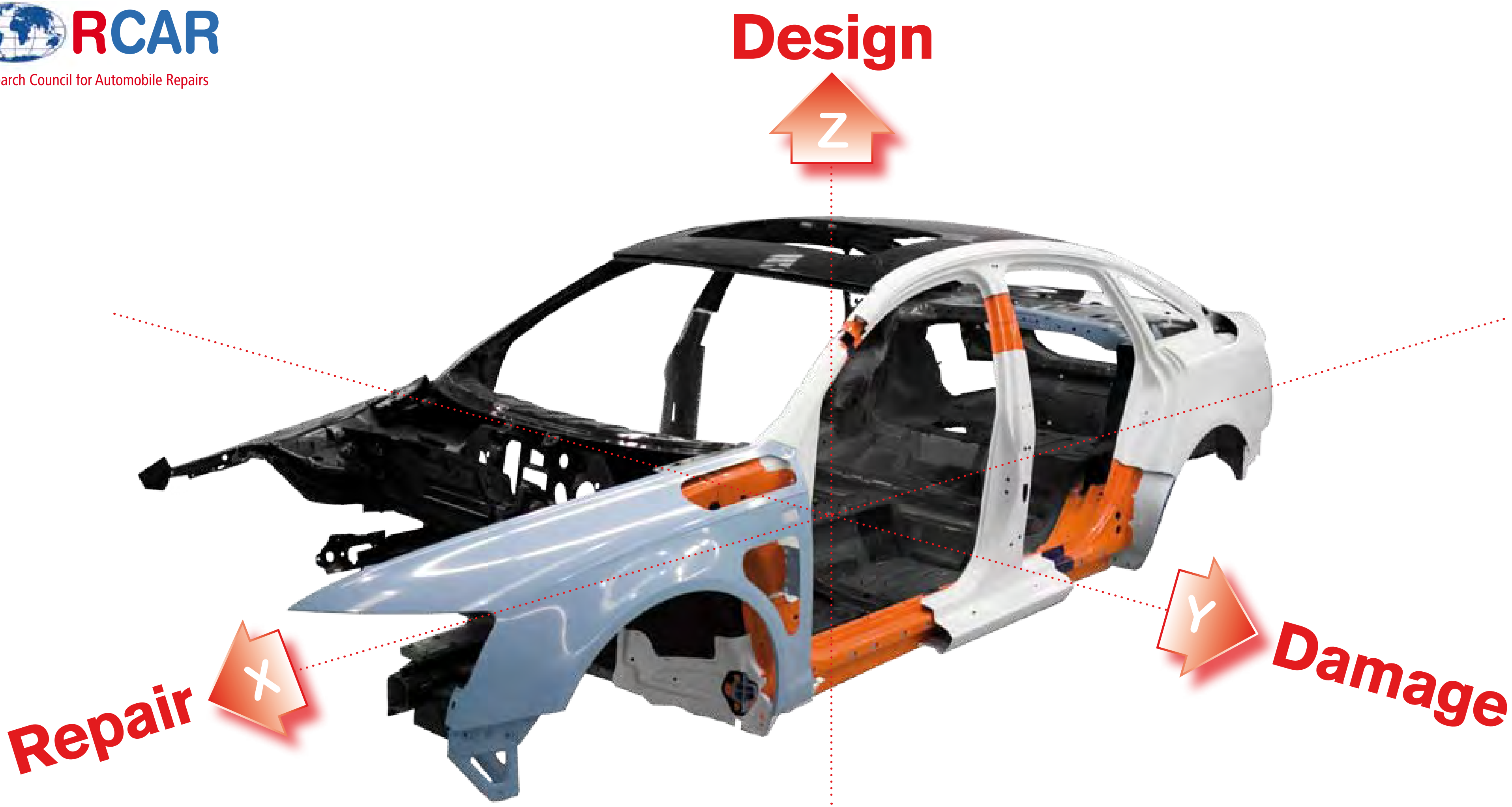
RCAR

Research Council for Automobile Repairs



RCAR Design Guide - A manufacturers' guide to ensure good design practice for repairability and limitation of damage.

Version 1.1

List of Acronyms

ABS	Anti-lock Braking System
BOF	Body over Frame / Full Frame Vehicle
ECU	Electronic Control Unit
ELV	End of Life directive for Vehicles
HVAC	Heating, Ventilation and Air-Conditioning
MAG	Metal Active Gas, gas shielded metal arc welding
MET	Mechanical, Electrical and Trim
MIG	Metal Inert Gas, gas shielded metal arc welding / brazing
NVH	Noise, Vibration and Harshness
OEM	Original Equipment Manufacturer
PU	Pickup Truck
RCAR	Research Council for Automobile Repairs
RSW	Resistance Spot Welding
SUV	Sport Utility Vehicle
UHSS	Ultra High Strength Steel
VIN	Vehicle Identification Number

Foreword

An important strategic goal for the Research Council for Automobile Repairs (RCAR) research centres is to work with automobile manufacturers to improve the damageability and repairability of vehicles. These elements taken together affect the insurance industry and their policy holders, the vehicle repair industry and, of course, the automobile manufacturers. Damageability and repairability are defined as follows:

Damageability is the capacity of a vehicle to withstand the force of a collision. RCAR's definition of damageability embraces the ability of the vehicle to absorb crash energy and in so doing limit the physical displacement, deformation and damage to structures and high cost components.

Repairability means the possibility and ease of repair, firstly in the physical sense and secondly in terms of cost. So, "good" repairability will mean that the vehicle can be restored to its pre-accident condition either by repair or by economic component replacement. On the other hand, "poor" repairability will mean difficulty or, in extreme cases the impossibility of repair with an increase in cost due to the need to replace high cost components.

Both damageability and repairability enhancement must, however, be achieved without compromising the safety of vehicle occupants or other road users.

It is one thing to have a strategic goal, but quite another to be able to measure its achievement. For damageability and repairability the measurement is in two stages. First the vehicle is subjected to a standard RCAR low speed test and the resulting cost of damage is used as a measure of the level of success. This process validates the design. Results are subsequently evaluated by the use of real world data when the vehicle enters services.

However, there is a great deal to be done during the development phase and a growing body of knowledge exists to assist the automobile designer in the task of optimising designs. There is a tradition of involvement and engineers from RCAR research centres work closely with automobile manufacturers to assist in the achievement of good results. Indeed in countries where it is legally permitted, insurance rating systems have been introduced and the cost of repairs as a result of applying the RCAR standard low speed crash test criteria play a major role in deciding the insurance group rating and therefore the whole life insurance costs of the vehicle.

There is also a strong sense of mutual benefit as by optimising damageability and repairability the automobile manufacturer has a competitive vehicle with a strong economic selling point, the insurer and the policy holder pay less for insurance, and the vehicle repair industry is able to carry out the repairs needed.

It is in this context that I strongly welcome this publication, which represents a substantial update to the current RCAR Guide. An international team of RCAR automotive engineers has developed the guide to help both themselves and their colleagues in the automobile manufacturing industry. I congratulate them for their contribution and commend the use of this guide by RCAR research engineers and automobile designers.

Andy Walker, Chairman,
RCAR Repairability Working Group
Research Council for Automobile Repairs
August 2008

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Introduction

'Design for Repair' is a guide for manufacturers and designers who are at the centre of vehicle development. They have the influence to make a vehicle efficient to build, compliant with legislation, safe for the end user and, above all, economically viable to produce.

Improving vehicle damageability/repairability while maintaining safety design standards is critical to the automobile buying consumer, as it relates to personal safety, the affordability of the vehicle being purchased, and the costs associated with maintaining and insuring the vehicle.

In order to meet the needs of the consumer, manufacturers need to take a proactive role in developing vehicle designs and manufacturing processes focused on both consumer safety and vehicle damageability/repairability.

Using text and photographs, this guide shows a range of some of the good and poor examples of vehicle repairability that we have encountered during our research. In the end, the design of a vehicle can affect not only the costs of repair and cost of ownership, but even whether a vehicle can be repaired at all. We have issued this guide to encourage manufacturers to design their vehicles with an awareness of the issues that can arise during repair.

The Design for Repair Guide has been created by the RCAR Repairability Working Group which comprises members of the Research Council for Automobile Repairs (RCAR). The focus of the Working Group is the development of an RCAR Design For Repair Guide to aid the automobile manufacturers in developing vehicle designs which meet critical repairability concerns. Development and updating of the guide requires the involvement of non-RCAR stakeholders such as the vehicle manufacturers, members of the collision repair industry, collision repair training organisations, consumer advocacy groups, collision repair equipment manufacturers, collision estimating information providers and other members of the automobile insurance industry. Input and participation by non-RCAR stakeholders will be sought to ensure the creation of an effective and well-defined guide.

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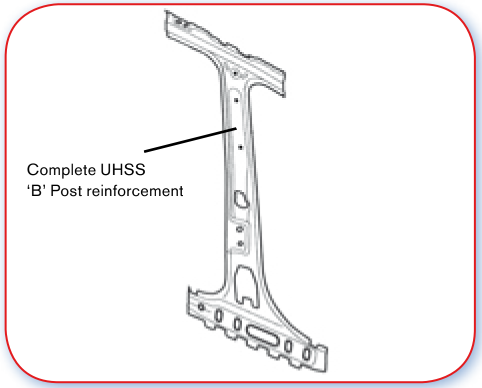
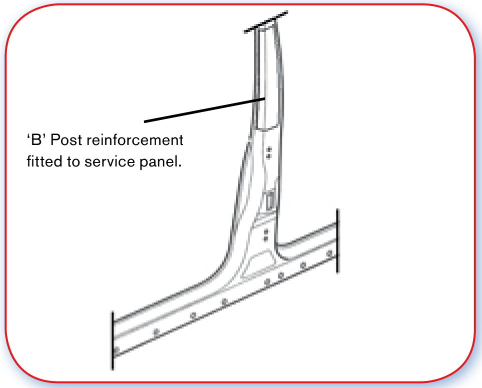
Types of Materials

A.1.1 Poor example. Subsequent panels can be damaged during sectioning.



A.2.1 Poor example. 'B' Post made out of UHSS, requires complete replacement.



A.2.2 Good example. 'B' Post with a UHSS reinforcement can be sectioned.

Steel

Steel is the predominant material used in cars due to its particular physical characteristics. There are many different types of steel used in different applications and all have different characteristics. Higher strength steels are used in areas where passenger safety and vehicle structure requirements are demanding higher strength materials and lower weights.

A.1 Multi-panel nodes

Effect on repair: The areas where several panels of different materials are used in close proximity to create particular body side assemblies do not allow safe sectioning in repair (e.g. 'B' Post joint to sill or roof).
Due to the order of panel removal and the stepping of the joints, damage to subsequent panels can occur. Consequently, repairs in these areas are restricted to avoid a reduction in strength.

Design for repair guidance: Allow enough space for tooling between the panels for sectioning in likely areas of repair, as specified in existing repair manuals (pic A.1.1).

A.2 Use of Ultra High Strength Steels

Effect on repair: Panels made of UHSS generally cannot be repaired and the entire panel must be replaced. The consequence of this is that larger sections of the outer body have to be cut away to enable fitting of the complete panel in repair (pic A.2.1).

Design for repair guidance: A joint configuration allowing for better removal of the panel is recommended as this will make replacement easier. Alternatively, introducing a smaller local UHSS reinforcement fitted to a lower strength steel full panel, serviced as an assembly, will allow sectioning of the carrier panel (pic A.2.2).

A.3 Material properties of service panels

Effect on repair: Panels which have not received an equivalent treatment to the original can result in service panels being inferior in strength.

Design for repair guidance: Service panels need to receive the same treatment as the original body of the vehicle before being supplied to ensure that the same body characteristics and safety performance are maintained.

Effect on repair: Welding treated service panels during the repair process will mean localised heat input affecting the material characteristics locally.

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Design for repair guidance: Consideration should be given to the joining method used in the repair process.

Aluminium

Aluminium is a lightweight alternative to steel and is more corrosion resistant. If you compare like for like materials, aluminium will show a weight reduction due to its lower density. However, to meet an equivalent strength and/or rigidity, more material is required. The characteristics of aluminium make it more complex to manufacture and repair a vehicle.

The drawback of some types of aluminium is the limitation it has with stretching and work hardening, which means that common repairs like dent removal as used on steels cannot be utilised.

A.4 The use of aluminium

Effect on repair: Cross-contamination between aluminium and steel has to be avoided as the oxides from steels and the alloying elements in aluminium cause corrosion. Therefore, repairers will have to make additional investment in facilities, tooling and training. Because of this, it will reduce the number of appropriately equipped workshops available for repair, resulting in increased transport costs for the insurer.

Design for repair guidance: Designers should be aware of the additional facilities required for the repair of vehicles containing aluminium, resulting in repairs being more expensive and there being fewer appropriately equipped repair facilities available. A separate bay will be allocated for aluminium repair only, including its own extraction system as alloying elements make the dust from aluminium highly flammable. The tooling used should be identified (e.g. colour coded) and used for aluminium only. Geographical coverage should reflect the quantities of vehicles sold in the market.

A.5 Castings used in joints

Effect on repair: The shapes that are possible when using castings allow panels to be joined in an optimised way for production, meaning that surrounding panels will often overlap the casting. This means that the removal of the casting or panels joined to the casting is problematic during repair.

Design for repair guidance: Consideration must be given to the order of overlapping panels, as well as the possibility of replacing a casting. This means that castings should be able to be separated from the vehicle, and parts separated from the casting, without the substantial dismantling of surrounding parts.

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A.6 Welding castings

Effect on repair: Welding panels to castings during production makes replacement in repair difficult. Joint separation as well as re-welding can have a detrimental effect on the quality of the repaired joint and casting.

Design for repair guidance: Avoid the welding of castings and use an alternative technology that does not require heat input. If panels are welded to castings, use stitch welds instead of long runs of welds.

A.7 Post accident inspection

Effect on repair: Castings and adhesives do not exhibit proof of minor damage or failure.

Design for repair guidance: Designers should be aware of the additional requirements and costs involved in post accident inspections. More strict procedures for examining and recording damage have to be set. There is also a need to inform engineers and estimators of the known effects of particular deformations and their patterns through a vehicle.

Plastics

The use of plastics (thermoplastic and thermosetting) is increasing and plastics are slowly being introduced into vehicle structures, as well as being the predominant material for aesthetically pleasing surfaces (e.g. facia panels, trim panels and finishers).

Outer panels manufactured from plastic are an advantage as they can resist minor damage.

The huge variety of different plastics makes this material suitable for a range of applications like outer panels, brackets, trim panels etc. The use of reinforced plastics (either glass, synthetic or natural fibres) enables the plastics to have certain structural strengths, and specific plastics are used to reinforce metal pressings.

Composites

Composites are an enhanced material and are, in general, carbon fibre matting enclosed by a type of resin, giving it shape and rigidity. At the moment, these types of materials are mainly used in the niche and low volume market. Expectations are that due to improving characteristics, durability and production technologies, as well as the increasing demand for lightweight vehicles, we will see an increasing use of composites. The main advantages are weight and strength, but manufacturing of these parts requires controlled processes and sufficient investment.

The use of carbon fibre for visible panels is rarely specified. Any damage, however minor, will show and cannot be repaired, resulting in the replacement of the panel. However, this can

A.8.1 Composite roof.

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also be an advantage, as damage to cosmetic composite panels can be easily detected (pic A.8.1).

A.8 Location of composite material

Effect on repair: Composites that form structural parts within the vehicle should always be completely replaced when damaged.

Design for repair guidance: Strong consideration should be given to the ease of replacement and the location of natural joints, as this affects the repairability of this type of part. An example could be a bonded transition plate on a service part allowing a mechanical joint, instead of relying on demanding, time consuming, bonding processes.

Effect on repair: The use of non-structural parts manufactured from composites should be minimised in areas where they are at risk of being damaged, especially if they are large and have complex shapes. This will avoid an increased requirement for costly replacements or sectioning (pic A.8.2).

Design for repair guidance: Introduce smaller panels in areas where there is a greater risk of damage occurring, to allow the replacement of complete single panels without affecting any adjacent panels.

A.9 Joining of composite material

Effect on repair: The separation of composite panels joined by adhesive can damage the subsequent panel (e.g. delaminating).

Design for repair guidance: Allow enough space between the panels most likely to be replaced for cutting the adhesive. This will allow removal of the panel without applying too much stress on the bonding path, as tooling readily can access the adhesive. Consideration should also be given to types of adhesive which will allow easier removal.

A.10 Adhesive wipe off when fitting panels

Effect on repair: There is a risk that there will be insufficient adhesive in bonded areas due to wipe off when panels are fitted underneath other panels during repair.

Design for repair guidance: Take into consideration the order of panels when a vehicle is assembled and have the panel most prone to accident damage as the upper panel.

A.8.2 Single piece SMC boot surround.

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General Comments On Materials

A.11 Material identification

Within the repair industry, the inability to recognise different types of material makes it difficult to assess which joining technologies are required. For example, if a joint is to be welded, what welding equipment and settings are required?

Effect on repair: This is causing particular confusion during repair in respect to sectioning and joining technologies, so as not to affect the design characteristics of the original structure.

Design for repair guidance: Material identification on steel parts is required, similar to the ELV requirements for plastics. This would be very helpful during repair.

A.12 Protection of employees and the environment

The use of alternative materials like aluminium and composites has an effect on the working environment and the people working with these materials.

Effect on repair: Additional training to enhance skills and expertise is increasing operational costs. Similarly, costs are also rising to enable compliance with additional Health and Safety Executive regulations such as those on the use of aluminium and composites; the greater requirement for Personal Protective Equipment; and protection against electrical conductivity caused by fibres and dust.

Design for repair guidance: Take into account how panels are replaced to reduce the exposure of repair technicians to material dust. This can be achieved by making it possible to separate panels without the need to cut into the core material. This will also have a positive effect on the repair strategy and repair network needed for these vehicles.

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Joining Methods

The purpose of this chapter is not to explain what the particular joining methods are, but what issues are found with them during repair.

Resistance Spot Welding (RSW)

B.1 Differences in RSW capabilities

The main requirements for RSW are set by the type and thickness of materials used in a joint stack. This affects the programme settings and the parameters for the spot welding machines, as well as the required tip pressures and electric current.

Effect on repair: The manufacturer's specification for RSW can be higher than the capacities of aftermarket spot welding machines. At the moment, the maximum tip pressure achieved by aftermarket spot welding machines is usually about 5 kN.

Design for repair guidance: Avoid the requirement for high specification spot welds due to the types of joints and materials used in areas that are exposed to collision damage.

B.2 Spot weld size

Effect on repair: The size of spot welds used in the manufacturing process exceeds aftermarket capability, where currently the maximum diameter is 8mm. This will affect the strength of the joint and has to be compensated for by increasing the number of spot welds. This can cause problems when a panel is shape formed (pic B.2.1).

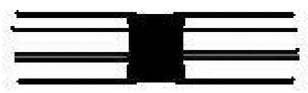
Design for repair guidance: Instead of having large spot welds, use smaller welds and increase the number.

B.3 Accessibility of spot welds

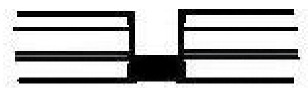
Effect on repair: The location of spot welds determines the possibility of replication in repair. During manufacture, a bodyshell is created by the joining of many sub-assemblies. This can result in the flange required for repair being covered or not being accessible due to subsequent panels.

Design for repair guidance: Consideration during design should be given to the accessibility of spot welds for vehicle repair requirements.

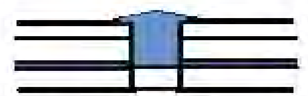
B.2.1 Poor example. Locations for new spot welds limited, due to shape of flange.



B.4.1 Step one: Spot weld in multilayered stack.



B.4.2 Step two: Spot weld removed to allow removal of outer panels.



B.4.3 Step three: New panels joined with plug weld.

B.4 Multilayered stacks (3 or more)

Effect on repair: The removal of an outer panel from a multilayered stack of panels can be awkward, especially when spot bonding has been used between the remaining panels. The original location of the spot weld cannot be used again in repair, as this will create an unreliable joint. In repair, therefore, this is overcome by using a spot welder with adaptive welding control, placing the new spot weld in an alternative location near the original spot weld. Alternatively, a plug weld can be used in the original location (pic B.4.1, 2 & 3).

Design for repair guidance: Both methods mentioned above and alternative joining methods should be evaluated and clearly specified in repair methods.

MAG Welding/Brazing – MIG Brazing

B.5 Heat input

Effect on repair: The material to be welded, as well as its thickness and its particular coating (e.g. galvanised), have to be considered with regard to the heat input created by MAG welding. For example, if this is too high for the material being welded, its properties and performance will be affected.

Design for repair guidance: MIG/MAG brazing or an alternative joining method should be considered.

B.6 Weld caps

Effect on repair: When a joint with a weld cap is to be replaced, the weld cap is retained. In all non-OEM joints introduced into the vehicle during repair, where weld caps are not removed, there will be unacceptable evidence of repair.

Design for repair guidance: To take away any evidence of repair, the weld cap will be removed. This has to be considered when a repair method is written for parts where these joints can occur. If this affects the mechanical properties post repair, a sleeve should be introduced to increase strength.

B.7 Limitation of sectioning in relation to NVH barriers and adhesive joints

Effect on repair: The location of NVH barriers and adhesive joints can limit the possibility of sectioning in repair. NVH barriers are normally attached to the panel using foam which activates when the body goes through the paint baking process. Barriers and adhesives are normally applied just before the panel is offered up to the vehicle for assembly and, in general, can ignite easily due to the release of solvents.

Design for repair guidance: Consideration during design should be given to the position of barriers and adhesives in relation to possible locations for repair sections.

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B.8 Incomplete instructions about joining method

Effect on repair: Repair methods, which do not specify enough information on a joining technology in the repair instructions, leave too many factors open which could affect the quality and safety of the repair.

Design for repair guidance: Guidance should be given about the equipment, welding parameters, gas mixture and filler wire. When welding or brazing galvanised steel, clear preparation instructions should be given to avoid affecting the welding process and anti-corrosion properties in a negative way.

B.9 Extensive preparation work required on service panel for MIG brazing

Effect on repair: Surface panels are supplied without any holes, but when MIG brazing is chosen as the repair method to join these panels they require holes. Manually slotting holes in panels is time consuming and not cost effective.

Design for repair guidance: Supply the service parts with pre-stamped slots to reduce the preparation time of the panel.

Laser Welding

B.10 Replacement of OEM weld

Effect on repair: Laser welding is not available to the repair industry, nor will it be in the near future. This means that laser welded panels have to be replaced with an alternative joining method.

Design for repair guidance: In the service information, a clear indication of the method for the replacement of laser joints is required.

B.11 Removal of laser welds

Effect on repair: The removal of laser welds is awkward due to the thin shape of such welds. This makes it time consuming and costly in repair.

Design for repair guidance: Avoid laser welds in joints of regularly replaced panels or introduce appropriate tooling for the removal of the laser welds.

B.12 Enough flange height

Effect on repair: Laser welding requires a small flange on panels, meaning that when this panel is replaced with spot welding, there is not enough space to fit a spot weld properly.

Design for repair guidance: Avoid laser welds in joints of regularly replaced panels or provide a flange size suitable for spot welding in repair.

B.11.1 General example of laser welding applied close to flange edge.

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Laser Brazing

B.13 Replacement of OEM brazing

Effect on repair: Laser brazing is not available to the repair industry, nor will it be in the near future. This means that laser brazed panels have to be replaced with an alternative joining method.

Design for repair guidance: In the service information, a clear indication of the method for the replacement of laser joints is required.

NOTE: Where laser brazing of large sections (e.g. roof panels) has been carried out in manufacture, a combination of riveting and bonding is usually used in repair. Spot welding these panels will not be possible due to the shape and position of these joints.

Adhesive Joints

Manufacturers are tending to use more and more adhesives for both structural and non-structural joints. This is a result of manufacturers using combinations of different materials, the requirement for new types of joints and the need for lighter weight vehicles.

B.14 Use of adhesives in production

Effect on repair: OEMs use single pack, high temperature curing adhesives. This means that the use of the same adhesive in repair is not an option as the baking process cannot be repeated. This is due to the fact that these temperatures cannot be reached, as well as that a vehicle would require a complete strip out to protect any parts that cannot withstand such high temperatures.

Design for repair guidance: In repair, an alternative single or two pack, low temperature curing adhesive will be used to create an adhesive joint. These adhesives have lower mechanical properties and this has to be taken into account during design and the development of the repair method.

B.15 Open time needs to be long enough

Effect on repair: A short curing time for an adhesive can mean that positioning will not be as accurate as it could be. When a panel is spot bonded and an adhesive cures quickly, it might mean that by the time a panel is positioned and ready to be spot welded, the adhesive will already have started to cure, which isolates the panels it is between and, therefore, affects the quality of the spot welds.

Design for repair guidance: When specifying a particular adhesive for repair, make sure that the curing time is slow enough to allow a panel to be fitted properly.

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B.16 Different types of dispenser required

Effect on repair: A repairer using adhesives wants to avoid investing in a range of adhesive dispensers for every type of adhesive. Although this is partly stipulated by the adhesive supplier, it would mean considerable investment for every type of adhesive.

Design for repair guidance: Offering different sized cartridges could introduce the possibility of exchanging dispensers between different adhesives. Offering repairers a choice of adhesives from a number of manufacturers can also be helpful.

B.17 Avoidance of heat input into bonded service joints

Effect on repair: Heat input into an adhesive joint can be serious and can result in the failure of the joint.

Design for repair guidance: Consideration should be given to the location of adhesive joints in relation to the service joints. This should also be reflected in the repair manual.

B.18 Allow for shrinkage of adhesive

Effect on repair: The location where adhesives are applied is critical when a shrink sensitive adhesive is used. If used on a large surface, it can mean that the panel is perfectly in line initially but, after curing, is deformed due to shrinkage.

Design for repair guidance: Avoid the use of adhesives which are shrink sensitive on large areas. Either select an adhesive which is not sensitive to shrinking, or use a different joining method.

B.19 Adhesive wipe off when fitting panels

Effect on repair: There is a risk that there will be insufficient adhesive in bonded areas due to wipe off, when panels are fitted underneath other panels during repair.

Design for repair guidance: Take into consideration the order of panels when a vehicle is assembled and have the panel most prone to accident damage as the upper panel.

B.20 Failure of the adhesive joint

Effect on repair: Adhesive joints are difficult to inspect and only show visible evidence of failure when parts start separating from each other.

Design for repair guidance: Designers should be aware of the additional requirements and costs involved in post accident inspections. More strict procedures for examining and recording damage have to be set, as well as informing engineers and estimators of the known effects of particular deformations and their patterns through a vehicle.

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Rivet Joints

B.21 Access of rivet position

Effect on repair: Rivets cannot be accessed during repair as subsequent panels do not allow the removal tool to gain access to both sides.

Design for repair guidance: To achieve a proper removal and replacement, tooling should be able to access both sides of the rivet.

B.22 Replacement rivets showing evidence of repair

Effect on repair: There should be no visible evidence of repair following the use of rivets.

Design for repair guidance: The repair method should require rivets to match the look of the original rivets and they need to be available as service parts.

B.23 No alternative place available for repair rivet

Effect on repair: The existing perforation on the carrying panel cannot always be used for the fitting of new panels.

Design for repair guidance: Allow ample space around rivets, so an alternative position for the replacement rivet can be used during repair.

B.24 Colour coding rivets

Effect on repair: The increasing use of both steel and aluminium rivets by manufacturers also increases the risk of cross-contamination occurring during repair, especially when both are used on the same car.

Design for repair guidance: The coating of rivets, as well as the use of a colour code to assist recognition of the type of material, aluminium or steel, will help avoid cross-contamination.

Shape Formed Joints

B.25 Working space

Effect on repair: Restricted access does not allow a hemming joint to be used in repair.

Design for repair guidance: When a hemming joint is used, make sure there is enough surrounding space for hemming tools.

B.26 Re-clinching joint

Effect on repair: When clinching is used to join panels, re-clinching the same panel cannot be done as the material characteristics will not allow the same deformation to take place, causing additional deformation adjacent to the old clinch.

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Design for repair guidance: An alternative joining method has to be recommended. The alternative joining method or the new location for the joint should be clearly stated in the repair method.

B.27 Combination joints

Effect on repair: The use of adhesives in combination with clinching or hemming will make the removal of the panel difficult and time consuming.

Design for repair guidance: Avoid combining these joining methods.

Threaded Fasteners

Although the majority of threaded fasteners are used on mechanical components, some panels, or parts of panels make use of this type of fastener.

B.28 Combination joints

Effect on repair: Using a range of fasteners with different thread sizes and of varying quality or type can cause confusion and result in the fitting of fasteners in the wrong place, affecting the quality of repair.

Design for repair guidance: Reduce the number of types of fastener and sizes used on a vehicle. This will ease the repair and reduce the required number of parts, as well as required tools in both production and repair.

B.29 Fitting information missing

Effect on repair: Repair information given for the fasteners is missing the instructions for torque settings, as well as the pre-treatments for locking.

Design for repair guidance: For critical joints, clear instructions should be given in repair manuals.

B.30 Fastener supplied with service panels

Effect on repair: Threaded fasteners for service parts often need to be ordered separately when the panel is ordered. This is time consuming and leaves room for error.

Design for repair guidance: When parts are supplied as aftermarket repair parts, the panel should come with the required fasteners, or they should be automatically supplied through the ordering system when the part is ordered.

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Mechanical, Electrical & Trim

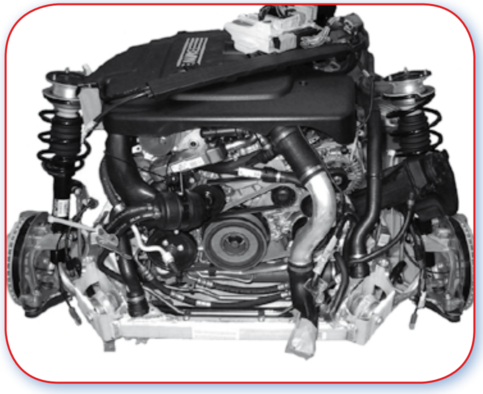
Repair of a vehicle is not just restricted to body panels. When an impact has occurred, the amount of secondary damage to other parts can cost as much, if not more than the repair of the panels.

Mechanical stands for all the parts that are related to the power train, primary protection, steering, braking, glazing and fuel system.

Electrical covers all the wiring and auxiliaries feeding into or connected up to the electrical loom, for example HVAC, motors for windscreen wipers and windows, electric looms, airbags, restraint systems, ECUs, lighting, entertainment systems and batteries.

Trim is all the parts that are used to give the interior its looks, touch and functionality and they usually go hand in hand with the electrical items. Apart from providing for comfort, seats are also part of the occupant safety system, with integrated airbags and active head restraints. Most electrical controls are fitted into, or are part of trim panels, for example switches, heating controls and airbags. Trim panels are also used for noise reduction and thermal insulation of the interior.

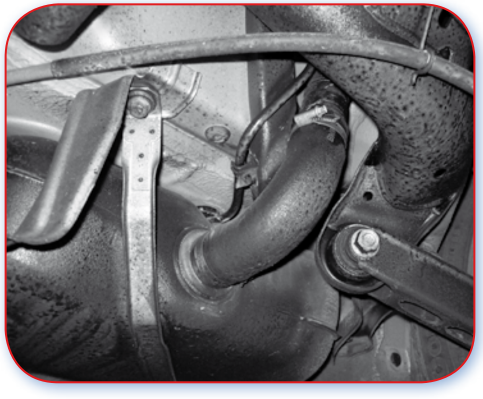
Although the list is not exhaustive, below are some of the most common examples found on cars.



C.1.1 Good example. Complete removal of engine.

C.1 Power train

Ideally, it should be possible to remove the power train as a single unit. This is time effective and in most cases replicates the production process. The requirement is that connections should be easily reachable and detachable. See also Front Sub-Frames (pic C.1.1).



C.2.1 Fuel filler neck and fuel tank joint with removable elbow, allowing it to be separated.

C.2 Fuel tank removal

Effect on repair: If it is not possible to remove the fuel tank and filler neck independently, it can mean that for removal of these parts the rear suspension has to be removed, increasing repair times.

Design for repair guidance: The filler neck should be able to be detached from the tank and panel. The tank should be able to be detached from filler neck and body (pic C.2.1).

C.3 Access for draining fuel tank

Effect on repair: It should be possible to drain the fuel tank during the repair process. With current fuel systems, draining the tank through the filler neck is not possible and drain plugs are not appropriate due to current health and safety requirements covering evaporation.

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Design for repair guidance: Access to the fuel pump/sender unit for drainage before the removal of the tank is the best option for repair.

C.4 Position of auxiliary units

Effect on repair: The costs of a repair can be greatly increased due to the position of expensive auxiliary units fitted close to vulnerable panels. For example, this can occur where ABS units are fitted behind front lights, HVAC pumps are fitted between wheel arch closures and side panels, and satellite navigation or CD players are fitted inside rear quarter panels (pic C.4.1).

Design for repair guidance: Consideration must be given to the positioning of these units an appropriate distance away from panels prone to damage. This will reduce the amount of labour required, and more importantly, the costs involved in having to replace these parts.

C.4.1 Poor example. Expensive auxiliary units positioned in vulnerable areas.

C.5 Lighting clusters

Effect on repair: If light clusters are fitted to front panels, they will normally be damaged in a frontal impact. For example, in the UK, there is a consumer and insurance requirement to remove any evidence of a repair following accident damage. Breakaway brackets will be visible after the repair. This means that light clusters have to be fully replaced when damaged, inflating the cost of repair.

Design for repair guidance: Position light clusters in a less vulnerable location and not fixed to panels which are likely to be damaged. A good alternative is a cheap slide-in bracket holding the light cluster, which will break on an impact and can be replaced when damaged. This will save the costly light cluster and make the repair cheaper (pic C.5.1).

C.5.1 Good example. Light cluster (in grey) removed from bracket (green). Source: Audi AG.

C.6 Rear light cluster position

Effect on repair: The vulnerable position of rear light clusters increases the cost of repair when a rear impact occurs.

Design for repair guidance: Fit rear light clusters higher up the vehicle body, well away from areas prone to damage (pic C.6.1).

C.6.1 Good example. A light cluster fitted in a higher position avoids damage on impact.

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C.7.1 Poor example. Parts and looms that cannot be detached.

C.7.2 Poor example. Loom partly detachable. Use a larger multi-plug or an additional plug, so both sets of wires can be detached.

C.7 Looms restricting parts removal

Effect on repair: Parts containing electrical units, mainly trim panels, need to be removed when repair on adjacent panels is required. Frequently, the part can be detached from the panel holding it, but it cannot be separated from the loom. This suits a production system, but is not ideal for repair. It means that the trim panel has to stay in the vehicle which will obstruct the repair procedure. It can also cause damage to the trim panel during repair or require further stripping out. Both will increase repair costs (pic C.7.1, C.7.2).

Design for repair guidance: The ability to separate parts should be a requirement for the loom design. It could mean either the introduction of connectors in the loom, or the availability of a repair method for a loom, possibly involving the introduction of connectors after the loom has been cut.

C.8 Looms close to vulnerable panels

Effect on repair: Looms should not be carried on or enclosed by panels which are prone to damage. When these panels are damaged during an impact, the loom is also likely to be damaged. This makes a repair difficult, as damage to the loom must be avoided.

Design for repair guidance: Consider locating the loom in a less vulnerable place. This will reduce damage and repair costs.

C.9 Trim panel fixings

Effect on repair: Trim panel removal will often damage both the trim panel itself and the body panel to which it is fitted. This is due to the way the panels have been fixed to each other.

Design for repair guidance: Avoid the use of adhesives for soft material panels like head linings. Use one piece clips when clips are used and ideally clips which are reusable. Clips should also be available as service parts.

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C.10 Removal of clips

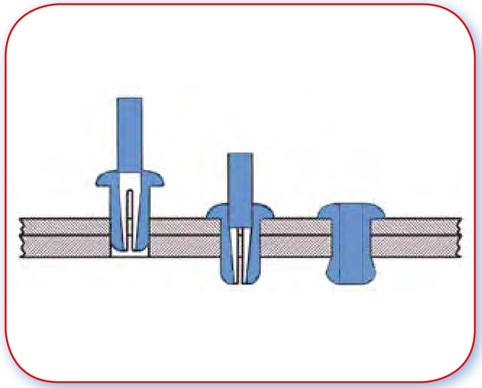
Effect on repair: The removal of clips results in parts from the clips dropping into the hollow parts of the body, which can cause irritating rattling noises whilst driving the car (pic C.10.1).

Design for repair guidance: Only use clips on parts that are to be removed fully. Ideally, it should be possible for clips to be reused (pic C.10.2, C.10.3).

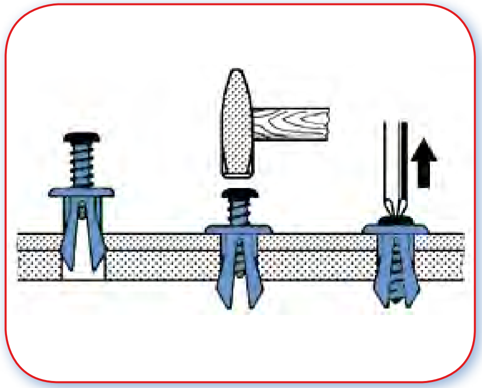
C.11 Overlap of trim panels

Effect on repair: The overlap of trim panels can mean that when a repair has to be done on an ‘A’ Post, the trim from all the other posts and roof line covers have to be removed, to be able to remove the ‘A’ Post trim.

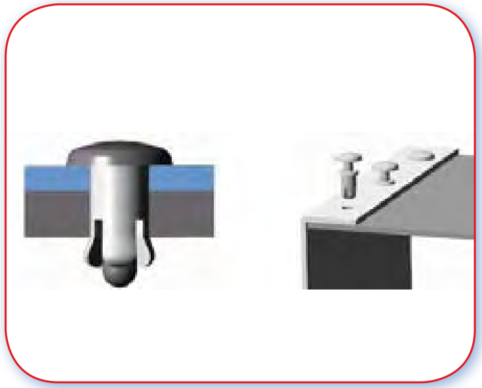
Design for repair guidance: Avoid overlap of trim panels through the whole vehicle by working from the centre out. This will reduce the removal time and the possibility of damage during removal.



C.10.1 An example of poor clips. Pin will be lost on removal.



C.10.2 An example of good clips.



C.10.3 An example of good clips.

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C.13.1 Good example. Facia can be partly removed after being damaged by deployment of airbag.

C.12 Single piece floor lining

Effect on repair: The floor lining (or carpet) is normally fitted under the facia and requires the removal of the facia to allow the floor lining to be removed.

Design for repair guidance: It would be better if the floor lining had only one section under the facia and if it could be in separate sections on either side of the transmission tunnel.

C.13 Airbags causing protrusion of trim panels

Effect on repair: The deployment of airbags causes significant damage to the trim panels through which they protrude, meaning that the replacement of airbags and trim panels is required.

Design for repair guidance: To avoid excessive repair costs, passenger airbags should be fitted in a replaceable module, not relying on the perforation of trim panels. This will avoid the replacement of the whole facia and reduces the cost of repair.

C.14 Selective deployment of airbags

Effect on repair: Deployment of airbags can significantly increase the cost of repair.

Design for repair guidance: To reduce the cost of repair, selective deployment of airbags, depending on the occupation of a seat, should be considered.

C.15 Accident position sensitive

Effect on repair: Deployment of airbags can significantly increase the cost of repair.

Design for repair guidance: Restricting the deployment of airbags according to the location and severity of the impact by triggering only the appropriate airbags will reduce repair costs by minimising the replacement of both airbags and trim panels.

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C.16 Rivet Joints

It is advisable to avoid the use of rivets to fix plastic elements to the bodyshell. In general, when removed by drilling out, the rivet will rotate and be difficult to remove. Additionally, the plastic part will be damaged by friction and heat.

Effect on repair: The damaged plastic part will need replacement when it could have been reused, if an alternative fixing mechanism had been used.

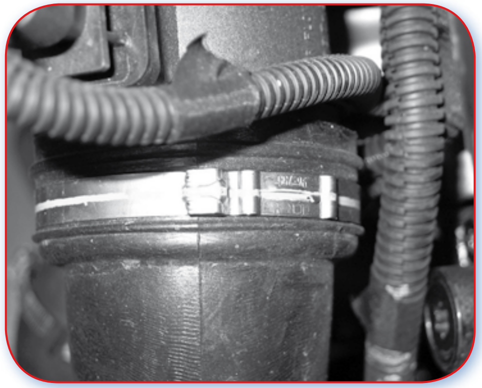
Design for repair guidance: Use a fastener that can be removed without drilling.

C.17 Quick release joints

Use quick release joints in hoses/pipes for the cooling system, air conditioning system and also, if possible, in the exhaust pipe.

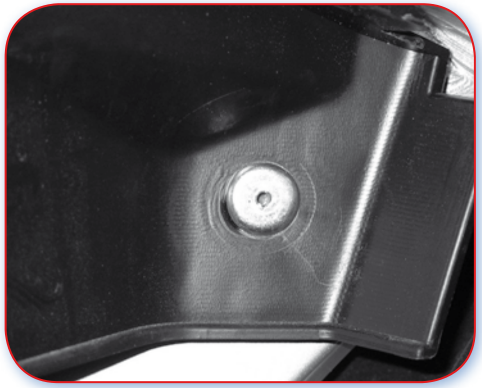
Effect on repair: By choosing good locations to add quick release joints, manufacturers can improve the ease of removal and assembly of main components during repair.

Design for repair guidance: Introduce reuseable quick release joints on specific systems and locations. (See also the door area within M.E.T.).



Poor Example. Conventional joints are difficult to remove, especially when access to the clip is restricted.

Good Example. Quick plug joints facilitate removal of the mechanical elements.



Poor Example. Plastic element fixed with rivets. Removal of the rivets could damage it.

Good Example. Plastic element fixed with screws. Removing the screws is easy and causes no additional problems.

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Paint

Paint is the finish of the vehicle but consists of more then just adding a colour to a bodyshell. It also contains all the base layers - the protective coatings and pre-treatments. During manufacture, these are applied by automated systems, using paint robots and high bake ovens. Consideration should be given to the fact that the application and type of paint in a manufacturing environment is different to the paint applied and the method of application in repair. In manufacture, paint is applied to an empty shell, whilst in repair the vehicle contains all the trim parts, engine and running gear, which restricts the way paint can be applied and baked.

D.1.1 Poor example. Body showing different finishes.

D.1 Difference in finish

Effect on repair: There may be differences in the colour and finish of the visible and non-visible surfaces (e.g. in engine bays). This particularly shows when panels such as the hang-on panels at the front of the vehicle are covering both visible and non-visible areas, where the engine bay has only had a layer of base coat and a clear finish. When the panel is replaced, it will be fully painted to the same quality as the visible surface. This will show as a difference between the new panel and the rest of the panels in that area and is, therefore, unacceptable as there will be clear evidence of repair.

Design for repair guidance: Avoid visible and non-visible surfaces having different paint and finish treatments (pic D.1.1).

D.2 Masking service parts

Effect on repair: Masking should be avoided on service parts as it can dry out or be damaged when shipped, incurring extra costs for repair.

Design for repair guidance: Do not mask up service parts. Alternatively, always use high quality masking materials.

D.3 Pre-painted service parts

Effect on repair: Service parts that are supplied painted to the body colour will show slight differences in colour. Customers are more critical about colour differences after a repair than on first delivery when the vehicle is new. This means that a re-spray is required to match the vehicle colour better, obviously incurring extra costs for repair.

Design for repair guidance: Supply service parts in a base primer or untreated.

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D.4 Removal and fitting of plastic inserts, covers and surrounds

Effect on repair: Any inserts or covers should be detachable from the panel to which they are fitted. When this is not the case, it means that masking is required whilst the retaining panel is painted, requiring extra time. Also, the quality will not be as good as when a panel can be sprayed without any inserts (pic D.4.1).

Design for repair guidance: Inserts should be detachable from the retaining panel, either as clip in/on or by means of screws without the removal of interior trim panels. If a permanent fixing cannot be avoided, the plastic part should be surrounded by a soft rubber seal which can be lifted to assist masking the component.

D.5 Different colours on a panel

Effect on repair: Two colours on the same panel are difficult to blend in and will always show evidence of repair (pic D.5.1).

Design for repair guidance: Avoid the application of two colours on the same panel.

D.6 Use of decals

Effect on repair: Decals are difficult to remove should they need replacing in repair. The application of new decals is problematic as air can often be trapped under the surface, leading to a poor quality repair (pic D.6.1).

Design for repair guidance: Avoid the use of decals.

D.4.1 Poor example. A hard plastic insert is difficult to mask around, so it will require removal.

D.5.1 Poor example. A bonnet showing different colours on one panel.

D.6.1 Poor example. Decal applied to door edges.

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D.7 Different paint colours on service parts

Effect on repair: The quality of service condition parts will affect the quality of the repair. Panels in a black base paint will need more paint to be applied when a lighter final colour is required, costing more in both time and materials. The same problem can arise when there is a different colour between the bodyshell and closure panels.

Design for repair guidance: Use the same colour for all service parts, ideally in a more neutral colour like beige or grey.

D.8 Consistency of service panels and bodyshells

Effect on repair: The same service parts are delivered sealed one time and not sealed another. This means that application times in repair vary, depending on whether sealant has to be applied or not. This can affect both costs and quality.

Design for repair guidance: Make the supply of service parts consistent, which will improve service parts quality. Any closure panel should be supplied with sealing to match that used in production. This will remove any evidence of repair, improve the overall quality of repair and reduce the repair time.

D.9 Shipping damage to service parts

Effect on repair: Supplied service parts arrive damaged and deformed at repairer.

Design for repair guidance: The packaging of service parts has to be sufficient to avoid any damage to the surface or the shape during shipping.

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D.10 Doors

Effect on repair: In many cases, depending on the location and extent of the damage, it is not necessary to paint the complete door. The option of painting only part of the door can still produce a quality finish.

Design for repair guidance: Fitting a moulding across the whole width of the door will avoid colour match problems when painting only part of the door. This contributes to a high quality finish and also to cost savings. The option to remove the exterior accessories on the door, such as the handle, lock, moulding and mirror, without the need to remove the door trim, will facilitate their removal for painting and avoid masking operations.

Poor Example. A moulding that does not cover the whole width of the doorskin does not allow painting of only part of the door.

Good Example. A moulding across the whole door enables either the top or bottom of the door panel to be painted separately.

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Vehicle Body Panels

Front Bumper Cover

The front bumper cover has become more and more of an aesthetic part of the vehicle, able to resist small bumps and covering the more structural parts which may absorb the energy of a low speed impact. This plastic part can contain several high cost items like spray units for lights, distance sensors and sensors for pedestrian protection.

1.1 Adjacent panels damaged on low speed impact

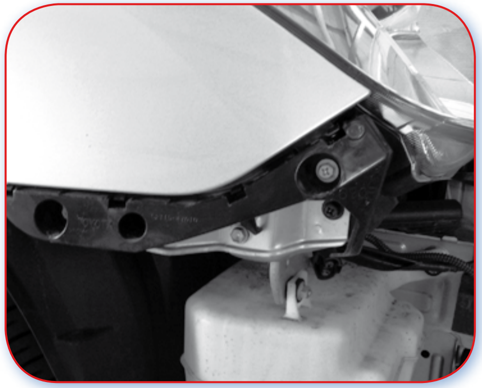
Effect on repair: Adjacent panels may be damaged when bumper covers are joined to these panels, increasing repair costs and time (pic 1.1.A, 1.1.B).

Design for repair guidance: Either have bumper covers separate from panels or have sacrificial joints that will separate before any damage occurs to the panel (pic 1.1.C, 1.2.D).

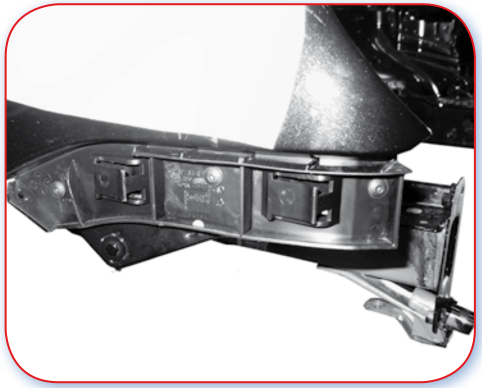
1.2 Sectional bumper cover

Effect on repair: When a single piece bumper cover suffers sufficient damage, a complete replacement is required, incurring excessive costs for repair.

Design for repair guidance: If a bumper cover is made out of sections, when only a piece is damaged, only this single piece needs replacement. During refinishing, it will also reduce the amount of blending required, due to a reduced area of repair.

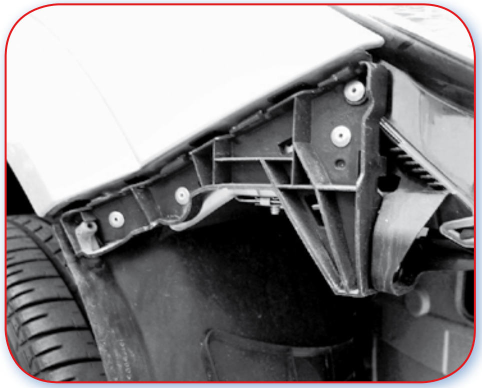


1.1.A Good example. Bracket is supporting the panel and bumper independently.



1.1.B Good example. Bracket is supporting the panel and bumper independently.

1.1.C Poor example. Bracket to carry bumper is fitted to panel.



1.1.D Poor example. Bracket is supporting the panel and bumper independently. Fastener for the panel is covered by the bracket.

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1.3 Thickness of bumper cover material

Effect on repair: When bumper covers are too thin, the heat used for local repairs will deform the bumper.

Design for repair guidance: A bumper cover with a minimum thickness of 3mm will be easier to repair and deforms less.

1.4 Material of bumper cover

Effect on repair: When materials, like Polyethylene (PE), which is used for bumper covers, are too brittle it makes them more difficult or impossible to repair. This will increase the repair costs.

Design for repair guidance: By selecting a material that stays soft, for example UV stable Polypropylene (PP), it will mean that a small local repair can be done on the bumper cover.

1.5 Safety critical bumper parts not separable

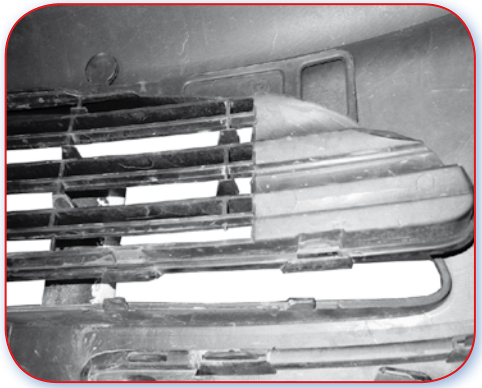
Effect on repair: When a bumper has minor damage, a small local repair may be sufficient. This option may not be possible, when there is a safety critical part permanently attached to the bumper which requires replacement, dictating the need for a complete bumper assembly. This will increase the repair costs significantly.

Design for repair guidance: It will be advantageous to have safety critical parts detachable from cosmetic parts and have them available as service parts.

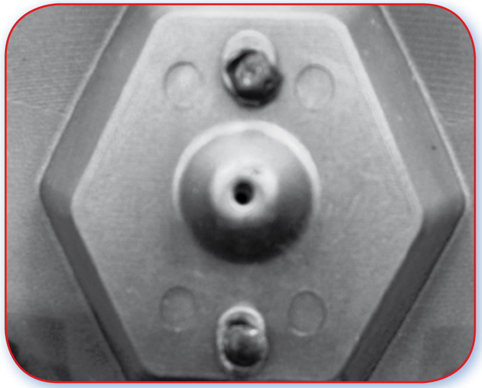
1.6 Fixing inserts in bumper covers

Effect on repair: Inserts fitted to bumper covers are fixed permanently, using adhesives or welding, which means that the service part requires either separate parts or when the colour is different, it will need masking when painted (pics 1.3.A, 1.3.B, 1.3.C).

Design for repair guidance: When clips are used to hold an insert to the bumper cover, the clip should be on the inside of the bumper cover.



1.6.A Good example. Bumper grille can be removed for refit of new bumper.



1.6.B Poor example. The badge fixed to the bumper panel and the fastener for the panel is covered by the bracket.

1.6.C Poor example. The badge fixed to the bumper panel and the fastener for the panel is covered by the bracket.

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1.10.A Good example. Bumper will require fresh masking before paint.

1.10.B Poor example. Pre-masked bumper; masking will age before part requires paint, so it will require re-masking.

1.7 High value items fitted to bumper cover

Effect on repair: The fitting of high value items in the bumper cover means that when an accident occurs it will cost more to repair.

Design for repair guidance: Consider an alternative position away from the bumper area to avoid costly damage in a minor impact.

1.8 Removal of under tray

Effect on repair: The under tray is difficult to separate from the bumper cover either for the removal of the front bumper cover or the under tray, as the joint is secured using staples or rivets.

Design for repair guidance: Use removable fixings, such as screw fasteners or clips.

1.9 Pre-painted service parts

Effect on repair: Service parts that are supplied painted to the body colour will show slight differences in colour. Customers are more critical about colour differences after a repair than on first delivery when the vehicle is new. This means that a re-spray is required to match the vehicle colour better, obviously incurring extra costs for repair.

Design for repair guidance: Supply parts in a consistent service base primer.

1.10 Masking service parts

Effect on repair: Masking should be avoided on service parts as it can dry out or be damaged when shipped, incurring extra costs for repair (pics 1.7.A, 1.7.B).

Design for repair guidance: Do not mask up service parts. Alternatively, always use high quality masking materials.

1.11 Shipping damage to service parts

Effect on repair: Supplied service parts arrive damaged and deformed at repairer.

Design for repair guidance: The packaging of service parts has to be sufficient to avoid any damage to the surface or the shape during shipping.

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Front Bumper Reinforcements

The bumper reinforcement is a part of the energy absorbing structure in an impact and normally joins the front ends of the chassis legs through the crash cans. It carries the bumper cover and is either welded or bolted onto the crush can.

2.1 Level and height of bumper reinforcement

Effect on repair: The level and height of the reinforcement determines how much damage is caused around and behind the reinforcement (pic 2.1.D).

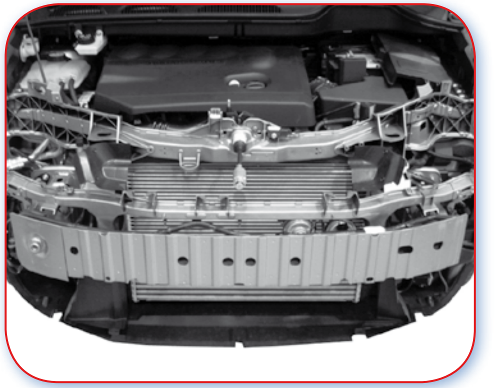
Design for repair guidance: Increase the height of the reinforcement to have a sufficient area. Together with an average level, this will avoid excessive damage when override or underride occurs (pics 2.1.A, 2.1.B, 2.1.C).

NOTE: A RCAR standards are available and are called “RCAR low speed structural test” and “Low speed bumper test”.

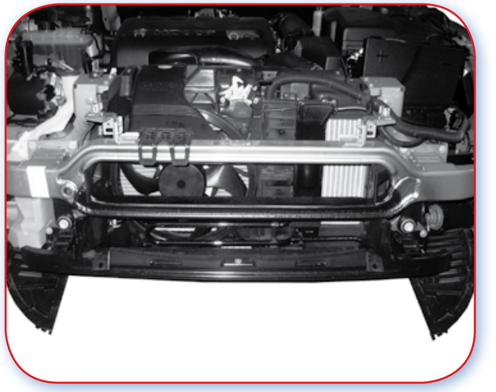
2.2 Clearance between bumper reinforcement and surrounding parts

Effect on repair: A small gap between the reinforcement and any parts behind it can result in the need to replace additional parts as they may be damaged by the intrusion of the reinforcement in a low speed accident (pic 2.2.A).

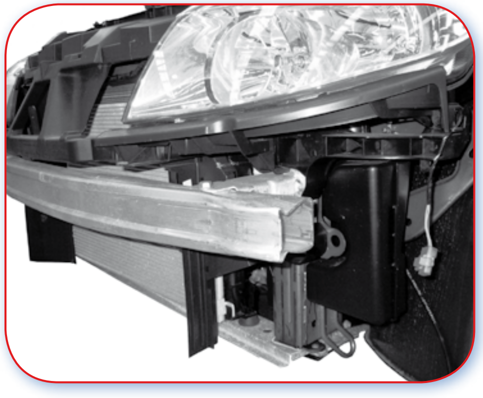
Design for repair guidance: Keep an appropriate amount of space between the reinforcement and any parts behind it.



2.1.A Good example. Good distance between reinforcement and cooling pack. Good reinforcement height and no parts clip onto it.



2.1.B Good example. Parts clip onto the bumper beam for easy release.



2.1.D Poor example. Narrow reinforcement. No pedestrian protection bar. Good distance between reinforcement and cooling pack. No parts clip onto reinforcement.

2.2.A Poor example. Not having enough distance between reinforcement and cooling pack - will cause damage to adjacent parts on impact.

2.1.C Good example. Good reinforcement height. Good distance between bumper beam and cooling pack. Low pedestrian protection bar. No parts fixed to the bumper beam.

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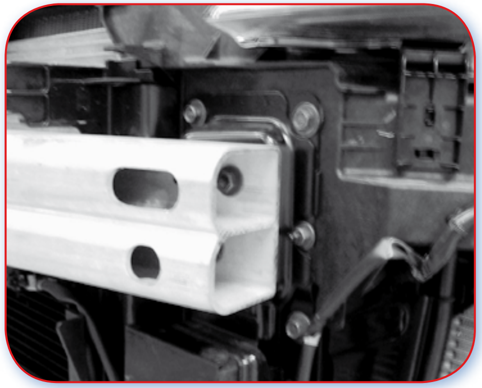
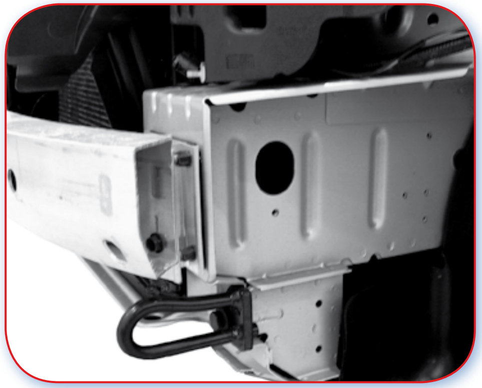
Front Crush Cans

Crush cans are fitted on the end of the chassis leg as part of the load path to absorb energy. By doing this, they also provide a crumple zone in a low speed impact to help avoid structural damage to the chassis leg.

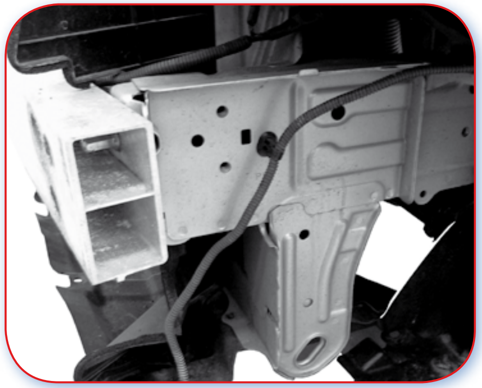
Crush cans are made of various materials and are of different sizes, depending on the requirements needed to perform well in both low and high speed impacts for a particular vehicle (pics 3.0.A, 3.0.B, 3.0.C, 3.0.D, 3.0.E, 3.0.F, 3.0.G, 3.0.H, 3.0.I, 3.0.J, 3.0.K, 3.0.L).



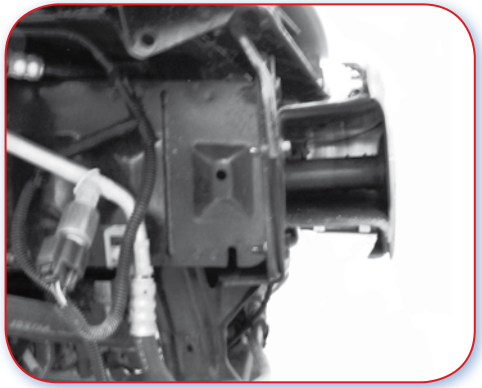
3.0.A Poor example. No crush can, so the chassis leg will be damaged on impact.



3.0.B Poor example. No crush can, so the chassis leg will be damaged on impact.



3.0.C Poor example. No crush can, so the chassis leg will be damaged on impact.



3.0.D Poor example. No crush can, so the chassis leg will be damaged on impact.

3.0.E Poor example. No crush can for energy absorption, leaving the chassis leg to be damaged on impact.

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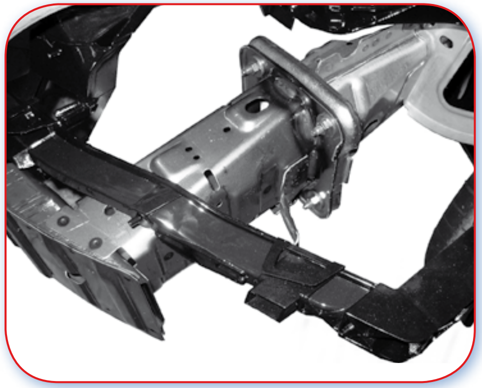
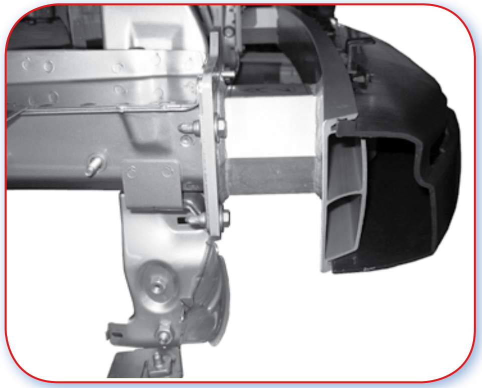
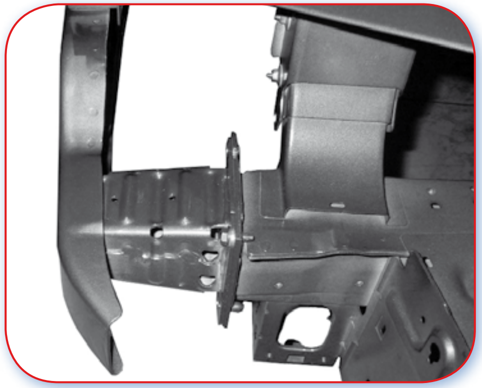


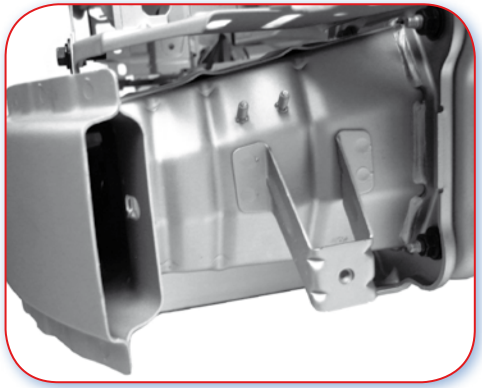
3.0.F Good example. A bolt-on crush can. This is a long crush can made from steel.



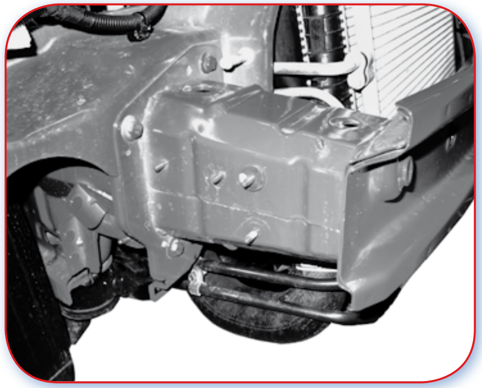
3.0.G Good example. A bolt-on crush can. This is a short crush can made from aluminium.



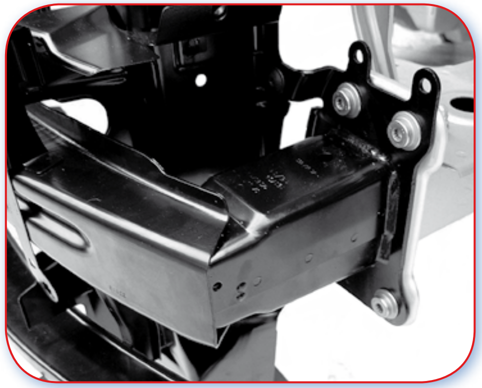
3.0.H Good example. A bolt-on crush can. This is an average length crush can made from steel.



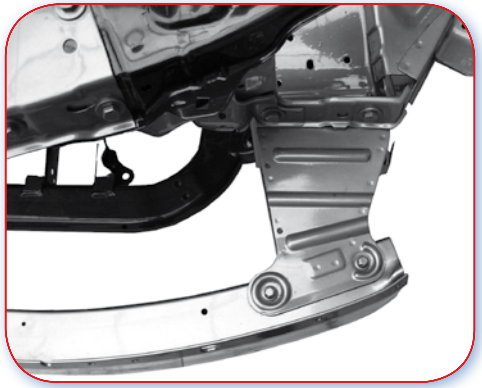
3.0.I Good example. A bolt-on crush can. This is an average length crush can made from steel.



3.0.J Good example. Good space between bar and cooling pack. This is an average length crush can made from steel.



3.0.K Good example. A bolt-on crush can. This is an average length crush can made from steel.



3.0.L Good example. A bolt-on crush can. This is an average length crush can made from steel.

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Front Inner Wing

The front inner wing is the part that joins the forward part of the front outer wing and its reinforcement to the front chassis leg and suspension strut.

4.1 Space for front panel movement

Effect on repair: The inner wing suffers damage in frontal impacts when the front panel, cooling pack and other auxiliaries move backwards. This means that the wing panels and other panels surrounding the inner wing need to be removed for repair, increasing repair times and costs (pics 4.1.A, 4.1.B).

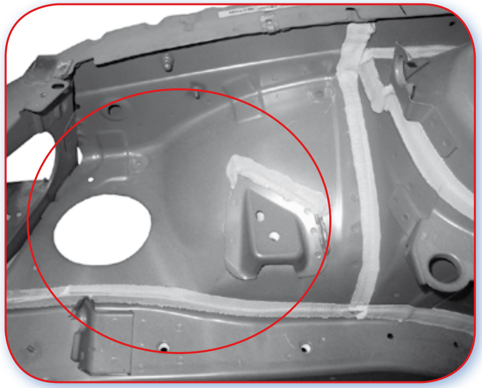
Design for repair guidance: The front edge of the inner wing should be fitted as far back as possible. This will allow the front panel to move without damaging the panel in an impact (pics 4.1.C, 4.1.H).

4.2 Natural joints

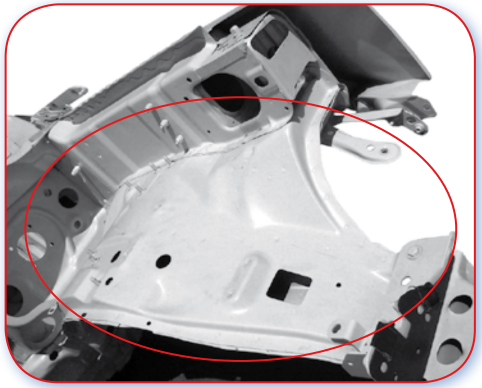
Effect on repair: When a front inner wing requires replacement, the panel is normally separated at a natural joint. If the inner wing has no natural joints which can be used, the repairer will create a joint and will also have to remove any evidence of the repair. This will increase repair times.

Design for repair guidance: Introduce natural joints to use in repair.

NOTE: A RCAR standard is available called "A Low Speed Crash Impact".



4.1.A See pic 4.1.B.



4.1.B Poor example. Both pictures show an inner wing that extends to the front panel and light fittings. This does not allow movement of parts on impact and results in them being damaged.

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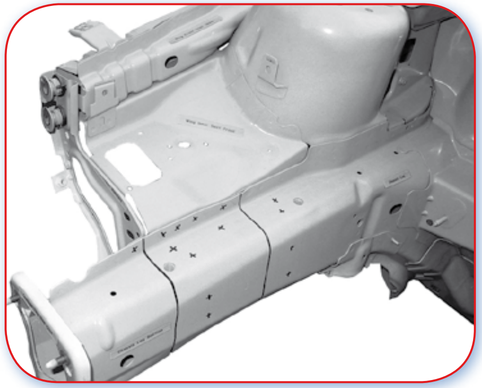
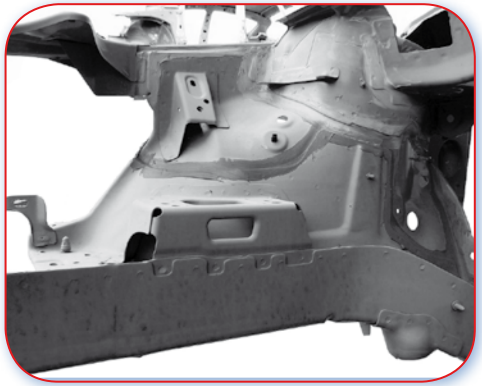
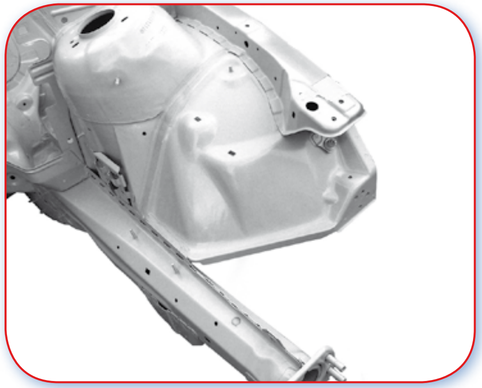


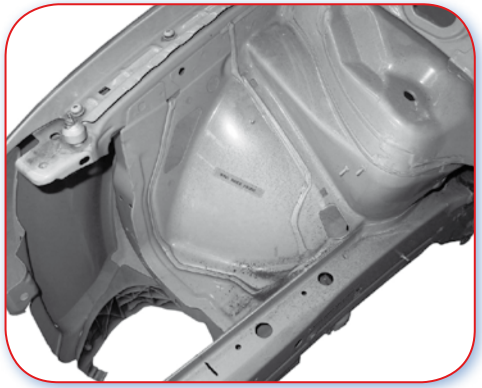
4.1.C Good example. These panels are set back, leaving space for light clusters and the front panel to move. Panels have natural joints to work to for removal of the part when damaged.



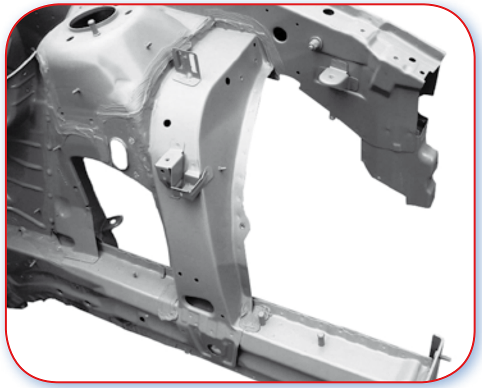
4.1.D See pic 4.1.D.



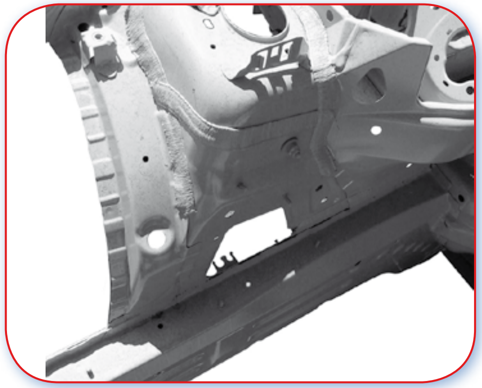
4.1.E Good example.



4.1.F See pic 4.1.E.



4.1.G See pic 4.1.H.



4.1.H Good example. No inner wing, just a reinforcement joining the panel reinforcement and chassis leg. An arch lining forms the joint between the front panel, inner wing and panel reinforcement.

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Suspension Strut Tower

This is the upper fixing point for the front suspension and shock absorbers.

5.1 Strut tower part of front inner wing

Effect on repair: If the strut tower is part of a front inner wing, which requires replacing after an accident, it will also be necessary to remove the suspension parts. This will severely increase repair times.

Design for repair guidance: Avoid having strut towers as part of the inner wing.

5.2 Strut tower fitted to plenum chamber

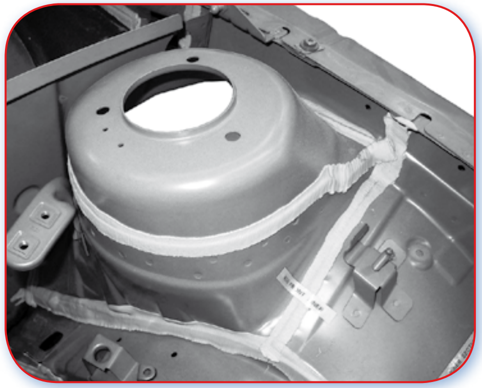
Effect on repair: When the tower is fitted close to the plenum chamber, or is fitted into or as part of it, a repair can be difficult, as removal of the strut tower will also require the removal of the front interior trim inside the passenger cell to avoid damage. This will cause excessive repair costs due to the position of the strut tower.

Design for repair guidance: Ideally, a front suspension tower should be fitted as a panel by itself, but this may be difficult due to the amount of space and the set up of the suspension (pics 5.2.A, 5.2.B).

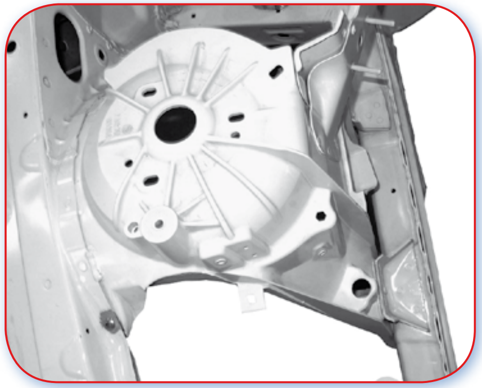
5.3 Natural joints

Effect on repair: When a front inner wing requires replacement, the panel is normally separated at a natural joint. If the inner wing has no natural joints which can be used, the repairer will create a joint and will also have to remove any evidence of the repair. This will increase repair times.

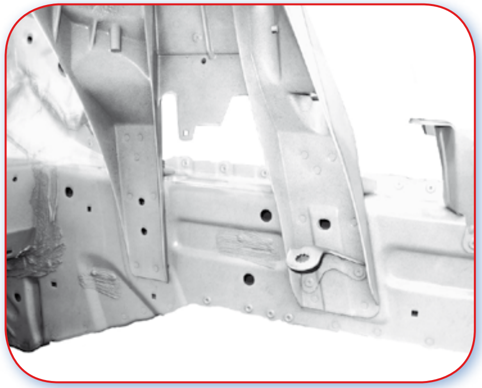
Design for repair guidance: Introduce natural joints to use in repair (pics 5.3.A, 5.3.B, 5.3.C).



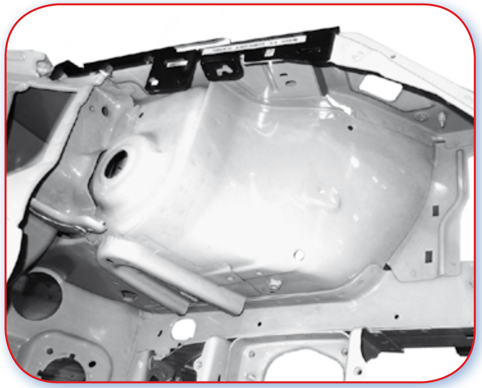
5.3.A Good example. Suspension strut tower, separate from the plenum chamber, showing joints to work to for replacement.



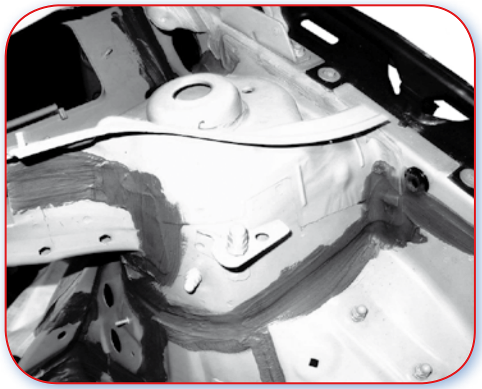
5.3.B See pic 5.3.C.



5.3.C Good example. Showing a separate suspension strut tower fitted to the front chassis leg. The front panel reinforcement is only supported by a bracket attached to the firewall.



5.2.A Poor example. Suspension strut tower is positioned as part of the firewall plenum chamber.



5.2.B Poor example. Suspension strut tower is positioned as part of the firewall plenum chamber.

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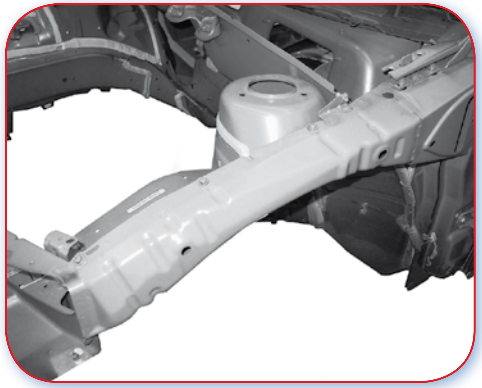
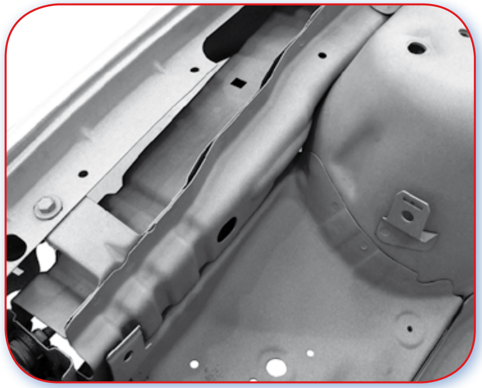
Panel Reinforcement

In most cases, the front inner wing, front outer wing and suspension strut tower are supported by the front panel reinforcement. This reinforcement joins both the front inner and outer panel, as well as the suspension strut tower and is fitted to the 'A' Post and/or firewall.

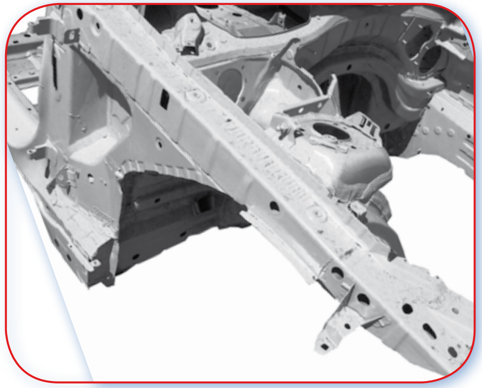
In most cases, when the reinforcement is damaged in the front part of the reinforcement, a section can be made to replace the damaged part. Replacement of the whole reinforcement is time consuming and is only carried out when there is substantial damage (pics 6.0.A, 6.0.B, 6.0.C).



6.0.A See pic 6.0.C.



6.0.B See pic 6.0.C.



6.0.C Typical examples of front panel reinforcements.

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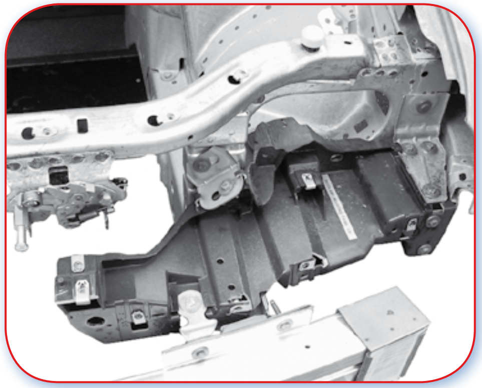


7.1.A Poor example. Front panel welded to side member.

Front Panel

The front panel covers the front of the vehicle and, in general, is fitted to the front chassis legs, supplying a support for both outer wings. It is also the area for the bonnet to rest on and it supplies the frame for the bumper joint/grille or part of it.

In many cases, it will also cater for the fixing positions of the front lights and the cooling pack.

7.1 Front panel fixing

Effect on repair: As the front panel is a frequently damaged part, removal should take as little time as possible. Steel front panels fitted to the body by using spot welds, creating a permanent joint, will cause longer repair times and will increase costs (pic 7.1.A).

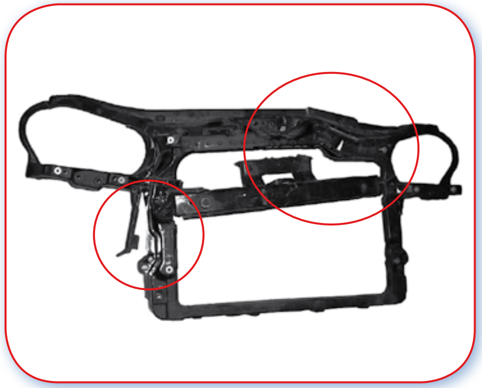
Design for repair guidance: The front panel should be a bolt-on part to ease removal of the panel.

7.2 Subsequent damage

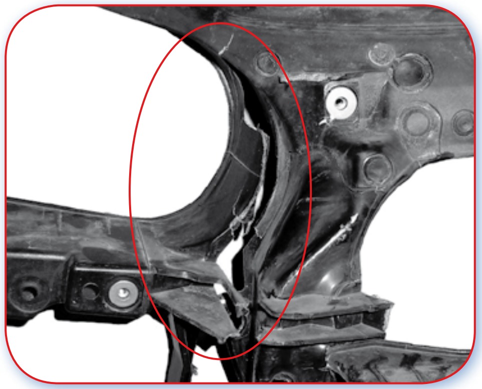
Effect on repair: Due to the location of the landing panel, it will damage surrounding parts when it is pushed in as a result of an accident. This will cause damage to the parts it is fitted to or surrounded by.

Design for repair guidance: The landing panel should have the ability to break away from its fixings. The panel should not be fitted to the bumper, crush cans or chassis leg. This will avoid damage when the vehicle has a low speed impact only affecting the bumper. An allowance for space should be made behind the panel to allow travel of the panel (pics 7.2.A, 7.2.B, 7.2.C, 7.2.D, 7.2.E, 7.2.F, 7.2.G, 7.2.H, 7.2.I, 7.2.J, 7.2.K, 7.2.L).

7.2.A Good example. Bolt-on front panel made out of reinforced plastic.



7.2.B Good example. On impact, the panel has broken, allowing parts fitted to the panel to move, but not to be damaged.



7.2.C Good example. Detail of damage to offer up panel.

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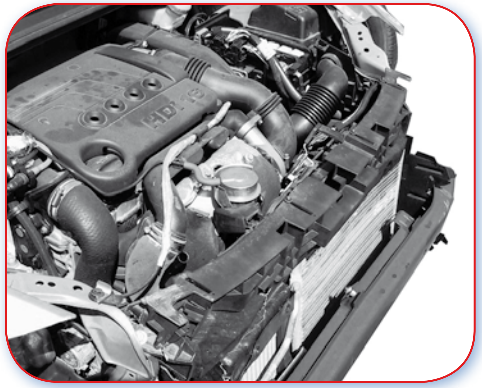
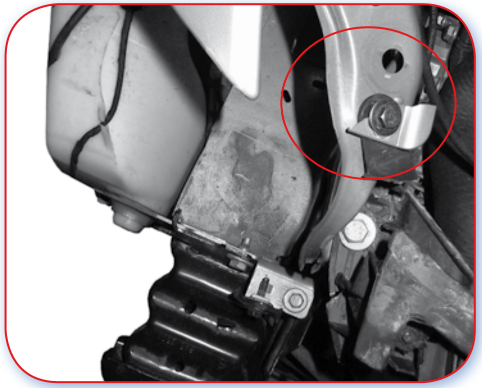
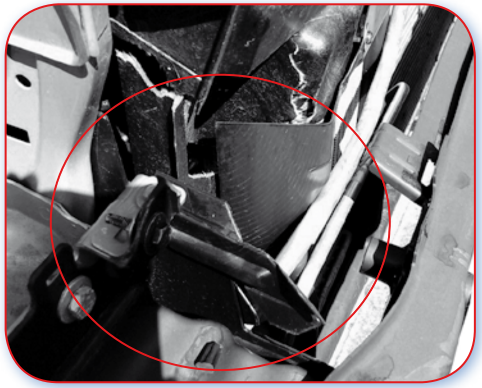


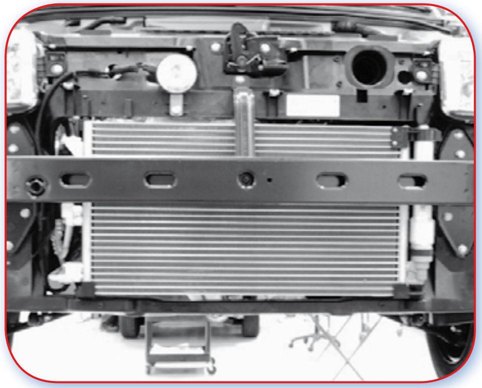
7.2.D Good example. Bolt-on front panel made out of reinforced plastic.



7.2.E Good example. On impact the panel has broken, allowing parts fitted to the panel to move but not to be damaged.

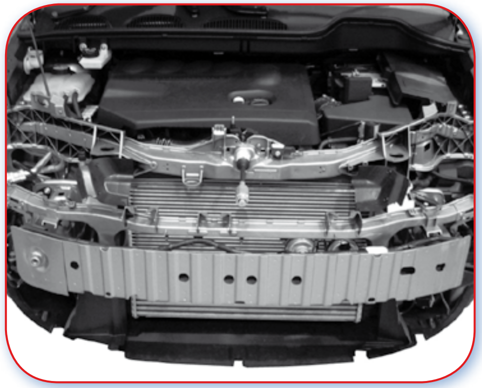


7.2.F Good example. This panel can be replaced easily. The cooling pack can move, but will not be damaged on impact.

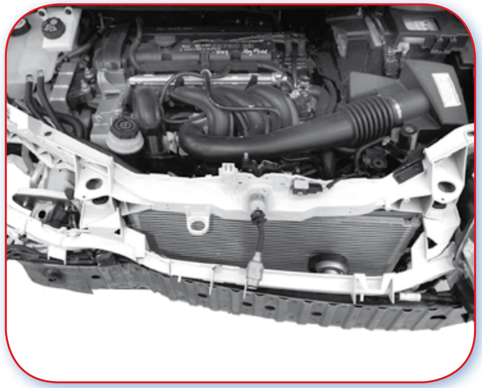


7.2.G Good example. The front panel comprises a landing panel but no lower parts. Costly parts set back enough to reduce damage.

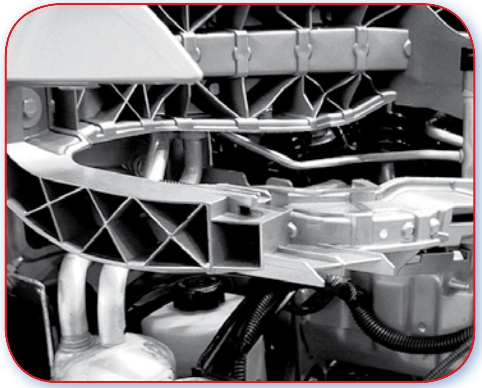
7.2.H Good example. The front panel comprises a landing panel but no lower parts. Costly parts set back enough to reduce damage.



7.2.I Good example. Front panel bolted on.



7.2.J Good example. Bonnet landing panel set back from the front bracket, avoiding subsequent damage.



7.2.K Good example. Auxiliary parts are fitted further back (apart from the horn). They are made out of plastic, so no paint is necessary.

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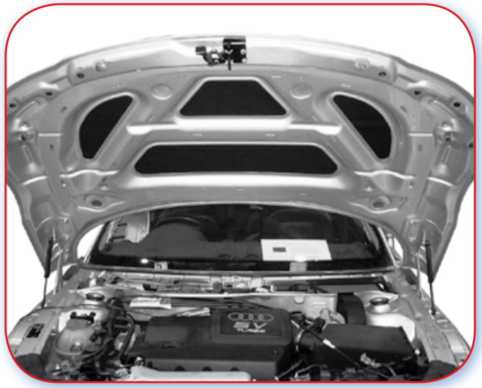
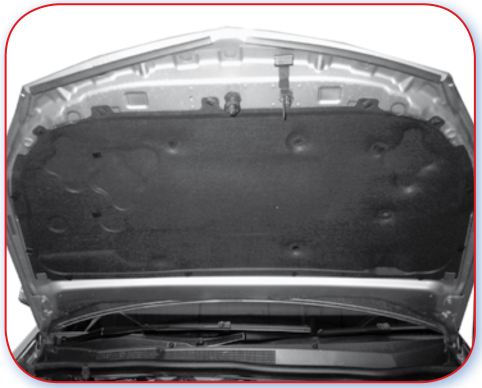
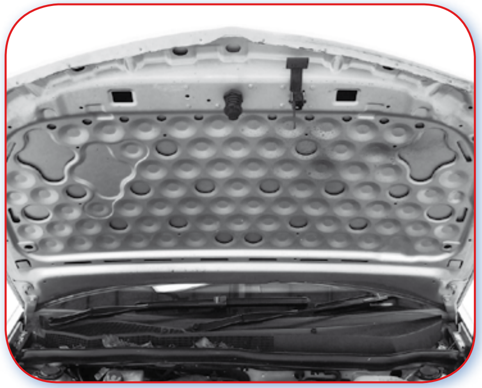


8.0.A Single skinned bonnet with reinforcing sub-frame, easier to repair as both panels are accessible.



8.0.B See pic 8.0.C.



8.0.C Double skinned bonnet without reinforcing frame, compliant with the new pedestrian legislation. More difficult to repair, due to limited access to both panels.

7.3 Lower crossmember

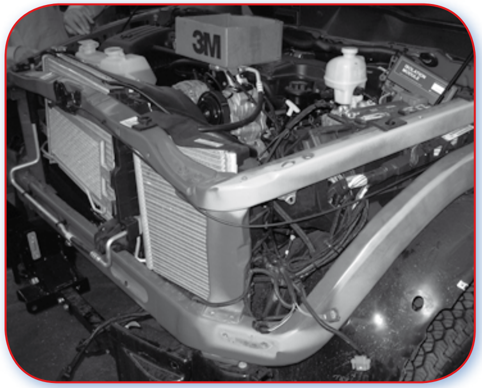
When the front section of the car is fully assembled, the front crossmember cannot be replaced.

Effect on repair: Replacement of the front crossmember will require additional parts to be removed and replaced.

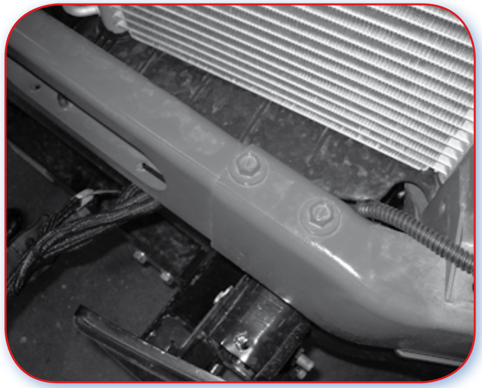
Design for repair guidance: Avoid parts being unreplaceable due to their order of assembly.

Bonnet

Bonnets are becoming more service parts than repairable parts. This means that when a bonnet is damaged it gets replaced instead of being repaired, unless very minor damage like damaged paint or damage to plastic inserts occurs. This is also reinforced by the new pedestrian safety regulations, which are pushing car designs towards a single or a double skinned part, without any reinforcements in the centre part of the panel. This means that repair of these parts has become more or less obsolete (pics 8.0.A, 8.0.B, 8.0.C).



Poor example.



Good example.

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8.1 Shape of bonnet

Effect on repair: Exposure of the bonnet affects how much it will be damaged during a frontal impact (pics 8.1.A, 8.1.B).

Design for repair guidance: Wrap around bonnets should be avoided as they will be more exposed to damage. Bonnets that are set back are better in a low speed frontal impact, as the bonnet will be less affected (pics 8.1.C, 8.1.D).

8.1.A Good example. See pic 8.1.B.

8.1.B Good example. Front edge of bonnet set back. Side edges protected by side panel.

8.1.C Poor example. Wrap around bonnet which results in more exposure to damage.

8.1.D Poor example. See pic 8.1.C.

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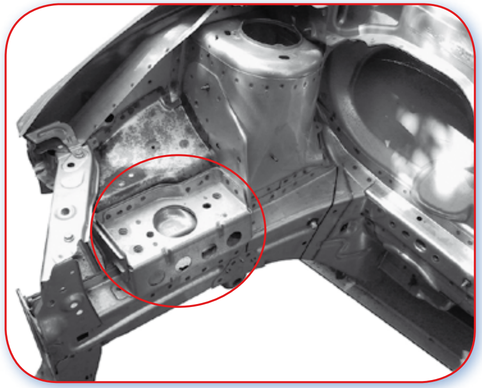
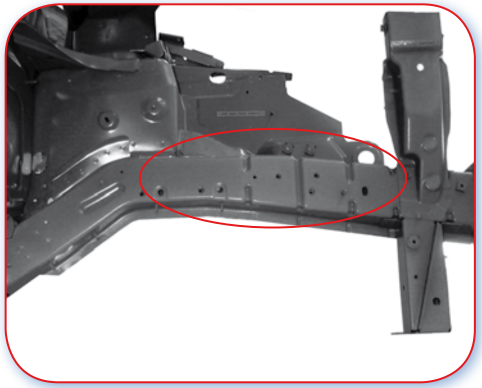


9.1.A Poor example. Small chassis leg with bracketing and holes not offering a good location for sectioning.



9.2.A Poor example. Chassis leg with too many reinforcements, leaving no area for any proper section.

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Front Chassis Leg

The front chassis legs are an integral part of the front load path, absorbing energy from a frontal impact and distributing the loads around the passenger cell.

9.1 Length of chassis leg

Effect on repair: The reduction of length to accommodate crush cans has left a smaller proportion of the chassis leg available for energy absorption. This means that there is a reduced possibility of sectioning following deformation of the chassis leg, especially on smaller and medium sized cars (pic 9.1.A).

Design for repair guidance: The repair of chassis legs after a low speed impact will usually be unnecessary because of the crash cans, which are designed so that damage from a high speed impact is restricted to a smaller area. For this reason, a shorter chassis leg should have energy absorbing areas in the most forward part of the leg, with the possibility of sectioning the leg to remove the damaged part.

With larger cars, the length of the crush cans, as well as the length of the front chassis leg is normally ample to have sections done.

9.2 Assembly of chassis leg

Effect on repair: Reinforcements inside the replaceable area of a chassis leg will reduce the possibility of sectioning the chassis leg in that particular area (pic 9.2.A).

Design for repair guidance: Chassis legs manufactured from tailored blanks will not have the same requirement for reinforcements and will allow for sections in different locations. If an assembled chassis leg is used, consideration should be given to the location of any reinforcements to allow sections. An indicator on the chassis legs to show where sectioning is possible or technically allowed will be useful for both tailored blank and assembled chassis legs.

9.3 Chassis leg fitted against plenum chamber/firewall

Effect on repair: A direct joint between the chassis leg and the plenum chamber/firewall should be avoided. When removal of the chassis leg is required, it means that the interior trim directly fitted to the plenum chamber/firewall has to be removed. This will increase labour time and repair costs.

Design for repair guidance: Provide a natural joint near the plenum chamber/firewall to allow repair on the chassis legs (pic 9.3.A, 9.3.B).

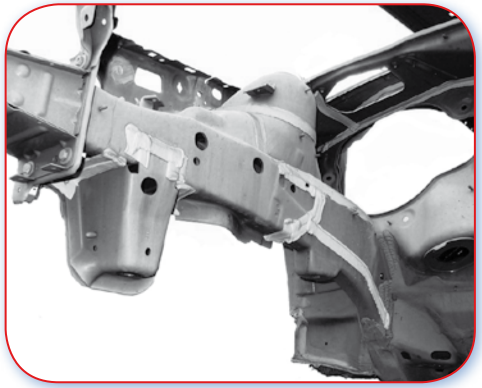
NOTE: The fittings on service parts should match the joining method and align with the natural joints.

9.4 Measuring points

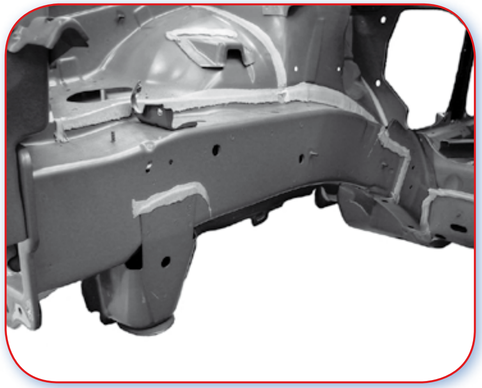
It is important that the front chassis legs are straight, especially in the longitudal direction. It would be useful to have intermediate measuring points between the front of the chassis legs and the engine mounts, so they can be used as a reference in the first pulling operation.

Effect on repair: The lack of measuring points reduces accuracy when straightening the chassis legs.

Design for repair guidance: Introduce additional measuring points to assist repairers when straightening is required.



9.3.A Good example. These pictures show chassis legs with natural joints near the firewall for complete replacement.



9.3.B See pic 9.3.A.

Poor Example. Front chassis leg without a central data point, does not have a suitable reference to control pulling operations.

Good Example. Front chassis leg with a central data point, offering an additional reference for pulling operations.

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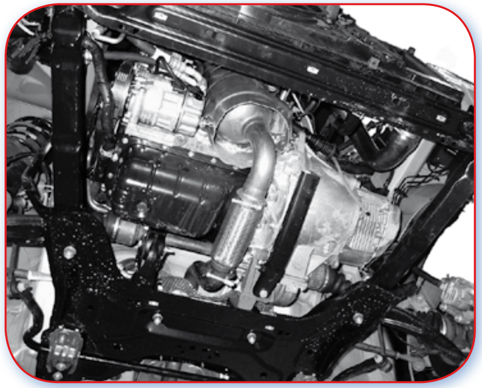
Front Sub-Frames

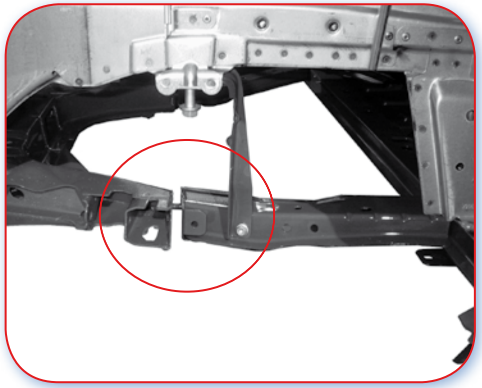
NOTE: Sub-frames are primarily used to position the engine and front suspension, as well as for the lower fixing of the front panel and bumper and/or for underrun protection. During production, they are used as an alignment tool to join the engine and front suspension to the vehicle body. This is done by bolting the sub-frame to the front area of the chassis legs and other parts further back on the body for load transfer. This can be advantageous in repair as engine removal is relatively straightforward, using the same procedure and fixings.

With the current pedestrian legislation, in some cases, the use of the sub-frame has been extended to support the lower front bumper. In other cases, the front part of the sub-frame has been eliminated to avoid damage to the frame and the subsequent fixing points.

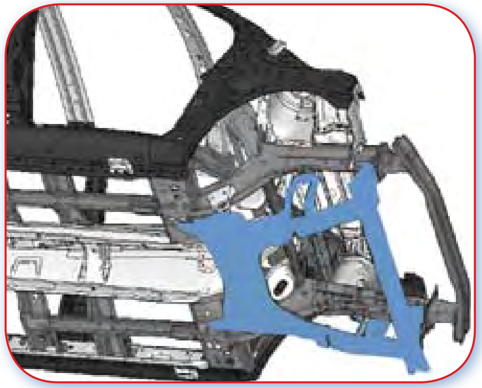
Full frames are ideally assembled from one or two half circular pieces (single or double C-shape) and this either avoids damage altogether or is easy to replace when damaged. Ideally, the sub-frame is fitted as far back as possible and contains crush cans to absorb energy from the lower load path and avoid subsequent damage (pics 10.0.A, 10.0.B, 10.0.C, 10.0.D, 10.0.E).



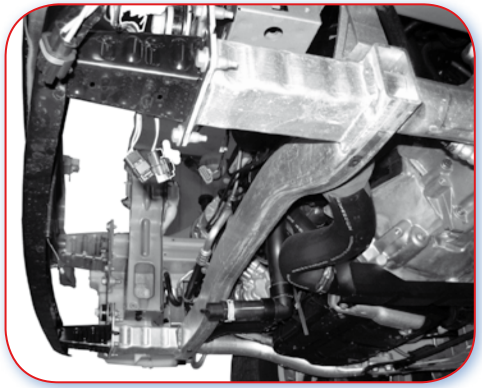
10.0.A Good example. Sub-frame segmented, any damaged parts can be easily replaced.



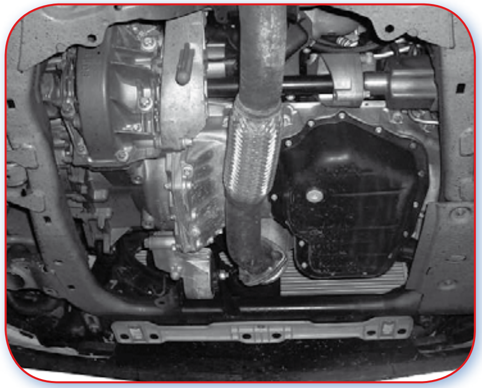
10.0.B Good example. Sub-frame can be separated to remove damaged front part.



10.0.C Good example. Sub-frame as a two piece unit. Separable in the middle.



10.0.D Good example. Sub-frame segmented, any damaged parts can be easily replaced.



10.0.E Poor example. Single round sub-frame, any damage means complete replacement will be required.

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Under Tray

To protect the engine bay from debris and damage, as well as any possible underrun, most vehicles are fitted with under trays. These covers are not structural and are fitted to the front bumper or front panel. The sides of the tray are fitted to side parts of the vehicle.

11.1 Under tray used as reinforcement

Effect on repair: Under trays which are reinforced to support lower parts of the bumper and front panel, as part of pedestrian protection, will be damaged on impact and require complete replacement in repair. This will increase the repair costs.

Design for repair guidance: Design the tray as a two piece part where a damaged front part can be easily replaced (pic 11.1.A).

11.2 Fixing of under tray to other panels

Effect on repair: The removal of wing liners requires more time when the under tray is fitted to the wing liner and needs separation before removal can take place. This will increase labour time during repair.

Design for repair guidance: Avoid attaching the side fittings of the tray to wing liners. This will ease removal of both parts independently.

11.3 Removal of under tray

Effect on repair: The under tray is difficult to separate from the bumper, when removing either the front bumper or the under tray, if the joint is made using staples or rivets.

Design for repair guidance: Use removable fixings such as screw fasteners or clips (pic 11.3.A).

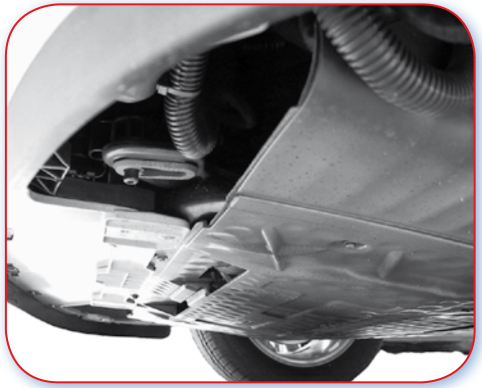
11.4 Under tray streamliner cover

Some vehicles have the underfloor area covered for streamlining reasons. This implies that for anchoring and measuring operations on a jig, these plastic covers have to be removed, increasing labour times.

Effect on repair: Streamlining panels cover up anchoring and measuring points, so these panels must be removed before any anchoring or measuring can be done, increasing labour times.

Design for repair guidance: Avoid restricting any access to measuring and anchoring points.

11.3.A Good example. Under tray covering engine bay, fixed with hexagonal head screws, not breakable clips or staples.



11.1.A Good example. Under tray fixed to lower bumper, but built in several segments.

Poor Example. Covers under the vehicle will hinder the diagnosis and measurement of damage, as well as anchoring to the jig.

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Body Side – General

In recent years, body sides and their reinforcements have been forced to provide more protection against intrusion from side impacts by, for example, the New Car Assessment Programmes run on different continents. This has a direct influence on the way body sides are designed and reinforced. The introduction of reinforcements made out of Ultra High Strength Steels (UHSS) has affected the way sills, 'A' and 'B' Posts are repaired.

Body Side – 'A' Post

The 'A' Post forms the outer front edge beside the front screen and runs all the way down to the sill, behind the front outer wing and also supports the roof. It normally contains reinforcements made of UHS steels, creating load paths that separate loads into the roof line and sill around the passenger cell. It is generally strong enough to resist a roll over of the vehicle without the roof intruding into the passenger cell (pics 12.0.A, 12.0.B, 12.0.C, 12.0.D).

12.1 'A' Post overlap

Effect on repair: Overlap of the 'A' Post under the side panel reinforcement and roof reinforcement makes replacement difficult and increases repair times.

Design for repair guidance: A bridging panel would be better, having the side panel reinforcement and 'A' Post butting against each other. This will ease the removal of the 'A' post and reinforcements, as there will be no requirement to remove adjacent panels (pics 12.1.A, 12.1.B, 12.1.C, 12.1.D, 12.1.E).

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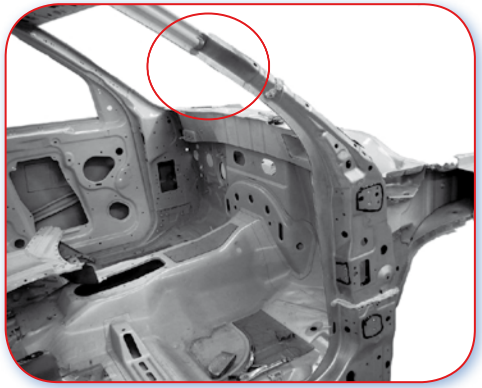
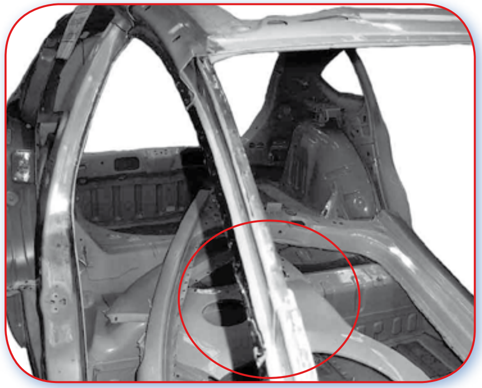
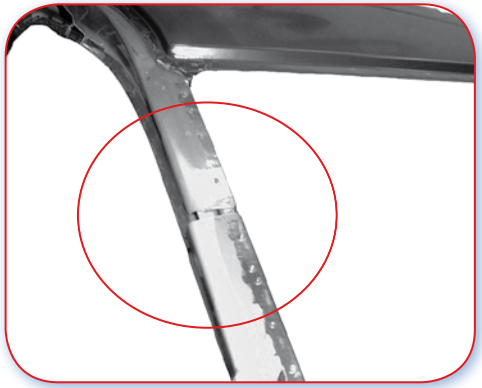


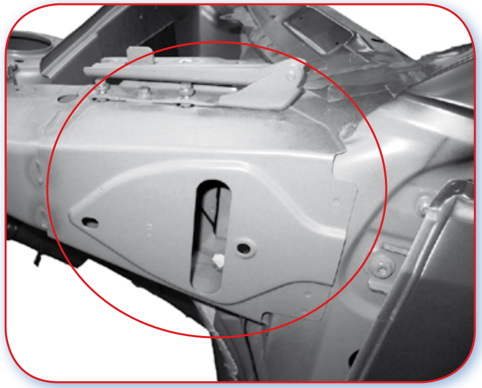
12.0.A Good example. See pic 12.0.B.



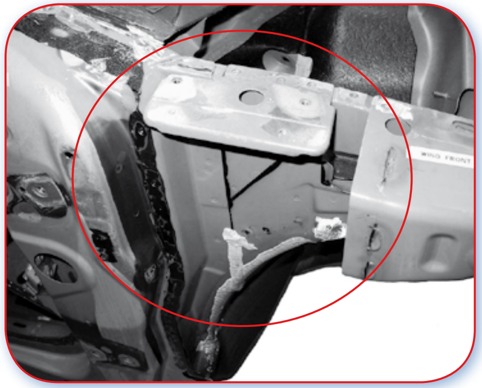
12.0.B Good example. ‘A’ post reinforcement is sectionable at natural joint in upper part, avoiding complete removal.



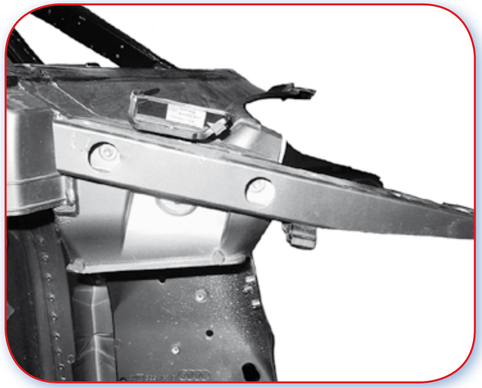
12.0.C Good example. ‘A’ Post reinforcement is sectionable at natural joint in upper part, avoiding complete removal.



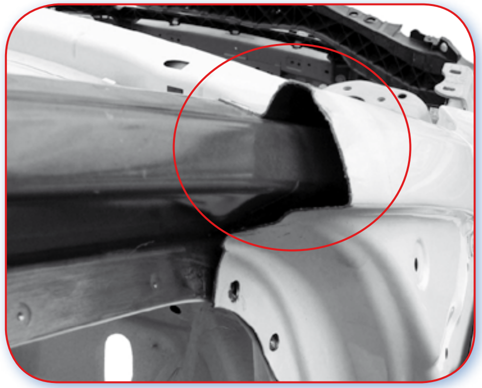
12.1.A Good example. Bridging plate creates a joint between ‘A’ Post and side panel reinforcement, easing removal of both panels.



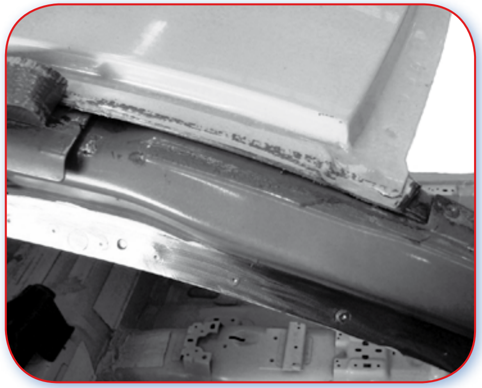
12.1.B See pic 12.1.A.



12.1.C Good example. Side panel reinforcement bolted onto plenum chamber/’A’ Post. This will ease the replacement.



12.0.D Good example. ‘A’ Post outer panel set away from reinforcement, which will avoid damage on sectioning.



12.1.D Good example. Outer panel fitted over roof panel.

12.1.E See pic 12.1.D.

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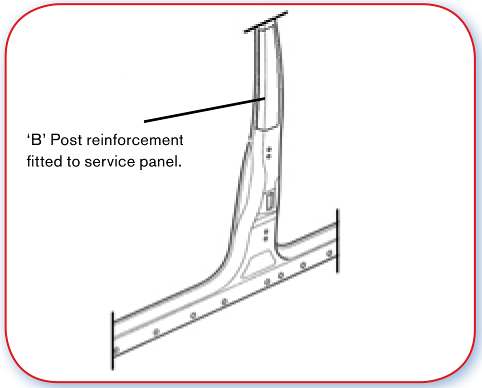
Body Side – 'B' Post / Sill

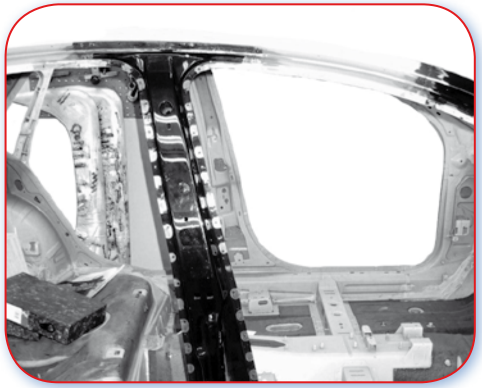
Sills and 'B' Posts have a range of functions within a vehicle. They provide rigidity and stiffness to the body and are normally made up from several layers, including one or more reinforcements. The sill is the lower visible panel and forms, or carries the aesthetic panel between the front and rear wheel arch. The 'B' Post also forms the main structural protection for occupants against a side impact. Because the 'B' Post and sill are physically joined, a repair to either of these parts indirectly affects the other (pic 13.0.A, 13.0.B, 13.0.C, 13.0.D, 13.0.E).



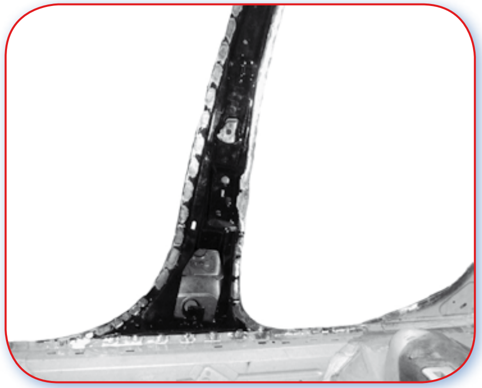
13.0.A Good example. 'B' Post with a UHSS reinforcement can be sectioned.

13.0.B See pic 13.0.C.

13.0.C 'B' Post has to be sectioned and roof rail has to be opened to allow the reinforcement to be fed between the panels, avoiding damage to the reinforcement due to space restrictions.



13.0.D 'B' Post cannot be sectioned so the roof rail has to be opened to allow the 'B' Post panel with its 'non-weldable' press hardened reinforcement, to be fitted onto the roof rail and sill.

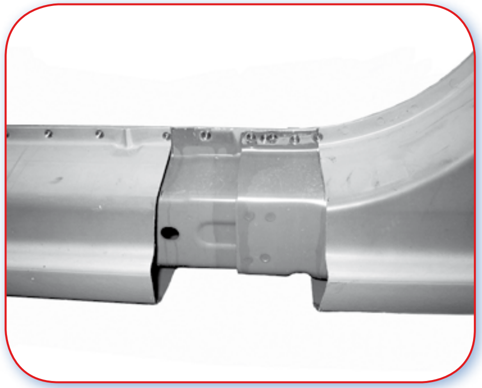


13.0.E See pic 13.0.D.

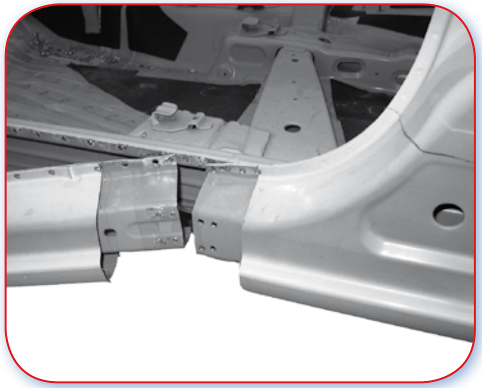
13.1 Overlap of reinforcements

Effect on repair: Damage to the sill reinforcement requires the removal of the outer panel which covers both the sill and 'B' Post. This will increase the time and overall cost of repair.

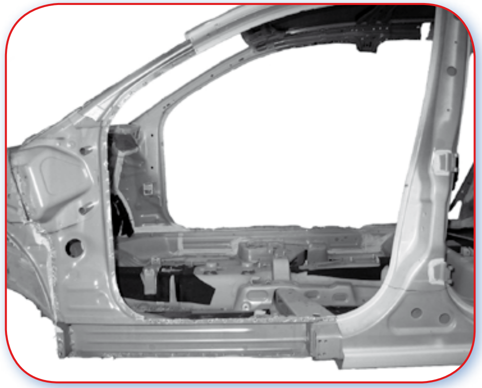
Design for repair guidance: The possibility of removing sill reinforcements without extensive removal of other parts is recommended. This can be achieved by having reinforcements made out of sections, allowing partial removal and reducing labour times and parts (pics 13.1.A, 13.1.B, 13.1.C).



13.1.A Good example. See pic 13.1.C.



13.1.B Good example. See pic 13.1.C.



13.1.C Good example. 'A' Post cover and reinforcement where it joins the sill which are sectionable, making removal of the 'A' Post reinforcement easier and allowing for sectioning of the sill.

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13.2 (Ultra) High Strength Steels used in 'B' Post reinforcements

Effect on repair: Their material characteristics do not allow reinforcements made of UHSS to be sectioned and then welded. When the reinforcement is joined to both the sill and the roof, it requires a complete replacement. This means excessive labour times and parts requirements, as both the roof and the sill have to be opened up. More paint work will also be required, due to the increased repair area (pics 13.2.A, 13.2.B, 13.2.C, 13.2.D).

Design for repair guidance: Introducing a smaller local UHSS reinforcement fitted to a lower strength full panel serviced as an assembly will allow sectioning of the carrier panel (pics 13.2.E, 13.2.F, 13.2.G, 13.2.H).

13.3 Reinforcements too close to outer panels

Effect on repair: The areas where several panels of different materials are used in close proximity to create body side assemblies do not allow safe sectioning in repair. Due to the order of panel removal and stepping the joints, damage to subsequent panels can occur. This damage must be avoided, as it will reduce the strength.

Design for repair guidance: Allow enough space for tooling, as specified in existing repair manuals, between the panels for sectioning in likely areas of repair.

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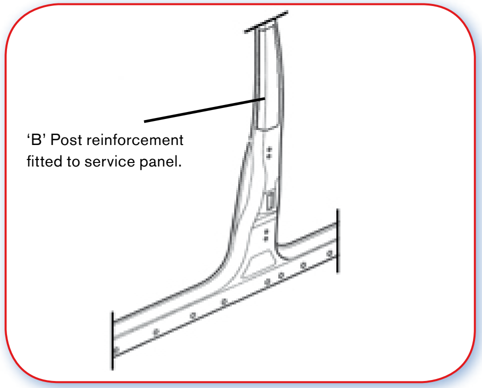
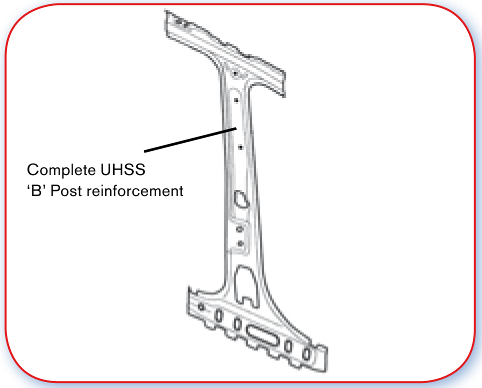
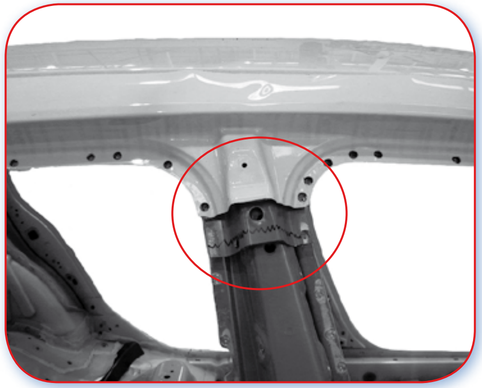


13.2.E Good example. 'B' Post with a UHSS reinforcement can be sectioned.



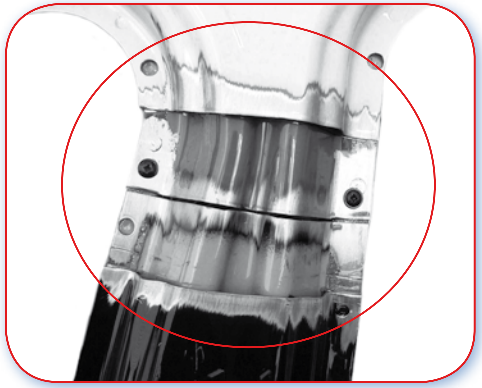
13.2.A Poor example. 'B' Post made out of UHSS, requires complete replacement.

13.2.F Poor example. 'B' Post has to be sectioned and roof rail has to be opened for the reinforcement to be fed between panels.



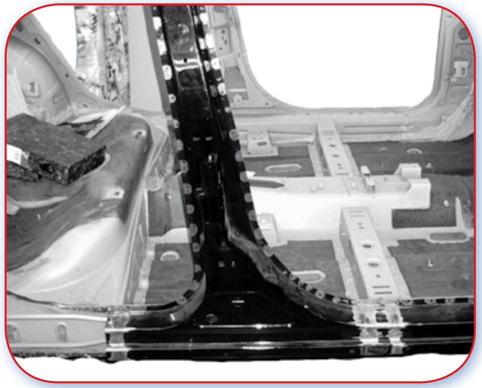
13.2.G See pic 13.2.H.

13.2.B Poor example. Damage must be avoided to the reinforcement due to limited space between the outer panel and reinforcements.



13.2.H 'B' Post can be sectioned through reinforcements and both outer and closing panel without having to cut into upper roof rail. Most reinforcements made from UHSS cannot be sectioned.

13.2.C 'B' Post cannot be sectioned so the roof rail has to be opened to allow the 'B' Post panel with its 'non-weldable' press hardened reinforcement, to be fitted onto the roof rail and sill.



13.2.D See pic 13.2.C.

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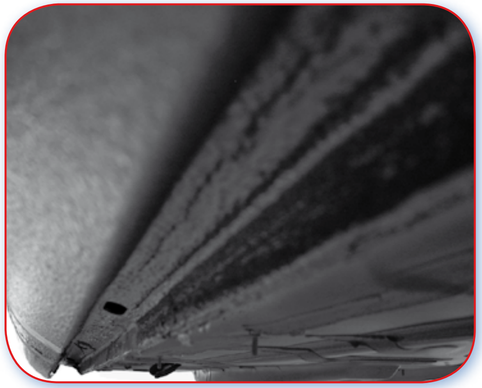
Sill joints

Effect on repair: When sill panels are joined to the chassis or the floor, a single joint is preferred over a bridging panel joining the sill panel and floor, as this reduces accessibility. It makes repair awkward when both panels are damaged and increases repair times (pics 13.4.A, 13.4.B).

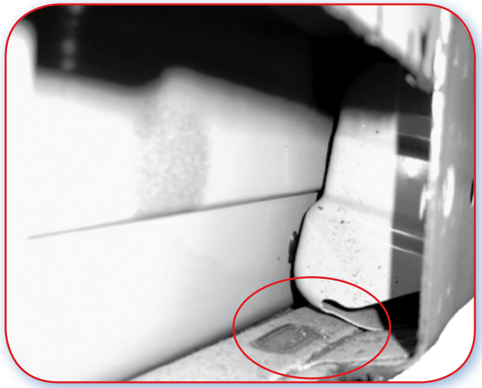
Design for repair guidance: Avoid any different joining configurations which can complicate repair when panels are damaged (pics 13.4.C, 13.4.D).

13.4.A Good example. See pic 13.4.B.

13.4.B Good example. Sill cover panel runs from edge to edge over the reinforcement around the 'B' Post and rear reinforcement.



13.4.C See pic 13.4.D.



13.4.D Poor example. The sill cover panel runs to a bridging panel, not to the inner edge of the chassis/floor.

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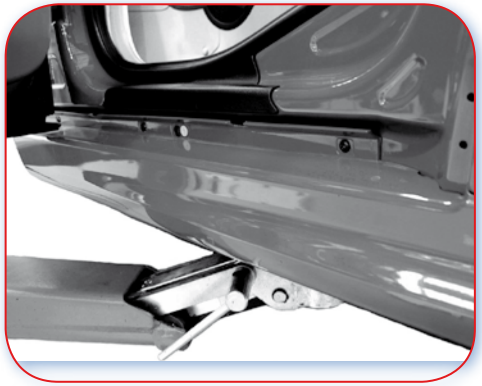
Sill reinforcements

Effect on repair: Sill reinforcements made from a single piece require extensive removal of both the sill cover and the reinforcement when damaged (pics 13.5.A, 13.5.B).

Design for repair guidance: Design sill covers as cosmetic panels only which can then be removed easily. Reinforcements should be made out of separate parts to limit the requirement for removal. This will reduce repair times and makes repair easier (pics 13.5.C, 13.5.D, 13.5.E).



13.5.A Sill shape is given by fitting a plastic cover in the body colour.

13.5.B Poor example. Sill reinforcement is a single piece and when damaged will require sill cover removal and sectioning.

13.5.C Good example. Sill reinforcement is made of separate parts and can be repaired by partially removing the sill reinforcement.

13.5.E See pic 13.5.D.

13.5.D Good examples. Sill cover panel runs from front edge to rear edge, over the reinforcement and around the 'B' Post and rear reinforcement. Sill shape is given by fitting a plastic cover.

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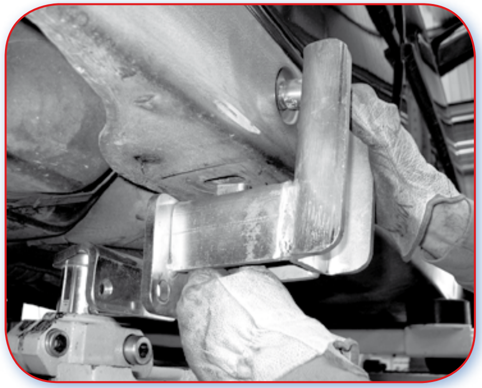
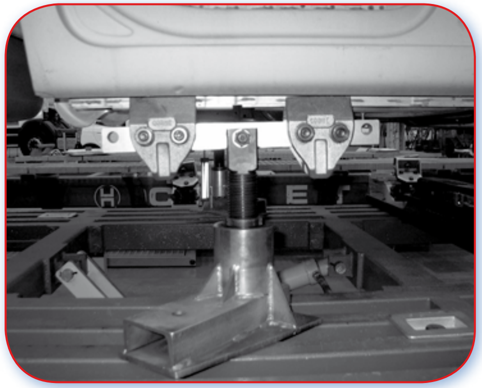


Poor Example. Sill panel without longitudinal flange implies the use of a special anchoring system.



Good Example. Sill panel with a classic longitudinal flange facilitates the use of a universal anchoring system.

Sill Flange

It would be advantageous for the sill panel to have a longitudinal flange joint, so a universal anchoring system can be used. It would simplify repair work and reduce the need for equipment investment in special anchoring systems to cope with certain vehicle models.

Effect on repair: Using a different type of sill joint requires the use of special jigs and requires the investment into this equipment, increasing costs for the body repair shop.

Design for repair guidance: Maintain the the sill joint as a traditional flange joint to allow the use of standard clamps.

Doors

14.1 Shape of doorskin makes replacement more difficult

Effect on repair: A doorskin that surrounds the window is more difficult to replace due to its complex shape.

Design for repair guidance: Avoid complicated door skin shapes surrounding windows.

Poor Example. A doorskin with window frame will be difficult to replace.

Good Example. A doorskin without its own upper window frame will make doorskin replacement easier.

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14.2

Doorskins are usually manufactured from steel with a thickness of 0.7mm. The door contains a side impact protection bar, welded to the inner structure and bonded to the doorskin, so it is not possible to remove it. The doorskin is fixed to the inner structure by means of a hem flange and some supplementary resistance spot welding.

Effect on repair: If the car manufacturer does not have the option to service the doorskin as a separate part, the only options are either to repair the door skin or to replace the complete door.

Design for repair guidance: It is preferable for doorskins to be serviced as a separate part, which would allow only the doorskin to be replaced.

14.3

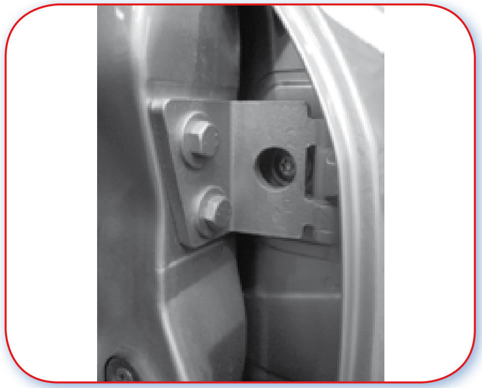
The use of door hinge bolts, which have to be inserted from inside the bodyshell means that trim has to be removed for access. This causes excessive labour time requirements, if it is necessary to replace a hinge or align the door properly.

Design for repair guidance: Make sure that when hinge bolts are used from inside the bodyshell, access is available through the use of easily removable trim panels.

Poor Example. The limited access through holes in the door frame makes repair difficult.

Poor Example. The limited access through holes in the door frame causes problems in repair.

Good Example. Good accessinility for panel beating operations. The side impact protection bar is mounted by bolts, so it is possible to remove it to improve the accessibility.



Good Example. Good accessibility for panel beating operations. The side impact protection bar is mounted by bolts, so it is possible to remove it to facilitate access.

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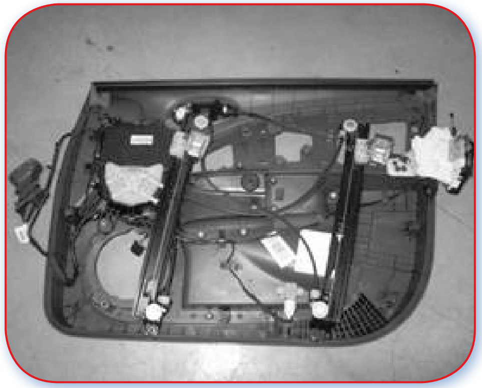
Poor Example. A doorskin with the curvature inwards makes it difficult to repair and paint.



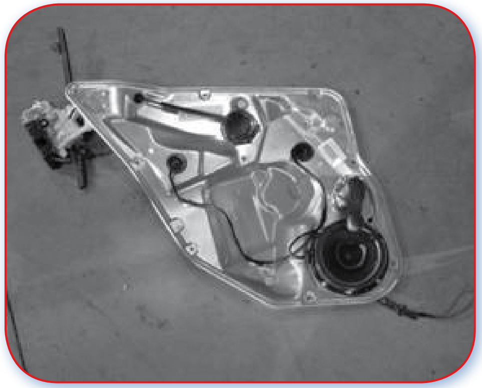
Good Example. Most of the door mechanisms are fixed directly into its trim, which will facilitate repair and replacement operations.

Good Example. A door trim with separate access covers will facilitate the disassembly and adjustment of door mechanisms without the need to remove trim.

14.4

Being able to repair the doorskin in a proper and cost effective way depends on factors including: type of material (usually steel), accessibility of the internal face of the panel, and the shape and configuration of the panel.

Design for repair guidance: Good access should be available to the door inner frame, so it can be worked on properly. Avoid an inward curvature on the doorskin, as it would hinder the repair and paint operations. To have a screwed central frame, on which the door mechanisms are fixed, would allow the removal of the entire system, which would reduce labour times. To have separate access covers in the door trim allows the removal and adjustment of the window, without needing to remove the door trim completely. This will reduce labour times.



Good Example. The door has a screwed central frame, on which the various door mechanisms are fixed. This will allow the removal of the entire set, saving labour times.

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14.5

Effect on repair: Doors have a lot of electrical wiring for different electrical devices. When it is necessary to remove a door, the wiring system must be disconnected completely.

Design for repair guidance: All the electrical wiring should have a centralised multiple connector, which will allow all electrical devices to be disconnected at the same point. This will allow the door to be removed as easily as possible.

Poor Example. The door does not have a central electrical multi-connector, so it is necessary to remove the door trim and to disconnect the different electrical devices

Good Example. A central electrical multi-connector will make it easier to remove the door.

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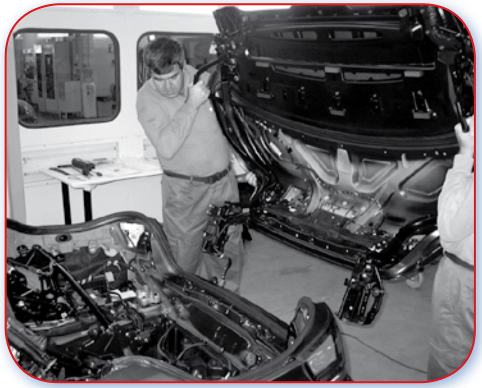
15.1.A Poor example. Removal of the complete roof in stowed position is difficult due to the shape and available space.



15.1.B Poor example. Removal of the complete roof in stowed position is difficult due to the shape and limited space available.

15.1.C Good example. The whole assembly is easily removed from the vehicle due to availability of moving space.

Folding Roofs

Folding roofs are now being introduced to cars across a greater range of levels and models. The complexity of the automatic operating, hydraulic and/or electrical mechanisms, together with the use of hard panels made of glass, steel or plastics make it more difficult to remove the unit from a car if it is damaged, especially when the roof is folded in the boot. Additionally, the size and the weight of a folding roof mean that specialist training and tooling is required.

15.1

Effect on repair: The removal of a folding roof is complicated due to the number of elements, joints, hydraulic and electrical connections it has, as well as its size and weight.

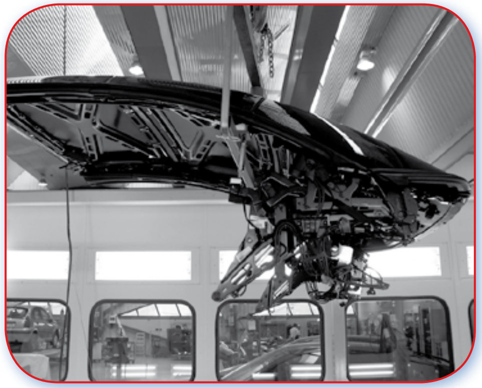
Design for repair guidance: It is preferred to be able to remove the roof in its deployed (closed) position. This will make the disassembly and adjustment easier and reduce the overall repair time.

15.2

Effect on repair: The need to lift the folding roof assembly from the car using several people is time consuming. In general, the need to operate in an awkward position increases the risk that the car will be damaged.

Design for repair guidance: The use of special tooling for lifting and removal of the folding roof will eliminate the need for several people to lift it and reduce the risk of damaging the vehicle.

15.2.A Poor example. Removal and assembly requires several people.



15.2.B Good example. Appropriate lifting tool reduces the number of people required and reduces risk of damage.

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15.3

Effect on repair: Using an electro hydraulic system means on some occasions that the hydraulic pump needs to be separated from the rest of the system with the risk of oil spillage into the car.

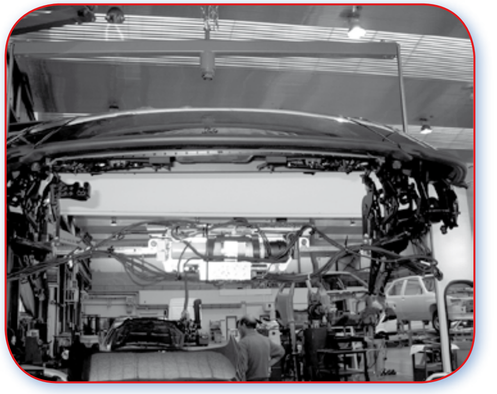
Design for repair guidance: Avoid the requirement to separate the hydraulic system from the rest of the folding roof when removing from the car. Instead, the removal of the complete system is preferred.

15.4

Effect on repair: The more sections a roof has, the more difficult it is to adjust both the roof itself and the roof position in relation to the car. The option to adjust is necessary, as this will reduce the gap sizes to make the car watertight and to reduce any wind noise during driving.

Design for repair guidance: It is preferred to have a folding roof with the smallest number of sections possible.

15.3.A Poor example. Hydraulic system to be drained before separation of the system from the folding roof.



15.3.B Good example. The complete assembly, including electro hydraulic system, can be removed.

15.4.A Poor example. Folding roof assembly consisting of more then three panels.

15.4.B Good example. Folding roof assembly consisting of two panels.

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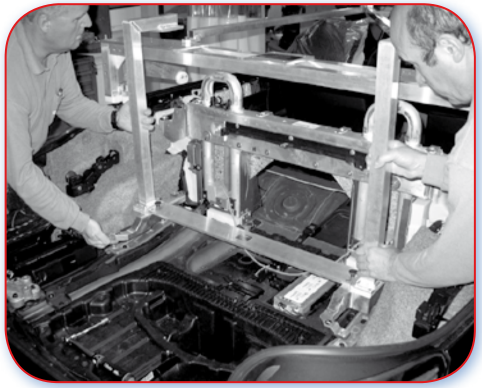


15.5.A Good example. Substantial jigs to check alignment of critical locations.

15.5.B Good example.

15.5

Effect on repair: As the position of the roof is critical to its performance, good measurements for critical locations on the bodyshell and adjustments are required. If these are not accurate, it could result in misalignment of the folding roof when installed.

Design for repair guidance: Have an overall measuring jig available to allow the folding roof to be adjusted.

15.6

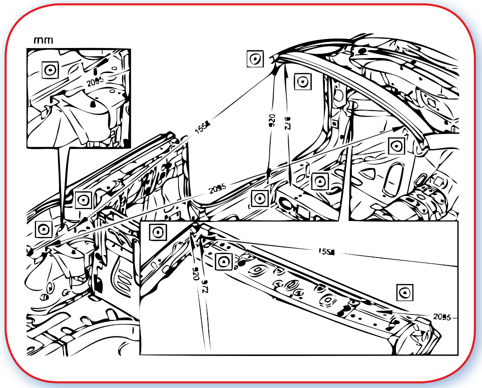
Effect on repair: As the position of the roof is critical to its performance, good measurements for critical locations on the bodyshell and adjustments are required. If these are not accurate, it could result in misalignment of the folding roof when installed.

Design for repair guidance: Replacement methods should provide dimensions and reference co-ordinates for all critical fixing locations, including locking and folding mechanisms.

15.7

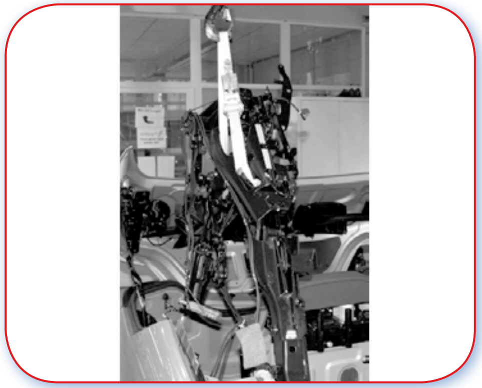
Effect on repair: The availability of a full assembly, complete with painted panels, assists the replacement of a damaged system and will reduce costs.

Design for repair guidance: Having the assembly available as a service part does not mean that separate parts should not also be available. If this is not the case, it could increase the cost of repair significantly.



15.6.A Good example. Reference dimensions to check alignment of critical locations.

15.7.A Good example. Full folding roof assembly, as well as small part assemblies available for repair.



15.7.B Good example. (see description middle left).

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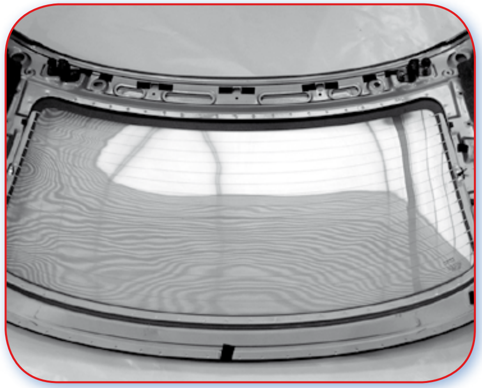
15.8

Effect on repair: When a rear window is fixed to the folding roof by means of adhesive, it is more difficult to remove the glass when damaged. This is due to the complex shape and location of the glass.

Design for repair guidance: It would be better if the glass is fitted in its own frame, which then is fixed to the folding roof using removable mechanical fasteners, e.g. bolts.



15.8.A Poor example. Glass panel bonded into complex shaped folding roof panel.

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Body Side – Service Parts

16.1 Matching service parts

Effect on repair: Service parts are normally available as separate panels. Although this is in principle a good solution, the reality is that outer panels are cut from whole body sides and the location of the cuts varies, resulting in service panels not joining accurately. Also damage to the vehicle may occur between areas covered by two service panels (e.g. panels cut on the dog leg) (pics 16.1.A, 16.1.B, 16.1.F, 16.1.G, 16.1.H, 16.1.I, 16.1.J).

Design for repair guidance: The servicing of a sympathetically priced whole body side panel avoids discrepancies on joints and also allows the repairer to cut the best section for each repair. Parts of panels can be separated out of the whole body side and accurately positioned according to the damage on a particular vehicle (pics 16.1.C, 16.1.D, 16.1.E).

16.1.A See pic 16.1.B.

16.1.B Good example. Service parts supplied as a whole rear segment to cover the most vulnerable parts like the dog leg.

16.1.D See pic 16.1.C.

16.1.C Good example. Service parts supplied as a whole that can be cut where required to suit the damage to the vehicle. This avoids any mismatching joints.

16.1.E See pic 16.1.C.

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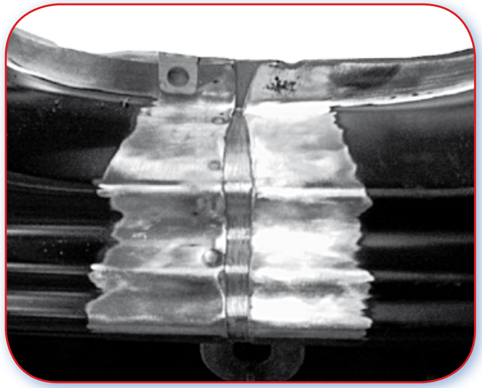
16.1.F Poor example. See pic 16.1.G.

16.1.H See pic 16.1.J.

16.1.I See pic 16.1.J.

16.1.G Poor example. Service parts supplied as a side panel segment but having a joint at one of the most vulnerable and most frequently damaged parts like the dog leg.



16.1.K Poor example. The alignment and joining of the supplied service panels do not match.

16.1.J Poor example. Service parts supplied in separate units need joining up when fitting, unless the part covers the damaged area.

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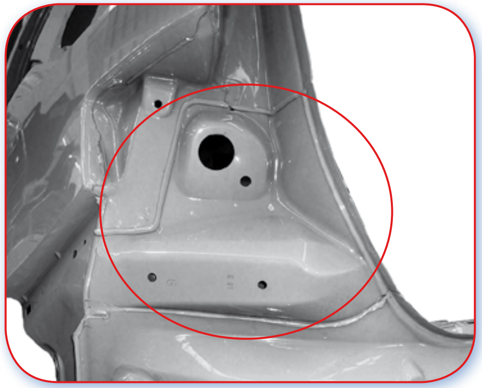
Rear Quarter Panel

The rear quarter panel is the area of the vehicle where several panels are joined together. It accommodates the shape of the tailgate aperture, light clusters and bumper. This means that there is a build up of variously shaped panel edges and joining technologies in a relatively small area. Manufacturers have got around this in different ways.

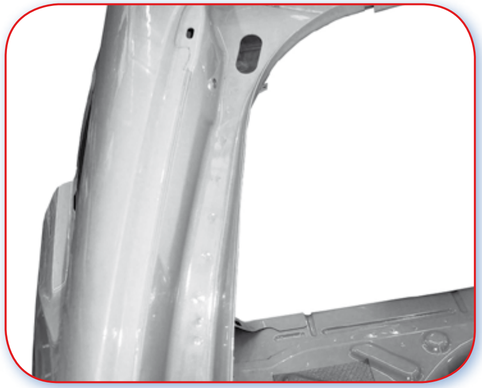
17.1 Overlap of panels

Effect on repair: Independent removal of panels in this area can be obstructed by overlapping panels. This requires more labour, affecting repair times (pics 17.1.E, 17.1.F).

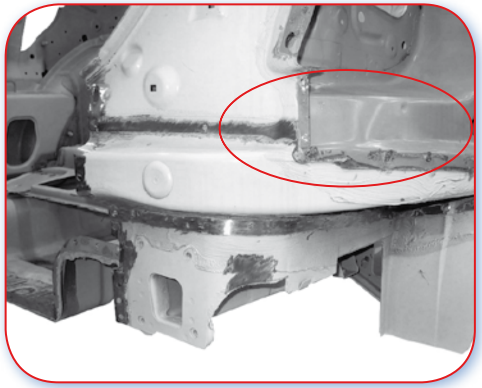
Design for repair guidance: The rear quarter panel is the most vulnerable panel in this area and removal of this panel without the removal or sectioning of undamaged surrounding panels should be possible (pics 17.1.A, 17.1.B, 17.1.C, 17.1.D).



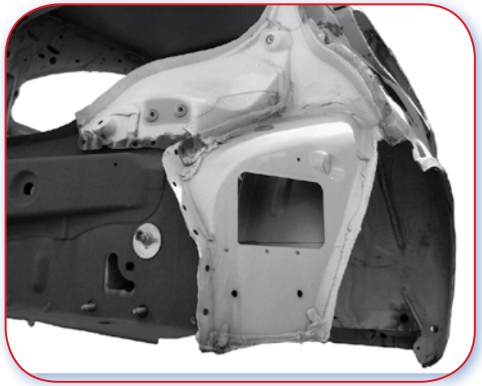
17.1.A Good example. The rear outer panel and the rear panel are joined separately, bridged by the light panel and bridging panel.



17.1.B Good example. Drain channel made out of one piece, joining outer and inner panel.

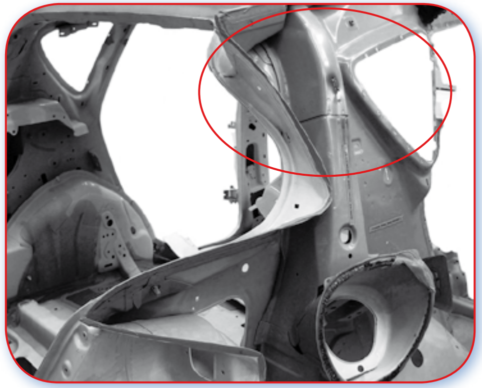


17.1.E See pic 17.1.F.



17.1.C Good example. The rear outer panel and rear panel are separately joined by the light panel and bridging panel, ending in outward facing flange joints.

17.1.D See pic 17.1.C.



17.1.F Poor example. The reinforcement requires removal of the side panel before it can be replaced. The drain channel is made of separate parts, making alignment and positioning difficult.

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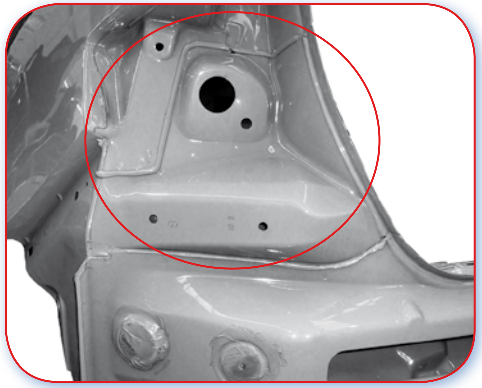
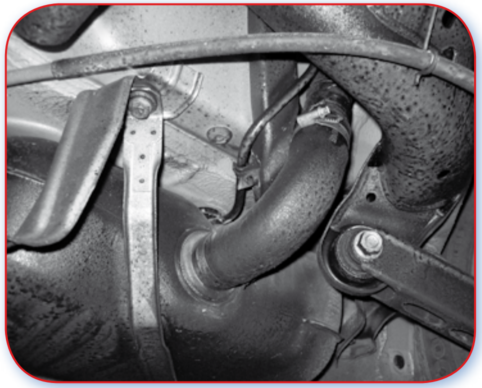
17.2 Panel assemblies

Effect on repair: Rear quarter areas can be built up from several small panels. This is not advantageous as it is difficult in repair to jig them up when refitted and to join them. This will also increase set up time (pics 17.2.A, 17.2.B).

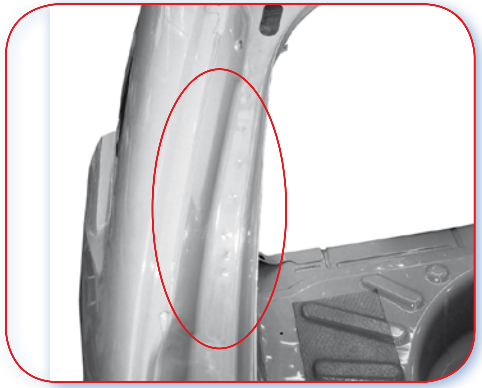
Design for repair guidance: Keep the number of panel assemblies as low as possible (pics 17.2.C, 17.2.D, 17.2.E).



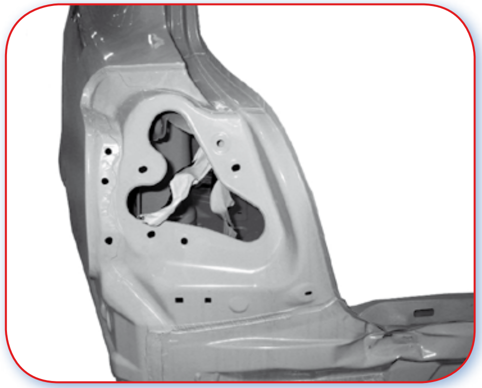
17.2.C Good example. The rear outer panel and rear panel are joined separately, bridged by the light panel and bridging panel.



17.3.A Good example of a filler neck.

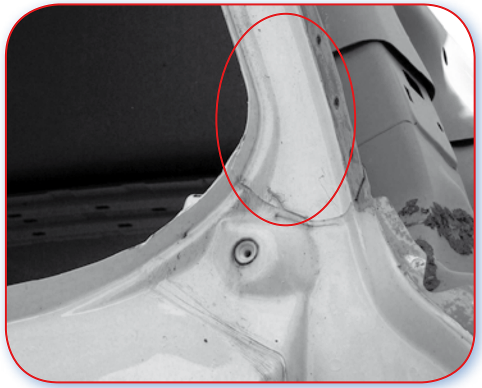


17.2.D Good example. The drain channel is made out of one piece, joining the outer and inner panel.



17.2.A Poor example. Rear quarters built up from several parts cause difficulty when separating and aligning parts in repair.

17.2.B See pic 17.2.A.



17.2.E Good example. The drain channel is made out of one piece, joining the outer and inner panel.

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17.3 Fixed fuel filler neck

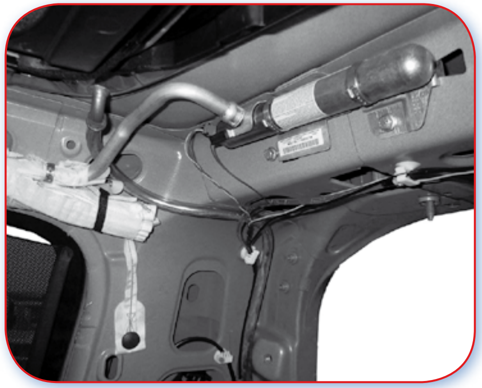
Effect on repair: When a rear quarter panel with fuel filler is damaged, best practice is to remove the filler neck. This can become an issue when the filler neck and fuel tank cannot be separated. To avoid a dangerous situation arising, the removal of the fuel tank is required and, in some cases, the fuel system cannot be removed from the vehicle without removing the rear axle. The removal of the rear axle requires extensive work, which is unnecessary in a body repair situation.

Design for repair guidance: To avoid the need for the fuel tank to be drained and capped before any heat (welding and painting process) is applied, it would be better to be able to separate and remove both the tank and filler neck (pic 17.3.A).

17.4 Curtain airbags fitted close to panel

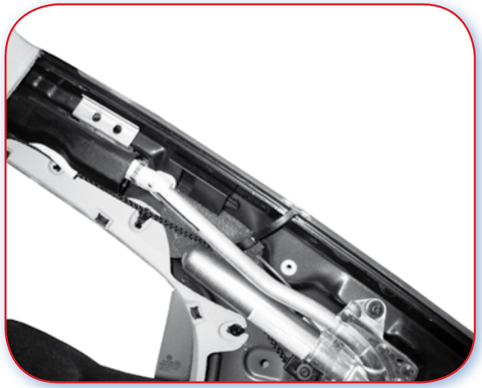
Effect on repair: Curtain airbags tend to have the gas generator fitted on the inside of the upper rear quarter panel. This means that when removal or sectioning of the rear quarter is required, the whole airbag unit has to be removed, together with the headlining. This is labour intensive and there is the risk that the removed parts may be damaged, and may not be refitted correctly (pics 17.4.C, 17.4.D).

Design for repair guidance: Have airbags fitted in a position less prone to damage, which will avoid excessive labour costs in repair (pics 17.4.A, 17.4.B).



17.4.A Good example. See pic 17.4.B.

17.4.B Good example. As the curtain airbag generator is fitted onto the upper roof joint, removal is not required during repair.



17.4.C Poor example. See pic 17.4.D.

17.4.D Poor example. As the curtain airbag generator is fitted onto the rear roof joint, removal is required during repair.

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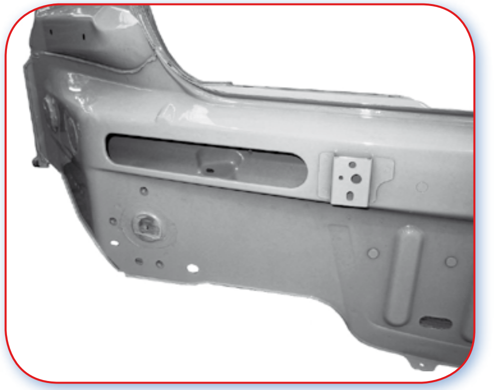
Rear Centre Panel

This panel normally covers the rear of the vehicle between the rear chassis legs or rear quarter panels and usually consists of an inner and an outer part.

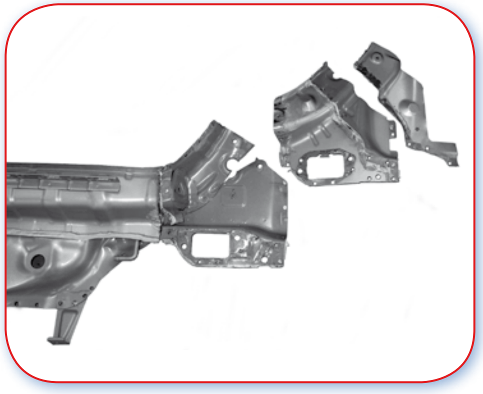
18.1 Overlap of panels

Effect on repair: Independent removal of panels in this area can be obstructed by overlapping panels. This requires more labour to remove panels, affecting repair times (pics 18.1.A, 18.1.B, 18.1.C).

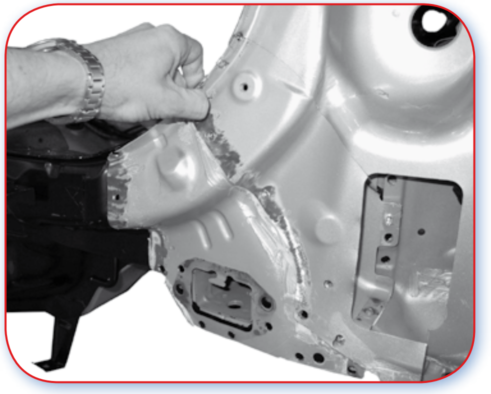
Design for repair guidance: The rear centre panel is the most vulnerable panel in this area and removal of this panel without the removal or sectioning of undamaged surrounding panels should be possible. This will reduce the cost of repair (pics 18.1.D, 18.1.E, 18.1.F).



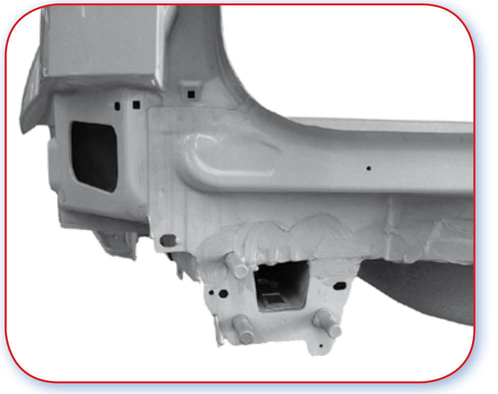
18.1.D See pic 18.1.F.



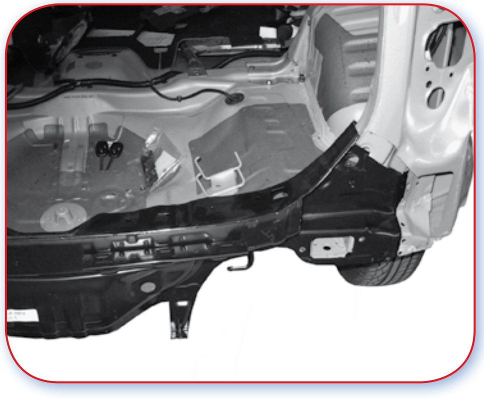
18.1.A See pic 18.1.B.



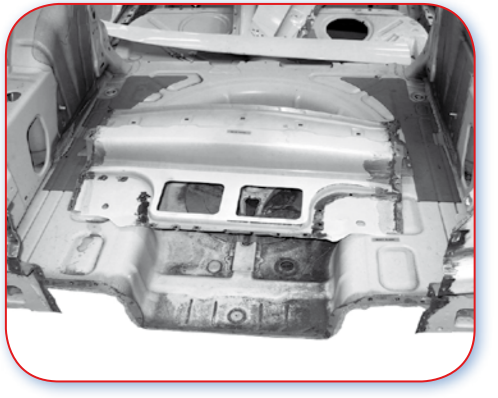
18.1.B Poor example. The rear panel has been fitted behind two panels which need removing before it can be replaced.



18.1.E See pic 18.1.F.



18.1.C See pic 18.1.B.



18.1.F. Good example. As the rear panel is fitted last, removal of the rear panel will not require any other panel to be removed.

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18.2 Joint Access

To obtain a good welded joint, an accessible flange between the rear panel and boot floor is required.

Effect on repair: If access is limited, longer arms are required for spot welding, resulting in lower tip pressure, or the introduction of a different joining process altogether.This will affect the quality of repair.

Design for repair guidance: Make sure that the weld flange is easily accessible to ensure that weld quality is maintained.

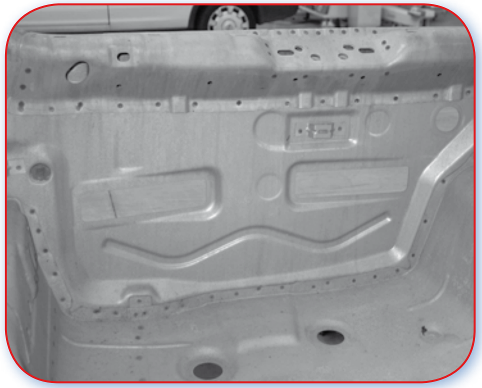
Boot Floor

The boot floor is normally a fill in panel made out of reinforced plastics or steel, usually holding a spare wheel or equivalent. More of these panels are added to the body as a trim panel after the body has been built. This is obviously an advantage in repair as it keeps labour time down (pics 19.0.A, 19.0.B, 19.0.C, 19.0.D).

Rear Chassis Leg

The rear chassis leg is the load path for rear impacts, transferring the loads into the chassis and sills. It also acts as a reinforcement for the boot floor and rear wheel arches. The rear ends of the chassis legs form the base for the rear centre panel and crush cans. The location and size of the chassis legs are generally determined by the size of the vehicle and this obviously affects the location of sub-assemblies and parts fitted to the chassis leg.

Good Example. Rear centre panel with the flange pointing downwards facilitates drilling and welding operations.



Poor Example. Rear centre panel with the flange pointing upwards hinders drilling, and more importantly, resistance spot welding operations

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20.1 Chassis leg predefined deformation area

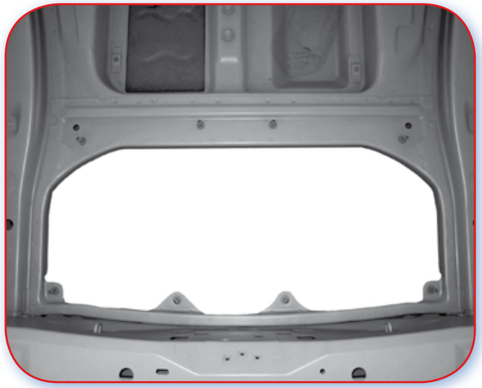
Effect on repair: The lack of predefined deformation areas in the chassis leg can result in loads being transferred further into the chassis leg, causing more extensive damage and higher repair costs.

Design for repair guidance: Allow deformation to be caused in the part of the chassis leg close to the bumper, so that only a small part requires replacement, ideally at a natural joint (pic 20.1.A).

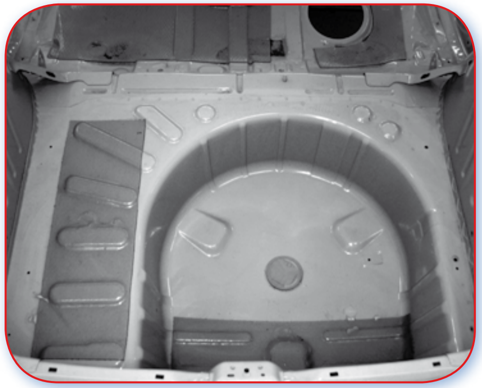
20.2 Suspension parts fitted to chassis leg

Effect on repair: Removal of suspension and suspension reinforcements fitted to the rear of the chassis leg costs time during repair.

Design for repair guidance: Have suspension parts fitted towards the front of the chassis leg, reducing repair times.

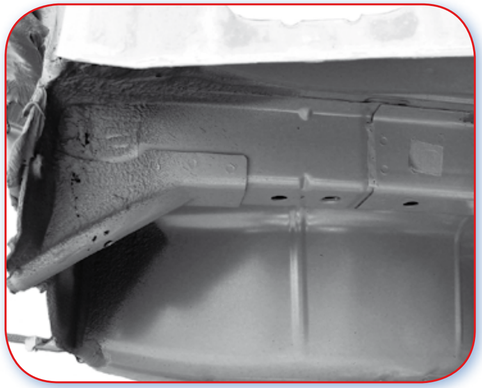


19.0.A See pic 19.0.B.



19.0.C See pic 19.0.D.

19.0.B Good example. Boot floor area in BIW without reinforced plastic infill and service repair part.



20.1.A Good example. Chassis leg is sectionable on a natural joint. This will improve ease of repair.

19.0.D Poor example. Boot floor area in BIW without reinforced plastic infill and service repair part.

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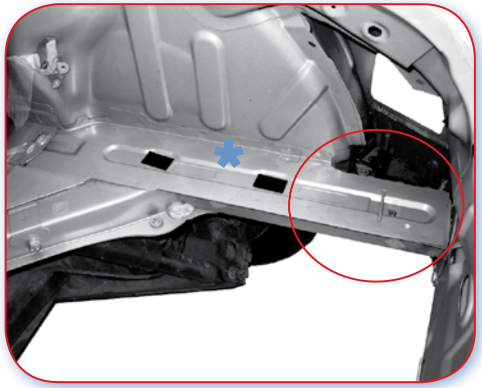
20.3 Chassis legs sandwiched between panels

Effect on repair: Chassis legs sandwiched between or as part of the wheel arch, boot floor and other closing plates or reinforcements should be avoided, as removal will take longer (pics 20.3.A, 20.3.B, 20.3.C, 20.3.D).

Design for repair guidance: Have chassis legs as separate panels to make removal easier, whilst minimising the effect on other panels.

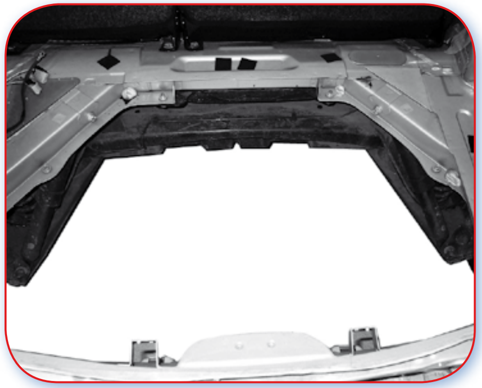
NOTE 1: Repair on chassis legs is made easier when accessibility is improved. Vehicles with a plastic inserted boot floor are preferred, as these are easily removable and there is space in which to work (pics 20.3.E, 20.3.F, 20.3.G).

NOTE 2: The fittings on service parts should match the joining method and align with the natural joints.

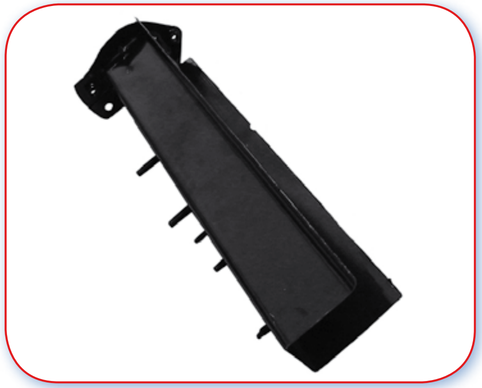


20.3.E There is enough space on the leg to deform in an impact, and enough space between the leg and wheel arch to remove the leg.*

20.3.F There is enough space on the leg to deform and enough space between the leg and wheel arch to remove the leg.

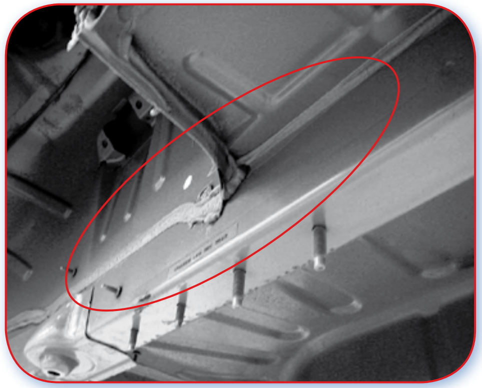


20.3.G Note 1. Good example. Ample access after plastic boot floor insert has been removed.

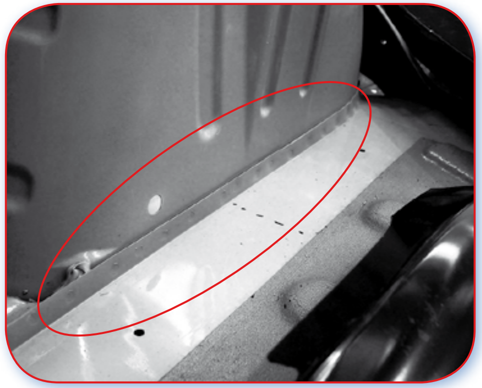


20.3.A Note 2. Good example. Service part for rear chassis leg.

20.3.B Poor example. The chassis leg is part of the boot floor and therefore difficult to take apart.



20.3.C Poor example. Chassis leg is sandwiched between the wheel arch and boot floor, which is difficult to remove and replace.



20.3.D See pic 20.3.C.

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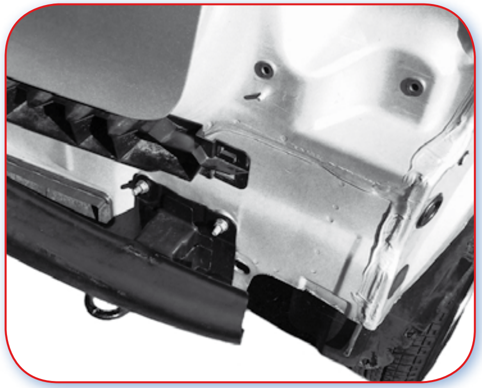
Rear Crush Cans

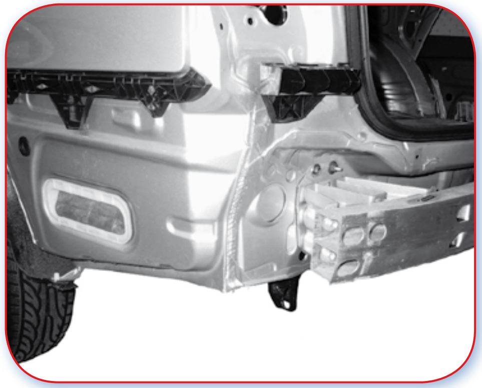
Although rear crush cans are not as common as front crush cans, they have the advantage of reducing the damage that may otherwise travel to other parts of the vehicle. They also create space between the rear bumper reinforcement and the rear centre panel to allow deformation, whilst minimising further damage (pics 21.0.A, 21.0.B, 21.0.C, 21.0.D).



21.0.A See pic 21.0.C.

21.0.B See pic 21.0.D.

21.0.C Good example. A bumper beam fitted on crush cans absorbs energy on impact and creates space for deformation.



21.0.D A bumper beam fitted on crush cans, which absorbs energy on impact and creates space for deformation.

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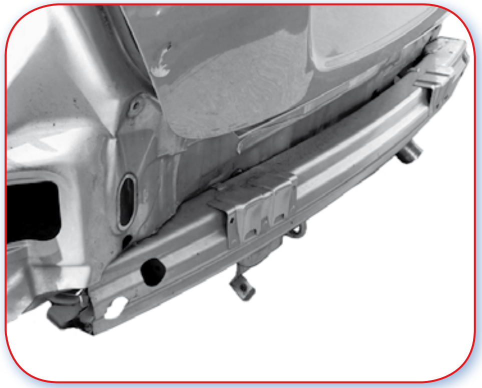
Rear Bumper Reinforcement

There are the same service parts requirements as for the front bumper. The fixing points of the bumper should be independent from the rear outer panel to avoid subsequent damage when the bumper is pushed up (pics 22.0.A, 22.0.B).

The position and type of material can influence the damage caused by a low speed impact dramatically (pics 22.0.C).

22.0.C Slight deformation of the beams.

22.0.A Beam has been pushed forward, deforming the rear panel slightly.



22.0.B Beam has been pushed into the rear of the car and has deformed the rear inner and the outer panels, pushing the outer panel into the rear door.

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General Notes

23.1 Location of vehicle specific information

Repair parts are defined as parts that could typically be replaced as part of the repair strategy. These parts should be avoided when stamping VIN numbers or other vehicle specific information (pics 23.1.A, 23.1.B, 23.1.C, 23.1.D, 23.1.E, 23.1.F, 23.1.G).

23.2 Accessibility of consumables

Side indicator lights and other units holding consumables are sometimes covered by lining panels or other parts, making the replacement of a consumable difficult and time consuming. Consider the position of units or the location of lining panels so they stay accessible.

23.1.A Good example.

23.1.B Poor example.

23.1.C Poor example.

23.1.D Good example.

23.1.E Poor example.

23.1.F Poor example.

23.1.G Good example.

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Body on Frame Platforms

General

Frame design has changed significantly over the years and has evolved with current designs being much more complex. The complexity of these design parameters is due to various reasons. Fuel economy and safety regulations have played a significant role in pushing to enhance the development of frame designs utilised in current full frame vehicles. Body over Frame design is principally used for light / medium / heavy trucks, pickup trucks and SUV platforms.

1.1 The basic requirements of a frame are to provide:

- A platform in which the separate body can be mounted
- The primary structural support for the vehicle
- Mounting locations for the brakes, steering and suspension components
- Support for the complete power train and its related components
- Primary load bearing structural component in a collision.

Frame Composition

There are many favourable properties possessed by steel. It remains the predominant material used in body on frame platforms as a result of its particular physical properties. Current platforms use varying types of steel based on certain characteristics a manufacturer is looking for. When steel is formed during the manufacturing processes, the material is stretched and compressed to some degree. The corners are the areas most affected as the material is bent. This bending causes internal stress in the metal, which increases the strength of the part.

2.1

Effect on repair: Additional stress develops in the material of structural components as it deforms during a collision. The material becomes stiffer after being deformed a second time. The repair process involves pulling and straightening operations to bring the damaged components back, as close as possible, to their original location. Work hardening occurs as the material is bent a third time. The molecules in the damaged areas are stretched and compressed and become stiffer each time the material is bent.

Design for repair guidance: Utilise steels that allow for multiple repair procedures in the repair process. While cold pulling is the preferred method during the straightening process, consideration for the use of minimal heat should be an option, when applicable. Controlled heat can help in returning the component back to its pre-collision condition.

Construction:

Three main types of BOF designs exist – perimeter and hydro-form frame, which are found in passenger car and light truck applications, and ladder frame, which is primarily utilised for larger commercial or bus applications. Perimeter and hydro-formed frames have the frame and the unitised structure working in conjunction with each other to provide structural support, while the ladder frame is, by design, far more rigid and does not rely on the unitised structure for added strength.

It is becoming more common to find a combination of these designs in current vehicle production. For example, a PU or SUV may incorporate the perimeter and hydro-formed design in one platform.

2.1.1 General example of a perimeter frame body.

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Frame Design:

4.1 New frame designs are optimised to:

- Provide maximum strength and rigidity
- Be cost efficient to manufacture
- Contribute minimal weight to the vehicle
- Provide the desired energy management characteristics

With the increased focus on repairability and damageability by governing bodies, frame designers need to address repairability and damageability in the platform's energy management characteristics, with regard to the forces placed on a vehicle during a collision.

Effect on repair: Collision energy management is the process of controlling collision impact energy. The goal from a collision repairability perspective is that the vehicle's structure absorbs the majority of the impact energy at the outermost structural components before the load travels inboard. Therefore, the vehicle damage is most severe at the perimeter with progressively less damage being transferred inboard. This approach enhances the ability to repair the vehicle.

Design for repair guidance: Consideration should be given in the design of the front and rear structural rails of current production frames to:

- Provide for increased localised rigidity of certain areas
- Absorb collision impact energy
- Initiate controlled buckling with designed-in collapse or crush zones
- Transfer unabsorbed impact energy around the passenger compartment

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Frame Repair:

Vehicle frames are the largest single component in the BOF vehicle and significantly will increase the cost of repair when damaged, especially when replacement (re-framing) is required. It will be highly beneficial for repair if re-framing can be avoided.

5.1

Effect on repair: A limitation on the repairability of a frame will require full replacement of the frame when damaged.

Design for repair guidance: The frame assembly should allow for repair of damage to the rail, crossmembers, mounts and brackets. The extent of repairability of these components needs to be considered during the design stage. By considering and allowing this, the repair times and costs of a Body on Frame vehicle will be reduced. This needs to be supported with well documented instructions and the availability of service parts to match these requirements.

5.2

Effect on repair: Measurements and alignment of a frame are critical to assure dimensional accuracy after correcting any misalignment, as well as ensuring the appropriate state and shape of the frame structure.

Design for repair guidance: Repair methods should state the requirements for 3-dimensional measuring systems, the proper anchoring of the vehicle to the equipment and whether the use of heat on a frame is allowed. Clear identification of tools and their limits on use should also be available, together with a post repair examination process to avoid the requirement of replacing the complete frame. Dimensional data should be readily available from the manufacturer or the equipment supplier and there should be easy access to body measuring points.

5.3

Effect on repair: Consideration needs to be given for the removal of the entire body off the frame, removal of brakes, steering, suspension components and the complete power train and related components.

Design for repair guidance: The removal of the entire body and all the components fitted to the frame needs to be explained in available service documentation and any service parts used need to be available through the aftermarket supply chain.

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Frame Sectioning:

As mentioned previously, a frame provides the platform to which a separate body can be mounted. It remains the primary structure for the vehicle, as well as the primary structural load bearing component in a collision.

6.1

Effect on repair: The complexity of switching out a non-repairable frame from a collision is extremely labour intensive. Consideration needs to be given to the removal of the entire body off the frame, removal of brakes, steering, suspension components and the complete power train and related components.

Design for repair guidance: Optimally, designers need to consider multiple frame sectioning components and locations. These components should mimic the outermost portions (crush initiators) of the frame rail. The sectioning components should be pre-sleeved for easier installation. Highly visible sectioning locations need to be stamped in the frame itself, as well as detailed sectioning guidelines being included with the replacement part. These guidelines should include metal composition, welding and corrosion protection recommendations.

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Welding Considerations:

Welding principles are covered in depth in Part B - Joining Methods. New vehicle designs and materials specific to frame development have required repairers to now consider numerous types of welding applications in the repair process. Further, robotic welding in a manufacturing environment often cannot be replicated by the repairer.

In the automotive repair industry, the most common welding method is the Gas Metal Arc Weld (GMAW) also referred to as Metal Inert Gas welding / Metal Active Gas welding (MIG/MAG) method which replicates factory resistance spot welds in strength.

7.1

Effect on repair: Welding requirements by the manufacturer for frame repairs and frame sectioning need to consider the limitations of what can be accomplished by a repairer. Additionally, the collision industry needs to be aware of the proper type of weld and sequence that should be utilised.

Design for repair guidance: Guidance should be given about the equipment, welding parameters, gas mixture, distance between components and filler wire. Clear preparation instructions should be given to avoid affecting the welding process and anti-corrosion properties. Rather than stipulating specific brands of equipment, manufacturers should supply necessary equipment performance requirements to properly complete the welding process. Lastly, guidance should be given on the use of weld tabs for minor frame deformation and cosmetic frame repairs (tabs are additional lugs welded onto the frame to create an additional pulling point, where standard points are not sufficient).

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Crush Zones:

Various energy management features help control how the vehicle responds to collision impact forces. Crush zones are special areas of the frame rail typically at the outermost portion of the front and rear rail end, which are intended to absorb energy by bending or crushing. Crush zones can include holes, slots, convolutions, buckle initiators, notches or dimples stamped into the frame rail to initiate and control deformation due to a collision.

8.1

Effect on repair: During a collision, the outermost portion of the front or rear frame rails usually experiences the impact forces first in conjunction with the bumper assembly, which is typically bolted to the frame end/extension. These crush zones tend to create a weakened area or cross-section changes that cause the frame to bend or collapse at that location. The reaction of the frame is dependent upon other adjacent crush zones or structural constraints. Some frame designs cause the frame to bend rather than actually crush or collapse. With either method, the effect is to control and absorb the impact energy, i.e. controlled energy management.

Design for repair guidance: With current designs, crush zones are behind the primary impact areas on a full frame vehicle. These crush zones need to perform in such a way as to absorb the majority of the impact energy, especially in low speed collisions. Controlled energy management in these areas is crucial in determining the type of repair that will be necessary after a collision. These considerations include overlapping damage into other impact absorption areas, repair vs. replacement or sectioning of those structural components and method of repair. Minor distortion should be readily repairable. If replacement is warranted, then a sectioning component should be available. The net goal is to absorb the impact energy of the collision, so that it does not propagate into other areas of the frame rail and passenger compartment, as well as help to absorb energy and reduce the degree of deformation further back.

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Bumper Systems:

(Bumper systems are covered in depth in the ‘Vehicle Body Panels’ section)

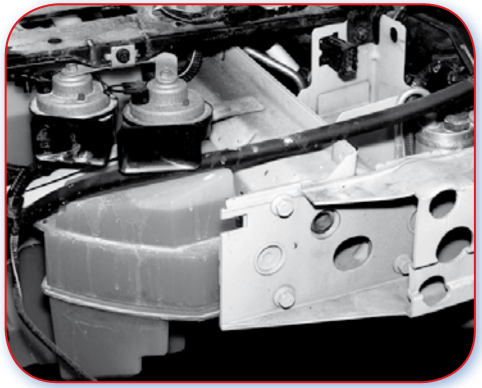
The majority of vehicle collisions involve either the front or rear bumper system of a vehicle. Bumper systems on Body over Frame vehicles can include a metal/steel bumper attached through assorted mounting brackets, or they can utilise plastic covers over a bumper reinforcement, as found in the majority of private passenger vehicles in the market. Either way, both bolt to the frame end/extension. Either bumper system should be able to absorb minor impacts with little or no damage.

NOTE: A RCAR standards are available and are called “RCAR low speed structural test” and “Low speed bumper test”.

9.1

Effect on repair: The bumper reinforcement or mounting brackets affect the energy absorbing capability after a collision. An important consideration of the reinforcement is the level, height and width of the part, which affects the amount of secondary damage absorbed into the crush initiators, frame rail and other inner structural components.

Design for repair guidance: Designers should consider the use of crush cans incorporated into the bumper reinforcement design on full frame vehicles. This design approach will help to direct the load path to absorb energy and help to contain damage to this component, especially in low speed impacts. All bumper mounting brackets should be serviceable. Additionally, reinforcements should be increased in height and length to cover a broader area. This is especially important to avoid additional damage when override or underride occurs. Lengthening the bumper beam will help to minimise damage to key structural components as a result of corner impacts.



9.1.1 Poor example. Chassis rail does not have crush cans incorporated in bumper system.

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Frame Mounts and Brackets:

As explained earlier, the primary purpose of a full frame vehicle is to provide a platform to which a separate body can be mounted, to supply mounting locations for brakes, steering and suspension components and to support the drive train. Typically, these mounts and brackets are welded directly to the frame assembly in some fashion using robotic welders in the manufacturing process.

10.1

Effect on repair: Frequently, these frame mounts and brackets need to be replaced as a result of a collision. The ability to replace these components often can determine whether the vehicle will be repaired or become a total loss. Welding requirements by the manufacturer for repairs and replacement need to consider limitations of what can be accomplished by a repairer.

Design for repair guidance: These components need to be serviced and available as individual service parts. With regard to replacement, guidance should be given about welding parameters, gas mixture, distance between components and filler wire. Clear removal and replacement instructions should be supplied to ensure a proper repair is achieved.

Trailer Hitches (Tow Bars):

Many full frame vehicles are used for commercial purposes due to towing capacity and carrying ability. Customers also utilise these vehicles for recreational use to tow boats, campers etc. Typically, the vehicle utilises a trailer hitch that is classified as a Class 1, 2 or 3 (U.S. specific). Each has specific load capacities. Often, as a result of an impact, these trailer hitches become damaged and cause damage to the vehicle itself.

11.1

Effect on repair: Due to the design and construction of the hitch, it may not incur any damage. However, as a result of that design, it can cause significant damage to the frame and rear of the vehicle.

Design for repair guidance: If a hitch is a factory installed component, consideration needs to be given to the following:

- Serviceability of the hitch for individual replacement by the manufacturer
- Consideration for the transference of damage from the hitch, and repairability factors of the frame itself and rear body / box of the vehicle

Vehicle Identification Numbers:

All full frame vehicles have a vehicle identification number stamped into the frame in some location. The primary purpose of the vehicle identification number is to give an accurate description of the vehicle as a result of mass production of vehicle platforms.

12.1

Effect on repair: Often, if a frame is repaired utilising a sectioning procedure or the frame is replaced, the VIN may be altered or removed from the vehicle. Depending on the location of the number, this may impact the ability of a repairer to complete the repairs.

Design for repair guidance: Designers should consider the placement of VIN numbers on the frame. If multiple sectioning procedures are available in the repair process, placement should be located in an area that will not be affected by any repair. This should also include confidential VIN placement for law enforcement. Typically, this approach will alleviate any issues regarding re-titling concerns.

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Panel names

United Kingdom	Australia	France	Germany
‘A’ Post or Front Pillar	‘A’ or Front Pillar	Pied avant	Pfosten/Säule
Bonnet	Bonnet	Capot	Motorhaube
Boot	Boot	Coffre	Kofferraum
Boot floor	Boot floor	Plancher arrière	Kofferraumboden
Boot lid	Boot lid	Couvercle de coffre	Kofferraumdeckel
‘B’ Post or Door Post	‘B’ or Centre Pillar	Pied milieu	Türsäule (B-Säule)
Bulkhead	Firewall	Tablier	Stirnwand
Bumper	Bumper	Bouclier ou Pare-chocs	Stoßfänger
Chassis leg	Chassis rail	Longeron avant	Rahmenlängsträger
Crush Can	Crush Can		
Dash Assembly/Board	Dash assembly	Planche de bord	Armaturenbrett
Doorskins	Doorskins	Panneaux de porte	Türblech
Inner Wing / Flitch Assembly	Rail & Skirt	Demi bloc avant	Radhaus
Front Panel	Front Panel	Face avant	Frontblech
Front Wing / Outer Wing	Front Guard	Aile avant	Kotflügel vorne
Headlamp	Headlamp	Phare	Scheinwerfer
Headlining	Headlining	Bandeau de pavillon	Himmel
Heelboard	Heelboard	Traverse arrière	Querträger innen hinten
Inner Wing	Front Skirt	Doublure d’aile	Radhaus hinten

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Translator

Italy	Spain	USA	The Netherlands
Montant anteriore	Pilar delantero	Pillar	A-pilaar
Cofano motore	Capó	Hood	Voorklep
Coperchio/Cofano	Maletero	Trunk	Kofferbak
Coperchio ruota di scorta	Piso maletero	Trunk Floor	Kofferbakvloer
Coperchio bagagliaio/ Portellone	Capó maletero	Deck Lid	Achterklep
Montante centrale	Pilar central	Hinge/Lock Pillar	B-pilaar
Parete cruscotto	Chapa salpicadero	Firewall/Dash Panel	Voorscherm
Paraurti	Chapa salpicadero	Bumper	Bumper
Longherone	Larguero delantero	Lower Front Rail / Frame Rail	Chassis arm voor
		Bumper Mounting Bracket	Crush Zone
Plancia completa	Cuadro de mandos	Instrument Panel	Dashbord/facia
Pannelli esterni porte	Panel de puerta	Door Outer Panel	Deurpaneel
Gianchetto vano motore completo	Conjunto larguero y pase de rueda	Apron Assembly	Wielhuis
Rivestimento anteriore/ traversa anteriore	Frente	Radiator Core Support	Voorpaneel
Parafango anteriore	Aleta delantera	Front Fender	Zijscherm voor
Proiettore/Faro	Faro	Headlamp	Voorlicht
Rivestimento interno padiglione	Montante lateral de techo	Headliner	Hemelbekleding
Paratia sottosedile posteriore	Traviesa posterior habitàculo	Rear Floor Pan Kickup	Vloerversteveging
Passaruota/Fianchetto	Pase de rueda	Inner Fender	Binnenscherm

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Panel names

United Kingdom	Australia	France	Germany
Kerb Weight	Kerb Weight	Poids à vide	Leergewicht
Quarter Light	Quarter Light	Custode	Dachsäule
Quarter Panel	Quarter Panel	Aile arrière	Seitenwand
Rear Chassis Leg	Rear Chassis Leg	Longeron arrière	Längsträger hinten
Rear Flitch	Rear Quarter Panel Inner	Doublure d'aile arrière	Kofferraumverkleidung
Rear Lamps	Tail Lamps	Feu arrière	Rücklicht
Rear Panel	Back or Rear Panel	Jupe arrière	Heckabschlußblech
Rear Screen	Rear Screen	Lunette arrière	Heckscheide
Rear Wing	Rear Quarter Panel	Aile arrière	Kotflügel hinten
Roof Rail	Roof Rail/Roof Side Frame	Traverse de pavillon	Dachrahmen
Windscreen	Windscreen	Pare-brise	Windschutzscheibe
Side Lamps	Side Lamps	Feu avant clignotant	Seitenlicht/Blinker seitlich
Sill Assembly	Sill Panel	Bas de caisse	Schweller
Squab	Squab	Séllerie	Sitzpolster
Suspension Turret	Strut Tower	Caisson de Mac-Pherson	Federbeinaufnahme
Tailgate	Tailgate	Hayon arrière	Heckklappe
Tow Hook/Tow Eye	Tow Hook	Crochet de remorquage	Abschlepphaken
Wheel Arch	Rear Wheel House/Arch	Passage de roue	Radhaus hinten
Wiring Loom	Wiring Loom	Faisceau électrique	Kabelstrang

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Italy	Spain	USA	The Netherlands
Peso in ordine di marcia	Peso en orden de marcha	Curb Weight	Leeggewicht
Vetro fisso Laterale posteriore	Custodia	Quarter Glass	Zijraam
Pannello esterno fiancata posteriore	Aleta trasera	Quarter Panel	Zijscherm achter
Longherone pavimento posteriore	Larguero trasero	Rear Rail	Chassis arm achter
Ossatura fiancata posteriore	Cierre de aleta trasera	Wheelhouse/Quarter Inner Panel	Wielscherm
Fanale posteriore	Pilotos traseros	Tail Lamps	Achterlicht
Rivestimento posteriore/ Traversa posteriore	Faldón	Rear Body Panel	Achterscherm
Cristallo lunotto	Luneta trasera	Rear Window	Achterraam
Parafango posteriore	Aleta trasera	Quarter Panel - car / Side Panel - truck	Zijscherm achter
Centina tetto	Cercha de techo	Roof Header	Dakrail
Cristallo parabrezza	Parabrisas	Windshield	Voorraam
Fanale ripetitore laterale	Intermitentes	Side Marker Lamp	Zijknipperlicht
Longherone sottoporta completo	Estribo	Inner & Outer Rocker Panel	Langsrail
Schienale	Asiento	Seat Cushion	Stoelkussen
Duoma	Torreta de suspensión	Strut Tower	Veerpoot
Parafango posteriore	Porton	Tailgate/Liftgate	Achterklep
Gancio di traino	Gancho de remolque	Tow Hook	Trekoog
Passaruota	Pase de rueda	Wheel House	Wielhuis
Cablaggio elettrico	Cableado	Wiring Harness	Kabelboom

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