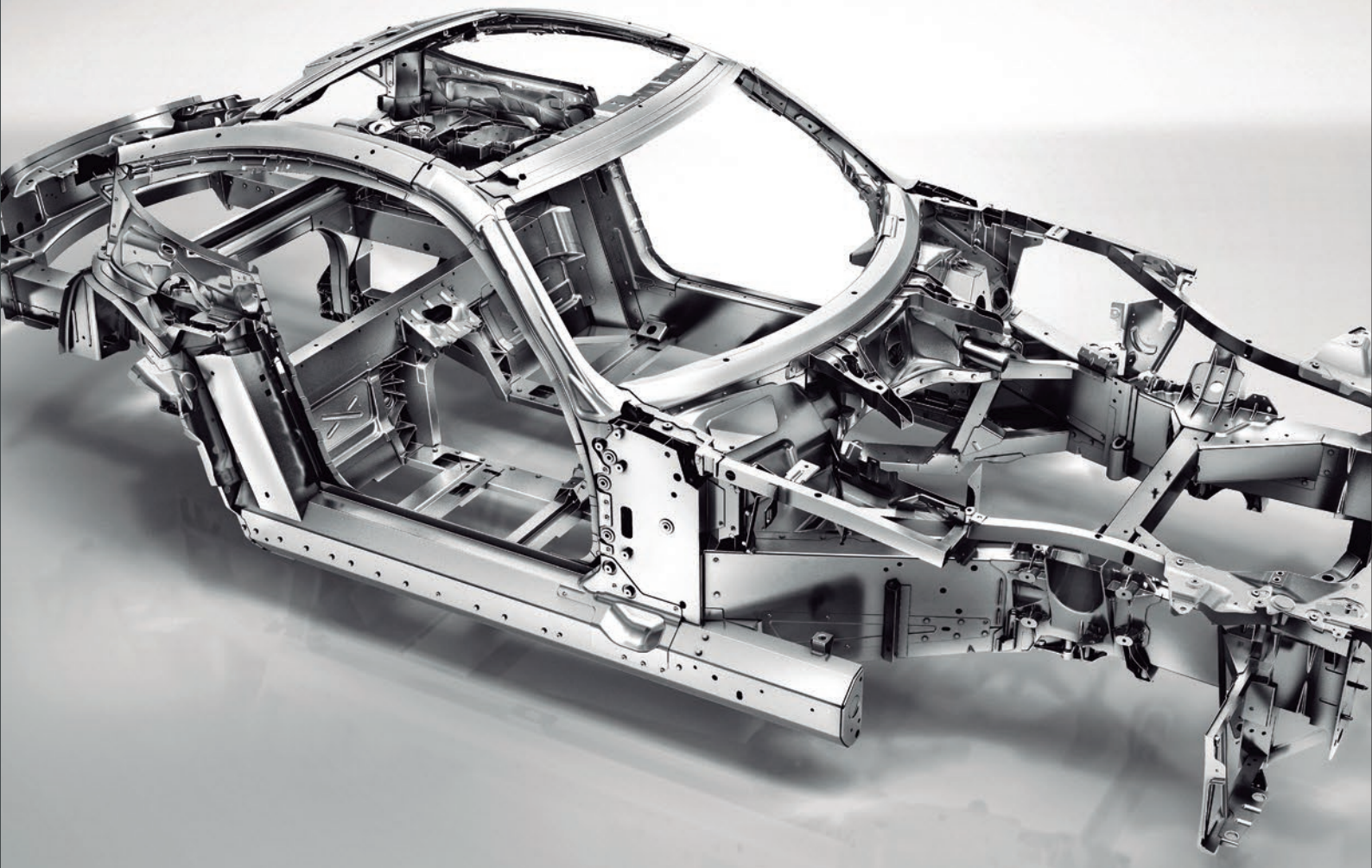
UACJ

Special Feature / Automobile Technology

# Motor Fan illustrated

*Special Edition*

*The more technologies are revealed, the more interesting cars become.*



# ALUMINUM AUTOMOBILE TECHNOLOGY

Use of aluminum alloys in automobiles ❶

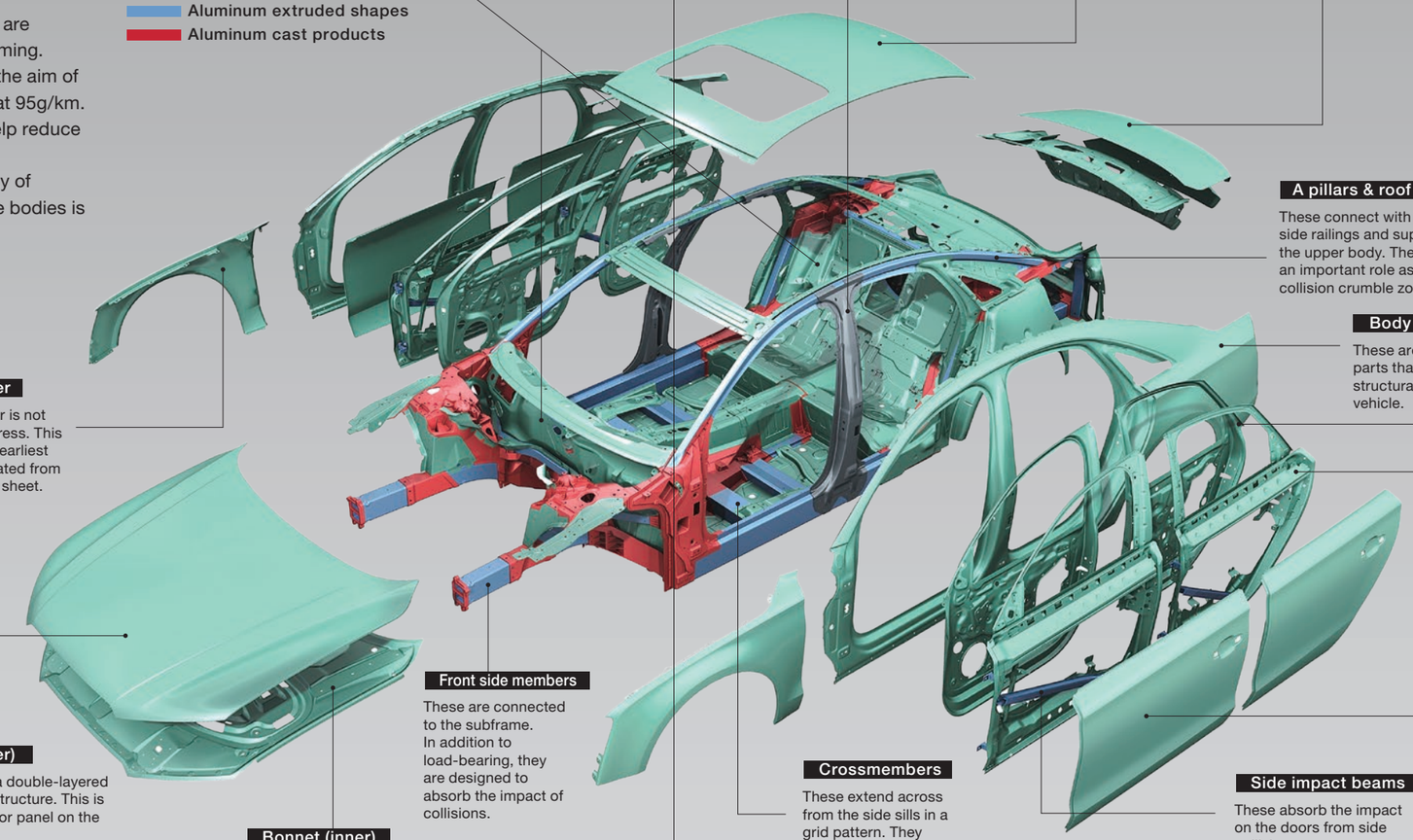
# BODY & CHASSIS

Automobile fuel efficiency standards around the world are becoming increasingly strict in response to global warming. In Europe, legislation is currently being prepared with the aim of setting new-vehicle $CO_2$ emission standards for 2020 at 95g/km. The key to achieving this is the use of materials that help reduce the weight of vehicle bodies.
Thanks to improvements in the strength and workability of lightweight aluminum alloys, aluminum's use in vehicle bodies is now moving into high gear.

## Audi **A8**

The Audi A8 is the first mass-market car with an aluminum chassis.
The vehicle features a unique Audi Space Frame structure with the upper body connected onto an underbody frame base.

Aluminum alloy sheet
Aluminum extruded shapes
Aluminum cast products



**Bulkhead**
Also called the firewall, this is a wall used to separate the passenger compartment from the engine room and the trunk.

**B pillars**
These support the roof and door latches, and also absorb the impact of side collisions.

**Roof**
The roof panel features a structure that bears the stress of the forces acting on each of the pillars. The roof area is large, so changing from steel to alloy works as well as for the bonnet.

**Trunk lid**
As with the bonnet, the use of aluminum alloys for trunk lids is also making good progress.

**A pillars & roof pillars**
These connect with the roof side railings and support the upper body. They play an important role as a collision crumble zone.

**Body side panels**
These are structural parts that form the structural skin of the vehicle.

**Front fender**
The front fender is not subjected to stress. This was one of the earliest parts to be created from aluminum alloy sheet.

**Bonnet (outer)**
The bonnet has a double-layered interior/exterior structure. This is the largest exterior panel on the vehicle.

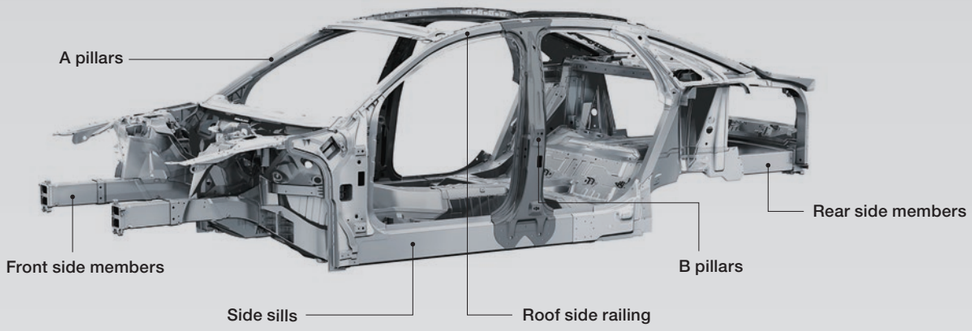
**Front side members**
These are connected to the subframe. In addition to load-bearing, they are designed to absorb the impact of collisions.

**Bonnet (inner)**
This part is used to reinforce the outer panel. With collision safety in mind, the panel structure is designed to crumple on impact.

**Crossmembers**
These extend across from the side sills in a grid pattern. They support the passenger compartment floor and bear torsional stress.

**Side impact beams**
These absorb the impact on the doors from side collisions.

**Doors**
These are constructed from internal and external sections. The internal sections are often made from 5000 series aluminum alloys, while the external sections are often made from 6000 series aluminum alloy sheet.




### › Aluminum alloy sheet

6000 series aluminum alloys are used for body panels, bonnets, doors, roofs, etc. They are highly formable and have low-yield strength in the forming process, but feature high bake hardenability, meaning they become high-yield strength after the coat baking process.

### › Aluminum extruded shapes

There are commonly used for parts that require a uniform cross-sectional shape, strength, and rigidity such as bumpers, side members, side sills, etc. 5000 and 6000 series aluminum alloys are most commonly used, and 7000 series aluminum alloys when more strength is required.

### › Aluminum cast products

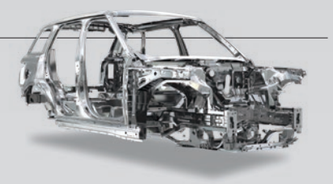
These commonly include cylinder blocks, transmission cases, and wheels, but moldings are also used in body components. The use of aluminum alloy die casting is appropriate when creating parts with complicated structures that require a high level of strength.

Aluminum alloy space frame | Audi **R8**

This car features a mid-ship layout with a bathtub-shaped monocoque structure that is used to provide strength and rigidity to the body as a whole. This is a hybrid vehicle body featuring aluminum alloys and CFRP.

All-aluminum alloy monocoque | Jaguar **XE**

The latest XE is an aluminum alloy monocoque vehicle based on the common Jaguar/Land Rover platform.



All-aluminum alloy monocoque | Range Rover **Sport**

Based on knowhow accumulated through the development of the Jaguar XJ, this is the first SUV to feature an all-aluminum body design.

## Mercedes AMG **GT**

The AMG GT, the flagship Mercedes sports car, features an all-aluminum body. The engine and transmission are positioned separately, with the transmission in a transaxle position connected to the engine via an aluminum torque tube.

**Suspension arms**

As critical safety components, these need to be highly reliable. The use of high-strength forged aluminum parts is increasing.

**Hub carriers**

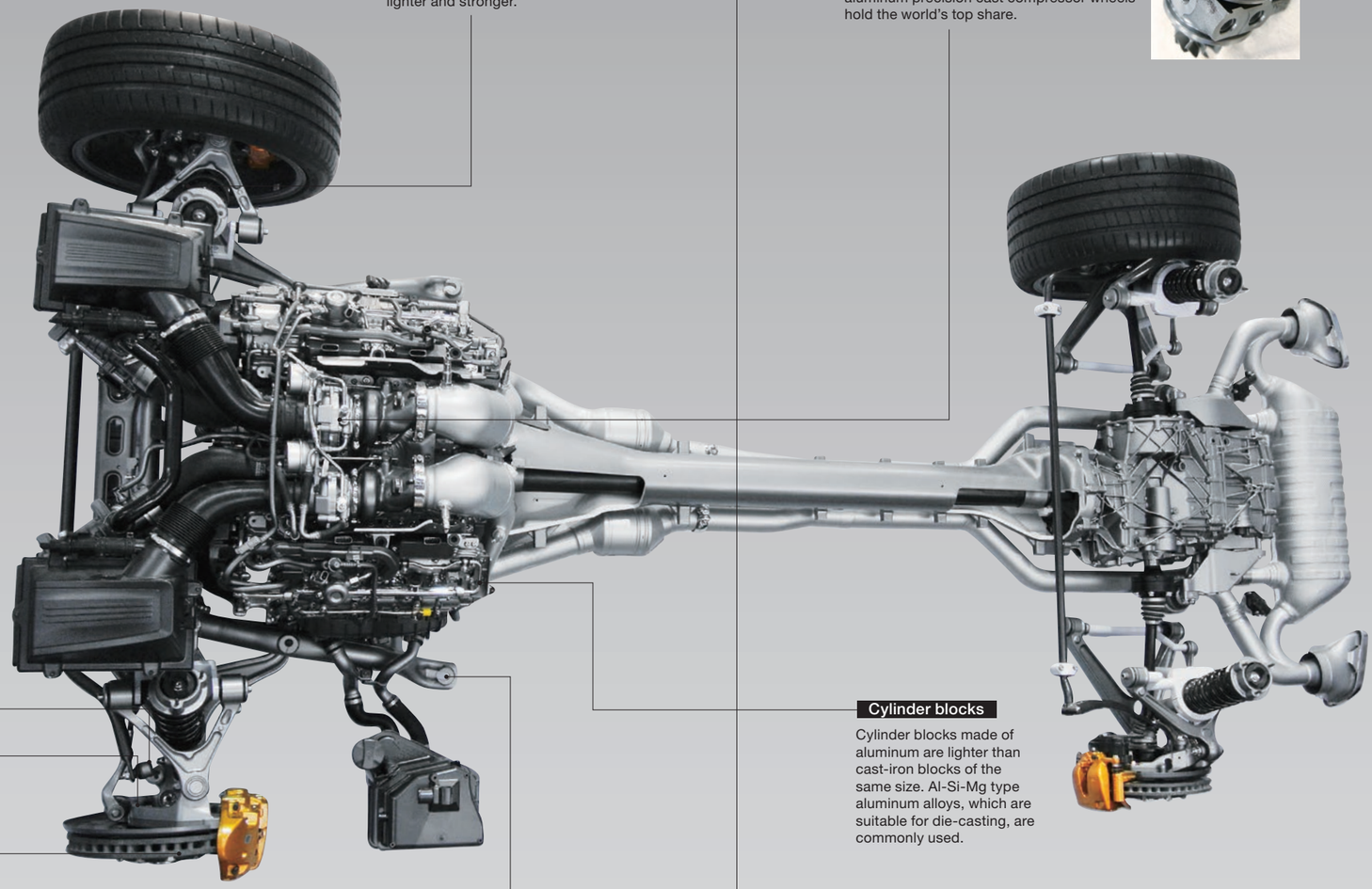
These components connect the suspension arms with the brakes and wheels.

**Brake calipers**

As these are exposed to high temperatures, while also being repeatedly subjected to stress, they need high thermal stability and good abrasion resistance.

**Aluminum wheels**

Although both cast and forged aluminum wheels are used, forged aluminum wheels are lighter and stronger.



**Compressor wheels for turbochargers**

These are precisely manufactured aluminum alloy impellers used to compress air. UACJ's aluminum precision cast compressor wheels hold the world's top share.

**Cylinder blocks**

Cylinder blocks made of aluminum are lighter than cast-iron blocks of the same size. Al-Si-Mg type aluminum alloys, which are suitable for die-casting, are commonly used.

**Subframes**

A subframe is a structural component that is a separate structure within a larger monocoque. It carries certain components, such as the engine drivetrain or suspension. Subframes need to have high rigidity and shock-absorbing capabilities.

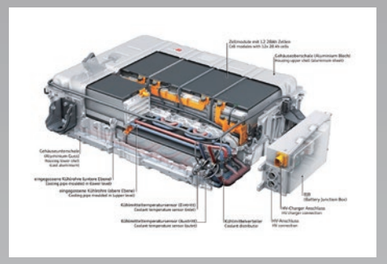
Use of aluminum alloys in automobiles ❷

# DRIVETRAIN & POWERTRAIN

Almost all cylinder blocks are currently made from aluminum casting, and use of aluminum alloys in suspension components, which require higher strength, is also increasing.



### Use of aluminum in electric vehicles and hybrid electric vehicles

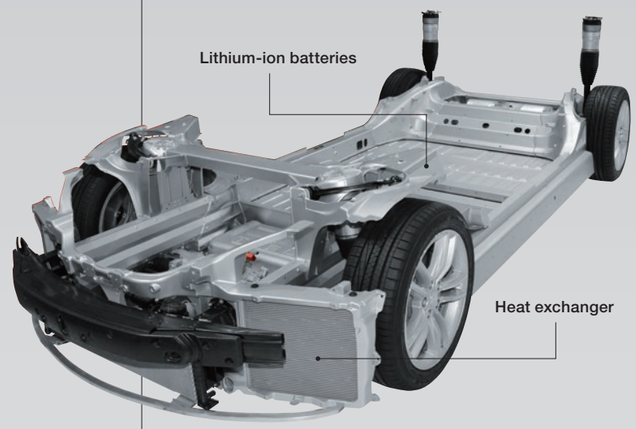


**The Audi Q7 e-tron 3.0TDI quattro battery**

Lithium-ion batteries are now commonly used in note PCs, smartphones and other mobile devices, but capacity-enhancing technologies are rapidly increasing the popularity of their use in automobiles as well.

**The Nissan Leaf lithium-ion battery**

The battery cases and sealing components of lithium-ion batteries, which are the most important component in electric vehicles, are made from aluminum alloys, and aluminum foil is used in the current collectors.




TESLA **MODEL-S**

The Tesla Model S uses a bathtub-shape frame made with aluminum alloy extruded shapes, and is equipped with a lithium-ion battery pack. The heat exchangers are also manufactured from an aluminum alloy.

ALUMINUM MATERIAL

Aluminum alloys used in automobiles : 1

# 01 Aluminum alloy sheet

## Aluminum alloy sheet features superior formability and strength

### 6000 series aluminum alloy sheet for body panels

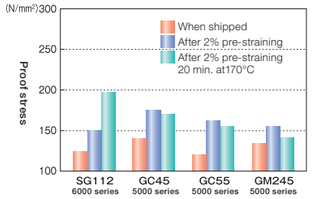
Producing body panels from aluminum alloy sheet is a highly effective way to reduce weight and enhance fuel efficiency. Currently, 6000 series aluminum alloy sheets are the type most commonly used in body panels, and since they have “bake-hardenability,” they can be strengthened during the coat baking process.
The 6000 series aluminum alloy sheets are characterized by low strength during the molding process, making them highly workable, but the coat baking process makes them substantially stronger.

**Required properties of automobile body sheet**
- Bake-hardenability
- Formability
- Hemmability
- Dent resistance
- Corrosion resistance
- High-luster paint finish

Mercedes Benz S Class

**Ford F-150**

In the F-150’s latest facelift, the body panels were changed to aluminum, reducing the weight by 320 kilograms and improving fuel efficiency by 5% to 20% compared to the previous model.




**Change in proof stress from during forming to after coating**

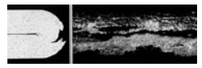
6000 series sheets are strengthened more than 5000 series sheets.

Change in proof stress of body sheets

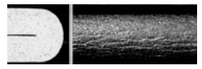
**Bonnet of Toyota Prius**

Both the interior and exterior structures are made from 6000 series aluminum alloy sheet.

Ordinary body sheet



High-hemmability sheet



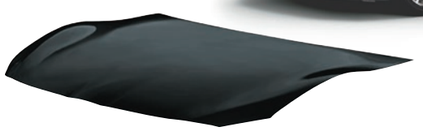
**Hemming**

Since aluminum alloy sheet is less elongate than steel sheet, it cracks easily during hemming. This means that flat hemming involving bending by 180 degrees has previously been difficult to achieve. However, UACJ Corporation has created an aluminum alloy sheet that can be subjected to Sharp Hemming, a process that is even more problematic than flat hemming.

### 5000 series aluminum alloy sheets for body panels

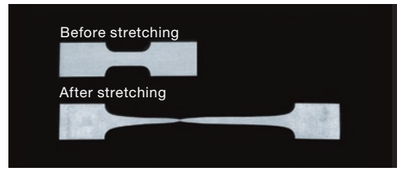
5000 series aluminum alloy sheets are the strongest of the non-heat-treatable alloys and also have excellent press formability. Through finding the right amount of magnesium to add, and through nanostructure design control, UACJ Corporation has created aluminum alloy sheet that has formability similar to that of steel sheet.

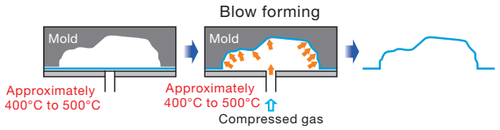
Toyota GT86 Bonnet



### Superplastic aluminum alloy sheet

Superplastic material has elongation of more than several hundred percent at high temperatures. Using the blow-forming method (using compressed gas to force heated material into a metal mold), superplastic aluminum alloy sheet permits greater design flexibility.

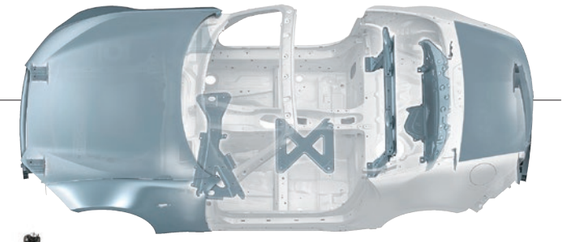



The “ALNOVI” superplastic aluminum alloy sheet developed by UACJ Corporation is widely used in body panel production.

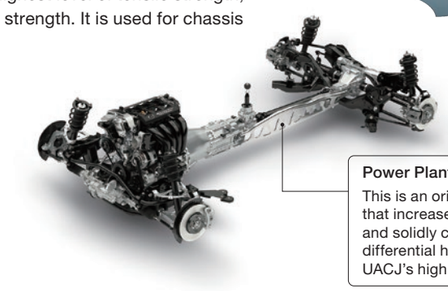
### Aluminum alloy sheet for high-strength structural components

Aluminum alloy sheet designed for high-strength structural components is suitable for use in automobile framework structures. The 7075 alloy (ultra-super duralumin) features the highest level of tensile strength, proof stress, and fatigue strength. It is used for chassis and subframes.



**Mazda MX-5**

The new Mazda MX-5, which weighs less than 1 ton, is a new-generation lightweight sports car. The silver-colored parts in the illustration are all produced from aluminum alloys.



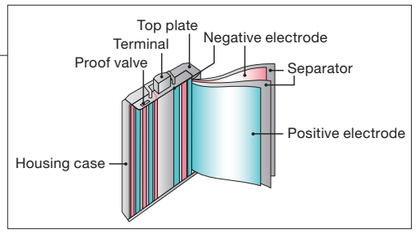
**Power Plant Frame**

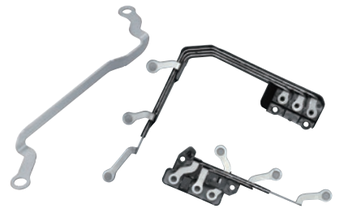
This is an original Mazda-developed frame that increases the rigidity of the drivetrain and solidly connects the transmission to the differential housings. The frame is made from UACJ’s high-strength aluminum alloy sheet.

### LIB products for EVs and HEVs

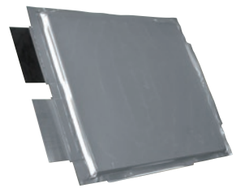
Aluminum alloy materials are also used in LIB products. They are indispensable in the production of the foil used in the positive electrode, cans, busbars, and other peripheral components.

**Aluminum materials used in LIB**
- Aluminum cathode foils
- Housing cases
- Busbars
- Disclosure sealers
- Laminated pouches



Aluminum alloy busbars



LIB cell

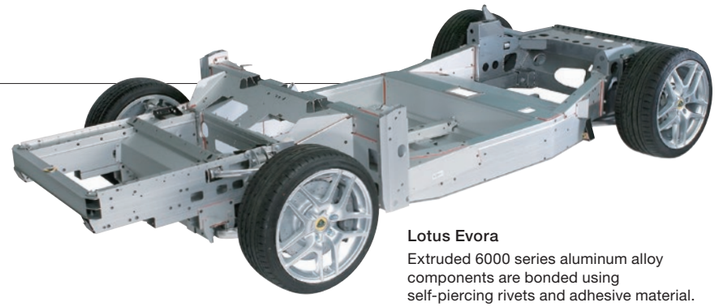
LIB module

# 02 Aluminum extruded products

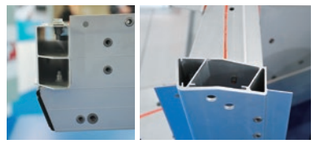
## Components with complex cross-sectional shapes

### Aluminum extruded shapes

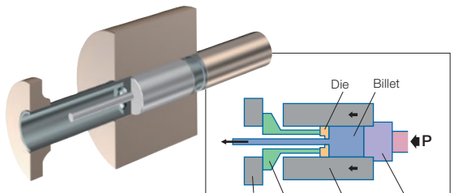
Using extrusion, it is possible to produce complex shapes. The process involves heating the aluminum alloy up to 400-500°C and pressing it through a die. Various shapes can be extruded, including complex shapes and hollow materials. They are normally used for automobile subframes and bumper beams.



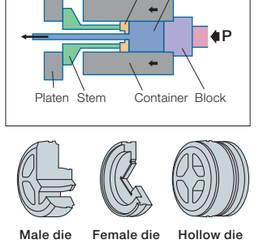
**Lotus Evora**
Extruded 6000 series aluminum alloy components are bonded using self-piercing rivets and adhesive material.



Extruded components are produced using 6060 aluminum, and there is a clear difference in the cross-sectional shape of components formed in this way. The ability to create this kind of shape is characteristic of extrusion processing. The red lines in the photo are adhesive material: a large amount of adhesive material is used in the Lotus aluminum alloy chassis.




Solid shape
Hollow shape



Male die Female die Hollow die

Aluminum extruded products are used to produce motorbike frames and front forks. UACJ's front fork outer tubes hold the world's top share.

**Bumpers of the Mazda MX-5**
This bumper is manufactured using a 7000 series aluminum alloy produced by UACJ Corporation for use in hollow shape extrusions.

### Forged aluminum alloys

Forged materials are strong and can withstand being repeatedly subjected to stress, so they are used to produce parts such as aluminum wheels, suspension arms, and brake components, which require a high level of reliability. There are various different forging methods, including hot, cold, open die, and closed die forgings.



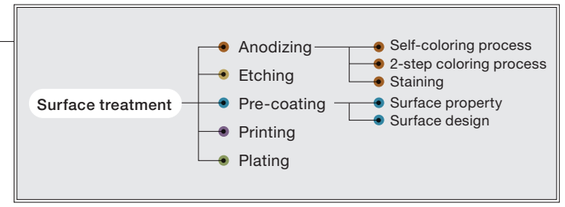


# 03 Aluminum alloy surface treatment

## The beautiful transmuting appearance of aluminum with processed surfaces

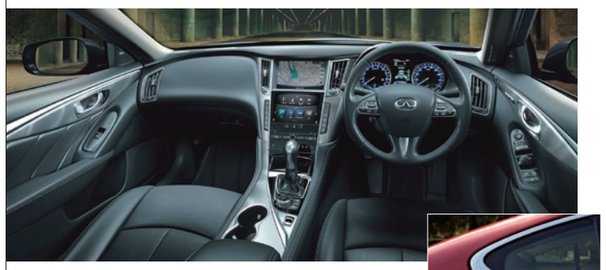
### Aluminum Design Sheets

The aesthetically pleasing appearance of aluminum is one of its major features. The sheen of luminous aluminum alloys can be further enhanced through electrolytic and chemical polishing, and they are used for decorative parts, such as vehicle moldings. Various surface treatment technologies can be used to accentuate the aesthetic qualities of aluminum.




#### Aluminum Design Sheets

Aluminum alloy panels are commonly used for interior decoration, such as in the center console, door trim, and other parts of the Infiniti Q50. Their surface is very smooth, detailed and shiny.

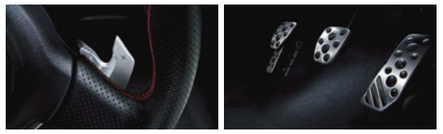


#### Anodizing

Anodizing is a process that involves turning a piece of aluminum into an anode in an electrolytic solution to create a surface layer of oxidized aluminum. Colored oxide layers can be produced in black, red, blue, etc.



Scuff plates

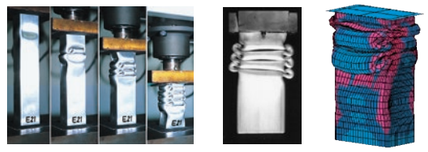


(Left) Gearshift paddle. (Right) Pedals. Aluminum alloys have been used instead of resins for these parts because of their attractive luster and texture.

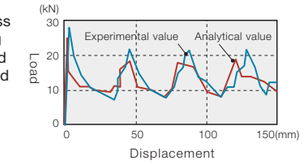
### Evaluation and analysis technologies

UACJ works on simulations, analysis and evaluations in order to develop better aluminum alloys. Particularly useful for development is impact simulation analysis, fluid analysis and thermal analysis. CAE is used for considering the characteristics of materials and shapes to improve collision safety.

**Crash boxes**



The crumpling process of crash boxes during collisions is compared using experiments and CAE.



Aluminum alloys used in automobiles : 4

# 04 Aluminum alloy joining technologies

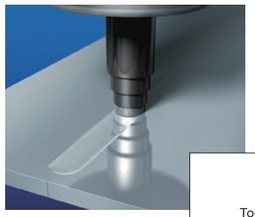
## Welding, adhesion, and bonding of materials with different properties

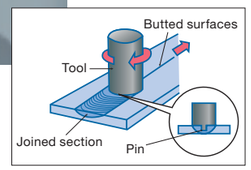
As the use of aluminum alloys in vehicle bodies has become common, dramatic advances have been made in aluminum joining technologies, such as laser welding and friction stir welding. There have also been advances in mechanical joining such as riveting, screwing, and clinching, and the use of adhesive materials.

Bonding of materials with differing properties such as aluminum-iron, and aluminum-resin, is also garnering attention. Such joining technologies as these are expected to lead to a considerable increase in the use of aluminum.

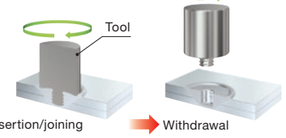
### FSW-FSSW

Friction stir welding (FSW) is a joining technology that involves the use of a tool with a pointed revolving tip that is pressed against the metal, which is then softened by friction-generated heat. This plasticized material is used to join pieces of metal together.
This method has many benefits, including low levels of distortion and residual stress, and less significant reduction in strength when exposed to heat.






Friction stir spot welding (FSSW)



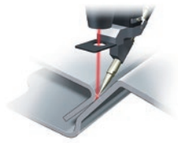

FSW (aluminum and copper)

### Joining technologies

#### Punch riveting

Two sheets are joined by forcing a wedge-shaped rivet through them.

#### Laser welding

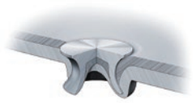


A laser light is pointed at the parts to be joined to weld them together.

#### Flow drill screwing

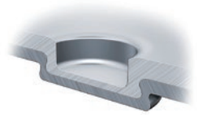
A method of screw fastening in which the fastening member can be removed.

#### Self-piercing riveting



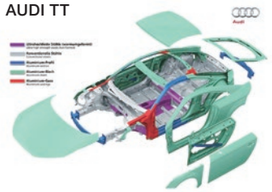
The leg portion distorts and cuts into the base materials to fasten them together.

#### Mechanical clinching



A die is used to clinch materials together from above and below.

AUDI TT

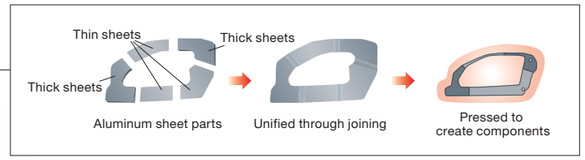


The green, blue, and red parts shown here are made from aluminum alloy.



### Tailored blanking

The first-generation Audi R8 was the first mass-market automobile to employ tailored blanking.




Tailored blanking is a production method that involves joining materials of differing thicknesses or qualities before press forming them. Since it is possible to position materials of differing strengths, thicknesses, and qualities only where they are required, the method contributes greatly to weight reduction.

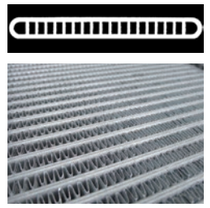
#### Comparison of different joining methods

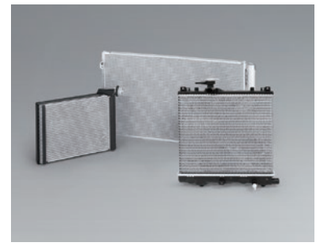
| Method | Joining efficiency (speed m/min) | | Quality | | | Cost | |
|---|---|---|---|---|---|---|---|
| | Thickness: 1 mm/1 mm | Thickness: 1 mm/2 mm | Tensile property | Formability: Stretch forming | Formability: Deep drawing | Device | Shielding gas |
| FSW | ◎ | ◎ | ◎ | ◎ | ◎ | ○ | ◎ |
| | 2.0 ~ 4.0 | 2.5 ~ 3.5 | Base material fracturing (5000 series) | Base material part fracturing | Base material part fracturing | Medium | Not needed |
| YAG laser | ◎ | ◎ | ◎ | ◎ | ◎ | △ | △ |
| | 2.0 ~ 4.0 | 2.0 ~ 4.0 | Base material fracturing (5000 series) | Base material part fracturing | Base material part fracturing | Expensive | Needed |
| Arc welding | △ | △ | ◎ | × | ◎ | ◎ | △ |
| | ~ 1.2 | ~ 1.2 | Base material fracturing (5000 series) | Welded part fracturing | Base material part fracturing | Inexpensive | Needed |

◎Excellent ○Good △Acceptable ×May require further consideration

### Brazing

Automobile heat exchangers are produced by assembling multi-hole flat tubes and corrugated brazing sheets. To reduce weight and enhance performance, heat exchanger materials are made thinner, so corrosion proofing is vital.





Intercooler: Nissan GT-R

### Adhesion

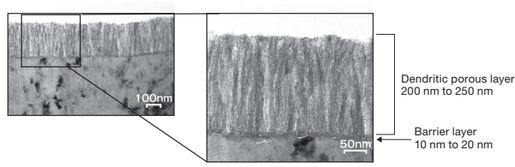
Cockpit cross-car beam created by joining aluminum alloy and resin.

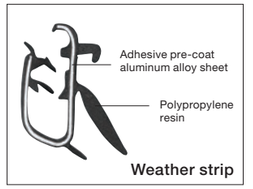
#### High-adhesive strength pre-coated aluminum alloy sheet

Aluminum alloy sheet material with a coating that is highly adhesive to resin is used to support the weather strip.

#### KO treatment sheet: high-adhesion aluminum sheet surface processing

UACJ Corporation's KO processed aluminum sheet is covered with a high-adhesion oxide layer with a complex porous and dendritic configuration.



# Aluminum usage guidelines

The table on this page explains the characteristics of the different alloys types and what automobile components they are used in.

| | Alloy denomination | | Characteristics | Use in automobiles |
|---|---|---|---|---|
| | AA | UACJ | | |
| **1000 Al** | 1050 | A50 | Excellent processability and surface treatability. The most corrosion-resistant of all aluminum alloys. | Heat insulators |
| | 1100 | A30 | General-purpose aluminum with over 99.0% purity. Surface appears slightly white after anodizing. | Heat insulators, license plates |
| | 1200 | A0 | | Heat insulators |
| **2000 Al-Cu** | 2014 | 14S | Very strong alloy used for structural components. Because of relatively higher copper content, inferior corrosion resistance. | Motorbike handles, ABS |
| | 2017 | 17S | | Shock absorbers, handles, spokes, conrods |
| | 2024 | 24S | | |
| | 2219 | B19S | High-strength, excellent properties at high and low temperatures, superior weldability, but inferior corrosion resistance. | Rotors, brake components |
| | | CG29 | Higher strength at elevated temperatures than that of 2618. | Conrods, pistons |
| | | CB156 CB256 KS26 | Lead-free highly-machinable alloys. | AT valves |
| **3000 Al-Mn** | 3003 | 303S D3S | 10% stronger than 1100. Good processability and corrosion resistance. | Piping |
| | 3004 | 304S 4S | Stronger than 3003. Excellent deep-drawability, and good corrosion resistance. | Cowl grilles, heat insulators |
| **4000 Al-Si** | 4032 | 32S | Excellent heat and abrasion resistance. Low thermal expansion coefficient. | Pistons |
| | | SC100 | Excellent abrasion resistance and forgability. Stronger than 4032. | Power steering housing, compressor scrolls, valve lifters |
| | | SC300 | A stronger version of SC100. | |
| | | TF06B TF08 TF10B | Excellent abrasion resistance and forgability. Stronger than 4032. | |
| | | SC150 TF12B | A hypereutectic alloy with enhanced forgability. | Compressor rotors |
| **5000 Al-Mg** | 5052 | 52S | A medium-strength alloy. Good corrosion resistance and formability. High fatigue strength. | Meter display panels, AT drums, air bag inflators, covers |
| | 5454 | D54S | 20% stronger than 5052. Good corrosion resistance. | Wheel rims, suspension components |
| | 5083 | 183S | An alloy for use in welded structures. The strongest of the non-thermally treated alloys. | Tanks, gas cylinders |
| | | 383S | A high formability version of 183S. Excellent superplastic properties. | |
| | | 483S NP5/6 | An extrusion alloy version of 183S. | Lashing rails |
| | 5182 | A82S | Nearly as strong as 5083. Good processability and corrosion resistance. | Dust covers, seat frames, air cleaner cases, spring sheets |
| | | GM145 | Good formability and stress corrosion cracking performance. | Body panels (interior) |
| | 5154 | A154S | 20% stronger than 5052. Good formability. | Wheels, underbody components, drivetrain components, suspension components |
| | | A254S | 20% stronger than 5052. Good stress corrosion cracking performance. | |
| | | GC32 | Good formability and stress corrosion cracking performance. | |
| **5000 Al-Mg** | 5022 | GC45 TG19 | High-strength, high-formability body panel material. Low coat-baking proof stress reduction. | Bonnets, roofs, doors, pillars, oil pans, floors, rear fenders, air cleaner housings |
| | | GC150 | A slightly stronger alloy than GC45. | Body panels |
| | 5023 | GC55 TG25 | Body panel material with further enhanced formability. | Bonnets, roofs, trunk lids, instrument panels, seat buckets, knee protectors |
| | 5110A | 257S | A high brightness alloy with the same strength as 3003. Good deep-drawability and corrosion resistance. | Moldings, trims, reflective panels, headlamp bulb shades |
| | 5056 | 356S | A non-heat-treatable alloy for welded structures. Excellent seawater resistance. | Brake pistons, fuel delivery pipes, airbag inflators |
| **6000 Al-Mg-Si** | | SG112 SG212 TM30 TM55 | Body panel alloy with high bake hardenability, formability, and high-hemmability. | Bonnets, rear fenders, front fenders, pillars, wheel housings, roofs, doors |
| | | SG312 TM66 TM67 | BH type body panel alloy. Even stronger than SG112 with good formability. | |
| | 6061 | 61S 161S | Heat-treatable alloys with good corrosion resistance. | ABS, crossmembers, wheels, propeller shafts, arms, links, air bags, joists, receiver tanks |
| | | 561S | | Power plant frames |
| | 6013 | SG210 | High-strength aluminum alloy for forging. | Suspension arms |
| | 6063 | 63S 163S Y63 | Typical extrusion alloys. Lower strength than 6061, but superior extrusion properties. | Moldings, seat frames, truck bed gates, roof railings, piping |
| | 6005C | 465S L55 | Intermediate strength between 6061 and 6063. Good corrosion resistance and weldability. | Bumpers, space frames, engine brackets, seat frames, ABS, side sills, shock absorbers |
| | | SG109 | High-strength alloy with good bendability and corrosion resistance. Hollow extrusion is possible. | Bumper reinforcement, space frames |
| | | SG310 | The strongest of the 6000 series alloys. | Wheels, propeller shafts, arms, links |
| | | GT209 KS69S | Lead-free high-machinability alloy. | AT valves |
| **7000 Al-Zn-Mg** | 7075 | 75S | Typical high-strength alloy for use in aircraft manufacture. | Seatbelt hinges, links, bobbins, retractors |
| | 7178 | A78S | The strongest aluminum alloy. | Keys |
| | 7003 | ZK60 K73 | An extrusion alloy for welded structures. Better extrusion properties than 7204. | Bumper reinforcement, seat sliders, motorbike frames, door impact beams, motorbike rims |
| | 7204 | ZK141 K70 | Alloys for welded structures. The strength at the welded part recovers almost to the same as that of the raw material by natural aging. | Steering components, crossmembers, brake pedals |
| | 7204 | ZK147 K70Y | | Jacks |
| | | ZK55 | Even stronger than 7204. Welding and hollow extrusion is possible. | Bumper reinforcement, impact beams, motorbike frames and rims |
| | 7046 | ZK170 | | |
| | 7050 | ZG62 | High-strength aluminum alloys. | Motorbike front forks |
| | | ZC88 | | |

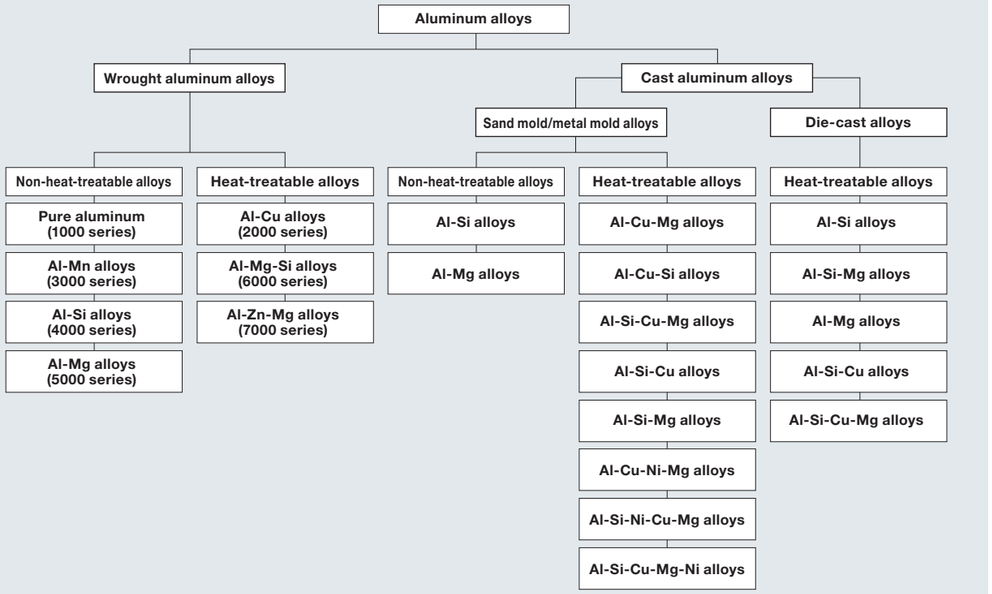
Alloy denominations: "AA" means the denominations used by the Aluminum Association.

# Basic aluminum alloy information

Lightweight, strong, corrosion-resistant, highly formable, and featuring a beautiful surface, a great variety of aluminum alloys are used in automobile production.

Aluminum alloys can be roughly divided into wrought alloys and cast alloys. These two categories can be further divided into heat-treatable alloys and non-heat-treatable alloys.
There are two different types of cast aluminum alloys: sand mold/metal mold alloys and die-cast alloys.

Wrought aluminum alloys are processed by rolling, extrusion, etc., into a wide range of different shapes, including sheets, foil, shapes, tubes, and bars.
The properties of aluminum alloys change with the types and amounts of added elements.




## The International Alloy Designation System

Rolled aluminum alloys are classified in accordance with the International Alloy Designation System (IADS) based on an agreement to which 22 countries and 24 organizations are a party. Four-digit code numbers are used to identify alloys, and the various alloys are precisely classified according to the types and amounts of added elements and impurities they contain, and their various threshold limit values.

There are currently more than 400 different aluminum and aluminum alloys registered and administered by the system.
The European standard ENAW-5052 alloy and the Japan Industrial Standard A5052 alloy share the same four-digit number (5052), and this means that the chemical constituents of the alloys are exactly the same. For this reason, it is reasonable to say that rolled aluminum alloy specifications are more internationalized than those of any other metallic material. Cast aluminum alloys, on the other hand, are still not subject to an international alloy registration system like the one for rolled aluminum alloys.

Reference from European Aluminium
www.european-aluminium.eu



## The general properties of aluminum alloys

### 1000 series aluminum

This refers to pure aluminum materials: 1100 and 1200 are the most common types. 1050, 1070, and 1085 indicate that they have a purity of at least 99.50%, 99.70%, and 99.85% aluminum respectively.
1000 series aluminum is not a high-strength material, but it has excellent corrosion resistance and formability, and because it also has a highly lustrous surface it is often used for decorative parts, nameplates, reflective plates, etc.
The material also features excellent electrical conductivity and heat-conductivity, and 1060 and 1070 are often used for power lines and heat dissipation materials.

### 2000 series alloys

Representative alloys in this series are 2017 and 2024, which are known as duralumin and super duralumin respectively. They are almost as strong as steel.
On the other hand, they include copper, so they are relatively lacking in corrosion resistance, and when used in corrosive environments they therefore require anti-corrosion treatment.
2014 is commonly used as a high-strength forged material.
2000 series alloys are highly machinable. 2011, in particular, is commonly used for machine components due to its high machinability.

### 3000 series alloys

The representative alloy in this series is 3003, and the addition of Mn means it is an alloy that retains the formability and corrosion resistance of pure aluminum while boasting increased strength. It is commonly used for utensils, containers and as a building material.
The 3004 and 3104 alloys are based on the 3003 alloy but contain approximately 1% Mg to further increase their strength. They are used for aluminum cans, roof cladding, door panels, etc.

### 4000 series alloys

The addition of silicon to the 4032 alloy reduces thermal expansion and improves abrasion resistance. Forged material for pistons also has other trace additives such as Cu, Ni, and Mg, which enhances heat resistance.
As the melting temperature of 4043 is low it is used for welding wire and brazing filler metals. Thanks to the dispersal of Si particles, 4043 also has a beautiful gray coloring when anodized.

### 5000 series alloys

5000 series alloys with relatively low levels of Mg are used as decorative materials, etc., and those with relatively high Mg levels are used for structural materials.
Typical of the alloys with a moderate amount of Mg is 5052. It is the most versatile. The alloy 5083 contains a large amount of Mg and is the strongest of the non-heat-treatable alloys. Also being suitable for welding, it is used for welded structural materials in boats, automobiles, chemical plants, etc. It performs well in environments exposed to seawater or pollution.

### 6000 series alloys

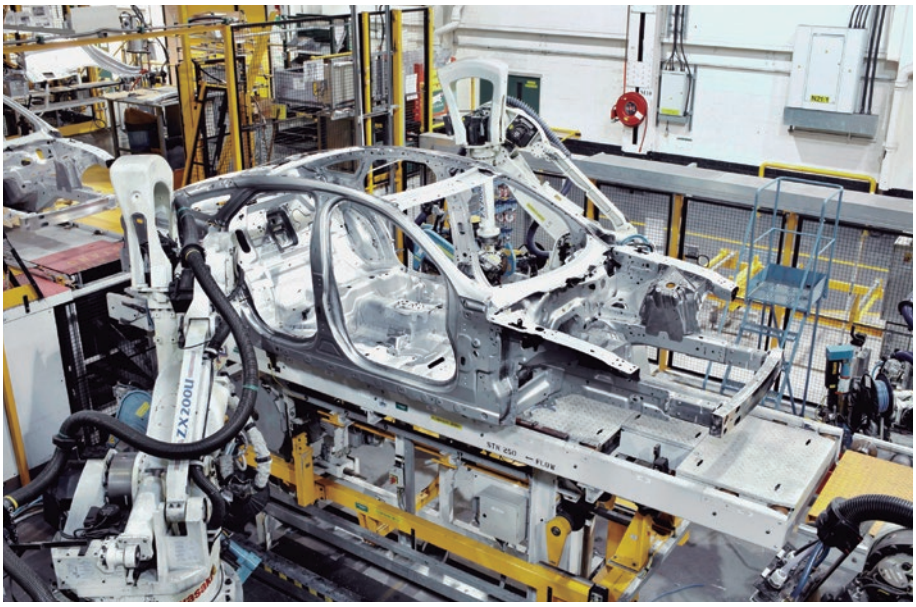
6000 series alloys have medium to high strength and good corrosion resistance.
The 6061-T6 alloy has a proof stress of over 245N/mm$^2$, meaning it is a high-strength alloy comparable to ASTM A36 (JIS3101 SS400) structural carbon steel.
The 6063 alloy is excellent material for extrusion, and it is widely used as a construction material, particularly for window frames.

### 7000 series alloys

The 7000 series alloys can be divided into two groups: Al-Zn-Mg-Cu alloys, which are the strongest of all aluminum alloys; and Al-Zn-Mg alloys, which are used for welded structural materials.
7075, one of the leading Al-Zn-Mg-Cu type alloys, is used in aircraft and trains.
7204, one of the leading Al-Zn-Mg type alloys, is strong, and room-temperature age hardening means that welded parts recover to a strength similar to that of the base material, giving it superior joining efficiency.

### Other alloys

Since the addition of Li to aluminum makes it less dense and increases its Young's modulus, it is garnering attention as an ideal low-density, high-strength material suitable for use in aircraft and large structural materials.
New 8000 series alloys are being developed, such as internationally registered powder metallurgy aluminum alloys, etc.



epilogue

# Aluminum Material for Automobiles

The environment-friendly metal underpinning
next-generation automobile development

The issue of how to reduce $CO_2$ emissions through the improvement of fuel efficiency has become the top priority in automobile development. One major solution is to reduce the weight of vehicle bodies…and that is precisely why aluminum is now garnering a great deal of attention. Its specific gravity is only 2.7, compared with 7.8 for steel.

Aluminum, a tough high-specific strength material, has many other merits. It is highly corrosion-resistant, readily formable, and environment-friendly because it is easily recycled. What's more, it's a very attractive material for use in vehicles.

Aluminum is increasingly being used for structural components, body panels, and a wide range of other parts, and significant advances are being made in forming and joining techniques, as well as in the development of aluminum alloys.

Aluminum… Without doubt, it will become an increasingly indispensable material in automobile development.

PHOTO & FIGURE : Hiroya YAMAGAMI/AUDI/BMW/DAIMLER/JAGUAR/MAZDA/TESLA MOTORS/TOYOTA/Motor Fan illustrated and UACJ

UACJ Corporation

The largest manufacturer of rolled aluminum products in Japan, UACJ was established by the integration of Furukawa-Sky Aluminum Corp. and Sumitomo Light Metal Industries, Ltd.

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