

Steel Structure Damage Analysis

Textbook



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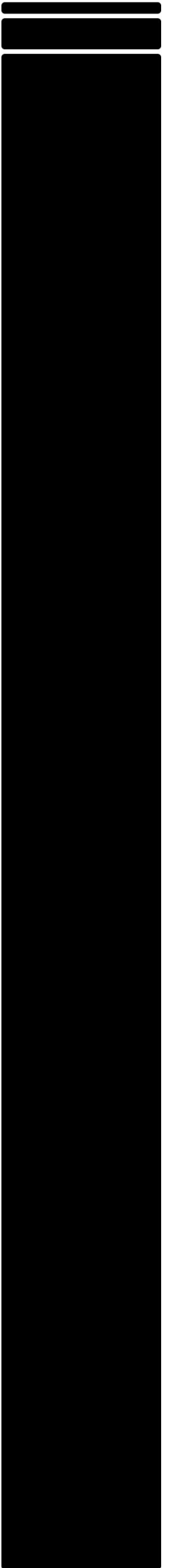
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Introduction



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Obligations To The Customer And Liability



The Collision Repair Industry has an obligation to correctly repair the customer's vehicle. Collision repairs must be performed using:

- recommended or tested procedures from vehicle makers, I-CAR, and other research and testing organizations.
- quality replacement parts and materials.
- repair processes and parts as written and agreed upon in the repair order.
- If items on the repair agreement are not consistent with the repair order, it can be considered fraud.

Performing proper collision repairs requires using parts and procedures that keep remaining warranties intact.

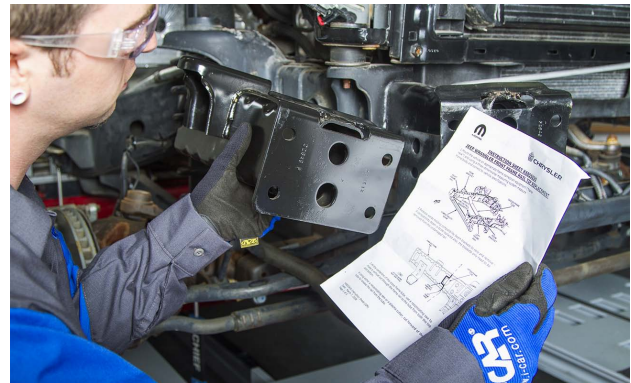
Collision repairs must restore:

- safety.
- structural integrity.
- durability.
- performance.

- fit.
- finish.

Throughout the damage analysis and repair process the repairer and insurer must:

- communicate with each other.
- maintain constant communication with the customer.
- be in agreement with each other and the customer on how repairs will be performed.
- inform the customer of any changes in the repair plan from the original repair agreement, and explain the changes and why they have to be made.



To reduce liability:

- make sure that all repairs are performed thoroughly, correctly and as listed in the damage report.
- follow proper procedures.
- use quality replacement parts and materials.

- have documentation of required repairs with detailed record keeping available for customers. Technicians are considered the experts and are expected to be knowledgeable on how to perform a quality repair.

Keeping thorough records includes more than recording the date, mileage, and pre-existing damage. Record keeping also includes: making sure all notes are legible.

- verifying the repairs that were made or not made.
- having the customer sign a waiver for repairs that they do not want performed. Repairers must determine their liability on not repairing safety systems such as restraint and anti-lock brake systems.
- keeping computer printouts or worksheets on file showing wheel alignment readings or vehicle dimensions before and after repairs.
- keeping scan tool printouts and records of computer codes for airbag, anti-lock brake, emission, and powertrain control module (PCM) systems. attaching the OEM or other tested procedure printout to the vehicle repair order.
- keeping receipts for all sublet work performed.

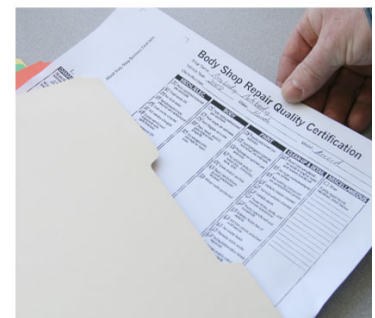
Liability insurance that covers the repair facility may not always cover all damages. For example:

- the policy may not cover faulty repairs, leaving liability responsibility completely on the facility.
- a shop owner may find that repair facility liability coverage may not cover the full amount awarded in a lawsuit. The shop owner would have to pay the difference.



It is difficult to reduce the risk of liability exposure. The part that the repairer can control is the chance of being found at fault. Chances can be minimized by:

- using recommended or tested procedures from other research and testing organizations.
- using quality replacement parts and materials and perform at least as well as the original.
- keeping thorough records.



Keeping thorough records includes more than recording the date, mileage, and pre-existing damage. Record keeping also includes:

- making sure all notes are legible.
- verifying the repairs that were made or not made.
- having the customer sign a waiver for repairs that they do not want performed. Repairers must determine their liability on not repairing safety systems such as restraint and anti-lock brake systems.
- keeping computer printouts or worksheets on file showing wheel alignment readings or vehicle dimensions before and after repairs.
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Module 1 - Vehicle Structures



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Types Of Vehicle Construction

Learning objectives for this module include:

- identifying the different types of vehicle designs.
- explaining how unitized structures are designed to collapse.
- identifying how different impact angles transfer collision energy and create different types of damage.
- reading vehicle measurements to determine structural damage.

Jaguar XF



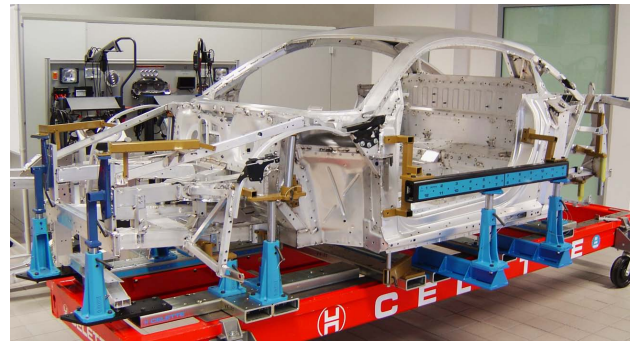
This Jaguar XF unibody shows the inner structure with the outer panels and trim removed.

A unibody structure:

- has a single structure built by attaching multiple parts of sheet metal. Attachment methods include spot welds, laser welds, rivets, adhesives, or a combination of methods.
- has exterior welded-on body panels, such as roofs and quarter panels, included in the overall structure.

- is built with the drivetrain, steering, and suspension parts mounted directly to the body structure.
- depends on correct structural alignment for proper steering and suspension alignment.
- is commonly used for most cars, an increasing number of sport-utility vehicles (SUVs), and some trucks, such as the Honda Ridgeline.

Audi R8



This is the space frame for an Audi R8.

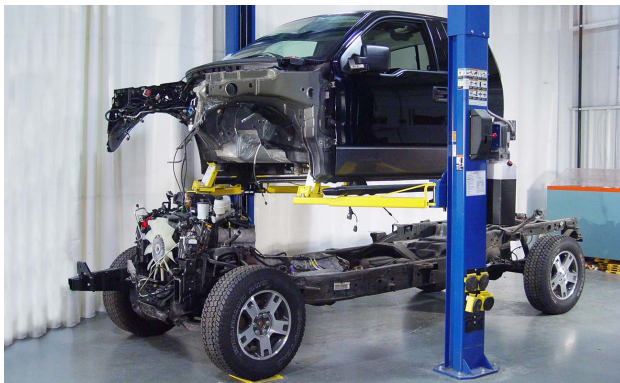
Space frame vehicles:

- are similar to the unibody structure.
- are unitized structures with attached outer body panels.
- like unibody structures, have the drivetrain and steering and suspension mounted to the body structure.
- like unibody structures, may have the outer panels attached with adhesives, fasteners, welds, or a combination of these attachment methods.

The primary difference between space frames and unibody structures is that space frames are:

- lighter weight, either made from lightweight metal or a metal and composite structure combination.
- less dependent on outer body panels for strength.
- similar to the inner structure common on race car designs.

Ford F-150



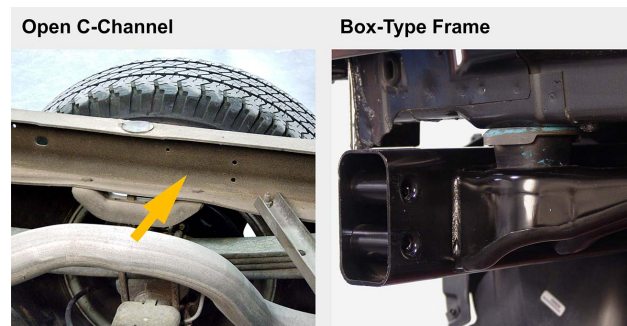
A body-over-frame vehicle has a separate unitized structure that is bolted to the frame.

Body-over-frame vehicles:

- have a frame independent of the unitized structure. Two main types of frames include perimeter and ladder designs. Ladder frames are more common on recreational vehicles (RVs), busses, and commercial trucks.
- have a separate unitized structure bolted to the frame. It uses the same energy management characteristics that are used for unibody vehicles.

- have the engine, drivetrain, and steering and suspension parts bolted to the frame.
- may be called full-frame vehicles.

Body-over-frame designs in non-commercial applications are used for pickup trucks and many SUVs, vehicles primarily used for heavy-duty purposes.



Frames are either C-channel-type styles (left) or box-type (right).

Modern pickup truck and SUV frame designs vary depending on the vehicle. Features of modern frame designs include:

- a combination of characteristics from both ladder-type and perimeter-type frame designs.
- both open C-channel and box-type rails.
- hydroformed rails. Box-type and tubular hydroformed rails are flangeless, one-piece structures formed from a metal tube. More information on hydroformed parts will be discussed later in the course.
- welded or riveted mounting brackets.
- crossmembers that are welded or riveted to the frame.

- collapse zones.
- torque boxes.

Many pickup trucks and SUVs have modern frames with a lower center of gravity for better handling and a more car-like ride.

The Collision



A thorough damage analysis may require some part removal to accurately assess damage.

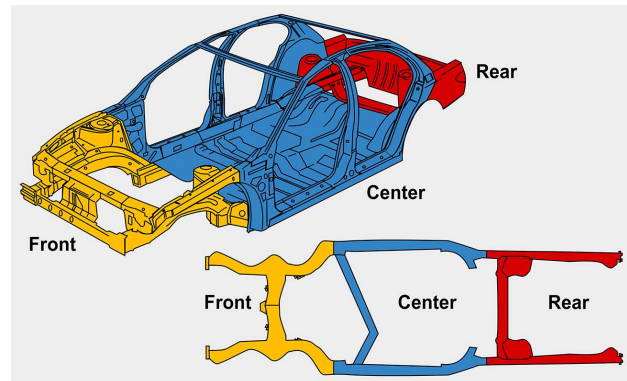
During damage analysis, the estimator / appraiser must:

- determine how to ensure a complete and safe repair, ensuring that the collision characteristics are restored.
- ensure that the damage report is written so that the vehicle structure is restored to pre-accident integrity. This will make sure the structure reacts as designed by the vehicle maker in a subsequent collision.

Using specific materials and part design, automotive engineers have designed the vehicle to collapse in a predictable manner to protect those inside the

passenger compartment. Changing a part design or repairing parts that should not be repaired can affect the original design, which can alter the collision energy management of the vehicle.

It is important to note that the repairer and / or insurer may be liable for any personal injury or property damage caused by improper repairs.



Basic vehicle design divides the unitized body or frame into three sections.

To determine how the vehicle is repaired, it is helpful to understand how the vehicle is constructed. Each vehicle is designed with three distinct sections:

- front.
- rear.
- center.

Each section has a specific function in the event of a collision. The front and rear structure is designed to:

- collapse up to a specific point.
- transfer energy to the opposite end of the vehicle.

This “controlled deceleration” of the vehicle helps absorb collision energy as well as re-route the collision energy around the center section.

Toyota Venza



Late model vehicle structures have increased the strength of the side structures to limit intrusion into the passenger compartment.

Unlike the front and rear sections of the vehicle, the center section (or passenger compartment):

- is not designed to collapse.
- has collision energy transferred around it.
- remains intact and provides a safe space for the vehicle occupants.
- keeps occupants inside the vehicle during a collision.

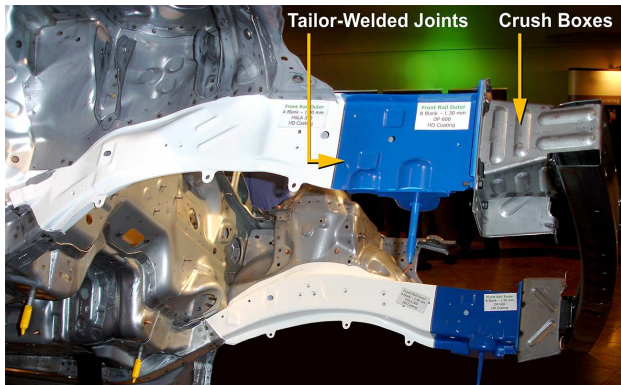


The left and right front rails and bumper reinforcement have absorbed collision energy from this offset impact.

Collision energy starts at the point of impact on the vehicle. The absorption and transfer of collision energy is done using:

- crush zones, which are specific designs in the steel used to collapse or bend a part in a controlled manner. These areas absorb the collision energy.
- different strengths of steel, which may be used to either absorb or transfer the collision energy.
- different thicknesses of steel. Steel thickness can vary within a part depending on design.
- reinforcements. Reinforcements are used to transfer collision energy to other areas of the vehicle.

Ford Fusion



Vehicle makers use crush boxes and tailor-welded parts to absorb collision energy.

Crush zones are designed into the vehicle to absorb collision energy. Crush zones may be:

- holes, dimples, or slots stamped into a part.
- made by using tailor-welded blanks, tailor-rolled blanks, and / or reinforcements.
- different types of steel strength and thicknesses.
- formed ribs or stamped areas across the width of the part. These may also be called convolutions.
- kick-up or offset areas. These are designed to bend during a collision and redirect collision energy in certain ways. A kick-up or offset area may be designed to direct the engine and transmission under the passenger compartment, rather than into it, during a collision.



Refer to, "Video: Understanding Collision Forces" in the presentation for a video on how collision energy management designs have advanced over the past several decades.

Analyzing Vehicle Damage

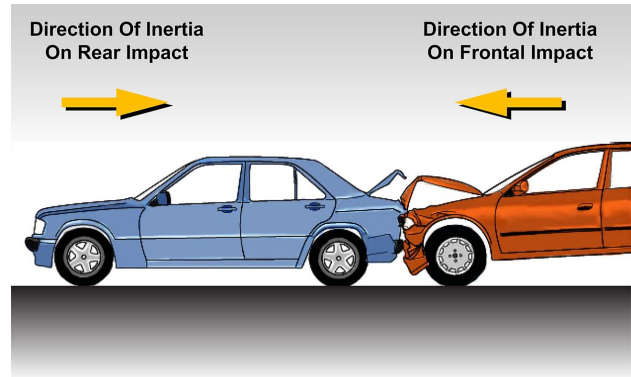
Audi Q5



Direct damage to this vehicle occurred at the passenger-side front rail.

When analyzing vehicle damage, it is helpful to determine the area of direct damage. Direct damage:

- is the point of impact.
- is the area of the vehicle that has the most obvious damage.
- is generally the point where damage analysis begins.
- may also be referred to as primary damage or initial impact.

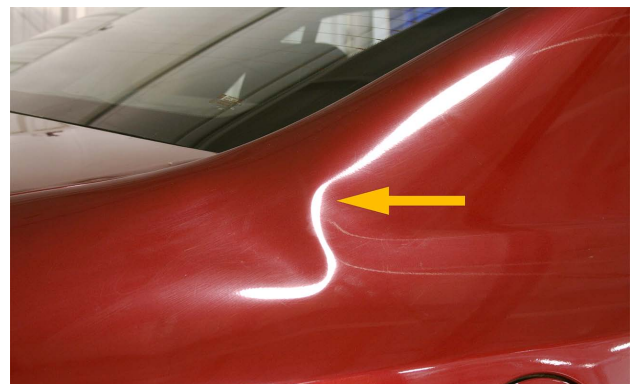


The inertial damage will vary depending on the collision energy. For example, vehicles involved in a front impact will have inertial damage from parts and objects moving forward.

Mass inertia damage is caused by unrestrained objects in the vehicle, or parts of the vehicle itself, that continue momentum after the vehicle has been stopped by a collision. This can damage both the interior and exterior of the vehicle.

An example of mass inertia is a train engine with several boxcars attached. When the engine brakes, the first boxcar behind the engine wants to continue its forward motion as well as all the other boxcars.

Chevrolet Malibu



The dent in this quarter panel is caused by stress from the damaged structure.

Indirect damage is essentially the same as mass inertia damage. Indirect damage:

- is caused by the force of the collision as it moves through the vehicle.
- occurs away from the point of impact.
- can be found anywhere on the vehicle, which makes it difficult to locate.
- may not be evident without close inspection.
- may be identified by accurate measuring.
- can include mechanical parts such as wheel bearing damage caused by an impact to a wheel. Bent engine mount brackets may also be considered a type of indirect damage.
- can include electrical and electronic parts. Examples include shorted wires or damage to electronic parts caused by collision forces.

What are some types of damage that can be caused by collision inertia?

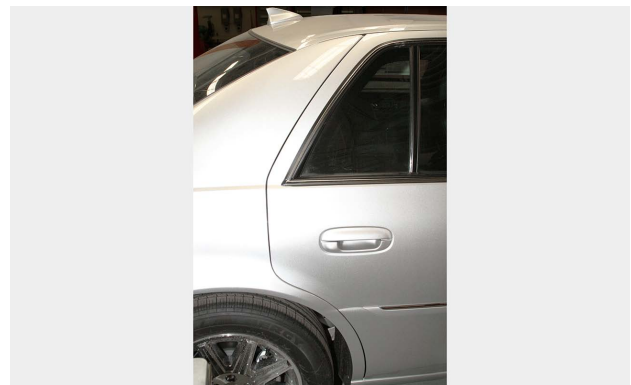


Motor mounts can be damaged from the engine moving forward or rearward during impact (left). Items in a pickup truck bed can cause damage to the front of the box or the tailgate (right).

Types of damage that can be caused by mass inertia include:

- damaged pickup bed or trunk from unrestrained items.
- motor mount damage from a front or rear impact.
- cracked composite radiator core support from a rear impact.
- collapsed steering column from the driver impacting the steering wheel.
- damage to seat frames, center consoles, and door trim panels.
- windshield cracks.

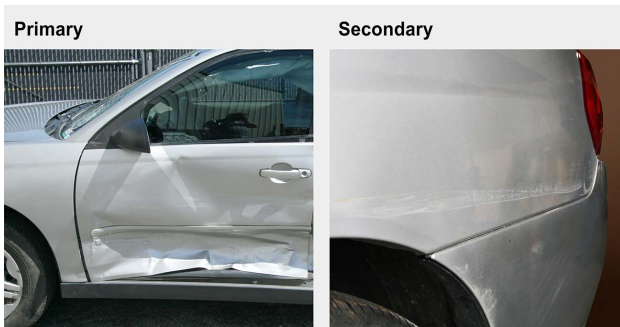
Cadillac DTS



The uneven gap between the quarter panel and door is an indication of indirect damage on this vehicle.

Indirect damage today looks different from indirect damage on older model vehicles. Stronger steels transfer more collision energy around the passenger compartment. There may be no visible panel gap misalignment, but still be indirect damage away from the direct impact area. Measuring may be the only way to verify indirect damage due to collision energy transfer.

A buckle in the roof used to be a very common indicator of structural damage, but this is no longer the case. The solid structure of the center section often prevents this from happening, however, collision energy still may have radiated to the opposite end of the vehicle. New body designs change the way a vehicle is inspected.



Primary damage to this vehicle is the direct impact to the door (left), however, the bumper cover (right) also took an impact during the same collision. This type of damage is considered secondary.

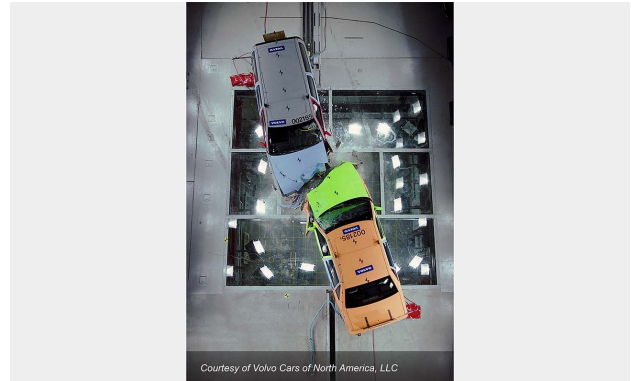
Secondary damage:

- is damage that resulted away from the initial impact, during a second impact with another object.
- includes direct and indirect damage.

Depending on the collision, there may be multiple locations of damage that is secondary damage. For example, a vehicle may hit a barrier, spin, and hit another barrier or oncoming vehicle. This can present unique challenges when trying to determine the point of initial impact since there may be several areas that show direct damage. Customer

interviews can be helpful in determining how a collision occurred.

Analyzing Vehicle Damage (con't)

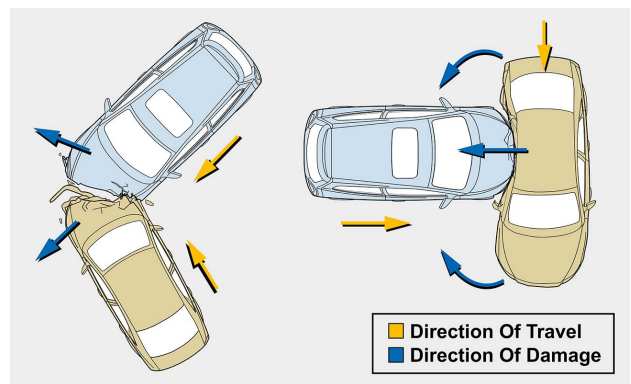


This is an example of an offset collision. (Courtesy of Volvo Cars North America, LLC)

Types of impact angles include:

- straight on, front or rear.
- offset, which is just a portion of the front or rear of the vehicle.
- rollover.
- side.

Another type of impact angle is when an object directly hits the underbody. This is not as evident, as most of the damage will be underneath the vehicle.



This is an example of an offset collision and a straight-on side impact collision.

Determining the direction of the impact is helpful for a thorough analysis. Understanding how energy traveled through the vehicle structure:

- helps the appraiser / estimator identify likely secondary or indirect damage. It is necessary to look for where the damage was initiated, then try and follow the path the energy likely traveled through the vehicle.
- starts by examining the impact angle. Each impact angle can affect how damage is transferred into the vehicle structure. For example, a side impact, due to the very strong side structure, may result in the front and rear swaying to the side of the collision, giving the vehicle a banana shape. With late model vehicles, a banana shape generally requires severe impact forces due to the reinforcement of the center section.

Another example is when a vehicle has an offset front-end collision. This type of damage may cause the front end to sway toward one side of the vehicle. Depending on the speed of the collision, the energy can be diverted to the rear of the vehicle, causing height problems in the rear section, or having it swayed to one side or the other.

Refer to the "Activity: Impact Angles And Damage Analysis" for an activity on determining the impact angle.

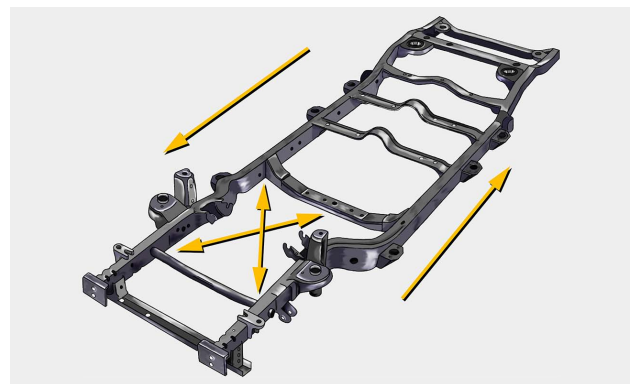


This particular damage shows mash, twist, and possibly diamond.

Collision impacts result in specific damage conditions to the vehicle structure. The extent or number of conditions created in the vehicle structure depends on the angle and severity of the collision.

Types of damage conditions include:

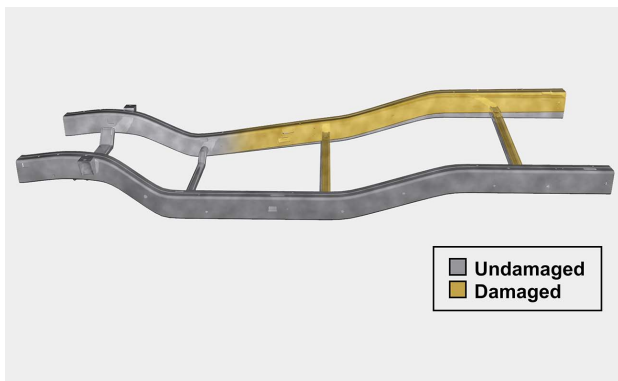
- diamond.
- twist.
- sag.
- mash.
- side sway.



A diamond condition is when one side of the vehicle is pushed forward or rearward of the opposite side.

The diamond condition:

- is often created by an offset collision impact where one side of the vehicle is moved forward or rearward of the opposite side.
- causes the center section to be out of square, taking on a diamond-like appearance.
- is commonly associated with full-frame vehicles.
- is starting to be found on unibody vehicles as increased use of reinforcements and ultra-high-strength steel (UHSS) become standard in vehicle construction. For example, diamond may occur from a direct impact to the rocker panel. If there is diamond in a unibody vehicle, it is generally accompanied by a dent or wrinkle in the floor pan.



Twist occurs when a portion of the center section is higher than the other.

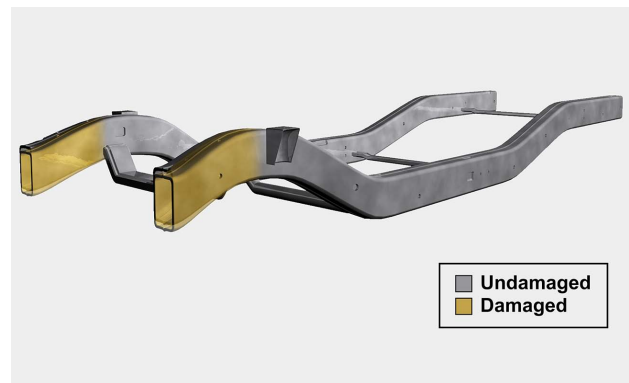
Twist:

- occurs when the center section of a vehicle is out of level. Either one

or both ends are out of level with each other.

- is a height problem, where a portion of the vehicle center section is higher or lower than the opposite side.
- may not be evident in the upperbody structure, however, the vehicle may appear as though there is suspension damage. On full-frame vehicles, twists can occur in the frame and / or the unitized structure.
- can occur from colliding with a curb or ditch at high speed, becoming airborne at one point, or being involved in a rear impact.

It is important for technicians to repair the twist condition before it is anchored for pulling. Not making this repair ahead of time can lock the twist condition into the vehicle.



Sag occurs when there are height problems with the front or rear of the vehicle.

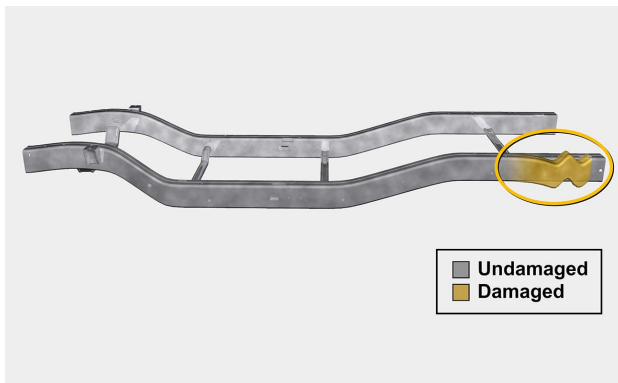
Sag is:

- a condition where the front or rear sections of the vehicle or the cowl

have height measurements that are out of specification.

- generally the result of a straight-on collision.
- indicated by body panels having inconsistent panel gaps from top to bottom, generally tighter at the top and wider at the bottom. This happens when the cowl drops down in a front-end collision.

Due to the stronger center sections, this condition is not as common as it was on older models.

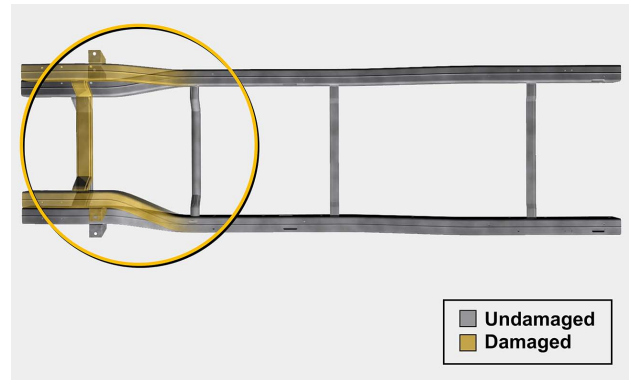


Mash occurs when the frame has collapsed from collision forces.

Mash is:

- also called collapse or short rail.
- a condition where any section or frame member is shorter than factory specification.
- common on front and rear rails from front and rear impacts. Damage may be more visible in the front and rear section of the vehicle compared to the center section. For example, collapse of the rails may lead to distortions or

buckles in panels such as fenders, hoods, and quarter panels.



Side sway occurs when the front or rear of the vehicle is pushed to one side.

Sway, or side sway:

- occurs when collision energy forces a part of the vehicle to one side or the other.
- is a width misalignment.
- generally occurs to the front or rear section of the vehicle.
- may be evident by wide gaps on one side of the vehicle and narrow gaps on the opposite side. Direct impact would generally take place on the side of the vehicle.

When analyzing damage, an indication of side sway is evidence of buckling on the inside of the driver side rail and buckling on the outside of the passenger side rail.

Refer to the "Activity: Determine The Damage Condition" for an activity on determining the damage condition.



Checking wheel positioning can determine if there is damage to the suspension or vehicle underbody.

Additional damage indicators commonly associated with the damage conditions include:

- the position of the wheel in the wheelhouse. The most obvious assumption is that there is suspension damage. However, if this is not visible, it is likely that there is damage to the suspension mounting areas that are part of the vehicle structure.
- cracked seam sealers or paint. This may require lifting the carpeting or raising the vehicle to view the floor pan or trunk floor. Cracked seam sealer may be an indication of inner structure damage.
- improper closure panel operation. If the door, hood, or deck lid binds, drops, or sticks when opening, it may be an indication of larger structural damage.
- a cracked windshield. This particular damage is an indicator that there is stress in the upperbody structure that caused the glass to crack.
- buckled exterior panels. While dented panels are often a result

of a direct impact, structure misalignment will also cause panels to buckle.



This estimator is checking for visual indicators of more extensive structural damage.

When looking at visual clues regarding structural damage, note that:

- these should only be used as guides.
- they should never be used as the only method to determine structural damage. However, they can be used as evidence that structural three-dimensional measuring must be done.
- in most instances, measuring may be the only practical method to determine if structural damage exists. The visual indicators simply show that the vehicle should be measured.

Most estimators and auto physical damage appraisers use visual clues to identify if measuring is required. It is rare to do field measurements. Most structural misalignment problems are generally

evident. However, there are situations when damage is very subtle, and only measuring will identify a structural problem.

Measuring For Damage Analysis



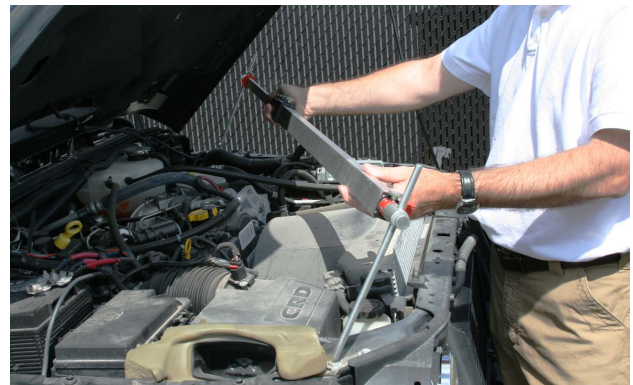
Three-dimensional measuring systems, such as this one, can be used to measure without anchoring to a bench.

Measuring for damage analysis helps:

- locate indirect damage. Knowing that damage in unitized and full-frame structures radiates beyond the area of initial impact, means that locating the indirect damage is critical in ensuring an accurate estimate.
- locate hidden damage. Hidden damage is structural damage that may not be evident, as exterior panels and trim often hide bends and kinks in the structure.
- determine a repair plan. The repair plan allows the technician to determine what precisely must be done to restore vehicle safety, performance, and appearance.
- identify suspension damage.

The estimate, or damage report, is generally not considered complete until a complete and thorough damage analysis is done that includes measuring the vehicle structure.

When making measurements or looking at measuring results, compare the measurements with the visual damage. Try and determine if the measurements match the appearance of the vehicle and the direction of impact. Try to determine how far the damage radiates into the vehicle. In other words, measure until measurements are found within normal tolerance.



Crosscheck point-to-point measurements can be used to determine movement in the upperbody structure.

Types of measurements used for vehicle repair include:

- point-to-point. Point-to-point measurements are used for damage analysis only, and are not a substitute for three-dimensional measuring.
- three-dimensional measuring. This type of measuring is required for any type of structural repair and

can be used for damage analysis as well.



Tape measures and tram gauges are used to make point-to-point measurements.

Point-to-point measurements can be taken with a:

- tape measure.
- tram gauge.

Tape measures must:

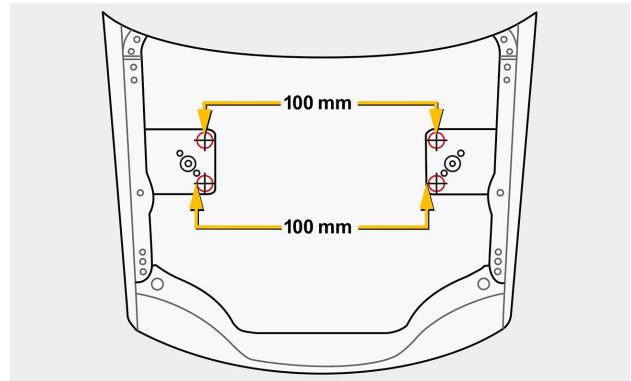
- have a metric scale, since most dimension sheets list dimensions in metric measurements.
- lay flat between the points being measured. Bends or twists will give inaccurate readings.

A tram gauge:

- is a telescoping measuring device with adjustable pointers on each end. It is used for making point-to-point measurements.
- may require a tape measure to measure between the pointers. This is used for tram gauges that

do not have a built-in measuring device.

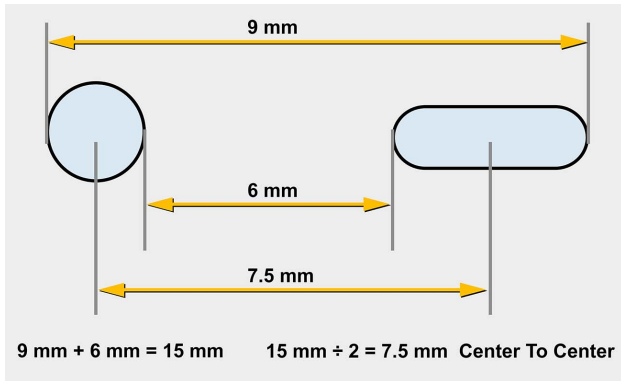
- is available in different sizes.
- may be digital or equipped with a built-in tape measure.
- often have metric measurements printed on the bar and pointers.



On holes, measure from edge to edge or center to center.

Point-to-point measurements for:

- holes of the same size are made either edge to edge or center to center.
- fasteners will typically be center to center, measuring to the center of each bolt head.



Measuring between holes of different sizes requires making the proper calculations.

To measure between reference holes that are different sizes, make two measurements where the:

- first measurement is made from the inside edge of one hole to the inside edge of the other hole.
- second measurement is made from the outside edge of one hole to the outside edge of the other hole.

Add the two measurements together, then divide by two. This calculation will provide a center-to-center measurement for two reference holes that are different sizes. Typically, this type of measurement is not found in dimension guides and is used for comparison measurements only.



Refer to the "Video: Making Point-To-Point Measurements - Part 1" in the presentation for a video on how to make quick point-to-point measurements to identify potential structural damage.



Refer to the "Video: Making Point-To-Point Measurements - Part 2" in the presentation for a video that concludes the discussion on how to properly make quick point-to-point measurements to identify potential structural damage.



Common point-to-point measurements include door openings (left) and specific points beneath the hood such as the radiator core support mounting points (right).

Common point-to-point measurements used to perform quick checks for structural damage include:

- lower ball joint to frame.
- underhood crosscheck.
- underbody crosscheck.
- door and deck lid openings.

Point-to-point measurements can also be comparative measurements from side to side. Point-to-point measurements should not be a substitute for three-dimensional measurements, a requirement for structural alignment.



This is a three-dimensional measuring system that can be used for damage analysis.

There are several types of three-dimensional measuring systems used to measure a vehicle and return it to proper dimensions. Each of these systems uses a specific method for providing measurement readings to the technician. Some of these systems include:

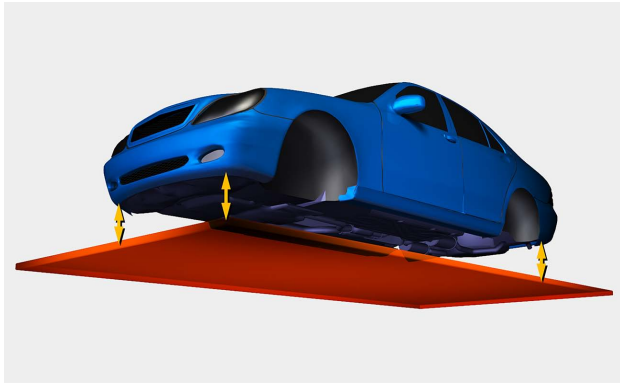
- universal mechanical or laser.
- fixture measuring systems. This is not commonly used for damage analysis as it requires the vehicle be mounted to a bench.
- computerized measuring systems.

Each of these systems must read all three dimensions to verify a specific point on a vehicle. These dimensions include height, width, and length.

Three-dimensional measuring equipment may be installed in the estimating bay to assist in writing accurate damage reports. This type of equipment generally does not require anchoring the vehicle in place.

Examples of measuring equipment for damage analysis include:

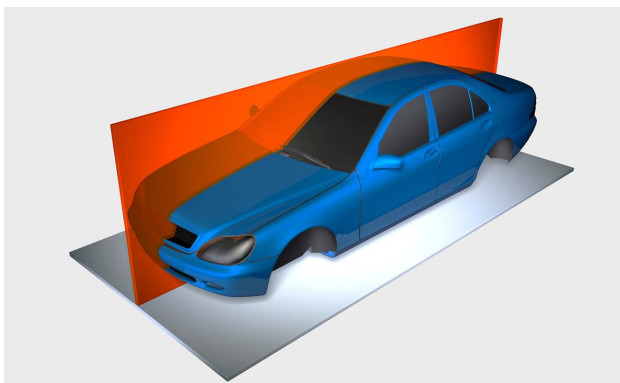
- NAJA from Celette.
- M802 with Car-O-Tronic from Car-O-Liner.
- Contact from Car Bench.



The imaginary datum plane is positioned below a vehicle and is used to measure vehicle height.

A datum plane:

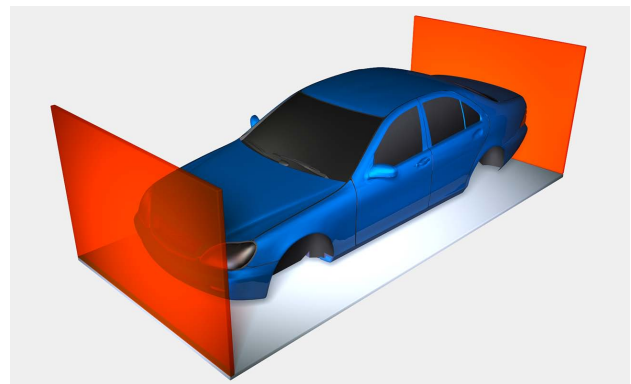
- is used by measuring systems as a starting point from which height is measured to various reference points on the vehicle.
- is an imaginary surface or plane positioned beneath the vehicle that is parallel to the vehicle underbody.
- distance from the bottom of the vehicle varies according to the maker of the measuring system or vehicle maker's dimension guide.



The centerline plane cuts the vehicle in half lengthwise, and is used to measure width.

Centerline plane is:

- an imaginary plane that cuts the vehicle in half from the floor to the roof lengthwise, front to rear.
- used by measuring systems as a starting point for width measurements.
- used to establish a width position for vehicle reference points.



The zero plane is used to measure length and can be placed anywhere along the length of the vehicle depending on the measuring equipment maker or vehicle maker's preference.

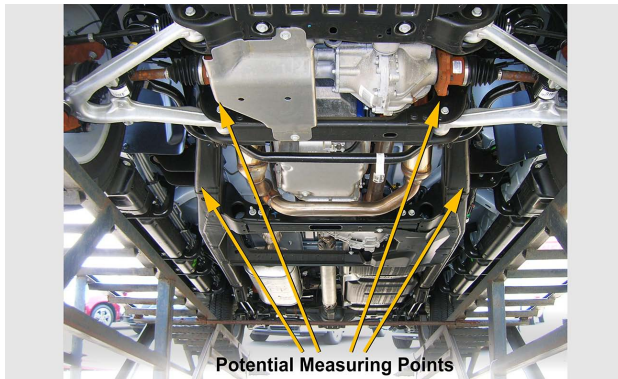
Zero plane is:

- used by measuring systems as a starting point from which length is measured.
- an imaginary plane that extends across the width of the vehicle.
- projected at different locations depending on the maker of the dimension guide.

The zero plane should not be in an area that has been damaged. If the dimension guide shows the zero plane in an area

that has been damaged, such as the front torque box area, the zero plane can be moved to the rear torque box area. The listed measurements in the dimension guide, however, must be adjusted accordingly.

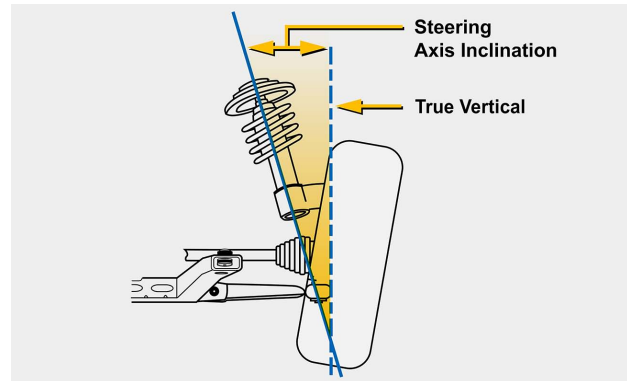
Chevrolet Tahoe Hybrid



Three-dimensional measuring points are located throughout the vehicle, including underbody points as shown here.

Points used for measuring the vehicle are control and reference points. These points:

- may be the same points used during vehicle assembly.
- are used for damage analysis.
- include bolts, slots, holes, formed and pierced parts, and divots.
- generally require starting with three known good points to set up the measuring system.



Suspension measurements can be made from the upper or lower pivot points to the vehicle centerline.

Similar to the point-to-point measurements taken from the lower pivot point, three-dimensional measurements:

- are made from the vehicle centerline to verify proper positioning of the suspension.
- can help determine if lower rails, strut towers, suspension parts, or engine cradles are out of alignment.

One suspension measurement that is used is called steering axis inclination (SAI). These points can be verified by measuring the distance from centerline to the upper (top of the strut tower) and lower pivot points (lower ball joint). When the upper and lower pivot points are at specification, the SAI angle will be correct. The purpose of SAI is for directional control of the vehicle. If the angle is different from side to side, the vehicle may pull. SAI is measured with true vertical.

An engine cradle that has moved or been damaged may cause an incorrect SAI.

When making three-dimensional measurements, technicians start with the center section of the vehicle. This part of the vehicle is essentially the foundation of measuring, and provides a reference for all other measurements. There are instances when the center section is damaged, however, only three good points are needed to establish a good foundation.

More information on measuring and alignment angles can be found in the I-CAR live “Measuring (MEA01)” and “Wheel Alignment and Diagnostic Angles (STE04)” training courses.



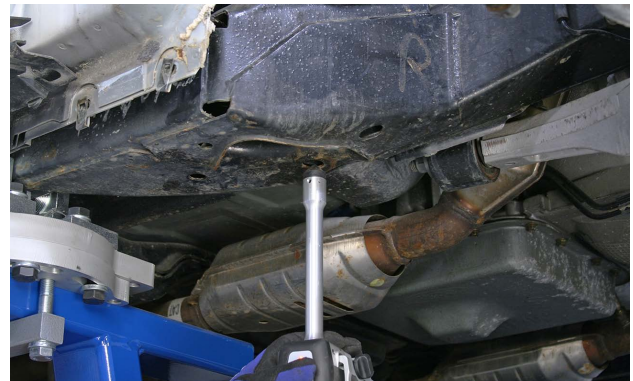
Electronic measuring system equipment provides vehicle specific measurements.

Specific points used to make three-dimensional measurements are provided by:

- measuring equipment makers.
- vehicle makers.

Estimating guides and vehicle makers also provide quick point-to-point measurements. Measurements, whether three-dimensional or point-to-point,

are almost exclusively provided in millimeters.



Most electronic measuring systems set their tolerance range to 3 mm.

During vehicle production, most vehicles are built within a certain tolerance.

Tolerance:

- is the range that a measurement can vary by and still be acceptable, so the vehicle panels fit and operate properly and the suspension allows the vehicle to handle properly. This may be as low as zero, or no tolerance, for some vehicle makers.
- may include variations in dimensions between vehicles of the same make. This is called vehicle build tolerance.

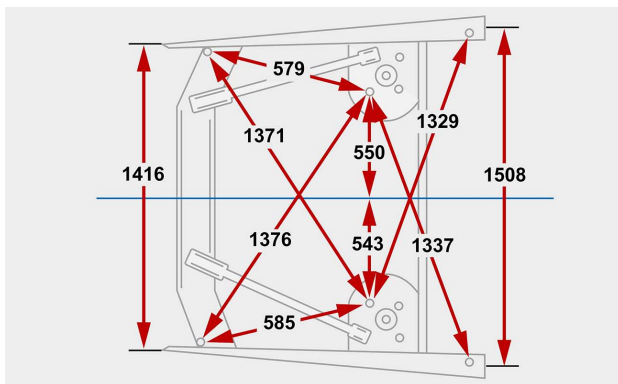
Due to this tolerance, not all vehicle measurements will be identical and may vary by a millimeter or two. During collision repairs, the vehicle must be returned to proper specification.

For collision repair purposes, tolerance depends on what is being measured.

For example, areas with very low or no tolerance may include nonadjustable door hinges, uniside construction, nonadjustable suspension mounting locations, and airbag sensor mounting locations.

Items with more tolerance may include rail measurements. However, in most cases, tolerance will not exceed ± 3 mm.

Buick LaCrosse



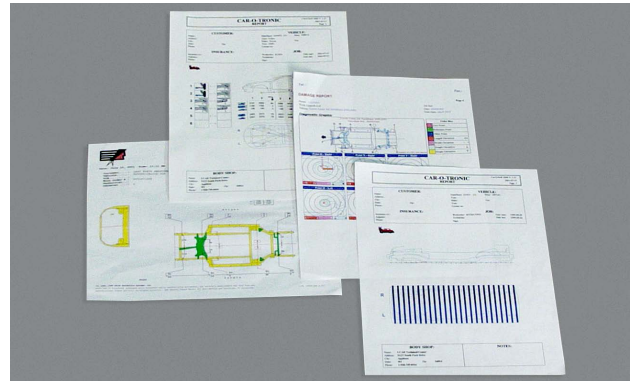
The underhood dimensions for this vehicle shows that the strut tower bolt locations are providing asymmetrical measurements.

Most points on a vehicle are in the same location on the left and right side, or symmetrical. Asymmetrical vehicles have:

- structural variances from the left to right side.
- reference points in different locations.

For example, some older model vehicles may have door openings with different dimensions for the passenger and driver side door. This is an example of a structural variance. Some vehicles

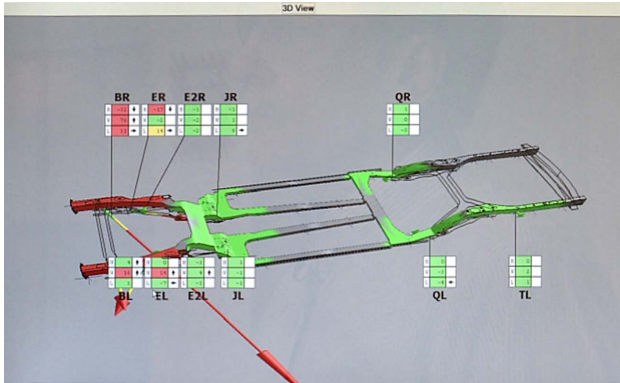
may have strut tower bolts in different positions. Since the strut tower bolts are reference points, the measurements may be different even though there is no structure variation between the left and right side of the vehicle.



Most computerized measuring systems allow measurements to be printed.

Most three-dimensional measuring systems offer the option of printing out the measuring results. On these particular systems:

- a computer is required to measure and record.
- the readouts vary by manufacturer.
- improper measurements may be highlighted in a different color. Some colors may vary depending on if the measurement is too long or short, or too high or too low.



Measurements that are out-of-specification are often a different color to highlight problem areas.

The measuring printouts note the specific measuring locations, and provide the profile and overhead view of the vehicle. The computerized printouts:

- provide complete measurements and an overall picture of damage.
- may have a negative sign to indicate a short or narrow measurement.

Some systems provide a three-dimensional display of damage once the measurements are complete.

Module Wrap-Up

Topics discussed in this module included:

- the different types of vehicle designs.
- how unitized structures are designed to collapse.
- how different impact angles transfer collision energy and create different types of damage.
- how to read vehicle measurements to determine structural damage.

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Module 2 - Structural Damage Analysis

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General Repair Considerations

The learning objectives for this module include:

- identifying general repair considerations for structural parts.
- identifying front structural parts and common techniques for analyzing damage from front impacts.
- identifying side structural parts and common techniques for analyzing damage from side impacts.
- identifying rear structural parts and common techniques for analyzing damage from rear impacts.
- identifying specific damage to determine if structural glass should be repaired or replaced.
- listing common types of damage that can occur to body-over-frame vehicles and determining if it can be repaired.

Ford Fiesta



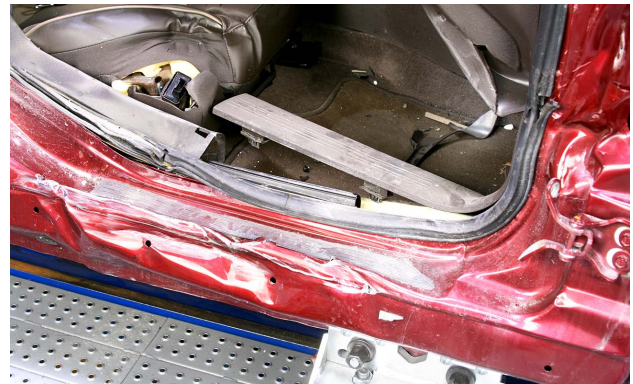
This shows the HSS and UHSS inner structures on the Ford Fiesta.

When deciding to repair parts on late model unitized structures, appraisers must take into consideration several more variables compared to older model vehicles. These include the fact that:

- steel parts have become much stronger, requiring different damage analysis and repair techniques.
- attachment methods have been altered to reduce the effects that welding has on advanced high-strength steels (AHSS).

Estimating processes must also change with vehicle technology. Old repair standards of the past are no longer viable with today's modern construction technology.

Chevrolet Malibu



This rocker panel was work hardened during part forming, and hardened again from the collision.

Metal is work hardened each time it is formed, bent, stretched, or compressed. As a part becomes more work hardened, it becomes more brittle, making it prone to cracking. A metal part is work hardened initially when it is formed at the

manufacturing plant. However, it is work hardened further when it is:

- deformed during a collision.
- straightened during repair.

Work hardening changes the original characteristics of the part. This can be an issue if the part is not repaired properly. A work-hardened part may not react properly if it is involved in another collision, possibly allowing more intrusion into the passenger compartment. Although the effects of work hardening can be reduced with the use of heat, applications of heat are primarily limited to mild steel.



This rail shows a bend in the lower flange area.

There is a common statement in the collision industry that if a part is bent, it can be straightened, if it is kinked, it must be replaced. A bend:

- is a smooth, continuous change in shape.
- can be repaired without altering the state or shape.

The "Demonstration: Bent Metal" shows a picture of what is classified as a bend in a steel part.

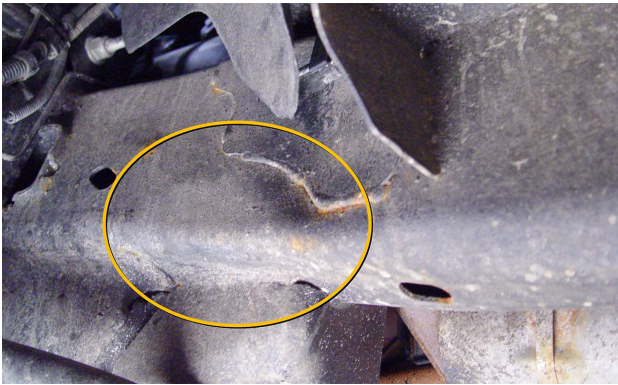


This portion of a frame rail is kinked.

A kink is defined as a sharp bend with a small radius over a short distance.

A part is considered kinked if, after straightening, there is a permanent area of deformation that will not return to its original shape without the use of excessive heat. The kinked area has experienced changes in the metal, and may have visible cracks or tears. These changes create permanent damage that cannot be repaired regardless of the type of repair performed.

The "Demonstration: Kinked Metal" shows a picture of what is classified as kink in a steel part.

Ford F-150

This frame rail has a minor bend that may be difficult to straighten.

When making a part repair decision, the most important factors to consider are that the metal state and shape must be restored. In other words, both strength and appearance must match the pre-accident integrity of the part.

Metal has a molecular grain structure. This structure gives metal its strength and cannot be seen with the naked eye. When metal is damaged, its grain structure is rearranged. This grain structure damage can:

- weaken the part.
- cause the part to react differently if involved in another collision.
- occur when an area is kinked. The grain structure in kinked areas will likely be irreversibly affected. When an area is kinked, it is likely to have microscopic cracking of the grain structure. Aluminum is especially vulnerable to this and will often crack during straightening.

Some high-strength steel (HSS) and ultra-high-strength steel (UHSS) are typically not repairable regardless of whether the part is kinked or bent. UHSS is almost always replaced if damaged due to permanent changes in the steel.

When taking into consideration state and shape, the kink vs. bend rule is no longer as simple as it sounds. It does not always provide a definitive repair vs. replace answer. For example, if the part is bent, but the thickness or strength of the metal will not allow for straightening without leaving an area of permanent deformation, then replacement, either partial or complete, would be appropriate.

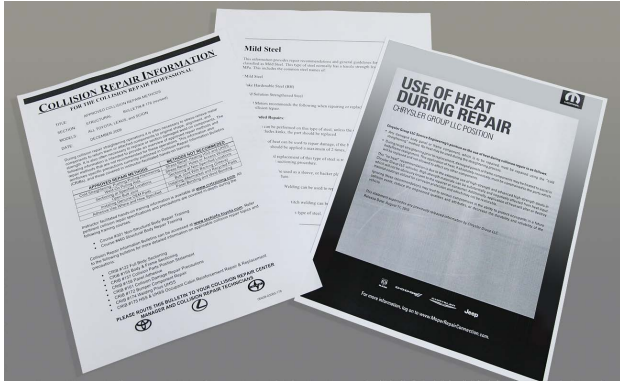
Chevrolet Corvette

If heat is allowed by the vehicle maker, the amount of heat applied should be monitored to make sure it does not exceed recommendations.

HSS and UHSS are altered by the application of heat. Heat makes HSS and UHSS softer, more malleable, or weaker, essentially losing their high tensile strength.

Heating a part to straighten it is generally not recommended unless the part is

a mild steel part where limited heat application will not affect the integrity of the steel.



Vehicle makers provide heat limitations in their collision repair information.

To determine if heat can be applied for stress relieving, refer to the body repair or service manual. Some vehicle makers have specific guidelines for heating steel during repairs. These may include:

- not allowing heat to be used for repairs, such as straightening kinks. The vehicle maker may only allow cold straightening.
- that HSS should generally not be heated.
- using heat only as a last resort. This may include using heat when straightening the vehicle back to proper dimensions.
- the maximum temperature a part is allowed to be heated.
- the total amount of time heat may be applied. Heating times are generally cumulative. This means that the metal can only be heated for the total time given. It cannot be reheated after the total time has been reached.

If the material cannot be identified, it should be treated as a type of HSS and not be heated.



There are a variety of heat monitoring materials and equipment that can be used to ensure heat limits are not surpassed.

If heat is used, it is recommended to have the repair facility document the amount of heat applied, the length of time, and where it is used. This data should be attached to the repair order.

Temperature indicators are recommended to ensure the heating temperature does not exceed vehicle maker recommendations. Temperature indicators are available:

- in a variety of temperature ranges.
- as heat sticks made of a waxy, chalky, or liquid-type of substance. The substance melts when the rated temperature is reached.
- as thermal paints that work by either changing color or melting when the rated temperature is reached.

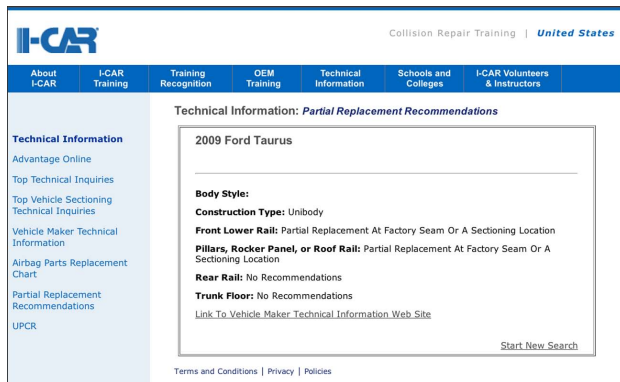
- as temperature-indicating labels that change color when a specific temperature is reached.
- as noncontact thermometers that can detect the amount of heat radiating from an object.

through the vehicle maker website or ALLDATA.

- OEM1Stop. This can be found at www.oem1stop.com.

Damage removal is generally done:

- by straightening.
- at factory seams by removing the entire part.
- at factory seams by only removing a portion of the part.
- by sectioning the part.



I-CAR has links to vehicle maker websites in addition to information on which specific parts have partial replacement procedures.

Determining how damage in a part can be replaced depends on recommendations from the vehicle maker. Vehicle maker recommendations can be found at:

- vehicle maker collision repair websites, typically for a nominal fee. General Motors and Chrysler body repair information is free. The websites can be accessed from the I-CAR website.
- ALLDATA, which is a subscription website.
- the Partial Replacement Recommendations matrix on the I-CAR website. The matrix only states if partial replacement is allowed by the vehicle maker, and does not provide part-specific procedures. This must be acquired

Refer to the presentation, "Demonstration: Partial Replacement Recommendations" for a demonstration that shows the Partial Replacement Recommendations Matrix.

Honda Accord



The front rail on this Honda Accord is being completely replaced at factory seams.

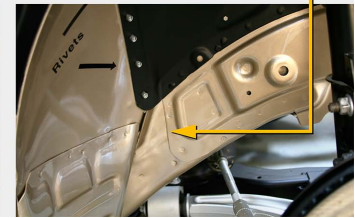
Replacing a complete part at factory seams:

- is common on UHSS parts, though some vehicle makers offer partial replacement of their UHSS parts. For example, the Audi Q5 has a sectioning procedure for its UHSS B-pillar reinforcement.
- may be done because reinforcements make partial replacement difficult.
- may require additional undamaged part removal.
- may require extensive part removal.
- may require disturbing factory seams that create additional corrosion hotspots.

Ford Mustang Sectioning



Chevrolet Malibu Partial Replacement Factory Seams



This Ford Mustang front rail has a sectioning joint (left), while this Chevrolet Malibu shows a partial replacement procedure at factory seams (right).

A portion of a part can be replaced at factory seams, or a new joint can be created away from factory seams. This is called "sectioning."

Many parts of a vehicle are not one piece, but composed of multiple pieces that are joined together. Replacing a portion of a part at factory seams is sometimes recommended. Sectioning does this at an area of the part away from factory seams, creating a new joint. Either of these partial replacement methods requires a recommendation from the vehicle maker, with either a procedure or available partial part. There may also be a recommendation to partially replace a part at factory seams at one location, and section in another location.

The advantages of partial replacement includes:

- the repair affects a smaller area.
- fewer, undamaged OEM welds are disturbed.
- less original corrosion protection is disturbed.
- less disassembly may be required.

Laser-welded joints are not considered a good factory seam for partial replacement. Most vehicle makers do not recommend this joint.

Chevrolet Malibu



The A-pillar on this Chevrolet Malibu has a recommended sectioning location in the windshield area.

When considering if partial replacement is a viable repair option, determine:

- if a procedure exists to make this type of repair, or if there is a partial part available, such as a portion of an assembly.
- if the partial replacement option removes all of the damage.
- which joints are recommended.
- how corrosion protection will be applied after the joint is complete.

Chevrolet Malibu



The cutting of an access window in the roof rail is recommended on this Chevrolet Malibu to install the B-pillar.

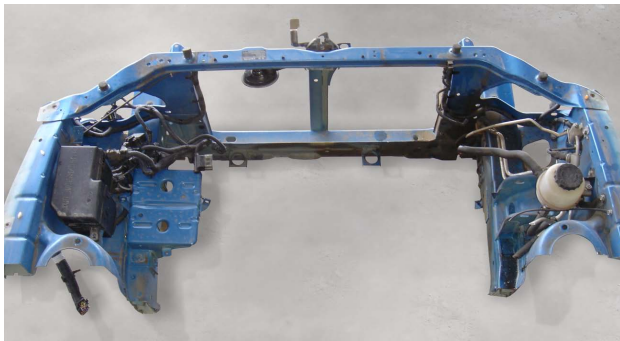
Some repair procedures from vehicle makers have been developed that require cutting access windows into a part to access the opposite side of a part. This is generally done to allow access to a:

- reinforcement for sectioning.
- part so that it can be removed for complete replacement. For example, on the 2009 Honda Accord, access windows in the outer, upper B-pillar are required for removing the reinforcement. A similar method is used to access the rocker panel reinforcement on this vehicle. These are vehicle maker-approved access windows.

Toyota also has a procedure for cutting an access window to reach the offset joint on the rocker panel reinforcement. This is because the replacement outer panel, due to how it is cut at the factory, may not extend over the reinforcement area. This procedure is recommended on several Toyota/Lexus/Scion vehicles.

Cutting any type of access window is technically considered a sectioning joint, and can be more intrusive since a window has two or more cuts compared to just one in a traditional sectioning joint. Re-welding all these cuts creates a larger heat-effect zone, which can be damaging to higher strength steels. It also requires a larger area to be cosmetically finished.

For these reasons, this procedure is done only when recommended by the vehicle maker.



Recycled assemblies, such as this radiator core support, are often used for collision repairs.

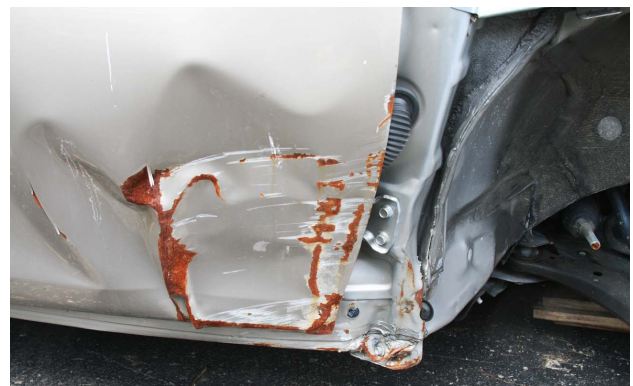
Recycled assemblies are used for vehicle repairs. While generally not recommended among vehicle makers, it is a reality of the collision repair industry, and is used to reduce the number of total losses by providing a more economic alternative.

It can also be a less intrusive repair. For example, using a recycled assembly may require fewer spot welds to be removed compared to removing and replacing multiple panels individually.

If recommending a recycled assembly, note that there may be additional steps required, such as cleaning up the part, trimming the part for proper fit, removing any mild surface corrosion, and removing attached trim or unwanted panels. The recycled part must be in good condition, such as no structural damage of any kind, if it is going to be used.

Note that when ordering recycled parts, the parts may not be the same design even if they are from the same model year. On occasion, there are model changes within the same model year. There are also different trim levels that must be taken into consideration when determining if a recycled part can be used.

More information on the use of recycled parts for collision repair can be found in the I-CAR live "Recycled Parts for Collision Repair (RCY01)" training course.



A corroded panel may be an indication that the part was damaged from a previous collision.

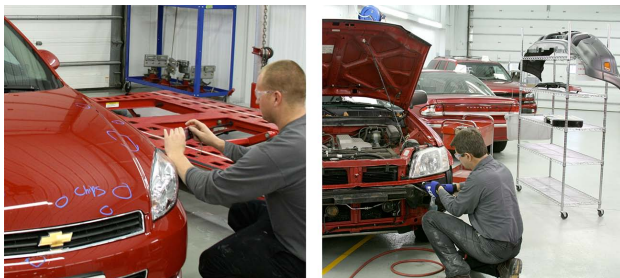
Items to consider when inspecting collision-damaged parts include:

- corrosion that may affect the repair process or indicate previous damage.
- previous repairs that may affect how repairs will be made to the new damage. Previous repairs are often indicated by plug welds, flange variations, or a thicker finish that requires identification using a film-thickness gauge. If a part was previously repaired, the same repair may not be possible. For example, instead of sectioning in the same location, complete part replacement may be the only option.
- damage to the vehicle finish.
- damage to suspension or suspension mounting locations. Make sure that the steering wheel is in the straight-ahead position, and check the position of the front wheels.
- all the necessary parts have been ordered. This requires finding any hidden damage. It is important to note that up to 40% of collision damage can be located underneath the vehicle.
- an accurate report is written. This ensures that the repairs are completed within expectations of the customer. Finding significant damage after the repairs have started will delay delivery time.
- any sublet work is scheduled.

A process known as "blueprinting" allows the estimator and repair facility to see the entire repair picture before repairs are started and ensures that the vehicle, once repairs have been started, will not be held up to wait for additional parts to be ordered or sublet procedures to be performed. Blueprinting includes an orderly teardown, which can play an important role in identifying hidden damage. Removing bolt-on parts, such as fenders, bumpers, doors, etc., can show damage that is otherwise undetectable.

For more information on blueprinting, consider attending the I-CAR live "Overview Of Cycle Time Improvement For The Collision Repair Process (CYC01)" training course.

Performing an accurate estimate requires following a specific sequence, most commonly, starting at the area of direct damage and working toward the opposite side of the vehicle. The next step is to look on top and underneath the vehicle. From

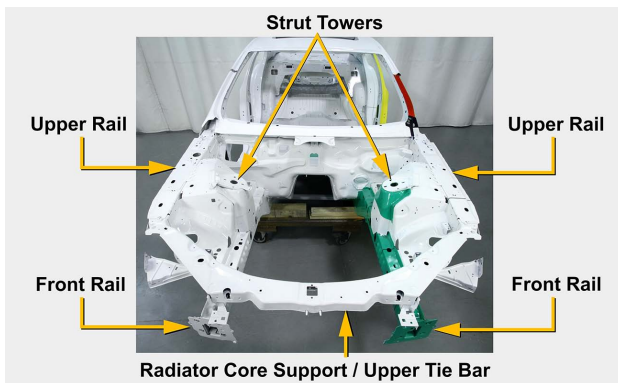


Taking pictures (left) and disassembling parts (right) may be part of performing a thorough damage analysis.

To ensure that there are no delays in the repair process, a thorough damage analysis is required to ensure:

there, the inspection continues to the vehicle interior. It also may be helpful to inspect the vehicle from a distance so the entire vehicle can be seen. This provides a broader perspective of the damage, and may provide a better view of the overall damage condition. For example, if the vehicle is sagging or a portion of the vehicle is lower on one side, a close-up inspection may not reveal this.

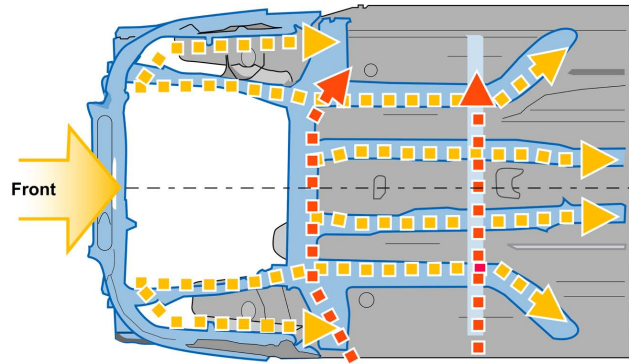
Front Impact



This shows the parts commonly associated with a unitized front structure.

Front impacts commonly damage one or more of the following parts of the unitized structure:

- Bumper reinforcement
- Front rails - upper and lower
- Radiator core support
- Engine mounts
- Front suspension
- Engine cradle



Collision energy is designed to be absorbed and transferred to other areas of the vehicle.

This front structure is designed to absorb collision energy by partially collapsing, followed by transferring the remaining energy around the passenger compartment. All these parts have specific functions, but they also work together to absorb the impact, so it is key that they are restored to proper state and shape so that they maintain their integrity and perform as intended in a subsequent collision.

Toyota RAV4



This shows a bolt-on radiator core support with upper and lower tie bars, and side panels.

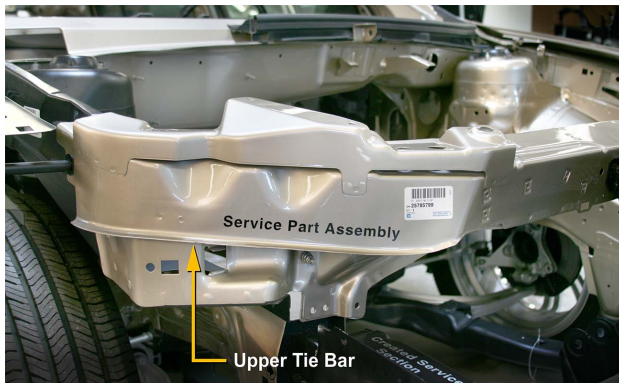
The radiator core support on a unibody vehicle generally consists of:

- an upper tie bar that connects the upper rails on both sides together.
- a lower tie bar where the radiator, air conditioning (A/C) condenser, and other coolers are fastened.
- side panels on some designs.

The radiator core support can be welded or bolted to the vehicle structure.

Radiator core supports may be made from several different materials, including steel, aluminum, magnesium, plastic, carbon fiber, and composite.

Chevrolet Malibu



Some radiator core supports allow parts of the assembly to be serviced separately.

The material type should be considered when making repair versus replace decisions. For example, minor straightening of a steel part may be allowed, however, a cracked magnesium or composite radiator core support is generally replaced.

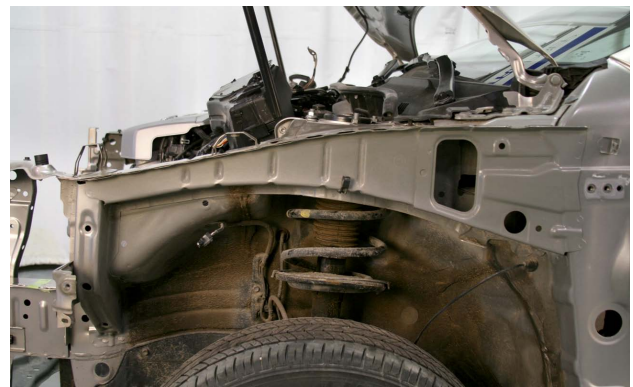
Considerations include replacing only the damaged portion of the radiator core support, if provided by the vehicle maker. Replacement of one side may eliminate

having to remove the fender and other adjacent parts on the opposite side. This may be done along factory seams. Generally speaking, this option is model specific. For example, the Advanced Compatibility Engineering (ACE) body structure from Honda does not allow for replacement of specific individual parts.

Adjacent parts for removal include the radiator, fluid coolers, A/C condenser, hood latch, bumper assembly, fenders, and electronics.

It is also important to remember to re-order labels for the upper tie bar if it is replaced.

Toyota Camry



This is the upper rail for a Toyota Camry.

The upper rails:

- connect the cowl (and / or inner A-pillar) to the radiator core support. They are generally welded in place.
- are the attachment point for the fenders and hood.

- have several different designs, depending on the type of unitized structure.
- may be made from mild steel or HSS.
- are designed to absorb energy and transfer the energy to other areas of the structure.

The upper rails on a body-over-frame vehicle:

- make up part of a unitized cab structure.
- may be welded to the pillars and radiator core support.
- may be integrated into the fender or fender reinforcement panels. General Motors typically uses this design on the C / K series trucks and SUVs.

Chevrolet Cobalt

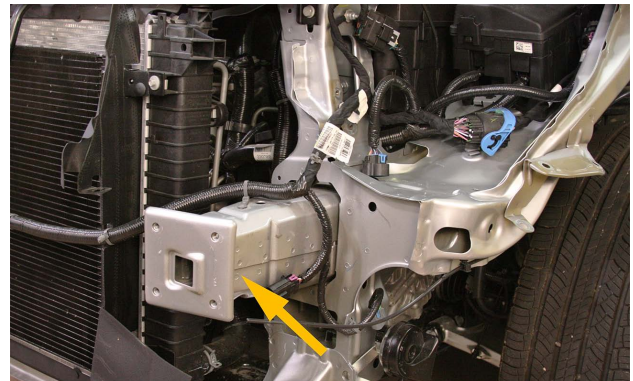


This is the sectioning location for the upper rail on the Chevrolet Cobalt.

When making repair and replace decisions on the upper rail:

- sectioning options may be available depending on the vehicle maker. While not the most common type of repair, there are some procedures available.
- it may be allowed to just replace the outer or inner portion of the rail.
- replacement procedures generally require separation from the strut tower.
- straightening may be possible depending on the steel strength, but note heat considerations or if heat may be used at all.

Cadillac SRX



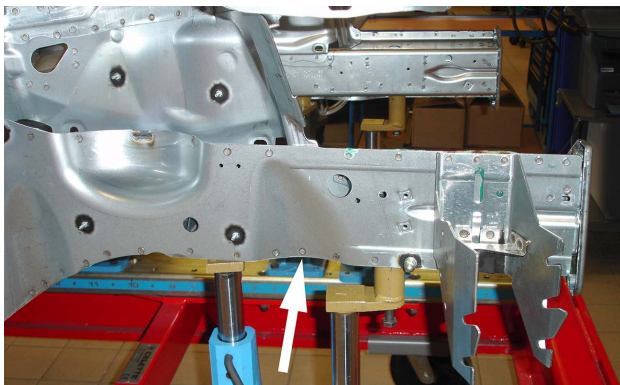
The crush box, such as on this Cadillac SRX, is a sacrificial piece that is replaced when damaged.

At the front of the vehicle, there may be a part called a crush box. This piece is:

- a sacrificial piece on the end of the front lower rail.
- designed to collapse before transferring damage to the front rail, minimizing structural damage in lower speed collisions.

- either bolted or welded to the bumper reinforcement. Toyota has bolt-on crush boxes featured on many of their late model vehicles. The Toyota Tundra has an aluminum crush box that is part of the bumper reinforcement. The 2011 Ford Fiesta, in addition to other Ford models, has a bolt-on crush box. Some older model GM full-frame vehicles have weld-on crush boxes. Audi uses bolt-on crush boxes for their aluminum vehicles.
- replaced if damaged. Do not straighten a damaged crush box.

Audi A5 Cabriolet



This is the lower rail on the Audi A5 Cabriolet.

Front lower rails extend out near the bottom of the front section. The lower rails may:

- be made of different shapes or thicknesses of metal that is designed to absorb or redirect much of the front impact energy.
- have crush initiators that cause the part to collapse in a predictable

manner, thus absorbing collision energy.

- have lateral and longitudinal stiffeners that direct the energy to another part of the structure.
- have tailor-welded blanks, where different types or thicknesses of metal are joined together with a laser weld.
- use mild, HSS, or AHSS.
- have sectioning procedures. Many models have multiple optional locations, however, some do not recommend any sectioning locations, requiring the complete rail assembly to be replaced.
- may allow replacing either the inner or outer portion of the rail.

It is recommended to only follow the part replacement guidelines outlined by the vehicle maker. If a vehicle maker does not offer sectioning guidelines, then sectioning should not be done.

Cadillac DTS



This is the strut tower on a Cadillac DTS.

The strut towers:

- are used with McPherson strut-type suspensions.

- have the top of the strut fastened to the strut tower.
- are the upper pivot point for the steering axis.
- are generally replaced when damaged.

Strut tower position is critical for proper alignment and affects alignment angles such as SAI, caster, or camber. Underhood measurement quick checks can be made to determine if the strut tower has moved. This requires measuring from strut tower fastener to strut tower fastener, as well as measuring to other areas under the hood. Point-to-point specifications can be found in vehicle service information or estimating guides.

Strut towers are commonly made from stamped steel. However, some vehicle models, such as the BMW 5 and 6 Series, are made from cast aluminum.

Considerations for replacing the strut tower assembly may include determining:

- if partial replacement is an option. Depending on vehicle maker recommendations, the design of the part, and the extent of damage, partial replacement at factory seams or sectioning may be an option.
- the shape and configuration of the front apron panel, forward of the strut tower. This portion is typically light gauge construction. Flat areas may be able to be

straightened. Some apron panels are highly formed and difficult to straighten.

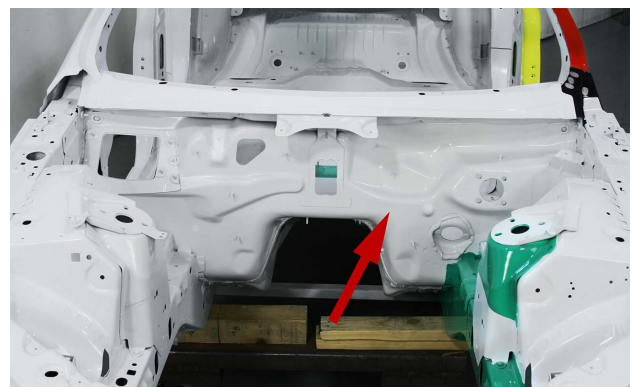


This is the apron on a Jaguar XF.

The fender apron, also called a skirt:

- fills in area between strut tower and radiator core support.
- connects upper and lower rails.
- adds rigidity to the front structure.

Minor repairs may be possible.



This is the cowl panel on the Jaguar XF.

The cowl:

- separates the engine compartment from the passenger compartment.
- is designed to reduce noise, vibration, and harshness (NVH), as well as preventing engine compartment fumes from entering the passenger compartment.

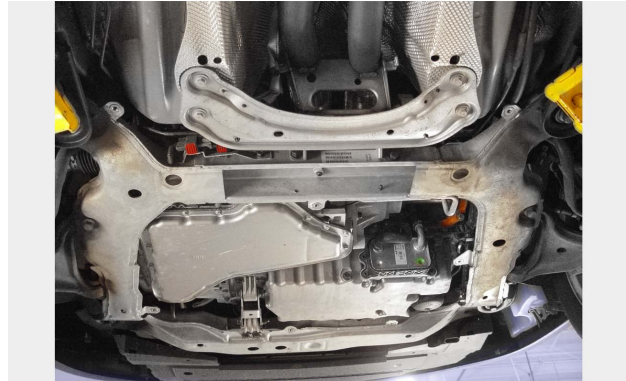
Cowls may:

- be multi-piece, which is common. The cowl may have one or multiple layers of sheet metal.
- be constructed of laminated steel, though this is rare. The 2011 Cadillac DTS and the 2011 Chevrolet Malibu are examples of vehicles with cowl panels made of laminated steel.
- include a cross-car beam or instrument panel frame, made of steel or magnesium.
- have VIN plates or labels that may require removal. VIN replacement is regulated by state, federal, provincial, and local laws.

The cowl panel is not often repaired. Damage that radiates that deep into the vehicle structure may have too many other issues, and often times the vehicle is a total loss. Any repair to the cowl generally requires removal of the:

- engine and transmission assembly.
- windshield.
- heating, ventilating, and air conditioning (HVAC) parts.
- instrument panel.

Volvo S40



This is an engine cradle on the Volvo S40.

The engine cradle:

- is used to hold the engine in place.
- attaches to the front lower rails.
- may also be called a subframe.
- is made from either aluminum, steel, or magnesium.
- is very difficult to straighten, so replacement is common. Some vehicle makers specifically prohibit straightening the engine cradle.
- dimension specifications are difficult to find.
- may contain the engine mounts, lower control arms, and steering rack mounts.
- must be properly aligned.

Some engine cradle bolts have a blue or reddish coating on the threads. This is an adhesive that is used to hold the bolt in place. For this reason, the fastener may be one-time use depending on the vehicle maker recommendations. This may not be a vehicle maker-specific

recommendation, but rather a model-specific recommendation. For example, the 2011 Ford Explorer requires new replacement bolts once the existing bolts are removed, whereas the 2011 Ford Edge allows the re-use of the engine cradle bolts.

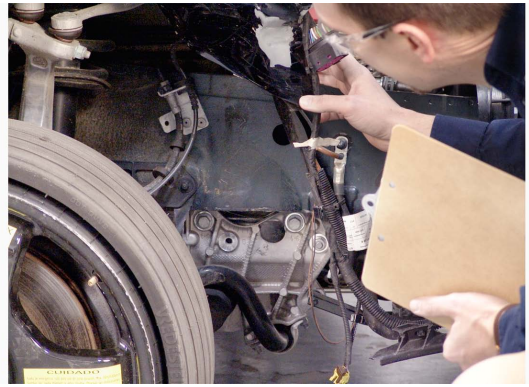


Refer to the presentation, "Video: Front Structure Damage Analysis - Part 1" that shows how to perform a front structural damage analysis on a 2010 Ford Taurus.



Refer to the presentation, "Video: Front Structure Damage Analysis - Part 2" which concludes the discussion on how to perform a front structural damage analysis.

Audi Q5

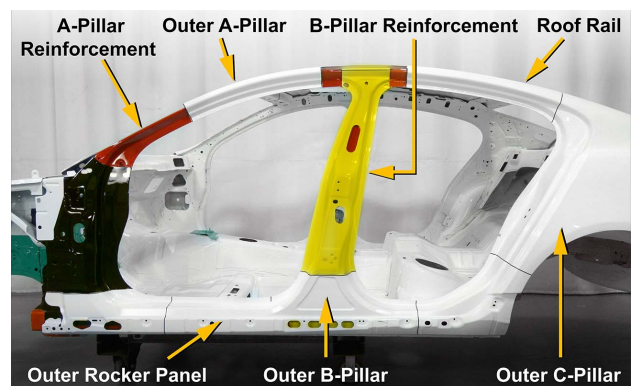


An estimator is examining the suspension on an Audi Q5.

When analyzing the front structure for damage:

- start at the area of impact and work toward the rear of the vehicle.
- visualize the direction of impact.
- check the operation of the doors, hood, and trunk. Do not operate the closure panel if opening it will cause additional damage.
- the fender-to-door gap is the most common indicator.

Side Impact Damage Analysis



This shows the parts commonly associated with a unitized side structure.

Pillars and rocker panels are part of the passenger compartment structure. To protect the vehicle occupants, the passenger compartment must remain intact. A-, B-, C-, and D-pillars, along with rocker panels:

- may have a one- or two-piece uniside for the outer panel depending how the quarter panel is attached, but most have multiple reinforcements.
- may use multiple reinforcements made from HSS and UHSS. This may include inner and outer reinforcements.
- use inner panels to close out the backside of the part.
- provide a stiff structure that prevents intrusion into the passenger compartment. These parts are also designed to transfer collision energy to other areas of the vehicle.
- support the structure. Pillars are also designed to prevent the collapse of the roof structure during a rollover. Convertibles do not have B-pillars that extend to the roof. For these types of vehicles, A-pillars with UHSS reinforcements along with other safety features may be used for supporting the roof structure.

There are federal standards from the National Highway Traffic Safety Administration (NHTSA) that must be met to ensure the passenger cab maintains its integrity in a rollover accident. This is known as Standard 216 that requires

every vehicle roof structure to be able to withstand one-and-one-half times its weight. Vehicles with good ratings from the Insurance Institute for Highway Safety (IIHS) can withstand at least twice the weight of the vehicle. IIHS did not start including this criteria in its safety performance evaluations until 2010.

Pillars and rocker panels may be referred to by different names. Examples include referring to the upper A-pillar as the “windshield post,” and the B-pillar as the “center post.” Rocker panels are sometimes called “sill panels.”

Chrysler 300



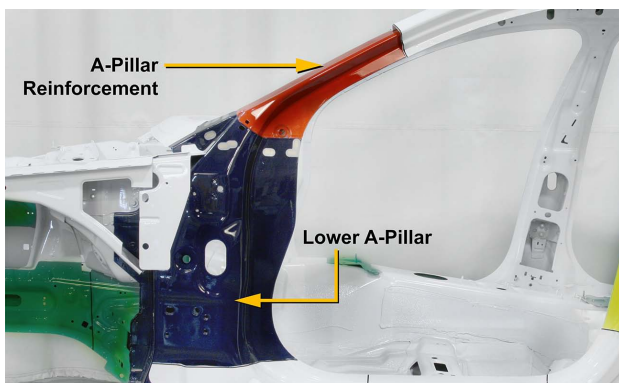
This is a partial uniside for the Chrysler 300.

A uniside is a one-piece seamless structure that typically includes the pillars, rocker panel, and roof rail. The quarter panel may also be included in a uniside. These are available for both full-frame unitized structures and unibodies. Uniside construction:

- reduces the amount of individual parts and body seams.
- enables vehicle makers to assemble vehicles with close tolerances.

- may be designed with tailor-welded blanks. This is done at the factory by laser welding separate pieces of steel to form a single part. Unisides made in this fashion have different strengths or thicknesses designed into one part. The 2009 Ford Mustang uses tailor-welded blanks for its unside construction.
- may be serviced as an assembly or as individual parts. For repairs, some vehicle makers offer either an entire unside or separate replacement parts. Partial unside assemblies may be available as well.
- may be able to be sectioned according to damage, not specific measurements. For example, Ford recommends that sectioning locations be determined based on the replacement part available and the amount of damage.

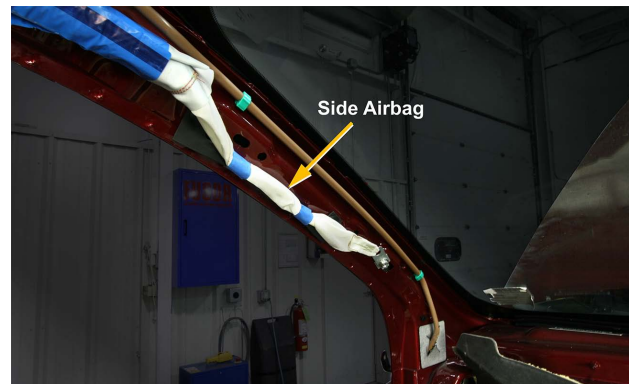
After unisides are built at the factory, they are joined to the floor and roof sub-assemblies.



The A-pillar supports the roof structure and the windshield.

A-pillars are designed to support the:

- windshield.
- front of the roof.
- front door hinges.
- apron assembly.
- cowl assembly.



Restraint systems may be positioned behind the A-pillar trim.

A-pillars are made from:

- mild steel.
- HSS.
- UHSS.

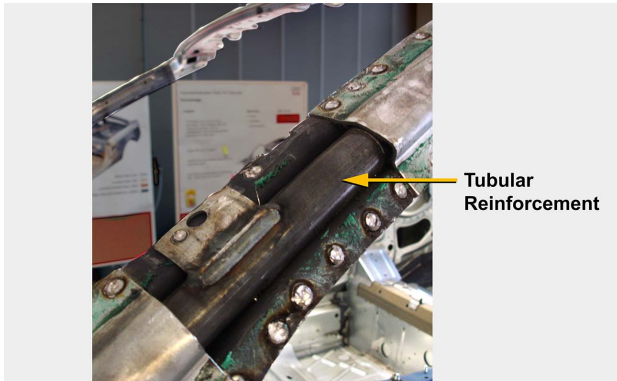
When making repairs to A-pillars:

- note that the instrument panel is generally removed if the inner A-pillar must be replaced.
- note that most A-pillars contain reinforcements that can affect repair decisions.
- there may be curtain airbags behind the A-pillar trim, so the airbag system must be deactivated and the airbag module removed when working in this area,

provided the airbag system has not deployed.

- there may be structural foams inside the pillar that may require removal and reinstallation. Technicians will be able to identify this in the vehicle collision repair information.

Audi A5 Cabriolet



The A-pillar on the Audi A5 Cabriolet has a tubular reinforcement.

The A-pillars on convertible vehicles are:

- designed to maintain their integrity in a rollover to prevent the roof structure from collapsing.
- may have a tubular shape reinforcement.
- may be two-part construction.
- may be multi-part construction that includes an inner, outer, and reinforcement.

Chevrolet Camaro

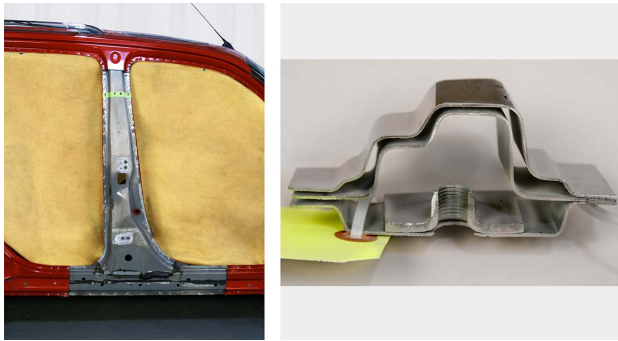


The Chevrolet Camaro has a sectioning procedure for the A-pillar.

When repairing the A-pillar:

- sectioning joints are often made in the windshield area and near the rocker panel.
- the windshield is generally removed.
- the outer A-pillar should not have body filler in the windshield flange. This is due to adhesion issues between the body filler and the A-pillar for best adhesion of the windshield.
- topcoats are generally not applied in the exterior windshield pinchweld flange. Most vehicle makers recommend this for best adhesion of the windshield. One vehicle maker, Audi, recommends applying topcoats on the windshield pinchweld.

Chevrolet HHR

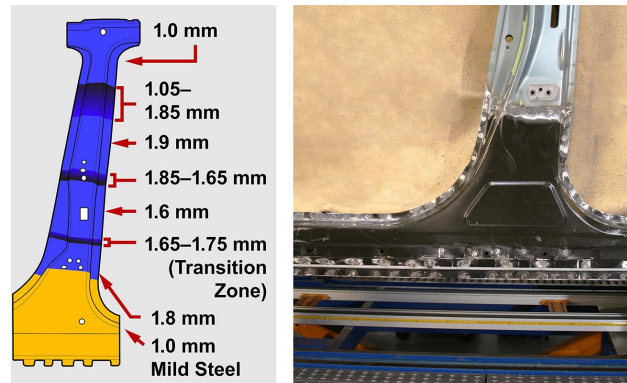


This is the UHSS B-pillar for the Chevrolet HHR (left). This steel cutaway shows the reinforcements commonly used for the B-pillar (right).

The B-pillar:

- has an inner panel, an outer panel that is generally part of a uniside, and at least one reinforcement.
- reinforcement is generally HSS or UHSS.
- is designed so that there is minimum intrusion into the passenger compartment.
- may be tailor-rolled or tailor-welded, hot formed, etc.
- on convertibles, is the lock pillar and is also made out of HSS or UHSS.

Toyota Venza



Some B-pillars are designed to have varying thicknesses throughout the part such as this Dodge Caliber B-Pillar (left). This shows the B-pillar and rocker panel sectioning location on the Toyota Venza (right).

The B-pillar is designed with strategic placement of different strengths and thicknesses of steel. These determine the collapse zone of the pillar. Most pillars are designed to have slight intrusion at the bottom of the pillar, near seat level, while maintaining integrity at the top near the occupants' upper torso and head.

It is important to determine if damage is limited to the outer panel, or if it radiates deeper into the reinforcement. Unless there is specific design information that shows how close the reinforcement is to the outer panel, it may be difficult to determine if the reinforcement is damaged. This may require cutting an access window to see if there is damage behind the uniside. The access hole is cut in an area of the outer panel that is going to be replaced.

For repairs, the B-pillar reinforcement sectioning procedures are limited. Most vehicle makers require complete

replacement of the reinforcement if it is damaged. If no recommendations exist from the vehicle maker, the part should be replaced at factory seams. Toyota does not recommend any sectioning of B-pillar reinforcements with strengths of 980 MPa or 590 MPa. There may be a sectioning procedure on 440 MPa reinforcements, or a portion of the reinforcement that is 440 MPa, but this can only be done if there is a procedure specified in the Toyota service information.

If repair procedures are provided by the vehicle maker, most will be accompanied with specific recommendations for welding to minimize the heat-effect on the high-strength steel. For example, Audi has a sectioning procedure for the B-pillar reinforcement on the Q5, however, a second complete reinforcement is installed behind the sectioning joint.

Honda Pilot



This shows the C- and D-pillars on the Honda Pilot.

A C- or D-pillar is defined as being either of the two pillars that support the rear door striker and the roof. Common to the other pillars on the side of the vehicle, the C- and D-pillars use different strengths and thicknesses of steel.

Two-door C-pillar designs may include the:

- sail panel.
- side glass.
- quarter panel or side panel.
- rear gate or hatch frame.

Four-door C-pillar designs may include the:

- dog leg area.
- sail panel.
- side glass.
- door opening or side aperture panel.
- quarter panel or side panel.
- rear gate or hatch frame.

Buick LaCrosse

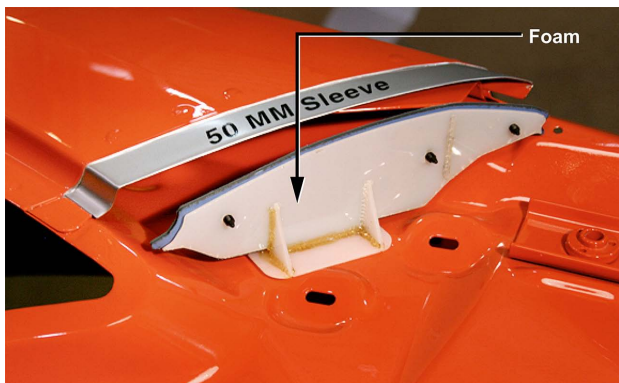


Some C-pillar assemblies have restraint systems attached to the inner side of the panel. These generally require disabling the restraint system before beginning repairs.

When determining procedures for repairing the C- and D-pillars:

- inner assemblies are generally replaced at factory seams.
- outer panels may be separated from the quarter panel at the roof-to-pillar seam.
- outer panels may be included with the replacement quarter panel.
- airbag systems may need to be deactivated so that inflators can be removed before work begins.
- the backglass typically requires removal for C- and D-pillar installation.
- foam. Pillars may be filled with foam. Foam that is removed during the repair process should be replaced with the same type and amount of foam. Some types of foam are used to increase the strength of a structural part, while other foams are used to control NVH. Identifying the foam type may be required by the repair technician if not called out by the vehicle maker.

Chevrolet Camaro



To reduce noise, foams may be placed on the sail panel backside such as on this Chevrolet Camaro.

Additional considerations for C- and D-pillar repair or replacement procedures include:

- removing adjacent parts. Adjacent parts may require removal when replacing parts at factory seams. For example, the roof, rocker panel, or quarter panel may require removal to gain access to a pillar. Interior trim will also likely require removal.

On some vehicles, to remove the outer C- and D-pillar panel, the roof panel overlaps the outer panel. This requires removal of enough roof panel flange spot welds to gain access to the outer panel, while being careful to not damage the roof panel. The same may be an issue with the B-pillar. In some instances, just a portion of the roof can be lifted to remove the part. In others, the entire roof panel may have to be removed.



Refer to the presentation, "Video: C-Pillar Damage Analysis - Part 1" which shows how to determine if damage extends deep into the vehicle structure.



Refer to the presentation, "Video: C-Pillar Damage Analysis - Part 2" which continues the discussion on analyzing the C-pillar damage on the Chevrolet Malibu.



Refer to the presentation, "Video: C-Pillar Damage Analysis - Part 3" which concludes the discussion by identifying the extent of damage to the C-pillar structure.

Chevrolet Camaro

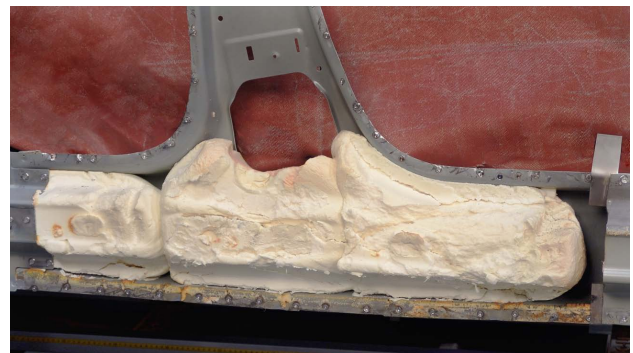


This shows the UHSS rocker panel reinforcement on the Chevrolet Camaro (left). This cross-section of a rocker panel shows the interior reinforcements (right).

The rocker panel:

- may be two-part or multi-part construction. Outer rocker panels are generally part of a uniside. To obtain the rocker panel, it may require ordering an entire uniside.
- has an UHSS reinforcement on most late model vehicles.
- may have multiple reinforcements at the base of the pillars.

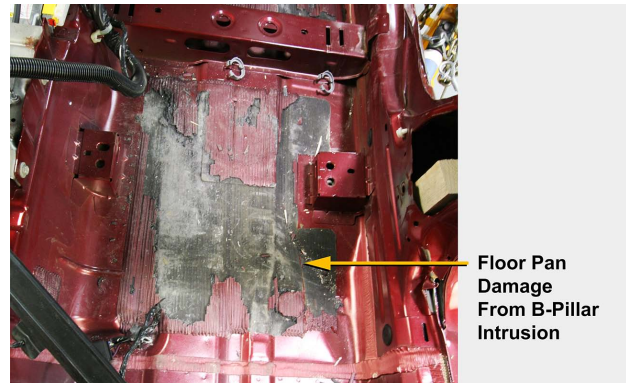
Chrysler 300M



Foam is often used in the rocker panel to reduce road noise.

Considerations for rocker panel repair or replacement procedures include:

- adjacent part removal. Parts that may require removal before repairing or replacing the rocker panel include the doors, fender, quarter panel, and interior trim. On the 2010 Chevrolet Malibu, the quarter panel must be removed to remove and install the rocker panel reinforcement.
- side airbag sensors. Side impact sensors may be located on or near the rocker panel. Side impact sensors are typically replaced after side airbag deployment.
- how it is attached to the floor pan.
- foam. Some rocker panels are filled with foam. Foam that is removed during the repair process should be replaced with the same type and amount of foam. Identifying foam type may be required by the repair technician if not called out by the vehicle maker.
- multiple sectioning locations are often provided for the outer rocker panel and some inner rocker panels. Reinforcement sectioning may be more limited depending on vehicle maker recommendations.
- vehicle makers may recommend to section according to damage.



The floor pan can be damaged from side impacts as the B-pillar pushes inward.

When inspecting floor pans, look for:

- dimensional alignment. Refer to vehicle-specific service information for vehicle dimensions.
- damaged undercoating. It is important that damaged undercoating be replaced to protect underbody parts from corrosion.
- cracked or missing seam sealer. It is important that cracked or missing seam sealer or sound-deadening material be replaced. This is to ensure that parts are protected from corrosion and the sound level of the passenger compartment is maintained.
- damaged carpeting.
- damaged crossmembers. Floor crossmembers may be made of HSS or UHSS and are considered structural.

Some floor pans are attached to cowl panels that are made from laminated steel. Refer to vehicle maker recommendations to determine which joining process

should be used for repairs involving attachment to laminated steel.

Chevrolet Corvette Z06



This shows the floor pan being replaced on a Chevrolet Corvette Z06.

Factors to consider when determining whether to repair or replace floor pans may include:

- part availability. Some vehicle makers provide replacement parts for floor pans. Replacement floor pans may be provided as one-piece or multiple panels.
- replacement procedures. Replacement procedures for front floor pans are typically done at factory seams. Some vehicle makers may provide replacement floor pans, but no procedures. In this situation the insurer, vehicle owner, and repairer need to discuss the considerations to determine how the vehicle should be repaired.
- accessibility. Most vehicles are built starting with the floor pan. The rest of the parts are then installed around it. This makes it difficult to remove a complete floor pan and install a

replacement. This may require an entire unside, the rails, or the roof to be removed to install a replacement floor pan.

- special collision energy management features. For example, the center of the floor pan on the 2009 Volvo S40 is designed with a mini-crashbox that collapses to protect the front occupants. This allows the seats to shift toward the center of the vehicle rather than collapsing. The mini-crashbox should be inspected for deformation when analyzing damage after a side impact. The mini-crashbox is part of the floor pan. The front floor pan is serviced as a replacement part.

Ford F-150 Super Crew



This roof panel is attached to the vehicle structure using laser welds.

Roof panels:

- are generally made from mild steel. However, roof bows may be made from a variety of stronger

materials to help strengthen the upperbody in side impacts.

- may be laser welded, spot welded, or bonded to the roof structure. Roofs that are laser welded by the vehicle maker are often replaced with welds, or a combination of welds and adhesives.
- may be fastened to the roof structure.

Some roof bows are made from UHSS, depending on the vehicle design, to help reduce intrusion during side impacts. For example, the roof bow over the B-pillar on the 2011 Volkswagen Touareg is made from UHSS hot-formed steel. On Touaregs that have the panoramic sliding roof, the glass is surrounded by a tailor-welded reinforcement frame.

When removing the roof, consider that it may require:

- stationary glass removal.
- additional interior trim removal.
- replacement. Undamaged roof panels may not be reusable after they have been removed. So if the roof has to be removed to access exterior panel flanges, a new roof may be required.



Some roofs can buckle from structural damage since the unitized structure can twist and distort body panels.

Roof panels should be inspected for:

- dents.
- separation from the roof bows.
- cracked seam sealer.
- a damaged or torn vinyl roof. Vinyl may be used on full vinyl roofs, landau roofs, convertible tops, or simulated convertible tops.
- damage to antennas.
- finish damage.

Volvo XC90



Roof bows between the B-pillars may be made of UHSS to help limit intrusion. The roof rail may be sectioned to allow adjacent panel attachment.

Considerations for repairs to the roof structure include:

- roof bows may be available separately.
- roof-to-roof rail configurations.
- center bow may be made from UHSS to limit intrusion.

When reinstalling the roof, some vehicles have laser welds or MIG brazing at the roof-to-roof rail seam. Some vehicle makers recommend grinding the laser weld seam for removal and replacing the laser weld seam with adhesive, spot welds, and GMA (MIG) welds where the spot welder will not reach. Audi, Volkswagen, Volvo, and Ford are examples of vehicle makers that recommend this procedure.

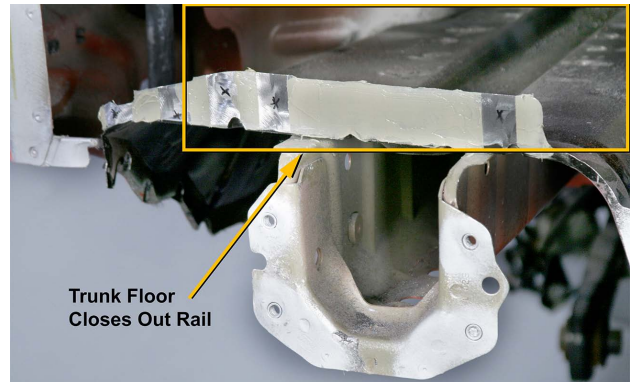
The 2011 Cadillac CTS uses windshield urethane on the roof rail area and GMA (MIG) plug welds on the windshield and backglass flanges.



Refer to the presentation, "Video: Side Impact Damage Analysis" for a video that shows some techniques used to analyze damage from a side impact.

Rear Impact Damage Analysis

Ford Mustang

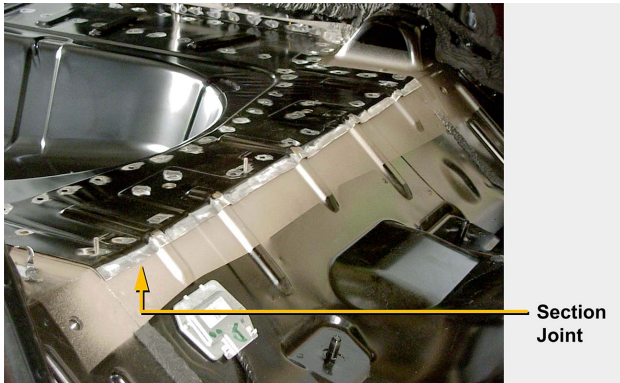


The trunk floor may be used to close out the rear rail, creating a complete rail structure.

Trunk floors:

- are generally single layer mild steel.
- may be part of the rear rail structure in that it contributes to structural integrity of the rail and can affect how the rear rail collapses. For example, trunk floors often close out three-sided rear rail hat channels.
- may be one- or two-piece construction.
- should be inspected for any attaching parts and damage to those parts. The vehicle battery or a CD / DVD carrier may be located in the trunk.

Ford Mustang



Floor pan sectioning may be done on select models depending on vehicle maker recommendations.

When determining possible repair procedures for the trunk floor, note that:

- one-piece construction may be able to be sectioned.
- two-piece construction has a separate trunk floor.
- there may be convolutions and compound shapes to absorb collision energy.

Chrysler Town & Country

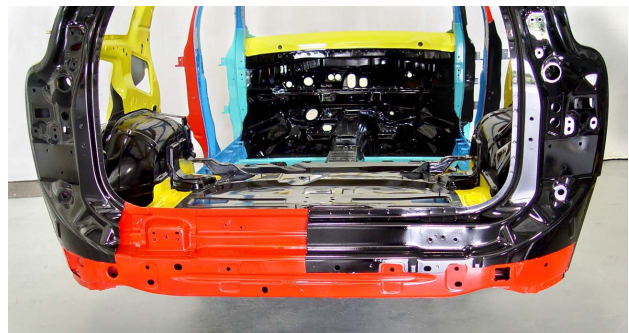


This Stow N' Go tub in the floor is used in the Chrysler Town & Country to hide rear passenger seats.

SUVs and minivans:

- have a rear floor pan instead of a trunk.
- typically have large rear door openings that allow easy access to the rear floor pan. This may reduce the number of adjacent parts that require removal compared to a trunk floor.
- may have storage tubs integrated into the floor. For example, Chrysler minivans have Stow N' Go seating that requires a storage place for the seat when it is folded down. This storage tub is bonded into the floor and, if damaged beyond repair, is replaced with a separate tub that is bonded with urethane adhesive.

Volvo XC90



The rear body panel on the Volvo XC90, here colored red, is made of boron-alloyed steel.

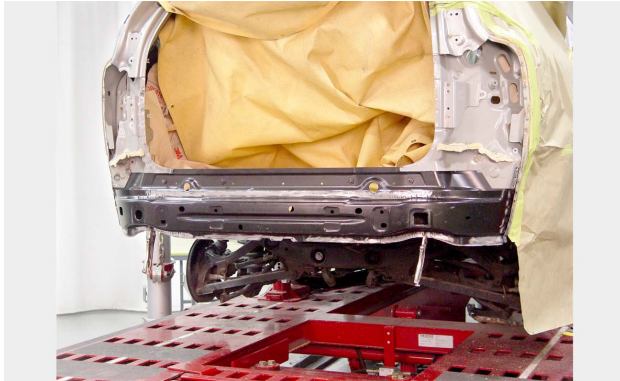
The rear body panel:

- is beneath the deck lid or lift gate and attaches the left and right inner quarter panel structures.
- may be made from multiple steel strengths depending on vehicle design. For example, some Volvo models make rear body panels

out of boron-alloyed steel, while other models, such as the 2011 Volkswagen Jetta, use a mild-strength steel (220 MPa).

- may be made of multiple panels and serviced as an assembly.

Volvo XC90



This rear body panel on the Volvo XC90 was replaced at factory seams.

Repair considerations for the rear body panel include:

- typically replacing the part at factory seams.
- sectioning may be an option depending on the vehicle maker.
- quarter panels may overlap.
- attached with squeeze-type resistance spot welds (STRSW) and / or adhesive.

Chevrolet Malibu



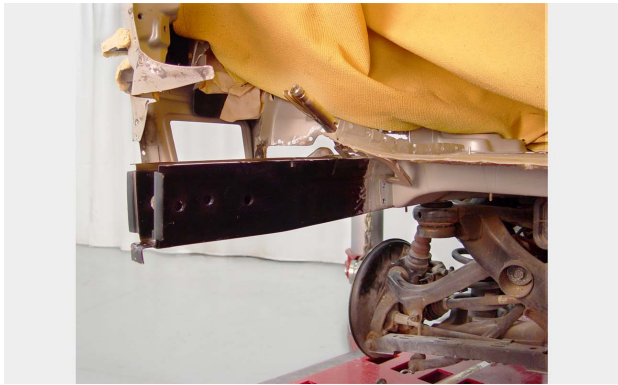
The rear rails on this Chevrolet Malibu allow partial replacement at factory seams.

The rear rails, together with the crossmembers, form the rear underbody structure on a unibody vehicle. The rear rails also support the floor pan and trunk floor.

Rear rails:

- are made from various steel strengths depending on vehicle design.
- may be closed out by rear body panel, floor pan, and bumper bracket.
- may be made from tailor-welded blanks.
- may be available as complete sub-assembly.
- may serve as the attachment point for the trailer hitch.

Volvo XC90



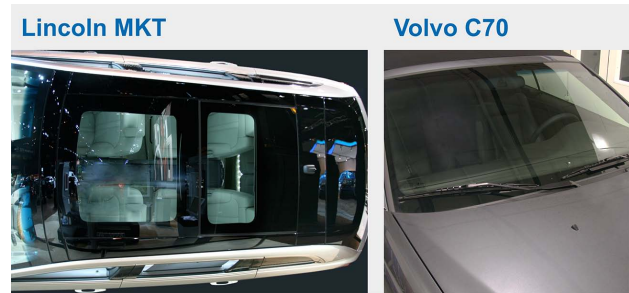
This shows the sectioning location for the rear rail on the Volvo XC90.

When determining rear rail repairability:

- closeout panels limit application of corrosion protection.
- multiple layers may be used at rear torque box areas.
- some rear rails have crush boxes. An example is the 2011 Ford Fiesta. These are designed to bolt on to the rear rails.

Cutting an access window in the trunk floor to assist with straightening, sectioning, or replacing a rear rail if an access window is not specified in the repair procedure is not recommended. Cutting out a section of a part, then rewelding the removed section back on the part is considered sectioning.

Stationary Glass



This shows the windshield on the Volvo C70 (left). This shows the panoramic roof on the Lincoln MKT (right).

Types of stationary glass include:

- windshield.
- backglass.
- panoramic roof glass.
- side glass (quarter glass).

Stationary glass:

- especially the windshield, is part of the vehicle structure.
- contributes to the strength of the roof and the pillars.
- helps manage collision energy. For example, in a front collision, a urethane-bonded windshield helps direct energy around the A-pillars and over the roof, away from the passenger compartment.
- may work with the passenger airbag. The passenger airbag may be designed to deflect off the windshield during deployment. With this type of design, the passenger airbag may be rendered ineffective if the windshield has been installed improperly.

- must be installed properly by following the proper procedures, using the proper materials, and following the specified cure times. This is important for ensuring that the structural integrity of the glass is maintained. Some vehicles may require special urethane adhesive for stationary glass installation.

Installing replacement glass, or re-installing glass that had to be removed for repairs:

- requires following proper procedures and product recommendations.
- should have documentation of the repair for liability purposes.

Toyota Corolla



This glass was damaged from the airbag deflecting off the windshield during deployment.

When checking stationary glass for damage, look for:

- visible damage. This may include cracks, pits, scratches, and leaks. Some types of minor damage are

- repairable as long as the damage is not in the driver's line of sight.
- damage to trim and moldings.
- signs of water leaks. Moisture at the interior seams may indicate hidden damage to the urethane adhesive. Repairing the leak may require removal and reinstallation of the glass. Corrosion on the pinchweld flange is another indication of a water leak.
- delamination of laminated glass. Delamination may appear as white streaks or spots and cannot be repaired. If it is determined that the delamination was pre-existing, it should be communicated to the customer.
- improper previous installation. This may include body filler, topcoats, or seam sealer on the pinchweld flange. Body filler and seam sealer should not be used under urethane adhesive because it creates a weak link in the bonding process. If this is found, remove any body filler or seam sealer, prime the pinchweld, and apply the recommended urethane primer and urethane adhesive. More information on treating a corroded pinchweld can be found in the article "Windshield Pinchweld Corrosion Repair" in the May 28, 2007 issue of the I-CAR Advantage Online.
- damage to the integrated radio antenna.
- damage to the defroster grid. Damaged defroster grids may be repairable.
- damage to the interior side of the glass caused by mass inertia.

If any of these conditions are present, glass replacement may be necessary.

Jeep Wrangler Unlimited



Glass repair depends on the extent and location of damage.

Stationary glass will often require removal when repairing or replacing adjacent panels. Other considerations for repairing or replacing damaged stationary glass include:

- nonconductive adhesive. Nonconductive urethane adhesive is required on some vehicles where there are antenna grids, defroster grids, and other electronic systems integrated into the glass. The bus bars on the side of the glass often contact the adhesive, which draws power and weakens the signal. This is often the case with aluminum pinchwelds. The conducting current also combines with moisture, causing pits and corrosion in the aluminum. Vehicles that require nonconductive adhesive are more common with European vehicles such as BMW, Mercedes-Benz,

and Volkswagen than on domestic and Asian vehicles.

- the type of glass. Repairs to damaged glass may depend on the type of glass. Only some minor scratches can be repaired on tempered glass. Minor repairs are defined as repairs to scratches that cannot be felt with a fingernail. These may be able to be buffed out. Windshields are typically made of laminated glass. Repairs to laminated glass may include "bullseyes," "star breaks," and some small cracks. However, repairs are only possible if the damage is contained to the outer laminate or if the damage is not located in the driver's direct view.
- fire damage. Stationary glass that has been exposed to fire may require replacement. Excessive heat may weaken the urethane adhesive that holds the glass in place. The inner plastic laminate may also be weakened when exposed to excessive heat. Delamination may cause large pieces of glass to come loose and injure the occupants during another collision. Cracks or warpage of the glass may indicate that it has been exposed to excessive heat.

Volvo XC60



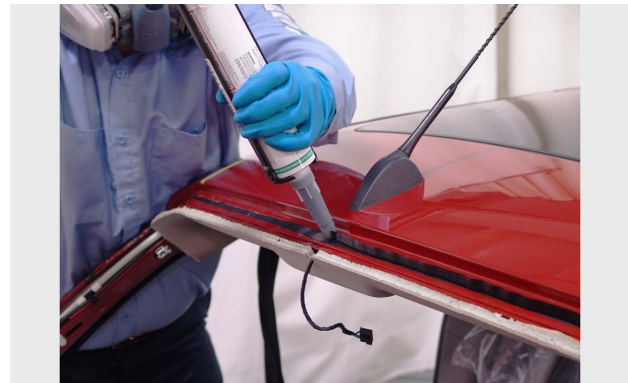
The label, or bug, on the glass will provide an indication on what type of glass needs to be installed (left). Vehicle options may dictate what type of glass should be installed (right).

Not all windshields are the same for each model of vehicle. This requires paying specific attention to the vehicle options when determining which type of glass to order. Options that may affect which windshield is ordered include:

- head-up displays (HUD). Vehicles equipped with HUD may require a special type of windshield. Installing the wrong type of windshield may result in a double or distorted HUD image. A glass surface on top of the dash panel or labeled switches and controls may be indications that the vehicle is equipped with a HUD.
- an acoustic windshield. This type of windshield is used on the 2011 Honda Odyssey to help reduce the amount of wind noise.
- a rain detection sensor.
- a lane departure warning sensor.
- attention assist.
- window tint. It may be required to identify between aftermarket and factory tinting.
- a heated windshield.
- heated wipers.

Each of these systems may require a unique windshield design to accommodate the vehicle options. This may include glass construction or frit design. The frit is the black band around the perimeter of the stationary glass. The frit helps prevent ultraviolet rays from deteriorating the urethane adhesive.

Chevrolet HHR



Urethane glass adhesive is being applied to the pinchweld on this Chevrolet HHR.

Glass replacement is often a sublet operation that is done by professional glass installers. Following installation, the vehicle must sit stationary while the glass adhesive cures. The adhesive must reach full strength before it is allowed to leave the repair facility. This ensures the integrity of the upper structure in the event of a rollover, and may be used to deflect passenger side airbags during a deployment.

This amount of time depends on the temperature and humidity levels, but generally takes several hours. This is important to note when informing the customer on when they can expect their vehicle repairs to be complete.



Refer to the presentation, "Video: Laminated Glass Damage Analysis - Part 1" that raises a question about whether specific damage to the vehicle windshield is repairable.



Refer to the presentation, "Video: Laminated Glass Damage Analysis - Part 2" which provides the answer about whether damage to the windshield is repairable.

Body-Over-Frame Vehicles

Jeep Wrangler

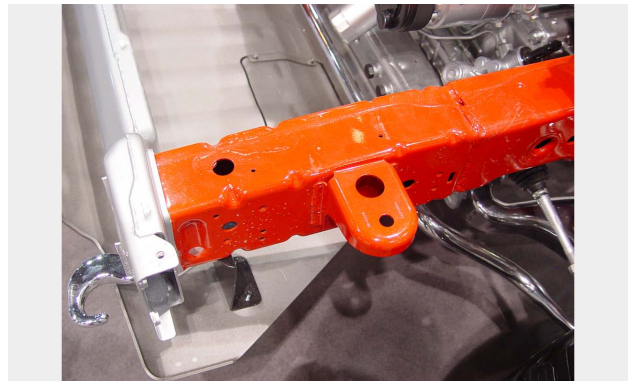


This is the complete frame for a Jeep Wrangler.

Vehicle frames are:

- designed to manage collision energy.
- made of mild steel, HSS, and / or UHSS.

Nissan Titan



Notice the dimpled crush initiators on the front rail of the Nissan Titan.

Collision energy management principles for frames is similar to a unibody structure in that the frame has:

- collapse and crush zones in the front rails.
- kickup or offset areas.
- elongated holes or slots.
- varying part shape.
- reinforcements or lateral stiffeners.

Each of these allows the frame to deform at specific locations to absorb or transfer collision energy.



Bends, such as this, may not be repairable due to the thickness and strength of the metal (left). Stress cracks such as this may be repaired depending on how they were formed (right).

When inspecting the frame, check for:

- bends in the structure. Depending on the thickness and strength of the metal, bends may or may not be repairable. Heat use when straightening bends is generally limited.
- kinks, which are not repairable.
- cracks. These may be repairable, but are limited to stress cracks. This may require welding a reinforcement on the front or backside of the crack. When repairing cracks in a frame, reinforcements should NOT be used in collapse zones.

Frame cracks that should not be repaired include those:

- near the steering box area.
- near a suspension mounting area.
- on the top or bottom flange on a frame with an open C-channel design.
- caused by straightening an area that was previously kinked.

Damage related to trailer hitches is a common occurrence on full-frames. Often the impact pushes the frame downward, bending at a point near the end of the trailer hitch.



Crossmembers with this type of damage are replaced.

Other items that must be inspected on full-frames include:

- damaged cab mounts. Inspect the cab mounts for damage due to inertia.
- bent crossmembers. Generally, damaged crossmembers are not a serviceable part unless they are part of an assembly. However, Toyota has many vehicles where

crossmembers are a serviceable part.

- control arm / suspension mounting brackets. These are difficult to straighten while ensuring that they do not deform due to repeated stress. Depending on replacement recommendations, parts may be available, or the frame or frame section may need to be replaced.
- steering mounting brackets.

Damaged bumper mounting brackets should not be straightened. These are usually replaced using a bolt-on replacement bracket.

Ford Expedition



Some vehicle makers have front or rear frame modules that can be replaced if damaged.

Partial replacement at factory seams may be done on full-frames depending on vehicle maker recommendations. Pieces of the frame that are often replaced may include:

- frame rail ends that are designed to crush in a frontal collision.
- a crush box, also designed to crush in a frontal collision. Crush boxes are sacrificial parts designed to collapse, preventing damage

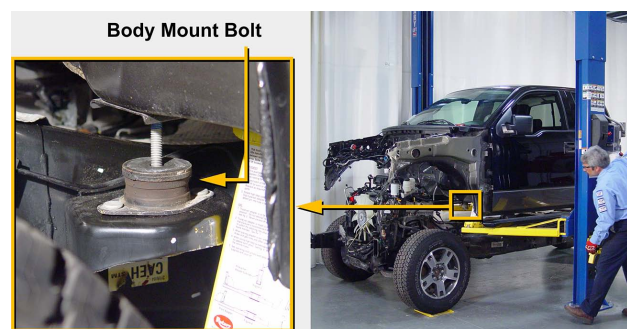
from radiating deeper into the structure.

- front or rear frame modules. For example, the 2011 Chevrolet Silverado has a replacement rear frame assembly service part available. The procedure uses a factory seam for rear module replacement.

Examples of sectioning or partial replacement on full-frames include:

- the front rail end on the 2011 Ford Expedition, and the 2011 Ford Crown Victoria / Lincoln Town Car.
- a sectioning procedure behind the front crossmember on the 2007 Ford F-250 and F-350.
- a frame sectioning procedure for the 2011 Cadillac Escalade. The procedure includes the front 400 mm of the frame rail, which includes the front crossmember.

Ford F-150



This is a body mount used to bolt the unitized structure to the frame (left). This is a unitized structure being lowered onto a repaired frame assembly (right).

The unitized structure that is bolted to the frame is repaired similar to a unibody vehicle. Pillars, rocker panels, and front upper rails must be repaired according to the vehicle service information, taking into consideration the different types of construction materials and part design.

When analyzing the damage:

- note that damage, similar to the unibody structure, can transfer energy and damage to areas away from the direct impact.
- distortions to the frame can also cause stresses to the unitized structure. Sometimes, when the frame is returned to factory dimensions, the stress on the attached unitized structure is relieved and the measurements return to specification, however, it is important to monitor both upperbody and frame dimensions at the same time.

Ford F-150



Inconsistent cab-to-bed gaps may be a visual indication of frame damage.

On full-frame vehicles, the frame assembly may not have visual damage, but there are several indicators that structural damage has occurred, including:

- shifted body mounts. The radiator core support on a full-frame vehicle is generally bolted to the frame assembly. It is common for the radiator core support to slide during a frontal impact, causing the hood-to-fender gaps to be inconsistent. Generally, the gap will be tight on one side and wide on the other.
- panel misalignment. An indicator of a diamond condition is inconsistent gaps between the cab and the truck bed on a pickup truck. One side will generally be wider than the other side.
- wheel position in the wheel opening.

When repairing full-frame vehicles, the frame is often pulled separately from the unitized structure. This requires removing the cab mount bolts to allow the two structures to move independently.

Module Wrap-Up

Topics that were covered in this module included:

- general repair considerations for structural parts.
- front structural parts and common techniques for analyzing damage from front impacts.

- side structural parts and common techniques for analyzing damage from side impacts.
- rear structural parts and common techniques for analyzing damage from rear impacts.
- specific damage to determine if structural glass should be repaired or replaced.
- common types of damage that can occur to body-over-frame vehicles and determining if it can be repaired.