# Applications – Car Body

## *Introduction*

The Body in White (BIW), seen as a single component, is the heaviest part of a conventional car with a share between 25 and 30% of the complete vehicle weight, depending on the size of the engine, the installed options, and the integrated safety features. In the European market, the dominating car body design concept is the monocoque design. Less than 5 % of the light vehicles built in Europe use a body-on-frame design.
The car body − comprising the body-in-white, the closures, the bumpers and different interior parts − is today still a domain of steel sheet materials. However, the substitution of steel by aluminium in the car body presents most interesting lightweighting possibilities. Moreover, the options for lightweighting with aluminium are not limited to material substitution, but the different aluminium product forms offer in addition the potential for lightweighting by design and – to a limited amount – also lightweighting by using new fabrication technologies. It has been demonstrated that substitution of conventional steel car body designs by proper aluminium designs offers a weight reduction potential of the order of 40%.

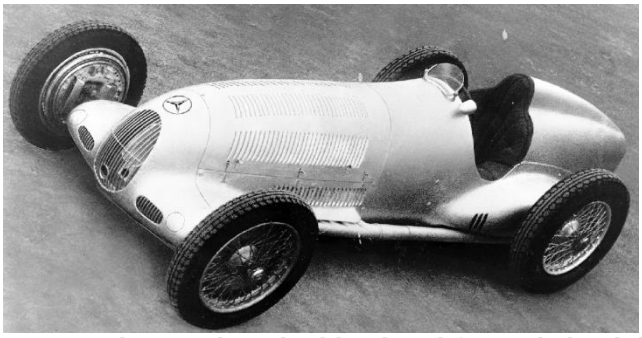
## Short history

Historically, aluminium applications in automobile bodies have been around for a long time. A small sports car with an aluminum body was already shown at the international motor car exhibition in Berlin in 1899. In the beginning, aluminium body components were produced by casting. As an example, in the model Great Arrow introduced in 1904 by Pierce-Arrow, large aluminium castings were used for body parts such as the side walls, the doors and the wall separating the engine from the passenger compartment. .

**Pierce-Arrow Great Arrow (1904) with cast aluminium body panels**

In the 1920ies, cast aluminium body panels were partly replaced by aluminium sheet panels, although window mouldings, firewalls, and other parts remained aluminium castings. Also other vehicles from the 1930ies used aluminium in the body, e.g. the bonnet of the Model T Ford was made of aluminium.

However, as a consequence of the rapid progress in engine technology, the vehicle weight did not remain a top priority issue for automotive engineers. Car manufacturers soon preferred steel for the economic mass production of vehicle bodies. Steel sheets were available in large quantities and offered, apart from the cost benefit, the advantage of long-term experience in processing and service performance. But for technically challenging high-speed vehicles such as the famous Mercedes Silver Arrows or for luxury cars, aluminium body structures were never out of use.



**Mercedes-Benz W 25 racing car (1936) with a hand-formed aluminium sheet body**

Aluminium car body sheets were again applied in large series production in the post-war period. Starting in 1948, Land Rover used aluminium sheets in different models. The first production car to use aluminium as a structural material for its body shell was the Panhard Dyna Z (1953). The spot welded aluminium body sat on an aluminium sheet floor which was reinforced with steel tubes and side sills. The applied sheet alloy was similar to EN AW-5754.


**Panhard Dyna Z, the first series production car with an aluminium sheet body structure**

But starting in 1956, the aluminium sheets in the Panhard Dyna were again gradually replaced by steel. In 1958, aluminium was only used for the bumpers, except for some aluminium components in the engine and driveline.

The broader market introduction of aluminium sheets for bonnets, fenders, doors, hard-tops or tailgates only followed in the eighties of the last century as a consequence of the first oil crisis in order to save weight and thus reduces fuel consumption.

**Mercedes-Benz 450 SLC 5.0 (1977) with aluminium bonnet, boot lid and bumpers**

As an example, the weight of the Mercedes-Benz 450 SLC top model could be reduced by more than 80 kg using aluminium bonnets and deck lids, front and rear bumpers as well as aluminium wheels.

The continuing lightweighting trend in the nineties of the last century led to the development of several sheet-intensive all-aluminium concepts. Some sheet-based all-aluminium models were also produced in small volumes, e.g. the electrically driven General Motors EV1 model or the Honda Acura NSX sports car, both presented in 1992.

The final impetus for the introduction of all-aluminium car bodies was the development of the Audi Space Frame®, first for the Audi A8 (1994) and then the Audi A2 (1998). The

advancement of the sheet-intensive Ford P2000 concept car led in 2003 to the first series application of a complete aluminium monocoque car body design with the Jaguar XJ.

## Purpose and scope of this section

Steel sheets in various grades, from highly deep-drawable qualities to ultra high strength steels, are today still the dominating material in automotive body design. In the course of time, the car manufacturers developed an enormous wealth of experience regarding design, manufacturing and use of car bodies made from steel sheets. Thus, a material substitution is not easily decided, but requires intensive development activities and asks for extensive adjustments in design and engineering, production planning and manufacturing.

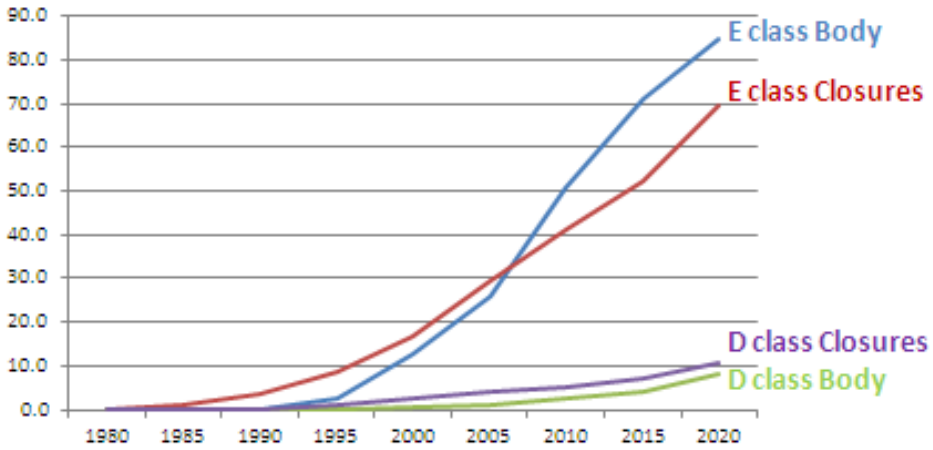
The partial or complete substitution of steel by lighter aluminium solutions takes place

- in the form of individual hang-on parts or structural modules integrated in a predominantly steel body, preferentially where the reduced weight allows also the realisation of additional advantages or
- by a consistent aluminium lightweight design of the car body structure (either as an all-aluminium design or in the form of large structural modules, e.g. an all-aluminium front section).

The requirements of the car producers with respect to materials properties, manufacturing productivity, fabrication cost and need for investments have led to the development of various aluminium design concepts and to significant advancements in aluminium material and manufacturing technologies. Apart from the intensified use of aluminium in hang-on parts, more and more aluminium components with structural functions are integrated into steel bodies. The extent of such a mixed material body design can vary considerably and reach from individual aluminium components in a steel body to an all-aluminium body with a few steel parts. An interesting example offers the aluminium/steel hybrid body of the BMW 5xx series (E60) where aluminium was used for the front of the car and steel for the passenger cabin and the rear, thus ensuring a 50:50 weight balance.

**BMW 5xx model E60 with an aluminium front section built from 2003 to 2010 (Photo: BMW)**

Today we are observing a significant growth of aluminium in closures and body applications, in particular in upper class models (E class), sports cars and luxury SUVs. However, the application of an all-aluminium car body will be limited also in future to specific upper class models and sports cars, in particular for niche applications and small to medium production series. For mass production, mixed material constructions will generally dominate, i.e. body design concept where steel provides the strength and the stiffness of the body structure and aluminium is the preferred material for closure parts and selected structural modules.




**Aluminium content (kg) of the average European car in closure and body applications (Source: Ducker, 2012)**

The purpose of this section is to illustrate a variety of aluminium body components and all-aluminium body design concepts which have been successfully developed for low, medium and high production volume cars. The different examples demonstrate that lightweight aluminium solutions are available for practically all car body applications (structural and non-structural).