BMW
Body & Paint Technical Training

Plastic Restoration Techniques

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Course Code: SB005E - Plastic Restoration Techniques

This reference 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 AG service publications available in the Integrated Service Technical Application (ISTA).

- 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) and Service Information Bulletins.

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Introduction

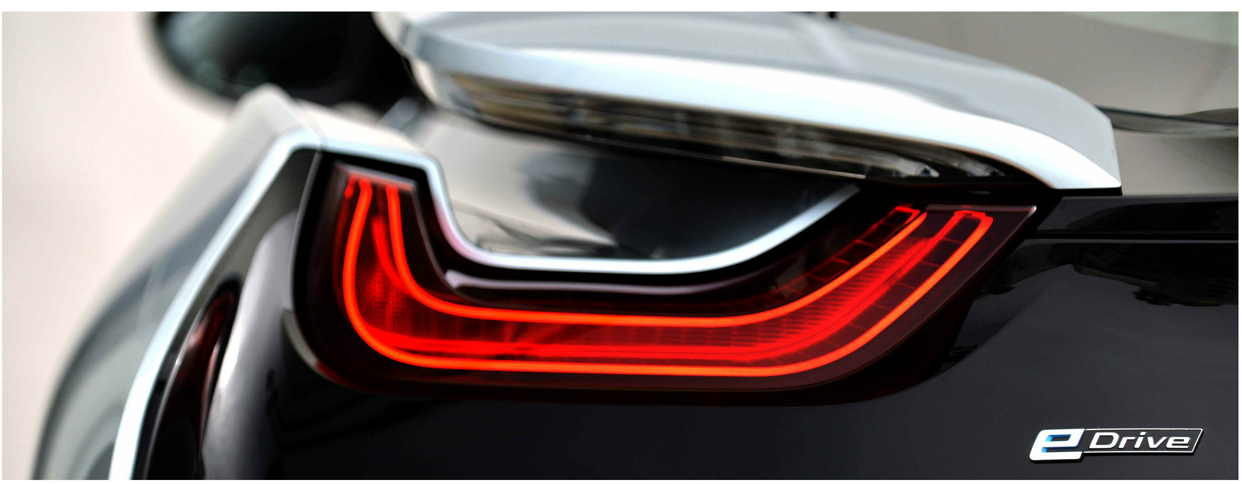
Over the years, automobile design and manufacturing have evolved extensively. The same may be said for the way vehicles are to be repaired. The basics of body repair have largely remained constant, but the methods have changed. The change is due not only to the way cars are designed and built, and also due to the materials and equipment being used.

Plastics have become more and more commonplace in our daily lives. The global production of plastics surpassed that of steel in 1989, and the pace of production has been rapidly increasing. Today's vehicles can contain as much as 50% of plastics by volume, while only contributing 10% to the vehicle's overall weight. This leads to greater vehicle efficiency.

With a greater percentage of plastic components in our vehicles, there is a greater chance that plastic components may become damaged. Using modern repair techniques, many types of damage can be repaired efficiently while retaining a high degree of quality. In certain situations, repairing damages may have several advantages over replacing damaged components:

- Maintaining repair quality
- Faster repair (lower cycle times)
- Higher profit per repair
- Lower overall repair cost
- Increased Customer Satisfaction

This manual will focus the material plastic as it is used in BMW vehicles, and the assessment and subsequent repairs of plastic vehicle components.



Definition of Plastic

Plastic is defined as a material consisting of any of a wide range of synthetic or semi-synthetic organic compounds that are malleable and can be molded into solid objects. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals. Plasticity is the general property of all materials that are able to irreversibly deform without breaking. Plastics may be also be composed of natural organic materials that may be shaped when soft and then hardened. Plastics are used in place of other materials such as glass, wood, and metals in construction and decoration. Plastics are often known by their trademark names, such as Bakelite, Vinylite, or Lucite.

In the automotive industry, plastics are being used in incredibly innovative ways to help make cars safer and more efficient. Plastics allow for beautifully complex shapes in the vehicle's exterior, and safer lightweight components throughout. Advancements in vehicle safety including seatbelts and airbags would not have been possible without the widespread adoption of plastics. The inherent recyclability of plastics also help automakers meet sustainability goals. An ever increasing percentage of car parts are being made using recycled plastics.

History

Prior to the development of man made plastics, Mesoamericans dating back to 1600BC utilized natural rubber for balls, bands, and figurines. Natural rubber was later used in the 14th and 15th centuries by Aztec and Maya cultures for making waterproof containers and textiles.

Parkesine

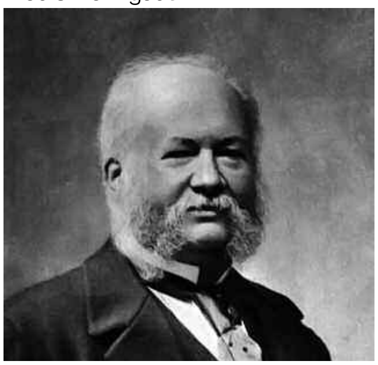
In 1862, Alexander Parkes invented the first man-made plastic known as Parkesine. His invention was transparent, could be molded, and retained its shape when it cooled. During its introduction at the Great International Exhibition in London, Parkes claimed that Parkesine could do anything natural rubber could do but less expensively.

Alexander Parkes

Rayon

Louis Bernigaut in 1891 developed Rayon in France while searching for a silk substitute. The modified cellulose was named Rayon since it was shiny and appeared to produce rays of light. Unfortunately, the material was extremely flammable, and was later replaced by more stable materials.

Louis Bernigaut



Bakelite

Leo Hendrick Baekeland invented the fully synthetic plastic Bakelite in 1907 as a thermosetting resin that could be molded and retained its shape when under stress and heat. He went on to receive more than 400 patents related to manufacturing and various applications of Bakelite which became known as "The Material of a Thousand Uses". Bakelite was used in electrical insulators, radio and telephone casings, jewelery, kitchenware, children's toys, and firearms.

Leo Hendrick Baekeland

Cellophane

Invented by Swiss chemist and textile engineerJacques Edwin Brandenberger in 1908. Cellophane was intended as a coating to make cloth more resistant to staining. Once refined production for industrial purposes began in 1920. Brandenberger sold the U.S. rights to DuPont in 1923. Cellophane itself is 100% biodegradable, and that has increased its popularity as a food wrapping.

Vinyl
PVC (Polyvinyl chloride) or Vinyl a semi synthetic plastic used in many applications including construction, plumbing, and electrical products. Vinyl was developed as a replacement for natural rubber and was created by German chemist Eugen Baumann in the 1920s. PVC has high hardness and its strength is enhanced with an increase in weight but decreases as its temperature increases.

PVC Tubing

Polyethylene
Polyethelene is the most common plastic with an annual global production of around 80 million tons. Primarily used in packaging such as plastic bags, plastic films, containers, and bottles. Although it was first discovered in 1933 by accident by Eric Fawcett and Reginald Gibson in Northwich, England it was rather unstable and did not become commercially available without many refinements taking place until the early 1950's. Polyethylene products are of low strength, hardness, and rigidity. The thermal, chemical, electrical, and optical properties of polyethylene vary greatly with different chemical compositions.

Polyethylene bags

Polyvinylidene Chloride
Discovered by accident in 1933 by laboratory worker Ralph Wiley. Wiley was a college student who worked part-time at Dow Chemical lab as a dishwasher. It was originally used to prevent corrosion by protecting military equipment from salt water. Since it clings to virtually any material, it forms an oxygen barrier. Its most popular application used as a film for food packaging and is now known by it's commercial name, Saran[tm] Wrap.

Nylon
Invented by DuPont, Nylon made its debut at the 1939 New York World's Fair as ladies stockings and quickly replaced silk in clothing and for military applications during World War II.

Polyester
Discovered in the 1940s, but not made famous until DuPont marketed polyester as the new fabric "Dacron". Dacron was the first washable synthetic. Polyester can be thermosetting, or thermoplastic depending on it's chemical composition. Polyester is an extremely versatile material, and has seen usage in bottles, tarps, LCD displays, wood finish products, auto body repair fillers, and as the matrix in some carbon fiber components.

Polypropylene
First polymerized in the 1950s, polypropylene is used in nearly all plastic applications and is one of the most versatile and popular plastics today. Polypropylene has uses in several industries such as medical, food service, textiles, automotive, and even bank notes. The properties of polypropylene make it such that it is an ideal material for engineering plastics. Both chemical and welded repairs may be performed on polypropylene components. Due to it's economical and material property advantages over other plastics, a large percentage of automotive interior and exterior parts are made from polypropylene.

BMW I01 featuring polypropylene body panels

Polystyrene
Introduced in 1954 by DOW Chemical under the commercial name of "Styrofoam", polystyrene is used in products such as packing material, drink cups, food takeout containers, buoys, and floatation devices. Polystyrene is generally non-biodegradable, thus making it a controversial material among environmentalists. Products made from polystyrene are recyclable, however are often not collected for recycling for economical and logistical reasons.

Vulcanization

Vulcanization is the process of converting natural rubber into a more durable material. It is a chemical process and it involves the addition of sulfur or other curing or accelerative agents. Vulcanized materials are less sticky than natural rubber and have superior mechanical properties. Charles Goodyear is credited with inventing the process in 1844. It is the process of vulcanization that allows for products such as automobile tires, shoe soles, hoses, drive belts, and hockey pucks.

Examples of vulcanized rubber products

Advantages of Plastic

Plastics have numerous applications and advantages when compared with other materials in automobile design and manufacturing. One such advantage is a reduction in weight. Innovative ways of using more and more plastic in today's vehicles helps to improve fuel economy, reduce exhaust emissions, provide safety benefits, and enable automobile designers to create beautiful stylish contours and sleek aerodynamic designs.

Weight Savings

As consumers and vehicle safety and emissions requirements demand more comfort & convenience equipment, improved safety, fuel economy, lower emissions, and minimal environmental impact vehicle weights continue to increase. At BMW, the extra weight caused by additional equipment is offset by increased usage of light weight materials such as plastics. Lighter weight also means improved vehicle dynamics (handling, acceleration, and braking).

Plastic vehicle components have been in use at BMW for many years. Bumper covers and outer body panels have seen the widest adoption of plastics due to their weight, resilience, and formability. With the launch of the BMW i3 in 2014, plastics were used as structural components in the form of carbon fiber reinforced plastic (CFRP). By utilizing light weight materials such as plastics, a lighter vehicle can be produced. Reducing a vehicle's weight by 10%, can have a 6-8% increase in fuel economy. In a modern automobile, there are on average 332 pounds of plastic, contributing up to 50% of the vehicle's volume.

BMW i3 carbon fiber reinforced plastic (CFRP) life module

Safety

Seat belts and vehicle air bags are two of the most safety relevant components in your vehicle. Neither of which would have been possible without advancements in plastic technology. Seat belts made of polyester fiber save thousands of lives every year. High strength nylon fabric air bags can reduce fatalities in collisions by 30% according to the National Highway Traffic Safety Administration (NHTSA). Plastic composites can absorb up to 12 times the energy of steel. Plastics used in bumpers and bumper supports provide increased protection by improved energy absorption.

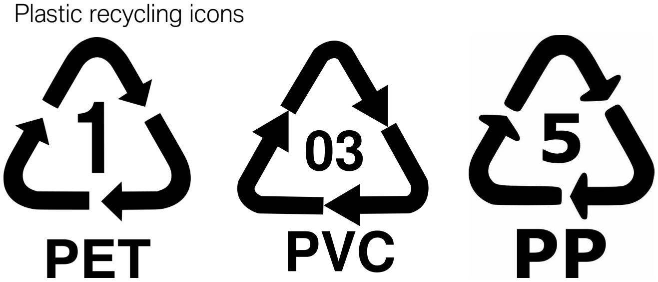
Sustainability & Recycling

Plastic is a recyclable material. Since there are many different types of plastic, not all plastics are recycled in the same manner. Thermoplastics can be melted down and reused. Thermosetting plastics can be ground up and used as filler for another material. Other plastics such as polystyrene packing peanuts can be saved for re-use at a later time.

Recycled plastic can also reduce overall energy demand. Producing plastics from recycled materials is often less energy intensive than producing plastic using conventional methods. For example, a process for producing PVC from recycled goods is 46% more energy efficient than manufacturing PVC from raw materials. Such reductions in energy usage can reduce the overall environmental impact.

Recycled plastics find their way into many vehicles today. For example, the fabric used in the standard equipment seats of the BMW i3 are made from recycled plastics.

Plastic recycling icons



Style & Innovation

Plastic's ability to be molded and formed give designers much more freedom than what was possible with metals.

Innovative design, styling, and manufacturing techniques have resulted from the use of plastics allowing BMW's designers to create aesthetically pleasing body styles including the i8's exciting, unique and dynamic rear quarter panels.

BMW i8 rear quarter panel design

Types of Plastics

Plastics for body components are split into three categories according to their mechanical and thermal properties:

- Thermoplastics
- Thermosetting plastics
- Elastomers.

Thermoplastics

Thermoplastics are plastics that do not undergo chemical change in their composition when heated and can be molded again and again. The mechanical properties of thermoplastics are highly temperature-dependent. As the temperature rises, they soften until the material finally liquefies. This mechanical/thermal behavior can differ very widely however. For example, coolant expansion tanks can withstand relatively high temperatures without suffering any appreciable decrease in strength. By contrast, outer body skin components are relatively malleable from the outset and have very pronounced shape changing properties, even with relatively minor temperature increases.

Common Thermoplastics	
Polypropylene - PP	Polyvinylchloride - PVC
Polyethylene - PE	Acrylonitrile-butadiene styrene - ABS
Polyamide - PA	Ethylene-proylene-diene - EPDM
Polycarbonate - PC	Polystyrene - PS

Thermosetting plastics

Thermosetting plastics are hardened plastics, which barely change at all in response to temperature changes. Thermosets can melt and take shape once. After they have solidified, they will remain solid. In the thermosetting process, a chemical reaction occurs that is irreversible. They are frequently used for electrical components such as ignition coils or printed circuit boards, as they have a very low conductivity. For vehicle body components, thermosetting plastics are often used in conjunction with reinforcing fibers. For example, sheet moulding compound (SMC) components are made of polyester resin (UP) reinforced with glass fibers.

Common Thermosetting Plastics	
Polyurethane - PUR	Polyester
Epoxy - EP	Melamine

Elastomers

Elastomers are plastics with a stable form, but which are extremely malleable and flexible, such as door seals for example. The term “Elastomer” is derived from “elastic polymer”, and is interchangeable with the word “Rubber”.

Identification

Plastic ID tag PP + EPDM

For some repairs, a precise knowledge of the type of plastic in question is required. The corresponding identification will be located somewhere on the component that is usually not visible from the outside.

Plastic which has been strengthened by the addition of fiber which will be indicated on the tag. For example PPGF would indicate a polypropylene with glass fibers added.

"Blends" are frequently used in addition to the pure form. A blend is a mixture of different plastics and corresponds to an "alloy" in the metallurgical sector. Blending allows for several desirable properties to be combined in a new plastic material. The trade names coined by the individual plastics manufacturers are also commonly used, but rarely give any direct indication of the type of plastic involved.

The following table contains a selection of plastic materials of various types used on motor vehicles.

Acronym	Designation
ABS	Acrylonitrile butadiene styrene copolymers
CAB	Cellulose acetate butyrate
CN	Cellulose nitrate
EC	Ethyl cellulose
EP	Epoxy resin
MF	Melamine formaldehyde
PA	Polyamide
PC	Polycarbonate
PE	Polyethylene
PBTP	Polybutylene terephthalate
PETP	Polyethylene terephthalate
PF	Phenol formaldehyde
PMMA	Polymethyl-methacrylate
POM	Polyoxymethylene
PP	Polypropylene
PPO	Polyphenylene oxide
PU	Polyurethane
PVC	Polyvinyl chloride
SAN	Styrene-acrylonitrile copolymer
SB	Styrene-butadiene copolymer
TPU	Thermoplastic polyurethane
UP	Unsaturated polyester

Trade Names for Plastics	
Akulon	PA
Araldit	EP
Bayblend	PC / ABS
Baydur	PU
Bayflex	PU
Demopan	PU
Durethan	PA
Elastoflex	PU
Hostalen	PE
Hostalen PP	PP
Hostalit	PVC
Keltan	PP / EPDM
Lexan	PC
Luran	SAN
Makrolon	PC
Noryl	PPO
Pocan	PBTP
Rilsan	PA
Terluran	ABS
Ultradur	PBTP

In addition to the identification label, there are other methods you can use to identify plastics.

In general, to find out if you are working on a thermoplastic or a thermoset, you can do the following:

- Sand the part: If it gets rubbery during sanding, then the material is a thermoplastic. If the part gets dusty, then it is thermoset.
- Heat the part: Over 200°C, the thermoplastic will soften.

Further tests can be performed which include burning the component to test for smoke color, odor, speed of burn, smoke formation, and whether the component melts. Plastic components on BMW vehicles that require identification will have some form of identifying mark on the part.

Properties of Plastic

The properties of plastic cannot be as easily compared to a more static material such as iron or aluminum. One characteristic of plastic is that it's properties, such as hardness, strength, elasticity, thermal and chemical resistance, vary greatly with the raw materials used and the manufacturing process employed. Some plastic components can be soft and supple, while others can be extremely hard and brittle. For example, comparing the properties of an elastomer door seal to those of a thermosetting epoxy used in bodyshell construction.

The chart below identifies the properties of polypropylene, as it is the most common plastic used in BMW vehicle exterior body panels.

Characteristics	Unit	Polypropylene	Steel (deep drawn)	Aluminum	Carbon Fiber
Density	g/cm^3	0.905	7.8	2.7	1.47
Coefficient of thermal expansion	$10^{-6} k^{-1}$	1.11	12	23	2-3 (multidirectional laminate)
Thermal Conductivity	W/mK	0.117	75	205	5-7
Melting point	°C	164	1539	660	100 (glass transition temp.)
Yield Strength	$[N/mm^2]$	35	180-230	145-165	approx. 1350
Tensile Strength	$[N/mm^2]$	113-155	300-360	180-240	approx 1425
Modulus of Elasticity	$[N/mm^2]$	1265	210,000	70,000	110,000
Elongation at Break	[%]	100-600	≥ 34	≥ 18	1.5-4

Thermal Expansion

Thermal expansion is described for materials with the so-called thermal expansion coefficients. This is a characteristic value for the change of a material as temperature changes in relation to its dimension. The greater the value is, the more the material expands upon heating.

Yield Strength

The yield strength describes the tension at which a transition from elastic to plastic deformation of the material is effected. A component that is bent, twisted or compressed following an accident has undergone permanent (plastic) deformation. If the tension is less, the deformation is reversed once the load is removed (elastic).

Tensile Strength

The tensile strength is the maximum tensile force a material can withstand. If this force is exceeded, a constriction occurs at one point in the test specimen. This increases if the tensile force is applied further, until the sample breaks. The yield strength ratio can be determined from the yield strength and the tensile strength. This value provides information on the distance between plastic deformation and collapse of the material. The greater the tensile strength of the material is, the greater the force it can withstand.

Modulus of Elasticity

The modulus of elasticity – also called E-module – describes the connection between tension and stretching of a material during deformation. The greater the value is, the more resistance the material sets against its deformation. This means a material with a high E-module is firm, while a material with a low E-module is flexible.

Elongation at Break

Elongation at break states the change in length of a component as percentage after it breaks due to the tensile force.

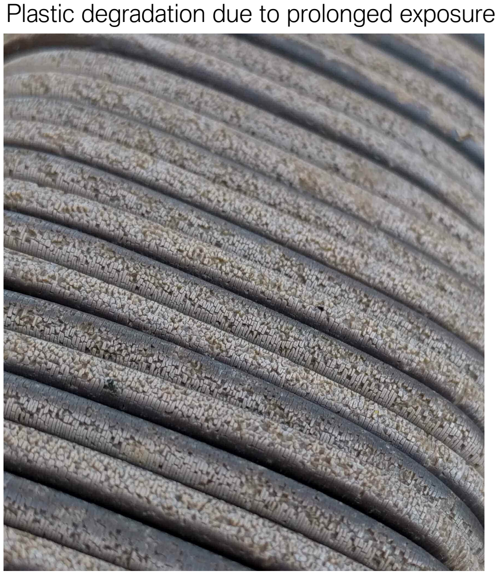
Corrosion

Corrosion is the reaction of a material to its environment that produces a measurable change in the material and can adversely affect the function of the component. A differentiation is made between different types of corrosion, depending on where the corrosion occurs.

Plastics do not corrode in the same conventional manner as most metals. For example, rust (iron oxide) can form on the surface of steel components as the metal interacts with moisture in the atmosphere. Rust is a common form of corrosion, and is widely accepted as an alternate term for corrosion. Corrosion can take many forms, and plastics are not immune from corrosion. The corrosion of plastics is more commonly referred to as "degradation" or "ageing". The degradation of plastics is a change in the properties of the material when under the influence of surrounding environmental factors (heat, light, chemicals, etc.)

An example of plastic degradation would be plastic outdoor furniture which has started to dry out and crack due to prolonged exposure to the elements.

Plastic degradation due to prolonged exposure to the elements



Manufacture

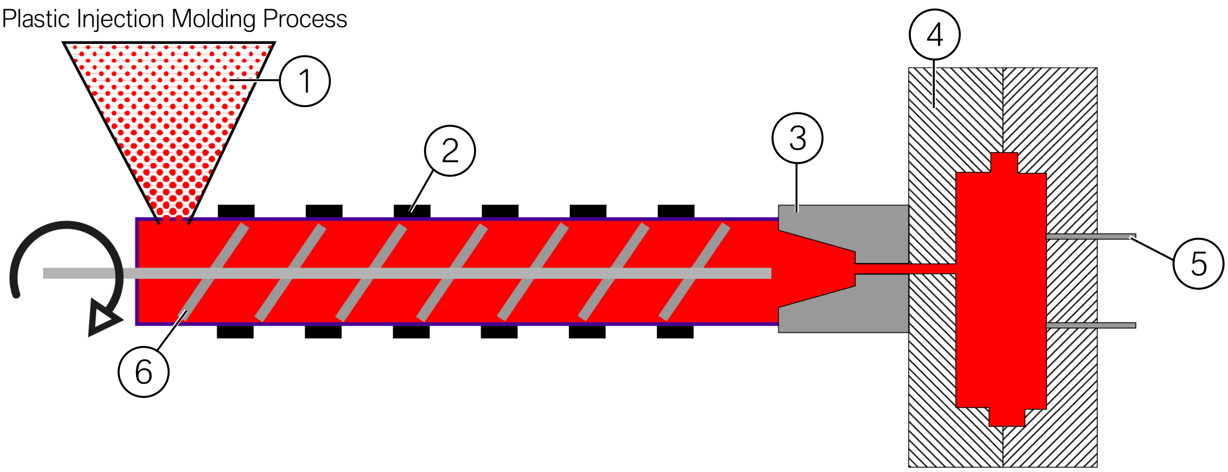
Injection Molding

The plastic injection molding process produces large numbers of parts of high quality with great accuracy, very quickly.

Plastic material in the form of granules is melted until they are soft enough to be injected under pressure to fill a mold. The result is that the mold is completely filled with liquified material and its shape is precisely copied. Once the plastic molding has cooled sufficiently to harden, the injection mold opens releasing the part. This process is repeated until desired production volume is met.

Injection molding machines, also known as presses, consist of a material hopper, an injection ram or screw-type plunger, and a heating unit. Molds are clamped to the platen of the molding machine, where plastic is injected into the mold through the sprue orifice. Presses are rated by tonnage, which is the calculation of the amount of clamping force that the machine can exert. This force keeps the mold closed during the injection molding process. Tonnage can vary from less than 5 tons to 6,000 tons.

Plastic Injection Molding Process



Index	Explanation
1	Plastic pellets
2	Heaters
3	Nozzle
4	Split mold
5	Ejector pins
6	Screw and tube assembly

Injection Molding Cycle

The sequence of events during the injection molding of a plastic part is called the injection molding cycle. The cycle begins when the mold closes, followed by the injection of the liquified material or polymer into the mold cavity. Once the cavity is filled, a holding pressure is maintained to compensate for material shrinkage. In the next step, the screw turns, feeding the next shot to the front screw. This causes the screw to retract as the next shot is prepared. Once the part is sufficiently cool, the mold opens and the part is ejected.

Wall Thickness

Prior to ejection from the mold, injection molded parts are cooled down from manufacturing temperatures so that they hold their shape when ejected. During the part cooling step of the molding process, changes in pressure, velocity and plastic viscosity should be minimized to avoid defects. Few aspects are more crucial during this period than wall thickness. This feature can have major effects on the cost, production speed and quality of the final parts.

The minimum wall thickness that can be used depends on the size and geometry of the part, structural requirements, and flow behavior of the material. The wall thicknesses of an injection molded part generally range from 2mm – 4mm (0.080" – 0.160"). Thin wall injection molding can produce walls as thin as 0.5mm (0.020").

Types of injection molding processes.

Reaction injection molding (RIM)

RIM is similar to injection molding except thermosetting polymers are used, which requires a curing reaction to occur within the mold. Common items made via RIM include automotive bumpers, air spoilers, and fenders. Reaction injection molding can produce strong, flexible, lightweight parts which can easily be painted.

Thin wall injection molding

Thin wall injection molding is a specialized form of conventional injection molding that focuses on mass-producing plastic parts that are thin and light so that material cost savings can be made and cycle times can be as short as possible. Thin wall means wall thicknesses that are less than 0.025” (0.62mm). Parts are often used in food packaging such as food containers and lids, automotive (e.g. both structural and non-structural) car parts, mobile phone housings, medical syringes, and computer housings.

Liquid Silicone Rubber (LSR) Injection molding

LSR injection molding is a process which produces pliable, durable parts in high volume. Liquid silicone rubber is a high purity, platinum cured silicone with low compression set, great stability, and ability to resist extreme hot and cold temperatures. Silicone rubber is ideally suited for production of parts where high quality is a must. Typical applications are products that require high precision such as automotive seals, sealing membranes, electrical connectors, multi-pin connectors, infant products where smooth surfaces are desired (bottle nipples), medical applications, and kitchen goods. Often, silicone rubber is overmolded onto other parts made of different plastics. For example, a silicone button face might be overmolded onto an Nylon housing.

Safety

The general protection and hygiene measures apply to plastic repairs as well. This means that eating, drinking and smoking are all forbidden during work.

When working with chemicals, all forms of eye and skin contact must be avoided, as the adhesive will cause irritation to your eyes, respiratory tract and skin.

Personal safety equipment must be worn throughout the entire repair. This includes:

- Safety goggles
- Chemical-resistant protective gloves
- Close fitting protective clothing

If any chemicals nevertheless come into contact with your eyes, they should immediately be rinsed under running water, and a specialist physician consulted.

Skin should also be rinsed under running water if it comes into any contact with the chemicals, and any items of clothing contaminated by the product should be removed.

People who are allergic to isocyanate should avoid handling the product. However respiratory protection is only necessary if the ventilation is inadequate. Further guidance can be found in the manufacturer's safety data sheet.

Damage Assessment

Damage analysis

Plastic repairs may be performed solely on painted outer bodyskin components. Unpainted surfaces cannot be restored with a sufficiently high level of quality using standard workshop methods and tools.

Severity of the damage

Plastic repairs should be considered only if the damage is slight to moderate. Examples of this level of damage include slight deformations, and abrasions, cracks or holes in the outer body skin provided that there is no damage to the underlying structures.

Deformations

Small dents and deformations can be repaired by reshaping, although the plastic must not have any cracks, as these will become visible again after paintwork has been applied.

Abrasions and scratches

Small abrasions and scratches can be filled in by plastic bonding. If the material thickness is reduced to the extent that the underlying components are showing, repair is not normally possible.

Cracks and holes

Small cracks and holes can be filled in by bonding or welding the plastic, although the cracks and holes cannot be any larger than 25 mm. BMW does not permit repairing damage extending to the edge of the component.

Repair Options

The table below contains information on the technical materials processing possibilities. Prior to any repair, however, a check should be carried out using the ISTA workshop information system to establish whether a repair to the component in question is permissible.

Type of Plastic	Plastic Bonding	Plastic Welding	Reshaping
Thermoplastics	X	X	X
Thermosetting Plastics	X		
Elastomers			

The latest information on the ISTA workshop information system must be respected for all repairs.

Economic efficiency

When asking the question: "Exchange or repair?" several issues need to be taken into account. The time required for the repair as opposed to the cost of a new part should be considered, for example. The repair (not including paintwork) should not exceed 50% of the cost of a new part. Exceptions apply if the new part cannot be delivered at all, or if the delivery timeframe is unacceptable.

The country-specific hourly cost rate will of course also play a role in determining cost effectiveness.

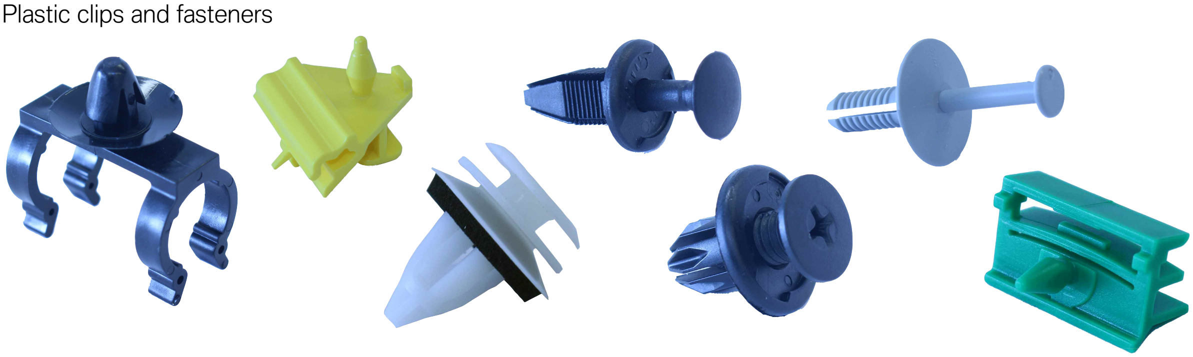
Repair Methods

Replace

Fasteners

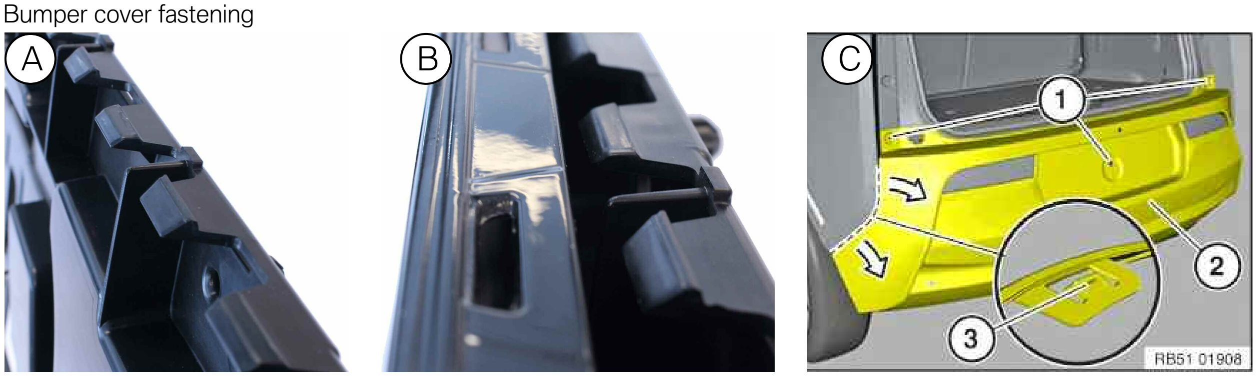
BMW utilizes several different types of joining and fastening methods for plastic components. Plastic rivets, clips, tabs, and even adhesive is used to fasten plastics. Extra care should be taken when disassembling and assembling plastic body components as they can be easily damaged. If a plastic fastener such as a rivet or screw is damaged, it must be replaced.

Plastic clips and fasteners



Bumper covers are fastened to the vehicle body by several means. The most common method for securing the bumper cover is by using a retaining bracket bolted to the body in which the plastic bumper cover clips into. When removing or installing bumper covers, the vehicle specific repair instructions should be followed to ensure the correct pulling force and direction. Previously, the bumper tabs could not be repaired if damaged. The Plastic Fusion welding machine now allows for a complete repair solution for damaged bumper tabs.

Bumper cover fastening



Index	Explanation
A	Retaining bracket
B	Bumper cover tabs and retaining bracket
C	Repair instructions noting pulling direction

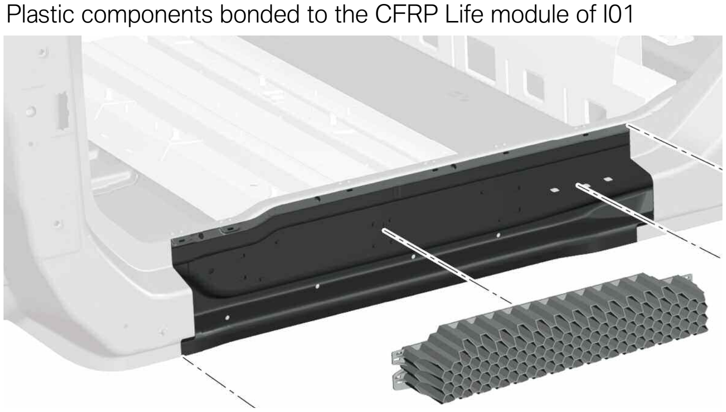
Adhesives

In addition to conventional fastening methods, plastic components can also be secured to one another through adhesion. The adhesives used in repair can be in liquid form, or as a tape with a removable protective backing. BMW offers repair kits for plastic body components including PDC/PMA sensor mounts and certain headlight brackets. Adhesives are also used to secure plastic structures to the Life module of BMWi vehicles. The vehicle specific repair instructions and electronic parts catalog will contain the necessary information on consumables used in the repair.

Always follow the procedures outlined in ISTA for surface preparation as an incorrectly prepared surface is the primary cause of insufficient adhesion.

PDC / PMA sensor holder repair kit

Plastic components bonded to the CFRP Life module of I01



Repair

Damage to plastic outer body skin components can be repaired up to a certain damage pattern, without replacing the component completely.

Different repair methods are available for the repair of the outer body skin. In order to be able to select the most suitable repair method, a thorough assessment of the respective damage should be carried out. A combination of different repair methods is often practical.

Repair Method	Advantages	Disadvantages
 Plastic Bonding	• No heating of material • Simple to apply • No identification of plastic required	• Restricted use (see repair instructions)
 Plastic Welding	• Complete fusion of plastics • No shrinkage • Ability to repair larger damages	• Heating of material • Restricted use (see repair instructions) • Certain skill required • Identification of plastic required
 Reshaping	• Can restore shape to deformed plastics • Minimal heat input	• Only used for soft deformations with no paintwork damages

The quality of the repair result has top priority. If in doubt, the faulty body component should be replaced.

The permissibility of the repair by plastic welding is dependent on the type and severity, as well as the position of the damage. The conditions for a repair can be found in the workshop information system ISTA.

In general, no fluid tanks, such as fuel tanks, can be repaired.

Plastic Bonding

Plastic bonding can be used as a repair method for thermoplastics and thermosetting plastics on the outer bodyskin. Therefore no precise identification of the plastic in question is required.

Work Preparation

Sanding the edges of the damage

For a high-strength bond between the substrate and the repair adhesive, it is necessary to ensure that the points of contact are as large as possible. To achieve this, the edges of the break are sanded into a wedge shape from the rear side of the component. A low-speed DA sanding tool with P80-P120 grit abrasive can be used here.

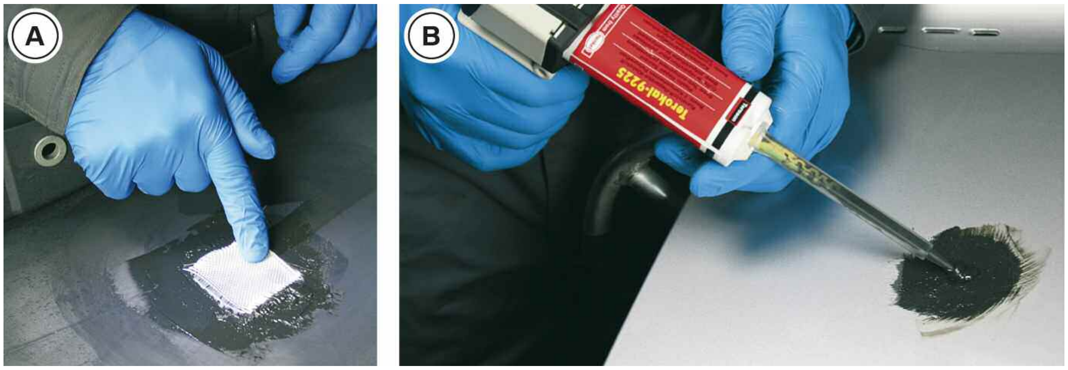
Where there is a crack, a 6 mm hole must be drilled at each end of the crack to prevent the crack from extending any further.

After this, the entire area must be thoroughly cleaned using a solvent cleaner and diluting agent, then treated with the plastic primer. It is crucial to respect the air drying times for each product.

Procedure Overview

The restoration begins on the inside (back) of the component. A fiberglass mesh can be incorporated into the plastics adhesive at this stage for reinforcement. The front can only be worked on after the plastics adhesive on the inside (back) of the component has hardened. The time needed for the adhesive to harden can be reduced to approximately 15 minutes by using an infra-red heater set to between 60°C and 70°C.

Application of plastic repair adhesive



Index	Explanation
A	Incorporating the fabric mesh (rear side)
B	Filling in the damage (front)

On the front, the adhesive simultaneously acts as a filler compound. For this reason, a certain amount of shrinkage during hardening must be factored in when applying it.

To avoid any air pockets, the mixing nozzle must always be submerged in the adhesive during application. The subsequent smoothing down of the adhesive must be performed from the center of the damage outwards.

Before the surface is smoothed over, the adhesive must be allowed to cure completely and cool down to room temperature, where appropriate.

Tools & Consumables

Plastic repair components

Index	Explanation
1	Repair Adhesive
2	Cartridge gun
3	Mixing nozzle

Cleaner
Prior to application of the repair adhesive, the bare plastic substrate must be cleaned. Cleaning with ColorSystem Aerosol Antistatic Cleaner or ColorSystem Plastic Cleaner is permitted. Wipe cleaner and allow to fully air dry.

Plastic primer
The plastic primer constitutes the base for the adhesive, filler compound, filler and paintwork. ColorSystem Polyolefin Adhesion Promoter Aerosol is permitted for use with Teroson PU 9225 repair adhesive. The ColorSystem primer has an air drying time of 10 minutes at 68°F. Without the plastic primer, it is not possible to create a sufficient bond between the plastic and the plastics adhesive.

Plastic adhesive
The plastic adhesive is a two-component, polyurethane-based adhesive, which can be used for joining and as a filler compound for plastics. The plastic adhesive can be easily sanded down and has good overpainting properties.

The working time is approximately 10 minutes. Cartridges which have only been partially used can be re-used, although the mixing nozzle must be renewed after each use.

Fabric mesh
The fabric mesh can be used to reinforce the rear side of repair areas in the case of holes and cracks.

No metal reinforcements should be used when repairing outer body skin components, as the passive pedestrian protection could otherwise be impaired.

Plastic welding

Plastic welding can be used as a repair method only on thermoplastics.

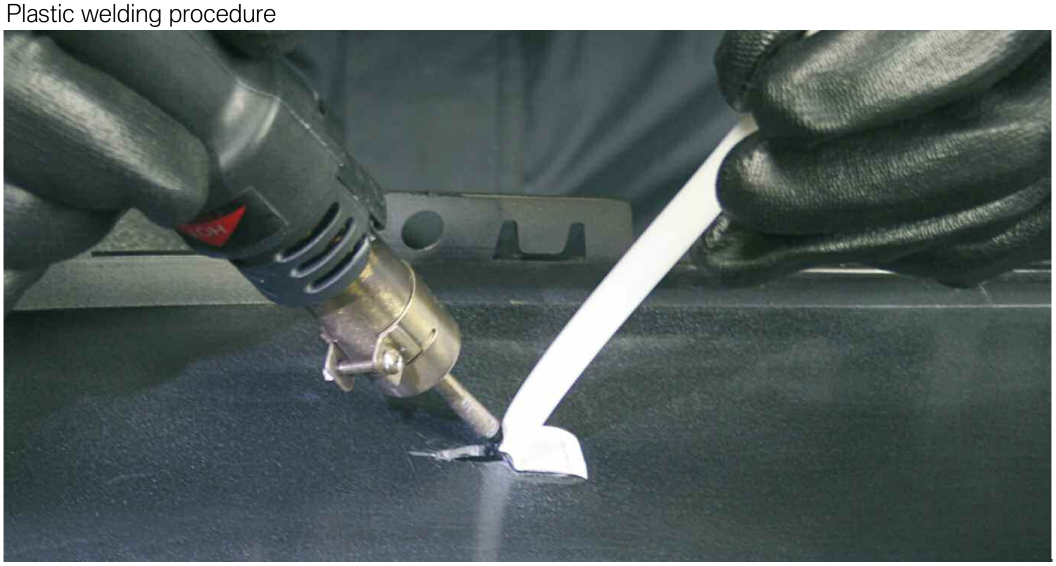
Work preparation
Repairs must always be carried out from the inner to the outer side of the component, which means that in most cases, it is necessary to disassemble the damaged body component.

The repair area must always be thoroughly cleaned prior to any repair.

To ensure that there is a good bond between the plastic and the filler material, the edges of the break must be sanded into a wedge or "V" shape on the inner and outer sides. In addition, the paint must be removed from the damage area. A low-speed sanding tool with P80-P120 grit abrasive can be used here, as the plastic could otherwise overheat and smear.

Procedure Overview

Plastic welding procedure



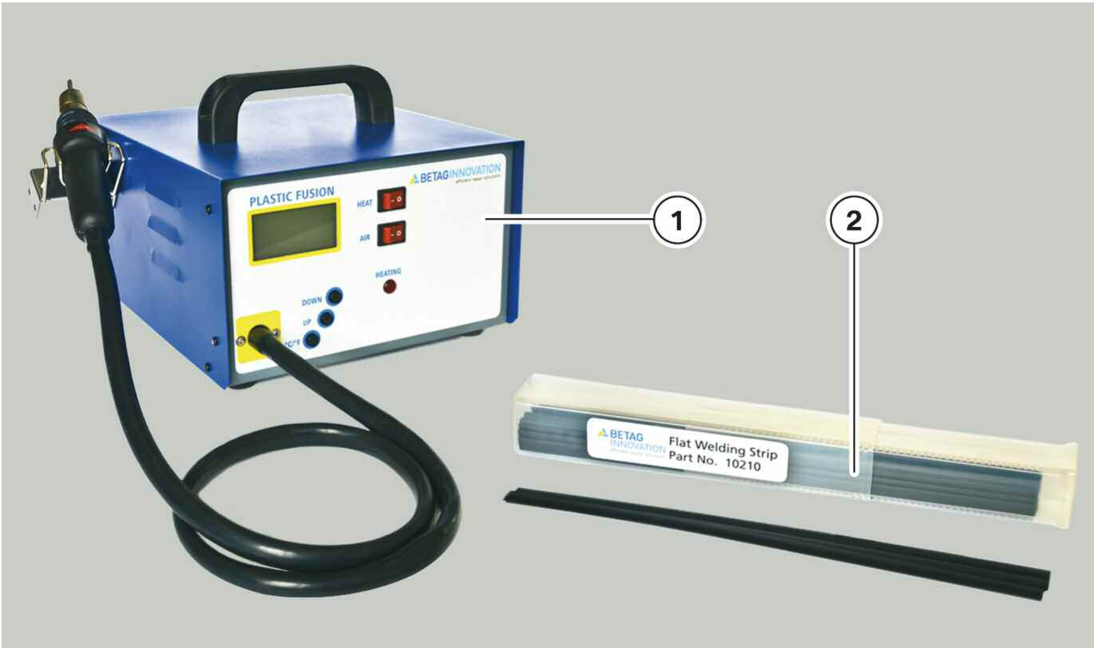
A one-sided repair will not be able to totally seal the damage, and would lead to the damage recurring shortly after the repair. This is why both sides of the plastic part must always be welded.

The repair always begins on the inside of the component. The plastic part and the filler material are fused and welded together with a jet of hot air. Several layers of the filler material can be overlapped and welded to each other in the process. A single weld seam is normally sufficient on the outer side.

Any protruding filler material on the outer side of the plastic part is sanded off. The part is then prepared for refinishing.

Tools & Consumables

Plastic Fusion welding components



Index	Explanation
1	Plastic welder
2	Filler material (PP + EPDM)

The plastic welder produces a jet of hot air with a maximum outlet temperature of 480°C. A compressor is located in the housing of the welder for this purpose. The air is conducted under low pressure through the hose assembly to the welding head and heated only just before it reaches the outlet nozzle.

The plastic welder's heating stage must never be switched on if the compressor is switched off, otherwise the welding head will be damaged by overheating.

After the heating stage has been switched off, the compressor must remain switched on for an additional minute or so to help the welding head cool down.

Filler material

Round or flat plastic strips made out of polypropylene (PP + EPDM) are used as a filler material. These can be obtained in black or white. In order to achieve an optimal bond, the base material and the filler material must be fused together uniformly.

Repair Steps

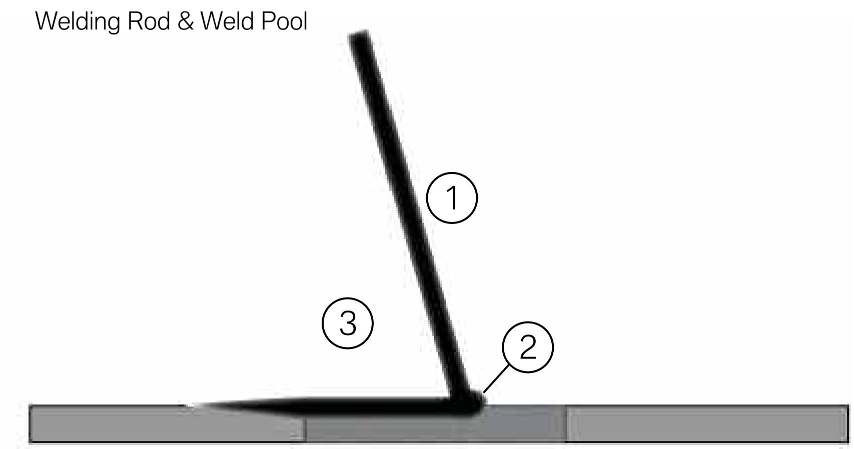
For proper fusion to occur, both the welding rod and the part to be repaired have to be in the molten (liquid) state. Each plastic has a different melting temperature as well as it's own Melting Flow Index (MFI). MFI is a measure of the ease of flow of the material when heat and pressure are applied.

Plastic Fusion utilizes a high welding temperature with a low air volume. This has the advantage of a controlled welding pool without deforming the surrounding area. There are three main points to consider during the welding process.

- Welding bath or pool
- Welding rod angle
- Pressure on the rod

It is recommended to set the welding temperature on the Plastic Fusion machine to 480°C for all plastics. Different types of plastics will melt at different temperatures. The angle and distance of the torch may require adjustment to ensure both the filler material and the repair part melt simultaneously to maintain a proper weld pool. A proper weld pool can be seen as a small rolled plastic near the front of the weld pool.

During welding, the angle of the filler rod in relation to the repair part should be at less than 90° (acute angle). Slight downward pressure on the filler rod is also important as this will create the right pressure in the weld pool. Without the correct rod angle and pressure, the weld pool will not be created successfully.



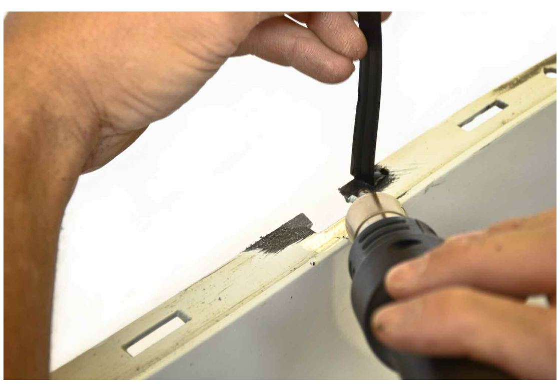
Index	Explanation
1	Filler rod
2	Weld pool
3	Filler rod angle less than 90°

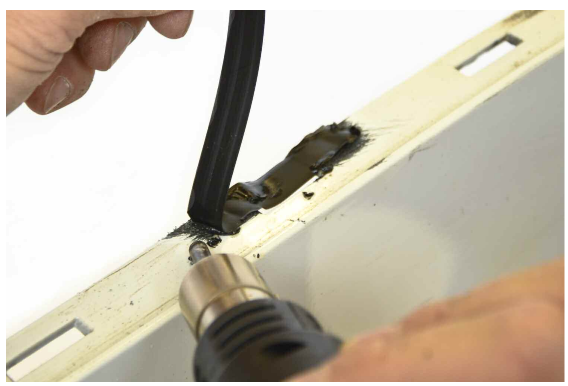
Repairing a Hole or Crack

Remove all coatings and expose bare plastic substrate on the front and rear of the repair area using P80-P120 grit sandpaper. Sand the edges to a wedge or "V" shape on both the front and rear. Start the welding repair on the back side first. Depending on the size of the damage, it may be necessary to overlap the welding strips. Proper overlap is 50%. Once the rear side is complete, you may optionally perform 1 more weld perpendicular to the repair for added strength.

Repeat the process for the front of the part. Allow the part to cool, then slowly grind the surface with P240-P320 to prepare for filler application.

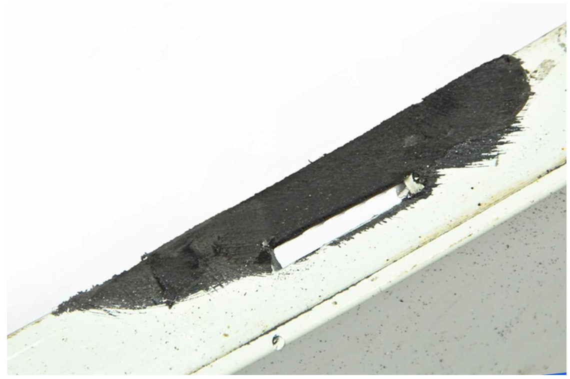
Repairing a Bumper Tab





Remove all coatings and expose bare plastic substrate on the front and rear of the repair area using P80-P120 grit sandpaper.

Make a slight groove into the broken edges. Start welding on one side, ensure proper fusion, and allow to cool. Heat the filler rod to allow rod to bend. Make a bridge over the broken bumper tab and weld on the remaining side.



Once both sides are bonded, use the flat vice-grip to smoothen out the repair area while still warm. Repeat the process on the underside of the bumper tab. Remove unnecessary material and test for proper fitment.

Reshaping

Sometimes there are deformations in the plastic parts. This may be due to damage or the repair process. If too much heat is brought into the part, a deformation may occur. In this case, the deformation can be removed by applying heat and pressure. Heat up the plastic component to 60°C (140°F) at the deformation. Carefully monitor the application of heat, as too much heat will damage the paintwork. Once softened, the damage can be pressed out. Continue to hold pressure on the deformed area, and cool the area with water. A spray bottle is useful in this case. The material will cool off and hold it's shape. Molded plastics have a memory, therefore it is easy to return back to it's original shape.

Always use personal protective equipment (PPE) when working with heat.

Aluminum reshaping tool