NEW VEHICLE TECHNOLOGY

ISSUES FOR RESCUERS

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1. INTRODUCTION

Motor vehicle manufacturers now develop and promote advanced safety features as an integral part of their marketing strategy. Manufacturers also have to incorporate an array of lighter, yet more rigid materials in order to meet national and international standards.

Motor vehicles are no longer made of just sheet metal. The metals used are newer state of the art steels like boron steel, micro-alloys, high strength low alloy (HSLA) that in some cases are over 100 times stronger than sheet metals of the past. Standard mild steel has a strength of approximately 150-250n/mm, while boron steel has approximately 1380n/mm. These blended steels, or tailor-blending as it is called, are now located in the areas where rescuers would normally cut, push, fold or flap to gain access to a casualty.

As well as the new steels, new safety systems are also often found in areas where the rescuer would cut, push, fold, etc. These pyrotechnic and pressure vessels can hold an accelerant to inflate the airbag in excess of 700 bar.

Most of these are positive developments – lives are being saved and serious injuries reduced. Occupants are now protected by crumple zones, supplementary restraint systems, and a wide variety of air bags. At the scene of an accident, though, the very system that protects the occupants, makes their extrication more complex and potentially more hazardous to the rescuer. Entrapment becomes more likely and injuries may have a different character, changing the nature of extrication.

Rescuers now need all the most up to date information to understand the risks and meet the challenges of today's and tomorrow's cars. Most structural and safety design improvements are not obvious to rescue personnel until they attempt extrication at the scene of a vehicle accident. Unfortunately, this is where many rescue teams learn the idiosyncrasies of particular vehicles. Few of us have the luxury of cutting apart new cars in the training environment, so we have to rely on information from vehicle manufacturers, which is often difficult to acquire. Understanding vehicle anatomy and new-car technology is paramount to successful rescues.

Rescuers also need to be able to evaluate whether current tools are able to keep up or whether investment in new tools will be necessary. Only a few hydraulic rescue tools on the market in Australia today are able to contend with these new steels. Standard rescue tools will have difficulty cutting through these new steels, and using the tools incorrectly or overstressing them will create safety hazards.

2. VEHICLE EXTERIOR

The exterior of motor vehicles have changed enormously since they were first produced, and with current technological advances, it will continue to change. The exterior of earlier models were dependant on “in fashion” shapes and curves. The vehicles of the 1950’s and 60’s were modelled from rockets, with large sweeping panels and points. Vehicles of the 1970’s and 80’s were still large but their shape had changed greatly. The price of fuel probably also played a part in the introduction of aerodynamic motor vehicle.

Yesterday’s vehicles were made almost entirely of steel. The steel varied from sheet metal to heavy box section for the chassis, but these cars were heavy. The average vehicle weight in the 1970’s and 80’s was approximately 2.5 to 3 tonne. Today’s motor vehicles are still made of steel but the percentage of steel is rapidly decreasing. Today’s motor vehicles weigh approximately 2 tonne, with many weighing less than this. This can be attributed to the introduction of composite metals and the increased used of plastics. Their exterior design allows the many safety features to be included. To the majority of the population, the exterior design shows little indication of what lies below the surface such as intrusion bars, airbags, pyrotechnics, laminated and safety glass.

Vehicles are lighter than ever before but are still very strong. The motor vehicle of yesterday was engineered to resist impact. The motor vehicles of today are designed to absorb impacts or energy, and when this cannot be achieved, the impact or energy is directed away from the occupants of the vehicle. This is partly due to the exterior shape of today’s motor vehicles. The energy is distributed not by shear mass as the older vehicles were, but by distributing the energy throughout the entire body of the vehicle. In a collision today, the forces are distributed between every panel and every part of the vehicle.

The exterior of today’s new motor vehicles will require rescuers to adopt new theories of extrication. Gone are the days of simply “blowing a door off”. The safety features that are designed to protect the occupants of the motor vehicle can have disastrous ramifications for the rescuer of today.

2.1. VEHICLE CONSTRUCTION

Aluminium

Aluminum, or aluminium if you prefer, was first discovered in the early 1800's and produced in quantity in 1824. By the turn of the century, aluminium was being reliably cast, rolled and formed. Vehicle manufacturers quickly discovered its attributes and it has played an important roll in automobile construction ever since.

Aluminium has been used for doors skins, bonnets, boot lids, engines, radiators, suspension components and interior trim. The weight saving and attractive appearance aluminium provides are definite benefits, but steel has been the more traditional material used in automobile body and frame construction because of low cost and easy joining methods. That is gradually changing. Racing cars use aluminium extensively to save weight, although carbon fibre composites have now replaced it in some areas.

Material	1975	1985	1995
Iron-steel	76	71	67
Zinc-lead-copper	4	3	3
Plastics	2	8	10.3
Glass	3.4	3.6	3.6
Other / non-metal	11.0	10.2	9.7

Table 2: Material Distribution (%) in medium-sized car

Ettore Bugatti used aluminium extensively in his cars and his son, Jean Bugatti, built a couple of cars in the 1930's almost entirely of an aluminium-magnesium alloy. Even the frame of the car used aluminium alloy sections riveted together. Many other European car builders such as Ferrari and Aston used aluminium in the 1920's and 30's. Aluminium was easy to shape by hand and was well suited to limited production runs.

A few modern cars are built with complete aluminium bodies as well. The Plymouth Prowler used an aluminium body on an aluminium frame. The Honda Insight and Acura NSX have aluminium unibodies that utilise construction methods similar to steel cars: panels are spot welded together. The Audi A8 and the Audi A2 use aluminium space frame construction that is welded, and riveted for structural strength. The A2 aluminium body is 43% lighter than a comparable steel body and Audi claims the resulting lightweight body is stronger than steel and cheaper to repair.

Jaguar's new XJ8 is the latest aluminium car to hit the showrooms. Alcan, the aluminium supplier, was a key technical partner in the development of construction techniques. This flagship sedan weighs almost 92 kg less than the previous model yet is larger and incorporates more features. According to Jaguar's XJ Chief Program Engineer, David Scholes, customers "may not care whether the body structure is aluminium or steel, but the Jaguar customer does care very much about performance, dynamics, emissions and safety. The choice was clear." To take full advantage of aluminium's properties, Jaguar has adopted construction techniques used in the aerospace industry.

The XJ8 uses several different types of aluminium parts to construct the car's monocoque body. High-pressure vacuum aluminium die-cast parts are used as mounting points for the suspension and drive-line components. High strength "green sand" aluminium castings are used to provide mounting points for the XJ's bolt-on front end. This allows parts damaged in low speed accidents to be easily replaced .Hydro-formed aluminium alloy tubular components are used to produce complex shapes that are stronger than welded assemblies. Aluminium alloy extrusions are used in door structures for enhanced security. Bake-hardened aluminium sheet is used for exterior panels, providing a tough surface resilient to dents that can occur in parking lots.

Over 3200 self-piercing rivets and 120 meters of adhesives are used to assemble the inner body structure, while many exterior panels are bolted on. The result is a body that is 40 percent lighter and 60 percent stiffer than the previous model XJ8. Improved handling, superior ride comfort, and better fuel economy are but a few of the benefits.

Pound for pound, aluminium can be up to two-and-a-half times stronger than steel and can absorb twice as much crash energy. Vehicles made lighter with aluminium can have improved acceleration, braking, handling and better fuel economy.

Carbon Fibre Reinforced Plastics

Carbon-fibre-reinforced plastics (CFP) offer a significant potential for reducing vehicle weight in "regular" production cars, CFP being highly suited for body components due to its superior strength and stiffness. The body of a modern car, depending on the model, accounts for 15-20 percent of the overall weight of the car. Body components made of CFP are up to 30 percent lighter than aluminium and 50 percent or more lighter than steel. So depending on whether CFP is used for individual components or for the entire structure of the body, this highly sophisticated material is able to reduce the overall weight of the car by up to 10 percent, without making the slightest concession in terms of stiffness and body strength. Clearly, this improves the car's performance and agility whilst reducing fuel consumption at the same time. More efficient designs will also allow engineers to focus on key issues, such as fuel consumption, crash management and vehicle stability - which all require stronger and stiffer vehicle structures.

Carbon Fibre can be found in many areas. For example, the tail shafts on the Mitsubishi Pajero 4x4 are made of Carbon Fibre. They are engineered to collapse when involved in a frontal impact, therefore reducing the likelihood of the tail shaft puncturing the floor pan of the vehicle and entering the “Safety Cell” where the passengers are.

Tailor Blending or Tailor Blanking

Tailor blending is a technology established over the past decade in parallel with the rollout of previous steel industry initiatives for the motor vehicle industry specifically. Tailor blending, as the name suggests, involves the combining of several metals. In the motor vehicle industry it involves the manufacture of components using different types of metals in one mould. Vehicle manufacturers can now place super strong metals in areas of the motor vehicle that require strength in the event of an accident.

Instead of manufacturing the entire vehicle out of heavy super strong metals, auto manufactures strategically place "tailor blended" materials into the areas that really need it. Typically found in the pillars of motor vehicle, this multi-layering of metals makes it super strong. As well as the A & B pillars, tailor blending can be found in the wheel arches to deflect the wheels from entering the cabin of the vehicle, fire walls, parcel shelves, parts of the dash board and door sills.

This type of vehicle construction is becoming more and more common in vehicles found on Australian roads every year. During an accident, tailor blending proves to be very important in occupant safety, however, it also makes rescuing the occupants a bit more difficult for the rescuer. Rescuers need to be aware of tailor blending so if it is encountered on the road, the tool operator can identify it and deal with it appropriately.

ISSUES FOR RESCUERS

As a rescuer, how do you identify aluminium, plastic, steel, or high strength alloys from other material? There are little or no characteristics to positively identify one material from another. At this stage, individual experience and vehicle familiarisation is the only source of knowledge that rescuers can draw from. Motor vehicle manufacturers appear to be changing materials and technology with each model they release, and rescuers are constantly playing catch up.

The introduction of high strength metals causes problems for rescuers in that very few powered hydraulic tools have the capacity to cut through them. The use of cutters, spreaders, air chisels and even electric reciprocating saws, have little effect on these materials. Once HSLA metals are discovered on a motor vehicle, Plan B must be initiated immediately. Standard rescue tools can easily cut around these new metals leaving the HSLA metal behind. Techniques will need to be continually altered with the further introduction of HSLA metals into motor vehicles. For example, intrusion bars are usually attached to either end of the door frame by either a plate of mild steel or a sleeve of mild steel wrapped around each end of the intrusion bar holding it place. These areas are the places where the tool operator needs to concentrate his effort.

This photo is evidence that hydraulic shears do not cut high strength alloys materials. These blades are from two separate shears.

The blade on the left failed during an extrication in the early 1980's whilst cutting a B pillar that had a toughened steel seatbelt mounting bolt. The blade on the right failed during an extrication in 2003 when the operator attempted to cut an intrusion bar made of HSLA.

2.2. GLASS

Glass has, since the introduction of laminated glazing, been an important part of vehicle construction. Currently, the front window is glued into the construction and is therefore jointly responsible for its strength. Glued down glazing poses more problems than glazing mounted in rubber when trying to remove the windscreen, but the tools presently available provide enough options to either cut the window or to remove it completely.

Glass does have some eminent drawbacks: it is expensive, relatively heavy and breakable. The use of plastics such as polycarbonate is therefore being researched extensively and its use in large sunroof construction, fixed side glazing and headlights in vehicles is increasing. Glazing will be the most prone to innovations in the coming years.

SAFETY GLASS

Safety glass is something many of us look through every time we ride inside a vehicle or enter a public building. There are two kinds of safety glass:

- Tempered
- Laminated

Glass on the left is laminated, and the one on the right is tempered.

Tempered Safety Glass

Tempered safety glass is a single piece of glass that gets tempered using a process that heats, then quickly cools, the glass to harden it. The tempering process increases the strength of the glass by 5 to 10 times that of untempered glass.

Tempered safety glass breaks differently than regular clear glass. When tempered safety glass is struck, it does not break into sharp jagged pieces of shrapnel-like glass as normal windowpanes or mirrors do. Instead, it breaks into little pebble-like pieces, without sharp edges. It is used in the side and rear windows of automobiles. Eyewear uses tempered glass that has been tempered using a chemical process.

Laminated Glass

Auto makers began using laminated safety glass, also known as auto glass, for automobile windscreens in 1927.

DAMAGE TO A REAR LAMINATED WINDSCREEN

To make laminated safety glass, the manufacturer sandwiches a thin layer of flexible clear plastic film called polyvinyl butyral (PVB) between two or more pieces of glass. The plastic film holds the glass in place when the glass breaks, helping to lessen injuries from flying glass. The film also can stretch, yet the glass still sticks to it. It is also quite difficult to penetrate laminated safety glass, compared to normal windowpane glass. The 'sandwich with some give' that laminated safety glass is made of also helps hold the occupants in a vehicle.

Banks use a multiple-layer-laminated glass to help stop bullets. Laminated safety glass has two other additional benefits:

- It reduces transmission of high frequency sound.
- It blocks 97 percent of ultraviolet radiation.

Laminated safety glass is also used in:

- Thermometers for taking body temperature
- Cutting boards
- Greenhouse windows
- Shower enclosures
- Office partitions

ARMOURED GLASS - 42MM THICK!
ITS BULLET PROOF, TOO.

ARMOURED GLASS FROM THE OUTSIDE - ALMOST IMPOSSIBLE TO DETECT THE DIFFERENCE

Laminated glass is found in the windscreens of all motor vehicles found on the roads today. Laminated glass can also be found in the rear windows of some luxury motor cars. Today vehicle manufactures are fitting laminated glass in side windows of luxury motor cars. Unlike the windscreen, vehicle manufactures are not fitting laminated glass into the side windows for safety reasons. They are fitting laminated glass into the side windows to reduce the amount of vehicle theft by brake and enter or smash and grab. The majority of car thefts and vandalism occur through side windows.

The USA is a country introducing laminated side windows to motor cars. Carmakers in the USA are under pressure to devise methods of keeping unrestrained occupants inside a vehicle during a collision. Ejection from a vehicle during a collision dramatically increases a persons risk of serious injury or death. All these concerns have brought about changes in window materials that rescuers may encounter at a motor vehicle crash.

The vehicles that currently have laminated side windows are Audi, Volvo, BMW, Mercedes and SAAB. All other vehicle manufactures are seriously looking to include it as a standard feature to their vehicles in years to come. Laminated glass in side windows was introduced to the above vehicles as an optional extra in 1995 but soon became a standard feature after 1998. The same techniques used to deal with a laminated windscreen should be used when having to deal with laminated side windows.

The technological advances in laminated glazing have been enormous in the last decade. These developments now make it possible to construct glazing in almost every shape or form required. In the near future rooftops and front or rear windows will no longer be separate elements but an integrated structure made of laminated glazing. Rooftops can be left transparent or painted in the desired colour. Laminated glazing will also be more frequently used in side windows.

Thermopane Side Windows

This type of glass is designed to insulate the vehicle from heat and noise better than a single piece of tempered or laminated glass. It is simply a double layer of tempered glass. The same technique to break tempered glass is used to break thermopane glass however, you will have to break the glass on two separate occasions.

NOTE THE TWO SEPARATE LAYERS OF GLASS

THE OUTER SHEET OF GLASS IS BROKEN
BUT THE INNER LAYER IS STILL INTACT.

Polycarbonate Glass Windows

The term 'glass' in motor cars is rapidly changing. Vehicle manufactures are critical about the weight of a vehicle. Reducing the weight of a vehicle means big savings for the manufacturer AND the customer. Polycarbonate glass is 200 times stronger then conventional laminated glass and is half the weight of glass. Polycarbonate may soon replace ALL glass as we know it today.

Polycarbonate windows have been around for many years in agricultural vehicles like tractors and in the earth moving vehicles like excavators, etc. These industries have windows in their vehicles of all shapes and sizes. Headlights in vehicles today are already made of polycarbonate materials. The same materials used in headlight covers of yesterday are now being used to make the actual headlight lenses. Polycarbonate glass is all ready used in motor bike face shields, head lights and breathing apparatus masks where it has proved to be extremely effective and even heat resistant. Vehicle manufacturers are not far away from introducing plastic windows in vehicles. The problem manufacturers have is finding a see-through plastic, light enough and strong enough to resist scratching.

Polycarbonate is not yet scratchproof and it is for this reason not commonly used in car glazing. What goes for cars does not necessarily apply to other vehicles such as trains and buses. One of the major difficulties rescue workers assisting in the train crash in Eschede (Germany) had to face, were the strong windows in the ICE-train. The equipment used by the rescuers was geared to cope with 'traditional' construction materials, so extreme measures and tools were needed to remove the windows and gain access to the train. One of the tools used was an oxy-acetylene cutter. It did the job but also caused unwanted side effects such as fire hazard, toxic fumes and dripping of the material.

In the United States various experiments have been executed to test the behaviour of polycarbonate glazing when forced to deform. Results have shown that even in situations of severe deformation, the window/glass will largely stay intact. This complicates reaching the victim of a car crash for medical assessment and stabilisation.

Polycarbonate is now also being introduced to replace panels on vehicles. The VW Beetle is such an example.

ISSUES FOR RESCUERS

Rescuers will find windscreens, side windows and rear windows ALL made of plastic in the near future.

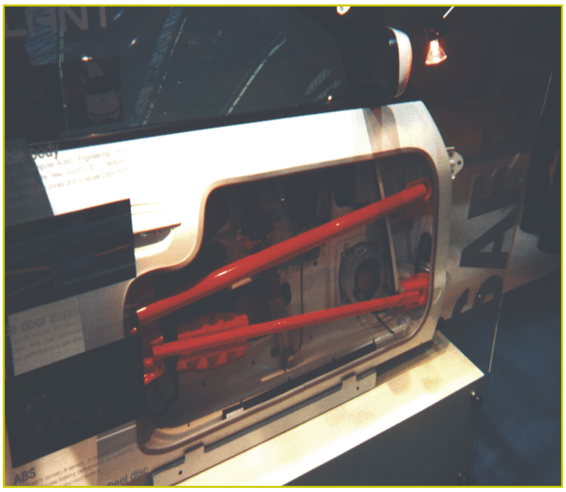
Another issue for rescuers of tomorrow will be the introduction of heating elements inside the front and rear windscreens. Rear windows currently have a type of wire stuck to the glass, which acts simply as a rear de-mister. Vehicle manufacturers have designed a heated front and rear windscreen. During the manufacturing stage of the laminating the windscreen a layer of very fine wires are placed between the laminated layers. These wires covered the whole windscreen. At the flick of a switch the driver can heat up either or both of the windscreens. This new type of de-misting should not prove to be a big issue for rescuers, BUT it highlights the need to isolate/disconnect the power to the vehicle from its battery or batteries to reduce the chance of electrocution during glass management.

The health effects of cutting, sawing, grinding, drilling and melting the polycarbonate windows are to early to predict. The current procedure for when cutting, grinding or sawing any plastics is to wear respiratory protection like a dust mask as a minimum for both the patient and the rescuer. More research will have to be done in this area to establish what the hazards are of exposure to the fumes or fibres generated by these materials.

2.3. INTRUSION BARS

Motor vehicle doors are designed that in a low-speed impact, the front outer door skins will overlap the rear outer door skin. The idea is so the occupants can exit the vehicle easily. The problem arises when the impact is not low-speed. The force of the impact forces the doors either in or out. This increases the potential danger of severe injury to the occupants of the motor vehicle.

Intrusion bars or, as they are known in the United States "collision beams", are found in all new motor vehicles. Intrusion bars were introduced into the Australian motor vehicle market in the late 1970's to improve a vehicle's crash worthiness. The intrusion bars are usually a metal pipe, but can sometimes be a pressed steel plate. Depending on the motor vehicle, they may one or two intrusion bars in each door.



The intrusion bar is designed to reduce the impact into the safety cell (cabin) of the vehicle to protect the occupants. They increase the resistance and rigidity of the doors, therefore increasing the strength of the entire side of the motor vehicle. In a side-impact or T-bone crash, the force of the impact is spread over the entire side of the motor vehicle instead of just the door itself. Intrusion bars also assist in frontal and rear impacts. The intrusion bars once again spread the forces of an impact down and around the safety cell (cabin) of the motor vehicle spreading the forces over the entire motor vehicle.

This photo shows the driver side intrusion bar clearly. This 4x4 was side swiped by a log truck travelling at approximately 60 km/hr in the opposite direction. The strength of the intrusion bar protected the driver, and he walked away from the incident.

Motor vehicles fitted with a single intrusion bar can be found between the hinges running parallel with the floor. In other words, the intrusion bar runs parallel to where the occupants legs would be, if in the seated position. With all the doors closed, the intrusion bars "link" up together to strengthen the entire side of the vehicle.

Intrusion bars in the 70's and 80's were made of either pressed steel plate or steel rod of approximately 3-4mm thick. Today it is not uncommon to find intrusion bars made of alloys like Boron steel and HSLA metal and various other Micro Alloys.

This is another example of intrusion bars. Before the door skins are attached to the door, a simple pressed plate (intrusion bar) is welded into position. To maximise the strength and yet reduce the weight of the intrusion plate, two plates are folded separately but attached together to increase rigidity and strength. These intrusion plates can be made of HSLA metal.

Another option vehicle manufactures have considered is to include the intrusion bar into the structure of the door itself. This type of intrusion bar is very efficient and very strong. Having the intrusion bar surrounding the entire door gives the door enormous strength. This type of intrusion bar will make extrication more difficult as they can be constructed from HSLA and the bars surround the entire doorframe.

ISSUES FOR RESCUERS

Before any door is removed from a vehicle, the inside of the vehicle must be inspected. The rescuer needs to look at where the intrusion bar is in relation to the patient. The intrusion bar could be damaged and any addition force on the door may encourage it to protrude into the cabin of the vehicle.

As the intrusion bars may be manufactured from HSLA/toughened materials standard tools will find it difficult to cut or spread and other tactics and techniques will need to be employed. For example this may involve the cutting of the mild steel brackets that holds the intrusion bar in place.

2.4. HINGES & DOORS

Hinges on motor vehicles come in several forms. Hinges can be welded, bolted from the inside, bolted from the outside or a combination of both. Some hinges are bolted to the body of the motor vehicle externally with a small bolt or screw holding the hinge from the inside. This type of screw on the hinge is called a “keeper”. Normal door extrication techniques can be used on all these hinges except those hinges made of high-strength alloy material.

All hinges come in two parts, they have a pin that joins the two parts of the hinge together. The doors that have welded hinges have easily removable pins. Simply punch the pins out and the door and the door will come away from the body of the vehicle.

Hinges that are welded into position are the easiest to remove. The weld holding the hinge in place is the weakest point. Like bolted hinges, rescuers should concentrate their efforts on tearing away the hinge from the body of the vehicle by spreading it away from the frame. Ideally this would involve spreading the top hinge from the top and spreading the bottom hinge from the bottom.

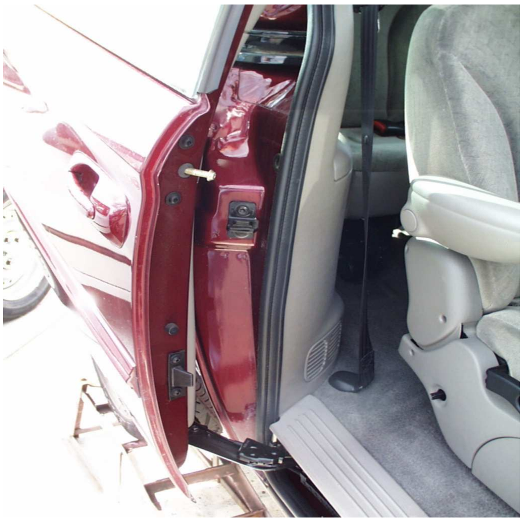
High-strength hinges

High-strength alloy hinges are welded into place. They may also be made from Boron steel or similar high strength metals. Standard rescue tools will not cut these hinges. Attempting to cut a high strength alloy or similar metals may result in tool failure. Tool failure may also result in disintegration of the tool, causing pieces of it to become shrapnel.

Sliding Doors

Mini-vans or people movers are popular in Australia. The two front doors of these vehicles are very similar to those found on other motor vehicles but the side sliding door will present problems to the rescuer. People movers may have one or two sliding side-access doors plus a rear-opening door. The rear-opening door is usually on gas struts and lifts upward. Both side-opening doors will slide parallel with the body of the vehicle to open.

During a collision, the force of the impact will be transferred away from the occupants through to the body of the vehicle. This is a design feature. The body of these motor vehicles will ripple if not crushing the panels on the sides of the vehicle. Any panel damage to these vehicles will render the side opening access doors inoperable. A small amount of damage to the small tracks that guide the doors open will stop the doors from opening jamming the door either closed or partially open. Some luxury mini-vans will even have electric opening doors that will prove to be more difficult to open.



Reciprocating Saws and air chisels are the best tools to use on people moving type vehicles. Both these tools are very quick in gaining access to obstructed hinges, locks etc. As these vehicles are large and may contain many passengers (casualties) a multi-tool attack to gain access to the occupants is vital.

Rear Opening Doors

Until recently all motor vehicles had forward opening doors. Rear opening or "suicide doors" as they were known back in the 1930's have made a comeback. Suicide doors can be found in many models of vehicles from sports cars to commercial vehicles.

Forward opening rear doors can not be opened until the front door is fully open. The handle to open the rear door is hidden by the front door when it is closed.

Vehicles fitted with suicide doors could prove to be more difficult to access patients in both frontal and t-bone motor vehicle accidents. These vehicles technically don't have a B Pillar. Therefore even in a small impact the doors may jam shut. Rescuers will need to identify this type of vehicle quickly as the technique needed for a side extrication will differ from normal side-out rescue techniques.

The locking mechanism on the top and bottom of the forward opening rear doors is the same as the ones used for rear opening doors. The only difference is the Nada bolt, pin, latch, etc are mounted in the horizontal position NOT the vertical position like on standard vehicles.

With no B Pillar, extreme care needs to be taken. If the rear door is forced from the hinges (closest to the rear wheels) care needs to be taken to see if both doors are not bending or pivoting inwards towards the patient. Rescuers must be aware that this style of B Pillar construction may lead to uncharacteristic movement when cutting or spreading. Also be aware of side or door mounted airbag systems or roof mounted airbag curtains on some vehicles.

This is the rear-opening door of the Mazda RX-8. Note the reinforcing used to stiffen and strengthen the door. The metal bar painted red in the photo is actually hardened. The door is locked in the closed position at three separate points. One locking point is where the door locks into the roofline. The second is in the middle of the door where the door handle-lock is located and the third is where the door locks into position on the sill of the vehicle. Including both hinges, rescuers will have to deal with five separate points in order to totally remove this door.

Another issue with the Australian Mazda RX-8 is that the door skin on the rear opening door is aluminium, like the bonnet, and special care needs to be taken when an extrication is to take place. The extrication techniques and door characteristics will all be different as the aluminium door skin will act differently than a door skin made of conventional sheet metal.

The aluminium door skin will fold a lot easier than a steel door skin so special care needs to be taken to the prevent skinning the door. Skinning the door is when the outer door skin peels away from the structure of the door decreasing the strength in the door and making its removal much more difficult.

ISSUES FOR RESCUERS

Standard rescue tools will not cut hinges made from high strength metals. Attempting to cut a high strength alloy or similar metals will result in tool failure. Tool failure may also result in disintegration of the tool, causing pieces of it to become shrapnel. The practice of using normal motorised hydraulic shears to cut a motor vehicle hinges should cease on new motor vehicles unless the tool operator is convinced the hinge is not made of a HSLA or toughened metal.

Doors can be removed in some situations without the use of motorised hydraulic tools by the simple application of a Pin Punch to punch out the pins that hold the door to the door hinge.

In a multi tool attack, this technique will compliment the use of motorised hydraulic tools in the speedy access to the patient.

Rescuers must be aware that on vehicles with suicide doors, this style of B pillar construction may lead to uncharacteristic movement when cutting or spreading. Be aware of side or door mounted airbag systems or roof mounted airbag curtains on certain vehicles. Cutting the top of both doorframes, front & rear where the B pillar is normally located, will isolate the top locking mechanism from the remainder of the doors.

Options may be to:

- perform a side removal starting from the front door hinges and working backward toward the rear door,
- cutting the roof with shears or reciprocating saw where the B pillar contacts the roof, taking into account the strength in the roof, place the hydraulic spreaders in the opening between the roof and either door and spread the door away.
- cross ramming. This should not be over looked as this technique will reduce the intrusion of the doors during a side-out extrication. Cross ramming is the technique of putting a large ram between the two B Pillars or similar strong points to force parts of the motor vehicles outward.

2.5. BATTERIES & ELECTRICAL SYSTEM

(This section will not cover electric motor vehicles)

All motor vehicles today have a battery. Some have two batteries. With the introduction of devices in motor vehicles such as GPS navigation, DVD players etc, the need arises for more power. That means a bigger battery or several smaller batteries.

The vehicle battery is used to store power to start the engine and to run auxiliary devices. The vehicle electrical system in the majority of motor vehicles is 12-volt and most heavy vehicles 24-volt. This has been the case for many years.

Locating the battery

In most cars the battery or batteries can be found in the engine bay under the bonnet. It is not uncommon for vehicles to have two batteries. The placement of the battery in the front of the engine bay area means that the battery is within the crumple zone during most crashes. Thus some vehicle manufactures are locating the battery in alternate locations. Placement of the battery away from the engine bay in a cooler location will also extend the life of an automotive battery because it will no longer be exposed to extremes of temperatures generated by the engine. These batteries may be disguised from the normal appearance by plastic panels. Unfortunately these plastic panels may prove to be difficult to find let alone access the battery for isolation purposes.

Batteries in today's vehicles may be found in the following areas:
- Under the bonnet.
- Inside front quarter panels.
- Inside the vehicle, under the front or rear seats.
- Inside the boot.
- Inside rear quarter panels.
- In or under the tray of a ute.

If during the inspection under the bonnet of a new motor vehicle you can't find a battery, look for terminal posts marked " positive and negative" in yellow, red or black paint. This indicates the battery or batteries are out of sight, and these two terminals are to be used to jump-start the vehicle. For the rescuer this is a sign that a battery, or batteries, are hidden in the vehicle.

THIS HONDA HAS A BATTERY LOW DOWN BEHIND THE INDICATOR LENS.

Capacitors

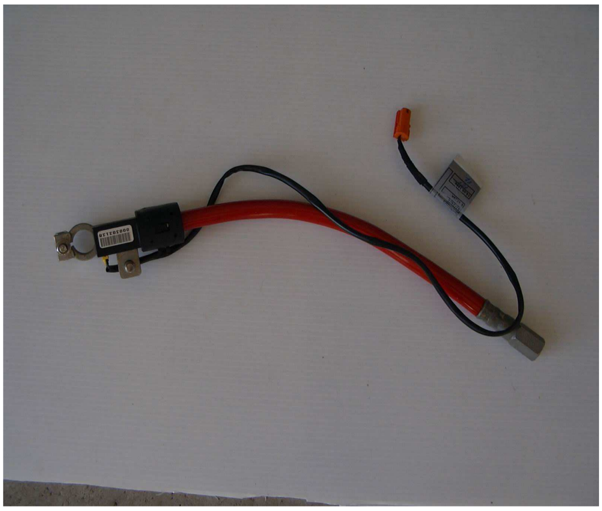
Vehicle manufactures have also built capacitors into the vehicle to energise the electrical system for a short period of time should the battery be disconnected or damaged. This is a safety feature in vehicles so the airbags, supplementary restraining devices, etc. can be activated if the battery is destroyed during an accident.

There is debate as to how long a capacitor will hold charge in the vehicle and thus how long a loaded airbag will be armed and dangerous. The capacitors will be drained of power within approximately 2 minutes. Generally speaking, by the time a rescue vehicle or ambulance arrives on scene, the capacitors will have been drained. This does not, however, suggest the rescuer should be complacent about air bags, supplementary restraining devices, etc. The rescuer still needs to turn the ignition key off, isolate the battery and warn other rescuers of the dangers that the particular vehicle may have.

The Future

Car manufactures are approaching the limit of what today's 12-volt electrical systems can handle. Next generation power-trains, as well as new technologies such as Internet access, mobile phones and navigation equipment will require manufacturers to move up to a 42-volt system. Ford engineers are preparing for the shift to 42-volt systems saying: "The question isn't IF the industry will shift but WHEN." With 42-volt systems, components such as brakes, transmission and steering will all be linked to a computer to react to road conditions. Higher voltage systems also will have fuel savings benefits making the IC engine more efficient by running accessories such as air-conditioners and power steering. These electrical systems initially will be more expensive and are likely to appear in luxury cars first. Ford says 42-volt systems could begin appearing on cars as early as 2006.

BMW has developed what it calls “battery safety terminal”. Connected to the positive lead that connects to the battery is an explosive charge. Yes, an explosive charge! When a collision occurs and the frontal airbags are activated, the explosive charge detonates cutting the power lead from the battery to the vehicle. It does however still supply power to the vehicle hazard light, electric windows and interior light. This is another example of when cutting or unbolting the power lead to a battery you <u>must</u> remove all wiring off that battery posts.



ISSUES FOR RESCUERS

Shutting off the ignition and **removing the key** is a good idea at the scene of any motor vehicle accident. Most of the electrical functions of a car remain on a hot-switch circuit, meaning the electricity flows through the ignition switch before routing to the object it controls. The most important benefit of removing the key from the ignition is it keeps a disoriented patient from starting the engine. Once a car has crashed and it is no longer in an "as-engineered" state, all safety bets are off. Neutral safety switches can fail, and the car may start with the transmission in the drive position. Air bags can short-circuit, remain "live" and deploy accidentally. However, shutting the key off works well because it opens the circuit at a common point, adding a measure of safety in most cases.

Locate and disconnect both battery terminals. If during the inspection under the bonnet of a new motor vehicle you can't find a battery, look for terminal posts marked " positive and negative" in yellow, red or black paint. This indicates the battery or batteries are out of sight. Batteries may be found in areas such as inside front or rear quarter panels, under the front or rear seats, inside the boot as well as in the engine bay. Don't forget to check the car owner's manual—usually still in the glove box.

No matter what condition the battery or batteries are in, they must be disconnected. Batteries that look totally destroyed can still have enough energy inside them to activate the vehicle air bags, supplementary restraining devices, etc. When disconnecting the battery leads, be aware the leads may spring back to its original position, contacting the terminal and re-energising the vehicle's electrical system.

It is important that the electrical system is isolated by disconnecting both battery terminals, starting with the negative side first. This may prove difficult in a frontal collision. Unbolting the leads is better practice than cutting, as it may be necessary to re-energise the vehicle (eg. to move an electric seat). Extreme caution needs to be taken if this is to take place. When either cutting or unbolting the lead, all leads connected to that battery post must be disconnected. Any cables left connected to that battery terminal could still energise the electrical system of the vehicle endangering rescuers and patients.

2.6. CATALYTIC CONVERTERS

The Catalytic Converter was introduced into the Australian motor vehicle market in the late seventies early eighties. It is basically designed to clean up the emissions from the motor vehicles exhaust and is found on just about all motor vehicle on the Australian roads. The catalytic converter is found under the floor of the vehicle on the exhaust system. They appear as an expanded metal vessel attached to the exhaust system. In most vehicles there are at least two catalytic converters fitted to each exhaust pipe. The muffler on a motor vehicle should not be confused with a catalytic converter. They are completely separate units.

For a catalytic converter to work effectively it must operate around 700 degrees Celsius or 1300 degrees Fahrenheit. An idling or stationary vehicle may generate temperatures of over 1000 degrees Celsius or 2000 degrees Fahrenheit. Shields and insulation help keep the radiant heat away from the passengers inside the vehicle but are not used on the outer side of the converter. As standard road crash rescue training, we are made aware of the dangers of a hot exhaust pipe. The exhaust pipe temperature will be several hundred degrees but the catalytic converters will be many hundreds of degrees hotter again.

ISSUES FOR RESCUERS

The exhaust system of a motor vehicle, especially the catalytic converter, is often over-looked as a potential danger to patients and rescuers.

Accidental contact to the catalytic converters could easily occur if a vehicle is either on its side or on its roof. Bare skin or even gloved hands will have little chance against the high temperatures generated around the catalytic converter. Extreme care needs to be taken to when working on or around the underside of any motor vehicle.

Nylon ratchet straps, ropes and timber shoring used in various stabilisation techniques to make a vehicle safe to enter will not be able to withstand such high temperatures and may even start a fire when the material burns. Vehicle familiarisation and safe work practices is the key to working around catalytic converters that have the potential cause severe injuries.

3. VEHICLE INTERIOR

Like the exterior, the interior of today's motor vehicles have changed greatly. Gone are the heavy bakelite steering wheels, steel dash boards and sharp edges. The interiors of today's vehicles are designed not only for style and looks, but also to assist occupants in the case of a collision. During a collision, the occupants may also collide with the interior of the vehicle. The fabrics used today are designed to create less friction on the skin when flesh comes into contact with it. Steering wheels are now lighter and flexible and are designed to bend when impacted, unlike the older one's. Dashboards are designed to flex not break and no longer have sharp edges. They are now, to a degree, softer and contain safety features like airbags.

The interior of modern motor vehicles contain many safety features that the average person is not aware of, such as seatbelt pre-tensioners, pyrotechnics, airbags, break away pedals, tear proof locks, whiplash resistant headrest, and sometimes even roll bars!

3.1. AIRBAG SYSTEMS

Airbag technology continues to improve with every new vehicle introduced. From its beginnings with only driver's side airbags, airbag technology has expanded to include passenger front, side, and knee airbags, side curtains, and seat-belt pre-tensioners.

Air bags are made of a tightly knitted nylon fibre. The air bag is often covered in "Corn Starch" to act as a lubricant during activation.

Vehicle occupants can be hurt by airbags. One of the most common injuries is friction burn from the high speed of the airbag material rubbing against a person as it deploys. If there are objects between the airbag and the passenger when the airbag deploys, these objects can strike the passenger with tremendous speed. Drivers should place their hands on the steering wheel in the 3 and 9 O'clock positions to reduce the possibility of their hands striking them in the face. Passengers should be sitting in a comfortable upright position. Under no circumstance should anyone in a motor vehicle place his or her feet or knees against the dashboard. If an airbag was to deploy whilst feet, knees, legs or anything else were in contact with the dash, there could be fatal consequences.

To reduce the possibility of injury from front airbags, manufacturers have "de-powered" them in the last few years. Less forceful inflation rates are still designed to protect in most situations, but some manufacturers choose to use two-stage airbags that will inflate with less force or more force depending upon sensor inputs and accident conditions. One result of two-stage airbags is that the airbag may still be charged after an accident although it has already inflated. Even inflated airbags should be handled as if they could go off. An airbag that has not deployed is referred to as “**loaded**”. This loaded airbag is a danger to anyone inside the vehicle, be that the vehicle occupants or a rescuer.

Holden has optimised the performance of its driver and passenger airbags to suit seatbelt-wearing occupants. This means that Commodore airbags will not deploy in collision situations where seatbelts provide sufficient protection, or situations where airbags cannot contribute to occupant protection. The airbags will deploy in the case of a severe frontal or offset frontal collision that carries a high injury risk.

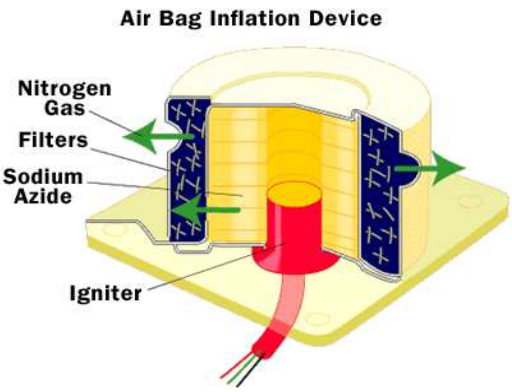
The Holden airbag features a ‘soft’, non-aggressive inflation onset. Its unique E-fold pattern and interior tethers cause it to inflate with a flat surface, eliminating the risk of it catching under the chin and causing neck injury.

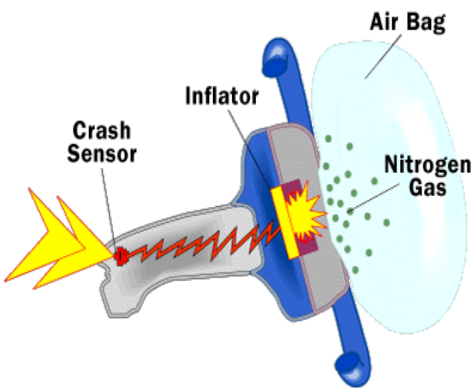
Airbags are not perfect. They are designed to help protect vehicle occupants during life-threatening accidents. Seatbelts, alert drivers, and good vehicle condition are still the best safety features.

How they Work

Most airbags still use pyrotechnic charges to trigger inflation. A small igniter starts sodium azide burning, which produces nitrogen gas. The nitrogen gas inflates the airbag. A white powder created by the chemical reaction may irritate skin but most powder after an airbag deployment is just corn starch or talcum powder packed with the airbag to lubricate it as it opens up.

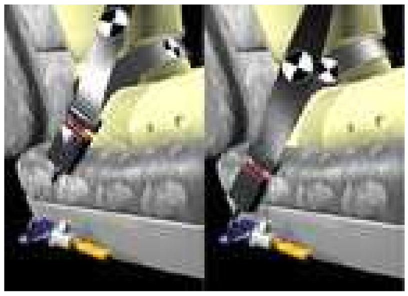
A compressed gas cylinder inflates some airbags. An explosive charge punctures the end of the cylinder allowing the gas into the airbag. Heat from the charge helps the gases expand so the airbag deploys quicker. From the instant crash sensors detect an impact until the airbag is inflated takes only thousandths of a second. High-speed cameras are needed to catch an airbag inflating. It occurs so quickly that our eyes cannot see it happening.





Seatbelt Pre-tensioners

Seatbelts are an integral part of airbag systems. They hold driver and passengers in position for airbags to work effectively. Some manufacturers are using seatbelt pre-tensioners, which are explosive charges that pull the seatbelts tight around the occupant just before the airbag is deployed. This seatbelt must be replaced after the pre-tensioner has been activated.

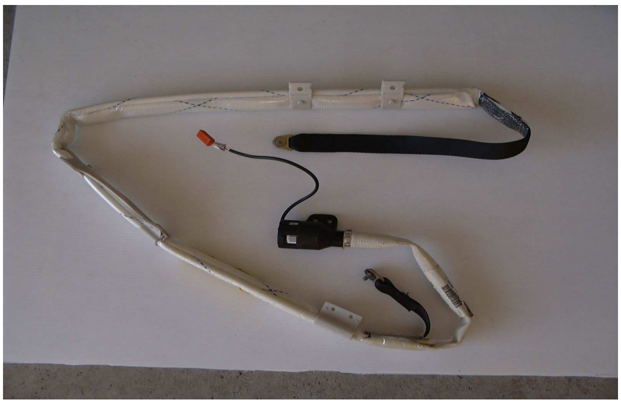


Side Airbags

Side airbags are usually located in the sides of the seats although some are located in the side doors. Some manufacturers use special sensors on side airbag systems. Honda has position sensors in the side of the passenger bucket seat that will prevent the side airbag from deploying if the passenger is in the wrong position. Jaguar uses ultra-sonic sensors to help determine passenger position before deploying airbags. Seat track position sensors are also used in some vehicles to determine airbag deployment force.

The white material scene in this picture is actually the folded up "loaded" airbag. The airbag is only 25mm in diameter but run the entire length of the roof line of the BMW.

The black straps are the retaining straps that bolt into the body of the vehicle, while the orange plug is the electrical lead that detonates the airbag. Unfortunately for rescuers, the activation canister is mounted very close to the bottom of the A pillar and the top of the front door hinge. These locations are often the exact position where hydraulic tools are placed during an extraction. This is another example where it is essential that the tool operator 'looks before cutting or spreading'.



Side Curtain Airbags

Side curtain airbags are becoming common in many vehicles and will become more prevalent as time goes by. BMW, Mercedes, Volvo, SAAB have them, but Toyota, Nissan, Ford and Mazda are increasingly using them also. Manufacturers use the side curtain airbags to cover the side windows, protecting occupant's heads during side impacts and roll overs. This can protect the occupant from objects entering the vehicle as well as the head coming into contact with the side of the vehicle. Some vehicles such as the Ford Explorer and Volvo, keep the side curtains deployed for up to 6 seconds if a roll-over occurs, compared to only a fraction of a second for front air bags.

Airbags and Pedestrians

Many cars have airbags on the inside of the car to help protect passengers during accident, but what about protecting pedestrians during an accident? A Ford Motor Company concept uses two innovative airbag systems on the outside of the car designed specifically to protect pedestrians during an impact. Activated by a pre-crash sensor, an over-the-bonnet airbag deploys from an area located just above the bumper.

The airbag spans the area between the headlamps and extends from the top of the bumper to several centimetres over the bonnet. A second airbag mounted in the cowl is designed to offer head protection for a secondary impact, such as when a pedestrian is thrown over the hood toward the base of the windshield. The two airbags each extend from the centre-line of the vehicle to the corresponding A-pillar and are triggered by a sensor that detects the pedestrian's initial impact with the bumper.

Other Innovations

The newest innovation in airbag systems is Mercedes Pre-Safe. Studies show that most impacts are preceeded by a few seconds of reaction by drivers. The Pre-Safe system senses the driver's reaction and vehicle movement to predict an impact. It then closes the sunroof, moves the passenger seat to the optimum position, and tensions the seatbelts with re-useable pre-tensioners to hold occupants in position before the impact occurs.

Some airbags use seat sensors to deactivate the system if nobody is sitting in the seat. This reduces repair costs if there are no passengers in the vehicle.

Locations of Undeployed Airbags

Airbags can be found in many locations on a motor vehicle. The most common areas are:

Driver	Passenger
Steering Wheel	Front Dash Board
Inside the Drivers Door	Inside of passenger Door
In the B Pillar	In the B Pillar
In the roof lining	In the roof lining

Manufacturers are introducing airbags in many other areas, such as:

- Under the steering column, to protect the knees
- Under the glove box to protect the front seat passenger.
- Under the pedals, reduce entrapment by the pedals
- Under the drivers and front seat passengers knees, to stop “submarining”
- Inside the seat below the knees of the driver and front seat passenger, to stop “submarining”
- Rear passenger door similar to front seat driver & passenger.
- Rear seat passengers side airbags mounted in the rear seat.
- Air bags in the rear of the front seats for rear seat passengers.
- External pedestrian airbag, to help reduce injuries to pedestrians.

Identification of Airbags

Today, there is an almost endless list of locations where to look on a motor vehicle to see if it has airbags fitted, and the list continues to grow. The new BMW, Volvo and Mercedes have up to 12 airbags fitted as standard features. The signs of an airbag installed may include the following initials and/or wording:

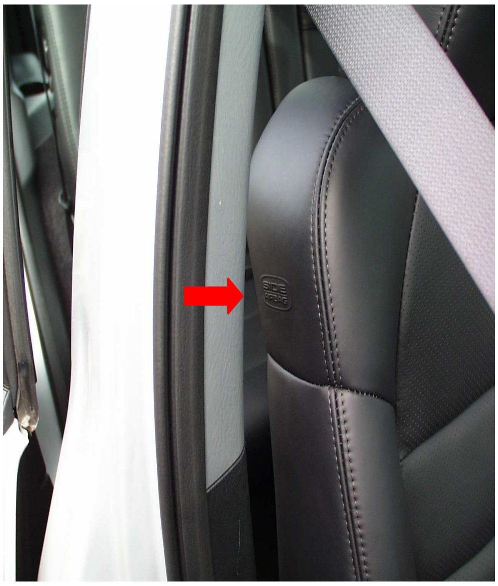
- HPS (Head Protection System)
- SIPS(Side Impact Protection system)
- SRS (Supplementary Restraint system)
- ITS (Inflatable Tube System)
- AB (AirBag)
- SIBS (Side Impact)
- ROPS (Roll Over Protection Structure)
- AIRBAG
- CAB (Curtain Air Bag)
- ICA (Inflatable carpet Airbag)
- IC (Inflatable Curtain)
- SMART (A symbol for a computer controlled airbag discharge system)
- SPS (Side Passenger Safety System)

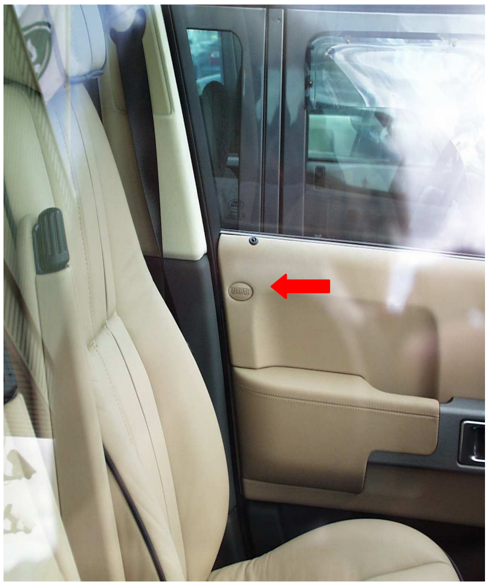
Unfortunately, it is not law to identify where an airbag is located but most motor vehicle manufacturers do provide signs of airbags. It may be a simple sticker on the inside of the door, an embroidered patch on a seat, a label printed next to the rego label on the windscreen, or a warning sign under the sun visor. A crease in the steering wheel, dashboard, roof lining, inside door skin, rear of the front seats, the sides of the rear seats or the outsides of the front seats may also be a sign that an airbag is present.

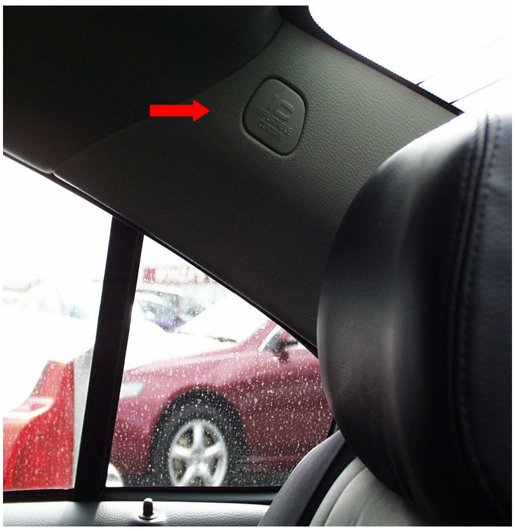
The following pictures are examples of signs that airbags are present.

WARNING FOUND ON SIDE WINDOW

WARNING LABEL ON WINDSCREEN


SYMBOL ON SIDE OF SEAT


SYMBOL ON INSIDE OF DOOR.


AIRBAG ID LABEL ON THE INSIDE OF THE C PILLAR


AIRBAG ID LABEL ON THE ROOF LINING

ISSUES FOR RESCUERS

A deployed airbag is of no danger to the occupants or to the rescuer, BUT undeployed airbags (**loaded**) can present risks for rescue personnel. Today, airbags have sensors that will not deploy an airbag if either the computer doesn't deem it warranted or if the seat is vacant. When approaching a vehicle involved in a crash, rescuers must be aware that loaded airbags may be present. They should scan the vehicle interior for possible loaded airbags BEFORE entering the vehicle. If a loaded airbag is found, ALL rescue personnel on scene should be informed. The recommended procedures for working in and around a vehicle with loaded airbags exist to ensure maximum safety for personnel and patients while the necessary tasks are completed.

There are four potential hazards that rescue personnel should avoid when working around loaded airbags:

1. Unintentionally powering the electrical system may cause an airbag to deploy.
2. Exposing the propellant of an airbag to heat, spark, or static electricity. This includes any force onto the loaded airbag.
3. Puncturing or cutting into the high-pressure cylinder of a stored gas airbag system.
4. A rescuer placing themselves, the patient, or their equipment within the inflation zone of a loaded airbag.

Generally speaking, a side airbag will protrude approximately fifteen centimetres outward from its stored location. A driver's side airbag will extend approximately 30 centimetres from the steering wheel, and a passenger side air bag will travel as much as 50 centimetres from the dash. This rule does not factor in the new dual-chamber thorax bags and the other side airbags that deploy from the upper roof rails. While these side airbags only extend out approximately fifteen centimetres, they also fill part or all of the side window area. So it would be prudent to not put yourself in a position where any of your body goes through the window. However, the delivery of emergency medical services still depends on medical personnel touching the patient. If you must reach into the car, do so for only a moment until someone has isolated the vehicles electrical system.

3.2. SEATBELTS & PRE-TENSIONERS

Over the years, seatbelts have proven to be far and away the most important safety device in cars and trucks. They are by no means infallible, however, and vehicle safety engineers see a lot of room for improvement in today's design. In the future, cars will be outfitted with better belts, better airbags and, most likely, completely new safety technology.

A typical seatbelt consists of a lap belt, which rests over the pelvis, and a shoulder belt, which extends across the chest. The two belt sections are tightly secured to the frame of the car in order to hold passengers in their seats. When the belt is worn correctly, it will apply most of the stopping force to the rib cage and the pelvis, which are relatively sturdy parts of the body. Since the belts extend across a wide section of the body, the force isn't concentrated in a small area, so it can't do as much damage.

Additionally, the seatbelt webbing is made of more flexible material than the dashboard or windshield. It stretches a little bit, which means the stop isn't quite so abrupt. The seatbelt shouldn't give more than a little or the wearer might hit the steering wheel or side windows etc. Safe seatbelts will only allow the wearer to shift forward slightly.

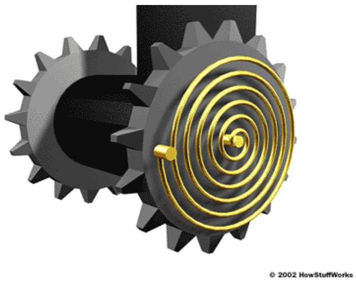
A car's crumple zones do the real work of softening the blow. Crumple zones in the front and rear of a car collapse relatively easily. Instead of the entire car coming to an abrupt stop when it hits an obstacle, it absorbs some of the impact force by crushing, like an empty soft drink can. The car's cabin is much sturdier, so it does not crumple around the passengers. It continues moving briefly, crushing the front of the car against the obstacle. Of course, crumple zones will only protect vehicle occupants if they move with the cab of the car - that is, if they are secured to the seat by the seatbelt.

The simplest sort of seatbelt, found in some roller coaster rides consists of a length of webbing bolted to the body of the vehicle. These belts hold the wearer tightly against the seat at all times, which is very safe but not particularly comfortable. Car seatbelts have the ability to extend and retract - you can lean forward easily while the belt stays fairly taut. But in a collision, the belt will suddenly tighten up and hold you in place.

Extend and Retract Seatbelts

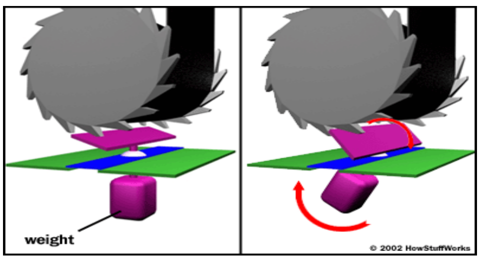
In a typical seatbelt system, the belt webbing is connected to a retractor mechanism. The central element in the retractor is a spool, which is attached to one end of the webbing. Inside the retractor, a spring applies a rotation force, or torque, to the spool. This works to rotate the spool so it winds up any loose webbing.

When you pull the webbing out, the spool rotates counter-clockwise, which turns the attached spring in the same direction. Effectively, the rotating spool works to untwist the spring. The spring wants to return to its original shape, so it resists this twisting motion. If you release the webbing, the spring will tighten up, rotating the spool clockwise until there is no more slack in the belt.



The retractor has a locking mechanism that stops the spool from rotating when the car is involved in a collision. There are two sorts of locking systems in common use today:

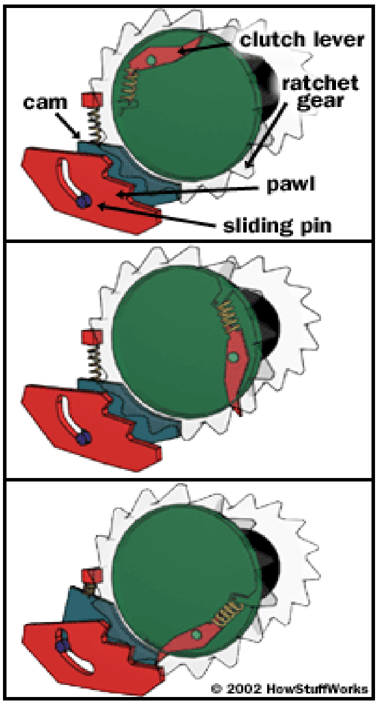
- systems triggered by the car's movement
- systems triggered by the belt's movement



The first sort of system locks the spool when the car rapidly decelerates (when it hits something, for example). The diagram shows the simplest version of this design.

The central operating element in this mechanism is a weighted pendulum.

When the car comes to a sudden stop, the inertia causes the pendulum to swing forward. The pawl on the other end of the pendulum catches hold of a toothed ratchet gear attached to the spool. With the pawl gripping one of its teeth, the gear can't rotate counter-clockwise, and neither can the connected spool. When the webbing loosens again after the crash, the gear rotates clockwise and the pawl disengages.



The second kind of system locks the spool when something jerks the belt webbing. The activating force in most designs is the speed of the spool rotation. The diagram shows a common configuration.

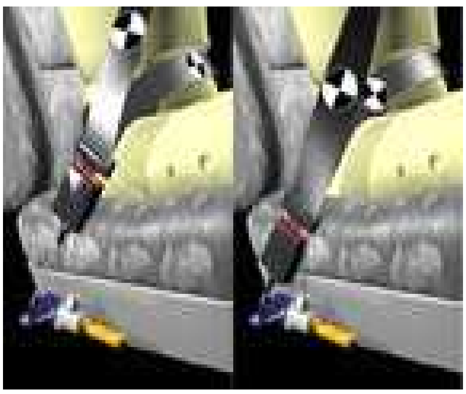
The central operating element in this design is a centrifugal clutch - a weighted pivoting lever mounted to the rotating spool. When the spool spins slowly, the lever doesn't pivot at all. A spring keeps it in position, but when something yanks the webbing, spinning the spool more quickly, centrifugal force drives the weighted end of the lever outward.

The extended lever pushes a cam piece mounted to the retractor housing. The cam is connected to a pivoting pawl by a sliding pin. As the cam shifts to the left, the pin moves along a groove in the pawl. This pulls the pawl into the spinning ratchet gear attached to the spool. The pawl locks into the gear's teeth, preventing counter-clockwise rotation.

The Pre-tensioner

In some newer seatbelt systems, a pre-tensioner also works to tighten the belt webbing. The idea of a pre-tensioner is to tighten up any slack in the belt webbing in the event of a crash. Whereas the conventional locking mechanism in a retractor keeps the belt from extending any further, the pre-tensioner actually pulls in on the belt. This force helps move the passenger into the optimum crash position in his or her seat. Pre-tensioners normally work together with conventional locking mechanisms, not in place of them.

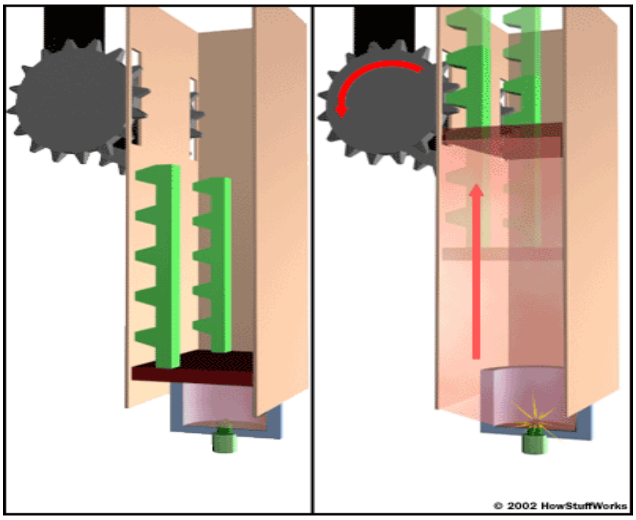
There are a number of different pre-tensioner systems available. Some pre-tensioners pull the entire retractor mechanism backward and some rotate the spool itself. Generally, pre-tensioners are wired to the same central control processor that activates the car’s airbags. The processor monitors mechanical or electronic motion sensors that respond to the sudden deceleration of an impact. When an impact is detected, the processor activates the pre-tensioner and then the airbag.



UN-DEPLOYED DEPLOYED

Some pre-tensioners are built around electric motors or solenoids, but the most popular designs today use pyrotechnics to pull in the belt webbing. The diagram below shows a representative model.

The central element in this pre-tensioner is a chamber of combustible gas. Inside the chamber, there is a smaller chamber with explosive igniter material. This smaller chamber is outfitted with two electrodes, which are wired to the central processor.



When the processor detects a collision, it immediately applies an electrical current across the electrodes. The spark from the electrodes ignites the igniter material, which combusts to ignite the gas in the chamber.

The burning gas generates a great deal of outward pressure. The pressure pushes on a piston resting in the chamber, driving it upward at high speed. A rack gear is fastened to one side of the piston. When the piston shoots up, the rack gear engages a gear connected to the retractor spool mechanism. The speeding rack rotates the spool forcefully, winding up any slack belt webbing.

Load Limiters

In severe crashes, when a car collides with an obstacle at extremely high speed, a seatbelt can inflict serious damage. As a passenger's inertial speed increases, it takes a greater force to bring the passenger to a stop. In other words, the faster you're travelling on impact, the harder the seatbelt will push.

Some seatbelt systems use load limiters to minimise belt-inflicted injury. The basic idea of a load limiter is to release a little more excess belt webbing when a great deal of force is applied to the belt. The simplest load limiter is a fold sewn into the belt webbing. The stitches holding the fold in place are designed to break when a certain amount of force is applied to the belt. When the stitches come apart, the webbing unfolds, allowing the belt to extend a little bit more.

More advanced load limiters rely on a torsion bar in the retractor mechanism. A torsion bar is a length of metal material that will twist when enough force is applied to it. In a load limiter, the torsion bar is secured to the locking mechanism on one end and the rotating spool on the other. In a less severe accident, the torsion bar will hold its shape, and the spool will lock along with the locking mechanism. But when a great deal of force is applied to the webbing (and therefore the spool), the torsion bar will twist slightly. This allows the webbing to extend a little bit further.

Another addition to seatbelt technology is “slow release stitching”. These special threads are sewn into the area of the seatbelt near its permanent attachment point. During a frontal collision the forces of the crash propel the passengers forward at such a force that these threads tear, slowing down the forward movement of the belted driver or passenger. A sign of this type of seat belt webbing or stitching used in motor cars involved in a crash would be a patch of fuzzy fibres at the base of the seat belt. The medical personnel attending a crash scene could use this sign to determine the patient's mechanism of injury.

The Future

Ford Motor Company is experimenting with a new safety belt design that could better protect drivers, while delivering improved comfort. Safety belts, when used properly, provide the best form of protection in an accident. Ford is taking the next step in safety by asking how we can make the best even better? To help achieve this, Ford is looking at consumer complaints about the comfort of safety belts and researching a concept borrowed from the company's extensive involvement in auto racing. A four-point suspender-type belt would move the belt fabric further out onto the shoulder and away from digging into the occupant's neck providing a higher level of comfort while effectively securing the occupant. Another style Ford is researching is a variation of the well-known three-point belt that adds a second belt, which criss-crosses down from the other shoulder. The use of two shoulder belts may better distribute crash loads across the chest, reducing the potential for injury. A third possibility being explored is an inflatable tube that can deploy from within a shoulder belt in the event of a crash. All three methods are being analysed and tested for effectiveness in safety and customer preference.

ISSUES FOR RESCUERS

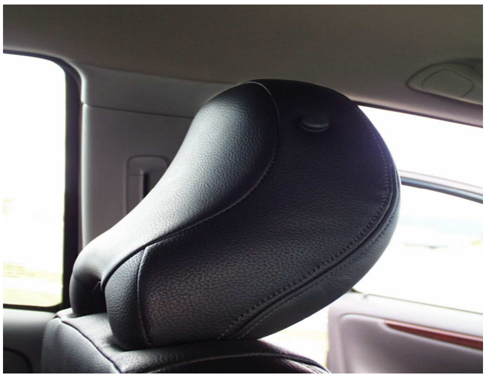
If the frontal airbags did not deploy, it would be safe to say that the seat belt pre-tensioners did not deploy. The same precautions as undeployed (loaded) airbags precautions must be taken. Disconnecting the power from the battery drains the airbag electrical system capacitors and also disables the seat belt pre-tensioners electrical system if it's design is electrically fired.

3.3. HEADRESTS & SEATS

The simple headrest has moved into the 21st century. Most people probably think headrests are just for comfort, but headrests are a very important safety device. In the event of a collision the headrest acts as a head restraint, stopping the head from extending too far back and therefore reducing the chance of head and neck damage due to whiplash.

Head rests of yesterday were a simple extension of the seat. The headrest often extended in excess of 25cm from the top of the seat. Today they are separate units, adjustable to the individual and designed to catch the head and prevent it from moving too far back. Engineers have designed the headrest to be as little as 7cm from the individual's head.

Some manufacturers have a headrest that acts on a slide arrangement. In the event of sudden deceleration, the headrest will move forward to catch the occupant's head. Other manufacturers have a headrest that tears in half, once again, to protect the occupant's heads from moving too far in the event of sudden deceleration.

Saab Active Head Restraint (SAHR)

The Active Head Restraints in the front seats help to reduce the risk of whiplash injuries. If the forces in a rear-end collision exceed a certain level, the head restraint is activated by the seat occupant's body weight. The head restraint moves upwards and forwards, thus catching the head as it moves backwards.

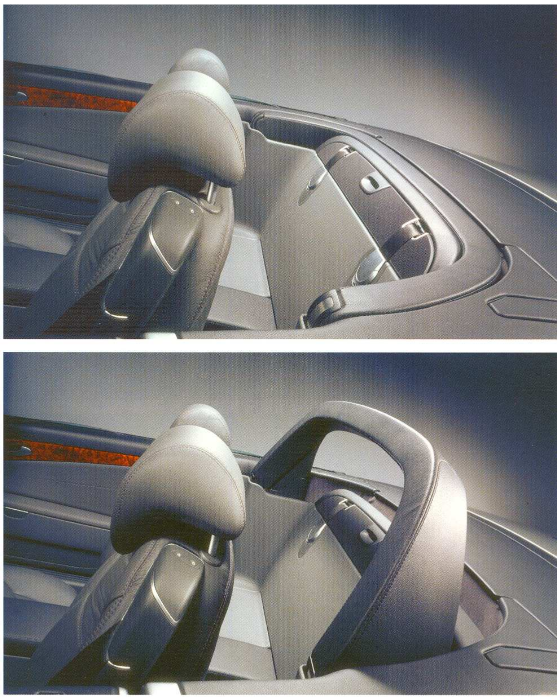
WHIPS, now fitted to the front seats of all Volvos, works by bending the seat backrest backward as the occupant's body is thrown backwards - first in parallel and then in a short reclining movement. At the same time the fixed head restraint, designed to be as close to the back of the head as possible, effectively catches the head to minimise the effects of whiplash.

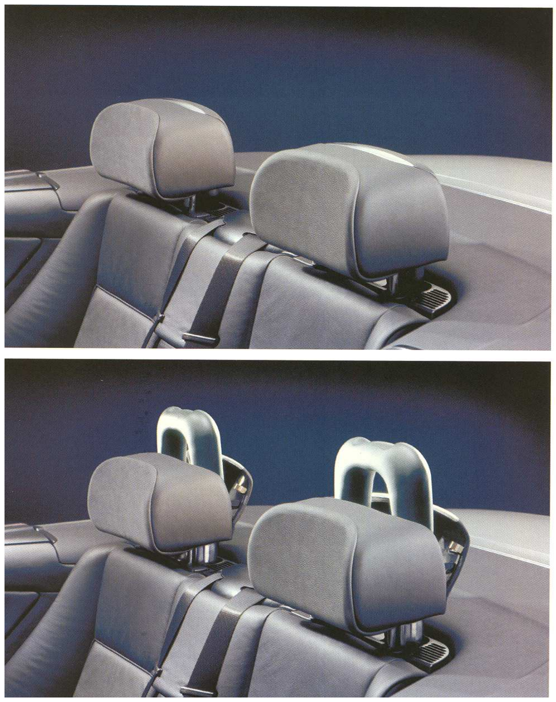
Deployable Rollbar Systems

Some vehicle manufactures have included pyrotechnic devices in their headrests so that in the event of a roll over, a rollbar bursts out of the top of the seat to protect the occupants.

Mercedes-Benz, BMW, SAAB and Volvo convertibles produced as early as the 1999 model may be equipped with a deployable or pop-up rollbar safety feature. These rollbars are hidden systems that consist of a concealed pair of horseshoe shaped rollbars placed below a cover or interior trim piece. Vehicles with a deployable rollbar have special sensors that deploy the rollbar instantly in the event of an impending roll over. The sensing of vehicle weightlessness, the lifting of wheels off the ground, or the excess of a vehicles pre-determined angle of tilt are all conditions that the can cause the rollbar system to pop up. The rollbar system can also be interconnected with the frontal airbag system and may deploy when either frontal air bag is deployed.

The Mercedes-Benz rollbar system has a centre dash board mounted switch that manually deploys the rollbar into the upright locked position.





Seats

Just to make things a little more interesting for the rescuers, vehicle manufacture are making seat frames out of High Strength Low Alloy (HSLA) metals. Where rescue teams consider cutting the seat back to extricate the patient, the introduction of this material to the seat will make this type of extrication more difficult if not impossible to achieve. The cutting of HSLA metals is near impossible for the average hydraulic shears.

The picture illustrates a one-piece seat frame made of HSLA. This seat frame may also act as a passive roll bar to protect the occupant.

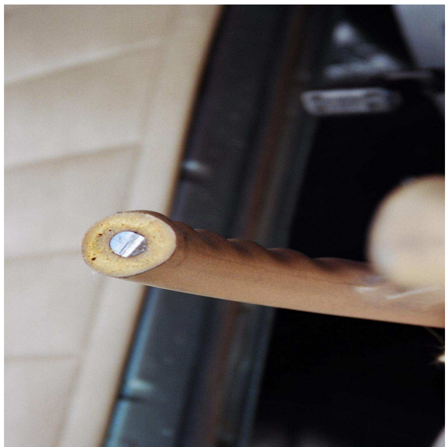
ISSUES FOR RESCUERS

Un-deployed rollbar systems pose a real safety concern to rescuers because of their location near the patients. Emergency service personnel as well as bystanders, particularly those maintaining airway and or spinal procedures, could unknowingly reach over or stand within the deployment zone of a pop up rollbar system. A rescuer performing a vehicle cutting or spreading operation could cut through or tear a wire, unexpectedly deploying the rollbar system if the vehicles electrical system has not been shut down.

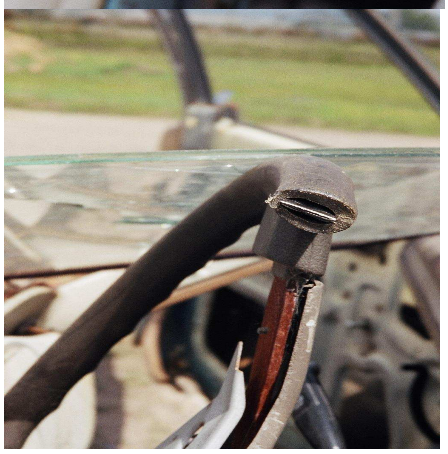
This picture shows the manufacturers warning of a “Roll Over Protection Structure”

Once rescuers have located or suspect they have a crashed vehicle with any loaded rollbars, they should shut down the vehicles electrical system. The simple isolation of the battery will minimise the chances of accidental deployment. In addition, staying out of the deployment zone maximises safety for operating personnel and patients.

3.4. STEERING WHEELS



Until recently, motor vehicle manufactures made the humble steering wheel out of rubber and steel. The inner part of the steering wheel, the part that actual gives the steering wheel strength was made of solid round bar steel approximately 8mm thick. The outer surface of the steering wheel used to be a type of bakelite and solid hard round plastic but now is a larger soft rubber material. The inner core of the steering wheel has also now changed. Instead of a solid steel rod running around the steering wheel we are now finding thin metal tubing.



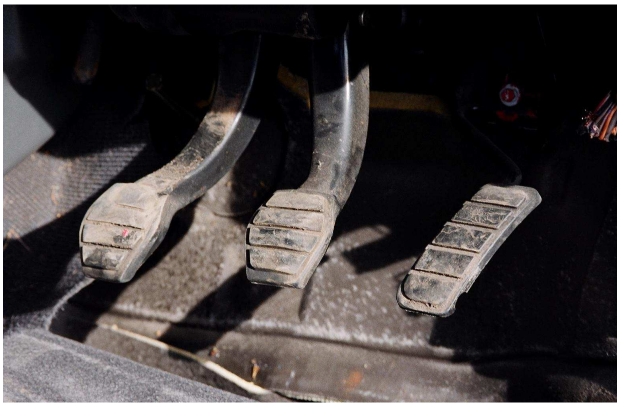
The older type steering wheels are very strong, and paramedics used the damage to the steering wheel as an indication of the damage to the patient’s upper chest, face and airway. These steering wheels were that strong and inflexible that removing the steering wheel for patient access was only achieved if the hydraulic cutting shears could access the steering wheel. Today with thinner tubing used it is designed to fold and flex, reducing the blunt trauma to a patient’s chest and airway. The material used in steering wheels is barely 2mm thick.

3.5. PEDALS

Although plastic or composite panels are on only on a few vehicles on Australia's roads today, this is slowly changing. More and more plastic or composite materials will be found in the future on and in motor vehicles.

Most vehicles of today operate with steel pedals. The Toyota Prado 4x4 has taken a step away from metal/steel materials in its clutch pedals by introducing plastic pedals. At this stage the clutch pedal is the only pedal that is plastic, with the accelerator and brake pedal remaining steel. This plastic pedal is only found on the manual model but Toyota is seriously considering introducing plastic pedals in all models. The plastic pedal is quite unique in appearance with the physical size of the pedal being approximately 5 times the width of a standard metal pedal. The width of the pedal is approximately 34mm x 34mm and the shape of the pedal shaft gives the pedal strength.

Here is another example of motor vehicle pedals that exceed 35mm. Several models of the VW range are now on the roads in Australia with brake and clutch pedals unlike anything else on the market. The pedals are made of steel but instead of having a single flat plate leading to the pedal these new pedals are actually metal C channel. Although made of steel, the C channel is at its narrowest at the pedal, and that is around 35mm increasing in size to over 50mm.



As with the new "Plastic" pedal on the Toyota Prado, very few pedal cutters have the physical opening to successfully sever these pedals

Other motor vehicle manufactures are using the break away, or tear away pedals as a safety feature to reduce the potential of having the driver's feet trapped in a collision.

ISSUES FOR RESCUERS

The issue for rescuers with plastic pedals is the physical size of the pedal. The use of a pedal cutter or small shear may be compromised due to the size of the shaft. Most pedal cutters on the market today will have difficulty cutting the pedal especially with feet and legs in close proximity to the pedals. An alternative tool may be a hand-operated hacksaw blade or similar, or the a reciprocating saw if room and patient safety is not compromised. Another option may be of bending the plastic pedal away from the patient. This has proved to be a poor option as the width of the pedal (34mm) gives it great lateral strength and flexibility. The bending of the pedal show little signs of release until it let goes in an uncontrolled fashion. A combination of cutting/sawing and gentle bending may result in a controlled release of the feet or lower leg.

Trials have even been carried with the use of a paint stripping type heat gun. A small amount of directed heat onto the pedal makes the plastic more supple and easier to bend. Although this trial works well in the test environment it may have limited application in the field.

4. CONCLUSIONS

Motor vehicle rescue is an evolving art, the boundaries are constantly changing and the rescuer is having to playing catch up with the technology and materials being used. Today's motor vehicles are no longer made of just sheet metal. New materials used in construction are increasingly common in both motor cars and heavy transports.

Metals

The metals used are newer state of the art materials like boron steel, micro-alloys, high strength low alloy (HSLA) that in some cases are over 100 times stronger than sheet metals of the past. These blended metals, or tailor-blanking as it is called, are now located in the areas where rescuers would normally cut, push, fold or flap to gain access to a patient. These metals/alloys provide superior protection to vehicle occupants during a collision, but pose a serious challenge if rescuers must extricate the casualties. Rescuers are increasingly required to understand precise details of a motor vehicle's anatomy to make effective use of available rescue tools. Only a few hydraulic rescue tools on the market in Australia today are able to contend with these new materials. Even when they can, cutting and spreading tactics are pivotal to accessing and releasing casualties.

This new technology in metals presents an important problem to rescuers. After the painting process in vehicle manufacture has been completed, a rescuer can no longer, from the outside, distinguish stronger parts of a vehicle. Determining the best place to cut the vehicle is now very difficult for a rescuer. A rescuer will only notice the difference between stronger and weaker parts when actually attempting to cut the vehicle. In most cases the rescuer will only know when the tool is not able to achieve it's task. This trial and error may lead to tool failure, which may result in injury to rescuers and/or patients. It has become even more important to have knowledge of the possible locations of reinforced orstronger metals and to evaluate the rescue tools that are being used.

Glass/Plastics/Polycarbonates

The use of glass and plastics is another area which is undergoing major changes. In future, all rescuers will need to wear some form of respiratory protection. The removal and handling of glass from motor vehicles should not be undertaken unless all rescuers and patients alike are wearing a dust mask as minimum protection from glass dust and fibres. Vehicle manufacturers are putting more and more plastics into vehicles. Polycarbonate windows will be the next safety feature in place of glass. Polycarbonate windows are super strong and take an enormous pressure to break. The problem for the rescuers is that new tools and techniques will have to be adopted to address this problem. Cutting and sawing this plastic will generate millions of fibres that could enter the lungs of rescuers and patients. Will these fibres be tomorrow's asbestos fibres? For rescuers that attend motor vehicle accidents on a regular basis, the accumulative effects of these fibres could be potentially life threatening.

In an ideal world, all rescuers would be wearing Self-Contained Breathing Apparatus (SCBA). That is not practical, operationally or financially. A paramedic working on a patient in a motor vehicle with a SCBA on would severely restrict their capability to manage their patient. However, a problem arises when there is any cutting, sawing, etc of any of these potential hazardous materials. Some form of respiratory protection must be considered. The introduction of dust masks today could prove to be life saving tomorrow.

Just as there was early resistance to wearing surgical gloves and helmets to motor vehicle accidents, today they are accepted as minimum protection for rescuers. Respiratory protection should be included as standard PPE during certain activities at a motor vehicle accident to protect rescuers and victims from inhaling these potentially harmful particles.

Pyrotechnics

With more and more motor vehicles fitted with pyrotechnic devices like seatbelt pre-tensioners, rescuers need specific training in the identification and handling techniques for the safety of the patient and their fellow rescuers. Rescuers must be able to positively identify and adequately manage pyrotechnic devices in motor vehicles. The consequence of not being able to do so is to risk the accidental or unplanned activation of these devices causing serious injury to both the rescuer and the patient. This pyrotechnic training also needs to include the cutting of seat belts, both high and low, to reduce the effects on the patient should a pyrotechnic seatbelt device accidentally fire.

<u>Airbag safety for rescuers needs to be a priority for all services.</u> More and more vehicle are being fitted with airbags. They can be found in a multitude of places inside vehicles today. Training must be provided to rescuers to enable them to positively identify all “loaded” airbags inside the motor vehicle. This training also needs to include the safe working distances of “loaded” airbags when working around them.

Motorised Hydraulic Tools

The supply and replacement of motorised hydraulic rescue tools will require a lot closer scrutiny. Motorised hydraulic rescue tools need to be purchased with enough reserve capacity to cater for continued changes in motor vehicle technology. A long-term strategy for the replacement of rescue tools needs to be established so rescue teams are equipped with appropriate gear to enable them to deal with increasing amounts of high strength metals found on motor vehicles today and tomorrow.

For VICSES, I believe this issue needs to be addressed now as the majority of VICSES motorised hydraulic rescue tools are operational for in excess of ten years. As motor vehicle technology has changed so much in the past 10 years, the next 10 years will render the current motorised hydraulic rescue tools almost useless against metals found in motor vehicles manufactured in the future. An option might be the rotation of hydraulic rescue tools. Instead of a unit owning the one set of motorised hydraulic rescue tools for the tools entire life, the tools could be rotated from busier units to quieter units, and then eventually retired from the system.

Hand in hand with the use of motorised tools must be the simultaneous use of hard protection. Hard protection is used to shield the patient and rescuers inside the motor vehicle from any debris from the operation or from tool failure.

Development of new techniques

A high proportion of motor vehicles on Australian roads are Australian made. The motor vehicle manufacturers are predominantly Holden and Ford. At present these manufacturers are not using the high strength metals and alloys as standard, unlike European motor vehicle manufacturers. Holden and Ford will begin using super strong metals in their motor vehicle manufacturing processes in the next few years.

Australian rescuers are lucky to point. The thing in our favour is that we only have a small proportion of European motor vehicles on our road, but this is increasing every year. More and more imported motor vehicles are coming to our shores. As more imported motor vehicles arrive it increases the likelihood of rescuers coming up against micro alloy and High Strength Low Alloys.

From my experience of road crash rescue in the United States and in Europe, Australia is right up there when it comes to techniques and knowledge. The leading road crash rescue units have been exposed to the cutting edge in rescue techniques. The problem arises in disseminating that experience and knowledge down to all the units that perform road crash rescue. There are units out in the field that have little if any experience in dealing with the newer motor vehicles found on the road today. This information and knowledge is a major part of the foundation of the skills required to perform road crash rescue.

I have briefly touched on some alternate approaches when discussing the new technology, However, there will be a need to develop new techniques and ensure the sharing of the knowledge between rescue organisations. In terms of new techniques, Australia will be able to follow the lead of Europe and the US where this new technology is more prevalent. Our continued participation in national and international challenges is one way of ensuring our continued exposure to what other countries are doing. Regular communication devices need to be established, such as articles in service magazines, to keep rescuers abreast of advances in anatomy and technology used in motor vehicles and techniques to address issues raised by the new technology.

Recommendations

The most significant issue raised by my research is that it is essential that rescuers are aware of the new technology and the anatomy of specific vehicles, as their anatomies and composition will differ and require different techniques to enable successful rescues. Awareness is essential for the safety of every individual rescue worker, and the safety of those around them including patients and other emergency service workers. There needs to be a campaign to increase awareness, which would include training for rescuers and other emergency service personnel.

The other major issue raised by my research is in relation to the tools we currently use at motor vehicle accidents. The motorised hydraulic rescue tools need to have enough reserve capacity to cater for continued changes in motor vehicle technology, and future purchases of equipment must take into consideration the need for reserve capacity and future changes in the technology applied to motor vehicle construction.

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