



# Technical Committee

July 2014

Detroit Michigan

# Accounting Auditing



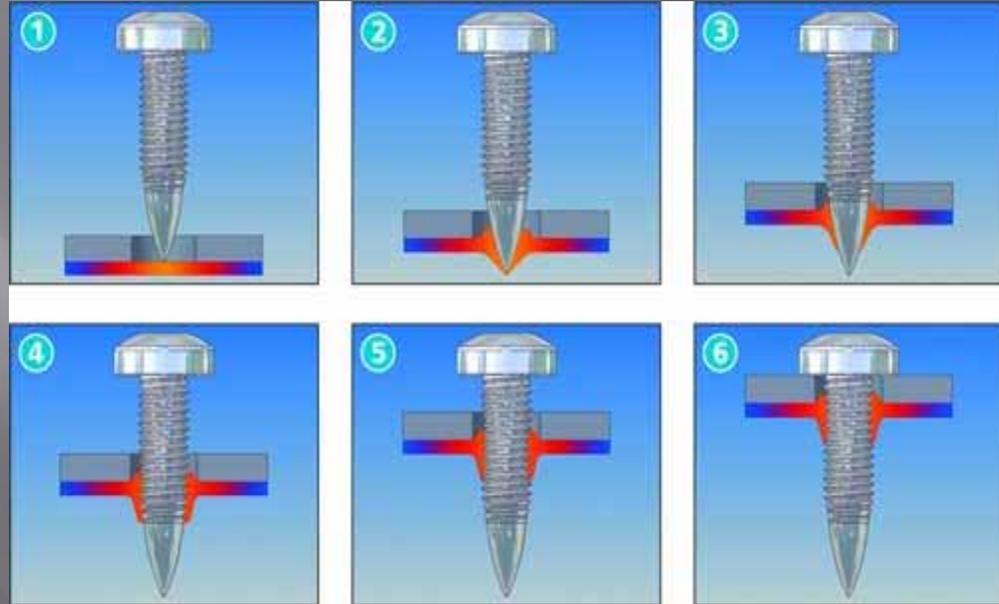
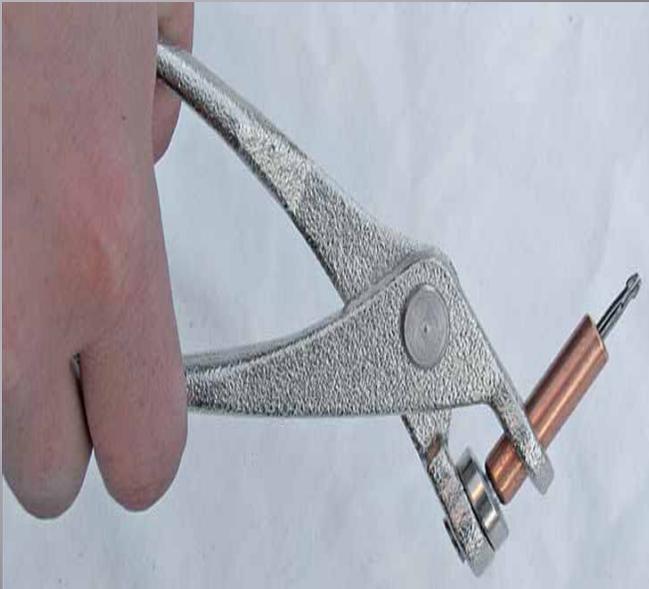
# Aluminum Presentation



**The Future is here, are you  
prepared?**



# Do you what are these items?



# **Characteristics of Aluminum**

- ▣ **Aluminum is a silver-white metal with a face-centered cubic crystalline structure. It is a member of Group 13 of the periodic table . It is ductile, malleable, and an excellent conductor of heat and electricity. The pure metal is soft, but it becomes strong and hard when alloyed. Although less conductive than copper wire of the same diameter, aluminum wire is often used for high-tension power transmission because it is lighter and cheaper. IT IS THE MOST ABUNDANT METAL ON EARTH.**

# **Why do we use Aluminum?**



**Light Weight**  
**Corrosion Resistance**  
**Electrical & Thermal Conductivity**  
**Ductility**  
**Abundant**  
**Recyclability**



# What are Aluminum Alloys?

Aluminum Alloys can be divided into nine groups.

- **2xxx**Copper is the principal alloying element, though other elements (Magnesium) may be specified
- **1xxx**Unalloyed (pure) >99% Al
- **3xxx**Manganese is the principal alloying element
- **4xxx**Silicon is the principal alloying element
- **5xxx**Magnesium is the principal alloying element
- **6xxx**Magnesium and Silicon are principal alloying elements
- **7xxx**Zinc is the principal alloying element, but other elements such as Copper, Magnesium, Chromium, and Zirconium may be specified
- **8xxx**Other elements (including Tin and some Lithium compositions)
- **9xxx** Reserved for future use

# Typical Use for different series Aluminum

- ▣ Alloy Series Main Alloying Elements
- ▣ 1000 series Pure aluminum
- ▣ 2000 series Aluminum and copper. (High strength aluminum used in the aerospace industry )
- ▣ 3000 series Aluminum and manganese. (Low- to medium-strength alloys, examples of products using these alloys are beverage cans and refrigeration tubing)
- ▣ 4000 series Aluminum and silicon. (Most alloys in this series are either welding or brazing filler materials)
- ▣ 5000 series Aluminum and magnesium. (These alloys are used primarily for structural applications in sheet or plate metals - all 5000 series alloys are weldable )
- ▣ 6000 series Aluminum, magnesium and silicon. (These alloys are heat treatable and commonly used for extrusions, sheet and plate - all are weldable, but can be crack sensitive. Never try to weld these alloys without using filler metal)
- ▣ 7000 series Aluminum and zinc. (These are high strength aerospace alloys that may have other alloying elements added)



## Let's Make a Cake



# What is the difference between heat treatable & non heat treatable alloys?

## Work Hardened Aluminium Alloys

The 1000, 3000 and 5000 series alloys have their properties adjusted by cold work, usually by cold rolling.

The properties of these alloys depend upon the degree of cold work and whether any annealing or stabilising thermal treatment follows the cold work. A standardised nomenclature is used to describe these conditions. The most alloys are designed with the letter “H”.

## Heat Treatable Aluminium Alloys

The 2000, 4000, 6000, 7000 and 8000 series alloys respond in this way. The wide choice of alloy compositions, solution heat treatment temperatures and times, quench rates from temperature, choice of artificial ageing treatment and degree to which the final product has been deformed permit a wide range of properties to be achieved. A system of standard designations is used, based upon the letter T followed a number after the alloy designation, to describe the various conditions

# What series Aluminum will you be working with in a body shop?

- ▣ **Series 4**
- ▣ **Series 5**
- ▣ **Series 6**

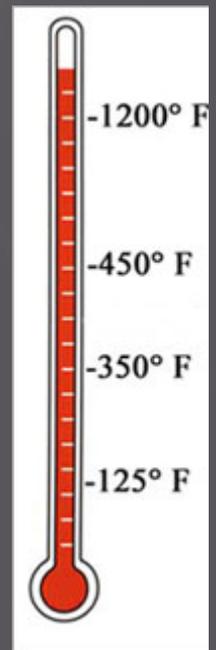


Series 4 is cast Aluminum and welding is not recommended

# Can heat be used on repairing Aluminum?

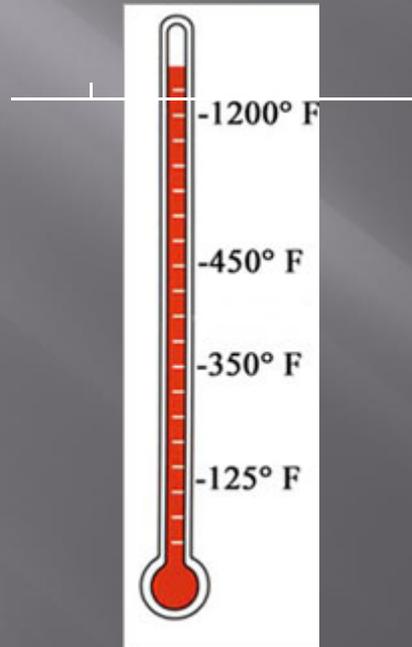
The answer is yes, but must be monitored? The reason is that at a certain temperature, aluminum will change its properties. In other words, the aluminum becomes permanently soften. This process is known as annealing.

Keep the heat below 570 degrees F to prevent annealing.



# What temperature does Aluminum melt?

- Aluminum melts at 660.32 C or 1220 degrees F.



# What color does Aluminum change to when it melts?

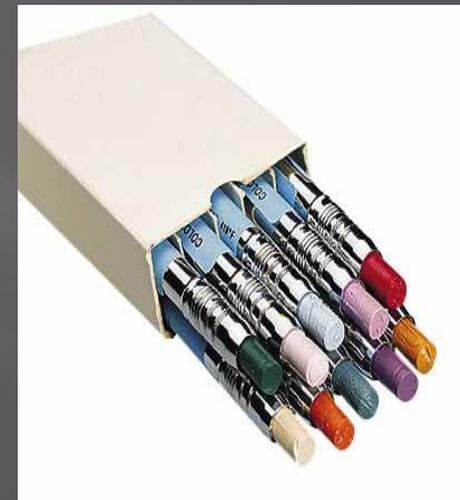
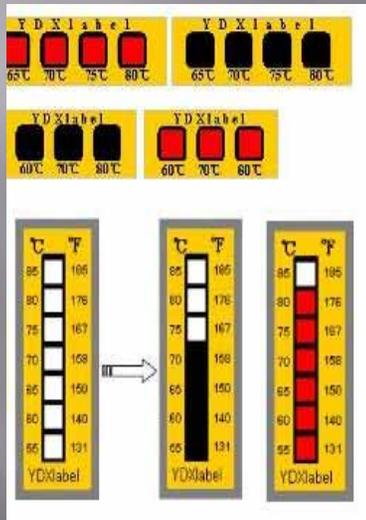
- ❑ Orange
- ❑ Light yellow
- ❑ Orange red
- ❑ Red
- ❑ Light Blue
- ❑ White

Actually it does not change color. Aluminum does not change color like steel and other metals when it reaches its melting point. These other metals will start to glow red. When aluminum gets near its melting point, it will darken slightly. When it hits the melting point it becomes liquid and disappears. |



# How is the heat monitored?

Heat can be monitored using heat crayons, heat paint, heat monitoring strips or non contact thermometers.



# What tools can be used to heat Aluminum?

**Induction Heater**



**Oxy-  
acetylene  
welding**



**Butane  
Torch**

**Heat  
Gun**



# What is Aluminum Oxide?

- Aluminum oxide forms when bare aluminum comes in contact with oxygen and water.  $\text{Al}_2\text{O}_3$  melts at 3498 degree Fahrenheit. It needs to be removed before welding and/or repairs. Aluminum oxide will protect the aluminum from corroding. Weld thru primer is not needed when welding aluminum.



# What is the best method of removing Aluminum Oxide?



80 Grit Sandpaper



Plastic Eraser Wheel



Wax & Grease Remover with a Scotch Brite Pad



Stainless Steel Brush



# What is Dye check?



“Dye Penetrant is based upon [capillary action](#), where low surface tension fluid penetrates into clean and dry surface-breaking discontinuities. Penetrant may be applied to the test component by dipping, spraying, or brushing. After adequate penetration time has been allowed, the excess penetrant is removed, a developer is applied. The developer helps to draw penetrant out of the flaw where a visible indication becomes visible to the inspector”<sup>a</sup>

# Dye Check Demo



# What is the most recommended primer for bare Aluminum?



Epoxy Primer



# Aluminum Joining Methods

## Most common joining methods used by vehicle manufacturers:

- Riveting-Self-Piercing (SPR)
- Blind Rivets
- Solid Rivets
- Bonding
- Welding (MIG)
- Laser Welding
- Threaded Fasteners
- Through Joining (clinching)
- Resistant Spot welding

## Joining Methods

Resistance welding								
MIG/MAG welding								
MIG welding								
Blind riveting								
Self-piercing riveting								
Flux core welding								
Clinching								
Flux core arc cladding								
Adhesive bonding								

Joining methods differ depending on the material types and design for mechanical stresses & the forces introduced into a vehicle during a collision.

It is especially important to use the correct joining methods during repairs in order for the vehicle to perform as designed in a subsequent collision!

# MIG Welding Aluminum

**MIG welding aluminum is a challenge for the vehicle repair technician. Steel welding is simple and has much less prep work than the same aluminum weld. Everyday welding tasks on a steel vehicle are easy while aluminum Welds are very challenging because there are so many variables involved.**



# Which of the following welding processes can be used in the body shop to weld Aluminum?

▣ MIG Welding



▣ TIG Welding



▣ STRSW



# What Shielding gas is needed?

You will use 100% Argon Gas.  
The pressure is 25 CFH to 50 CFH.



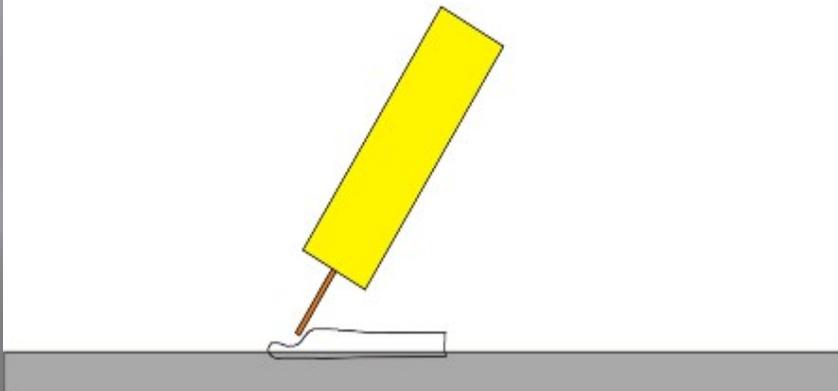
# Which method is correct?

Pushing the puddle

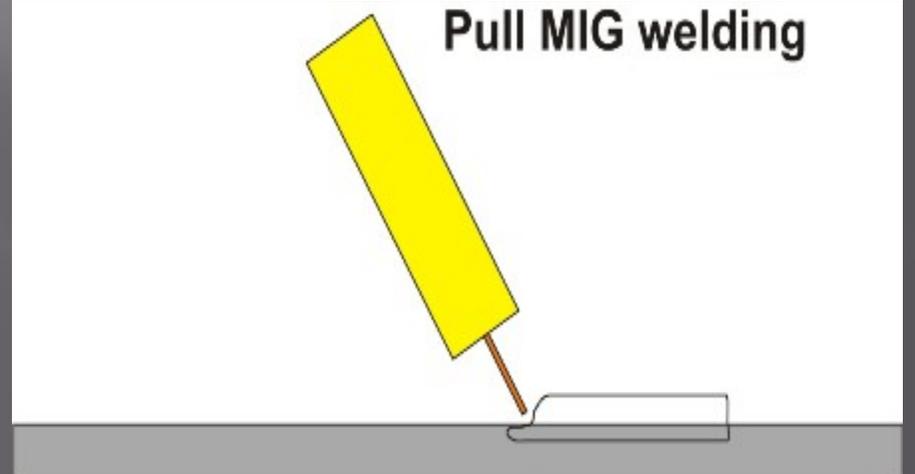
Pulling the puddle

Either one is correct

Push MIG welding



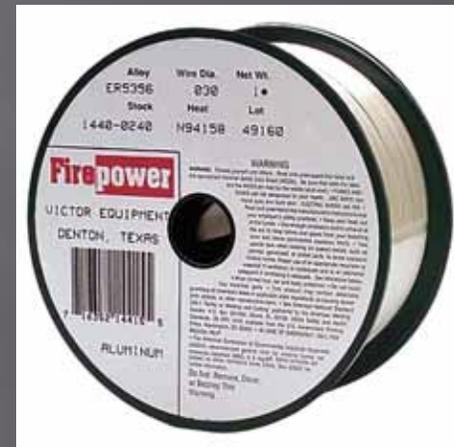
Pull MIG welding



# What wire is recommended welding Aluminum?

Welding series 5 Aluminum, use 5356 wire and now another wire is recommended by Ford for the Aluminum F150 and the new Chevrolet Corvette 5554

Welding series 6 Aluminum, Use 4043 & 5356

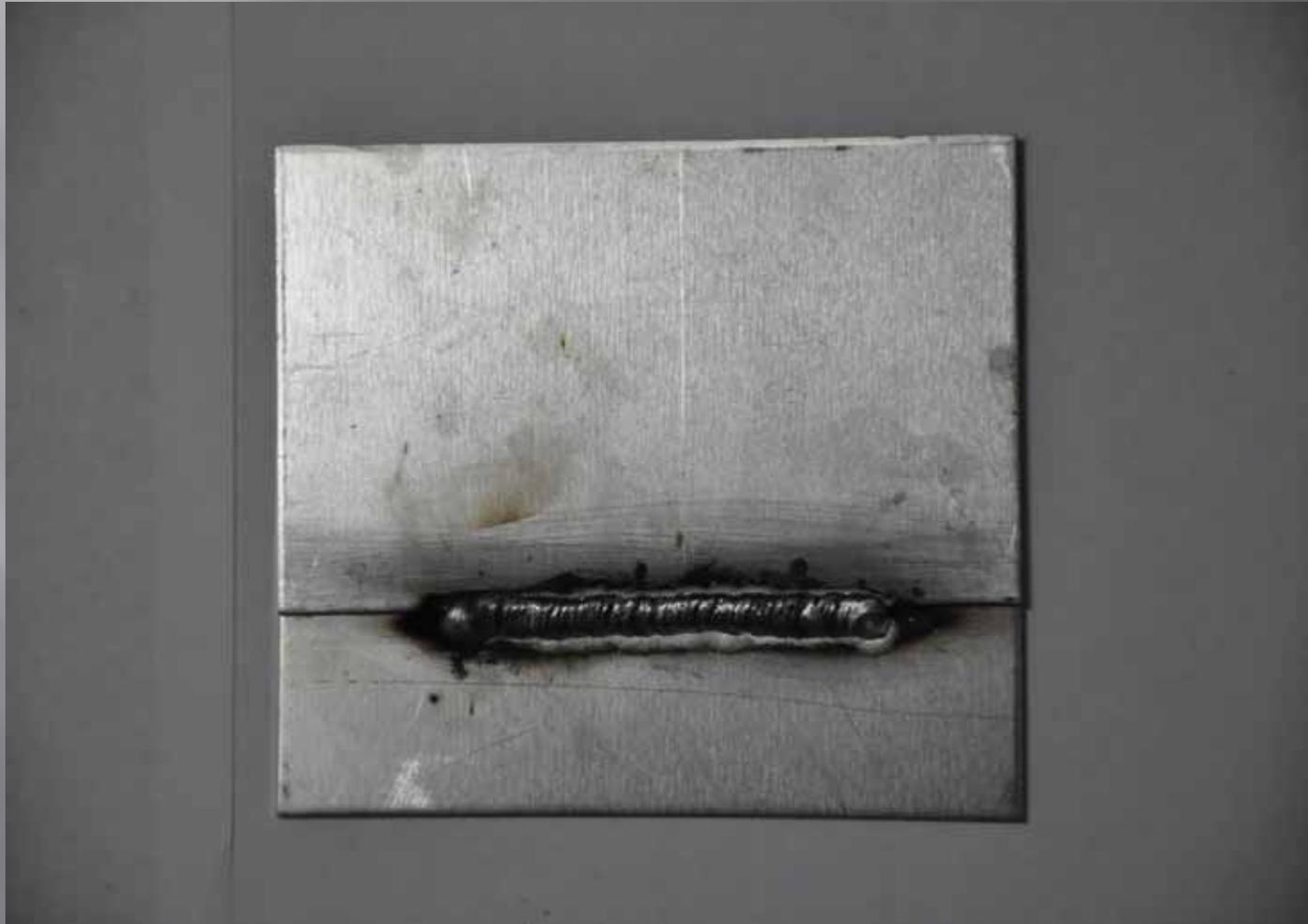


# Aluminum MIG Welding

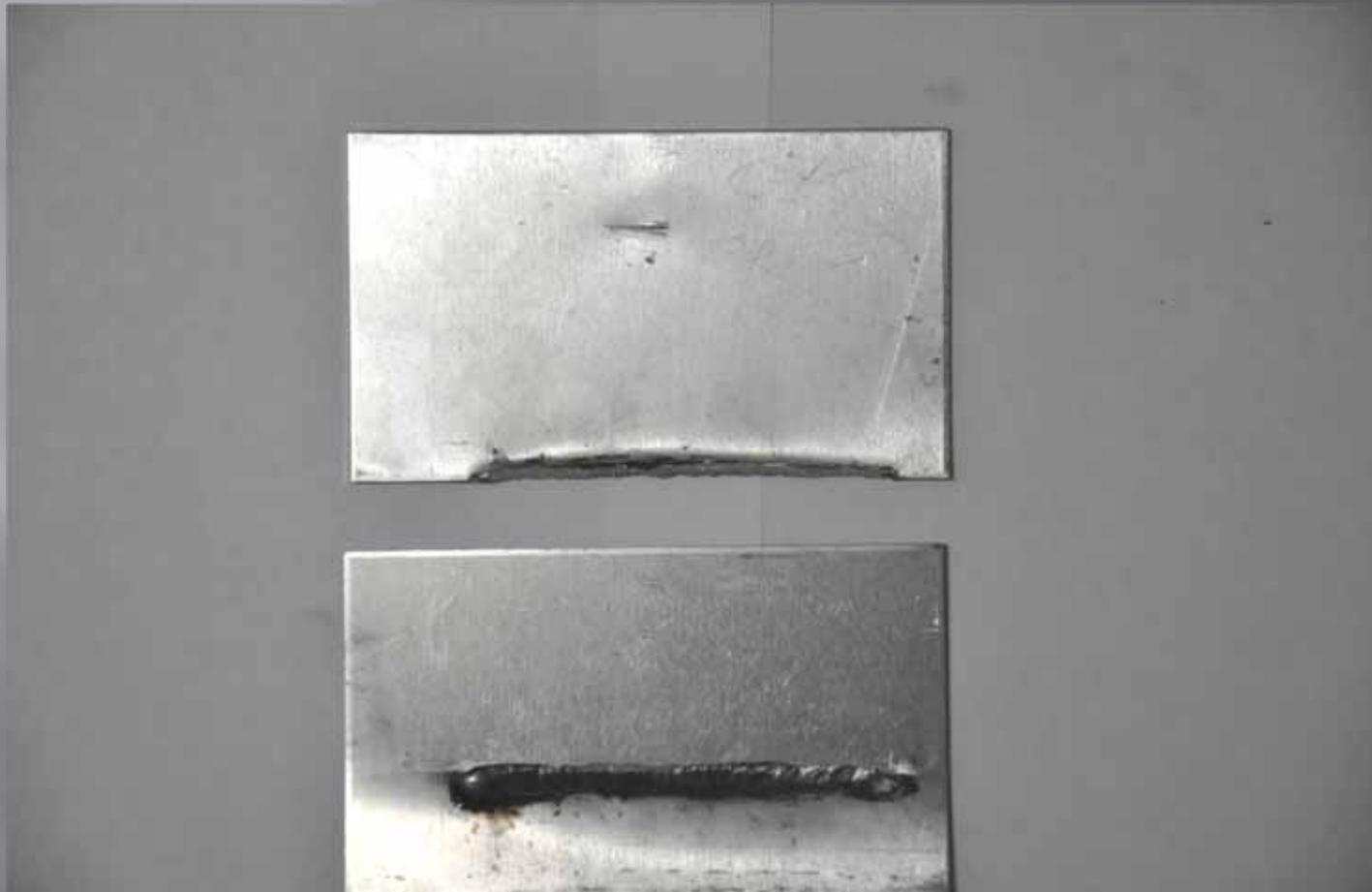


Video is courtesy of Miller Electric Company

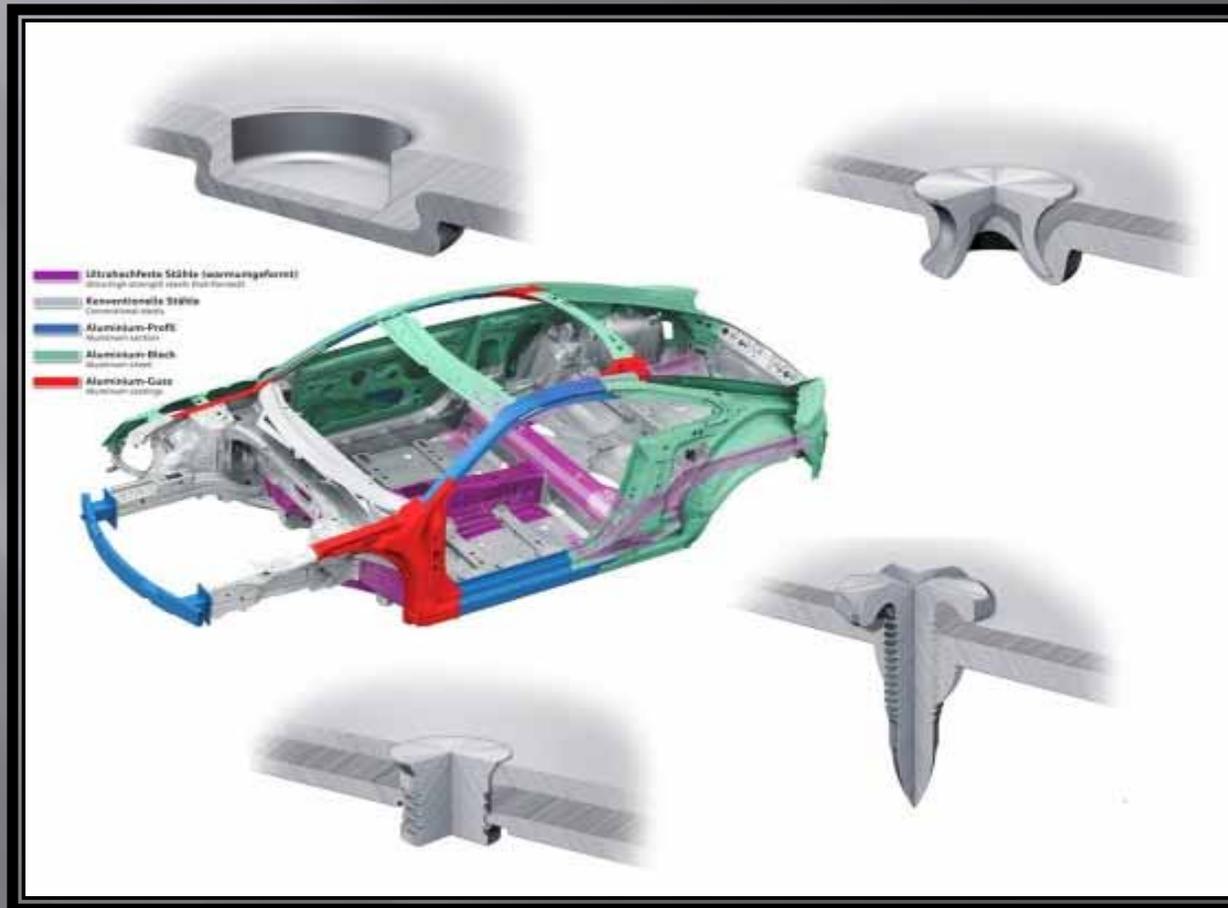
# Series 5 Aluminum welded with 4043 welding wire



# **Destructive Test on Series 5 Aluminum welded with 4043 welding wire.**



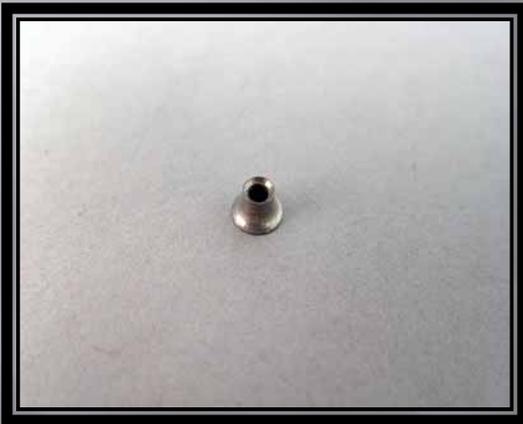
# Various Parts Attachment Hardware for Aluminum Audi Vehicles



# Rivet Fasteners

## Multiple Rivet Designs & Sizes

Self-Piercing Rivet



Solid Rivet



Blind Rivet



**It is absolutely Critical to follow the manufacturer guidelines due to many issues which can occur by using improper rivets or sizing.**

# Rivets

Special Rivets for Tesla and Jaguar Aluminum Vehicles



Common Rivets found in a Collision Center

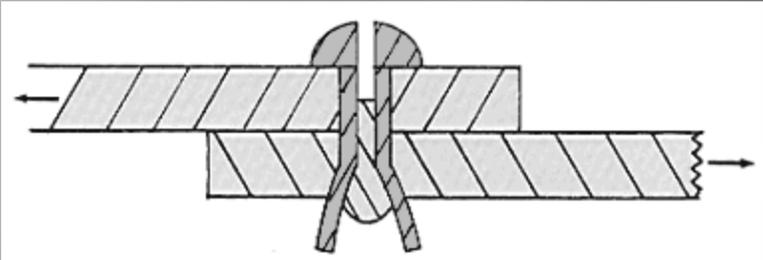
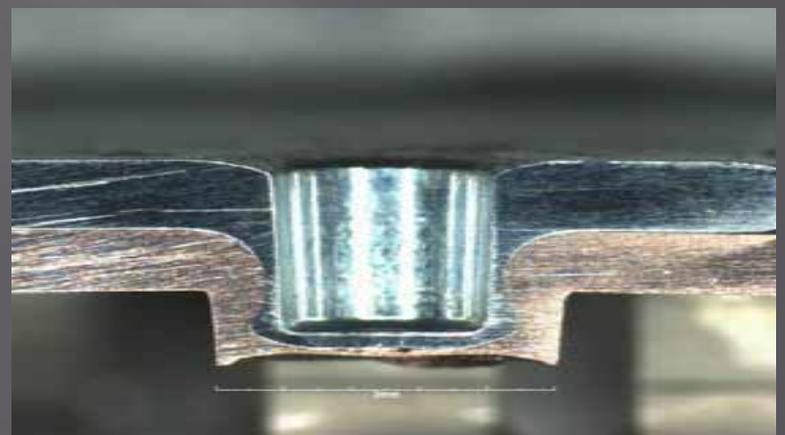
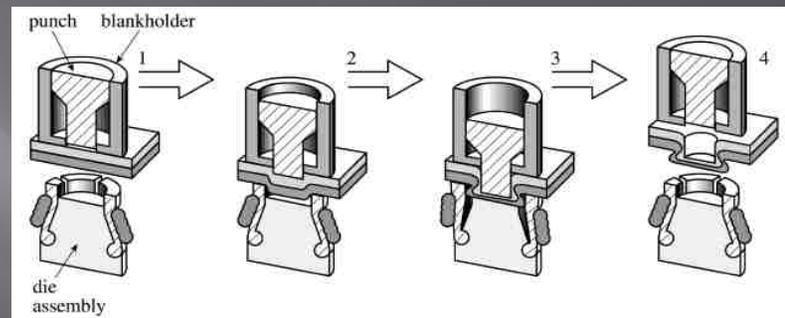
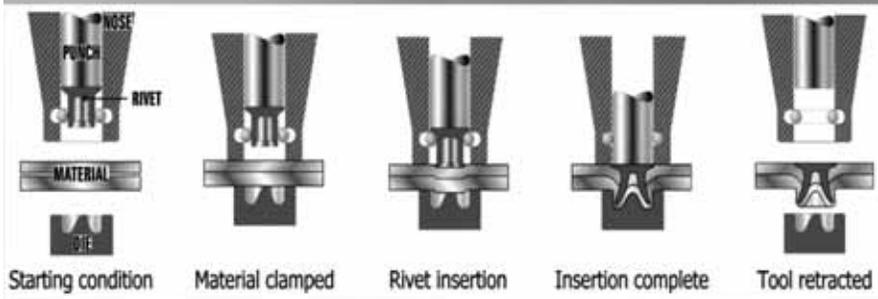
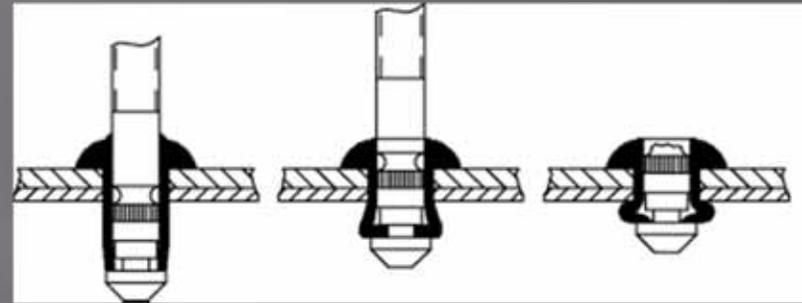


Fig. 4

Typical Bad Blind Rivet



# Deburring tool used to clean rivet holes prior to inserting the rivet



**A number of rivets need to be countersunk with a 100 degree or 120 degree champher.**



# Special Tooling & Equipment

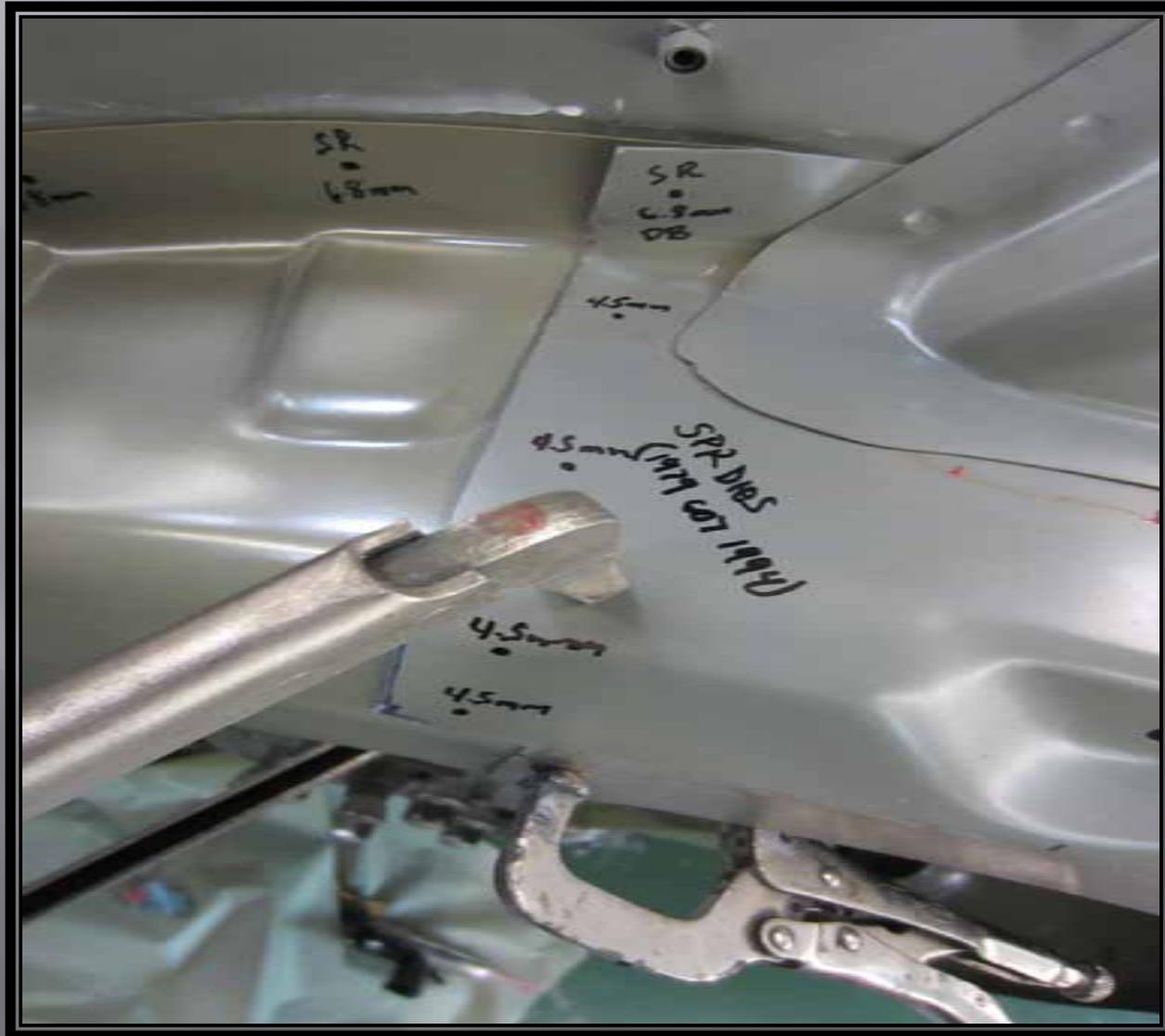
## Program Specific Rivet Guns & Dies



# Insertion Mandrals



**Before starting the repairs, rivet size and type is marked on part**



# **A comparison of Hemlock Rivet Heads and Pop Rivet Heads.**



# Front and Back of two panels joined with adhesive and SPR's



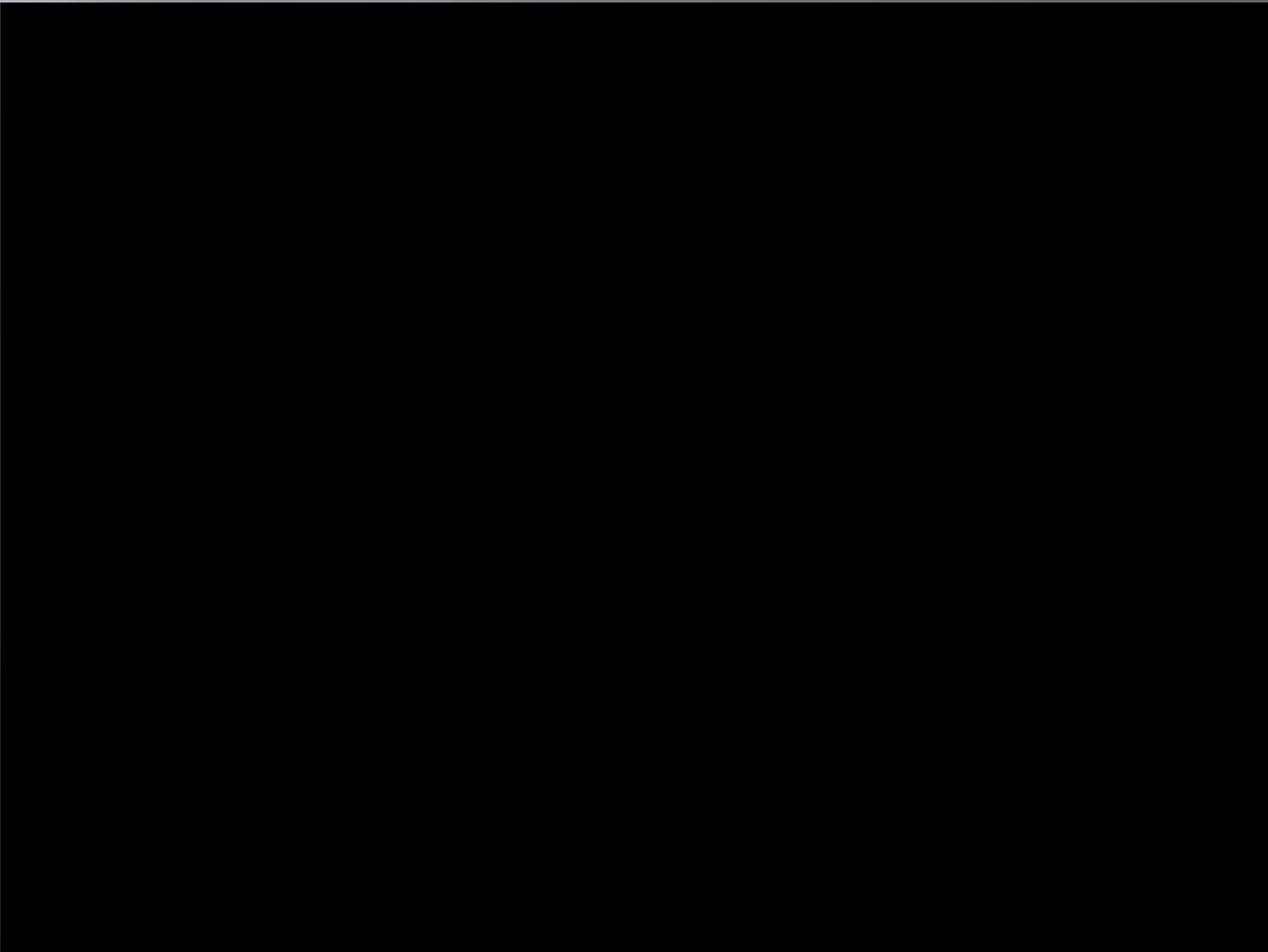
# Special Tooling & Equipment

**Dedicated Fixtures are required for most Aluminum program. They're capable of Measuring, Holding and Anchoring. Necessary to achieve zero tolerance specifications. Fixtures also hold parts in place while the bonding is curing; a process that can take up to 48 hours.**  
**No Pulling on Structural Aluminum recommended by most of the European Manufactures in their certified Aluminum Repair Program.**



# Special Tooling & Equipment for Adhesive Bonding





# What is galvanic corrosion?



**Galvanic corrosion can be defined simply as being the effect resulting from contact between two different metals or alloys in a conducting corrosive environment**

# Example of Galvanic Corrosion



# Example of Galvanic Corrosion



# Dedicated Aluminum Building

An Aluminum “Clean Rooms” are required to prevent galvanic corrosion caused by cross-contamination.



# The Attachment Process



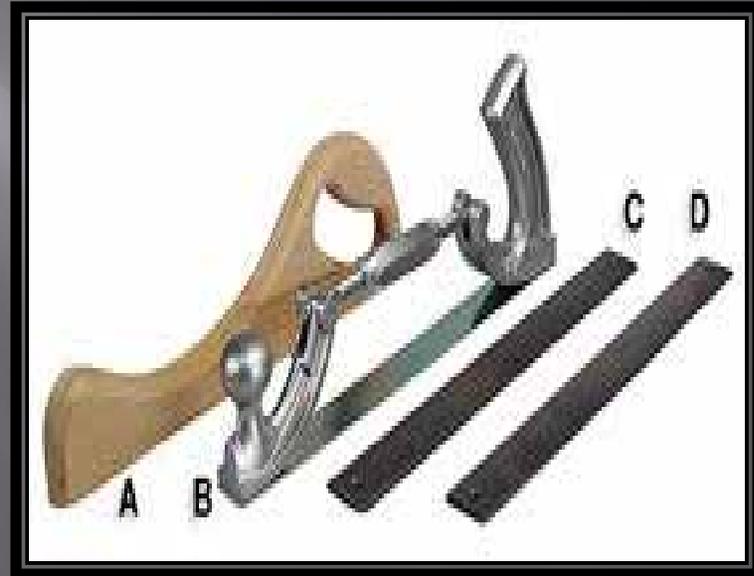
Remember to disconnect the battery before using  
A stud gun on a vehicle.

# Is it necessary to have a set of tools for steel & a set for Aluminum?



The answer to that question is yes  
To prevent galvanic corrosion.

# What is a Vixen File?



A flat file with curved teeth; used for filing soft metals

# Can a shrinking hammer be used to straighten a damaged Aluminum panel?



The answer is NO.





# **Steps Necessary to Repair Aluminum**

- ❑ **Remove paint from surface using an eighty grit DA.**
- ❑ **Clean with wax and grease remover**
- ❑ **Start working with body features or work harden damage.**
- ❑ **Disconnect the battery if you are going to use weld on body pins.**
- ❑ **Use heat in a circular motion to release the tension on the molecules.**
- ❑ **Monitor the heat.**
- ❑ **Clean surface with a stainless steel brush before applying the pins**
- ❑ **Cut the pins and file with a vixen tool.**
- ❑ **Check for peaks and valleys.**
- ❑ **Repeat prior steps until straight.**
- ❑ **Sand with 80 Grit DA.**
- ❑ **After final sanding, clean with wax and grease remover.**
- ❑ **Apply epoxy primer.**
- ❑ **Apply body filler that is recommended for aluminum repair.**

# Can PDR be used on Aluminum Panels?



The answer is Yes. You will need to have tools that have plastic tips (no sharp points).



# Safety Equipment Necessary to Repair Aluminum.

**Aluminum dust can be highly explosive. Special dust collection devices that utilize water to trap the Aluminum dust must be utilized. Several injuries have been noted due to usage of improper equipment.**





# Question—What class of fire extinguisher is used on combustible metals?



Class D: Metals—potassium, sodium, aluminum, magnesium.



# Collision Appearance

The strength of the Aluminum produces many challenges for the repair industry. After a collision, the damage can appear insignificant. Aluminum vehicles hide damage very well and it is hard to determine how severe the damage really is. Whereas steel vehicles have a different appearance after the collision, usually easier to depict the damage.

Aluminum requires special care and often repairs take longer when compared to steel. This makes it difficult for everybody involved to come to an agreement.



# Blueprinting

Blueprinting is the key to reduced cycle time, as well as accurate estimating. Today's vehicles are increasingly more sophisticated; requiring additional research, disassembly, and possible pre-repairs. This process is very time consuming but should not be avoided.

Aluminum vehicles usually take longer due to the hidden damage, complexity of construction, sophisticated engineered pair process.

## Key items to Address while Blueprinting:

- ✓ Repair procedures
- ✓ Energy transfer
- ✓ Energy absorption
- ✓ Energy Deflection
- ✓ Repair access
- ✓ Material needed
- ✓ Vehicle design & construction
- ✓ Tools & Equipment necessary
- ✓ Measuring
- ✓ Secondary damage
- ✓ Repair damage
- ✓ Specialty Sublet



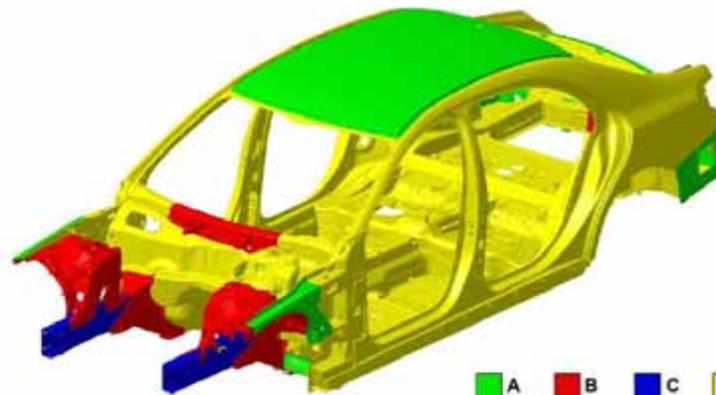
# The Different Aluminum Parts

**Parts: Castings, Extrusions and Stampings or Blanks**

**Each manufacturer designs a unique vehicle by using more or less of the parts.**

**For example, Audi relies on castings and extrusions for strength while Ford or Jaguar use multi layered sheet aluminum like stampings or blanks.**

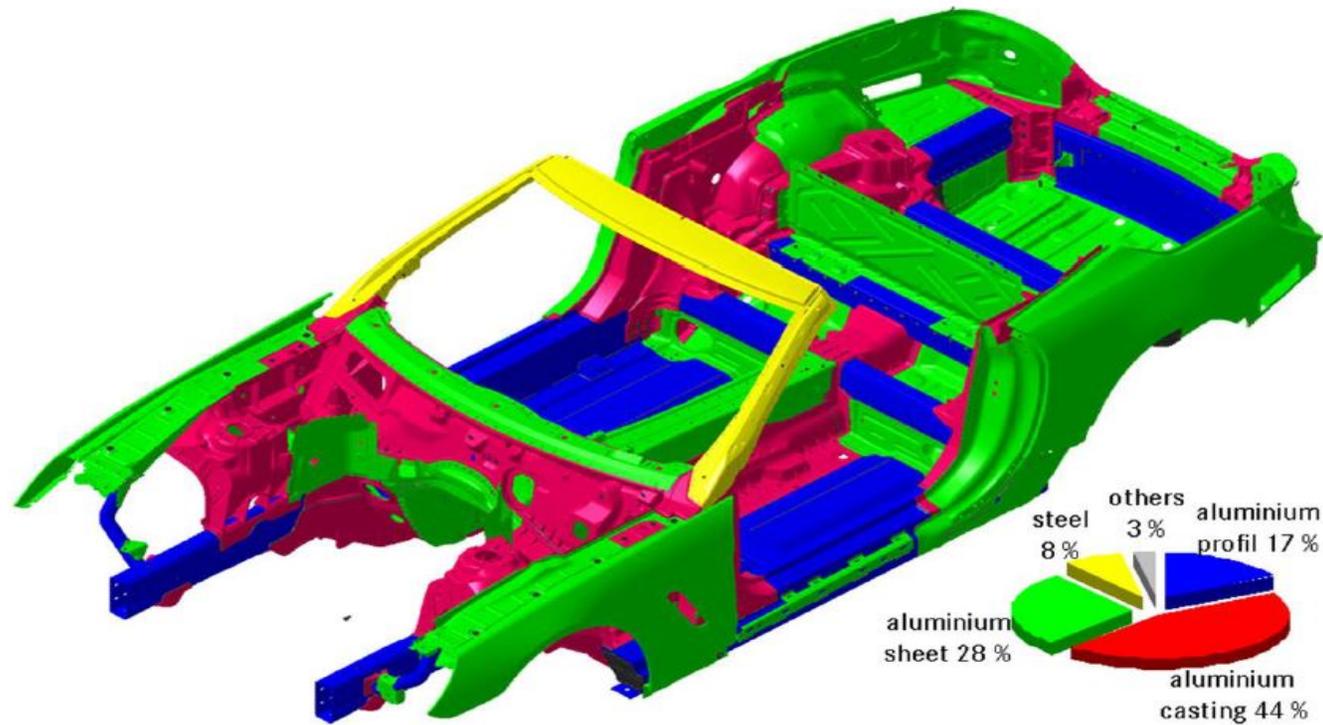
Body Shell Material Types in the New S-Class (V222)



A	Aluminum sheet metal	C	Extruded aluminum section
B	Aluminum casting	D	Sheet steel

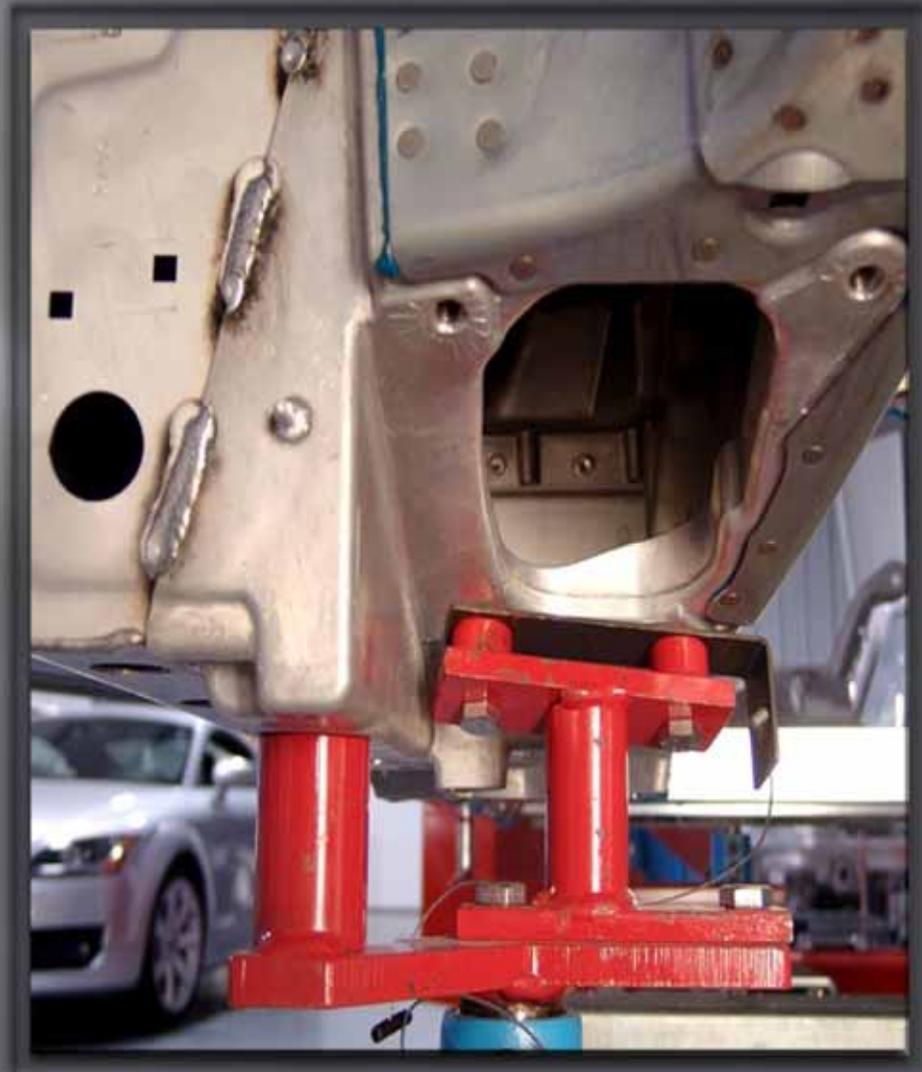
**NOTE:** Composites are also used (not shown)

## Body Shell Material Types in the SL-Class (R231)



# Castings

- **Are the most rigid part available**
- **Can not change form or shape without being damaged.**
- **Do not bent they break or crack**
- **If damaged they need to be replaced. None of the vehicle makers allows repairs**
- **Are generally hidden by stampings or extrusions they could be covered with seam sealer or other NVHS materials. This makes identifying cracks very difficult.**



# Castings



**Cast one-piece B pillar of the Audi A2  
(Photo: Alusuisse)**



**Spaceframe of the BMW Z8 roadster (side view)  
(Source: BMW)**

# Extrusions



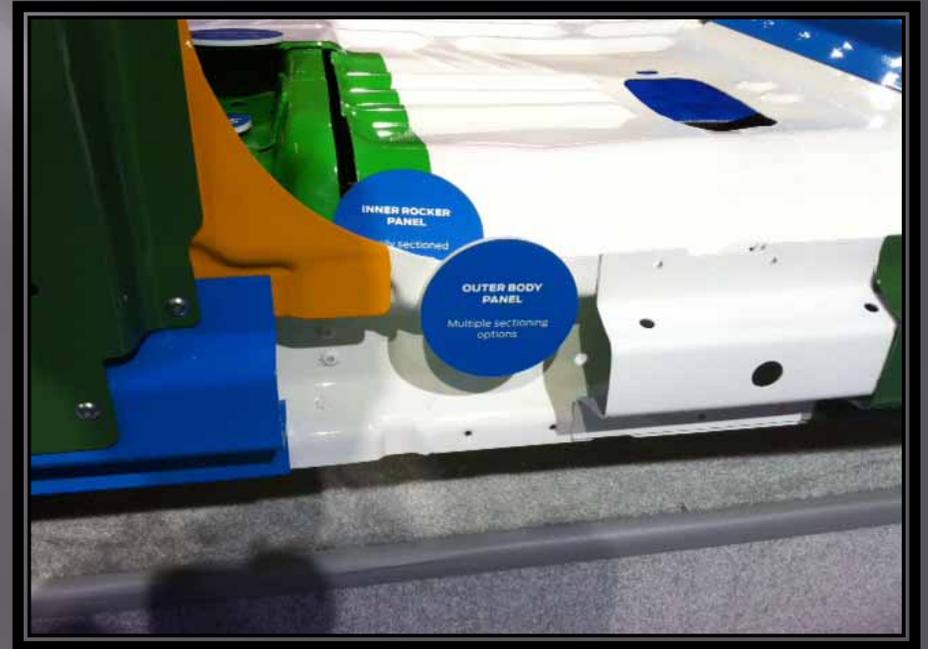
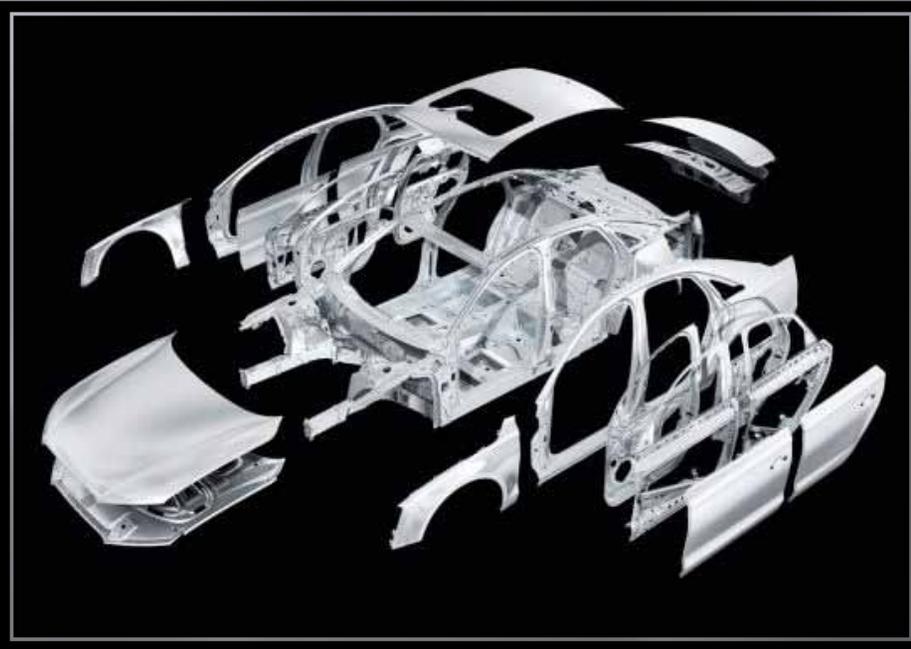
**4 Celled Extrusion  
sample Audi TT Rocker**

**The extruded inner B-pillar on the  
Audi R8 has eight cells.**



# Stampings

Stampings or Blanks are pressed into shape. They could be cold or hot formed. They make up all the outside Panels like Fender, Doors, Lids, Quarters and so on.

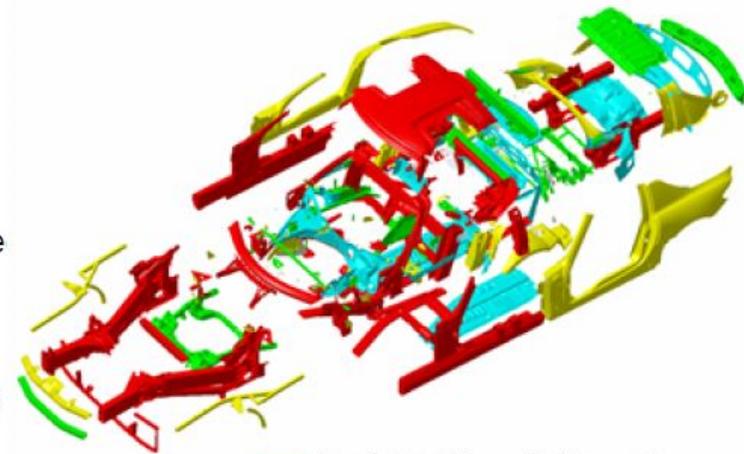


# Material types and Repair Methods

## SLS Repair Levels

Divided into 4 classifications:

- Level 1 (Bolt on parts)  
Experienced MB Repair Technician
- Level 2 (Bonded and riveted parts)  
Has Level 1 qualifications and has attended TECH283
- Level 3 (Welded non-structural parts)  
Has Level 2 qualifications and is proficient at welding aluminum
- Level 3+ (Welded structural parts)  
Has Level 3 qualifications, has attended special 10 day welding instruction course (TECH532) and has achieved and maintained structural aluminum welding certification (required for all structural and structural cast aluminum parts welding)



	Repair Level 1:	Bolt-on parts
	Repair Level 2:	Bonded and Riveted parts
	Repair Level 3:	Welded parts (nonstructural)
	Repair Level 3+:	Welded Structural parts

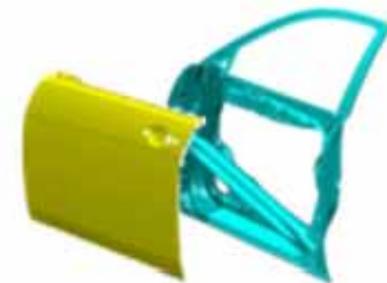
# Steel Shell with Aluminum Skin

Guess which vehicle manufacturer is using this technology?

## NEW DOOR STRUCTURE

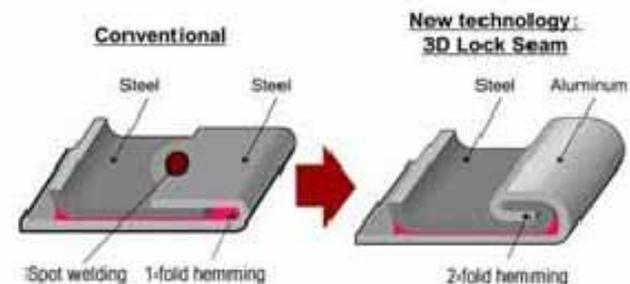
The doors on this vehicle use new technology to join steel and aluminum panels.

- This is the world's first application of this technology to a door panel.
- Door panel weight is reduced by approximately 17 percent compared to all-steel doors, improving vehicle handling and fuel economy.
- The inner door panel is a conventional steel structure.
- The outer door panel is made of aluminum alloy.



The two panels are joined using adhesive and a special "3D lock seam" joint.

- The outer door panels are not serviced separately.
- Minor damage to aluminum door panels may be repaired by body shops that have a dedicated aluminum repair facility and tools.
- Major damage to the aluminum door panels may require door replacement.

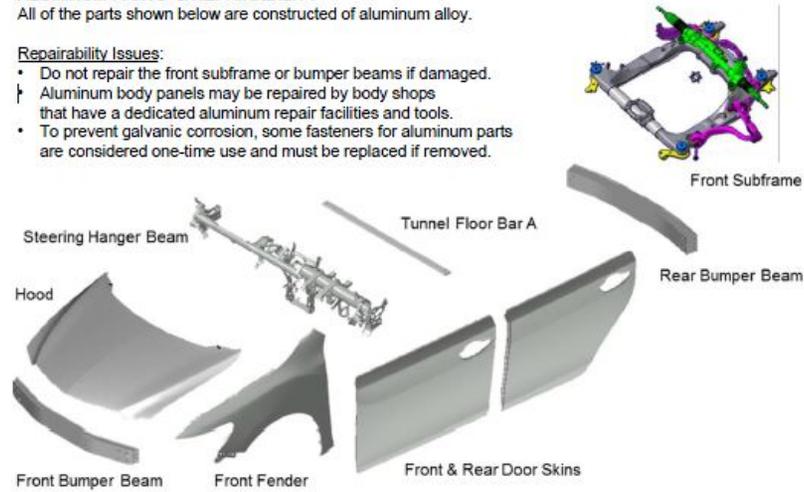


### ALUMINUM PARTS & REPAIRABILITY

All of the parts shown below are constructed of aluminum alloy.

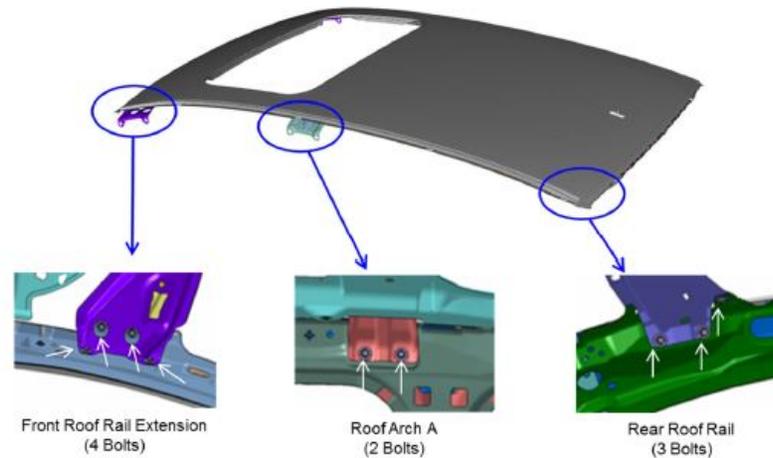
#### Repairability Issues:

- Do not repair the front subframe or bumper beams if damaged.
- Aluminum body panels may be repaired by body shops that have a dedicated aluminum repair facilities and tools.
- To prevent galvanic corrosion, some fasteners for aluminum parts are considered one-time use and must be replaced if removed.



### ROOF PANEL ATTACHMENT

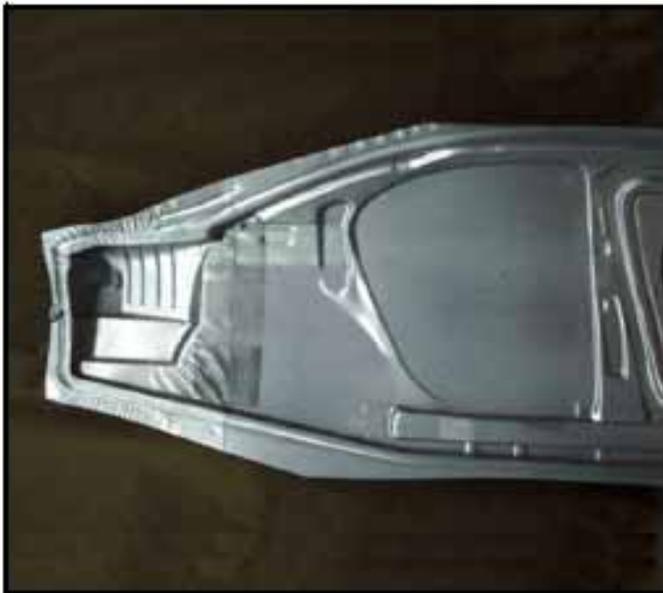
The roof rail and roof arch extensions are integrated into the roof panel assembly. The roof panel bolts and spot welds must be removed and installed to the inner pillar and roof rail structure using a specific procedure. Refer to the body repair manual section titled "Roof Panel Removal and Installation" for complete information.



# Tailor Welded Blanks



A tailor-welded blank (TWB) is a multi-gauge and/or multi-alloy **combination** of automotive sheet to produce a blank that is more optimised in its use of alloy and gauge than a single gauge sheet.



Tailor welded blank stamping (Ford P2000)



# Superplastic Forming



"A manufacturing process which utilizes the characteristics of certain aluminum, magnesium and titanium alloys to elongate several hundred percent when subjected to controlled strain rates at elevated temperatures.



# Repair or Replace Decision



Front end carrier  
manufactured as  
a plastic-  
aluminium  
composite  
structure for the  
Audi TT

(Photo:  
Faurecia/Lanxess

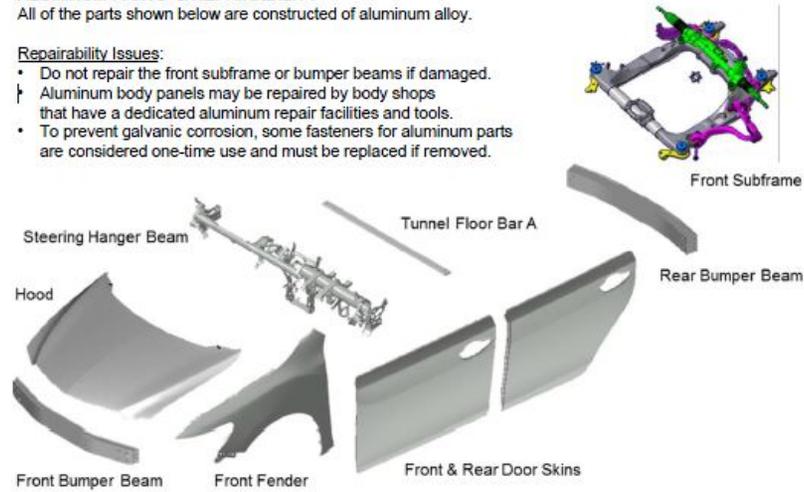


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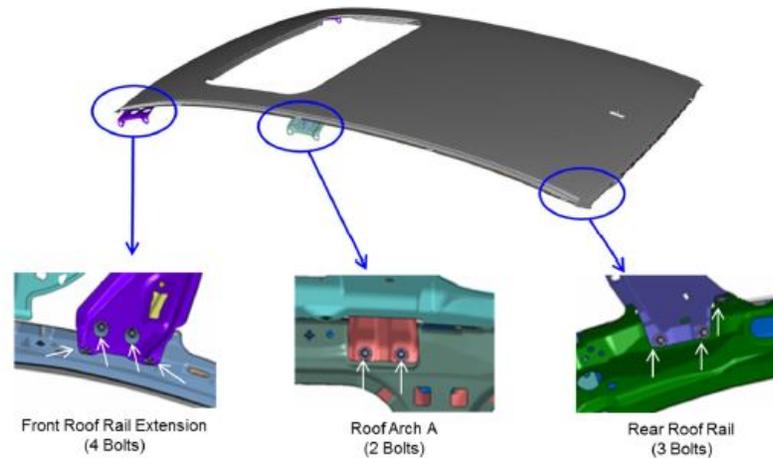
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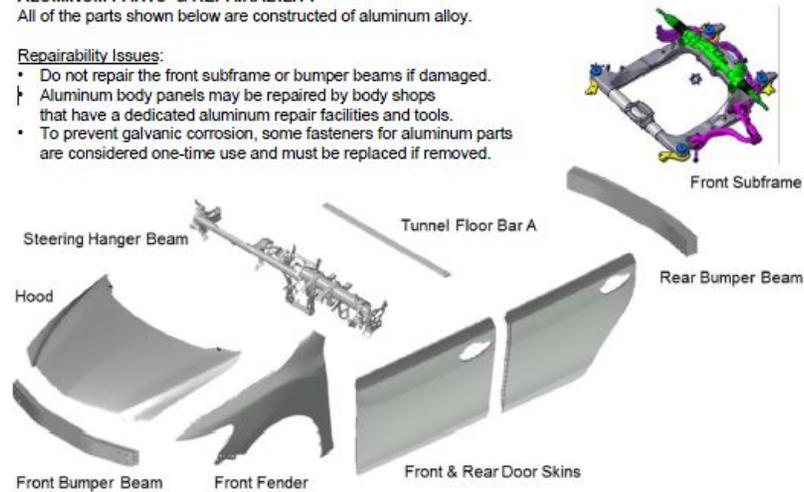


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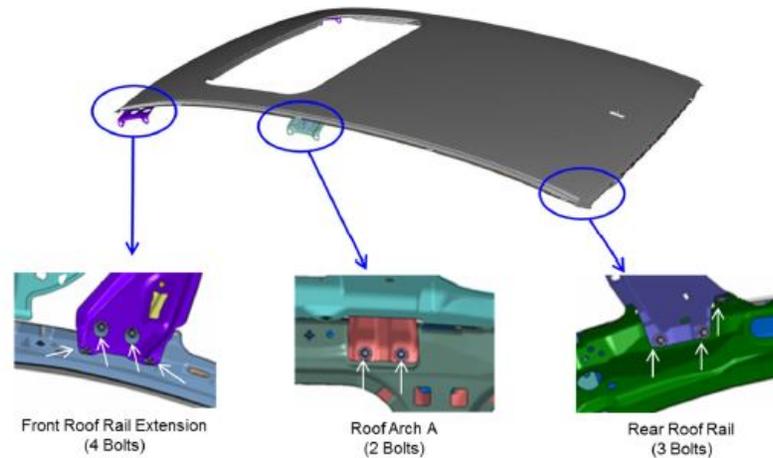
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# Bake hardening of Nanograin AA7075 aluminum

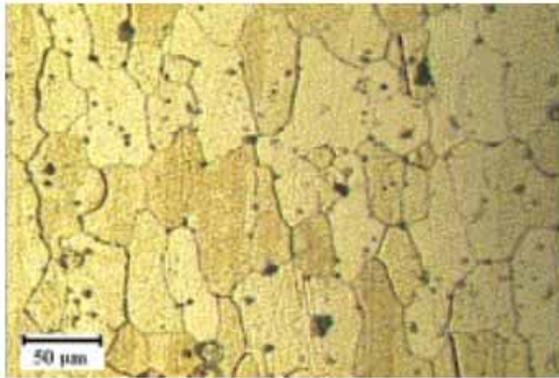
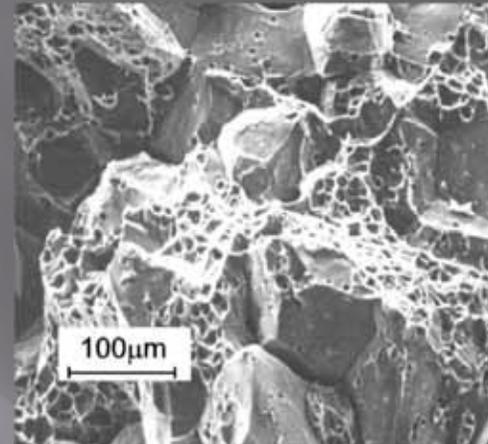


Fig. 3. OM image taken from the initial microstructure of AA7075 alloy.



Granular fracture mode in AlSiMg alloy

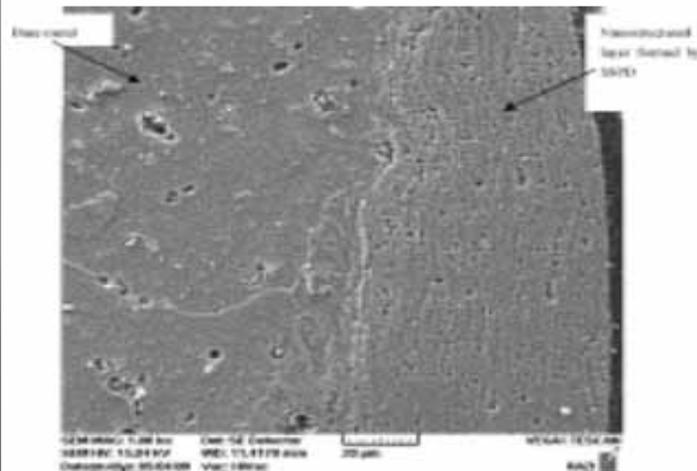
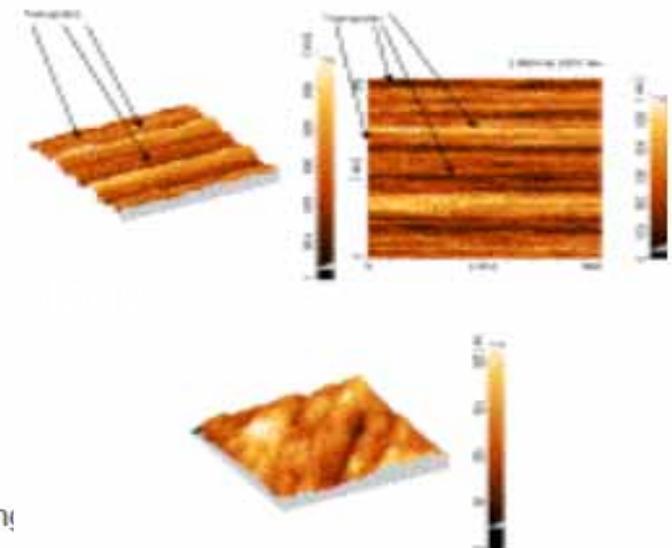


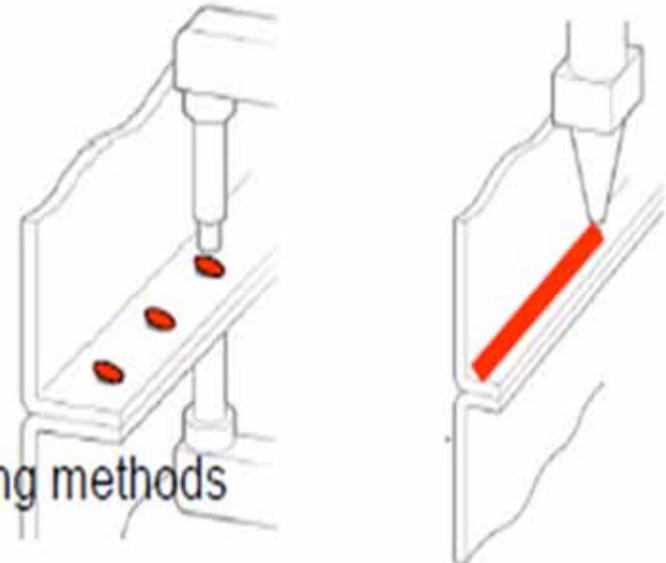
Fig. 4. The cross-section of AA7075 subjected to SSPD via wire brushing



# Laser vs Resistance Spot Weld

## Goals reached:

- Increased process speed (joining)
- Increased productivity
- Increased strength compared to alternative joining methods
- Reduced heat distortion
- Narrow or no flange => Weight reduction
- High flexibility via sharing & back-up of lasers into different work cells
- Reduced floor space

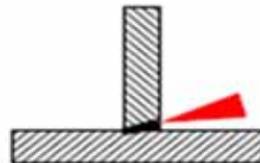


Seam weld on stepped lap joint



- + weld fusion area
- positioning tolerance

Seam weld on T-joint



- + weld fusion area
- positioning tolerance

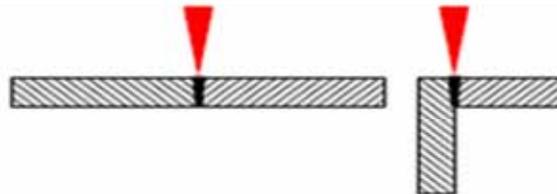
*Think about a positive & negative characteristic of both the butt & lap weld configurations.*

**Name**

**Example**

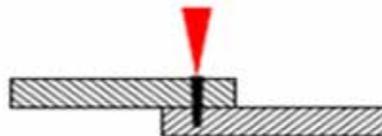
**Characteristics**

Seam weld on butt joint



- + **Weld Fusion Area**
  - less material = weight & cost savings
  - faster or less power
  - less HAZ / distortion
  - no issues w/ Zn
  - no step
- **Positioning Tolerance**
  - edge requirements
  - fit up can be more difficult to obtain

Lap weld on lap joint



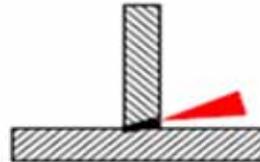
- + **Positioning Tolerance**
  - larger process window
  - can have aesthetic underside
- **Weld Fusion Area**
  - more energy required = slower or higher power & more distortion / HAZ
  - inefficient process

Seam weld on stepped lap joint



- + weld fusion area
- positioning tolerance

Seam weld on T-joint



- + weld fusion area
- positioning tolerance

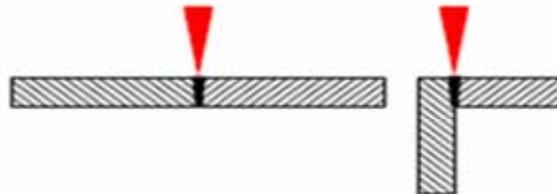
*Think about a positive & negative characteristic of both the butt & lap weld configurations.*

**Name**

**Example**

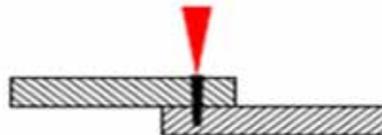
**Characteristics**

Seam weld on butt joint



- + **Weld Fusion Area**
  - less material = weight & cost savings
  - faster or less power
  - less HAZ / distortion
  - no issues w/ Zn
  - no step
- **Positioning Tolerance**
  - edge requirements
  - fit up can be more difficult to obtain

Lap weld on lap joint

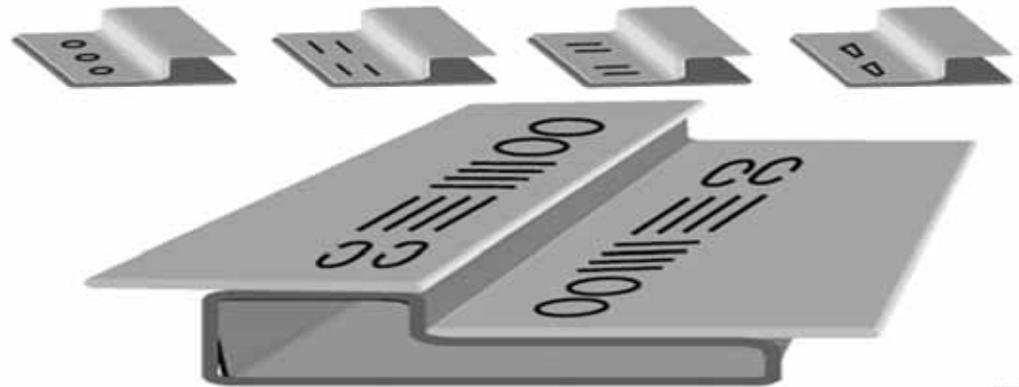


- + **Positioning Tolerance**
  - larger process window
  - can have aesthetic underside
- **Weld Fusion Area**
  - more energy required = slower or higher power & more distortion / HAZ
  - inefficient process

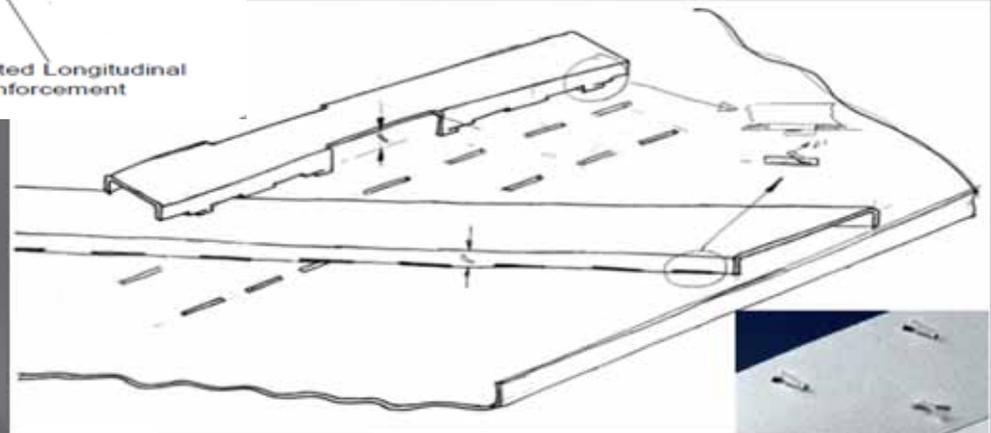
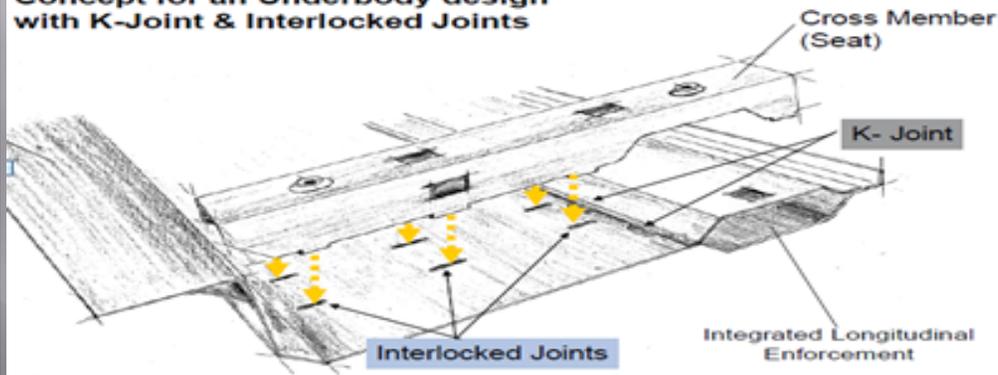
## Advantage: Programmable Weld Shapes

Customized weld patterns for optimal joint strength:

- Distribution
- Orientation
- Shape



Concept for an Underbody design with K-Joint & Interlocked Joints



# 2014-The Future Is Here

The new 2015 F150 Body will be made out of Military Grade Aluminum. This is one of the biggest change in the history of the collision repair industry.

The previous model F150, sold over 600,000 units per year. GM announced that the 2018 Silverado will be aluminum as well.

Asian auto manufacturers like Honda, are now using aluminum as well.

