



## Audi TT Coupé '07 - Body

Self-Study Programme 383

## Audi-Space-Frame ASF® of the Audi TT Coupé

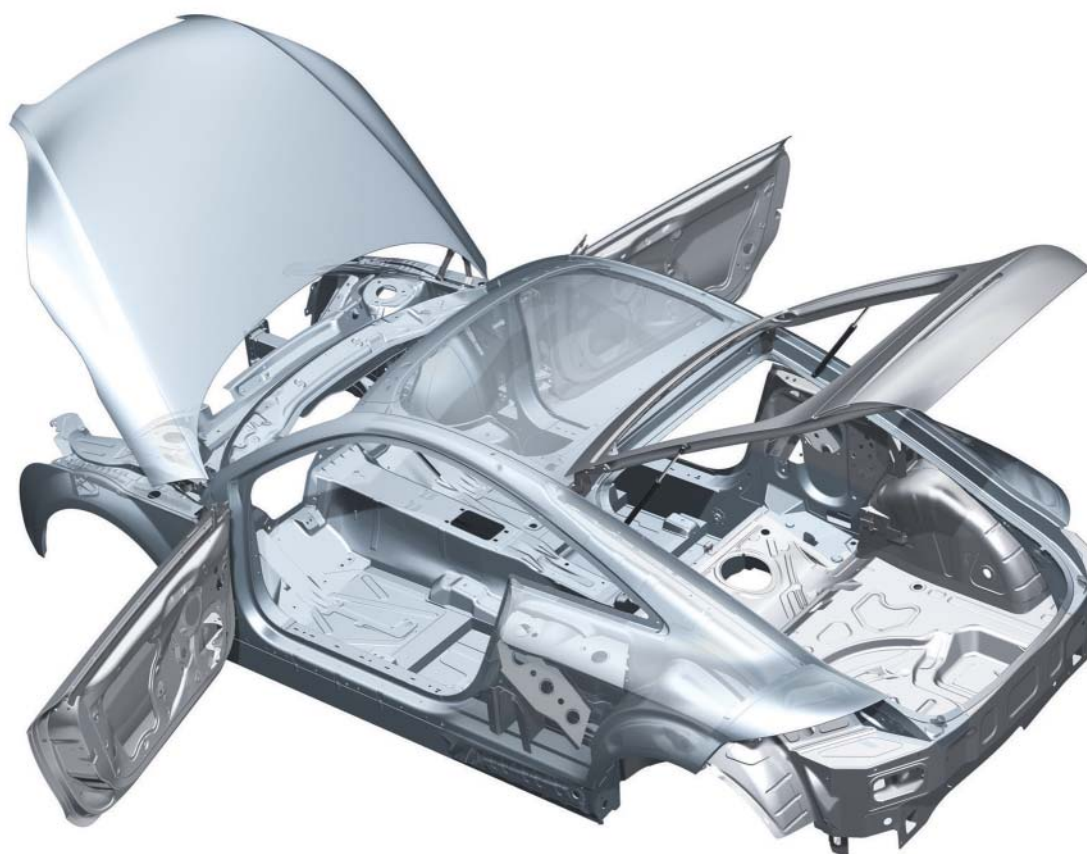
### The development targets for the bodyshell of the Audi TT

With a weight advantage of 48 % over a comparable all-steel bodyshell, in addition to an optimised weight distribution, the new composite aluminium-steel spaceframe body of the Audi TT marks yet another milestone in the development of modern Audi bodyshells.

Crash safety of the bodyshell is enhanced by means of load-bearing structures at the front end, sides and rear end, with a heavy emphasis on pedestrian safety.

To ensure efficient volume bodyshell production, various new joining and production techniques are employed.

The repair concept is based heavily on the well-known aluminium repair concept. However, of course, the materials combination of aluminium and steel necessitated that new approaches be taken.



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## Electromechanical rear spoiler

The self-study programme teaches the design and function of new vehicle models, new automotive parts or new technologies.

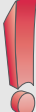
**The self-study programme is not a repair manual!**  
**All values given are intended as a guideline only and refer to the software version valid at the time of preparation of the SSP.**

For maintenance and repair work, always refer to the current technical literature.

Reference

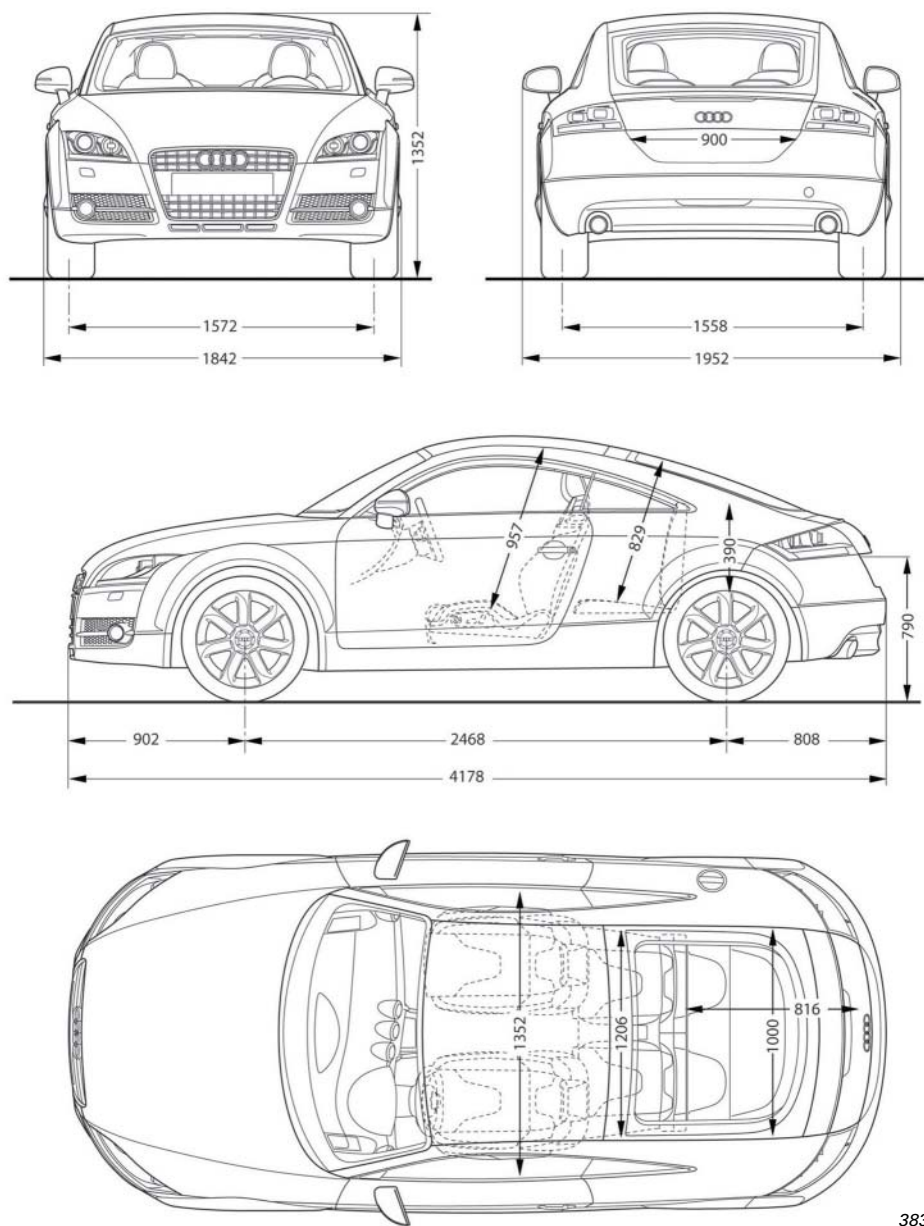


Note



# Audi Space Frame of the Audi TT

## Dimensions



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### Audi TT Coupé ' 07

### 2,0

### 3,2 quattro

	2,0		3,2 quattro	
Transmission	Manual gearbox	S tronic	Manual gearbox	S tronic
Kerb weight without driver in kg	1260	1280	1410	1430
Max. perm. gross weight in kg	1660	1680	1810	1830
cw (rear spoiler extended)	0.3		0.3	0.31
Boot capacity in l	290 (700*)		290 (700*)	
Max. power output in kW	147 (200 bhp)		184 (250 bhp)	
vmax in kph	240		250	
Acceleration 0-100 kph in s	6.6	6.4	5.9	5.7
Fuel consumption in l/100 km	7.7	7.7	10.3	9.4

\* with the rear-seat back folded forward

# Technological concept

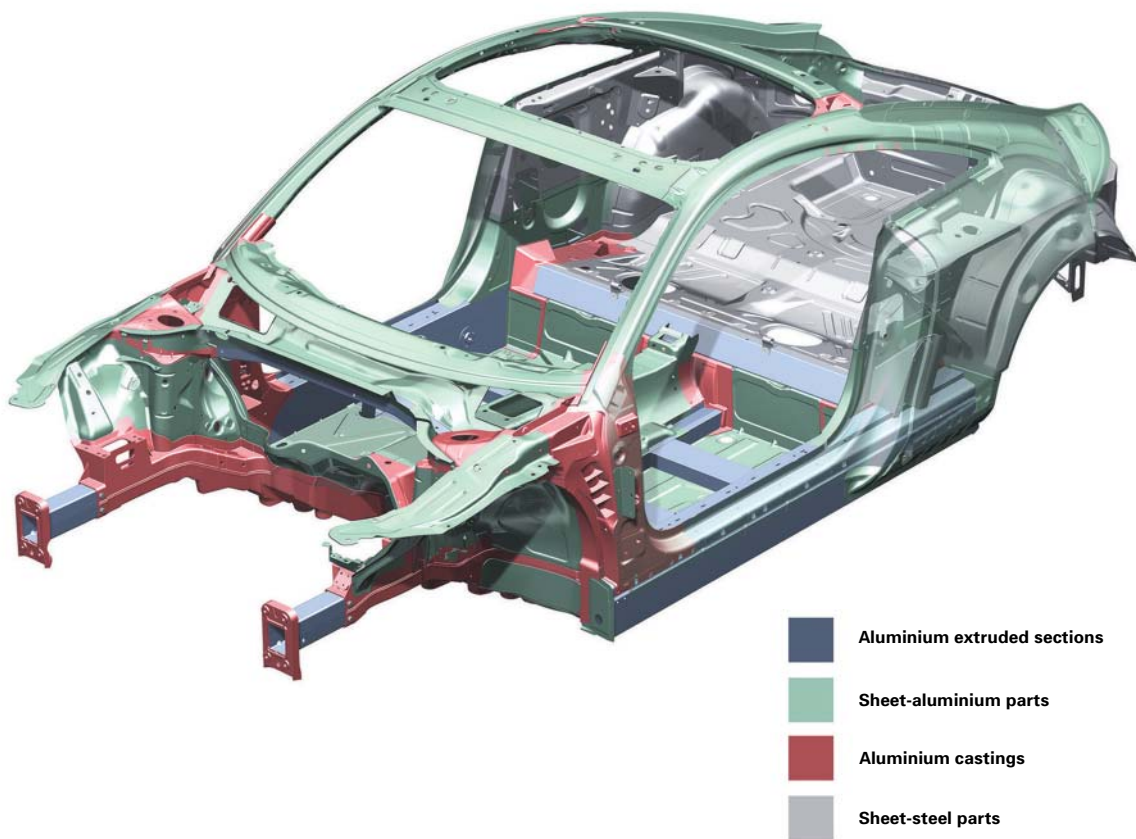
Sheet-steel parts are used for the first time in the ASF of the new Audi TT in addition to aluminium castings, aluminium extruded sections and aluminium sheet-metal parts. Collectively, they make up the body structure. Vehicle weight distribution has been optimised by using sheet-steel parts in the rear body section. This has a direct bearing on sporting characteristics, such as driving dynamics and acceleration as well as safety characteristics, such as stopping distance and driving stability. In spite of the partial use of sheet-steel parts, the total body weight of 277 kg, including attachments such as doors and lids, is considerably less than that of a comparable all-steel body.

Although the new TT has grown in size, the gross weight of the vehicle has been reduced through the use of the aluminium-steel bodyshell.

The body structure of the new Audi TT has higher strength and 50 % higher torsional rigidity than its predecessor.



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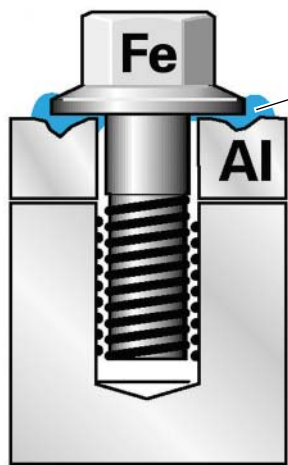
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## Contact corrosion

Aluminium has a passivating oxide surface layer which protects the material underneath from corrosion. This is why an unpainted aluminium part normally does not corrode.

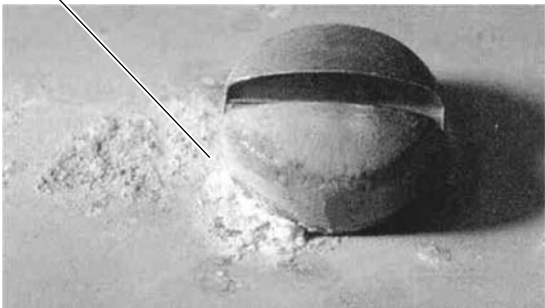
However, if there is contact between aluminium and a metal higher up in the electrochemical series than aluminium and if an electrolyte, such as salt water, is present in this region, contact corrosion will occur.

The greater the difference in potential, the greater the contact corrosion. As aluminium is normally the lesser noble metal, it degrades.



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Contact corrosion



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Schematic of contact corrosion with example

Contact corrosion can only be prevented by taking measures to stop the flow of electrical current induced by the potential difference between the two metals. This is best achieved by painting the surfaces. However, the risk of corrosion is high even if a tiny amount of paint damage occurs.

In the case of the Audi TT, the following anti-corrosion measures have been taken:

- coating of all steel screws and fasteners such as self-piercing rivets
- Galvanising of all sheet-metal parts (zinc and aluminium have a smaller potential difference than steel and aluminium)
- Insulation by means of adhesive
- Sealing of aluminium-steel joints

### Reference



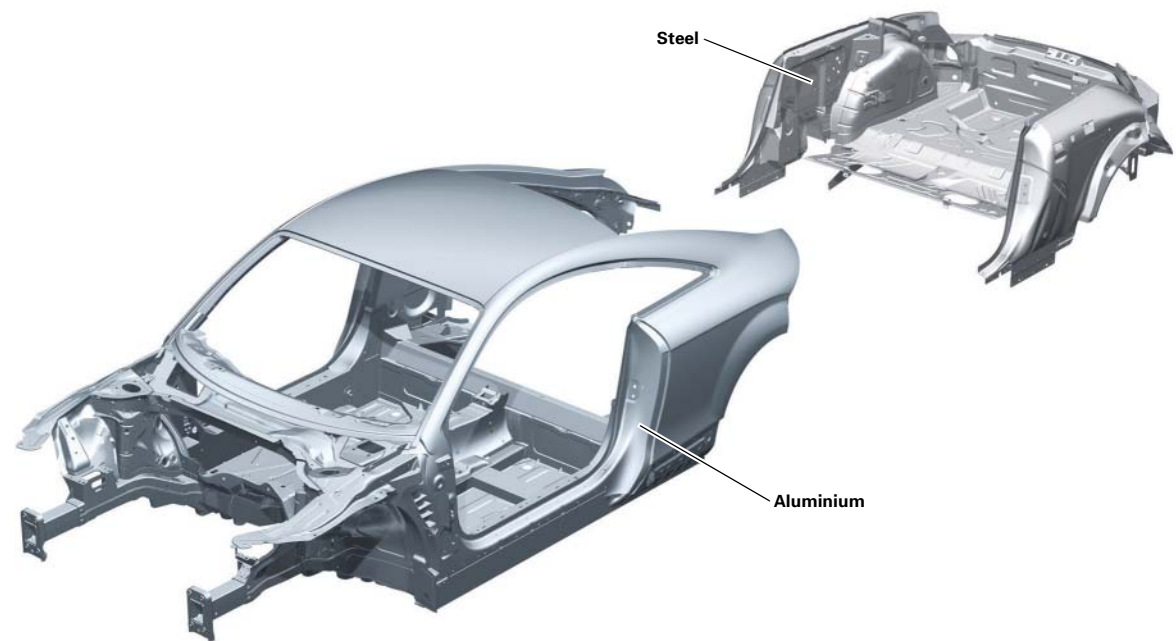
For detailed information on contact corrosion, please refer to Self-Study Programme 239 "Audi A2 - Body" .



# Joining steel and aluminium

One of the challenges for the development of the Audi TT bodyshell was the attachment of the sheet-steel rear-end parts to the aluminium body assemblies.

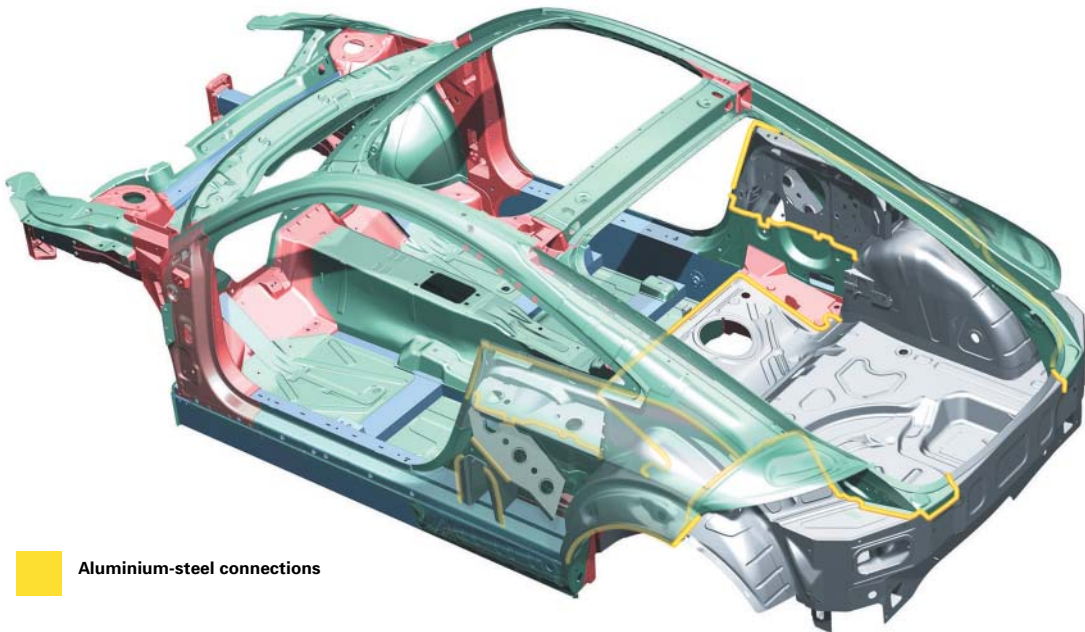
Thermal joining processes such as MIG welding can be ruled out because it is not possible by these means to make a joint which has the requisite structural and dynamic strength and will not result in contact corrosion.



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Audi

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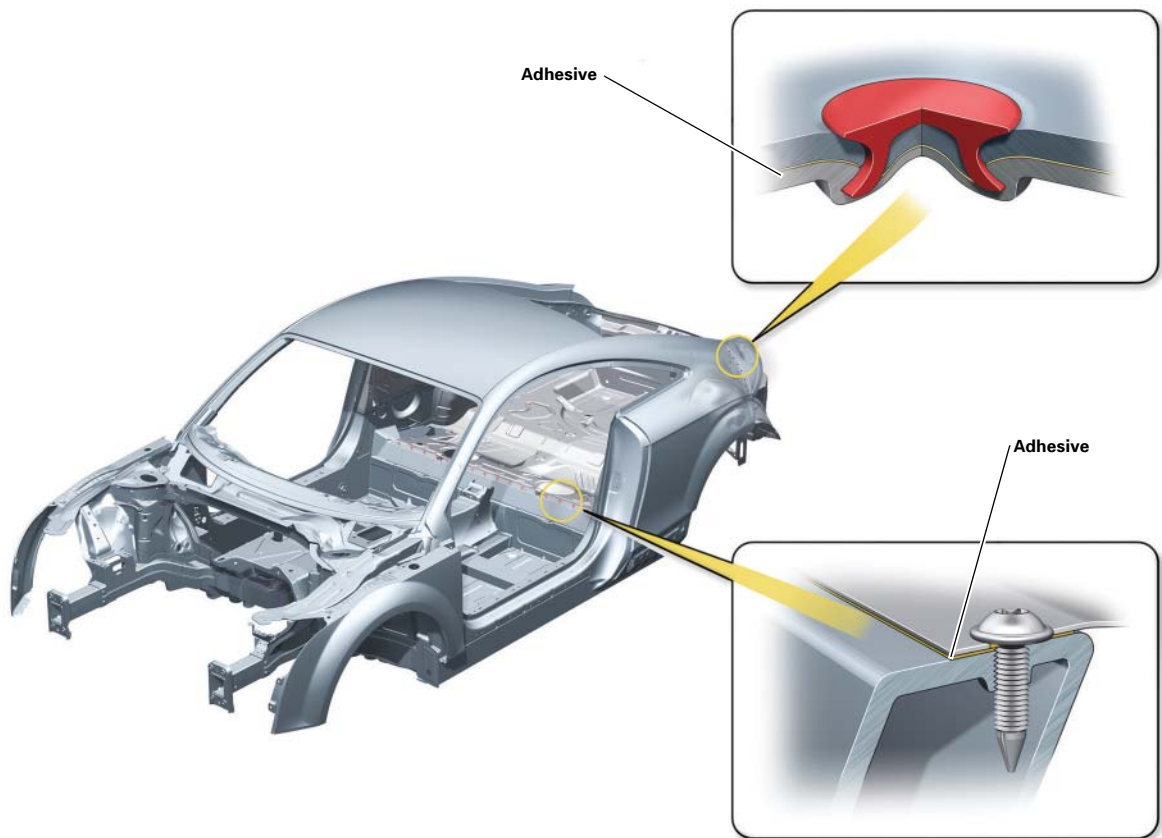


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# Audi Space Frame of the Audi TT

Special requirements are made with regard to the strength and corrosion protection of the joints between aluminium body parts and steel parts.

This is ensured by non-thermal joining of parts using coated self-piercing rivets and special screws in combination with bonding.



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Aluminium and steel joints with faulty corrosion protection can exhibit much higher corrosion rates than all-aluminium joints or all-steel joints. When making aluminium-steel joints, therefore, highest standards of quality must be maintained at all times during the production process and in the service workshop.

Adhesive bonding is the basis for the corrosion protection of corrosion-susceptible aluminium/galvanised steel joints in the bodysell of the Audi TT. In this way, the mating materials are superficially insulated, thus suppressing corrosion processes at the point of contact. As a further measure, all composite joints either sealed with PVC or coated with wax preservative after the cathaphoretic dip coating (KTL) process.



This illustration shows clearly what effects contact corrosion can have if adequate corrosion protection is not provided. At this joint, the flange was sealed in the bodyshell without using adhesive.

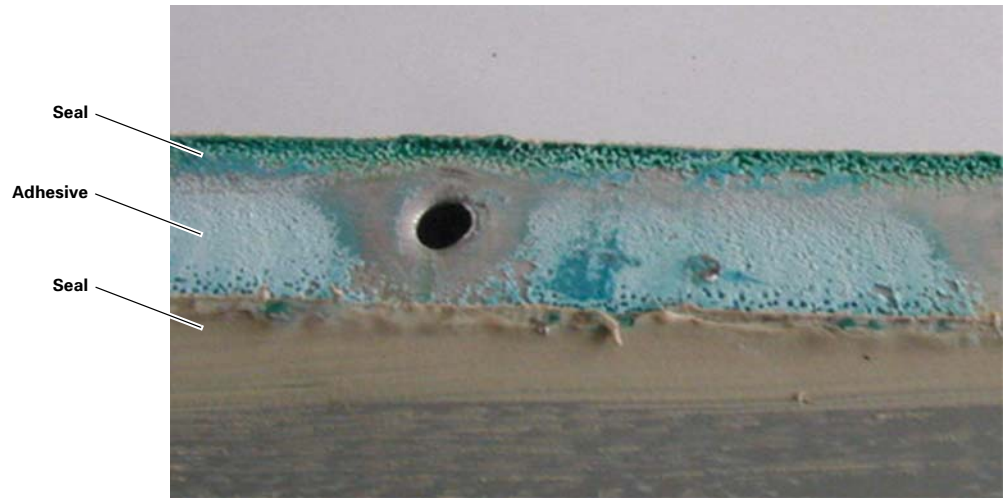
The aluminium sheet shown here exhibits severe contact corrosion, which has resulted in mechanical failure of the punch riveted joint.



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By way of a comparison, this illustration shows the same flange with an adhesive bond and sealing.

In this case, the aluminium sheet showed no damage due to contact corrosion after exposure to identical environmental conditions.



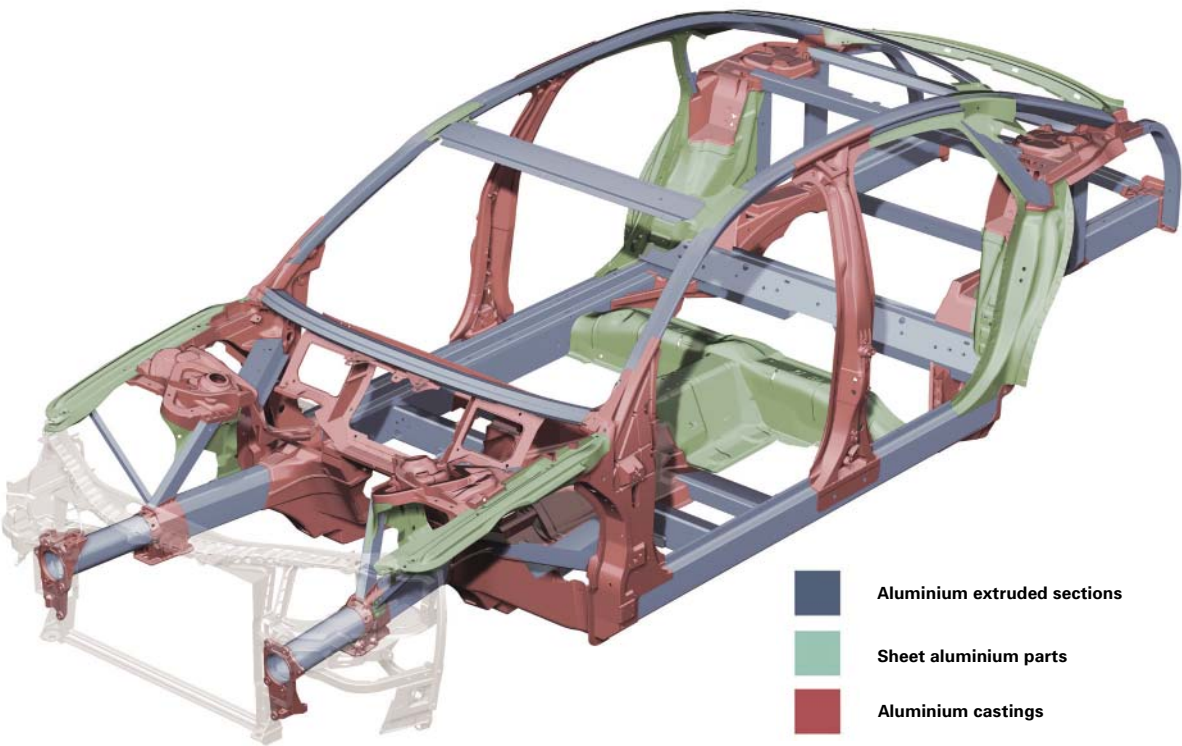
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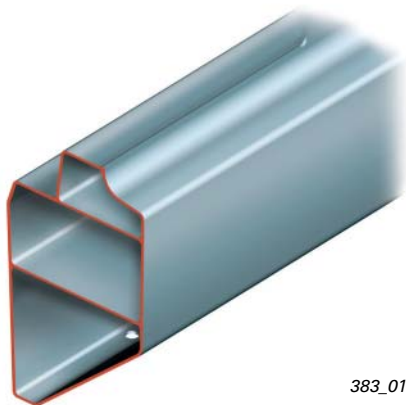
# Audi Space Frame of the Audi TT

## Comparison of ASF concepts

Audi A8 (2003 →)



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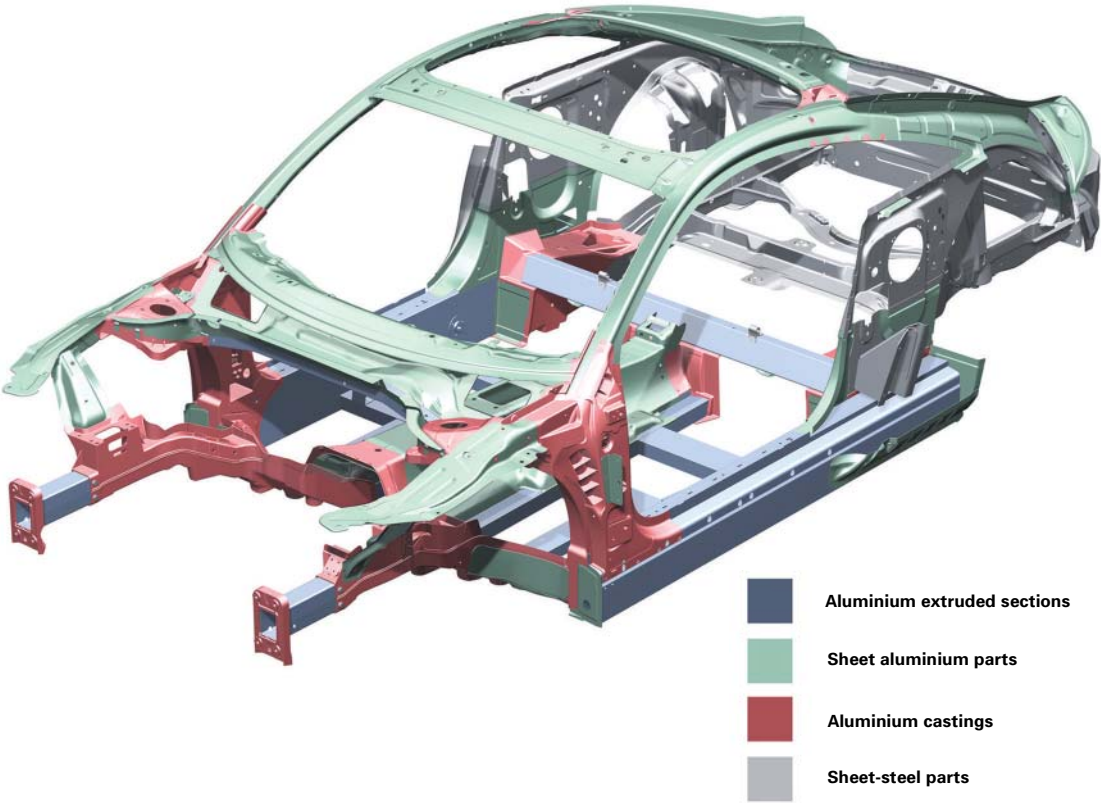
Sill section Audi A8  
Three-chamber extruded section



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A-post, Audi A8  
Single-chamber extruded section

Audi TT (2006 →)



- Aluminium extruded sections
- Sheet aluminium parts
- Aluminium castings
- Sheet-steel parts

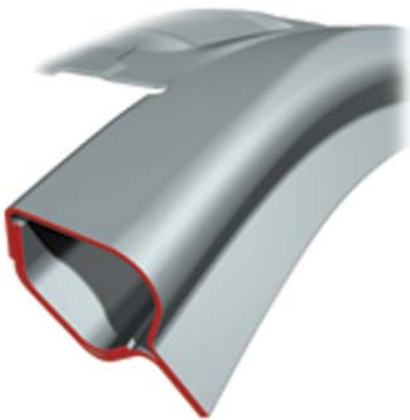
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Sill section, Audi TT  
Four-chamber extruded section

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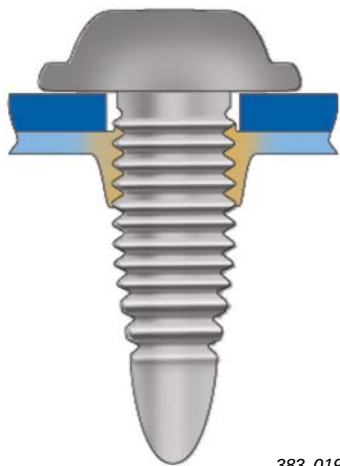


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A-post, Audi TT  
Sheet-aluminium sections (interior/exterior)

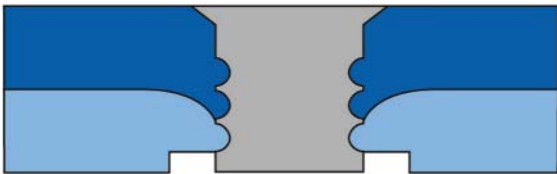
## Overview

In addition to well-known processes such as MIG welding or punch riveting, the joining techniques of Flow Drill screwing and Kerb-taper riveting are used for the first time on the Audi TT. In the production process, a laser cleaning method is used for cleaning before the roof drip moulding is attached by welding.



Flow-Drill screw connection

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Riveted joint

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Clean Laser

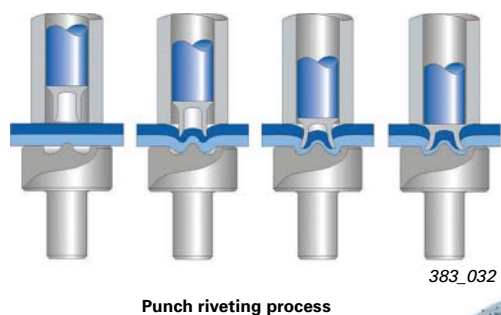
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Technology	Process	Quantity per vehicle
Mechanical joining techniques	Punch riveting Flow Drill screwing Solid punch riveting (Kerb-Konus) Clinching	1615 pce. 229 pce. 96 pce. 164 pce.
Thermal joining techniques	MIG welding Laser welding Resistance spot welding MAG welding Stud welding	21462 mm 5309 mm 1287 spots 809 mm 234 pce.
Bonding technology	Bonding	97156 mm
Machining technology	Milling Drilling Thread cutting Brushing Roll seaming Clean lasering	188 mm 16 pce. 8 pce. 2300 mm 26737 mm 4000 mm



## Punch riveting

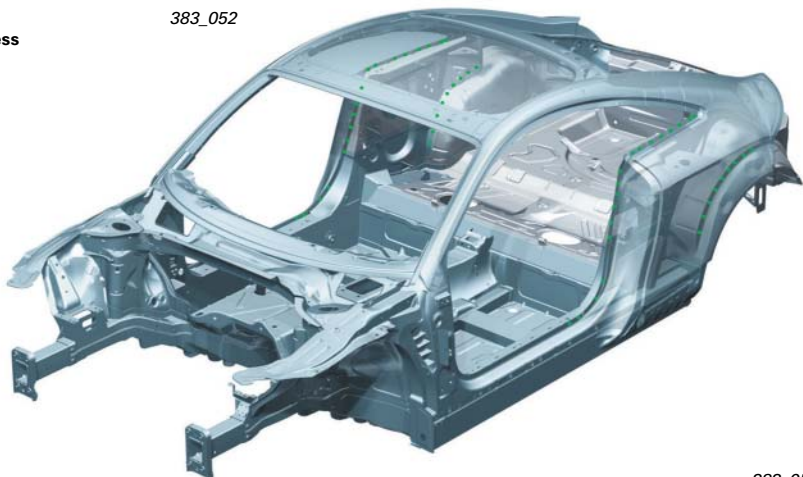
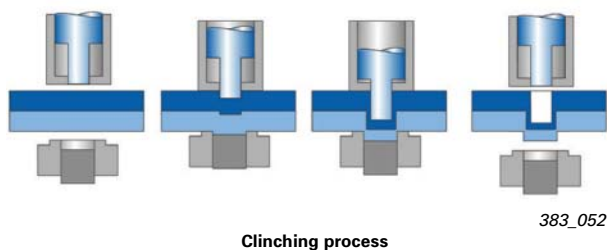
Punch riveting is one of the principal joining techniques used on the bodyshell of the new Audi TT. This technique is used for joining aluminium body parts and for joining aluminium body parts to steel body parts. The process has been in use since launch of the Audi A2. Self piercing rivets with two different diameters and lengths are used in the Audi TT.



Applications of punch riveting

## Clinching

With clinching, the metal sheets to be joined are clamped between a die and a blankholder. The sheets are then pushed down into the die by a punch to form an interlocking joint. However, joints produced in this way is not as strong as joints produced by punch riveting, for example. In the Audi TT, this technology is used on attachments such as doors and lids. Several clinched joints are also located in the area of the B-post and rear wheel arch. In this area, aluminium sheets as well as steel and aluminium sheets are clinched together.

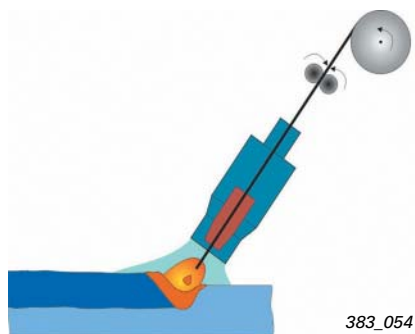


Applications of clinching



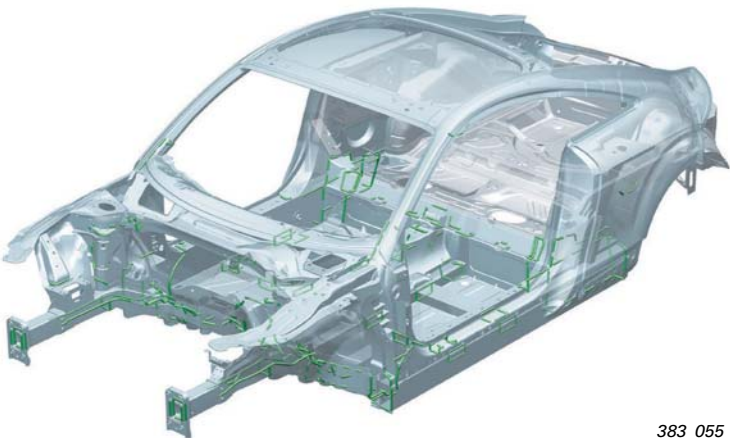
## MIG welding

Aluminium parts have largely been joined by means of metal inert gas welding since the launch of the Audi aluminium bodyshell in the Audi A8 (1994) . This technique is principally used to make joints between castings and extruded sections, as well as sheet-metal parts. This joining technique is notable for producing high-strength joints, but it introduces a great deal of heat into the joint and has a relatively slow process speed.



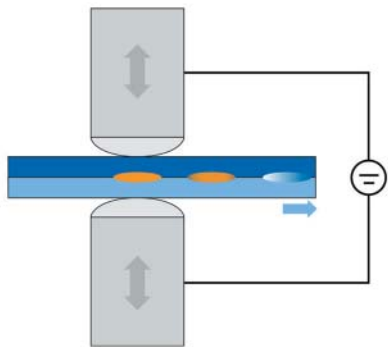
MIG welding process

Applications of MIG welding



## Resistance spot welding and MAG welding

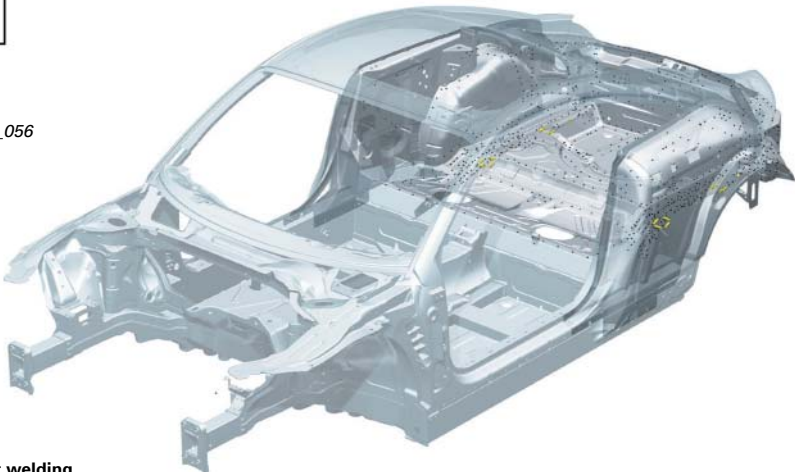
The usual techniques of resistance spot welding and, to a lesser extent, metal active gas welding (MAG welding) are used for joining sheet steel body parts in steel body manufacturing.



Resistance spot welding process

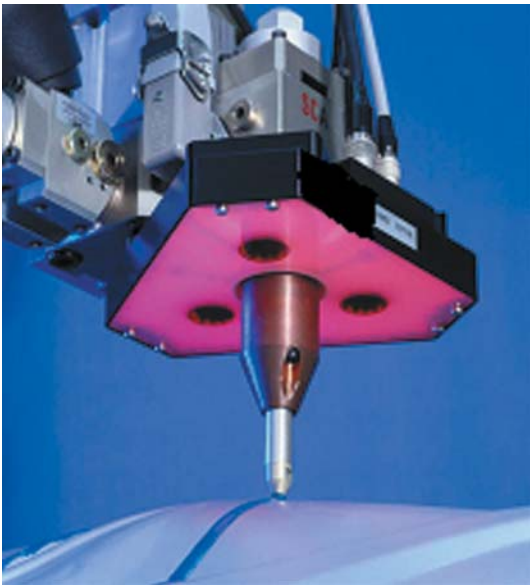
Applications of MAG welding

Applications of resistance spot welding



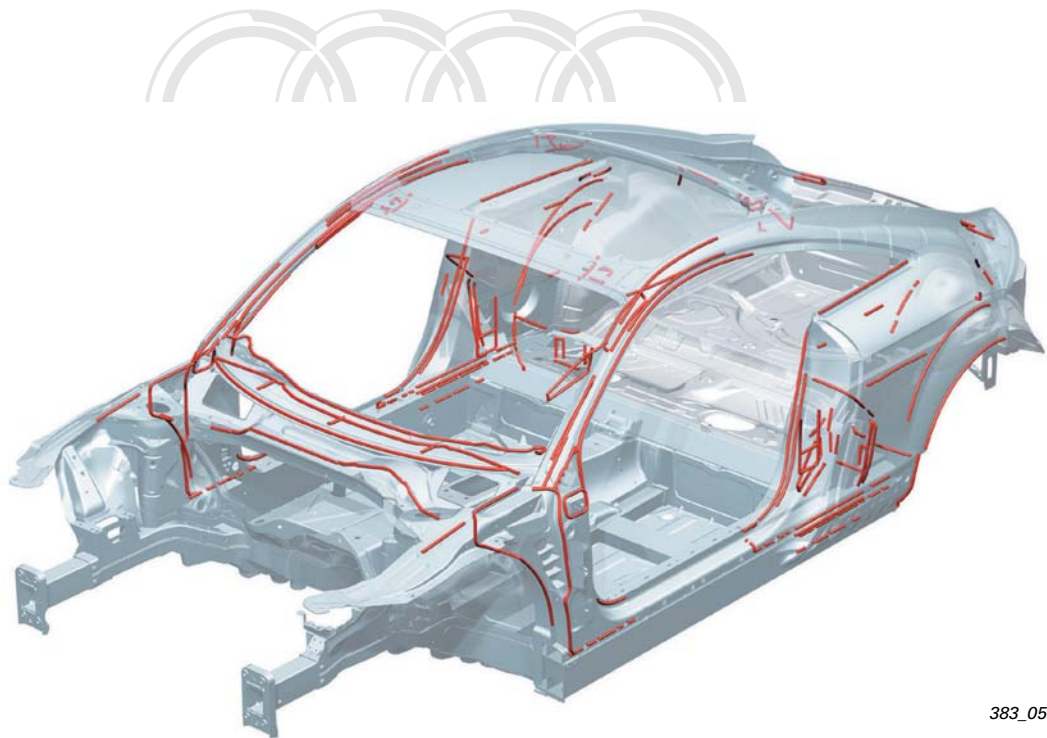
# Structural bonding

In certain areas, adhesive bonding is used supplementary to clinched joints and punch riveted joints, solid punch riveted joints, Flow Drill screw connections and resistance spot welds. This improves joint strength. Adhesive bonding is also used for strengthening of seam joints, e.g. in the rear wheel arch. In other areas of the body, adhesive beads are used for sealing and insulation between aluminium and steel sheets, as well as for noise reduction.



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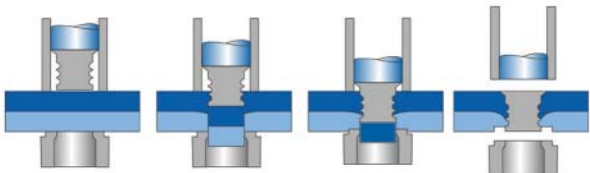
Structural bonding process in production



383\_059

## New joining technique: solid punch riveting (Kerb-Konus riveting)

Solid punch riveting or Kerb-Konus riveting involves the use of aluminium or coated stainless steel rivets. In contrast to punch riveting, the rivet is punched through both sheets to be joined. Unlike steel rivets, aluminium solid punch rivets can be reworked mechanically. This is the case with the joint between the body side section and the drip moulding. However, the strength of solid punch riveted joints is inferior to that of punch riveted joints.



Solid punch riveting process

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Solid punch riveting process in production

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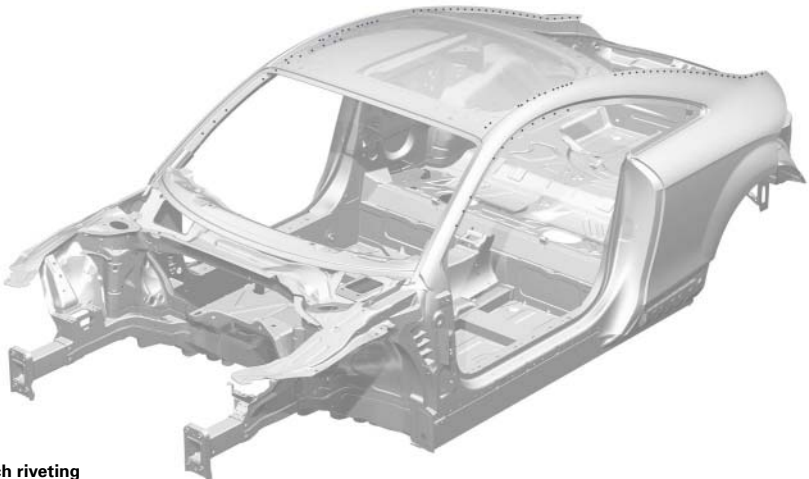
Micrograph of a solid punch riveted joint

383\_073

### Information on the repair concept

Aluminium solid punch rivets are used in the C-post drip moulding area, while coated stainless steel solid punch rivets are used in the region of the roof frame. Stainless steel rivets must not be drilled out or ground, due to the risk of corrosion.

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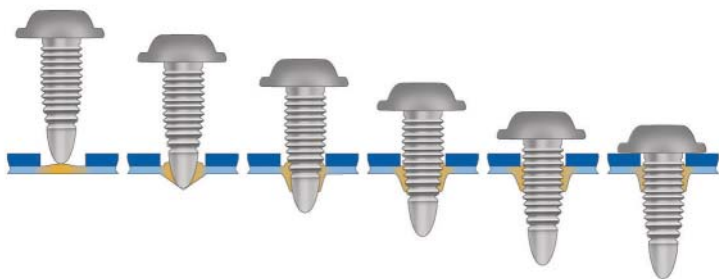


Applications of solid punch riveting

383\_048

# New joining technique: Flow Drill screwing

Automatic direct screwing enables joints to be made between any materials, even if these materials can be accessed from one side only. A special coated screw is driven under high surface pressure through a hole in the outer part to be joined. The lower part is not predrilled. The pressure and rotational speed soften the material and allow the screw to be inserted.



Flow Drill screwing process

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383\_063

Screwing process in production



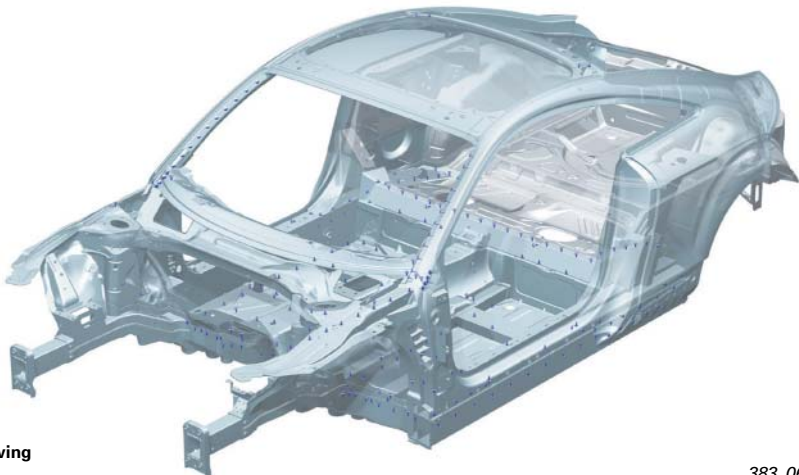
383\_074

Micrograph of a Flow Drill screw connection

## Information on the repair concept

Flow Drill screws can be removed in the service workshop and replaced with new screws. In case of thread damage, screws are also available in oversize (M6 instead of M5) . For use in new parts, it may be necessary to predrill the material.

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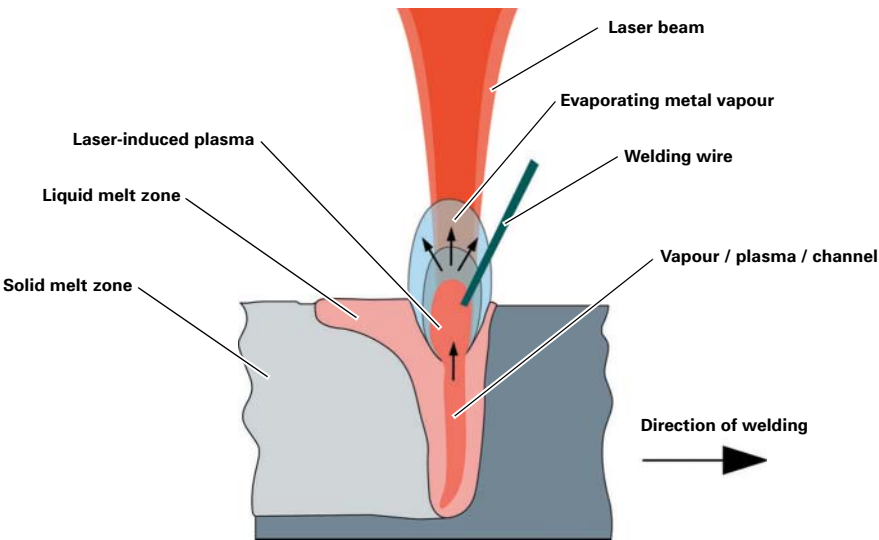
Applications of Flow Drill screwing

383\_064



## New joining technique: aluminium laser welding (invisible roof seam)

Laser welding has been used for joining aluminium body parts since the launch of the Audi A2. In most cases, sheet-metal parts are welded onto castings or extruded parts. The invisible joint in the roof area is joined using a new joining technique: laser welding.



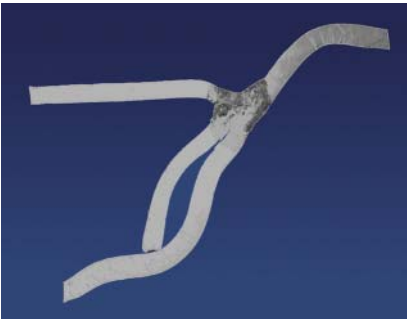
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Laser welding process in production



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Micrograph of the roof frame and roof panel joint



Applications of laser beam welding  
Invisible roof seam



Applications of laser beam welding

383\_067



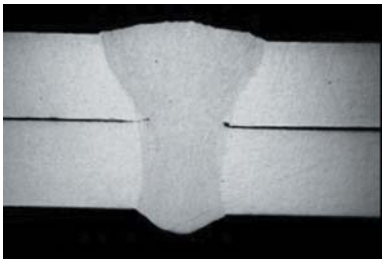
To ensure consistent laser welding of aluminium parts, the parts to be welded must have a perfectly clean surface. This is achieved either by washing the component parts followed by chemical pickling or by using the new Laser Clean process.

A controlled laser beam removes all residues from the surface by heating it for a short time. Parts cleaned using this method can be directly laser-welded.

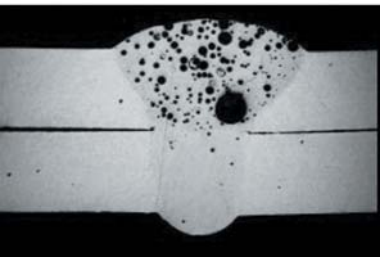


383\_068

Laser Clean process in production



383\_069



383\_075

Micrograph of a laser-welded seam with Laser Clean (above) and without cleaning (below)

The joint between the roof frame and roof panel is reworked and surface finished automatically in the production line by means of a brushing process.



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Brushing process in production



383\_071



383\_072

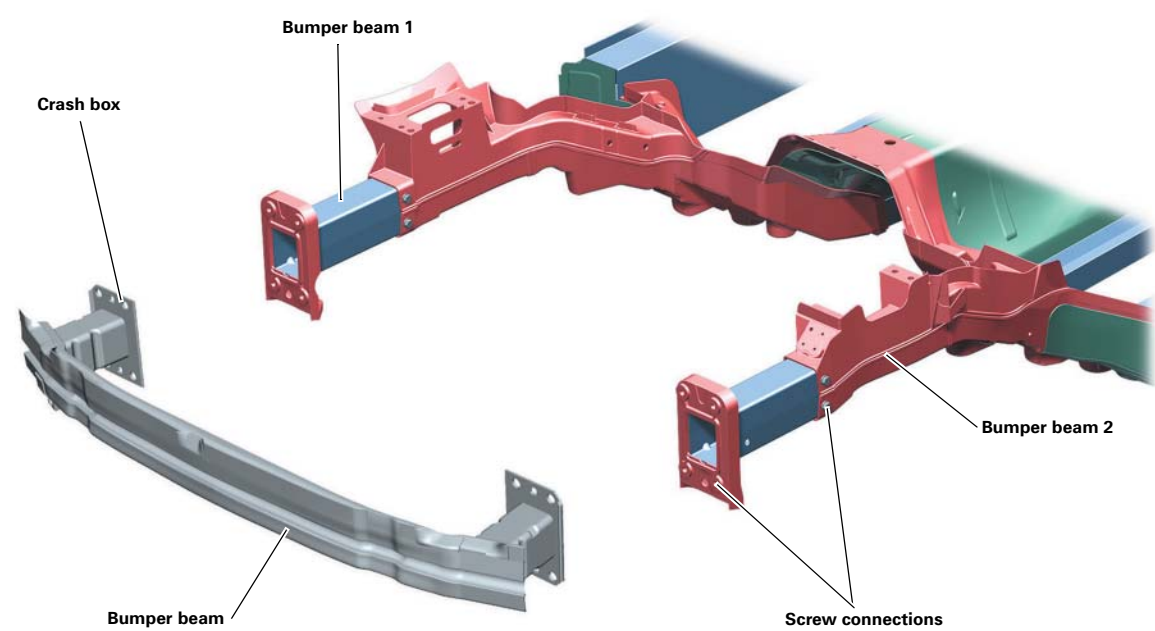
Laser weld seam before (above) and after the brushing process (below)

## Aluminium repair

The repair concept for the all-aluminium body parts is similar to that for the repair of previous Audi aluminium-bodied vehicles.

The front end of the vehicle is designed in such a way that the bumper beams and bolted crash boxes can be replaced after minor collisions up to approx. 15 kph.

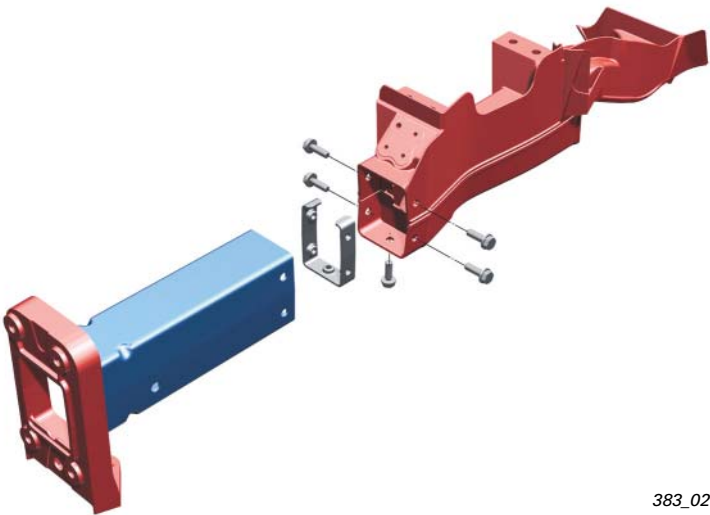
If the vehicle structure is damaged, beam 1 can also be replaced by undoing the screw connection. All further damage to the vehicle front end can only be repaired by welding suitable genuine parts into place.



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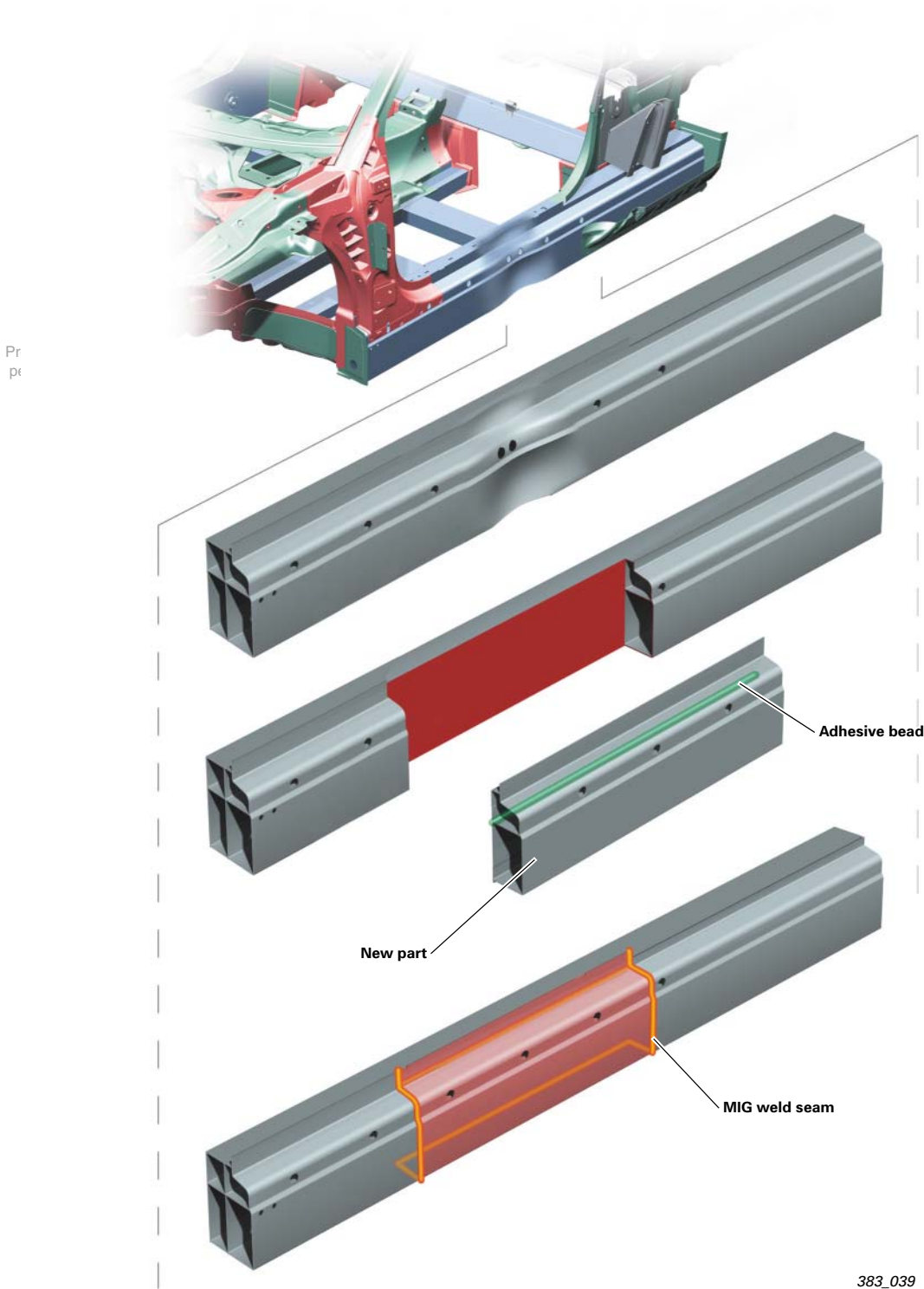


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Joint between beam 1 and beam 2

The four-chamber extruded section is located beneath the sill moulding. A special repair method was developed for damaged outer chambers. When repair work is needed, the extruded section is split vertically so that the two rear chambers including the centre ridge of the four-chamber profile remain.

A dual-chamber genuine part developed specially for this repair solution is welded to the remainder of the sill profile using a continuous MIG weld seam at the top and bottom. In addition, the U-shaped channel in the genuine part is filled with an adhesive bead which provides additional strength and eliminates noise transmission between the two sills.



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## Steel repairs

The rear end of the Audi TT is only area where it is possible to carry out repair work involving only steel parts and where the aluminium-steel joint is fully intact.

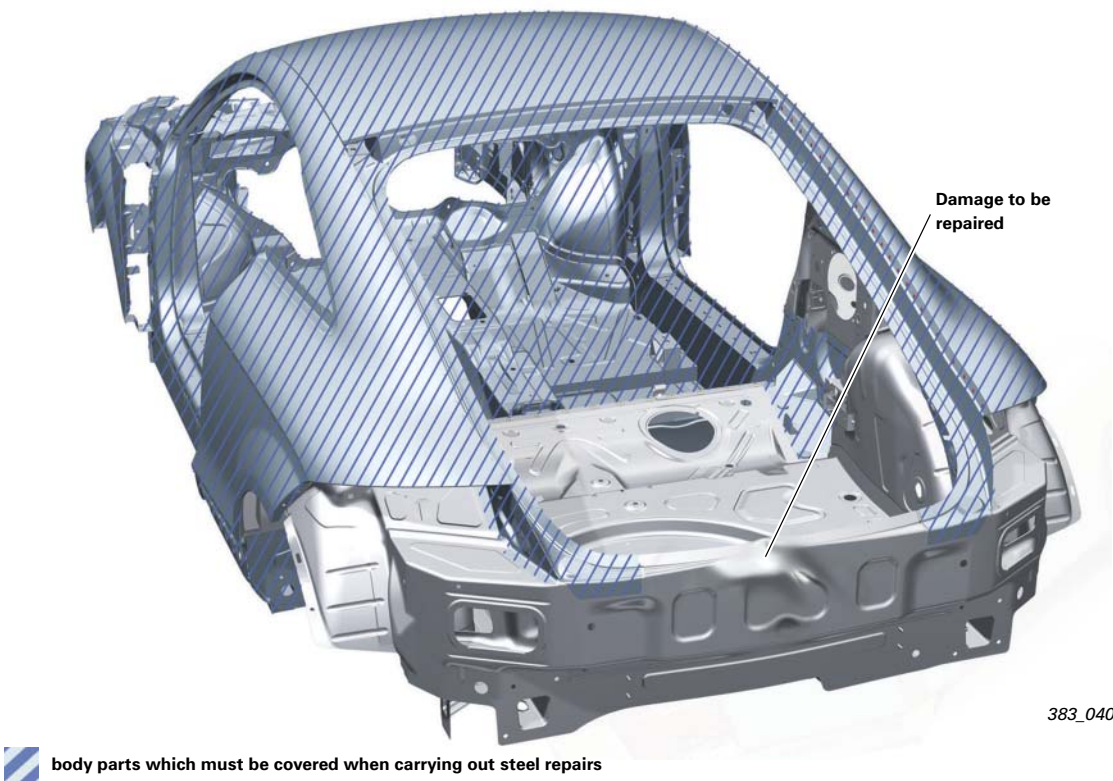
This repair work can be carried out on the

- rear end section
- rear side member (body side section undamaged)
- rear floorpan

Basically, the repair procedure is the same as for all-steel-bodied vehicles. Due to the danger of contact corrosion in aluminium body parts, however, special safety precautions must be taken. Grinding dust of steel parts, particularly flying sparks caused by cutting or welding work, must not be allowed to drop onto the aluminium parts.

This also applies to painted aluminium parts! Red hot steel parts can damage the paintwork and steel particles can come into contact with the aluminium body parts, leading to contact corrosion on the undamaged aluminium body.

Therefore, the complete bodyshell must be protected carefully when carrying out steel repairs. This is done by using suitable protective covers and by masking the body with masking tape. Furthermore, cutting work may only be performed using a body saw. If grinding work is needed, this must be done using grinding discs which produce little or no flying sparks. The spot welding machine should be used for welding work where possible, because it produces less weld spatter during the welding process.



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# Aluminium-steel repairs

In the case of body side or rear-end damage, both aluminium and steel body parts may become damaged. This is the case, for example, when the body side section (aluminium) and rear wheel arch (steel) are damaged. After removing the damaged parts, the new genuine parts are installed in accordance with the repair procedures described in the previous sections. Joining of steel and aluminium parts must be carried out with the greatest care in order to eliminate the possibility of future contact corrosion.

Two-component car body adhesive DA 001 730 A1 and rivets or screws are used for joining. As in series production, an insulating layer is placed between the two materials to prevent contact corrosion. When welding steel body parts, the aluminium parts must be carefully covered and masked!



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## Reference

All body repair work must be performed in accordance with the guidelines set out in the current workshop literature!



# Repair concept

## Workshop equipment

A special tool is required for repair work on aluminium-bodied vehicles. The basis is work scope 2010.

In addition to the special equipment and machines for stud welding, dent removal, bonding and riveting, the aluminium welding technology is of special importance.



383\_026

Aluminium body dent removal tools VAS 5196 and VAS 6049



383\_076

Cordless punch riveter VAS 5279A



383\_028

Aluminium inert gas welder V.A.G 2001B



383\_029

Aluminium inert gas welder VAS 6388

There are now two appliances with modern control systems which are ideal for welding work on the Audi aluminium body. The welding appliances, when used properly, produce perfect aluminium welded joints which have optimum strength.

### Reference

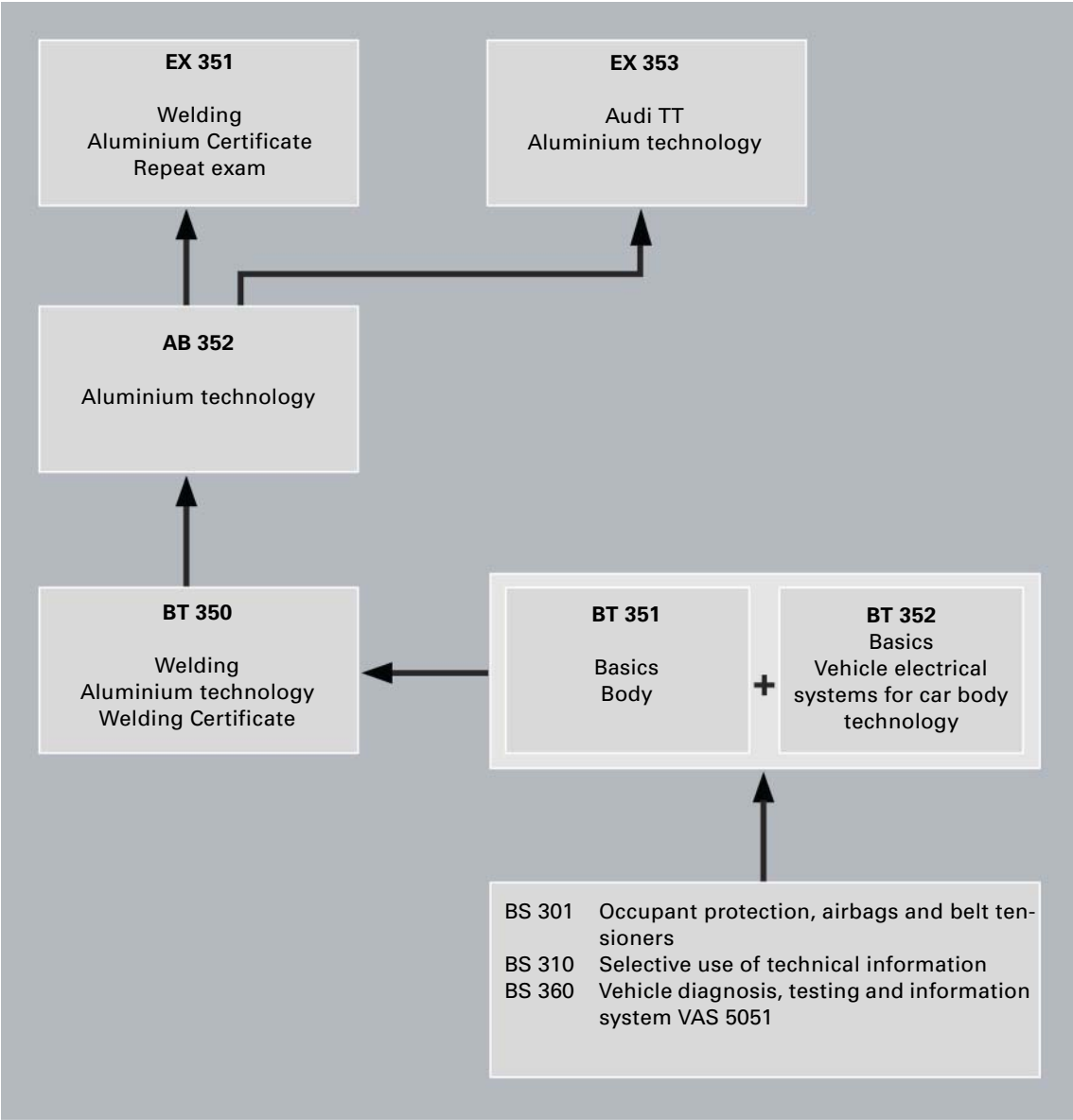


For further information on the workshop equipment for Audi aluminium-bodied vehicles, refer to the workshop literature and the Audi Service Net.

# Qualification of aluminium

A special knowledge and special skills are required to repair aluminium bodyshells. A prerequisite for successful body repairs is participation in the relevant training courses.

Particularly for welding work, certification of employees according to international standard DIN EN ISO 9606-2 is important.



383\_049

## Reference



For further information on the qualifications in aluminium technology, refer to the Audi Service Net.

# Car body safety concept

## Head-on collision, side impact and rear collision

Likewise, in terms of crash safety, the new TT makes no compromises. The front beams consist of aluminium extruded sections and aluminium castings. In combination with the front beams and a sub-frame, they reduce and distribute the forces which act on the car body during a head-on collision. Large-sized beams in the rear end protect the occupant cell. High-strength aluminium beams in the doors provide side impact protection. The aluminium bonnet is designed to all requirements for pedestrian safety.

The simulation provides information on the collision behaviour of the body structure at a very early stage in the development process. For this purpose, calculations are done on the basis of the available car body data using the Finite Elements Method. The results are incorporated into the ongoing design process, thus allowing the body structure design to be optimised in respect of the relevant crash loads.

Audi

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### Simulation Euro NCAP head-on collision



383\_031

To check the theoretical results and to meet statutory requirements, actual tests are conducted.

Various test conditions are simulated on the basis of the applicable standard.



383\_041

Euro NCAP head-on collision (64 kph with partial overlap)



383\_042

Euro NCAP side impact (50 kph)



383\_043

ECE and Japan rear collision (50 kph)

## Pedestrian safety

Pedestrian safety is an increasingly important factor. Various measures were implemented in the new Audi TT in order to meet the safety requirements.

When designing the bonnet, importance was attached to a stable design which yields to absorb head impacts. This is achieved by the honeycomb-like structure of the car body inner panelling.



383\_034

The overall concept provides for deformation zones between the bonnet and the units or car body structural parts.

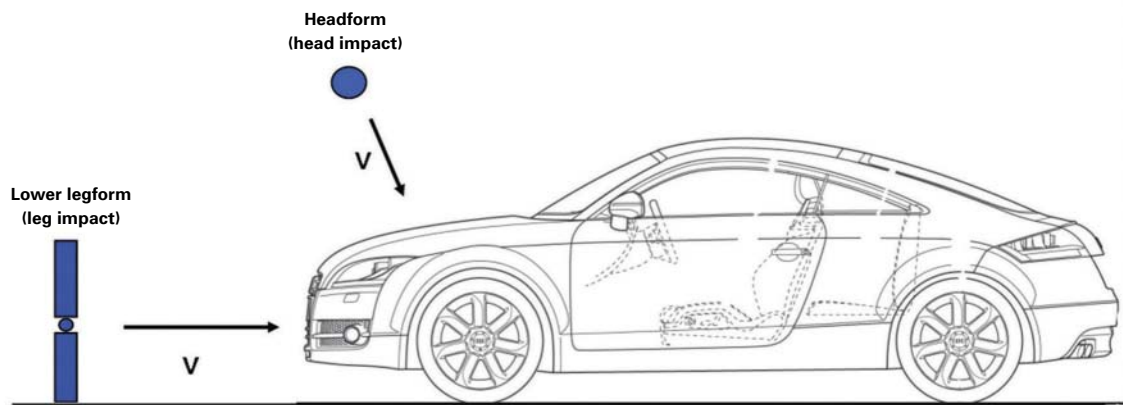
To reduce leg impact force at the front end, the bumper cover has been decoupled and an impact-absorbing foam part has been integrated between the bumper beam and bumper cover.



383\_044



The development tools "Simulation" and "Testing" were used for design.



383\_035

**Head impact**

To test the head impact a hemisphere which represents the head is catapulted onto the bonnet. The relevant physical variables are determined, on the basis of which conclusions are drawn regarding impact loads.



383\_036

**Leg impact**

Leg impact is simulated by means of a test configuration in which a test body similar to the actual body part impacts the vehicle bumper.



383\_037

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# Electromechanical rear spoiler

The new Audi TT has as standard an electrically extendable rear spoiler. The extended rear spoiler significantly increases driving stability at high speeds. The spoiler extends automatically at a speed of 120 kph and retracts at a speed of 80 kph. At speeds of less than 120 kph, the rear spoiler can be actuated manually with a switch in the centre console.

The unit consisting of the rear spoiler module and the spoiler wing is integrated in the boot lid of the Audi TT. The rear spoiler module with drive unit, input shaft and reversing mechanism (hinge) is bolted with self-adjusting elements to the sheet-steel spoiler wing painted in the body colour.



383\_038



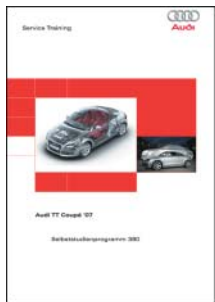
383\_045

When repair work is needed, the spoiler wing can be replaced separately. The rear spoiler module is replaced completely in case of damage.

## Reference



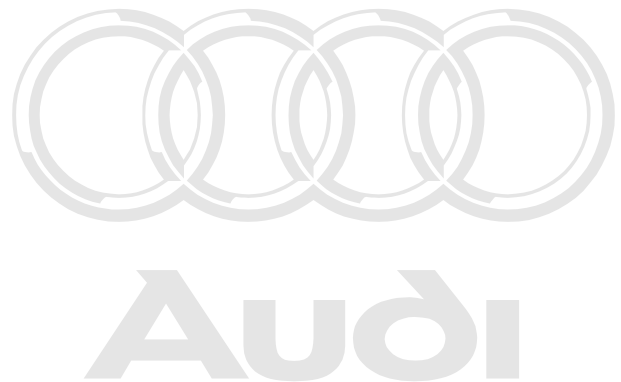
For further information on operation, function and diagnosis, refer to Self-study Programme 382 "Audi TT Coupé '07 - Electrical and Infotainment Systems".



### SSP 380 Audi TT Coupé '07

- Body
- Occupant protection
- Engine
- Suspension system
- Electrical system
- Air conditioning
- Infotainment

Order number: A06.5S00.25.20

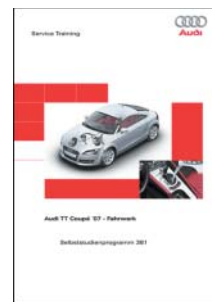


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### SSP 381 Audi TT Coupé '07 - Suspension System

- Front axle
- Rear axle
- Shock absorber system
- Brake system

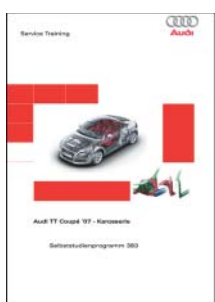
Order number: A06.5S00.26.20



### SSP 382 Audi TT Coupé '07 - Electrical and Infotainment Systems

- Networking
- Bus topology
- Convenience electronics
- Infotainment

Order number: A06.5S00.27.20



### SSP 383 Audi TT Coupé '07 - Body

- Audi Space Frame of the Audi TT
- Joining techniques and production processes
- Repair concept
- Car body safety concept
- Electromechanical rear spoiler

Order number: A06.5S00.28.20

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