

Applications – Car body – Interior and other applications

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7 Interior and other applications

Aluminium is used in today's cars for many different interior applications. Very often, the aluminium alloy components are quite small. Furthermore, they are generally part of an assembly including different metallic and non-metallic materials. Typical examples of such aluminium components – which are not covered in more details in this manual – are part of electric and electronic components or systems, the lighting system, etc.

Therefore this chapter only describes a few, more important applications of aluminium components in the interior of an automobile.

7.1 Seats

The seat is what connects the occupant to the vehicle. In case of a crash, the seat plays a key role in driver and passenger safety by being firmly anchored to the floor and holding the body in place. Apart from the safety requirements, the main role of the car seats is to provide a comfortable ride both for driver as well as the passengers. Consequently, car seats generally include different adjustment mechanisms, headrests and armrests to offer superior comfort. Also car seats are usually made from durable materials in order to withstand as much use as possible.

Up to now, car seats have been developed mostly based on the requirements for long journeys. The result are relatively complex, heavy vehicle seats which offer, in particular in upper class models, numerous comfort functions (convenient adjustments and controls for lower-back, shoulders, seat height, cushion angles, back tilt and body contour in case of the front seats as well as retractable, adjustable and foldable rear seats) and lots of mechanical and electrical features (e.g. memory control of the seat adjustments, heating, cooling and massaging functions, etc.). Usually, the seats add significant weight to the average passenger car. Therefore weight reduction is a factor of growing importance and the suppliers of seats are heavily committed to developing lightweight seat structures which retain optimum safety. In addition, there is a growing need to develop special seats optimized for small, short-range urban vehicles where low weight is a key design target (e.g. for cars with electric drivetrains).

There are essentially two types of car seats, bucket and bench seats. A bucket seat is a seat with a contoured platform to accommodate one person. Bucket seat designs are generally used for the front seats; they are standard in fast cars to keep driver and passengers in place when making sharp or quick turns. Bench seats have a flat platform designed to seat up to three people; a design usually used for the rear car seats.

When it comes to the selection of optimum materials for lightweight seat structures, both aluminium alloys (rolled sheets and extruded aluminium sections) and high strength steel grades are highly suitable. In addition, cast magnesium parts are occasionally used in seat frame applications. High strength steel is generally favoured for the slide rails and the backrest frames of front seats. Aluminium is usually the preferred lightweighting option for the bases of the front seats and the backrests of the rear seats. Regardless of the material, a well-designed modular construction with the integration of various additional elements offers further potential for weight savings and optimised logistics.

Up to now, aluminium seat frames are still used relatively seldom. On the other hand, specific seating parts such as seat rails (tracks), backrests of rear seats and components of the seat belt system have been made of aluminium for a long time.

7.1.1 Seat structure design with aluminium

Front and rear seats add considerable weight to passenger cars and vans. The target weight of basic seat versions is 11 or 12 kg, while the weight of more elaborate seats with electrical adjustment should not exceed 18 kg. But the weight of current seat constructions may be easily above 20 to 25 kg.

The application of aluminium technologies offers a significant weight reduction potential for the metallic substructures. But in general, a re-design of the traditional seat design concepts is required to achieve cost-efficient solutions. Only if a system's design approach is adopted,

the possibilities of extrusions and castings to integrate functional design elements (for the purpose of reducing the number of parts and assembly cost) can be fully exploited.



Aluminium seat design concept

Selected examples of aluminium solutions for front and rear seats are described in the following subchapters.

a) Front seats

All front seats consist of backrests and lower seat frames. Depending on individual specifications of the automobile manufacturer, the seats are configured with different adjustment mechanisms in manual or power versions:

- Height adjustment allowing up and down movement by using a parallelogram-type arrangement of lever-linked side frames.
- Tilt adjustment of the seat; the seat frame tilt which is mostly adjusted at the same time with the fore and aft adjustment and height adjuster.
- Back frame tilt adjuster; the adjustment is made through a recliner element which also connects the backrest with the lower frame.
- Lumbar adjuster; the adjustable lumbar mechanisms allows to change the seat's back shape in the spine region to make it more comfortable.
- Head rest height adjuster: In the beginning, the headrest was only a comfort feature. Nowadays, headrests can also help to protect occupants against or minimize whiplash in a rear-end-crash.

In principle, aluminium components can be used for the backrests, the lower seat frame (seat base) and the various adjustment mechanisms. Depending on the different requirements and functionalities of these parts, aluminium sheet stampings, tubes, extruded profiles, forgings, castings, or a mixture thereof can be used. But also mixed material designs are possible, e.g. aluminium or cast magnesium lower seat frames combined with high strength steel backrests. For the backrest, high strength is the main design criteria (better energy absorption in the event of a crash). Another possibility is a backrest where vertical high strength steel components are combined with aluminium extrusions for the horizontal parts.

For the construction of seat back structures, extruded aluminium tubes have been widely proposed. In most cases, the designs are based on either one or more tubes. In order to properly support the acting loads, the cross-section of the frame should taper towards the top. As extruded shapes can only be produced with constant cross section, it is necessary to find manufacturing solutions for the taper. Two possible solutions are shown below.



Aluminium backrest with an extruded frame

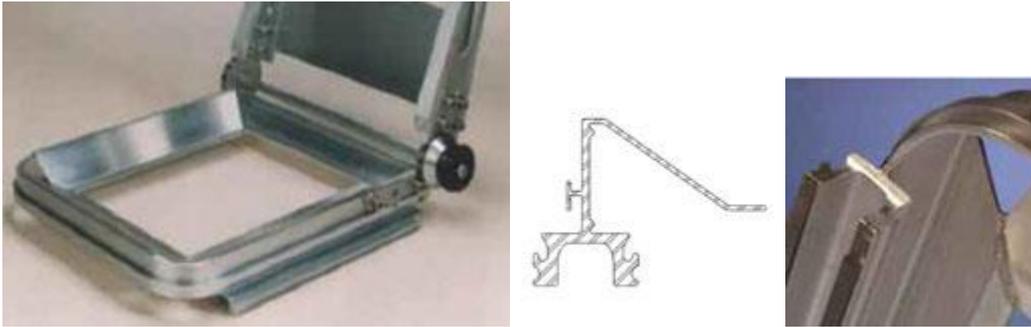
A single, double-tube extrusion with dimensions conforming to those required by the head rest is partly slit open along the frame sides. The tube ends are extended to accept a sheet metal insert which is attached to the tubes by welding and is screw fitted to the recliner. The rearward facing tube incorporates a groove for a secure form fit with an aluminium sandwich panels using structural adhesive. The shape of the two tubes has a crash-optimised design so that pull and push loads under crash impact can be absorbed. For the prototype production, a Metawell® aluminium sandwich panel was used.



Cross-section of the aluminium profile which was partially split and expanded

There are also extrusion-based design concepts for the seat cushion. The seat cushion frame shown below consists of only two types of extruded profiles: a U-bent main frame extrusion with attached upper rail and a transverse member. Both extrusions also provide grooves for seat cover assembly. The transverse member has integrated screw channels for assembly, but is also adhesively bonded. The lateral flange is removed in the corners while still offering the possibility to weld these sections for additional stiffness.

The continuous flange provides support for a seat-base suspension or a similar structure completing the functions of the seat-cushion frame. The fabrication of the seat-cushion frame can be combined with shearing and punching operations. This reduces manufacturing costs significantly. The extrusion of the seat-cushion frame is a truly unique shape utilizing all aspects of the extrusion process. A single extrusion incorporates all requirements of a seat base and even includes the upper seat tracks.



Extrusion-based design concept for the seat cushion

Aluminium extrusion designs are of particular interest for modular design concepts. Flexibility is achieved by using a specific extruded cross section and

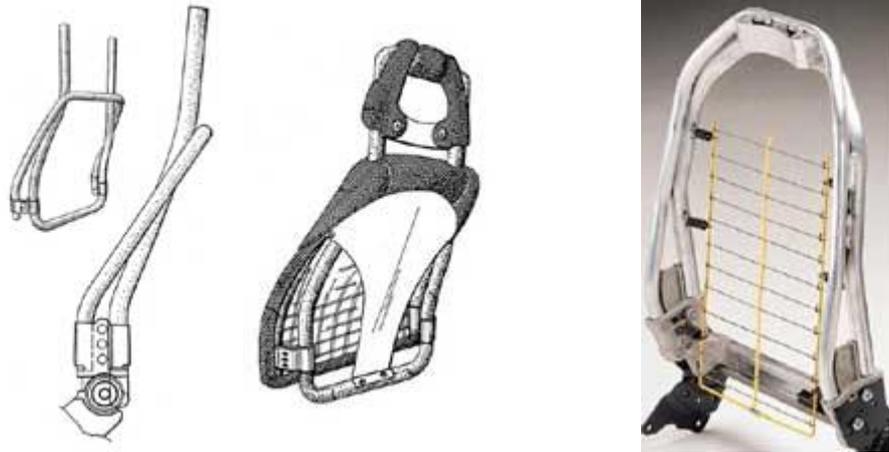
- by simple variation of the bending parameters, one can realise different seat back heights and widths; or
- by variation of the fabrication process and the bending radii, one can realize different seat cushion frame depths and widths.

The calibration of the metal insert (recliner mounting) allows a defined response to load conditions for various crash requirements. Each seat back and seat cushion frame can be combined through the recliner with any other back or cushion frame. The modular design allows a universal use and offers a great potential for customised solutions.



Modular seat design concepts using aluminium extrusions

Another option is a dual-tube design which was developed for large volume production seats. The back frame of the front seats for the Mercedes-Benz A class model consists of two bent tubes that are connected by welding. The ends of the tubes run into a cast node which provides for the recliner fastening. The head rests are attached by an extra extruded section, which is also connected by MIG welding.



Dual-tube design for the backrest of the front seat: Patent DE 43 03 006 A1 Keiper (left) and realized structure (right)

(Source: Keiper Recaro)

The advantage of the dual-tube solution is the improved transfer and distribution of loads especially in the area of the recliner fastening. On the other hand, a single-tube solution is the more economic choice.

Aluminium front seat backrests fulfilling the highest requirements can be designed for different applications. A modular concept developed for a low volume production, high performance car is shown below together with a front seat with the seatbelt mechanism integrated in the backrest frame. In the second case, utmost requirements regarding strength and load distribution have to be fulfilled.



Aluminium backrest structures for a high performance car (left) and seat structure with integrated seatbelt mechanism (right)

(Photos: SAG Aluminium)

b) Rear seats

Depending on the type of car, a differentiation between bench and single rear seat systems is necessary. The rear seats are part of a multifunctional vehicle's interior with many functionalities and individual solutions. Nowadays, rear seats are often adjustable as are front seats, and are more flexible (e.g. folding and removal options). Furthermore, with the seatbelts integrated into the seat's structure, the bearing points have to withstand very high loads.

Seating comfort options for second and third row seats may include length and tilt adjustment, the adjustment of the head rest, armrests and for luxury vehicles even footrests. In addition,

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optional folding, repositioning and even removal must be often possible. In order to provide a larger and flat cargo area, the backrest, and often also the seat area, can be folded in many cases.

In general, rear seats can be divided into folding and/or sliding seats in station wagons, hatchbacks, or vans, and fixed designs for sedans. The backs of fixed seats usually do not contain specific structural components, but consist of an upholstered frame which is attached to the bulkhead separating the passenger compartment from the luggage boot. For folding seats, two different cases must be considered. The backrest of the rear seat in a station wagon is locked in position by bolts at the side. On the other hand, the individual rear seats in vans require a design similar to the front seats.

For folding seats, unsecured luggage behind the seats presents an additional problem (not relevant for fixed seats). Even at relatively low speeds, the seat back may be subject to high forces due to the “flying” luggage. Under these conditions, a properly designed construction made from aluminium extrusions presents significant advantages and offers 25 – 30 % weight reduction compared to steel sheet designs.

A rear seat in an aluminium sheet design has been developed by Keiper for the Mercedes-Benz A class model. The rear-seat system features an adjustable and foldable backrest structure, aluminium seat pans as well as a multifunctional seat supporting structure made of aluminium sheet stampings. The back seats are divided in a 1/3 to 2/3 ratio and can also be easily removed or folded into a space-saving transport position.



Rear seat for Mercedes-Benz A class model

An extrusion-based aluminium design has been used for the backrest of the rear seats of the Volvo V70. It is composed of two wide extrusions which are joined by friction stir welding. A number of different functions are built into the extrusion which minimises the need for further processing. The length of the backrest is produced in 60/40 and 40/20/40 partitions. This enables folding down of individual parts to increase storage volume.



Two backrest profiles before joining by friction stir welding

The photo below shows the welded backrest for the Volvo V70 and V70CX.



Backrest for the rear seat of the Volvo V70

Newer developments focus on seat structures in mixed material design. As an example, Johnson Controls Automotive has developed a very light rear seat system where the rear part of the frame is partially made of aluminium and partially of steel. The two metals are joined by adhesive bonding and self-piercing rivets. Aluminium was chosen as the material for the upper and lower cross members. The reinforced side elements and crosspieces are made of steel. The result is a weight saving by 30% in comparison with the traditional seat structure without affecting safety requirements. The new joining technology also allowed a reduction of the thickness of the steel back panel from 0.6 to 0.4 mm. The multi-material structure is so resistant to stress that it complies with any standard in terms of durability, structural strength and stability even in case of impact.

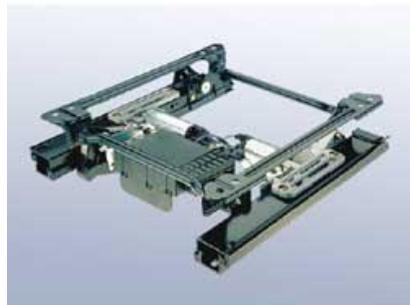
The mixed material design concept makes weight savings of 1 kg per seat structure possible. It is suitable for both front and rear seats. Seat elements that are subject to lower crash loads can be replaced by aluminium alloys, zones that are exposed to high crash loads are made of high strength steel.



**Rear seat back frame made of aluminium and steel
(Photo: Johnson Controls Automotive)**

7.1.2 Seat rails

The front seats in a car are generally assembled with a slide rail which allows an adjustment of the longitudinal position of the seats in the passenger compartment. In specific cases, a seat rail may be also used for the fixation of second and third row seats. Seat rails are used both for manually and electrically adjustable seats. Using serration tools, cost-effective high-precision seat slides allowing exact and reproducible positioning can be realized. Seat rails have to fulfil high quality criteria, there are very strict requirements regarding strength and crash worthiness as the seat rail is regarded as a safety component (it transfers forces from the driver / passenger to the car floor structure in case of a crash).



**Seat rail structure for an electrically adjustable seat
(Source: Borse Fahrzeugteile GmbH)**

The application of aluminium extrusions for the seat rail allows the integration of many functions into the product. A major advantage of using extrusions is that it is easy to change or modify the product, i.e. to adjust stroke length or fixation points. The complexity of applied cross sections shows that a high degree of functionality has been integrated in these rails – from the standard sliding structure to crash interlocking systems.



Extruded aluminium seat rails
(Photos: SAPA Aluminium / FWB Brökelmann Aluminium)

Ball bearing mechanisms were not able to gain general acceptance on the market as they tended to produce "chatter marks" resulting in a reduced serviceability. The majority of seat rails is therefore Teflon-coated or equipped with other plastic gliders. Extruded aluminium can be surface treated in different ways. Anodising is used when there is high demand for resistance to wear, for example when the seat must be frequently moved. Powder coating can be used to reduce friction when wear is not an issue.

7.1.3 Other seat components

A range of other seat components are also produced in aluminium. Of particular interest are seat components where the application of aluminium castings offers, in addition to lightweighting, important possibilities for part integration (i.e. cost reduction). Some examples are shown below.



**Aluminium arm rest produced by high pressure die casting (Magsimal[®]-59 in the as-cast state)
(Photo: Aluminium Rheinfelden)**

The arm rest is a multifunctional partition element which is used in the front and rear area. The arm rest combines comfort with functionality. Although functional as an arm rest, it can also be used for multiple options, e.g. as a storage area or a cup holder, it can be equipped with DVD players, CD changers or mobile phone capabilities, etc.



**Seatbelt spool
(Photo: TCG Unitech)**

Another application of a high quality aluminium casting is the spool of the seatbelt reel up and tightening mechanism. In case of a crash, coupling jaws are pressed into the sidewall by a pyrotechnic device in order to tighten and fix the seatbelt. Therefore, a high ductility of the spool material is necessary.



**Rocker arm for the back seat
(Photo: Aluminium Rheinfelden)**

A third example for a cast aluminium component which must fulfil highest requirements is the rocker arm for the back seat in the Mercedes-Benz E class. The rocker arm is subjected to very high dynamic loads in the crash case as it must support all the cargo in the baggage compartment. The part is made from the alloy Silafont[®]-36 in the as-cast state.

7.2 Interior trim

The cool impression of metallic surfaces associates a high level of sportiness and modernity. Aluminium with its durable shiny surface appearance, the different product forms and the large variety of possible surface treatment methods is particularly suited for such applications. Consequently, aluminium is increasingly the material of choice for high quality decorative display and design purposes in the interior of today's cars.

Aluminium sheets, extrusions, castings and forgings for decorative applications must meet extremely high manufacturer standards, including impeccable surface quality and a high degree of shine. There are many different types of attractive decorative aluminium surfaces. The aluminium surface can be ground, brushed, polished to a high gloss, matt-finished, pattern rolled, etc. For additional protection, it can be coated with a clear lacquer; it can be also anodized, plated with nickel or chrome, etc. An interesting option is for example satin brushed aluminium sheet which is insensitive to fingerprinting. This machine-polished brushed aluminium sheet effect gives a directional grained appearance that provides uniformity of finish while also helping to remove surface defects.



**Aluminium interior trim applications
(Photo: BMW)**



**Aluminium interior trim applications
(Photo: Novem)**

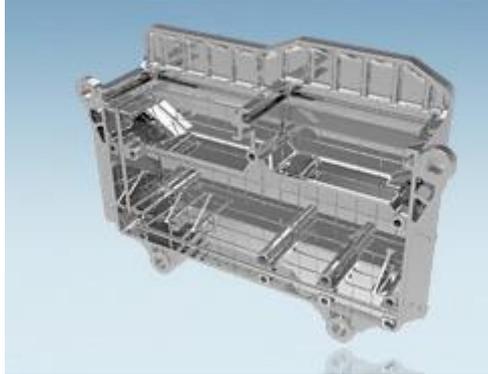
Aluminium foil is also often specified as an alternative to aluminized plastic trim when a long lasting, but more economical solution is required. The aluminium foil can be laminated or encapsulated. New alloys, brush finishes, anodising, embossing and coating techniques have extended the use of aluminium foil and thin strip into some demanding applications such as doorsills and fingerplates.

7.3 Passenger protection

7.3.1 Airbag components

The design of the airbag is conceptually simple; a central airbag control unit monitors a number of related sensors within the vehicle. When the requisite threshold is exceeded, the airbag control unit triggers the ignition of a gas generator propellant to rapidly inflate a fabric bag. As the vehicle occupants collide with the airbags, the gas escapes in a controlled manner through small vent holes.

Various airbag components ranging from housings to functional parts are made from aluminium. Many different aluminium product forms are applied.

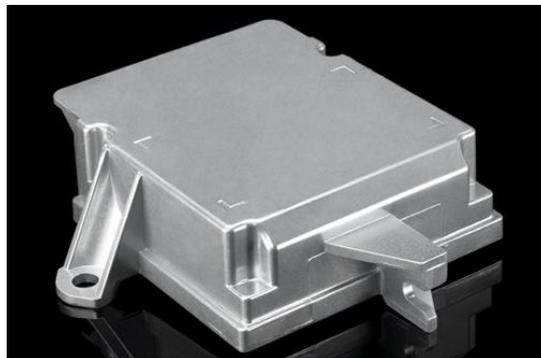


**Cast aluminium housing for the airbag control unit
(Photo: TCG Unitech)**

Precision extruded aluminium components are a preferred material for airbag housings. Another possibility to produce aluminium airbag housings is high pressure die casting.



Aluminium airbag housings



**Die cast aluminium airbag housing
(Photo: Dynacast)**

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Inflator body canisters can be manufactured from aluminium tubes, e.g. using the rotational forming technology developed by voestalpine Rotec. The rotational forming technology (also applicable to steel tubes) enables the adjustment of flexible wall thicknesses. Compared to other technologies, this technology requires significantly less forming tools (i.e. lower production cost). Another applicable production method is cold impact extrusion. The advantage of these technologies is that one end cap is already integrated.



Inflator body canisters produced by rotational forming (left) in a mixed steel/aluminium design and by impact extrusion (right)
(Photos: voestalpine Rotec/Pohlman)

Separate aluminium end caps are produced by impact extrusion or forgings. These production methods deliver near-net shaped starter blanks that drastically reduce CNC machining time and material scrap. The result is a fully wrought component with uniform grain structure maximizing the strength, toughness and machinability of the material.



Impact extruded (left) and forged (right) starter blanks for airbag end caps
(Photos: Pohlman/Alcoa)

Also precision deep drawn aluminium components are found in multifaceted automotive applications, e.g. in airbags. The dimensions of these small and precise deep drawn and stamped aluminium parts are 1 mm to 60 mm diameter, maximum length of 90 mm



Small deep drawn aluminium parts made from thin aluminium sheet material, e.g. used for airbags

(Photo: Stüken)

7.3.2 Energy absorbing aluminium elements

Energy absorbing aluminium elements can also be used as part of the passenger protection system in the car interior against certain crash scenarios (e.g. knee or head impact). The challenge facing designers of impact protection systems is to absorb the maximum amount of energy within a minimum amount of space.

In case of a frontal crash, there is a danger that the knees of the driver (and, to a lower degree, also the knees of front passengers) hit a stiff structure. A possibility to protect the knee is the introduction of “deployable” knee bolsters which are basically airbags for the knees. Another possible knee protection design is a crushable barrier under the dashboard that stops the knees from striking hard surfaces during a crash, reducing the likelihood of serious leg injuries. Such a deformable barrier can be made using a properly designed extruded aluminium profile. Other measures used to line interior surfaces and to protect passengers in the event of accidents include laminated and corrugated foil tubes and sections, aluminium foams or honeycomb structures made from aluminium foil.



**Aluminium knee bolster
(Photo: SAG Aluminium)**

Specific types of energy absorbing elements are aluminium-paper composite components. Designed for passive occupant protection during impact, they conform to the requirements of the US standard for head impact in the upper passenger compartment (FMVSS 201) as well

as side impact (FMVSS 214). The patented OHLER® Energy-Absorption-Elements are widely used in interior zones such as roof lining, main frame, pillar trim, knee bolster, door panel, bumper beam and bumper cover panel.



**Aluminium-paper composite energy absorption elements
(Photo: Novelis)**

The aluminium-paper composite tubes are multi-layered wound and grooved elements with one to three aluminium layers and a paper layer on the inner and outer surface (layered structure from the inside to the outside). The required capacity of energy absorption can be adjusted by the selective combination of both materials. After an intense energy build-up, the force level will be constantly held over the deformation path to absorb the energy uniformly. Decisive advantages are the nearly constant force - deformation path characteristics in the temperature range of -40°C up to +110°C, the low weight and 100% recyclability. The top layer made of paper serves as prevention against rattling. They are currently used in areas like roof lining, pillar trim, knee bolster, door panel, bumper beam cover panel, etc.



**CrushLite™ aluminium honeycomb material absorbs energy by crushing under load
(Photo: Plascore)**

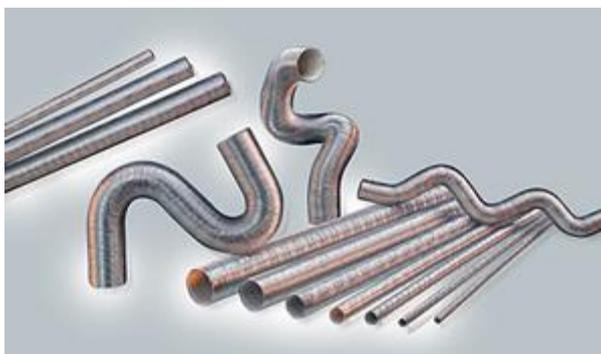
Another solution is provided by honeycomb energy absorbers. Aluminium honeycomb possesses remarkable kinetic energy absorbing properties. The honeycomb crushes under load in a uniform way, preventing damage to the supporting structure. Being virtually free of rebound and lighter than alternative materials, aluminium honeycomb structures are most reliable, efficient and practical energy absorbing materials. They are widely used in the automotive industry for impact protection and crash test barriers.

Aluminium honeycomb materials show predictable energy absorption properties, a high crush strength-to-weight ratio and yield at a constant force providing reliable and consistent energy absorption in almost any environment. Aluminium honeycomb structures are available as untrimmed sheets, cut to size, machined to complex shapes. They can be easily integrated into many applications requiring uni-axial deformable energy absorption. Similarly, aluminium foams can be also applied for energy absorption purposes.

7.4 Insulation and air distribution

The durability and heat insulating properties of aluminium foil qualify it for use in several components. It adds dimensional stability and permanence to soft linings in passenger compartments. It lends security against the spread of flame thanks to its incombustibility and heat conductivity. Passenger comfort is also enhanced through the reduction of noise levels using sound absorbent foil laminated tubes and padding components. As part of internal linings and insulation composites, aluminium foil adds only minimally to weight.

Flexible corrugated tubes created from aluminium foil - often laminated with fibre and other substrates depending on their function - provide the essential ducts for heating and cooling ventilation and for the protection of cables and articulated components. The ducts are light, durable and fire resistant.



**Heat protection tubes made from aluminium foil
(Photo: Novelis)**

Heat protection tubes are made by layering several kinds of aluminium alloy foil and other materials such as fibreglass and plastic with corrugations. The excellent reflectivity of the aluminium external surface reflects radiant heat, and its insulating power additionally serves to protect the tube's content from heat sources. An insulation layer on the inside provides additional protection to the component against the transfer of heat. The tubes are very flexible and dimensionally stable, but can be compressed or extended as required. They can also be fastened or mounted easily by crimping the end fittings. They can be used to protect any kind of hose, tube, conduit and ducting, as well as cable and wiring systems.

Air flow routing tubes (CARADUCT® tubes) are designed to channel different kinds of air to appropriate destinations. They are multi-layer, grooved, flexible tubes that are wound from a combination of aluminium foil and paper layers. They possess a particularly high crushing strength and very good insulation properties. Through high flexibility and small bending radii, they offer the user the ability for a good space usage, particularly when positioned in corners.



**Flexible Tubes for Hot & Cold Air Distribution
(Photo: Novelis)**

7.5 Controls

Aluminium is the preferred material for the production of customized control elements for the aftermarket. It can be used for example to produce attractive hand brake handles, steering wheels as well as accelerator pedals, clutch pedals and brake pedals.



Aluminium controls for the aftermarket

But aluminium components are not only used for their visual appearance. Many steering wheels include for example an aluminium cast structure.



Cast aluminium steering wheel (alloy Magsimal®-59)

(Photo: Aluminium Rheinfelden)

Another application for aluminium products are the pedals (accelerator, clutch and brake pedal), mainly in the form of cast components, but there are also extruded variants.



Pedal extrusion (alloy EN AW-6063)

(Photo: Otto Fuchs)



Cast aluminium parking brake pedal (A206 T7)



**Pedal bracket assembly for the Audi A6
(Photo: KSM Casting)**

7.6 Aluminium housings

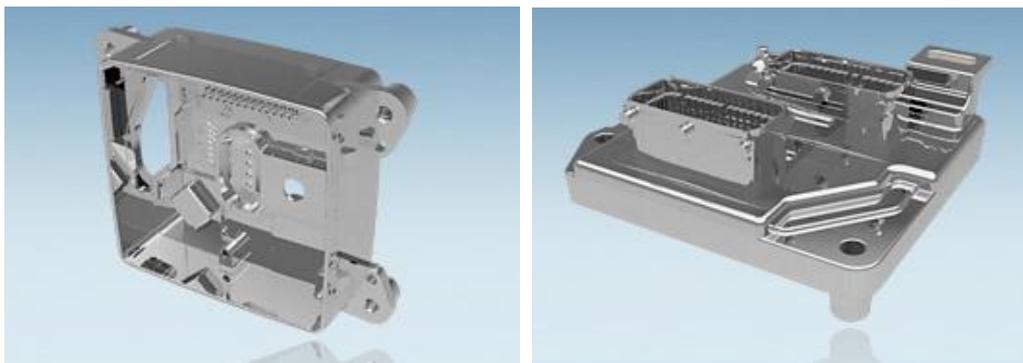
Aluminium is often used for different types of housings, in particular for electronic enclosures. Most interesting in this respect is the shielding effect against electromagnetic fields. But also the thermal properties of aluminium (high heat capacity and good thermal conductivity) are important decision factors.



**Deep drawn aluminium electronic enclosures
(Photo: Norpin)**



**Housing for an automotive rain sensor (alloy: Magsimal[®]-59)
(Photo: Dynacast)**



**Aluminium electronic housing with overmoulded connectors (left) and heat sink with overmoulded connector housing (right)
(Photo: TCG Unitech)**

Aluminium housings can be produced using either deep drawn sheets, extruded profiles with properly designed cross sections and castings. Attractive possibilities are offered in particular by aluminium/plastic electronic housings. In this case, aluminium die cast components are CNC machined and combined with suitable plastics in the injection moulding process.

7.7 Aluminium armouring solutions

An armoured car is a security vehicle where armoured plates are inserted into the body panels. But unlike a military armoured car, a civilian armoured car typically looks no different from a standard vehicle. Armoured civilian vehicles are often used in conflict zones or where violent crime is common, but also for presidential limousines, etc. In addition, they are routinely utilized by security firms to carry money or valuables.

Aluminium is generally employed for armouring of vehicles when light weight is a necessity. Traditionally, the aluminium alloys used for armoured vehicles and related applications are high strength, heat-treatable alloys of the EN AW-6xxx, 2xxx and 7xxx series. But also low-density and cost efficient EN AW-5xxx series alloys with excellent ballistic properties, good weldability and outstanding corrosion resistance are often used. Selection of alloy by the vehicle designer requires consideration of the type of threat in each particular area of the vehicle, but also must take into consideration other characteristics such as manufacturability (forming, joining, etc.) and corrosion resistance (in particular stress corrosion resistance).

Composite armour is a type of vehicle armour consisting of layers or mixtures of different material such as metals, plastics, ceramics or air (foam-type materials). Most composite armours are lighter than their all-metal equivalent, but instead occupy a larger volume for the same resistance to penetration. It is possible to design composite armour stronger, lighter and less voluminous than traditional armour, but the cost is often prohibitively high, restricting its use to especially vulnerable parts of a vehicle. Its primary purpose is to help defeat high explosive anti-tank (HEAT) rounds. Aluminium composite materials are often used, in general in combination with other the traditional armouring material as armour steel or aramid.

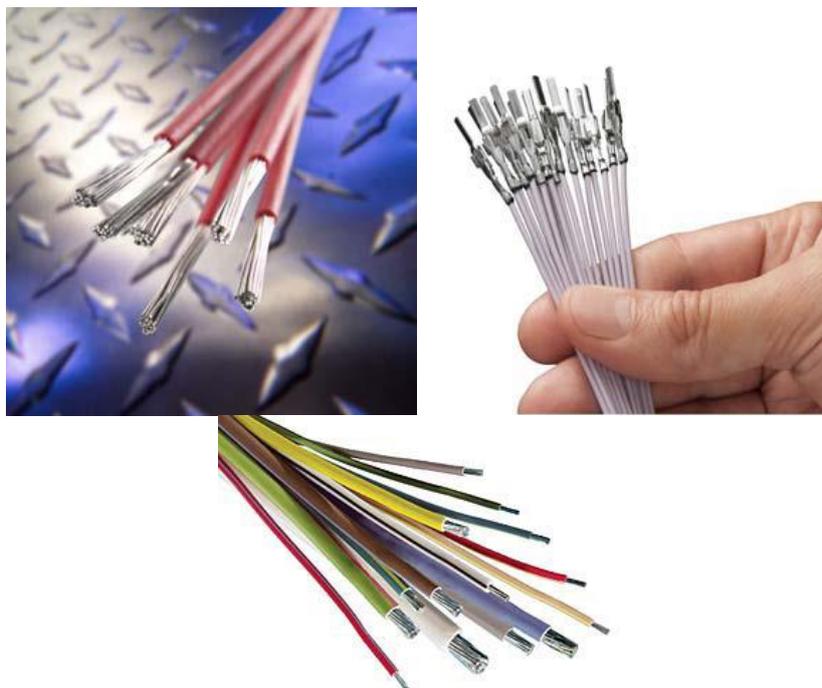
An example is “Kryon” which is a carbon nanotube aluminium metal matrix composite developed by Bourque Industries. The infusion of carbon nanotubes into the proprietary aluminium alloy allows the creation of armour materials with exceptional ballistic capability and low weight. Its ballistic capability stems from its unique characteristic of dissipating extreme amounts of heat in a very short period of time using a small amount of material.

7.8 Aluminium cables

Aluminium cable systems offer a cost-effective, lightweight wiring alternative that enables up to 45 % weight reduction compared to traditional copper core cables, providing equal conductivity. The saving is made possible by the fact that aluminium has a significantly lower specific weight than copper (2.7 compared to 8.9 g/cm³), but a considerably advantageous

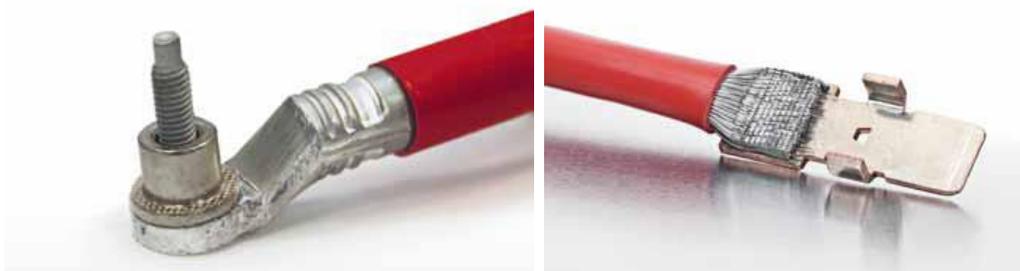
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electrical conductivity (60 compared to 100 % IACS for copper). Thus the aluminium cable is slightly larger than a copper cable with the same electrical conductivity due to the required greater cross section of aluminium.



Aluminium cable systems for automotive applications (Photo: Delphi Aluminium Cable Systems)

Aluminium cable systems enable improved fuel economy due to mass savings and lighter, easier vehicle assembly and, depending on the actual raw material price, also cost savings. A range of aluminium cable sizes is available, depending on the intended application (for wiring harnesses, from 0.75 to 8 mm², and for power/battery cable from 10 to 120 mm²). Also appropriate solutions for the necessary connections are available.

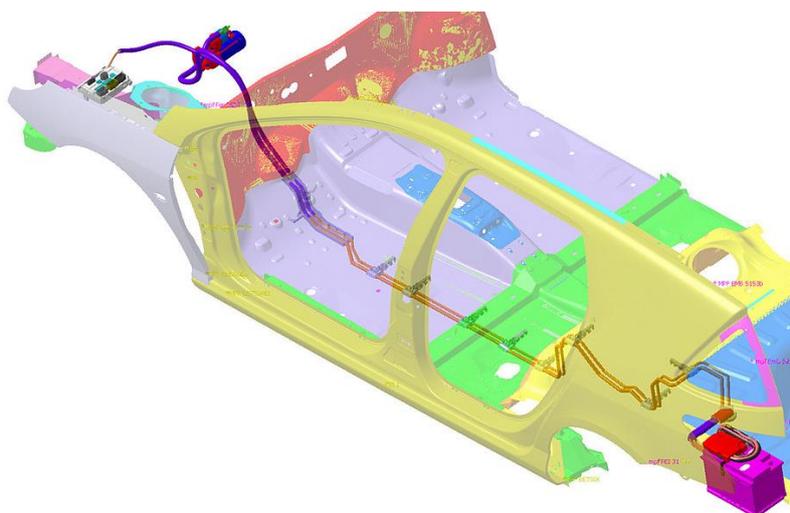


Attachment of a threaded bolt (left) and a flexible termination (right) to an aluminium cable by ultrasonic welding (Photos: Telsonic)

Of the roughly 3'000 m of cable that a modern vehicle contains, the connection between the battery and the engine is generally the bulkiest single cable. The weight reduction potential on this component is particularly large when the battery is located in the rear of the vehicle. The replacement of the copper battery cable by a solid aluminium busbar may save 40 to 60 % (or up to 3 kg). The solid busbar can be bent in all three dimensions and, thus, it can be perfectly fitted directly on or underneath the vehicle's chassis. It is insulated with a halogen-free

polyethylene jacket. Depending on the type of vehicle, it can have a length of more than 4 m and be deployed in either a single or twin track version.

In addition, there is the distinctive characteristic that the increased diameter, which aluminium conductors would normally necessitate, can be avoided with larger cross sections. Its solid structure and a special manufacturing process considerably reduce the busbar's diameter. Compared with a multi-core copper cable with a 15.5 mm diameter, the aluminium busbar of identical conductivity has a diameter of less than 14 mm. The technology thus helps to address the issue of diminishing installation space. Also, handling the rigid busbar is easier than in case of a limp cable, i.e. it saves time on installing in the vehicle.



**Aluminium busbar which can be fitted directly on or underneath the vehicle's chassis
(Source: Leoni)**

7.9 Aluminium in the lighting system

Modern reflectors are commonly made of compression-moulded or injection-moulded plastic, though glass and metal optic reflectors also exist. Nowadays, however, aluminium is hardly used for automotive headlight reflectors. Today 95% of the headlight reflectors are manufactured from bulk moulding compounds (BMC).



**Aluminium reflectors for headlights
(Photo: IAI)**



Aluminium sockets for Xenon (left) and LED (right) headlight bulbs



Car fog light with an aluminium body for heat dissipation and license plate light with an aluminium radiator

7.10 License plates

Aluminium sheet is the ideal material for the production of car licence plates. Rolled aluminium strips are pre-treated for the application of reflective foil or decoratively painted for non-reflective licence plates. The alloy composition and mechanical properties as well as the surface coating must comply with country-specific requirements.

Modern embossed aluminium security number plates, manufactured using a retro-reflective foil, usually also contain further security features in order to prevent counterfeiting, tampering attempts or duplication and to ensure controlled production, issuing and subsequent monitoring by the responsible authorities.



Embossed aluminium licence plate with an applied reflective foil
(Photo: Novelis)

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Alternatively, the “semi shear” method (also known as the French system) is used to manufacture reflective number plates made from acrylic / PET material. In this case, the embossing and colouring processes are not carried out in two independent steps. Differently from standard aluminium embossed number plates, semi shear number plates comprise of a combination of coloured aluminium foil on top of a base of reflective foil which is the background on the finished plate. Using specially designed tools, the alpha numeric is simultaneously embossed and scored through the outer foil. The scored reflective foil can then be removed from the embossed numbers and letters, the clean aluminium is revealed and the number plate is ready for application to the vehicle.