

# BMW

## Body & Paint Training

Reference Manual

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The Ultimate  
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# 012

## Bonding & Riveting Techniques



# INFORMATION STATUS: MAY 2019

## COURSE CODE: SB012 - BONDING & RIVETING TECHNIQUES

This training manual is not intended to be a complete and all-inclusive source for repair and maintenance. It is only a part of a training information system designed to assure that uniform procedures and information are presented to all participants in the BMW Group University Body & Paint Training Center.

The technician must always refer and adhere to the following official BMW service publications available in Integrated Service Technical Application (ISTA) & Aftersales Information Research (AIR).

- Service Information
- Repair Manuals
- Technical Reference Information
- Specifications

The information contained in the training course materials is solely intended for participants in this training course conducted by BMW Body & Paint Training Group or one of its approved vendors.

For changes/additions to the technical data, please refer the current information issued via the Integrated Service Technical Application (ISTA), Aftersales Information Research (AIR), and Service Information Bulletins.



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# INTRODUCTION

## BONDING AND RIVETING OF OUTER SKIN PARTS

### Introduction

With the use of bonding and riveting, for example when replacing a roof outer skin, the time and effort spent on repair can be reduced by up to 50 % in comparison to conventional welding. In addition, the installation effort for trim panels, electronic components and fuel tanks is less, as this repair procedure does not generate any flying sparks, heat or swarf. As a result, the quality of the repair is also improved considerably.

Specific previous knowledge (professional experience) in body repair is required for the joining methods bonding and riveting of Body Repair Level 2.

### Quality of repair

Repair quality is understood as the restoration of the quality standards after an accident repair. This applies in particular to work according to the repair instructions taking into consideration the "General Information on Body Repair".

Fundamental knowledge of the vehicle design and material properties is therefore the basis for the evaluation of the work scope and a proper repair



Impermissible repair solutions may lead to a reduction in the repair quality. A repair according to the current repair instruction must be carried out.

### Bonding

Bonding is understood as the joining of similar or different materials. With this procedure various materials can be joined or connected in the body construction without having to change the material structure, like for example during welding.

From a physical perspective, bonding, just like welding, soldering and vulcanisation, is an integral connection with which similar or different materials are held together by molecular forces. The bonded connection is a fixed connection that can only be disconnected through destruction of the joining means.

### Advantages

- Bonding offers optimal corrosion protection without thermal distortion of the component.
- Bonded components have high strength and vibration-reducing properties. In the event of a crash, the energy of bonded and riveted components is absorbed very homogeneously. This is important particularly for passive safety in the body area.

### Disadvantages

- Bonding cannot be disconnected without destruction. Bonded components can only be disconnected by thermal or mechanical means, whereby the component to be disconnected is damaged and can no longer be used.
- Adhesive residue at joining areas must be removed mechanically. This can also cause damage to the surfaces.
- The limited thermal resistance of adhesives must also be considered.

## Adhesives

An adhesive is a non-metallic material, which connects materials by adhesion and cohesion without changing the structure or the properties of these materials.

Adhesives types are distinguished by:

- physically bonding adhesives (escape of solvent)
- chemically curing adhesives (reaction adhesives).

Only chemically curing adhesives are suitable for the body repair.

The individual chemical adhesive components are inserted in the adhesive joint in the correct mixture ratio. The solidification is effected by a chemical reaction of the components (cohesion). Chemically curing adhesives are available as one-part, two-part or multiple components and have a certain application time immediately after correct mixing.

Adhesion forces can only develop within the chemical application time. The application time is strongly influenced by ambient conditions such as air humidity and ambient temperature. It is important to ensure the adhesives are stored properly. All necessary information is available in the corresponding information directories of the repair instructions.

The adhesives from BMW are designed for the following surfaces with regard to their compatibility and adhesion:

- cathodic dip coating
- bare materials
- fibre reinforced plastics (in the cleaning process before bonding).

## Adhesive selection

Depending on the strength requirement and material combination, at BMW two-component adhesives with different properties are used. Specific cartridge guns are used for adhesives, as the mixture ratios (adhesive and hardener) and the adhesive quantities are different.

The adhesives may vary (also in colour) due to the different applications. Depending on the application, epoxy (EP), polyurethane (PU) or semi-structural adhesives are used. The size of the joining gap, the material surface and the component function (strength) are decisive for the adhesive to be used.

Material Combination	Adhesive
Steel - Steel	K5a or K5b
Aluminum - Steel	K2
Carbon - Steel	K3



The use of cartridge guns with compressed air is not allowed as there is a risk of unequal mixtures of hardener and adhesive or air bubbles may form in the adhesive during processing. This leads to insufficient strength or inadequate drying of the adhesive.

An extension of the adhesive variants is necessary as a result of the increasing requirements. It is therefore recommended to check the adhesives to be used before a repair.

## Riveting

Rivet connections are frictional connections and can be subsequently disconnected without damaging the material itself.

Rivets can absorb high shearing, peeling and tensile forces. In terms of crash safety, rivet connections are therefore also used in combination with bonded connections. This way the arising peeling forces at the adhesive joint connection can be avoided and a homogeneous force is guaranteed in the body components.

Each type of rivet connection is based on the individual repair requirement. Ensure that the strength categories (alloys) and the corrosion resistance (coating) are not affected. This is why only rivets approved by BMW can be used.



The rivet direction (only in Body Repair Level 2) generally goes from the new part to the used part.

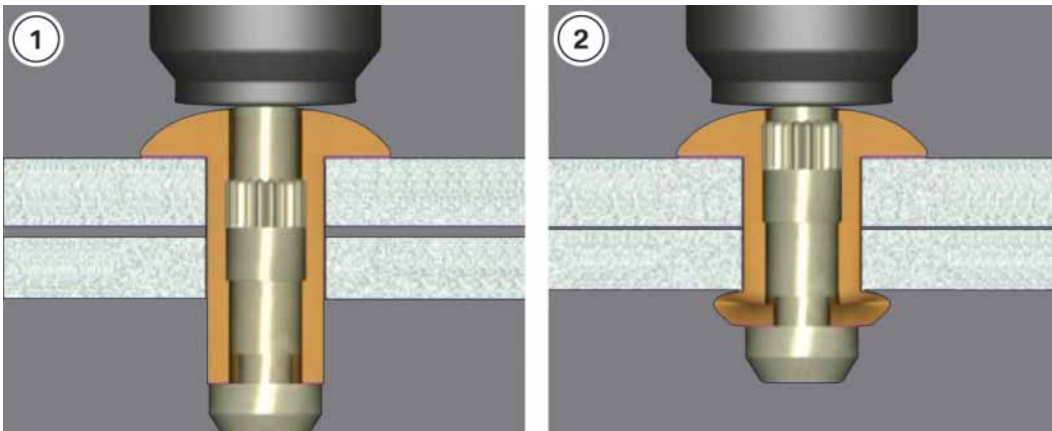
At BMW blind and punch rivets are used for rivet connections in the repair.

## Blind rivets

Steel blind rivets (tubular rivets) are generally used where access is only possible from one side of the component. The blind rivet is pulled at the mandrel with a predetermined breaking point by means of a blind riveting pliers and compressed in one work process. Its diameter enlarges as a result. The drilled holes therefore have to be slightly bigger than the blind rivet diameter.

Example: Blind rivet  $\varnothing$  4 mm  $\Rightarrow$  Drilled hole  $\varnothing$  4.2 mm.

For installation the replacement part is predrilled for the blind rivet in the adhesive area. The component is



Index	Explanation
1	Blind rivet cross-section before joining
2	Blind rivet cross-section after joining

positioned and secured with the blind rivet after the adhesive application. Blind rivets with the identification N3/N6 ( $\varnothing$  4 mm) are used. The clamping area of the blind rivet specified in the repair instructions is dependent on the material thickness of the component.



A blind rivet inserted in disregard of the clamping area is a resistance and strength risk. With blind rivets there can be no gap in the rivet area between the materials.

## Advantages

- Universal (materials)
- High shearing and tensile strength
- Guarantee of a consistent adhesive gap (between the blind rivets)
- Does not require rear access to the component.

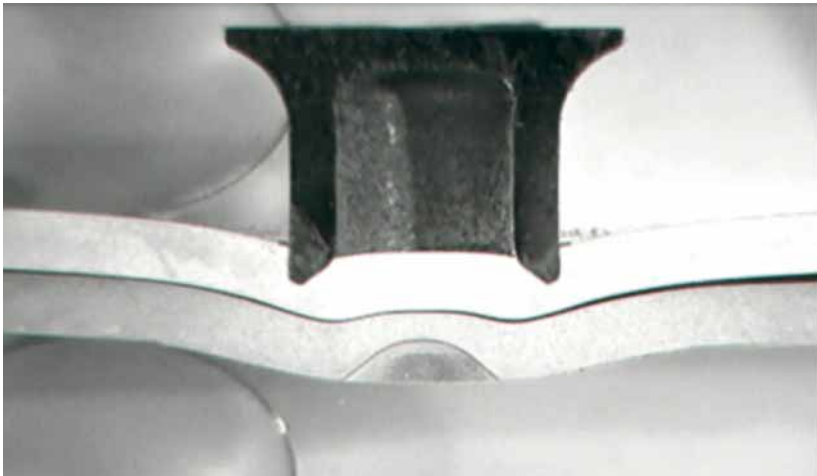
## Disadvantages

- Large rivet head
- Susceptible to corrosion, must also be sealed with sealant
- Component must be predrilled (in comparison to punch rivets).

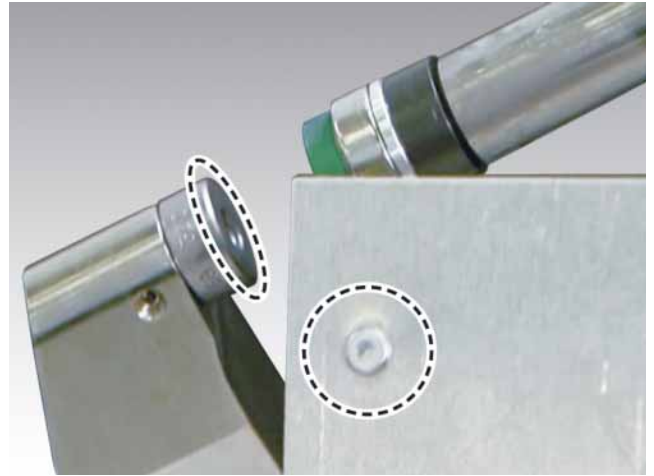
## Punch rivets

Steel punch rivets are pushed in without predrilling using a hydraulic hand riveter at a force of approx. 55 kN in a single process. After the maximum force (force-controlled) set is reached the self-piercing rivet is pressed through the first sheet material using a punch. In the second sheet material the punch rivet is pressed onto the counter support (die) and moulded on the rear side. A so-called collar is formed in the process. The riveting process is completed with the subsequent return stroke.

Riveting process, cross-section of punch rivet



Die imprint on the sheet metal flange



## Advantages

- Punch rivet connections have a concave design on their rear side and are therefore uncritical in terms of tightness
- The punch rivet head is flush on the surface (better optics)
- Permissible strength categories by automated process of punch riveting pliers.

## Disadvantages

- Optimal access to all component geometries necessary
- Risk of deformation of the sheet metal flange (die imprint on the surface).



# WORKSHOP ENVIRONMENT

## SAFETY AT THE WORKBAY

The smoke and dust arising from the work must be extracted in order to avoid endangering the health of people directly and in the surrounding area. In the case of pollutant emissions from chemical consumables (solvent) sufficient ventilation must be provided. If nec., open windows and doors.



Handling chemical products can cause allergic skin and respiratory reactions

Further information can be found in ISTA under REP 41 00 Occupational safety.

Body with extraction unit



## PROTECTIVE MEASURES AT THE VEHICLE

- The vehicle must be covered with specific protective covers against coarse dirt and swarf.
- In order to avoid contact corrosion, the inner areas and electronic components and plug connections must be protected with additional covers.
- The inside and outside of the vehicle, as well as the working area, must be cleaned using a vacuum cleaner.

Never use compressed air for removing dust

## TOOLS

In addition to the typical body tools, the following tools are also required for Body Repair Level 2:

- Punch riveting device
- Powerbird hand riveter plus extensions
- Genesis blind hand riveter

- Cordless cartridge gun
- Small cartridge gun
- Temperature measuring device
- Infrared heater
- Clamping tongs plus suction lifter for the roof outer skin (steel/aluminium/carbon)
- Sander with extraction for metal filler.

Body Repair Level 2 cannot be satisfied without suitable tools and equipment. The investment costs in comparison to welding are comparatively low and therefore also make economic sense in terms of repair friendliness.

Additional information: See Aftersales Assistance Portal (ASAP) – Service/Technology – Workshop equipment (Start-BMW) – Shop workshop equipment (<http://www.bmwgroup-wep.com>).

# PREPARATION AND DISCONNECTION

## PREPARATION

With the deletion of some installation work during bonding and riveting, the respective conversion and dismantling work in the repair instructions should be considered before the commencement of work. For example, fuel tanks and the battery do not have to be removed as with welding.

In addition to the suitable tools and equipment, a guarantee of the work processes is necessary. The repair instructions (ISTA), Electronic Parts Catalogue (EPC) and Commercial Service Data are required for the work preparation and should be available at the workbay for an efficient repair process.

Spare parts and consumables are ordered in the Electronic Parts Catalogue through the usual part ordering channel with a specific BMW part number. The parts and consumables required are shown in the graphic and are automatically listed upon entry, e.g. "rear side panel".

Graphic in the EPC

The screenshot displays the BMW EPC software interface. On the left, there is a search and navigation panel with fields for MG, FG, Diagram-Number, UG, and Part number. Below these are buttons for 'Graphic', 'Tree', and 'Search result'. A grid of thumbnails shows various body parts, with '41\_2524 Body-side frame' selected. The main area shows a 3D exploded view of the 'Body-side frame' assembly, with parts numbered 1 through 11. Below the diagram is a table titled 'Diagram - 41\_2524: Body-side frame - Parts'.

Description	Part number	Quantity	Info
01 Body-side frame left	41 00 7413123	1	
Required for repair:			
-- Blind rivet nut with collar (M7)	07 14 7363429	2	
-- Positioning aid T-bolt	41 21 2460191	1	
-- T-welding stud (L=5,4mm)	41 31 8412638	20	
01 Body-side frame right	41 00 7413124	1	
Required for repair:			
-- Blind rivet nut with collar (M7)	07 14 7363429	2	
-- Positioning aid T-bolt	41 21 2460191	1	

## DISCONNECTING WELDED CONNECTIONS

A challenge in the body repair at the start of the repair is the disconnection of spot-weld areas on sheet steel. Removing super high-strength and high-strength sheet steel with conventional weld spot drill bits is very difficult. This is why special carbide milling cutters were developed. The use of a conventional hand drill is not recommended for the carbide milling cutter as the cutting of the spot weld cutter can snap with slight tilting. Only a special Vario drill spot weld cutter with adjustable drilling depth and wheel circumferential velocity should be used for drilling.



In order to avoid overheating during drilling, chlorine-free cutting oil should be used. A low speed must be used for effective swarf removal.

During the removal of welding spots it is important to ensure that the sheet metal flange remaining on the body suffers as little damage as possible. Particularly critical is the release of the centring tip of the weld spot drill bit on the sheet metal flange. At inaccessible areas at which it is not possible to position the Vario drill upright, the welding spot can be opened using a belt sander. Deep sanding marks or material residue on the rest of the sheet metal flange must be avoided.

Damaged sheet metal flange



After the component has been disconnected only the remaining material peaks are sanded and levelled.

Material peak



## DISCONNECTING SOLDERING POINTS

Existing soldering points are carefully sanded using a belt sander. The belt sander is tilted and guided along the soldering point.

Tilted belt sander



Heating the soldered joint area using an acetylene/oxygen burner must be avoided due to the heat input (structural change of the material) and in terms of corrosion protection (burnt paint in the inner area).

## DISCONNECTION OF BONDING

By preheating the bonded connections (directly at the adhesive), the adhesion forces on the surface and the cohesion forces of the adhesive are destroyed. Using a body chisel the bonded connections are disconnected when heated.



A temperature measurement at the material surfaces, like for example carbon and aluminium, is always required during preheating as temperatures from 95 °C can already destroy the material.

Please note: Poisonous gases may develop during preheating. It is necessary to wear a suitable mask, eye and skin protection and use an extraction unit for dust and gases, as well as ensure a well ventilated workbay.

## DISCONNECTION IN THE CASE OF REPEAT REPAIRS

Disconnection in the case of a repeat repair is effected in the same way as for an initial repair. The effort is also identical.

### **Punch rivet connections**

Punch rivets are sanded at the rivet head up to approx. halfway using a belt sander or drilled out using a special punch rivet drill at the "head side". In order to avoid lateral slipping during a drilling process, a so-called punch-mark by centring at the punching head is required. The rear side of the punch rivet remains completely in the sheet metal flange. A complete removal is not required as this may weaken the material. The new punch rivets are positioned in the same quantity beside the already existing punch rivets.

## Blind Rivet Connections

In contrast to punch rivets, blind rivets are always completely removed. Centring during drilling is established by the mandrel remaining in the rivet. In the case of inadequate access, removal using a belt sander is possible. The blind rivet head is sanded approx. halfway (as far as the remaining component) and the end of the remaining rivet is removed with a punch. The existing drilled holes in the body component are transferred to the new component.

## Bonding

Similar to the initial repair, the bonding is heated using a hot air blower until the adhesive and cohesive forces are destroyed. The remaining adhesive residue is removed mechanically.

Mechanical removal of adhesive



# DISCONNECTING COMPONENTS

## Separation cut for partial replacement

In the case of a partial replacement of a rear side panel, reinforcement plates are used at the dividing line of the C-pillar and side sill for the connection at the body. The separating cut is described accordingly in the repair instructions. The dividing lines are created at a right angle to the vehicle contour, e.g. at a C-pillar. In order to define the correct position of the dividing line (length), the cutting dimension is taken from the repair instructions and transferred to the body and new part. An allowance of approx. 30 mm must be taken into consideration (rough cut).

Separation cut at C-pillar



It is recommended to create a template for determining the final dividing line. This is positioned in the new part and a precise fit is determined by moving. Then the new part is cut at the dividing line and transferred to the body. Parallel cut lines thus result on the new part and body. The respective operations for creating the template can be found in the repair instructions.

Template inserted in the new part



## Reinforcement plates

Reinforcement plate from template



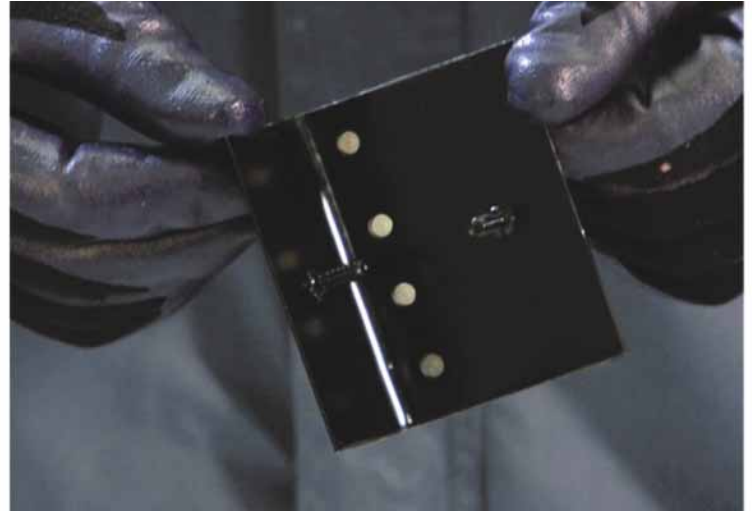
Reinforcement plates are prefabricated for entrance, C- and D-pillars and can be ordered in the Electronic Parts Catalogue (EPC) together with the rear side panel. In certain circumstances the edge area of the reinforcement plates has to be reworked in order to guarantee a good fit of the bonding surfaces.



Before bonding install reinforcement plates with cap nuts and check for fit at vehicle line contour

Additional universal plates must be ordered for vehicles with a tailgate. The universal plates are required as additional reinforcement plates – for example at the water channel (D-pillar) – and must be cut and adapted individually depending on requirements.

Universal reinforcement plate riveted and adjusted



When processing reinforcement plates do not sand or damage the cathodic dip coating primer

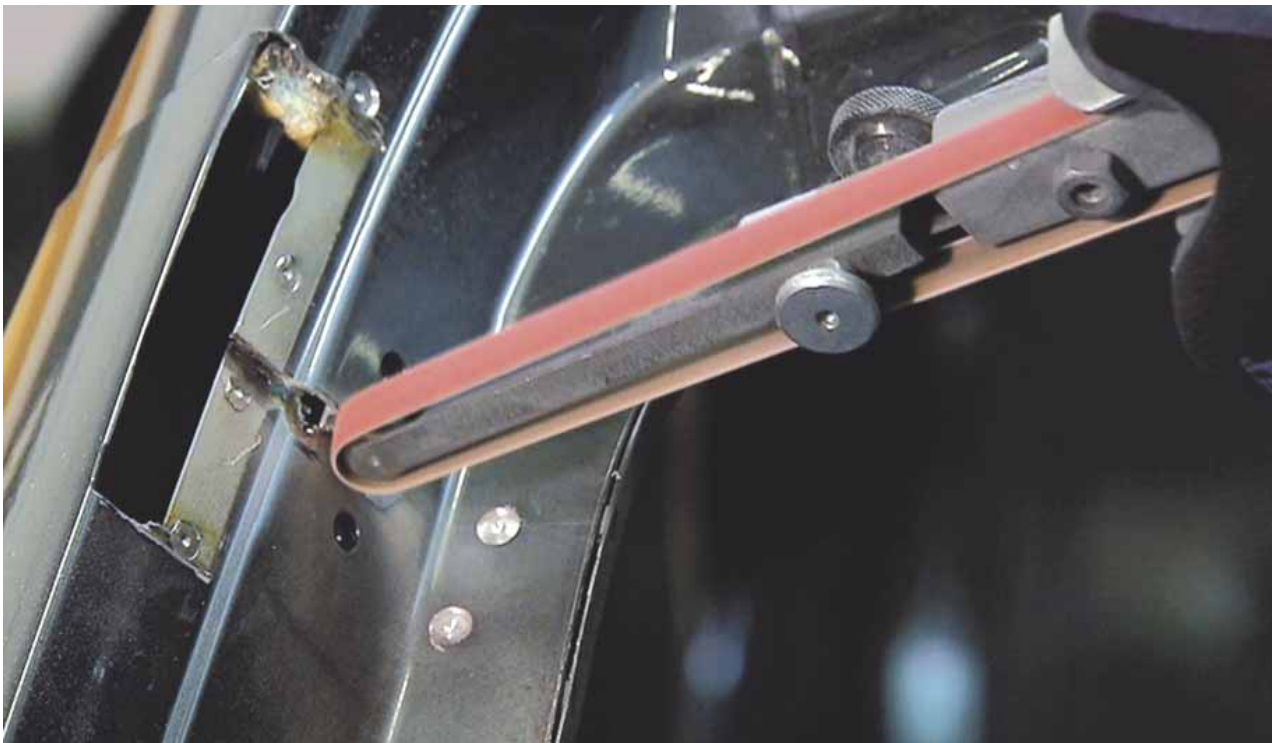
### Cutting tools

In order to disconnect body components, there are different mechanical options available.

In general, typical body saws with a variable stroke adjustment are offered. Saw blades with 24 tpi (teeth per inch) or 32 tpi are suitable for steel. 18 tpi are suitable for carbon and aluminium.

For double panels and narrow radii it is recommended to sand the dividing line using a belt sander. This makes possible disconnection of the first material layer, without damaging or heating the sheet layers underneath. Thus there is no risk of a structural change of the material and the inner component primer is not destroyed. Sanding the separation points is also offered as a method for tapering compound seams.

Separating cut with belt sander at a water channel





# PAINTWORK

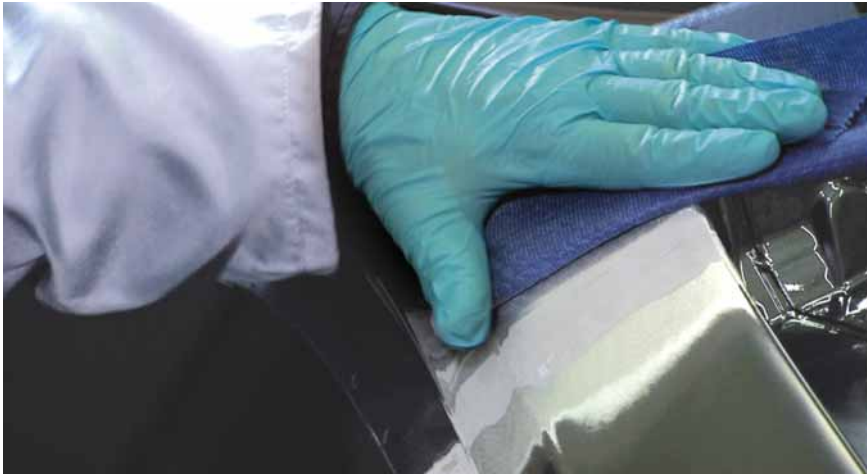
## PAINT STRUCTURE

The paint structure is performed by conventional means (see BMW paint manual).



Please note: Before applying primer to the component outer areas, do not clean the metal and polyester filler areas using silicone remover or other cleaning agents. Filler areas absorb moisture and then emit this later after the paintwork. As a result, there may be marks on the paint surface (filler edges).

Surface preparation



## CORROSION PROTECTION

After joining only primed materials (e.g. rivets) are sealed with D1 sealant. For blind rivets the sealing must be applied carefully on the outside and in the centre of the rivet head (mandrel), as well as on the rear. D1 sealants can be applied in a spray process or using a glue cartridge.



Ensure original sealing welds are used

After the painting process the cavities at the joints must be protected with cavity protection wax.

Cavity protection process



# JOINING & FILLING

## PREPARATION OF JOINING AREAS

### Body

The adhesive is applied on bonding surfaces with cathodic dip coating. Exceptions for bonding on bare panels (only Body Repair Level 2) are straight and sanded bonding surfaces, as well as open welding surfaces and soldering points. Damage to the cathodic dip coating should be avoided where possible.



Only remove adhesive in the areas of the adhesive line.

Always refer to the VIN specific repair instructions for surface preparation details.

### Sanding surfaces (without cathodic dip coating)

The following sandpaper grit grades are used for the bonding surfaces:

Material Combination	Grit Grade
Steel	P80 - For coarse sanding of metal panels P120 - For fine resanding of metal surfaces
Aluminum	P120 - For sanding metal surfaces P220 - For fine resanding of metal surfaces
Adhesive Residue	Nylon grinding wheels or fleece with medium degree of hardness (blue)



When sanding adhesives always work with a dust extractor and dust mask

### Spare parts

Replacement parts can be adjusted and secured before bonding, e.g. for the setting for the body gap dimension, using additional small sheet metal screws. The remaining drilled holes are sealed subsequently with adhesive.



The use of sheet metal screws for the alignment is only permitted for steel-steel connections. Sheet metal screws are not permitted for roofs.

## Corrosion Protection

In the case of mechanical removal of adhesive residues or for repair work, the primer coat and also the galvanisation on the material surface are damaged. Adhesive areas which are sanded too wide pose a corrosion risk and primer must be reapplied on the outside as far as the adhesive line. Repaired surfaces on body inner components are protected with a primer spray, EP base filler for steel or HS-AK multi primer filler for aluminium.



Do not apply primer to adhesive areas

Repaired surface, e.g. rear wheel arch



## APPLYING ADHESIVE

### Cleaning

Before applying the adhesive the body and partial replacement must be cleaned of dust and oil. If necessary, the cavity sealing wax must be cleaned using a cavity protection wax remover (R3). Joining areas with and without cathodic dip coating must be thoroughly cleaned using R1 cleaning agent in one direction. Important: Turn the cleaning cloth several times during the cleaning process.



Use lint-free cloths for cleaning

## Passivation

For bare aluminium surfaces (cathodic dip coating) the surfaces must be flame-coated before applying the adhesive. A chemical oxide layer must be applied using a gas flame and then primer applied.

## Preparing the adhesive

For better mixing of the adhesive components the adhesive cartridge gun temperature should be between 20 and 30 °C (68 - 86 °F).



Do not place adhesive cartridge guns in hot water for preheating

The adhesive quantity is based on the material and adhesive gap. For example, when bonding aluminium or CFRP roofs onto steel bodies more adhesive is required than for steel roofs. The reason here is that the adhesive gap for aluminium and carbon components is considerably larger.

Adhesive bead



## Application time

An adhesive reference bead (length approx. 10 cm) is applied to an underlayer before bonding the components. This is used to check the application time during bonding and the drying time after bonding (dependent on the working temperature).

Adhesive reference bead



The adhesive must be applied quickly and in the centre of the joining areas. Then the component is installed and secured. Afterwards the blind rivets are inserted and pulled. The punch rivets are then positioned. The adhesive is pushed from the joining area.



If there is not enough adhesive emerging, in particular when replacing a roof outer skin, this represents a strength and sealing risk

### **Cavity sealing**

For cavity sealing an adhesive bead is applied using D1 sealant. Cavity sealing is used to reduce noise (comfort) and prevent penetration of moisture (corrosion).

Adhesive on cavity sealing



Observe information on the installation of expanded and non-expanded cavity sealing in the repair instructions.

## Hardening

The vehicle can be moved for other operations (e.g. painting) if the adhesive no longer leaves any imprints at the reference bead (test with the finger nail). Bonding requires rethinking in the workshop process in terms of hardening. Unproductive time (e.g. at night) can be optimally used for this purpose.

Finger nail test



The adhesive does not harden at object temperatures below 15 °C (59 °F). If necessary, an accelerated hardening can take place using an infrared heater in 30 minutes (at an object temperature of 85 °C / 185 °F).

Only perform temperature measurements when the infrared heater is switched off. Do not use the infrared heater with self-measurement on open body components or on minimal body areas as otherwise there is a risk of overheating.

Infrared heater



## Ground

The adhesive has a stripping effect in the joint. Rivets alone can only partially re-establish the electromagnetic compatibility (EMC) of the component. This is why additional self-tapping screws are screwed in at component overlaps in order to re-establish the electromagnetic compatibility of the components.



Only install EMC screws after the adhesive has dried

## DRYING

Adhesives require a drying time of several hours depending on the room temperature. Therefore, a sufficient room temperature must be provided, also outside the working time (lowering of night-time temperature), as otherwise the chemical drying process is interrupted.

If this is not possible, the vehicle can be heated up in a paint chamber for an hour at 80 °C (176 °F) at least or by an infrared heater (directly on the component) before the end of the working time. The drying times are thus reduced considerably.

Heated paint booth



# STORAGE & DISPOSAL

## STORAGE OF ADHESIVES AND CHEMICALS

Chemical products should not be stored in large quantities due to the limited shelf-life.



In countries with no air-conditioned storage facilities for chemical products, it may lead to changes, i.e. an ineffective chemical reaction during processing

## DISPOSAL

Please follow local and state regulations and laws for proper disposal of any adhesive and chemical waste.