BMW
Body & Paint Training

Reference Manual

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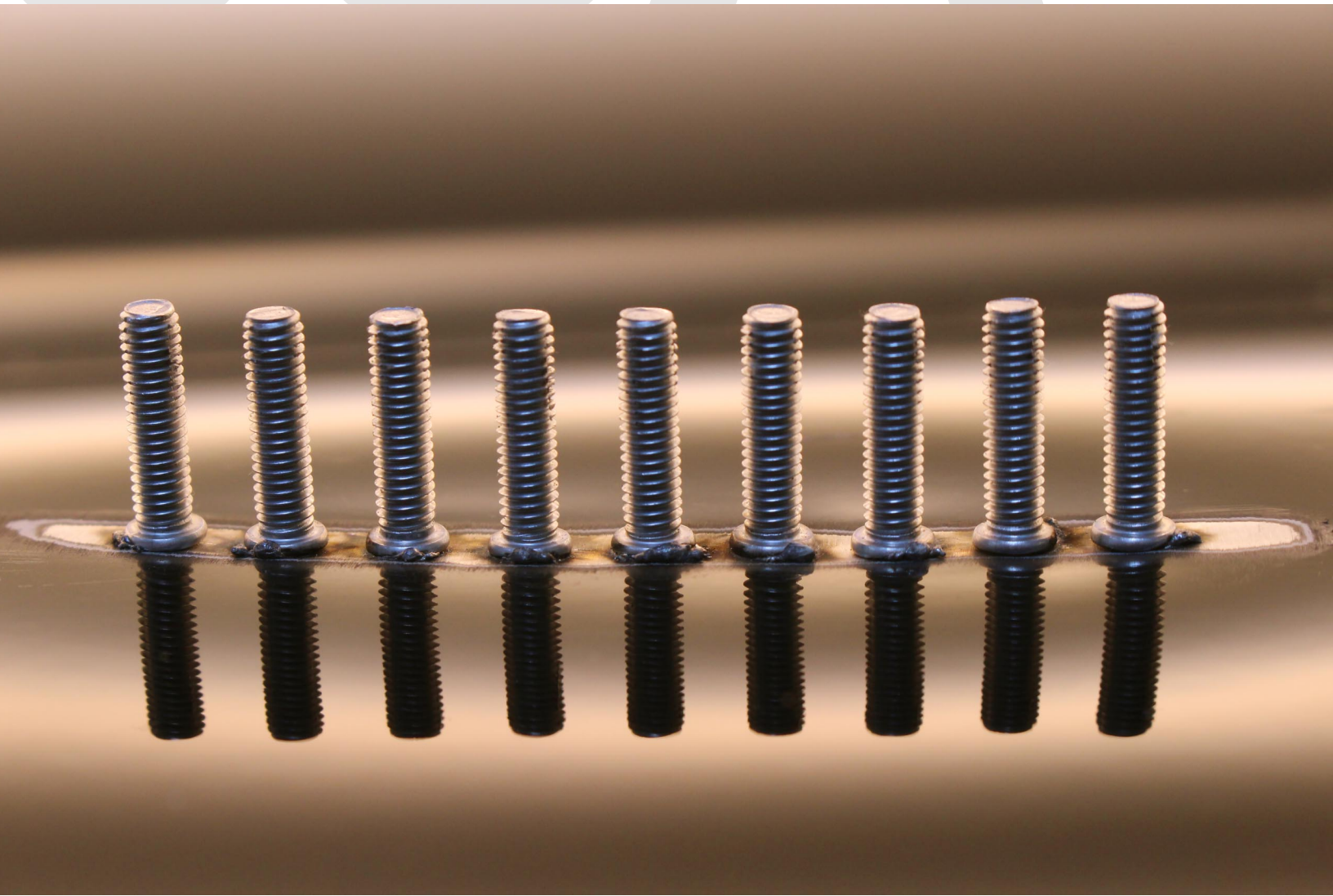
08A

Aluminum Outer Panel Repair Techniques



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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

BMW designers are faced with many unique challenges: produce performance oriented and appealing lightweight, fuel efficient vehicles that meet strict requirements for fuel economy, vehicle emissions, occupant safety and crashworthiness. BMW owners continue to demand more content and features in the vehicles they drive. This places a greater emphasis on materials science and the need to utilize lightweight construction techniques to counteract the increase in vehicle weight brought about by increases in vehicle content. Even though space-age materials such as carbon fiber composites as well as exotic metals like titanium and magnesium are being utilized on some vehicles, aluminum is the material of choice for many automotive design applications.

While some conventional body repair techniques can be utilized to restore and reshape damaged aluminum outer body panels, aluminum and aluminum alloys present some unique challenges to repair technicians.

HISTORY

Aluminum has been widely used for applications requiring high strength while retaining a lower weight for many years. The aircraft industry has dominated the use of aluminum in design and manufacture. Today, aluminum accounts for 70-80% of the modern airframe, its propulsion system, and interior fittings.

The use of Aluminum in the automotive industry dates back over 100 years. The first sports car featuring an aluminum body was shown at the 1899 Berlin Auto Show. Two years later, an engine was introduced with aluminum components.

BMW first used aluminum later in that decade. In 1936, BMW designed a lightweight aluminum-bodied vehicle named the 328 Mille Miglia, a race car design that utilized an aluminum outer body skin. This vehicle went on to become a competitive success. This so-called 'light metal' enhanced the handling characteristics of the car, but difficulties in metal working, lack of knowledge, and its high price at the time impeded the use of aluminum in mass automotive production in the beginning of the 20th century.

In 1971, BMW again constructed an aluminum competition vehicle called the 3.0 CSL (Coupe Sports Lightweight). Then, in 2000, BMW introduced the Z8 (E52), a low production aluminum sports car. This all-aluminum lightweight performance vehicle employed unitized structural components with bolt-on outer body panels. In 2003, BMW again made news introducing the E60 with its aluminum front structure being bonded and riveted to the high strength steel passenger compartment.

The E60 has aluminum engine supports (frame rails), engine bulkhead, upper fender supports, and front apron assemblies. Additionally, the hood, front side panels (fenders) and doors are also constructed of aluminum. According to BMW engineers, this achieved a near-optimum front-axle to rear-axle weight distribution.

The BMW 328 Mille Miglia

Modern vehicles built with aluminum components can be made 24% lighter than one with components made of steel. This will save about one gallon of fuel for every 70 miles driven. Aluminum is the second most used metal in terms of percentage on today's vehicles. Nearly 70% of all wheels in the US are made from aluminum or an aluminum alloy. According to AluminumTransportation.org, a 5 to 7 percent fuel savings can be realized for every 10 percent of weight reduction. Substituting lightweight aluminum components for a heavier material also allows the vehicle to accelerate faster and brake quicker.

Design engineers must consider many factors when selecting materials for a vehicle: malleability and ductility (forming properties), strength, electrical conductivity, weight, surface characteristics (suitability for refinishing) and its ability to be fused during construction (weldability).

Aluminum will continue to play an important role in the design and manufacture of BMW vehicles. This reference manual will help prepare collision repair technicians on how to effectively and properly repair BMW outer body panels made from these lightweight alloys.

MATERIALS SCIENCE

Aluminum and aluminum alloys have many outstanding attributes that allow a wide range of automotive applications. Some of these characteristics are resistance to oxidation and corrosion, high electrical and thermal conductivity, low density, high reflectibility, high ductility, and reasonably high strength at a relatively low cost.

Aluminum is considered to be a lightweight vehicle construction materal with a density lower than steel. Pure aluminum is relatively soft and is generally alloyed with other elements, then heat treated to achieve the desired strength characteristics. Aluminum alloys can be formed to exhibit a good combination of strength and ductility.

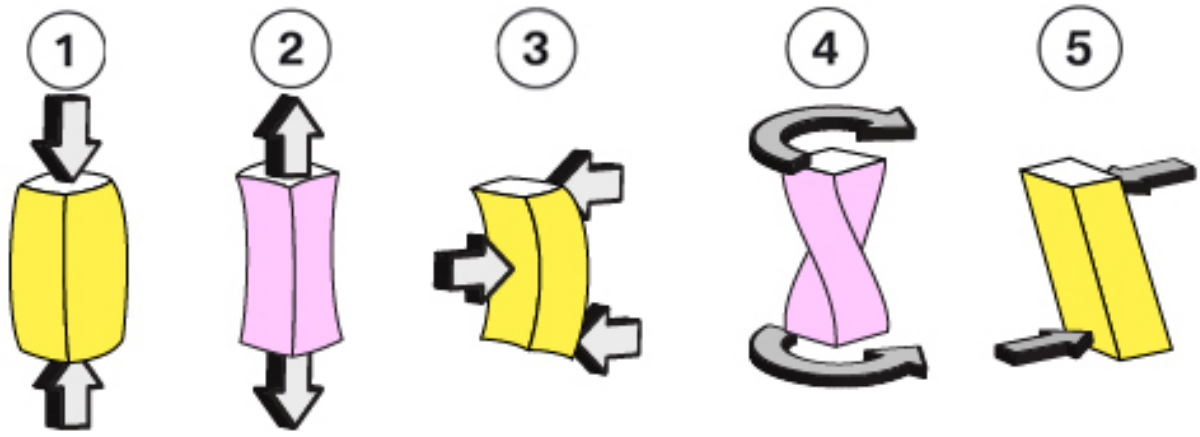
Ductility is the ability of a solid material to deform under tensile stress, or be drawn into a thinner shape such as a wire._

Malleability is a similar property that allows a solid material to deform under compressive stresses and be hammered or stamped into thinner sheets.

Tension is a pulling force exerted on an object by a string, cable, or other solid object.

Compression is the application of balanced, inward forces.

Mechanical forces acting upon solid objects



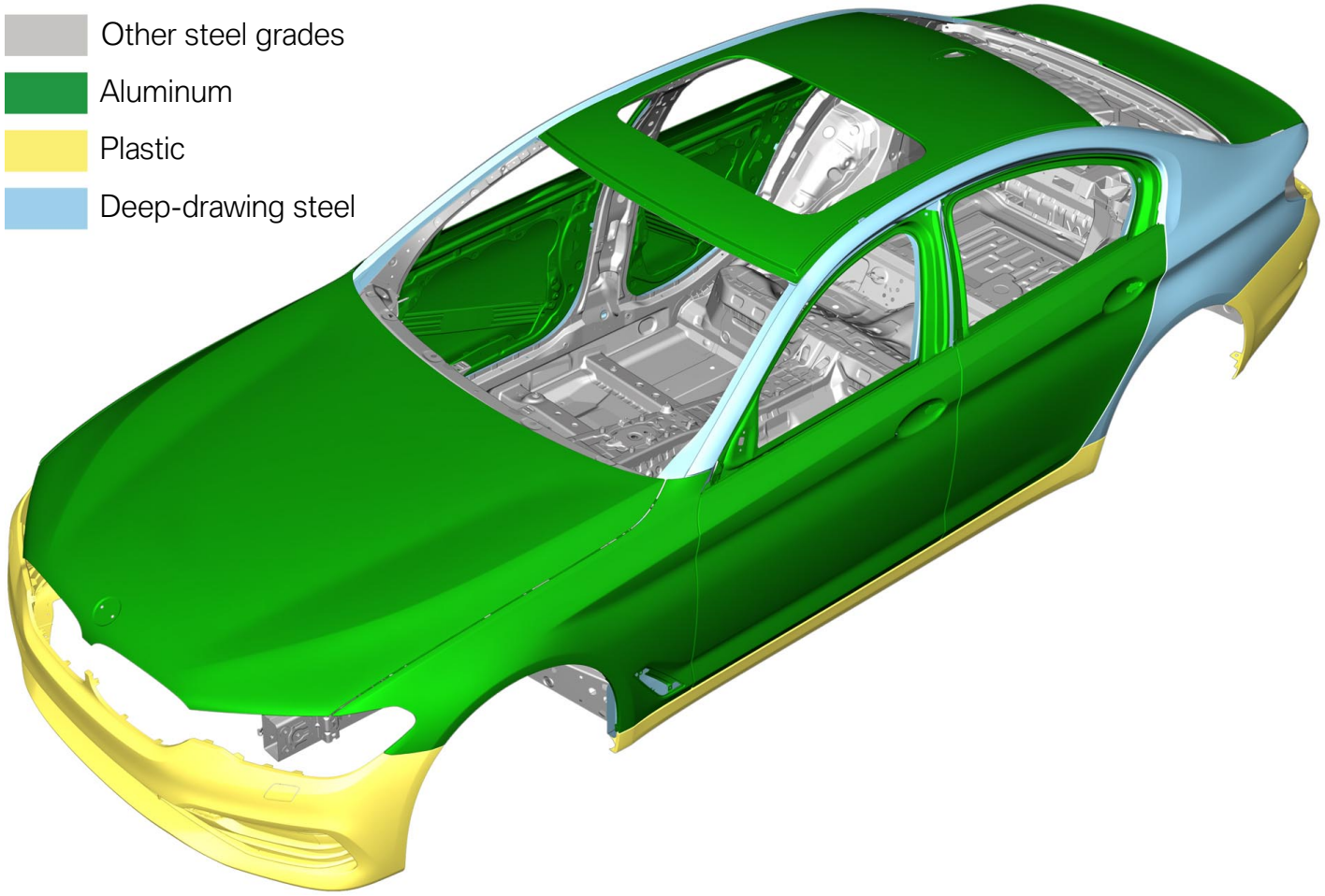
Index	Explanation
1	Compression
2	Tension
3	Bending
4	Torsion
5	Shear

Aluminum is the most abundant metal in the Earth's crust and is the third most abundant element on the planet. The element aluminum, chemical symbol Al, makes up about 8% of the weight of the Earth's solid surface. It is found in bauxite ore and is somewhat unstable in its pure form. Bauxite is so chemically reactive that it is easily subject to oxidation and corrosion. We will discuss this characteristic in more detail when we look at galvanic corrosion and its effects.

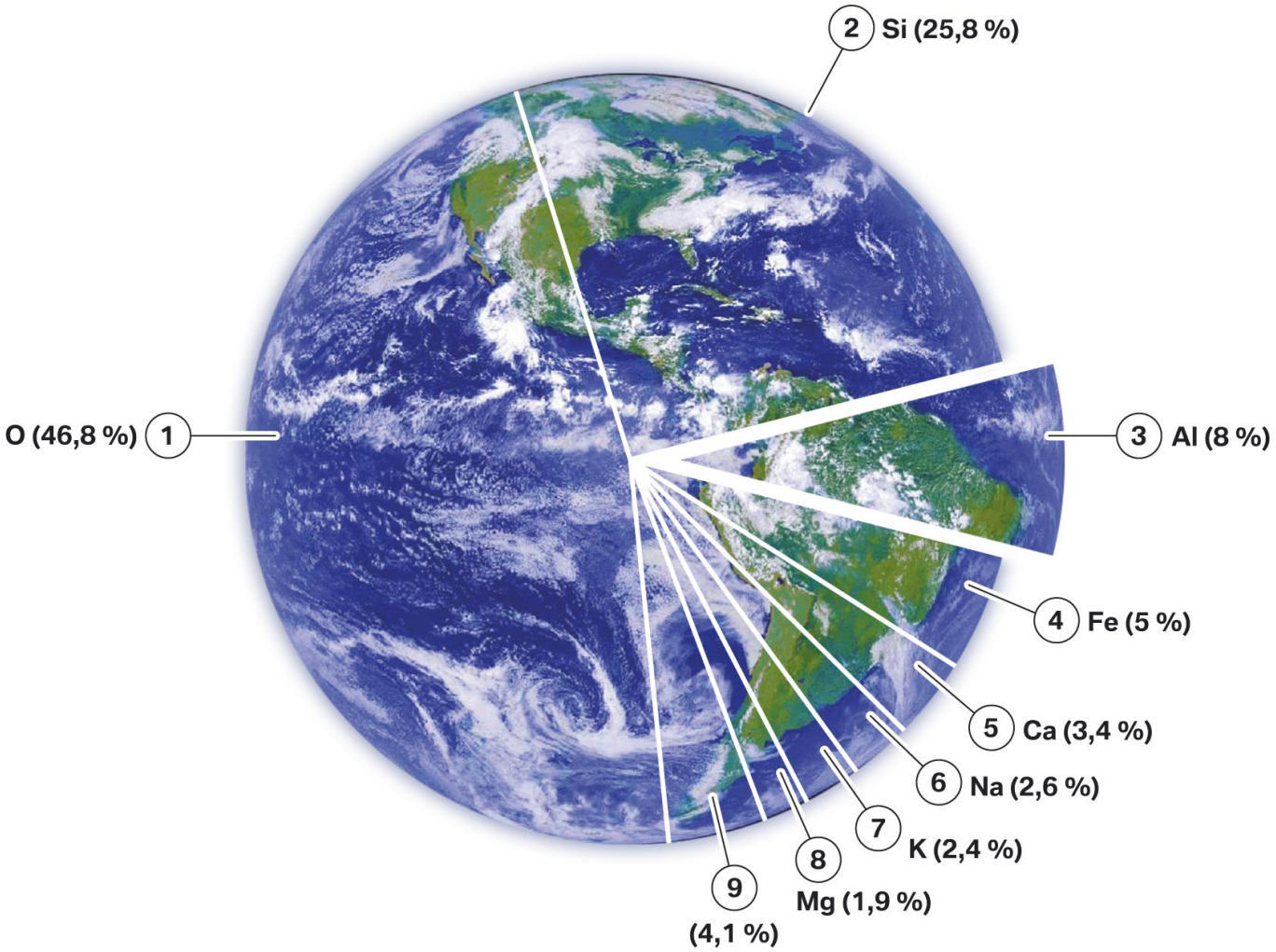
Well known to designers for its low density, Aluminum is easily formable, and has the ability to resist corrosion through a process known as passivation. Passivation refers to a chemical process whereby a material becomes "passive," that is, being less affected by environmental factors such as air, oxygen, or water. It involves the formation of a shielding outer layer of corrosion through the process of oxidation and occurs spontaneously in nature. This layer can also be applied as an electrolytic micro-coating (anodization) in a controlled environment. Aluminum oxide rapidly forms on the surface of aluminum and acts as a natural passive coating. This information will become important when the technician is preparing a bare aluminum surface for repair or refinishing.

Aluminum alloys are some of the easiest metals to form and machine. During forming processes, however, the metal needs to be first softened (annealed) before it can be formed. It can then be heat treated after forming to exhibit the desired strength. Aluminum and its alloys are nontoxic, and are among some of the easiest structural materials to recycle. Aluminum dust becomes readily airborne and should not be inhaled. Aluminum "fines" (aluminum dust particles smaller than 420 microns) are quite combustible and may become explosive.

BMW 5 Series G30



Distribution of elements on the earth



Index	Element and Symbol
1	Oxygen (O)
2	Silicon (Si)
3	Aluminum (Al)
4	Iron (Fe)
5	Calcium (Ca)
6	Sodium (Na)
7	Potassium (K)
8	Magnesium (Mg)
9	Other Elements

ALUMINUM ALLOYS

There are seven basic groups of aluminum alloys. Like steels, the base metal (aluminum) is combined with one or several metals depending on the properties desired of the alloy. The resulting alloy may exhibit considerable differences in strength, formability, or weldability.

Alloy selection is dependent on the manufacturing procedure and the final application of the component. Most cosmetic panels found on BMW vehicles use 5000 or 6000 series alloys.

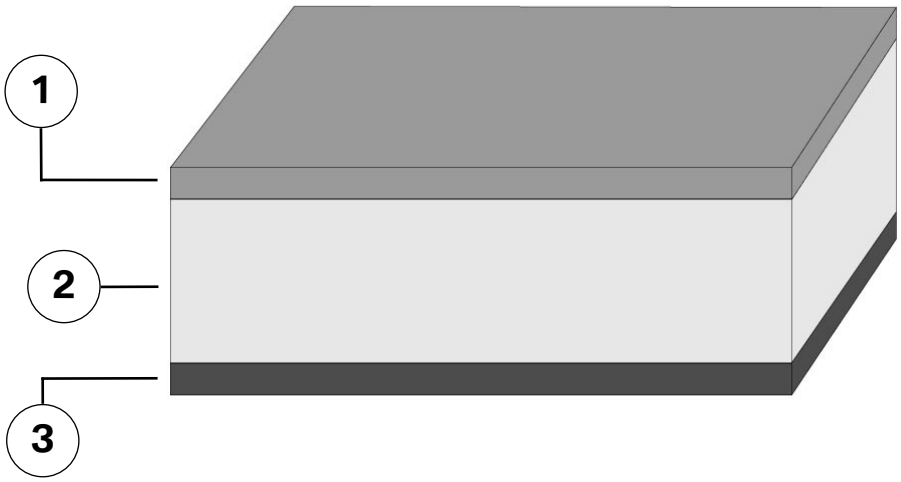
Alloy Group	Alloy Material
1000	Pure Aluminum
2000	Copper
3000	Manganese
4000	Silicon
5000	Magnesium
6000	Magnesium and Silicon
7000	Zinc

Although BMW uses some of these alloys in aluminum castings and extrusions, this program will focus on the characteristics of wrought aluminum. Wrought metal is a solid material that has been bent, hammered, stamped, or physically formed into the desired shape.

More recently, BMW has been using a sheet product composed of multiple alloy layers known as “core and cladding”. The core and cladding exhibit different characteristics. This material has several benefits:

- Down-gauging (thinner material with the strength of thicker materials)
- Lightweighting
- High strength
- Durability
- Corrosion resistance
- Formability during manufacture
- Damage-resistant surfaces
- 100 percent recyclable

Core and cladding construction



Index	Explanation
1	Outer layer
2	Core
3	Outer layer

These new core and cladding alloys have strict repair guidelines and can be damaged permanently if not handled properly:

- Welding is not permitted
- Softening temperatures must be kept low; Annealing is not permitted
- Metalworking guidelines must be followed
- Excessive grinding or filing should be avoided

MODEL USAGE

Aluminum outer body panels can be found on virtually all BMW models starting as early as the F01, with its usage sure to expand. Please refer to ISTA/Air Group 41 or the vehicle specific complete vehicle reference manual to identify BMW vehicles with outer body panels formed from aluminum.

MATERIAL PROPERTIES

THERMAL EXPANSION

Aluminum expands twice as much as steel. It conducts heat more readily and is easily distorted when heat is applied. This is one of the reasons why aluminum requires much more energy to weld. This poses a greater challenge with composite materials, as well as the new core and cladding alloys, since the expansion rates of the two alloys will be different. The clad aluminum will rapidly distort when subject to excess heat.

Another challenge is that the surrounding areas heat up rapidly when the panel is exposed to localized heat, causing the heat to travel over a much greater surface area than on a steel panel.

ELECTRICAL CONDUCTIVITY

Pure aluminum conducts electricity about four times better than carbon steel. The conductivity of aluminum, measured in Siemens, is about 38 million Siemens per meter. The electrical conductivity (at room temperature) of carbon steel is about 6 million Siemens per meter. Aluminum alloys can have much lower conductivities, but will be rarely as low as iron or steel. Note, however, that aluminum oxide acts as an insulator and will inhibit the flow of electrons.

Aluminum has 59% of the electrical conductivity of copper yet is 30% as dense. On a pound-for-pound basis, aluminum is a better conductor. Aluminum conductor sizes must therefore be larger to carry the same current loads as copper wires. These larger diameter conductors are still lighter than copper even though the conductors may have the same current flow capability (ampacity).

WORK HARDENING

Aluminum alloys work-harden much quicker than steel. That is, the aluminum panel's crystalline structure is altered and the material becomes more brittle when it is deformed. If steps are not taken to anneal or soften the aluminum before metalworking is performed, stress cracking can occur.

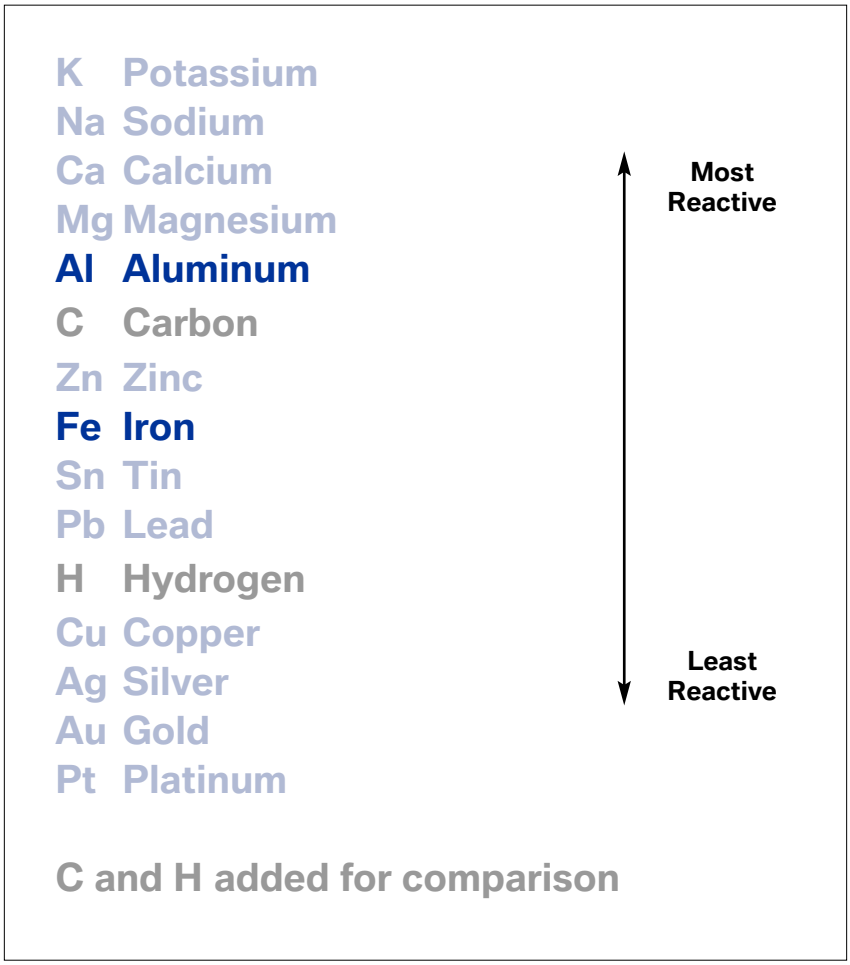
CORROSION

One of the primary chemical differences of metals is the ease in which the metals undergo chemical reactions. Corrosion is a chemical reaction whereby a metal reacts with oxygen. Galvanic corrosion occurs when two dissimilar metals are placed in contact with each other.

This is an electro-chemical process. The more chemically reactive metal corrodes when both metals are connected electrically and immersed in an electrolyte. Salt water is an excellent electrolyte and will increase the corrosive effects.

Aluminum is more chemically reactive than iron, the primary ingredient in automotive steels. Consequently, when aluminum and steel are in contact with each other and an electrolyte is present, the aluminum will corrode. This is commonly referred to as sacrificial corrosion. The aluminum "sacrifices" itself as the steel panel undergoes no chemical change until the aluminum is completely consumed. Steel galvanizing works in the same fashion but utilizes zinc as the sacrificial anode.

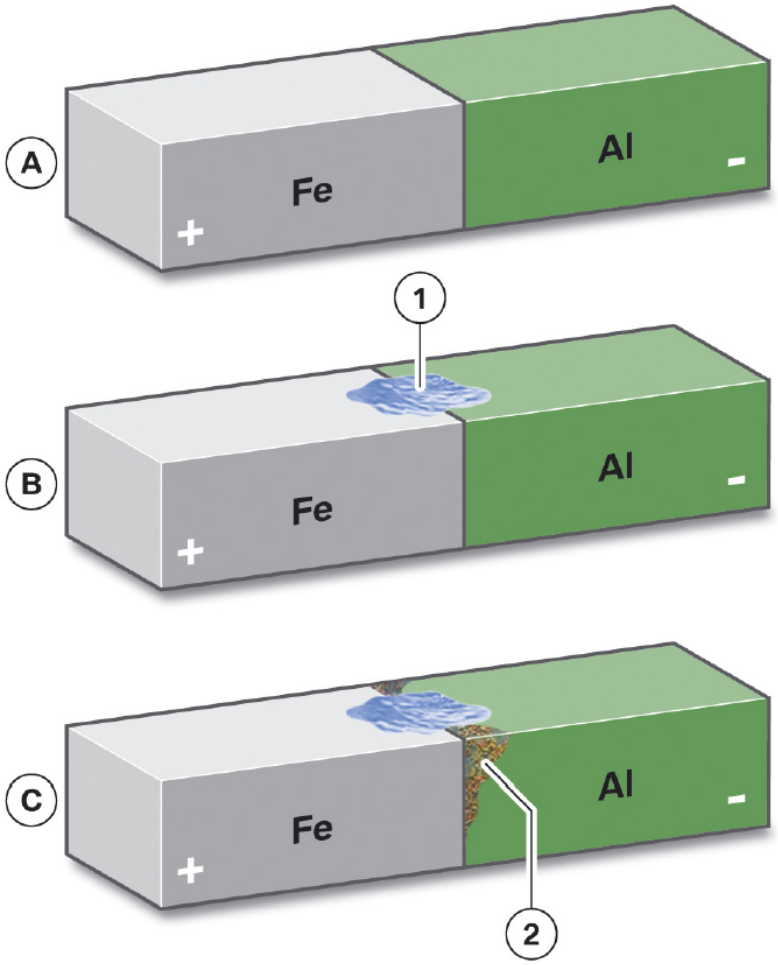
Reactivity of metals



Great care must be exercised when working with aluminum, either cosmetic or structural, to prevent the aluminum alloy from becoming contaminated with steel, or other less reactive metals, including zinc galvanized metals. Surface contamination will lead to galvanic corrosion.

As you can see in the following illustration, when aluminum (Al) and steel (Fe) come in contact and an electrolyte such as water is introduced, corrosion forms.

Aluminum will also corrode (oxidize) when exposed to oxygen in the atmosphere or in a liquid, such as water, where it goes through the process known as chemical corrosion. The exposed aluminum quickly forms an oxide layer that can be identified by its dull gray color. Once formed, this aluminum oxide layer is extremely resistant to corrosion and can protect the base metal from further corrosion until it is removed.



Index	Explanation
Fe	Iron
Al	Aluminum
A	Compound of iron and aluminum
B	A conductive fluid,electrolyte, gets into the gap
C	The less precious aluminum corrodes
1	Electrolytic fluid
2	Corroded area

Technicians must take the appropriate steps to safeguard against placing aluminum in direct contact with steel, or contaminating the aluminum alloy with steel particles from metalworking or welding operations. Contamination can be introduced by welding steel panels in close proximity to aluminum and not protecting the aluminum from weld spatter; sanding and grinding operations; performing repairs to steel components in close proximity to bare aluminum, and by using contaminated tools such as files, drill bits, sanding and grinding discs, wire brushes, and non-woven abrasives.

Technicians should also be cautious about bolting together steel and aluminum components. There is typically an isolating layer of material on the fasteners that will help minimize galvanic corrosion. Many bolted-on aluminum components employ one-time coated steel fasteners for securing parts. Always follow BMW service procedures as outlined in ISTA or AIR when servicing aluminum bolt-on components.

JOINING METHODS

On BMW vehicles, aluminum can be joined to the vehicle structure using several processes known as:

- Firmly Bonded
- Positive Locking
- Frictional Locking

Firmly Bonded panels are joined by fusion (welding), soldering, or with adhesives. The fused joint would need to be destroyed during panel separation. At this time, welding is not permitted on BMW vehicles, with the exception of the Z8. As such, aluminum welding will not be covered in this program.

Positive Locking joints use self-piercing punch rivets or blind rivets for fastening the panel. Riveted joints are almost always accompanied by an appropriate adhesive.

Since this program only addresses outer body panel service, the method of joining we will be concerned with is Frictional Locking: fastening components with threaded hardware (bolts, nuts, and screws). The exception to this are the aluminum roof panels found on some BMW models that are bonded to the roof frame with adhesives and would be considered to be Firmly Bonded in place.

Moto GP Safety Car

TOOLS AND EQUIPMENT

TOOLS FOR ALUMINUM WORK

Many conventional body straightening tools such as hammers, dollies, paintless dent repair picks and levers, "duckbill" spoon dollies, and abrasive wheels can be used for repairing aluminum surfaces with some precautions. Tool selection, surface condition of tool, surface smoothness, and tool cleanliness all need to be addressed to prevent cross-contamination and damage to the base metal from gouging or work-hardening.

Tools that will come in contact with aluminum components must be properly prepared and stored. Technicians must be ever-mindful of the potential for cross-contamination from steel particles. Proper tool selection will also help minimize the effects or work-hardening during straightening operations as well.

General Precautions

- Avoid using any tools with sharp edges and nicks; tool edges and striking faces should be properly prepared and polished.
- Do not use any tool showing signs of surface corrosion (red oxide); all corrosion must be removed before use.
- Always inspect aluminum repair tools closely before use to assure readiness.
- Do not drop aluminum straightening tools on a hard surface or the shop floor.
- Avoid tool contact with water.
- Wipe steel tools with an oily rag before storage; clean surfaces with denatured alcohol or a non-solvent wax and grease remover before use.
- A stainless steel wire brush can be used to clean a tool, anchoring clamp, or fixture that was used to repair steel; avoid using tools that cannot be properly cleaned before use.
- Select PDR tools carefully; tool faces used to apply pressure should distribute pushing or prying forces over a larger area than when repairing steel.
- Periodically touch up and re-polish aluminum body repair tools.

Body Hammers

- Do not use milled-face shrinking hammers.
- While pick hammers can be useful for removing small imperfections, blunt picks with smooth surfaces are preferred.
- Avoid hammer faces with highly curved (convex) profiles.
- Plastic mallets as well as non-marring tools can be effective.
- Teardrop-shaped rawhide or UHMW plastic mallets are effective for bumping larger areas of aluminum.

Dollies

- Shot dollies, plastic dollies, and rubber-clad steel dollies work well with aluminum.
- Hardwood blocks are also effective tools for shaping aluminum.
- Flat spoons and duckbill dollies can be helpful when used for stress relieving.
- Standard body repair dollies (heel, toe, general purpose, flat or “comma” dollies).

A typical selection of hammers and dollies

Slapping Spoons

Slapping spoons can also be used effectively for basic straightening tasks and for relieving stress. These tools are good at spreading, bumping or hammering forces over a larger surface area. Slapping files work well with steel because the serrations tend to work like a milled-faced shrinking hammer. This works against the slapping file when used for straightening aluminum as slap files will work-harden the aluminum. Slapping files should not be used to hammer aluminum panels.

The primary advantage of a slapping spoon is that it distributes hammering forces over a larger area with each blow. Slapping spoons can be used with dollies for stress relief.

Slapping spoons

PAINTLESS DENT REPAIR TOOLS

Paintless dent repair (PDR) tools can be used for metalworking to remove small dents, medium sized dents, and imperfections. While refinishing may not be needed in some cases, the goal is to restore the panel to within 2.0mm using PDR tools and then finish with cosmetic body filler.

PDR tool set

PDR tools will also need to be prepared for use with aluminum. Tool surfaces should be inspected and polished. PDR tools should have rounded or soft contact points. Here are some guidelines and precautions when selecting and preparing PDR tools for use with aluminum.

- PDR tools should be properly polished, cleaned of any residue, and maintained if they will be used on both steel and aluminum panels.
- PDR tool faces and contact points should be inspected and prepared for use with aluminum the same way that hammers and dollies are prepared.
- Like all other aluminum body repair tools, PDR levers and wire tools should be stored separately away from tools used to repair steel panels.
- Use tools with smooth or rounded faces. PDR levers are available with rubber faces which are suitable for aluminum use.
- A heat gun may be used to warm the panel before straightening begins. Monitor surface temperatures with an infrared thermometer as the panel is heated. Do not exceed a panel temperature of 60°C (140°F).
- Wire PDR tools can be used in some areas inaccessible with standard PDR lever tools.

PDR tools with plastic/rubber/nylon tips

TOOL PREPARATION

Before attempting to repair any aluminum body panel, tools must be prepared for use. This generally involves:

- Initial Shaping
- Sanding and Smoothing
- Final Polishing

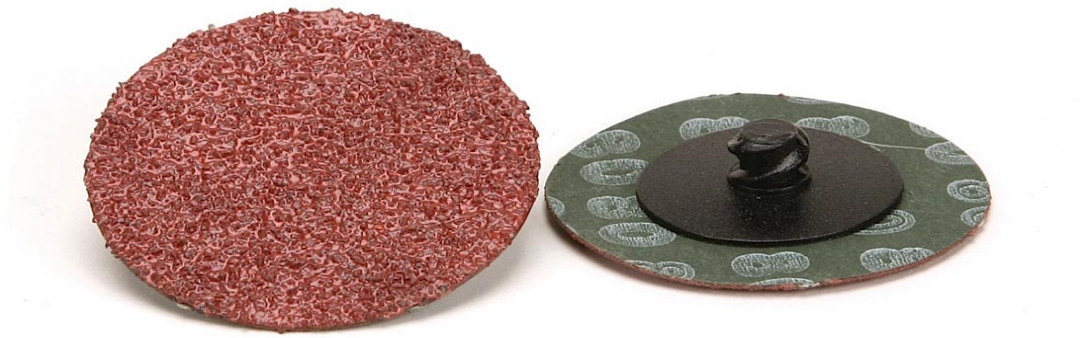
Preparation Basics
Before preparing tools for use with aluminum, you will need:

- Personal Protection Equipment such as a particulate respirator, safety goggles or a face shield, and protective gloves
- Cleaner or degreaser
- Shaping tools such as an angle die grinder, random orbital (RO), dual action (DA) sander, and belt sander
- Assortment of abrasive discs, sanding discs and sandpaper
- Automotive polishing compound
- Bench vise or other means of clamping to secure the tool that is being prepared

Initial Shaping

Begin the process by cleaning the tool to be prepared with a stainless steel wire brush, followed by a thorough degreasing. Remove all traces of degreaser, then inspect the surface to be prepared. If no imperfections can be found, start by softening (rounding) any hard or sharp edges. Begin with an 80-grit disc on the angle grinder and round any sharp edges to a bend with a radius of about 2.0-3.0 mm. To start the process, grind the edge at a 45° angle until a 3mm flat edge appears. Rounding can progress from here.

Abrasive Disks



If a new hammer is being prepared, the technician can proceed to the Sanding and Smoothing stage. For tools that have been in service, look for any pits, surface rust, and deep gouges or scratches. If gouges are present, shape with 80-grit abrasives first using the angle grinder. If the gouge is very deep, 50-grit abrasive wheels may be used. Coarse grit discs should be avoided as the deep scratches produced by these aggressive sanding tools will be more difficult to remove.

If a coarse 50-grit grinding disc had to be used, finish the shaping process with 80-grit grinding disc before moving to the sanding and smoothing step.

Before Shaping

After Shaping

Sanding and Smoothing

For the next step, switch from an angle die grinder to an RO sander, DA sander, or a belt sander. Start the process with 80-grit abrasives, progressively utilizing finer grades of abrasives. Do not skip abrasive grits during this process. As an example, if a technician jumps from 80 grit to 180, the 80 grit scratches may eventually be removed, but it will take a considerable amount of time and will waste sandpaper.

The grit progression should be:

Grit Selection	Explanation
P80	Coarse ↓ Fine
P150	
P180	
P240	
P320	
P400	

As the technician approaches 400-grit, the metal will become more reflective. Above 320-grit, the process starts to become one of removing fine scratches, polishing, and honing.

After sanding

Final Polishing

To complete the polishing process, the tool being prepared should be fine sanded. The final sanding can be performed either wet or dry. If wet sanding will be used, start the final preparation step with 600-grit wet/dry sandpaper and water. To finish, wet sand with 1200-grit. If a DA or RO sander will be used to dry-sand, a P800 sanding disc or sanding mesh works well. Finer grits can be utilized to produce a mirror-like finish.

As an intermediate step, a white non-woven abrasive or very fine abrasive disc can be used immediately before fine sanding and polishing.

The final metal polishing is performed with either a lambs wool buffer polishing pad, a felt polishing belt mounted on a bench top belt sander, a 2" or 3" felt buffing pad, or a spiral-sewn multi-ply 100mm buffing wheel. Spiral-sewn wheels are typically mounted on 1/4" mandrels and can be chucked in a drill. Use caution when polishing hand-held dollies.

Felt buffing pad

Automotive polishing compounds are preferred over jewelers rouge, which is a red buffing compound that contains ferric oxide. Jewelers rouge should not be used on or near bare aluminum, or tools that will come in contact with bare aluminum surfaces.

Polished and ready for aluminum use

SPECIALIZED DENT REMOVAL SYSTEMS

There are several specialized dent removal and panel repair systems available for working aluminum. These systems fall into three broad categories:

- Stud Welders
- Adhesive Pullers and Pulling Knobs
- Alu T-Hotbox

The stud welder and pulling systems generally include specialized leverage tools for applying straightening force, to pulling adapters that have been welded or glued to the damaged panel. Force can be applied by squeezing levers or by applying force with a screw. While some panel repair kits include slide hammers, this repair method is generally reserved for special applications as it tends to weaken glue studs and may possibly tear holes in the base metal when welded studs are overstressed or removed. The Alu T-Hotbox uses electronics and resonant frequencies to remove damage.

Stud Welders

Stud welders can provide enough straightening force to restore a "soft" contour line. The BMW Group approved Alumet stud welder does not produce excessive heat or warm the panel surface over 60°C (140°F). When using the Alumet, studs must be removed with angle cutters then ground down. Attempting to remove the studs by form of "rocking" will likely result in tearing the panel. Never use slide hammers with welded-on studs due to the high probability of metal tear-out, thus creating more surface damage. With core and cladding construction, stud tear-out damage cannot be repaired; the panel must be replaced.

BETAG Alumet aluminum stud welder

Sanding and Grinding Panel Surfaces
Follow these guidelines when sanding damaged panels and removing topcoats in order to facilitate straightening with stud welding equipment:

- Never sand or grind aluminum panels with abrasives coarser than 80-grit.
- Do not sand with abrasives that have been previously used on steel panels.
- When working with aluminum, keep sanding speeds low. Use only clean stainless steel wire brushes if needed to remove oxides and to clean tool surfaces.
- Do not use abrasives that contain steel or iron.
- Keep all sanding discs flat to the panel to avoid deep gouging.

On freshly sanded bare aluminum surfaces, an oxide layer will form within 30 minutes. It is best to sand panels immediately before applying any types of coating.

Core and cladding panels are extremely sensitive to abrasion and gouging.

ADHESIVE PULLERS

Pulling attachments or studs are attached to the damaged surface with fast-setting hot-melt adhesives. The pulling stud or pull knob can be easily removed after straightening the panel. Any residual glue can be removed by applying denatured alcohol. In this application, many of the adhesives can be removed without causing damage to the vehicle's finish. This makes adhesive tools suitable for straightening applications when the underside of the panel cannot be accessed.

BETAG GP2 glue pulling kit

Adhesive pullers are suitable for medium damage repairs, as well as soft dents with no noticeable metal folds or creases. Adhesive tool kits can sometimes be supplied with slide hammers. The slide hammer is more suitable for applying controlled tensile force, than it is for delivering hammer blows.

Adhesive pullers typically come with an assortment of pulling knobs, having various tip profiles that can be used to repair different types of damage. The tool provider will indicate the intended usage in their technical information and product setup guide.

Adhesion is enhanced and pulling forces will improve when the topcoats are not removed and pull knobs are attached directly to a painted surface in good condition. Adhesives work best on smooth surfaces and do not develop strong bonds to bare or sanded aluminum surfaces. Adhesives do not bond well to electrodeposition primers found on BMW genuine replacement parts.

Adhesive repair systems are capable of exerting tensile forces close to those that can be generated with a stud welding system. The major difference is that many pulling knobs have large bases designed to provide adequate surface area for attachment. The larger bases may prevent close spacing of the pulling knobs.

ALU T-HOTBOX

Depending on the type of damage on the outside skin, it may be possible to use the Alu T-Hotbox. The Alu T-Hotbox has been specifically developed for use on aluminum panels and is now integrated into the aluminum repair process. It is important to understand and respect the parameters on how it works, and what the limitations are.

This system works differently from the carbon steel version due to the characteristics of aluminum. A few things to keep in mind are the high heat conductivity, the need to have a focused point, as well as the different varieties of aluminum. The tool first has to find the resonant frequency in respect of the material. For aluminum, this range is larger than on steel being that a precise energy is required. After this process, the surface skin effect is being used. This means the tools frequency activates the top layer of the material and thus causing it to expand. Because of the materials high rise or expansion characteristics, the effect is much better than on a steel panel. The other key working function is the vibrating impulse in the tool which helps the process.

BETAG Alu T-Hotbox

General use
The main effect of the tool is in the center of the tool. It is very important to keep the tool on the material. The following has to be considered:

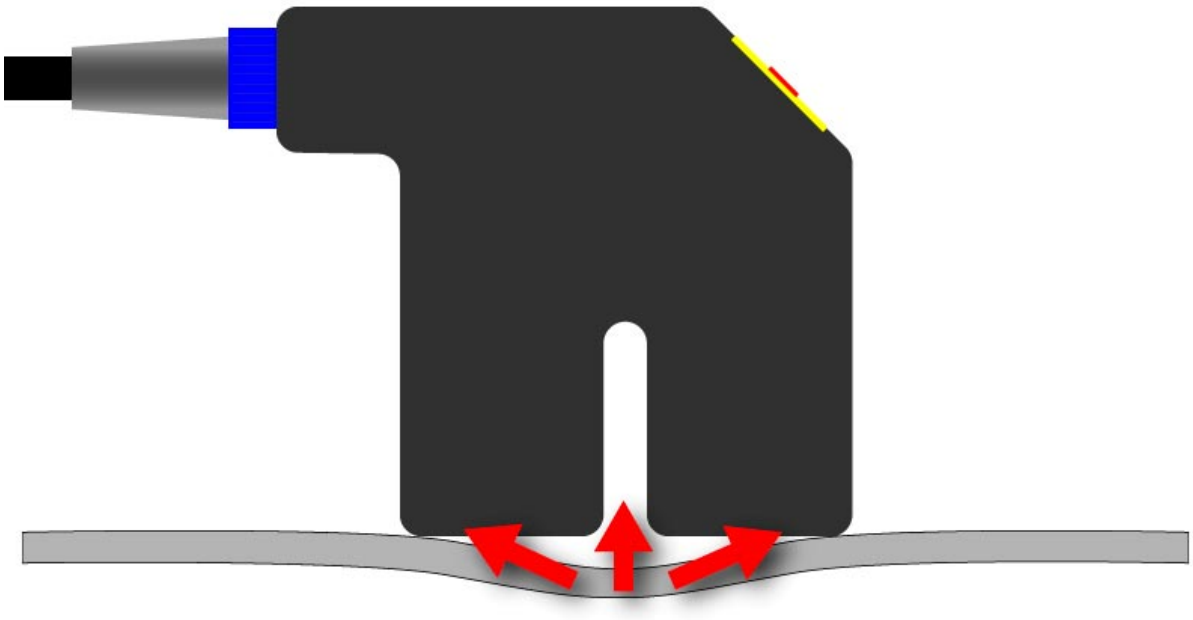
- It does not work on a negative curved area.
- It does not work on an area which has a glued brace behind it.
- If the dent is too large, there is a chance that the dent becomes larger. If this occurs, stop immediately, and let it cool off before trying it again.
- If you over apply the tool, there is a risk of damaging the coating.

With the Alu T-Hotbox, the power setting is always 100% if the time function is being used. The temperature effect or overheat is the key aspect to watch out for. This may happen very fast during the repair process. The paint thickness effects how far away the tool is to the metal which will impact panel temperature.

T-Hotbox Application
Alu T-Hotbox can be used for:

- Soft and medium dents
- Dent reduction of larger or sharper dents
- Area work or cleaning up an area that has been repaired by the dent removal tools or glue system.

Dent removal



The use of each applications
Soft, medium, or elastic dents can be repaired as long as the metal is not too far stretched and/or the main stress on the metal is not larger than the pulling force of the Alu T-Hotbox effect.

For dents that have a plastic deformation, dents which are larger, or dents where the center is stretched, the energy part (plastic deformation) of the dent can not be removed, as long as the main stress on the metal is not larger than the pulling force of the Hotbox

After repairing a dent with dent tool or the glue system, it is common that the general damaged area is still low, and may have some waves visible. This area can easily be brought up with the use of the Hotbox tool.

What to consider when using the tool

- Move from the outside to the center of the dent.
- Do not move behind of the center of the dent.
- Do not press down or apply pressure.
- The more aggressive during the pulling the better
- Hold the tool flat to the surface.
- Do not apply the tool too long as this may damage the coating.

TOOL STORAGE

Aluminum repair tools should be stored in a separate tool trolley. These special tools should be isolated from contacting each other during storage. This will help preserve the smooth surfaces achieved during tool preparation.

Aluminum repair tools as well as a dedicated aluminum tool storage cabinets are available through the BMW Parts System.

Tool set for aluminum processing

METALWORKING TECHNIQUES

Because of the tendency of aluminum to quickly work-harden and for damaged metal to require a larger bending force to be applied to straighten the distorted metal than was required to deform it, the technician needs to utilize straightening techniques that will not “lock in” damage and that will minimize the tendency of the aluminum panel to crack or tear during repairs.

DAMAGE ANALYSIS

Before repairs begin, the technician and advisor need to assess the extent of the damage. Damages cannot not be welded. This will permanently damage the panel and will cause a considerable amount of panel warpage. Certain types of damage may also be difficult to repair due to the location of the impact. Additionally, the panel must be restored to within 2.0mm of its original shape before cosmetic filler can be applied. If the damage resulted in considerable deformation and metal stretching, panel replacement may be indicated.

Damage that cannot be repaired:

- Cracked or torn aluminum
- Deformations to the panel that cannot be restored to within 2.0mm of the original shape
- Damage that has compromised interior bracing or reinforcements

Damage that is difficult to repair:

- Damage to a sharp body contour line
- Damage to door panels near the beltline
- Damage that resulted in the formation of sharp edges or folds in the metal

If PDR is being considered, access to the back side of the damaged area must be available. Damage centered over a bonded inner reinforcement cannot be properly repaired using PDR tools. Even with specialized dent removal tools, repairing this damage may be difficult or even impossible if the inner reinforcement has been damaged.

Clean The Panel Underside Before Repairs Begin

All traces of sound deadening material must be removed from the area to be straightened before metalwork begins. BMW has a special service tool used for removing seam sealers that works very well for removing solid-bodied sound deadening materials. Replace any material that has been removed after repairs are complete.

METAL SOFTENING

If the damage has softer contours, and is confined to a small area (less than 50mm in diameter), the technician can apply force and begin the stress relieving process. For larger areas and for more extensive damage, metal softening may be required.

Annealing is typically employed when repairing aluminum sheet metal. This softens the metal and helps remove any residual stress due to work-hardening.

In metallurgy and materials science, annealing is a heat treatment that alters the grain structure of a material to increase its ductility and to make it more workable (softer). Annealing involves heating material above its critical temperature, maintaining a suitable temperature, and then cooling. Annealing can induce ductility, soften material, relieve internal stresses and improve cold working properties. Annealing aluminum requires the application of heat to increase the temperature of the base metal to 205°C (400°F).

The annealing temperature of aluminum is well beyond the critical temperature established by BMW for its core and cladding alloys.

BMW has found that heating the base metal to 60°C (140°F) helps relieve internal stresses and improve ductility and malleability. Aluminum should be allowed to cool naturally; do not quench or quick-cool aluminum with compressed air after the application of heat.

To heat the panel, a controllable heat source and a hand-held infrared (IR) heat sensor (a digital thermometer), are required. Start by directing the heat at the edges of the damage and slowly working the heat gun in a circular motion in smaller circles, finally directing hot air towards the center of the dent. Monitor metal temperature with the IR sensor. To help lessen the potential for cracking, all damaged panels should be softened before repairs commence and occasionally during the repair.

Heatgun

Infrared thermometer

Infra-red (IR) temperature measuring tool
Often used but has several disadvantages. The aiming beam of the tool is not always precise, especially if it is used near the heating tool. It can also measure the heating tools temperature. High temperature disbursement makes it difficult to get an exact reading.

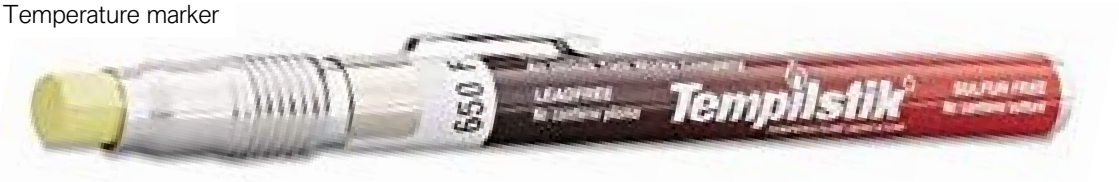
In addition to the IR thermometer, there are other methods available to measure the temperatures.

Temperature Tape
An adhesive backed thermometer can be applied to the surface of the panel. This approach is cost effective, but is slow to react to temperature changes.

Stick on thermometer

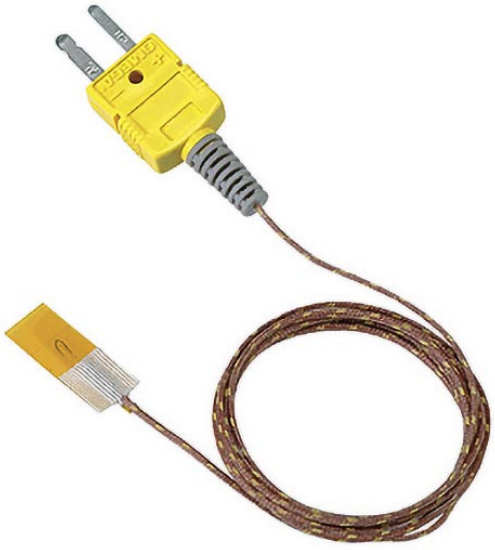
Temperature Pen or Marker
A pen or marker type is suitable, but has to be applied several times during the repair process. Once the marker has reached its temperature band, it will not work anymore, and therefore needs to be applied again.

Temperature marker



Surface Mount Thermocouple
Thermocouples are often used in laboratory conditions and can be extremely accurate and fast acting. Cost, complexity, and the required use of a reading device may limit their usability.

K-Type Thermocouple



STRAIGHTENING TECHNIQUES

Straightening techniques and tool selection will be determined by several factors:Type of damage and its severity

- Location of the damage
- Ease of access to the back of the damaged panel
- The presence of reinforcements or braces

If the back of the damaged panel can be accessed, a hammer and dolly may be the first choice for damage repair. If backside panel access is hindered because of tight fitting adjacent panels or the body structure, paintless dent repair tools or specialized straightening systems (stud welder or adhesive puller) should be considered. In cases where the damage is directly in front of a bracing or reinforcing member, the damage will need to be closely examined. Damage to reinforcements usually indicates that panel replacement is required. In situations where the reinforcements have not been stressed or bent, pulling tabs may be the only option for applying straightening forces.

Use care when performing metalwork around inner braces and reinforcements. These braces may be attached to the panel with an anti-flutter foam or other low tensile strength adhesive. All panel foams, sound deadening materials, and panel bonds must be inspected after the metal has been repaired.

HAMMER AND DOLLY

For smooth faced depressions, bumping with the rounded face of a general-purpose dolly can be beneficial. The slightly rounded face can be used to straighten the damaged aluminum panel and roughly get it back into shape. Tapping a depressed area with the face of a dolly helps distribute the forces being applied over a larger surface area. Dollies can also be beneficial when clearances are tight and there is inadequate clearance for to swing a hammer for roughing out damage.

Dollies are quite effective for stress relieving the metal. Because of the malleability of aluminum, care must be exercised when using a hammer and dolly when applying compressive forces. Working directly over the dolly may thin the aluminum and cause work-hardening to occur very quickly.

There are two basic types of metalworking techniques when working with a backing plate such as metal dolly:

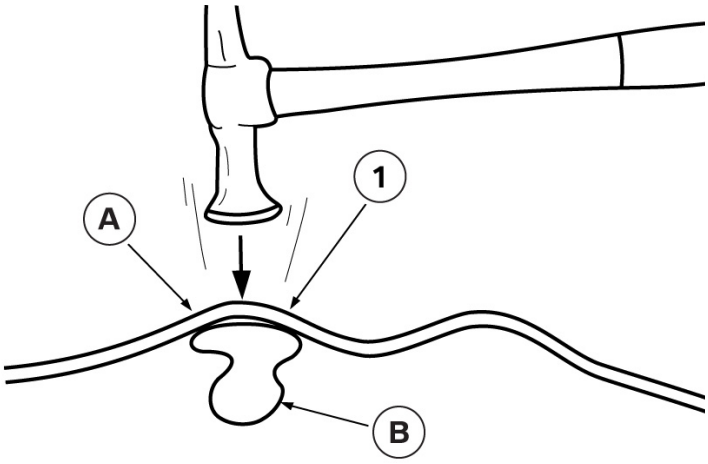
- On-dolly hammering
- Off-dolly hammering

To help minimize the possibility of stretching, thinning, and distorting the aluminum, off-dolly techniques are generally favored. On-dolly hammering should always be done with reduced hammering force.

On-dolly hammering is typically used during the final straightening steps. When working a low area, do not use a pick hammer or any hammer profile with a small contact area while working over a dolly. Keep the hammer face parallel to the work surface, and strike the metal with the flattest area of the hammer. To minimize the potential for thinning or distortion when working on-dolly, use sweeping strokes when striking the surface.

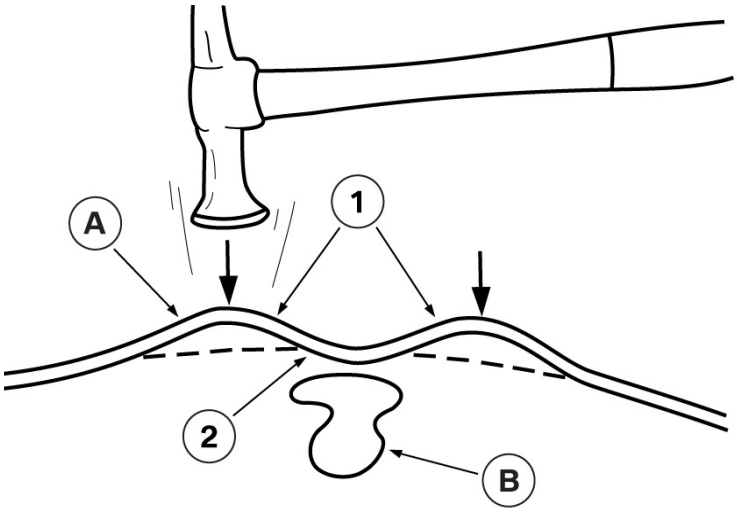
Small, high spots can be removed by striking high spots in the center with a rounded pick hammer backed by a dolly. Work slowly and deliberately, using very low striking force.

Hammer on-dolly technique



Index	Explanation
A	Metal crushed between hammer and dolly
B	Dolly under high spot
1	High spot

Hammer off-dolly technique



Index	Explanation
A	Tap down high spots with hammer
B	Rebound dolly off of low spot
1	High spot
2	Low spot

Slapping Dollies and Broad-faced Spoons

These tools excel at spreading the striking force over a very large area. This is especially useful when stress relieving a ridge or crease surrounding a depressed area. When striking the surface, keep the surface flat and avoid striking with the edges of a slapping dolly or a broad-faced spoon. The slapping dolly or spoon can be used to hammer directly off-dolly, but it may be best to use glancing or sweeping blows when working directly over a dolly.

In the past, slapping files were used on steel vehicles when there was adequate base metal to allow shaping of the metal and metal finishing by filing instead of using cosmetic fillers. High spots and surface irregularities were removed with a coarse body file and then finished with a slapping file. Because of the nature of today's steel and aluminum cosmetic body panels, do not strike aluminum with a slapping file or remove any metal from an aluminum outer body panel with body or slapping files.

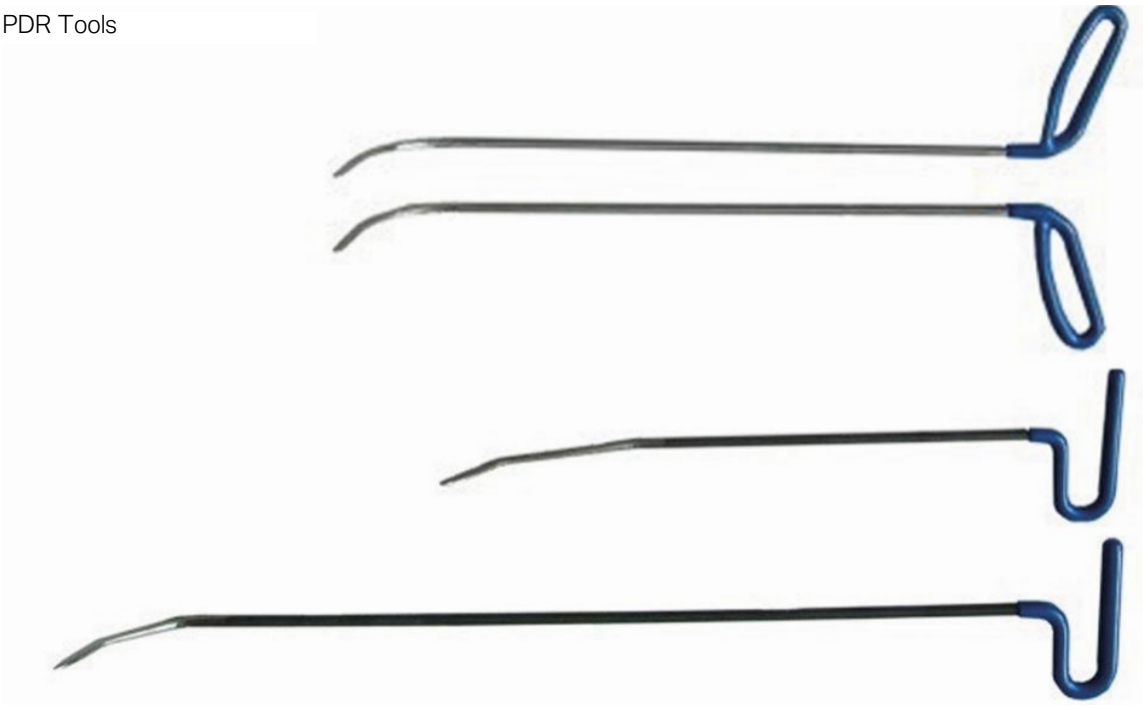
A slapping file can be used with great care to identify high and low spots. Do not remove high metal areas with the file. The file will either remove or dull paint and primer coatings in areas that are still high and leave topcoats untouched in depressed or low areas.

Like body hammers, duckbill spoons can be used with either On-dolly or Off-dolly hammering or sweeping techniques. Again, strike the panel with the wide, flat section of the tool; do not strike the panel with the edge or the tip of a slapping dolly or a broad-faced spoon dolly.

PAINTLESS DENT REPAIR TOOLS

Paintless dent repair (PDR) tools can also be used to remove small imperfections from aluminum. Tool selection, tool suitability, and preparation are important.

PDR Tools



While refinishing may not be needed in some cases, the goal is to restore the panel to within 2.0mm using PDR tools and then finish with cosmetic body filler. With care, the painted surface will remain intact, but again, PDR tools are used primarily to help restore the base metal to a surface smooth enough for the application of a filler.

All of the guidelines for repairing steel body panels apply to aluminum with the following notable exceptions:

- Use about 30% more pushing techniques as opposed to twisting or prying.
- Apply force gently yet firmly. Aluminum tends to resist initial straightening forces. Internal stress may release quickly, causing a high spot that may result in damage to the metal, painted surface, and substrate.
- To aid stress relieving, apply low heat with a heat gun before straightening begins. Monitor surface temperatures with an IR thermometer as the panel is heated. Do not exceed 60°C (140°F).
- A plastic knockdown tool or other soft striking device helps relieve internal stresses without damaging painted surfaces.

Adhesive Repair Systems

Adhesive repair techniques provide technicians with an alternative to conventional straightening methods using hammers, dollies, or PDR tools. Adhesive repair tools work best on soft damage (no discernible creases) that result in shallow depressions. Adhesive repair can be utilized for straightening medium damage that may require the application of conventional cosmetic fillers. Adhesion of pulling knobs or attachment studs is enhanced when pulling fixtures are adhered directly to painted surfaces. Do not remove any damaged paint at this stage of the repair.

Adhesive repair hand puller

Most adhesive repair tool systems are available with a hand puller that applies force by either using a lever or turning a screw. Many systems also come with a slide hammer. The slide hammer may be quicker for repairing small dents, but pulling knobs are easily detached from the painted surface if too much striking force is applied. Lever or screw-type hand pullers are easier to control and will work with deeper dents.

Most adhesives are applied with a hot-melt glue applicator. The adhesive may have a usable temperature range. In general, hot-melt adhesives do not develop maximum tensile strength if the panel is too hot or too cold. Some adhesive repair system suppliers provide different glue sticks for different temperature ranges. Follow the manufacturer's guidelines for adhesive selection.

Many glue sticks melt above 100°C (212°F). Certain glue applicators can become very hot. Wear approved PPE when working with these tools.

Adhesives develop the highest tensile strength when allowed to cool before any pulling force or pressure is applied. In general, one to two minutes of cooling time is adequate with many glue products. Again, follow the manufacturer's recommendations.

If an adhesive repair process is to be used, follow these guidelines:

- Become familiar with the various pulling knobs or studs supplied by the tool manufacturer. Many pulling studs are supplied in various shapes, diameters, and face profiles.
- Use only the adhesive supplied with the kit or specified by the tool supplier.
- Practice on scrap metal before attempting a repair on a customer's vehicle
- Allow adequate cooling time before applying pressure.
- Have release agents or cleaning solutions available before attempting any repairs.

ALUMINUM STUD WELDERS

The BETAG Innovation Alumet stud welder is approved by BMW Group for use on aluminum panel vehicles. This system uses threaded studs for attachment of pulling loops and fixtures. The Alumet features a separate grounding connection that must be affixed to the work piece. The grounding connection should be attached close to the damaged location where studs will be welded.

Like adhesive systems, the aluminum stud welding system is available with pulling fixtures and leverage tools. The system includes pulling bars that can be attached to several studs at one time.

After repairs have been completed, the studs can be removed by cutting off with a diagonal cutter. The remaining stud material can then be carefully ground down. If the remaining stud material must be ground down, exercise extreme caution so the core and cladding material is not damaged or gouged. The studs should not be removed by rocking back and forth as this has a high chance of creating a tear in the material.

One-time use studs for aluminum stud welder

Here are some guidelines for working with aluminum stud welders:

- Set up and test the stud welder settings using a piece of scrap metal that has the same physical properties as the vehicle being repaired. Do not experiment on the vehicle.
- Always use the lowest welder setting that will provide adequate grip and tensile strength.
- Clean off any oxide coatings from the studs as well as the vehicle surface to be repaired. Aluminum oxide acts as an insulator and will prevent solid attachment.
- Studs are one-time use only. Discard any used studs.
- If a slide hammer is provided as a pulling fixture, apply hand pressure only. DO NOT slap the hammer; tear-out may result.

Stud welded on aluminum panel

The aluminum stud welder should only be used as a last resort for removing damage. Always use the least invasive approach to removing the damage. It may be necessary to use a variety of methods to repair a large dent.

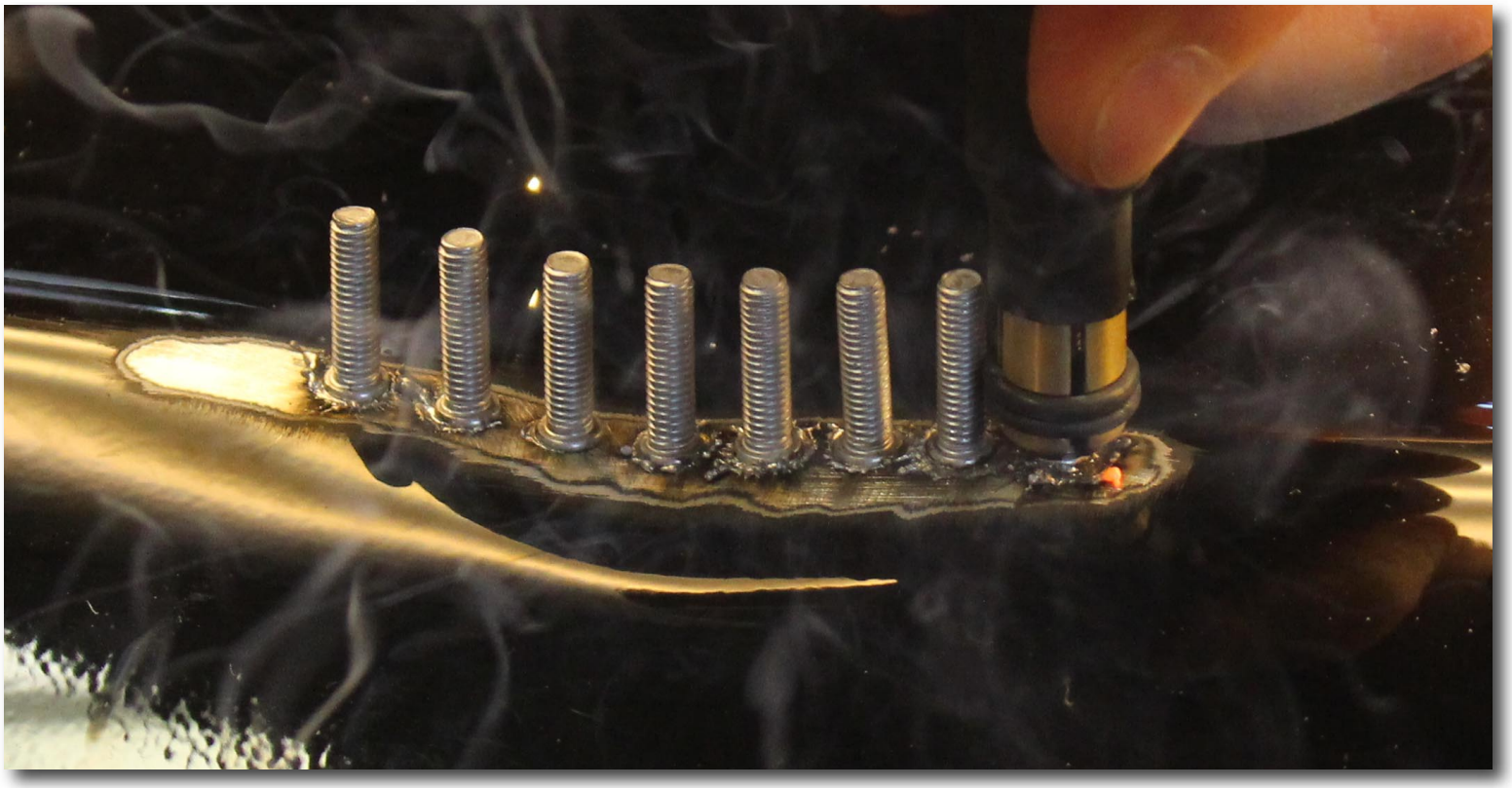
Typically, with larger dents, the stud welding system is being used. On one side, it has the advantage of being able to work only from the outside. Therefore, any “no access” area is not a problem. Next to that, damages over edges or bodylines can be repaired, as well as deep damages. In many cases, using a combination of systems in the repair process will be necessary. Before starting with the stud welding process, the previous modules have to be considered. Ideally, practice on medium panel straightening training before starting with the stud system.

Stud welding process
In general, due to the wide variety of aluminum alloys, different aspects have to be considered when stud welding. Overall, there are two types of studs being used.

- AlSi (Aluminum Silicon)
- AlMg (Aluminum Magnesium)

For repairs on BMW vehicles, use AlSi.

Studs being welded on damaged area



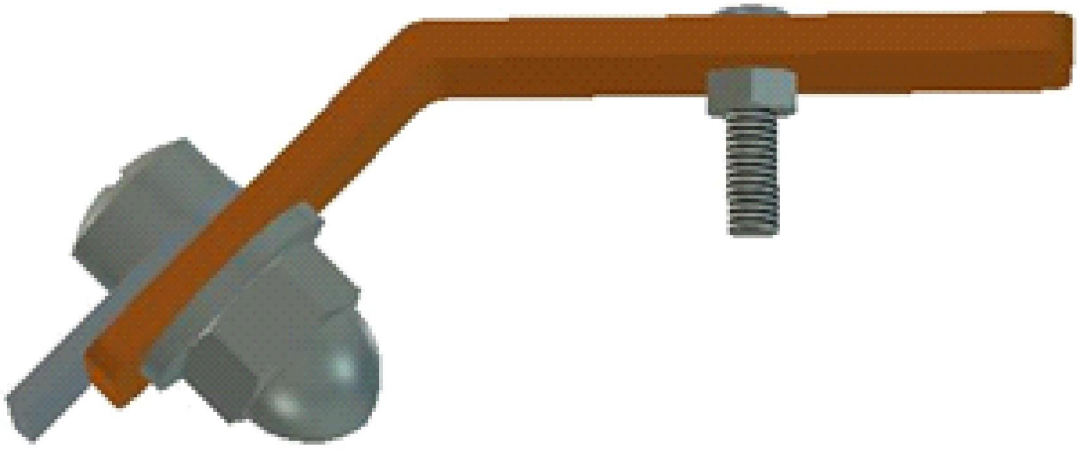
The main difference between the resistance welding of bits to steel, is the higher concentrated energy that is needed. Therefore a standard transformer welder does not work. Standard use is a condenser welder. Meaning that first the energy is charged in a capacitor bank, and then discharged bringing the required energy. On the tip of the stud is a small pin, which is barley visible. This pin, with the connection of the surface, is then welded to the panel. There are several points to consider in the process. The ground connection, holding angle of the tool, voltage applied and pulling force are all equally important points to consider when using the stud welder process.

Holding angle
The holding angle of the stud welder is another aspects which has an effect during the welding process. It is important to hold the tool vertical to the surface. There is a tip on the bottom of the stud, and if this gets damaged the welding doesn't occur.

Ground connection

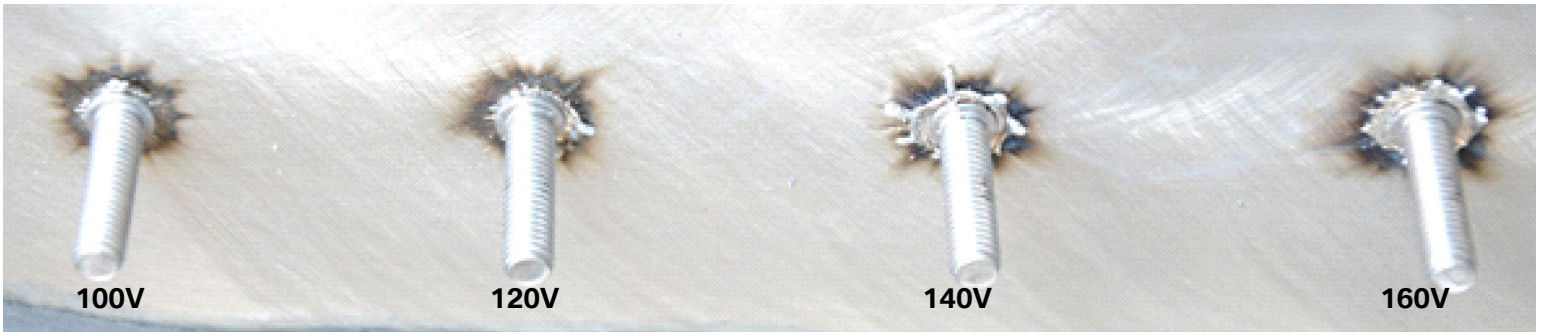
It is important that the ground connection be attached near the damaged area. There are two ways to attach a ground connection: either by using a lock plier, or by welding a stud to which the ground cable can be attached too. With this application, the ground can be held to the surface by hand, and then the ground stud can be welded on.

Ground connection



Voltage

Before attempting to make a repair, it is best practice to start with a setting test. With the same or similar gauge aluminum, apply 3 - 4 pins at a different voltage setting onto the material. This allows for more practice, in case you have no prior experience with the material or tool. First, apply a stud at 100V, 120V, 140V, then test the holding strength of the pins. This can be done by hand. If, for example, you see that the pins at 120V hold better than the others, use this setting for the repair, In the case of BMW, on older aluminum, the 140V is the best setting, while on newer aluminum, the 120V is the best setting.



Pulling

The amount of pressure being applied can have an effect on the holding strength of the stud. There can be a difference between light, medium and heavy pressure on the bridge. Heavy being the amount of pressure just before the stud gets damaged or pulled off.

In general, the risk is when attempting to pull too much, and create a hole in the material as the stud is pulled out.

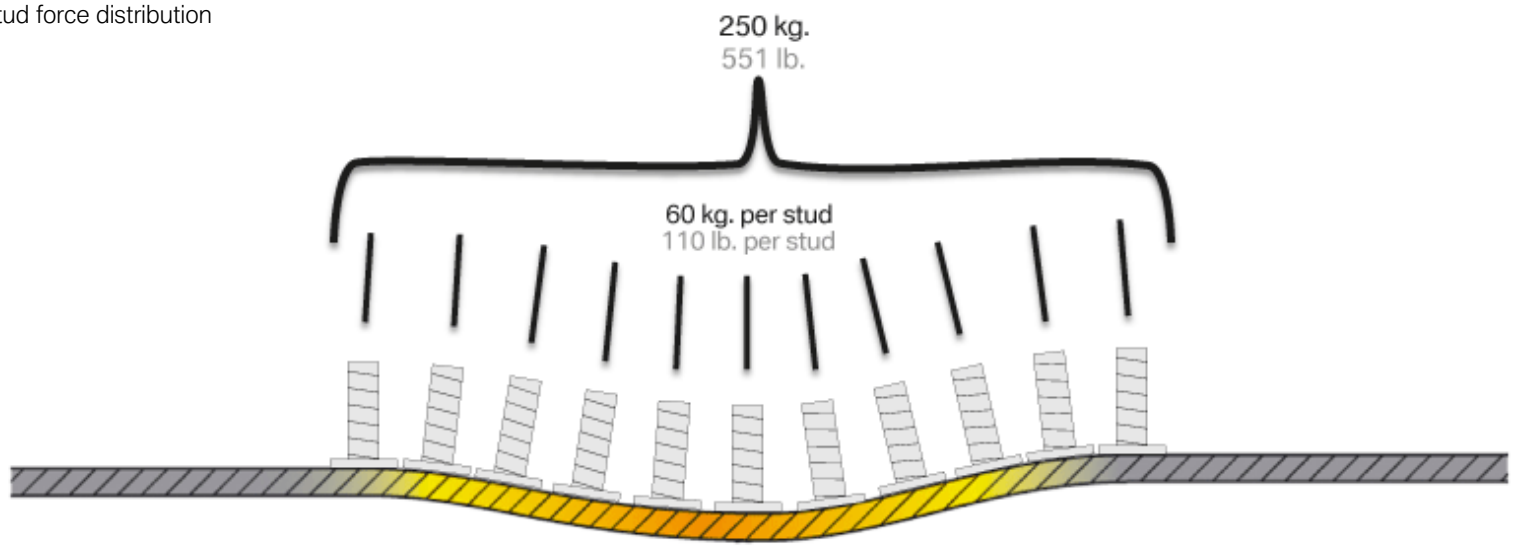
Depending on the different alloys and placement of damage, the pulling strength can vary. Generally, the holding strength of each stud welded is different due to the different factors that can influence the stud welding process.

The holding strength may vary from 40kg per stud up to 80kg per stud. If more pressure than 80 kg is applied, there is a high risk of puling out the stud and creating a hole in the panel. This is to be avoided. For this reason, it is important to apply many studs as close as possible on big or deep damages in order to distribute the needed pulling force.

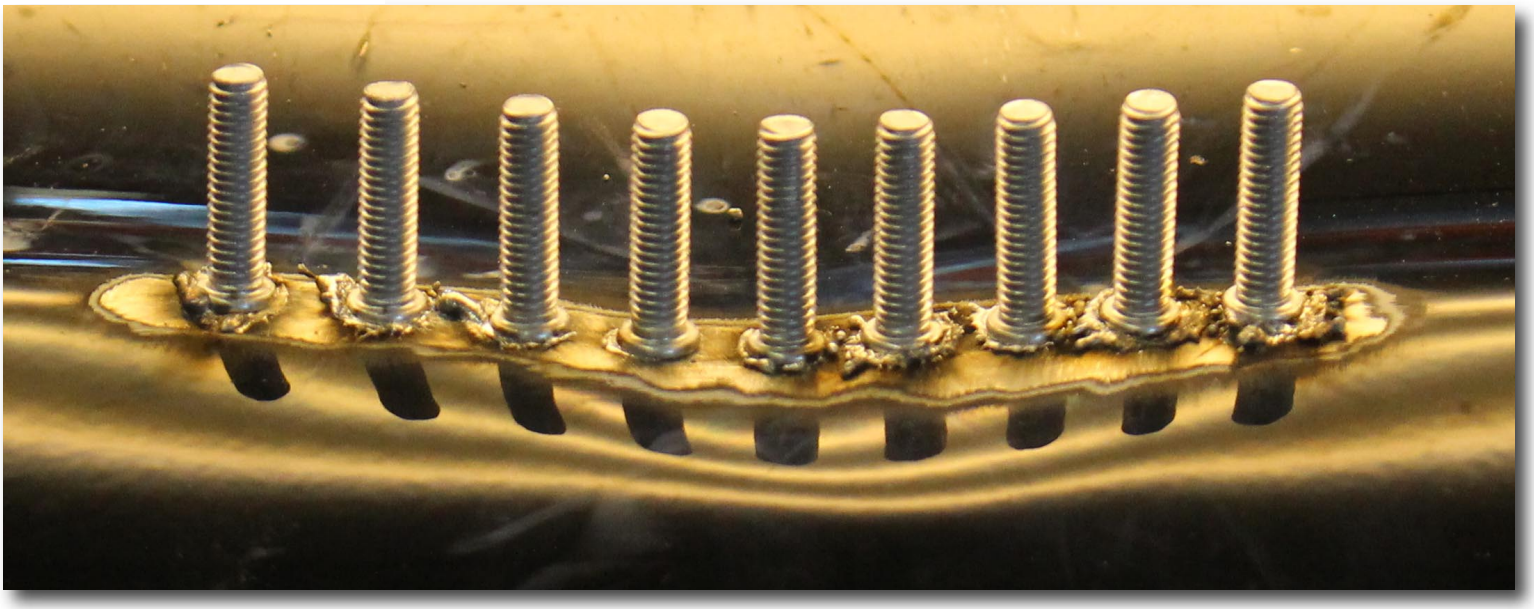
If, for example, the total pulling force needed to repair the damage is 250kg, then by using many studs the pulling force gets distributed evenly if each of the studs would hold only 60kg.

An additional advantage of applying many studs close to each other is the reduced risk of uneven pulls. The use of the nuts, as adjustable pulling height, helps during the repair, especially on complicated damages.

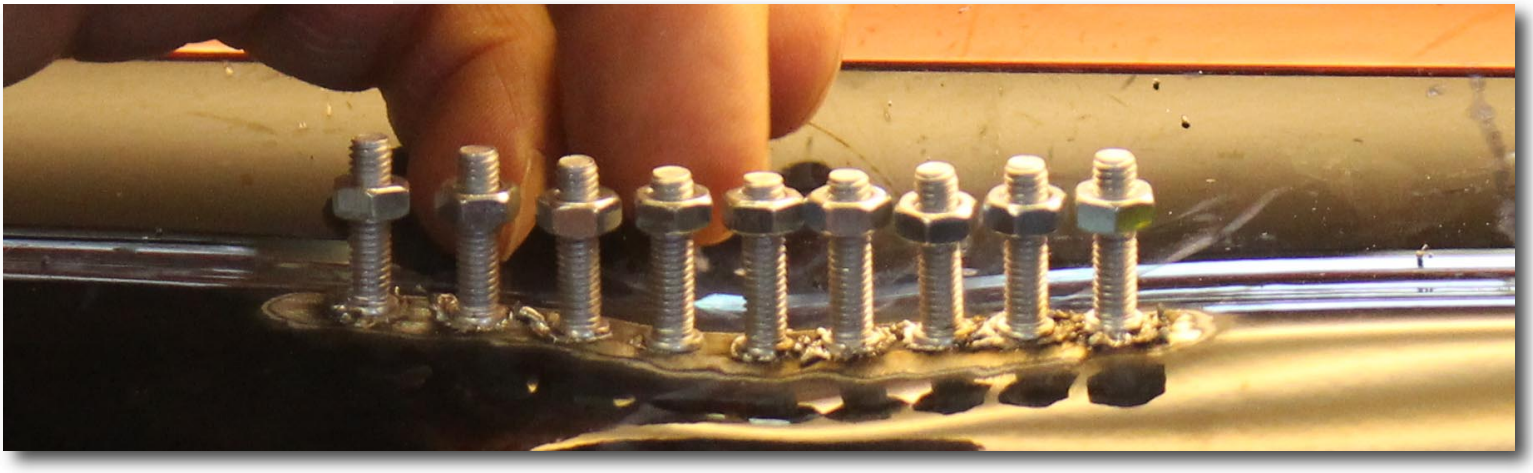
Stud force distribution



Studs applied to damaged area

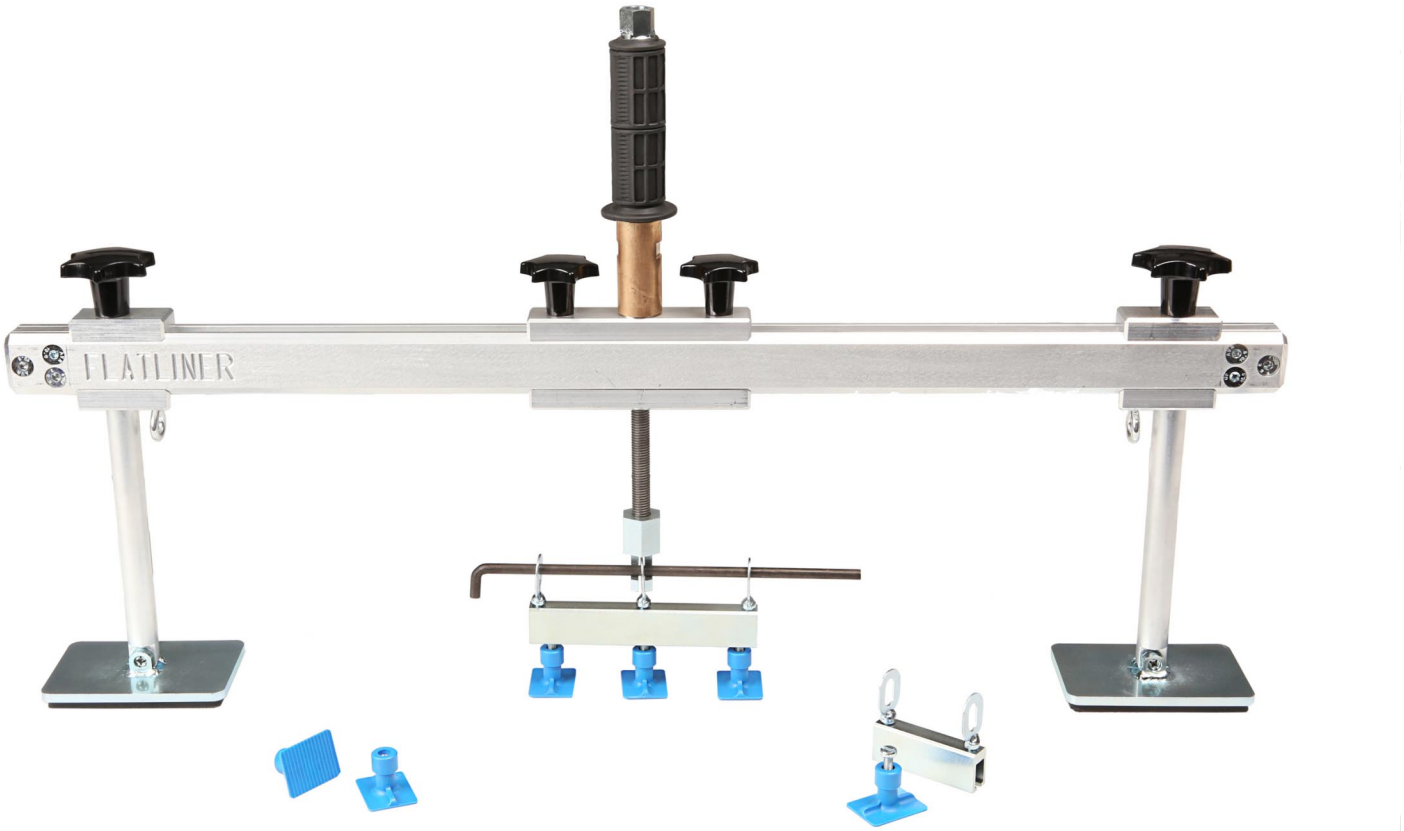


Studs with nuts applied



After mounting the nuts to the studs, apply the pulling element and the bridge assembly.

BETAG Flatliner (FL 80) bridge assembly with pulling element



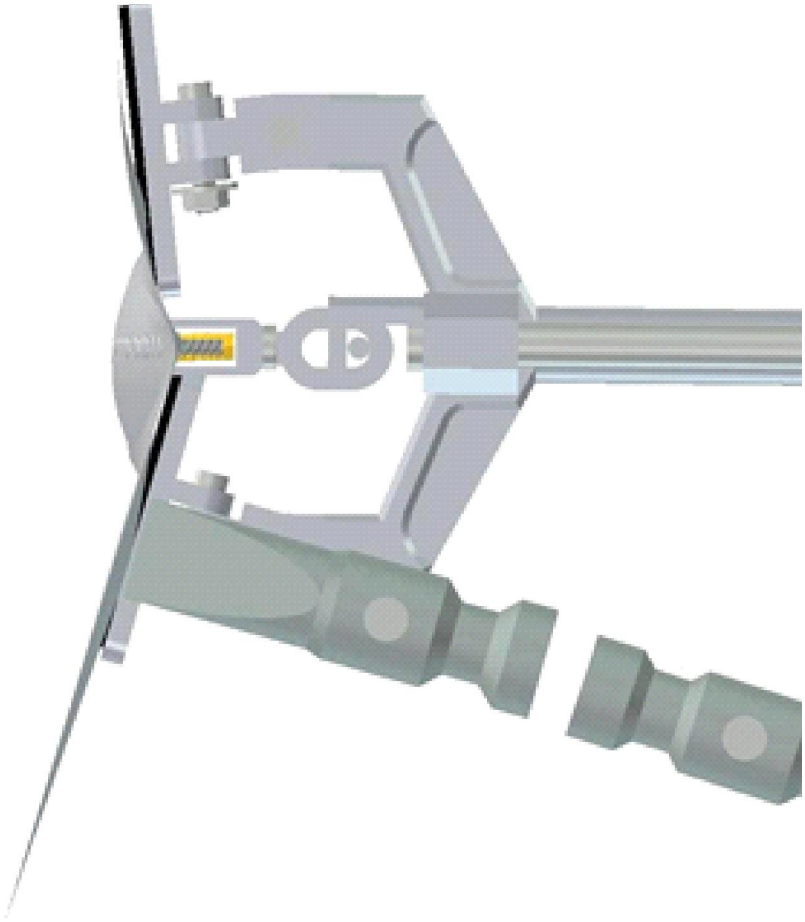
The Flatliner bridge assembly can be used with both the glue kit and the stud welder. This is to apply tensile force to the pull knobs or pins while relieving the tension of the damage.

It is important to use a constant pulling force to the studs. This has several advantages including

- Precise control
- Eliminating the risk of holes in the panel
- Ability to use heat during the pull
- Ability to relieve the crown pressure during the repair

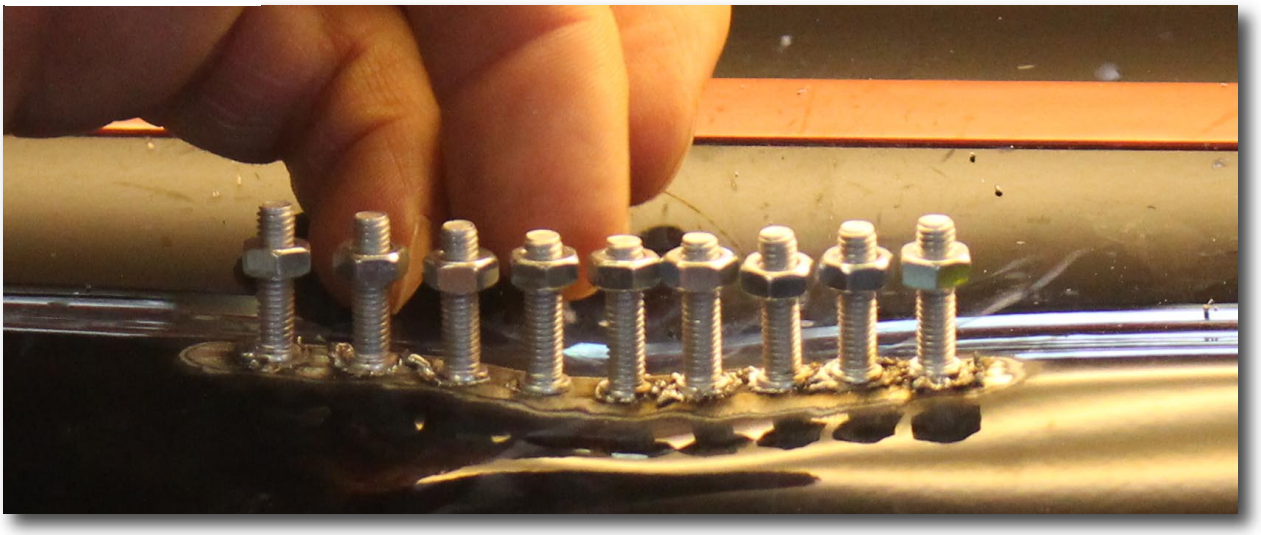
First you can apply some pressure to studs with the bridge. If the damage is big or deep, heat up the area with a heat blower. The temperature should not exceed 60°C (140°F). Once the pressure is applied by the bridge, knock down the crown. Try not to hit too hard, it should be more of a vibrational hit. There is no need for a large hitting force on the crown, as this might also weaken the studs.

Knock down crown using hammers



In some cases it might be necessary to pull on one, or a series of studs, more than the others during the repair, which might be due to the spring back effect of the material as well as the damage. This can be done by adjusting the height of the nuts on the studs.

Nut height adjustment



The remaining damage of the repair can be done with either the glue system, or the pre-push method.

All three methods can be combined depending on the outcome and development of the repairs.

Do not remove the studs too early, try and keep them on the panel until the repair is done as they might be needed for a final pull.

The adapters below can be used for applying tensile force to the welded studs.

Adapters for welded studs

After the panel repair, make sure to use filler which is made for aluminum. Often, metal filler is used, as this can be applied thicker. Another reason for the metal filler is that the expansion of the material is similar to aluminum as with standard filler. The heat expansion of the material is more than with sheet metal.

Follow the manufacturer's recommendation in regards to the filler curing time and process. After these steps have been taken, it should be safe to paint the panel.

REFINISHING AND CORROSION PROTECTION

After the aluminum panel has been restored to within 2.0 mm of its original shape, a cosmetic filler can be applied to smooth out any irregularities. Before applying any cosmetic fillers, the paint system will need to be abraded or removed.

SURFACE PREPARATION

Some cosmetic fillers can be applied over undamaged paint that is still firmly bonded to the base layers and aluminum substrate. The paint finish should be sanded with 100-grit disc before applying any cosmetic fillers.

In most cases, the paint will need to be removed. An 80 or 100-grit sanding disc as well as non-woven abrasive discs on an angle die grinder can both do an effective job of paint removal. Do not use any abrasives coarser than 80-grit and keep the sanding pad or disc parallel to the panel surface. When sanding aluminum, use slow sanding speeds.

For maximum adhesion and corrosion resistance, a two-component epoxy primer should be applied to bare aluminum that has been prepared for coating following the paint manufacturer's guidelines. Many paint manufacturers want the oxide layer removed by sanding with 100 or 120-grit sandpaper. Follow guidelines and product requirements for degreasing and final surface preparations.

In all cases, remember that the oxide layer forms within 30 minutes. It is imperative that mechanical preparation (sanding) be performed just before cleaning with a degreaser and topcoating with an epoxy primer.

COSMETIC FILLERS

Application of fillers and any polyester finishing material is the same for aluminum as it is for repairing steel panels. The key difference is the surface preparation required to help develop maximum corrosion resistance and adhesion.

ColorSystem 2K Epoxy Primer

REFINISHING

Follow the paint manufacturer guidelines for surface preparation and top-coating aluminum substrates. Several of the primers and primer-surfacers used during steel body preparation should not be used when refinishing aluminum. For more information, contact your paint manufacturer or ColorSystem representative.

Corrosion Protection

Like all metals, aluminum has a tendency to combine with oxygen in the presence of a electrolyte. This can be minimized by coating the aluminum panel or otherwise isolating aluminum from coming in contact with dissimilar metals.

Aluminum Isolation

When removing and installing or replacing an aluminum panel, follow all guidelines in ISTA/AIR regarding the use of isolating materials and fastener replacement. Many fasteners used to secure aluminum components to a steel structure are coated and are one-time use fasteners. Follow ISTA/AIR and any other BMW guidelines for servicing any fasteners when working with aluminum components.

There are several ways that aluminum can be isolated from dissimilar metals to reduce the effects of galvanic corrosion:

- Isolate the two metals from each other. If they are not in contact, no galvanic coupling will occur that may result in corrosion. Use any insulating materials specified in the repair instructions.
- Keep the metals dry or shielded from corrosive compounds such as road salts by coating the metal with a corrosion-resistant product such as a cavity wax or top coating with paint.
- Coat the two different metals with an impermeable protective layer such as an approved refinish material. Pay close attention to panel mating and joining surfaces.

Always inspect the underside of a panel if it has been hammered, pried with PDR tools, heated with a stud welder or other heat source to soften the metal.

Unprotected aluminum will last longer than bare steel, but the effects of surface oxidation will have a negative effect on any applied topcoats and result in customer concerns.

When installing aluminum components secured by frictional locking (mechanical fasteners), replace any fastener per ISTA/AIR guidelines and torque all attaching fasteners to specification.

Mating and joining surfaces are most prone to galvanic corrosion. After panels have been installed, apply a cavity wax to the panel mounting areas and flanges to seal these highly susceptible areas.

PROTECTIVE MEASURES

Airborne aluminum dust can collect on horizontal surfaces and create an explosion or ignition hazard. We will review shop practices to minimize this danger.

Vehicles with aluminum components also need to be protected from cross-contamination. This becomes very important when working on exposed aluminum outer body panels. Vehicle protection methods will also be covered.

PERSONAL SAFETY AND PROTECTIVE MEASURES

While aluminum dust is non-toxic, it is very lightweight and remains airborne for a considerable amount of time. The Occupational Safety and Health Administration (OSHA) classifies aluminum dust as an eye and respiratory tract irritant. Although inhalation of aluminum powder of particle size 1.2 µm for 10- or 20- minute periods several times weekly resulted in no adverse health effects among thousands of workers observed over several years, several other studies report X-ray evidence of pulmonary fibrosis. More information about potential health risks can be found on the OSHA website.

Personal Protective Equipment

Technicians should use appropriate personal protective clothing and equipment that must be carefully selected, used, and maintained to be effective in preventing skin contact with aluminum. The selection of the appropriate Personal Protective Equipment (PPE such as gloves, sleeves, encapsulating suits) should be based on the extent of the worker's potential exposure to aluminum. OSHA and the National Institute for Occupational Safety and Health (NIOSH) recommend the following PPE be used to limit exposure:

- Dust mask classified for N95 use as defined by NIOSH in standard 42 CFR 84
- Safety goggles
- Protective Gloves

Personal Hygiene

If aluminum dust contacts the skin, technicians should flush the affected areas with plenty of water, followed by washing with soap and water. OSHA also recommends that clothing items and uniforms contaminated with aluminum dust should be changed and laundered daily. A technician who is exposed to aluminum dust should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, applying cosmetics, or taking medication. Technicians should not eat, drink, use tobacco products, apply cosmetics, or take medication in areas where aluminum or a solution containing aluminum is handled, processed, or is stored.

Control Methods

Depending on the feasibility of implementation, the methods that OSHA says have shown to be effective in controlling worker exposures to aluminum dust are:

Control Methods	Implementation
Process enclosure	Isolated aluminum “clean room”
Local exhaust ventilation	Dust collection system
General dilution ventilation	Adequate shop ventilation and air movement
Personal protective equipment	Respirator, gloves, protective clothing

Capturing aluminum dust at the source with specialized dust collection equipment is an effective way to control fine dusts. Dust collection systems fitted to specialized tools can capture over 90% of aluminum fine dust at the source. Dust collection systems can generate static electrical charges that may pose a risk of discharge and sparking. Before using or installing any dust collection equipment for use when sanding aluminum, contact the supplier to confirm that the equipment has been approved for the capture and collection of fine aluminum dust.

Currently the United States Environmental Protection Agency does not categorize aluminum as toxic or hazardous. Solid aluminum is recyclable. The disposal of aluminum dust may be regulated by certain states. Please contact state and local authorities to assure that the disposal of aluminum dust generated by sanding is addressed properly.

Nilfisk explosion proof industrial vacuum

PROTECTING THE VEHICLE

During repairs, aluminum components must be protected from grinding residue and throw-off as well as MIG-welding slag when using steel welding wire. While this may be accomplished locally by draping a welding blanket over an aluminum part, it is best to separate the vehicle with aluminum body panels from the general work area to isolate it. If the collision repair center performs a high volume of repairs, a dedicated aluminum work bay or clean room may be the best way to protect and isolate the vehicle from cross-contamination.

For many shops, a portable plastic welding screen is an acceptable solution. These portable screens can be obtained through the BMW parts system.

Portable protective screen

Here are a few guidelines for protecting aluminum panels during repair:

- Isolate vehicles with cosmetic aluminum panels from steel repair processes and welding operations, either with a portable screen or by placing the vehicle in an isolation area specifically designed for aluminum repairs.
- Follow fastener replacement guidelines when replacing bolted-on components.
- Keep all aluminum components boxed until they are ready to be installed.
- Do not apply excessive heat to aluminum.
- Do not use tools or abrasives to repair aluminum that were previously used to repair steel panels