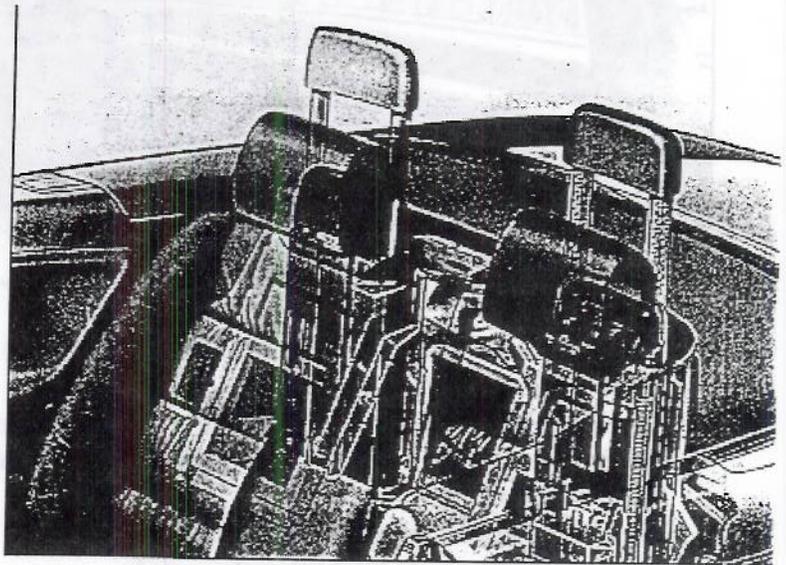
Surprisingly, there is a greater life safety issue involved than in the past because of the dangers presented by the possible untimely detonation of any of the inflators in the event of a car fire. These dangers are not limited to just firefighters, but also civilians, both to the vehicle's owner/occupant and to the innocent bystander. It is the responsibility of the fire department to oversee the safety of everybody by keeping uninvolved people at a safe distance.

ROPS: AUTOMATIC ROLLOVER PROTECTION SYSTEM

By Ronald E. Shaw, Fireline Educators, Plymouth, MA
James Onder, Ph.D., Communications Instructor, Washington, D.C.

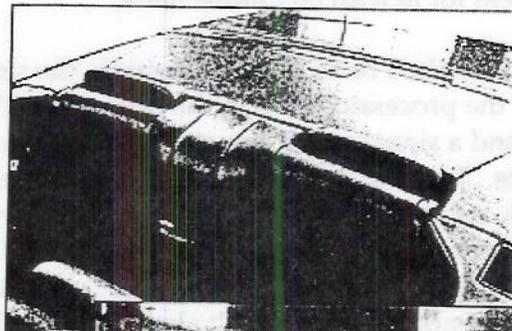
CONCERNS FOR OCCUPANT PROTECTION SYSTEMS

Safety features such as airbags have increased vehicle safety for the occupants; however, they have also increased the risk factor for the emergency service responder. Since an incident in Dayton, Ohio, where rescue personnel were injured by the accidental deployment of an airbag, occupant protection systems have become a concern for emergency responders during vehicle extrication. One occupant protection system that emergency personnel should be aware of is the automatic rollbar.

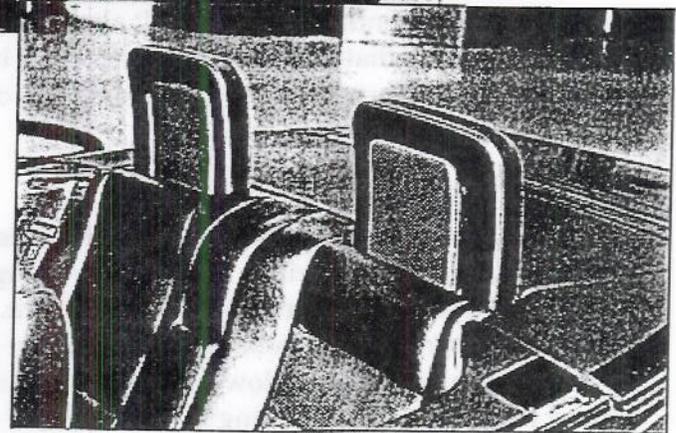


ROLLOVER PROTECTION SYSTEMS

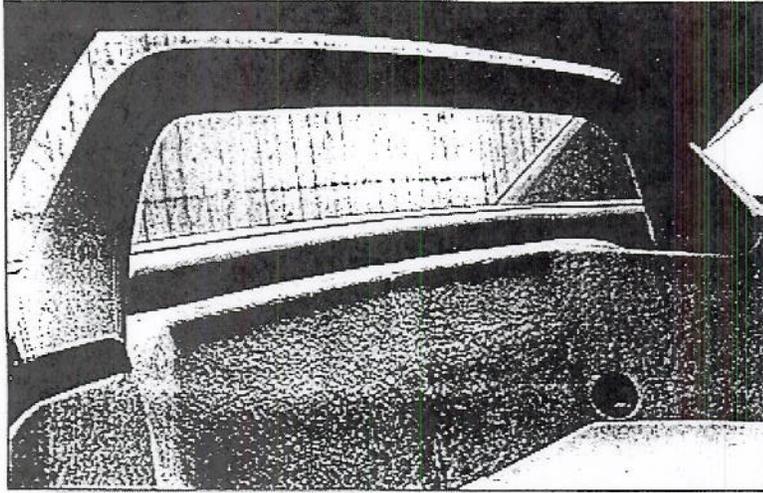
There are two types of rollover protection systems (ROPS) currently in use today: the common fixed-rollbar and a deployable-rollbar system. There are three automakers using automatic rollbars, either a pop-up or flip-up style. Automatic rollbars may be identified by the manufacturer's icon, or the letters RPS (the rollover protection system acronym used by some manufacturers) or ROPS. The pop-up model is mounted behind the seat, while the flip-up model looks much like a conventional, flat rollbar and rotates upward toward the front of the vehicle. Unlike fixed rollbars, deployable rollbars are somewhat concealed until activated when they will rise up to their travel limit in less than three-tenths of a second. Once deployed, they are locked into place and must be manually reset.



Deployable rollbars are somewhat concealed until activated when they will rise up to their travel limit in less than three-tenths of a second.



BMW, Volvo, and Mercedes have been using them in production models for some time, but with little notice until the recent publicity in some automobile periodicals. Both the Mercedes pop-up and flip-up systems are hydraulically deployed. The Mercedes pop-up system has a single, one-piece bar with two "U" shaped bends extending up through two openings. Volvo and BMW use a dual-spring mechanism housed in each of two separate cassettes to launch the rollbars.



The flip-up type is an option used only with the Mercedes two-seat roadster.

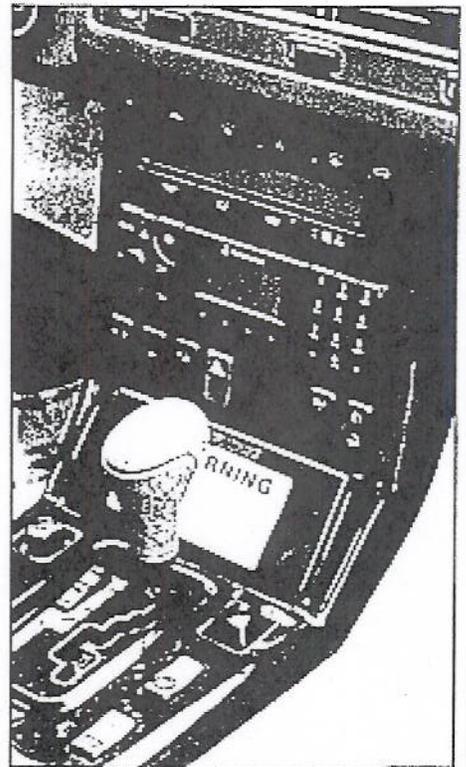
ACTIVATING THE ROPS

The Volvo and BMW ROPS/RPS are activated by an inclinometer that senses vehicle inclination and lateral acceleration. There is also a G-sensor that measures G-force and detects vehicle weightlessness. According to BMW, their system will deploy when the control module senses any of the following:

- When the vehicle approaches a lateral angle limit of 62 degrees.
- When the vehicle experiences a lateral acceleration of approximately 3 Gs.

- When the vehicle approaches its longitudinal angle limit at approximately 72 degrees.
- When a combination of longitudinal acceleration and longitudinal angle would cause the vehicle to roll over in the forward direction.
- When the vehicle becomes airborne and achieves weightlessness for at least 80 milliseconds.

When the vehicle is tilted or accelerated enough, the sensor will send a signal to the processing chip in the controller. The control unit will then send a signal to the actuator solenoids in each of the RPS cassettes. The actuator solenoids will then release the restraint catches, and the twin rollbars will spring upward in less than two- to three-tenths of one second! BMW claims that the force delivered by their rollbar "is not great," but that it deploys in less than three-tenths of a second. It also uses a mechanical (ratchet gear) lock that will stop and lock, when it comes into contact with an object. None of the automakers offered data on specific accelerated forces.



RESERVE POWER

The RPS/ROPS is like any SRS (supplemental restraint system) in that there is a controller with a backup power supply capacitor(s) that allows the system to function even if the vehicle power is interrupted in an accident. The controller looks exactly like the SRS controller box. Use the same precautions as you would for the SRS controller. The Volvo and Mercedes ROPS have a reserve powerdrain down time of approximately five seconds. BMW deactivation time is one second from the point of cutting the power source. Cutting the power source is very important and should be done as soon as possible. Remote batteries are now common and hidden in some vehicles. Another common problem is that you may not be able to access the battery due to the nature of the crash. In this case, patient care should not be delayed; a safe operating distance should be maintained around all undeployed ROPS until the system has been deactivated.

MANUAL DEPLOYMENT AND DEACTIVATING THE SYSTEM

Once the sensor in the vehicle predicts the car to be in a rollover situation, the bars will deploy. The Mercedes ROPS may also be deployed by the driver using a manual switch on the dash.

To reduce risk to emergency personnel, manually activate the RPS switch that is mounted on the dash, then de-energize the electrical system as soon as possible! Manual deployment of the hydraulic RPS is much slower and takes approximately four seconds or more to extend the rollbar. This slow extension process allows a safe, controlled, slow release. After the ROPS has been deployed, rescue personnel can safely work in close proximity to the rollbar. The BMW rollbar can be activated by the following:

- A BMW service tester,
- A BMW service person using the special tool, the MoDiC, or
- Trained personnel manually activating the system with a long-handled screwdriver

When transported, the Volvo convertible ROPS is deactivated at the factory. The dealer uses a computer to reactivate the system.

APPEARANCE AND PRECAUTIONS

Rollbars look harmless and blend in with the interior of the car's color scheme.

The pop-up type RPS looks like a headrest. This type RPS has padding or a protective plastic cap that snaps on a "U" shaped bar. The flip-up type is padded and folds down to wrap around the rear deck. It blends in perfectly, and you might assume it to be just part of the trim for the fabric top. When approaching, quickly survey the vehicle for telltale signs of automatic rollbars. Until safe to operate in close proximity of the ROPS, maintain a proper safe distance while performing rescue work.

For a rescuer holding traction for a C-spine injury, a normal position would be directly behind the patient. This position will now put the path of deployment in the rescuer's neck/head area! The Mercedes pop-up model extends approximately 10 inches from the deck to the top of the popup rollbar. The Volvo rollbar extends 20 inches. Once deployed, the RPS/ROPS will not redeploy, allowing rescue personnel to safely work in close proximity of the rollbar. The system can be manually rearmed by resetting the switch located on the dash or by a service technician. When in doubt about whether a rollbar has been deployed, keep a proper, safe working distance from the rollbar's path of travel, just as you would for any supplemental restraint device.

CONCLUSION

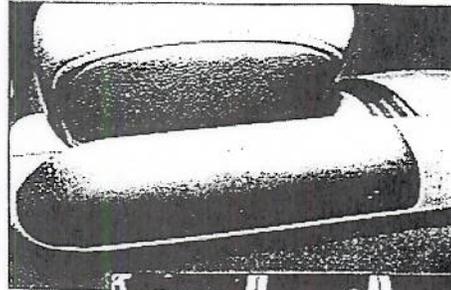
Perhaps the best way to avoid injury to a rescue worker is to de-energize the electrical system as soon as possible, or manually deploy the roll-bar in a safe, controlled manner. Mercedes convertibles have an electrical switch that can be used to slowly raise or lower the rollbar. Trained personnel can manually deploy the Volvo and BMW RPS using a screwdriver or special tool called a MoDiC. There is an RPS controller that appears to be similar to that of the SRS controller; treat it with the same respect. Never use a controller as an anchor point when using, hydraulic tools.

Remember:

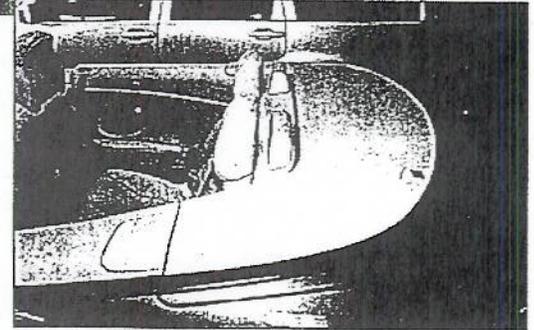
- Quickly survey the vehicle,
- Keep a safe operating distance from any ROPS/RPS until deployed or deactivated, and
- As soon as possible disconnect the battery to drain down the capacitor.

Check for power seats, windows, door locks, and trunk releases; you may need to operate them prior to eliminating the power source. If disconnecting the power is not possible, manually deploy the RPS/ROPS according to manufacturer's guidelines.

NOTE: For further information about rollover protection systems, contact the vehicle manufacturer. ROPS/RPS deactivation times mentioned in this article were provided by the automobile manufacturers: Audi, BMW, and Mercedes Cars of North America.



Rollbars look harmless and blend in with the interior of the car's color scheme.



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MODIFICATIONS TO PRINCIPALS AND TECHNIQUES OF EXTRICATION

A. New Material vs. Older Equipment

1. The introduction of micro alloys, boron steel, High Strength Low Alloy (HSLA) steels have increased survivability during a crash. However, some older hydraulic cutting tools may not be able to cut these new metals. It has been thought that hydraulic cutters actually cut through hard metal (hinges and pins) as similar to scissors cutting paper. To some degree this is true, however, as the cutter blades get to a certain point, the stress created by compression, actually causes the material to fail and fracture. Some of the older cutter blades will fail before the metal being cut will
2. It is important that departments contact their hydraulic equipment supplier or the manufacturer to see if the equipment that they are using will be able to safely cut the material without failure of the cutting device

B. Going Back to the Basics

1. In some cases, reverting back to hand tools may be an alternative method to cutting the new materials if your department has older hydraulic cutters. Reciprocating saws (corded or cordless) with quality extrication blades will saw through the new hard steel materials easier than that may be accomplished with some older hydraulic tools.
2. Proper blade selection and technique is very important for efficient cutting with a reciprocating saw. ***Some points to remember when selecting the proper blades are:***
 - Inexpensive blades bend easily, break, heat up faster and are less efficient
 - Select a good quality blade designed for extrication
 - Polycarbonate glazing may require a special plastic cutting blade
 - 6, 9 and 12 inch blades are available
 - 14 teeth per inch, best suited for extrication
 - .042 - .062 gauge blade stock
 - 1 inch wide
3. When considering purchasing saw blades, better quality blades designed for extrication will outperform the more economical bi-metal. Extrication blades come in many sizes to fit the needs of the materials being cut. When cutting the skin of a passenger vehicle, a shorter blade of 6 - 9 inches, 1 inch wide, 14 teeth per inch and .042 gauge will perform well for this application

4. However, in heavy trucks, commercial and school buses, the skin of the vehicle is much heavier and may have double steel outside an interior wall. With the deeper double wall depth, as in a school bus, the preferred choice of blade would be 9 - 10 inches. Consider using a .062 gauge blade for the heavy gauge metal on commercial vehicles. Some .062 blades may not allow the quick-change type chuck, instead, it may require a keyed chuck
5. One common factor that influences blade selection is economics. While inexpensive blades are less costly, they also are of lesser gauge. Heavier gauge blades are much stiffer, and will not heat up as quickly when properly used. This will extend the life of the blade, which will be more cost effective. Shorter blades that hit a double wall will bend or break, it is important that the blade extends beyond the depth of the material being cut with the blade during the short stroke
6. *Points to remember for efficient operation of a reciprocating saw:*
 - Blade length should extend beyond the material being cut
 - Place saw shoe directly against the material being cut
 - Operating speed should match the material to be cut
 - Replace bent or worn blades immediately
 - When possible use a soapy lubrication; 6:1 water/soap ratio
 - Run cordless saws down to the point that saw is inefficient then swap batteries
 - Follow recommended cutting operations by manufacturer
7. The best performance for a reciprocating saw will be obtained by placing the shoe of the saw against the material being cut. Harder or heavier gauge materials will require a slower speed. Replace the blade if the teeth are worn, don't attempt to cut from the tip where there is less wear to save changing a blade. Operating a tool other than the way it was designed could break the blades or cause injury
8. When starting the cut, increase the saw speed to the point where the material is cut at the fastest rate. Running the saw at full capacity will only heat the blade faster and actually reduce the efficiency of the cut. Worn or bent blades should be replaced immediately, new quick release chucks speed the changing blades to a matter of seconds
9. It is a common tendency to increase the speed of a reciprocating saw for heavier or harder steels, this is an incorrect method. Slower speeds will produce the most efficient cut for harder materials such as the new metals used in new vehicle construction. Soapy lubrication can also reduce friction and increase the life of the blade

10. Cordless saws are available in 18 & 24-volt capacity, however there is no difference in the performance by increasing the battery voltage. Having a second battery charged and ready to replace a drained battery will increase the readiness of the operation. Corded saws will outperform a cordless, but they have the disadvantage of needing a power source and an electrical cord

C. Coping with New Vehicle Construction and Development

1. With the development of newer supplemental restraint air bags, first responders must now learn to adjust their techniques to avoid personal injury during extrication, especially while displacing metal. Safety must extend beyond that of patient concerns, it is important that all responders practice safe operating practices within the work area at a crash site

D. Modified Dash Roll And Modified Jacking of the Dash

1. It is now important to perform an exterior/interior scanning when extricating a modern vehicle. There are safety components that can cause injury to rescue personnel and patients within the motor vehicle. The emergency responder must look for telltale signs of pretensioners and side impact airbags/curtains. Removal of interior trim may now be a required step to avoid cutting SRS or pretensioners. It is common practice to create an open environment (space making) within the vehicle to allow EMS personnel the greatest patient access. This may not be possible if extrication technicians want to avoid cutting the SRS components
2. The Modified Dash Roll (MDR) is an alternative to the ever-popular dash roll that was taught for decades in the Carbusters series. The MDR will allow you to perform a modification of the dash roll or jacking of the dash method. This will avoid cutting or breaching the impact curtains and components. Although you have not created a wide-open area, you have avoided or reduced the possible injury if an accidental deployment should occur
3. As you can see the dash has been lifted approximately 14 inches through the windshield. This method will keep the roof intact except where it was separated from the dash at A-pillars. At this point you can now complete the dash roll by using any of the following methods:
4. Steps leading up to the Modified Dash Roll (MDR)
 - Establish incident command
 - Establish standard site safety procedures such as a safety line
 - Scan the exterior of the vehicle looking for hazards, including SRS and ROPS
 - Stabilize the vehicle

- Carefully open the door scanning the interior for SRS and ROPS
- Cut non-airbag seatbelts as close to the pretensioner as possible, do not reach across the patient to release the buckle until the belt has been cut first
- Scan the interior looking for the presence of airbags, IC and pretensioners
- Power down windows, manually deploy ROPS (convertibles, Mercedes), release hood and trunk releases, power back electric seats, and then disconnect the power
- Remove interior trim as required to expose IC and pretensioner components
- Remove any side mirror from the A-pillar(s) if required

5. The following are steps to guide you through the MDR Procedure:

- Using the cutters, cut the A-pillar as low as possible near the dash on the side of the vehicle to be lifted
- Make an additional cut 2-3 inches above the first cut, but below the anchor point
- Keep a safe operating distance between all airbags: "5-10-20 Inch Rule", 5 inches from side impact bags, 10 inches from driver frontal and 20 inches from passenger frontal airbags. Cut the passenger's side seat back if you need more room
- Using the cutters, drop down to the bottom of the A-pillar where the rocker channel meets, cut through the A-pillar at a 45 or 90 degree angle. A noticeable drop and sound can be heard as the pillar is severed. This will be the hinge point for the roll. If you cut between the hinges you will meet resistance if the door is still on and the roll will be more difficult at best
- If possible open the hood, locate the strut tower, just behind the mounting, cut through the top rail on the front quarter panel. This will be just above the wheel well and aft of the center of the wheel well. This cut will help prevent the nose of the vehicle from diving into the ground and allow the dash to lift/roll easily. A reciprocating saw may also be used to make the cuts, providing a good quality extrication blade is use
- *The above outline is the same regardless of which tool or method you now wish to continue with.*

E. Using a Short Ram or Spreaders

1. Remove all trim on A-pillar under the dash, and along the rocker channel to avoid spillage
2. Using the cutters, move down the A-pillar to the bottom of the dash, make a very small pie cut, no deeper than one inch. This only needs to be large enough for the tip of the spreader or foot of the ram to bite into the metal. This small cut will prevent the tool from sliding out of position when opening the spreader arms or extending the ram
3. If you practice cutting the rocker channel to make a purchase point to foot the ram, be careful not to cut gas, fuel or electrical lines

4. It is imperative that you place substantial cribbing under the rocker panel at the point where the bottom tip of the spreaders or foot of the ram will be placed. Without cribbing, the rocker panel will bottom out. Unlike the large ram, the spreaders or a small ram will not have the reach and every inch of drop will be a loss of two inches in reach. Although it is not necessary, you may crush the rocker channel to prevent slippage as the tool is extended.
5. Place the tip of the spreader or ram in position and extend until the desired lift is achieved to free your patient
6. The tool can be left in position unless needed for other tasks

F. Using a Large Ram (Dash Roll)

1. Place the foot of the ram in position and aim for the arch of the A-pillar at the top of the dash. This will give you the best angle to roll the dash
2. Extend the ram to the point that dash is free of your patient

G. Modified Jacking Method Using the Spreaders

1. In this method, it is easier if the door was removed and the cutting point be above the bottom hinge instead of into the weld flange. Using the cutters, move down the A-pillar to the bottom hinge, cut just above the top of hinge through the A-pillar, make a second cut just above this. The space you have just created should be large enough to slip the retracted tips of the spreaders in. The tab can now be bent 90 degrees to the outside with the spreaders. Leaving the hinges intact will help distribute the downward force created by the spreaders.
2. It is imperative that you place substantial cribbing under the A-pillar/rocker panel at the point where the bottom tip of the spreader is positioned. Otherwise the rocker panel will bottom out, unlike the large ram, the spreaders or a small ram does not have the reach and every inch of drop will be a loss of two inches in reach
3. Place the tips of the spreader in position, extend until the desired lift is achieved to free your patient

4. These modifications were developed for vehicles with side impact curtains and pretensioners. This will avoid cutting or breaching a gas generator which is not mounted in the A-pillar, at present the IC inflators are mounted in the rear pillar. As newer models are designed and more and more auto manufacturers use the IC this may change. The December Popular Mechanics article for Toyota 2000 year IC shows the curtain starting in the A-pillar. This location is vulnerable to collision damage and could pose a problem for the extrication technician

The MDR and modified jacking of the dash method also works on vehicles that are not equipped with side impact curtains as in our test vehicle; Toyota pickup truck. The NOR can also be used in the case of a vehicle under ride where roof removal is impossible. Rapid intervention can now save minutes not seconds off the time it takes to roll a dash

AUTO EXTRICATION INCIDENT COMMAND

It should be noted that "Incident Command System" is a separate MFA/NFA course, this portion of your student manual will focus on ICS as it pertains to Vehicle Extrication Incident Command.

PRE-PLAN REQUIRED

Determine from your department SOP's, who will assume command and the transfer of command. This may be the *senior member/person in the right front seat* of the apparatus arriving on scene.

Evaluate the potential incident you may be called to versus the resources you can provide. Do you have a high speed limited access highway, are you prepared for an aircraft incident and what about possible incidents in remote locations? Address any discrepancies, and periodically update your pre-plan.

ON ARRIVAL

Life safety is our number one priority, this includes the safety of emergency responders. An "Inner and Outer" circle check gives the IC a better picture of what the incident will require.

Good information equals good decisions!

The establishment and announcement of command allows all members working at or responding to the incident to know who has command. This allows the IC to focus on the big picture, while other team members address their tactical objectives.

It is important for the IC to develop an action plan, communicate tactical objectives, define and monitor the action circle. Working with tactical objectives vs. task assignments will assist the IC and help to avoid tunnel vision. The IC should remain outside the action circle unless the situation requires combative vs. stationary command.

Entry into the action circle is controlled by the IC who must require the following for entry:

- Full personal protective equipment
- An assignment/task
- Tools to accomplish tasks

ON-SCENE OPERATIONS

Good command will enhance safety by minimizing freelancing and keeping the team(s) working toward the established common goal(s). It is the IC that coordinates simultaneous functions such as; rescue efforts, equipment requests and arrivals. Good preplanning will help eliminate redundant requests and tasks being made. Remember the IC makes decisions for the team direction! A good commander will coordinate and support the team. While it is important to have one person in charge, it is equally important to consider suggestions from subordinates and not be a dictator. This can be shown where a task is not progressing at a

reasonable rate and a subordinate suggests an alternative which may work better to reach the common goal. The IC should always be watching for firefighter safety and stop the action task if there is an unsafe practice before an injury occurs.

The IC should have a working knowledge and understanding of the principles of extrication. This allows for anticipation of what will be needed next, how and what will be used if the current procedure does not work. It is important to think of how to perform a task if the current one fails, and again if the progress is too slow.

Incident Command is constantly evaluating size up and addressing issues that affect the safety and progress of the incident. The following are among some of those issues, but not limited to:

- Keeping the "Action Circle" clear of unused tools, vehicle parts and unassigned personnel
- Crowd control, traffic and bystanders
- Rescuers on hand and those needed; tools, special equipment, personnel, etc.
- Categorize problems, determine severity and develop solutions
- Lighting

VEHICLE EXTRICATION COMMAND CONCEPTS AND CONSIDERATIONS

The IC will be handled by one member in most cases, IC is responsible for the five ICS functions. For complex incidents; sectoring, branching divisions, groups are all available to IC for the incident management.

A "Narrow Based Command" structure makes the IC very susceptible to tunnel vision. These faults would not be limited to the following:

- Members working on one aspect of extrication without preparing for the next step
- Members standing by with no assignments or direction, this invites the potential for freelancing and personnel may watch and not prepare for the next step
- Most firefighters are action oriented and self starters!

A "Broad Base Command" makes for a strong Incident Commander who monitors incident progress, anticipates needs, initiates actions, and calls for needed resources. IC has hands on the incident without having his fingers in it!

VARYING VEHICLE EXTRICATION INCIDENTS

Refer back to preplanning, identifying potential incidents and training for them will reduce stress at the scene. Using the systematic approach which can be built on as necessary depending on incident complexity.