The BMW Z8

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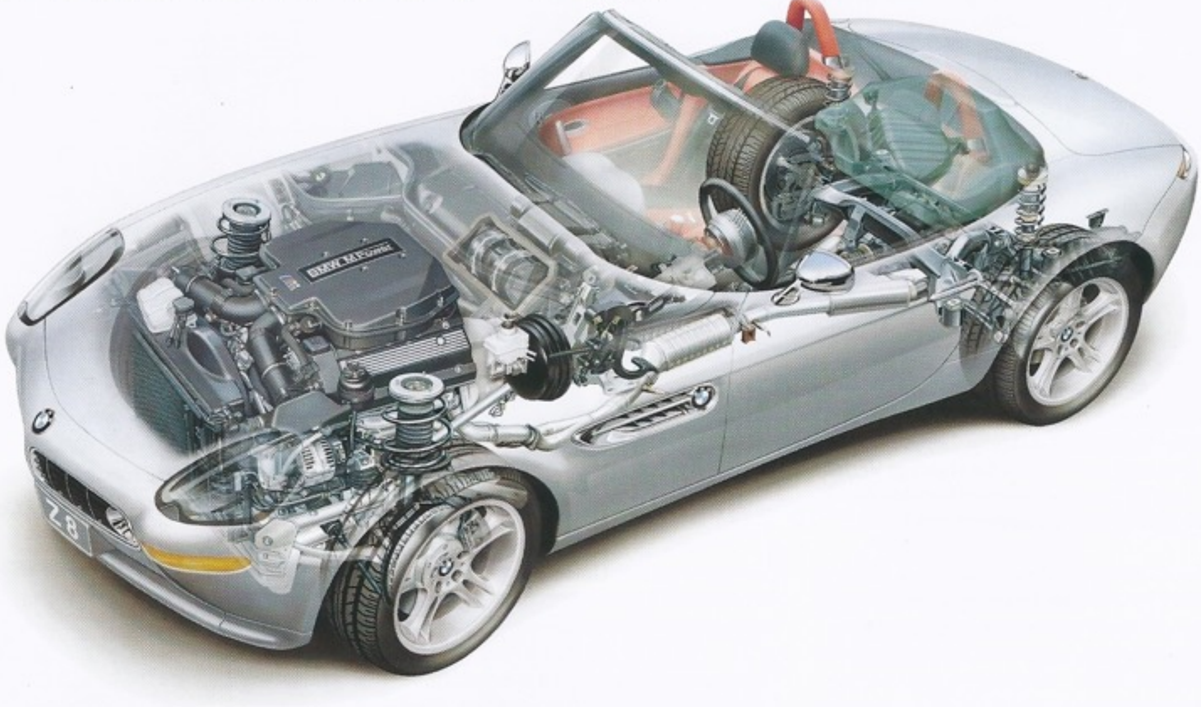

By Christian Dietrich

As the new kid on the block among the super sports cars, the Z8 is aimed at a small group of customers who have very high demands and wish to combine "the ultimate driving machine and the ultimate design with exclusivity, safety, reliability and quality".

The latest engineering, such as the aluminium structure and aluminium exterior skin, the high performance power train and the sophisticated sports chassis, the stability control system, the high performance braking system and the tyres with emergency features go together make the Z8 an extraordinary sports car.

A full range of equipment with a hardtop, telephone, audio and navigation system, attention to detail and lots of aluminium in the interior combined with high quality leather underline the exclusivity of the Z8.

Der Verfasser

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1 Aim, Styling, Vehicle Concept

1.1 Aim

The Z8 is a modern classic and as such is an attempt to combine the classic roadster with a high performance sports car in an attractive package. The Z8 is a dynamic, cultivated top quality automobile for the connoisseur, and as such is different from vehicles that are developed more along motorsport lines.

Under its exterior it contains the very latest technology.

Individual styling elements create an association with the legendary BMW 507, **Figure 1**.

The classic design of the economically tailored roadster was given priority over elements such as a folding softtop or softtop cover.

1.2 Styling

The uncompromising design of the Z8 makes it a classic roadster. Its rather romantic design represents a homage to the successful BMW tradition of sporting roadsters, such as the 328 and the 507. The long front end, short overhangs, large wheels and a puristic but very luxurious cockpit are just a few of the features that make the Z8 a dream car that goes beyond the bounds of fashion and vogue.

The sculptured, dynamic body design, which is supported by the wide wheels, is a

visualisation of the performance and power in this car, **Figure 2**.
The typical BMW feature of sporty design and a harmonious feeling of spaciousness are expressed by the puristic interior concept.

From the seat position to the centre cockpit and all the details, the design enhances the full concentration of the passengers on the unique driving experience, nothing gets in the way of the view over the long bonnet, which seems to pass seamlessly into the road.

1.3 Vehicle Concept

The aim of the development was to produce a 2-seater roadster with a long bonnet, low rear and a seat position near the rear axle. Based on the proportions of the classic BMW 507, **Figure 3**, therefore a conscious choice was made in favour of the tradition softtop solution with mounted tonneau cover. Table 1 shows the technical data of the Z8. The overall length (4400 mm) and the wheelbase (2505 mm) are only 20 mm greater than its famous predecessor, yet the car still manages to satisfy the very high requirements made on passive safety The Z8 is 1832 mm wide and 1306 mm high.

The 5.0 l V8 engine, which is the only engine version available for the Z8, has been set back a good way relative to the front axle (front centre engine) to achieve the aim of an axle load distribution of at least 50 %/50 % (front/rear). In combination with modern axle concepts this results in an ideal situation for handling, safety and traction. The aluminium space fame made up of extrusion pressed sections also makes a valuable contribution to this. It sets new standards for an open-top sports car in terms of torsion and bending strength as well as crash safety.

1.4 Interior

The independent character of the Z8 at first glance is dominated by the central circular instruments, a special design feature. A large seat adjustment range offers even the 99 % man plenty of space, as is the case for fitting the hardtop.

To ensure an extraordinary hi-fi sound experience large resonance components have been fitted in the floor module under the seats, near the A pillar, in the doors and in the rear. The multi-information radio (MIR) is supplemented as standard with oddments boxes behind the seats, containing a CD change on the left and a navigation computer on the right.
To make the car suitable for every day use it has a boot with a capacity of 203 litres (VDA), which provides space for two golf bags. From a package point of view it was a major challenge to achieve this capacity despite the marked rear design and the low boot height. The solution was only made possible by eliminating the spare wheel – instead the tyres on the Z8 offer emergency operation features. The battery was placed beneath the floor of the boot behind the rear axle gearbox. The fuel tank is under the softtop cover, to achieve a good compromise between a low softtop storage height and a fuel tank capacity of 73 litres.

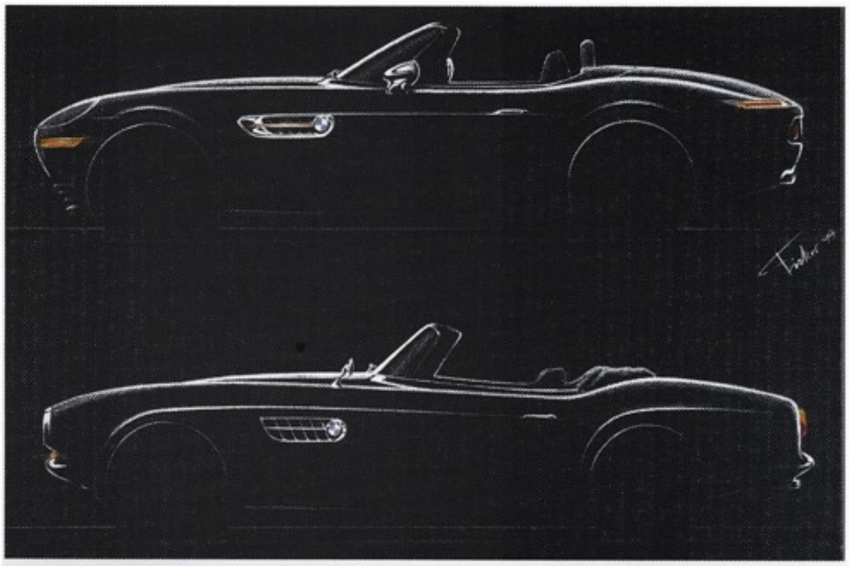


Figure 1: Proportions and styling elements 507 and Z8

2 Body

The list of requirements for the Z8 describes an elegant roadster that creates emotion, with the best technical equipment whilst maintaining a low weight.

This demand led to the use of lightweight aluminium for the body, the result of which is a high quality body with a space frame design. The exterior skin of the body is bolted and, with the exception of the plastic bumpers and side skirts, is made fully of aluminium. As is usual with BMW, the body development process was supported every step of the way using the latest CA tools.

2.1 Body shell structure

The weight target, economy with small numbers at the highest technical level and the product placement on the market led to this decision. The body shell and exterior skin concept result in moderate repair costs, which in turn leads to a comparatively good insurance classification (third party/partly comprehensive/fully comprehensive class: 21/38/36).

2.1.1 Construction

An independent convertible structure was developed for the Z8, some 68 % of which is made up of the weight of the aluminium extrusion press sections, whilst 31.2 % consists of aluminium sheet components, **Table 2**.

Only straight extrusion press sections and section that are bent in two dimensions are used, and all of them are tailored to the adjoining components at the joint area. The extrusion press sections each constitute a complete, rigid geometry, which can be stretched to the joint dimension locally during the assembly process.
Demanding targets in terms of driving dynamics, crash properties and acoustics require very high body rigidity, a feature that is achieved on this case by a striking tunnel support and the complete horizontal basic body structure. This ensures the direct flow of force between the front, the passenger cell and the rear of the car.
A framework structure is created using the two-dimension bent sections, **Figure 4**; the tunnel supports are joined to the engine mountings at the front and to the side skirts at the rear via a solid cross member.

Bild 2: Styling
Figure 2: Styling

This structure offers a further beneficial force route for the optimal connection of the ends of the vehicle to the cell. The static chassis forces are fed into the side skirts and tunnel supports through the supports including the A and B pillars, **Figure 5**.

In the rear section the large enclosed fuel tank space, **Figure 6**, which is designed in the form of a torsion box, supports the rear of the car against the tunnel. At the front the front end of the car is supported by the direct connection of the tunnel supports to the engine mountings.

The complete space frame, **Figure 7**, results in the following technical details for the weight and rigidity of the body:

- body structure: 230 kg
- body in white: 275 kg
- static: torsion 10500 Nm/°
- dynamic: inherent bending frequency 21 Hz (vehicle as a whole)
- inherent torsion frequency 23 Hz (vehicle as a whole).

2.1.2 Technology

Components made of extrusion press section are produced using CNC machining processes and then coated with titanium (Ti) in a piece goods process. The majority of the sheet metal components are produced using a bending process. The sheets are coated with titanium zirconium (Ti/Zr) using a coil coating process. The panels and components are cut using lasers.

The titanium or titanium zirconium coating prevents the formation of aluminium oxide and therefore guarantees stable production parameters for the jointing and painting process.

2.1.3 Jointing

The jointing concept for the Z8 is designed to ensure the zero stress construction of the

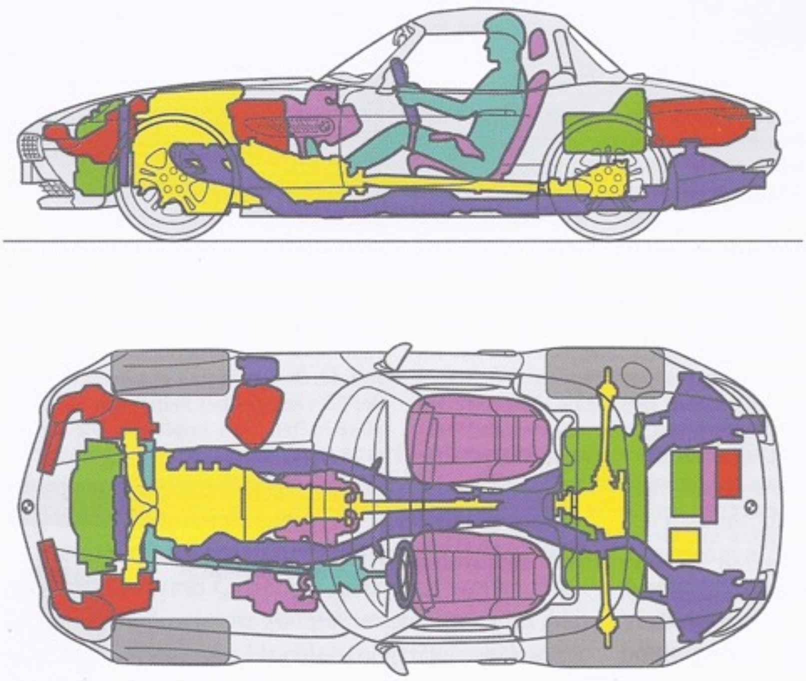


Figure 3: Position of the main components

Table 1: Vehicle data

	Technische Daten	Einheit	Z8
Karosserie, Maße, Gewichte und Füllmengen	Anzahl Türen/Sitzplätze		2/2
	Länge/Breite/Höhe (leer)	mm	4400/1830/1317
	Radstand	mm	2505
	Spurweite vorn/hinten	mm	1553/1568
	Wendekreis	m	11,8
	Tankinhalt	ltr	73
	Kühlsystem einschl. Heizung	ltr	12,45
	Motoröl	ltr	7,5
	Getriebeöl	ltr	1,8
	Hinterachsgetriebeöl	ltr	1,2
	Leergewicht (DIN)	kg	1615
	Leergewicht (EU) °	kg	1690
	Zuladung	kg	315 (nach DIN)
	Zul. Gesamtgewicht	kg	1930
	Zul. Achslast vorn/hinten 1)	kg	920/1070
	Zul. Anhängelast gebremst 12%/8%	kg	--
	ungebremst	kg	--
	Zul. Dachlast/Zul. Stützlast	kg	--
	Kofferrauminhalt VDA	ltr	203
Motor	Bauart/Anz. Zylinder/Ventile		V/8/4
	Motorsteuerung		MSS 52
	Hubraum eff.	ccm	4941
	Bohrung/Hub	mm	94,0/89,0
	Verdichtung/Kraftstoffart	:1	11,0/ROZ 98
	Leistung	kW/PS	294/400
	bei Drehzahl	min -1	6600
	Drehmoment	Nm	500
	bei Drehzahl	min -1	3800-5200
El.	Batterie/Einbauort	Ah/-	90/Kofferraum
	Lichtmaschine	A/W	120/1680
Fahrleistung	Leistungsgewicht	kg/kW	5,64
	Literleistung	kW/ltr	59,5
	Beschleunigung 0-100 km/h	sec	4,7
	0-1000 m	sec	23,4
	im 4. Gang 80-120 km/h	sec	4,3
	Höchstgeschwindigkeit	km/h	250 2)
Verbrauch	EU Zyklus	(Ltr/100 km)	
	EU, städtisch	(Ltr/100 km)	21,1
	EU, außerstädtisch	(Ltr/100 km)	10,6
	EU, insgesamt	(Ltr/100 km)	14,5
	CO2 g/km		349
Kasko	Haftpflicht		21
	Teilkasko		38
	Vollkasko		36
	Vollkasko Region München	DM	7.720 p.a. (bei 100%)

° Leergewicht inkl. 75 kg für Fahrer
1) gilt für Fahrzeug mit Hardtop
2) abgeregelt

	Technische Daten		Einheit	Z8
Fahrwerk / Kraftübertragung	Vorderradaufhängung			Doppelgelenk-Federbeinachse mit Querlenker und Zugstrebe
	Hinterradaufhängung			Integralachse
	Bremsen vorn			Zweikolben-Faustsattel-Scheibenbremse
	Durchmesser		mm	334, belüftet
	Bremsen hinten			Einkolben-Faustsattel-Scheibenbremse
	Durchmesser		mm	328, belüftet
	Fahrstabilitätssystem			ABS, DSC, CBC
	Lenkung/Gesamtübersetzung			Zahnstangen-Servolenkung, 20,5:1
	Getriebeart			6 Gang Schaltgetriebe
	Getriebeübersetzung	I	:1	4,227
		II	:1	2,528
		III	:1	1,669
		IV	:1	1,226
		V	:1	1,000
		VI	:1	0,828
		R	:1	3,746
	Hinterachsübersetzung			3,38
	Reifen			VA 245/45R18W, HA 275/40R18W
	Felgen			VA 8 J x 18 LM, HA 9J x 18 LM
	Vorderachse			
	Gesamtvorspur		'	8
	Radsturz		°	-0,5
	Spreizung		°	14,1
	Nachlaufwinkel		°	6,7
	Lenkrollradius		mm	12,8
	Störkrafthebelarm		mm	89
	Radlasthebelarm		mm	8
	Bremsabstützwinkel		°	2,4
	Schrägfederungswinkel		°	2,1
	Rollzentrumshöhe		mm	64
	Radhub einf.		mm	70
	Radhub ausf.		mm	100
	Radeinschlag aussen		°	28,6
	Radeinschlag innen		°	-34,3
	Hinterachse			
	Spurweite		mm	1568
	Gesamtvorspur		'	24
	Radsturz		°	-1,5
	Bremsabstützwinkel		°	21
	Rollzentrumshöhe		mm	82
	Radhub einf.		mm	80
	Radhub ausf.		mm	100

body structure.
The stresses inserted in the section by forming and stretching processes may be released by the heat conduction properties of aluminium during the welding process, which is why some method of tolerance compensation is extremely important during the jointing process. Using the example of the connection between the engine mounting and the tunnel support, Figure 8, the figure shows how this tolerance compensation is taken into account at the connection points by using movable individual parts.

2.1.4 Production

The body structure is produced by hand with 890 punch rivets and 57 m of MIG welds, Figure 9. The welds are completed in a gravity position using rotating drums, Figure 10, by specially trained aluminium welders.

2.2 Exterior Skin and Mounted Parts

The elegance and tone of a body are influenced to a large extent by the precise implementation of the design specifications at transition points, inclines and joints.

A high quality style is achieved by the bolted exterior parts. The installation of the exterior skin components in a floating arrangement relative to the space frame within the tolerance range results in a rounded whole.

The individual exterior parts have a shell design. They essentially consist of the exterior skin, interior plates and reinforcement elements. The hot hardening alloy Al Mg0.4 Si1.2 is used for the exterior skin whilst the interior parts are deep drawn using Al Mg3 or Al Mg4.5.

When fully assembly the adhesive ensures the required strength and force lines of the individual parts. Punch rivets are used to secure the parts during the production process until the adhesive is cured.

Doors are subject to complex crash, noise and seal requirements and in addition they are also the basis to which various functional components are fitted.

To ensure that they satisfy their function requirements and offer low weight in spite of being produced in small quantities the doors are built in a combination construction.

Table 2: Material table

	Werkstoff-bezeichnung	Zugfestigkeit Rm (N/mm2)	Bruchdehnung A5 (%)
Aluminium-Strangpressprofile (aushärtbare Knetlegierung)	AA 6060 AA 6063 AA 6082	130 – 310	> 10
Aluminium-Bleche (nicht aushärtbare Knetlegierung)	AW 5454 AW 5182	190 – 270	> 17

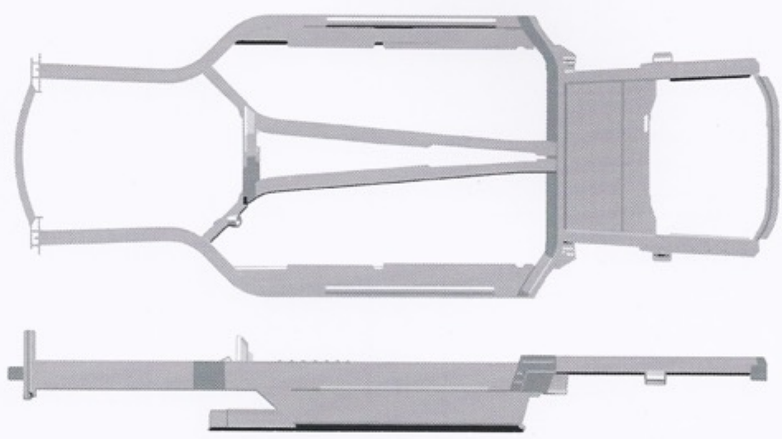


Figure 4: Frame base structure

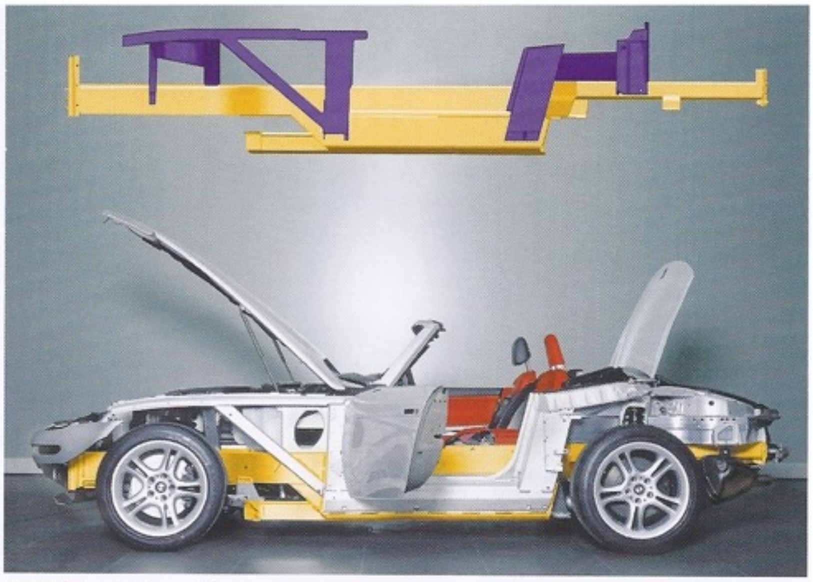


Bild 5: Rahmen Seitenansicht

Figure 5: Frame side view

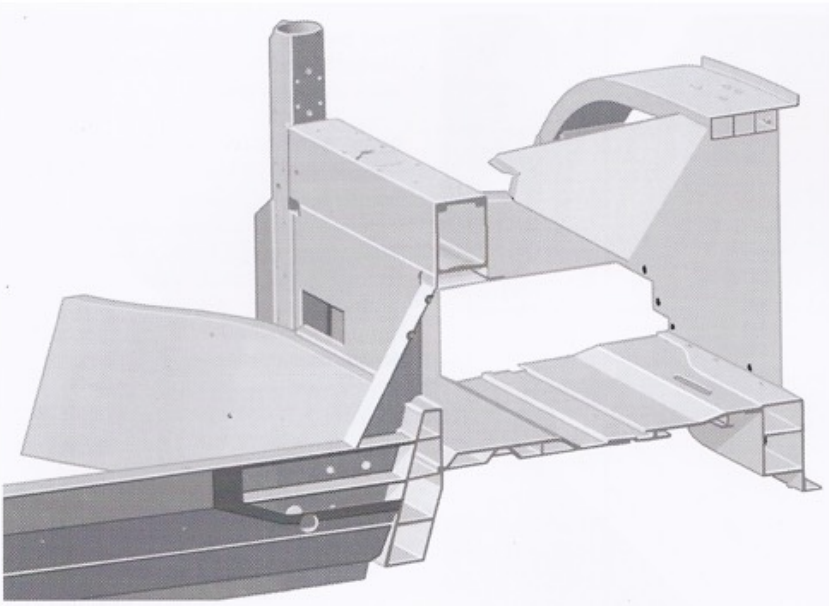


Figure 6: Tank compartment torsion box

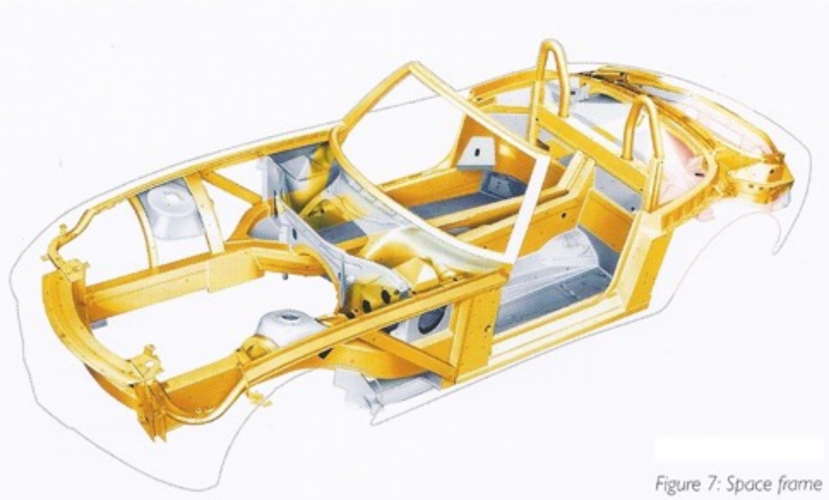


Figure 7: Space frame

This concept combines the specific benefits of various technology in the aluminium processing field for the integration of complex requirements.

In the hinge and lock areas the door structure is a thin-walled vacuum die cast construction, which allows the rigidity and mounting facilities for components inside the door to be integrated.

The longitudinal connections between the hinge and lock pillars are made of extrusion press parts and sheet aluminium with correspondingly higher yield points as a result of the energy absorption properties these areas must have in the event of a crash, **Figure 11**.

Here, too, the strength is provided by the adhesive whilst rivets are used to secure the parts. The door frame is glued all around its edge to the exterior skin and flanged in the visible and handling areas to avoid sharp edges.

2.3 Corrosion

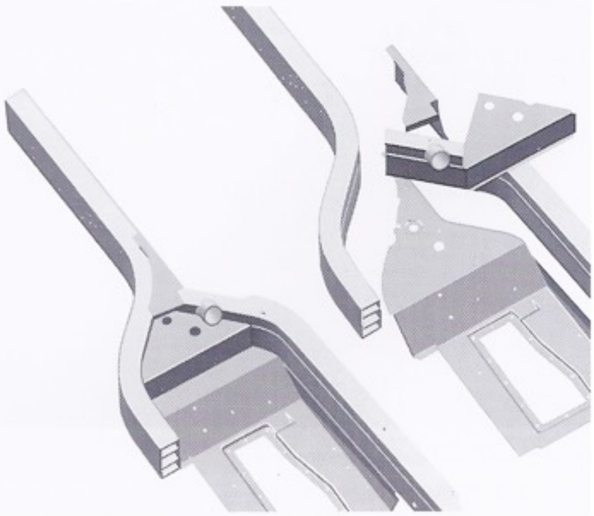
The basis for the long term corrosive quality of the material is provided in the initial phase by the careful selection of materials, surface coatings and constructive details. For example all extrusion press sections and cast parts are pickled and titanium-passivated to provide the basis for the paint structure and long term adhesion, whilst the sheet metal parts are coated with titanium / zirconium using a coil coating process.

To avoid gap corrosion the contact surfaces in wet areas have initially been minimised and then sealed or glued. Edge folds on the exterior skin and mounted parts are produced with excess adhesive to eliminate the need for fold sealant.

All structural cavities are designed in such a way that they are reliably protected from the ingress of dirt and moisture. This design means that there is no need for cavity sealant. To prevent contact corrosion, the steel connection and press-in elements are coated with surface protective. Depending on the requirement, this may be zinc/nickel, KTL primer or a Dacromet coating.

The total of all these individual measures adds up to a protective effect at a very high level. This makes it possible to eliminate conventional anti-corrosion measures such as coating with underseal.

Figure 8: Structure of the Y support



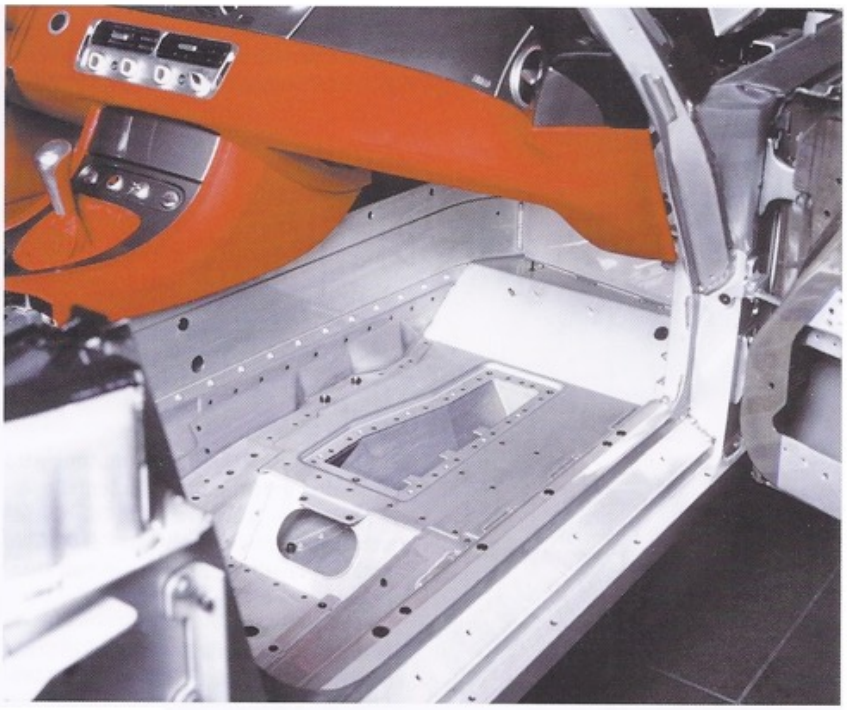


Figure 9: Jointing technology

Figure 10: Rotary drum welding unit

During the vehicle testing phase all the details defined in theory were tested, refined and assured.

3 Passive safety

One of the main aims in the development of this sporting roadster was the use of the readily acknowledged high level of safety available in BMW saloon cars to this dream car. To achieve this very ambitious aim the time-tested FIRST (Fully Integrated Road Safety Technology) was used.

This concept covers active and passive safety as well as vehicle safety. The development specifications contain the following safety principles to minimise passenger stresses and maintain the survival cell:

- high load support structures for frontal, side and rear collisions, as well as rollovers
- optimal use of deformation lengths
- extremely rigid passenger cell
- a conscious effort to move passengers forward within the interior
- compatible design of the front end structure
- highly efficient restraint systems.

The Z8 is one of the safety sports cars in the world.

3.1 Structure

The main features of the aluminium structure are shown in Figure 7.

3.1.1 Frontal collision

The space frame concept, Figures 4 to 8 and Figure 11, is capable of feeding the forces that occur, for example in serious collisions, for example with single-sided loads, into the side opposite the impact and protects the bulkhead area in the footwell by means of high dynamic deformation in front of it. The front axle is harmoniously included in this concept. It absorbs collision energy itself and feeds forced into the floor system. In addition this concept allows a compatible design since the inherent protection is divided among several support systems in three collision planes. The energy absorption properties this achieves, with high dynamic deformation in the front end, provides the basis for maintaining the survival cell and is a prerequisite for the successful coordination of the restraint systems by means of correspondingly low passenger cell deceleration.

The good compliance of the calculated de-

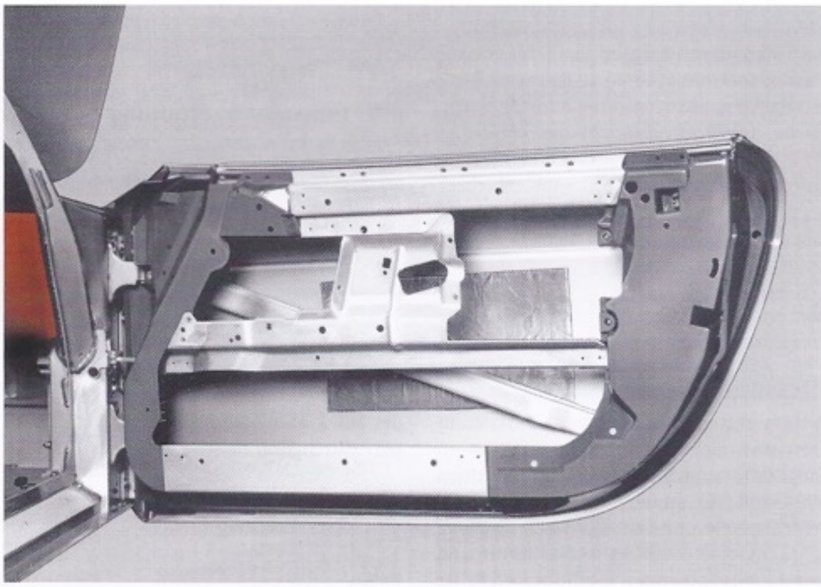


Figure 11: Door at the body in white stage

formation properties with the results from the crash test shows that numerical simulation has become an important part of the development process, **Figure 12**.

The concept development in terms of general rigidity and strength was based on knowledge gained from the pre-development phase and numeric simulations. In addition to the virtual world the development was supported by static and dynamic components tests.

The influence of heat radiation from the exhaust system on neighbouring vehicle structures, resulting in the possibility of the aluminium material becoming brittle, was investigated in drop tower tests, **Figure 13**, which produced extremely positive results in terms of rigidity and strength.

3.1.2 Side Impact

The lateral rigidity for side impacts has been optimised by the use of specially designed cross members. The seat mounting and a support in the rear bulkhead are supported on the tunnel side member. The doors, reinforced by longitudinal sections, are extremely strong in the hinge and lock areas in the way they are integrated into the body. This means that the interior passenger cell remains almost completely intact in all internationally used crash tests, **Figure 14**.

3.1.3 Rear

The Y structure, which is also used at the rear of the vehicle, allows optimal deformation in a rear impact. The sealing properties of the fuel tank system, a major aspect in the prevention of car fires, are guaranteed at all times.

3.1.4 Rollover

Special attention was given to maintaining the survival cell in the event of rollover accidents. As a result of the extremely rigid A pillar integrated in the front bulkhead area, the US safety standards required for saloon cars (FMVSS 216) has been satisfied. The fixed roll bars made of an aluminium tubing construction and integrated in the rear bulkhead also comply with the above regulations. These two roll bars are secured to the rear bulkhead by means of rubber mountings normally used in axle construction for this purpose. In addition the bars are padded. The integrated rubber mountings, which have been used for the first time in a roll bar construction, reduce the risk of injury in the event that of contact with the passenger.

3.2 Restraint systems

The restraint system supplements the structural safety effect of the body and is designed to allow the passengers to be included in the controlled deceleration process of the vehicle at the earliest possible time. In addition the space available in the passenger cell is used to minimise the forces and accelerations that act on the passengers by means of moving them forwards in the passenger cell so as to absorb the energy better.

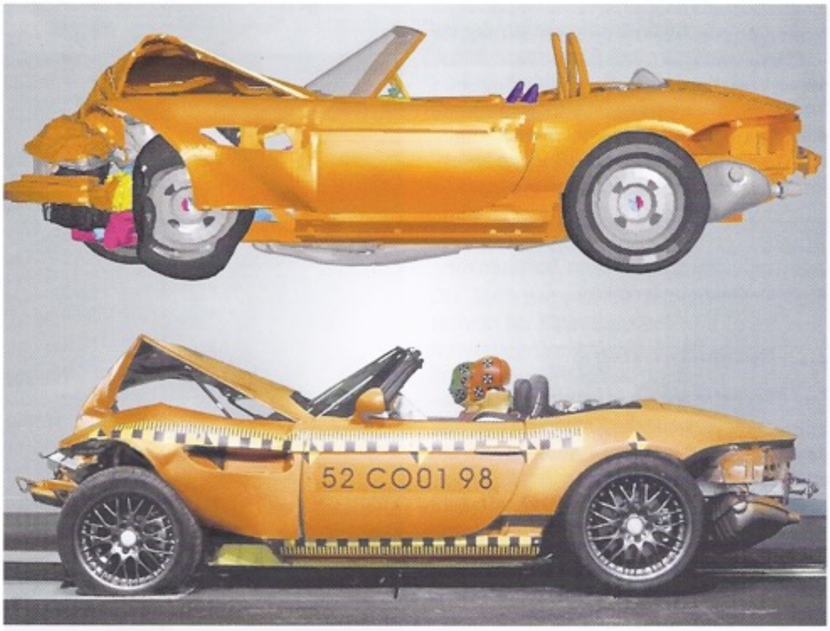


Figure 12: Compliance of the crash simulation with a real crash at a speed of 64 kph against a deforming barrier

The aim was to adapt the acknowledged highly efficient restraint components from the saloon cars to this new vehicle concept. In this case, too, the concept was helped by the virtual world. Simulations allowed a wide range of load cases to be examined at an early stage in the development process. The restraint characteristics were coordinated with the deformation properties of the car, Figure 15.

The main components are the front airbags, which are ignited with two different generator capacities so that they can be adapted to the severity of the accident. The belt system with pyrotechnic belt tensioners and the belt force limiters integrated in the retractor allows the passengers to be included in the vehicle deformation at the earliest possible time and limit the belt forces and therefore the forces that affect the head and chest to a tolerable level, even in very serious accidents. These components are supplemented by a seat with an anti-submarining ramp that prevents the passenger sinking below the lap belt.

To minimise the forces that act on the passengers in the event of a side impact, the door impact areas and the thorax airbag have been tailored to suit the door deformation properties. In this case, too, the concept was developed with the use of numerical simulation. Component tests and overall integration tests on carriage systems were used to complement the simulations. For all load cases the developers managed to ensure that the forces that act on the passengers were well below biomechanical limit values.

3.3 Interior Design

Under the aluminium skin of the Z8 there is a harmoniously coordinated concept for passenger safety, which is fully in keeping with the high quality of this extraordinary automobile.

The scoop with its circular instruments in the centre is in the potential passenger contact zone. To ensure the feasibility of the design concept early in the concept development phase, head impact tests were conducted with substitute bodies with a similar shape pursuant to ECE R 21 regulations.

4 Equipment

4.1 Interior Equipment

Special attention was given to the selection of materials to ensure "exclusivity and style" in the development of the Z8. For example, the instrument panel, consoles, door trims, trim parts, sun visors, storage compartments, etc. are all covered with high quality soft leather. A mixture of polyurethane foam and ABS/PC plastics was used for the support parts. All the handles, knobs and switches that are required to control a function are made of aluminium, Figure 16. Cool, solid aluminium is designed to underline the quality of the components. This exclusivity in materials is continued by making the door sill strips and footrest of stainless steel. The colour design is based on the 5 Series equipment variants:

- black
- cream
- cream and black (seat)
- sport red
- sport red and black (seat).

These interior equipment variants harmonise particularly well with the six exterior colours available, which are also used for some of the painted interior trim parts to provide excellent colour contrasts.

The interior, the storage space for the softtop and the boot have a back-foamed carpet in deep pile velour quality which offers good insulation and damping properties whilst also being lightweight.

In designing the instrument panel special attention was given to the simplicity and harmony of the surfaces and restricting the control elements to the bare essentials. The four circular instruments and their signal lights were placed in the centre to underline the clear visibility forwards. The exclusivity of the materials is also reflected by the electrically adjustable steering column, the steering wheel with aluminium spokes and integral 2-stage airbag, the aluminium controls for the Tempomat, the direction indicators and headlight/windscreen cleaning functions. At the bottom left-hand section of the instrument panel there is a toggle switch for opening the tank flap and tailgate. Slight pressure on this switch alternately releases these two openings electrically.

The doors and boot can also be opened using the remote control, which is integrated in the key. The trims on the windscreen panel comply with the HIC values that will be required in the future by law.

At the centre of the upper windscreen panel is the microphone for the hands-free facility and an LED light. New developments in the Z8 include an interior mirror with integrated reading lights, dazzle-free electrochrome technology and warning lights to show that the alarm system is armed. The reduction of the instruments to the bare essentials is also reflected in the centre console, where a multi-information radio with the following features is housed under an aluminium flap, Figure 17:

Figure 13: Tower drop test

Figure 14: EU side impact crash

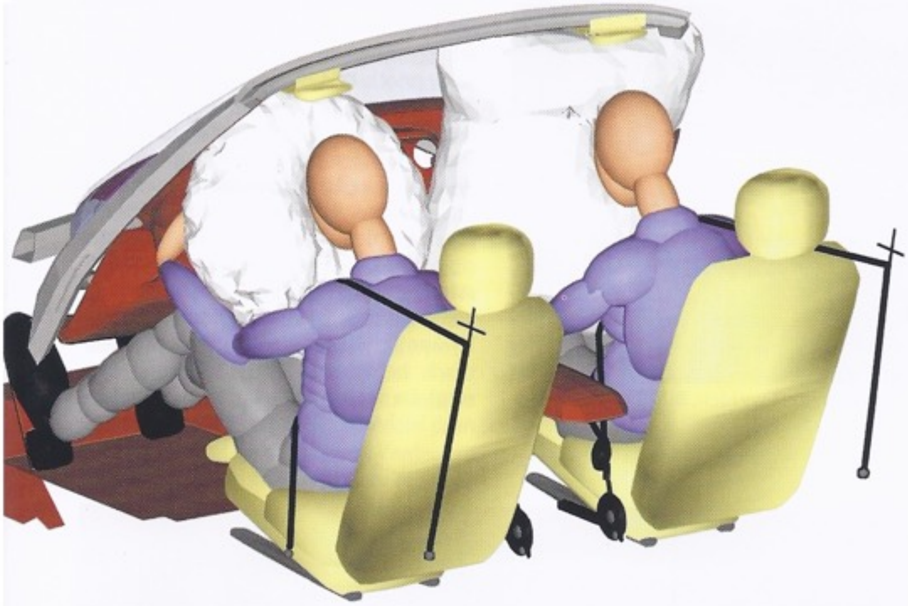


Figure 15: Tuning the restraint system in MADYMO (mathematical-dynamic modelling)

- audio system (radio and CD changer)
- telephone with hands-free facility
- navigation system
- temperature display.

Also under the radio flap are switches for the DSC (Dynamic Stability Control) and RFC (Run-Flat Combination).

The switches for the following are in clear view of the user:

- sport / comfort system (pedal recognition)
- hazard lights
- central locking
- softtop control.

The centre console is equipped with various storage compartments for small utensils and a central locking compartment with a standard integrated mobile phone.

A new generation of seats has been developed for the Z8, for which the following development targets were pursued:

- design of the adjustment range for a wide group of users (5 % women to 95 % men)
- electric longitudinal, height and backrest angle adjustment
- variable headrest adjustment
- recyclable materials
- attractive design.

The seats in the Z8 offer comfort for both a sporting driving style and for long journeys.

A special seam and a two-level seat heating system have been fitted to ensure extra luxury. The pyrotechnic belt tensioner is mounted on the seat sub-frame and offers a considerably faster response than a mechanical belt tensioner, thus preventing loose belts.

The headrests are adjusted manually and can be released using a button integrated in the headrest itself.

The backrest can be folded forwards using a loop in the side section so as to provide easy access to the two rear compartments.

These locking compartments contain a 6-disc CD changer and a torch on the driver's side and the navigation system computer, emergency control for the tailgate and mobile phone storage compartment on the passenger's side.

The door trims contain integrated side airbags and the armrests have soft padding underneath.

The controls for the exterior rear-view mirrors and electric windows are integrated in the armrests and are illuminated by an LED light in the door pull handle, thus allowing the units to be located easily in the dark.

The use of the Run-Flat tyre system eliminates the need for a spare wheel, thus allowing the boot volume to be extended to 203 litres, **Figure 18**.

4.2 Softtop

Very high demands were placed on the softtop for the Z8 in terms of its optical integration into the overall styling of the car, excellent spaciousness (headroom), compact storage when open, easy control and a good durability. The following requirements had a major bearing on the selection of the softtop system:

- low height of the softtop over the belt line when open
- small storage volume.

Two softtop variants were available:

- "tensioning rods" principle with spring clips
- "secure rear fastening" principle.

The decision was made to use an electro-hydraulic softtop with a secure rear fastening, **Figure 19**.

When the softtop is closed the roof frame stops with the securing hooks approximately 10 cm in front of the windscreen panel and must be pulled down gently by hand. An electric, servo-mechanical pulling tool helps to close it fully. It opens fully au-

Figure 16: Cockpit

tomatically. Two hydraulic cylinders, one at each side, are supported by an electrically powered hydraulic pump. Since the softtop had to have a solid, yet lightweight construction, the rods and clips were made of die cast magnesium. From the outside the softtop rods are coated with a high durability triple layer of acrylic material that is resistant to UV light. The TPU rear screen, which is 2 mm thick and replaceable, can be described as a real novelty. By using TPU instead of the conventional PVC rear screen, it was possible to considerably improve the scratching resistance and flexibility of the rear screen, which is particularly important when the softtop is opened in freezing temperatures.

The softtop is lined with an acoustic material between the bars on the inside and has a full headlining. The roof frame is foamed at the front and covered in soft leather so that it complies with the stringent head impact values that will be demanded in the future by law.
The opened softtop is covered in the softtop box by an unlined, folding soft leather tonneau cover. The tonneau cover is fitted by slotting it into the rear with a press-stud on each side.
The wind deflector is standard. It is carefully covered in soft leather. Following the philosophy of the car the wind deflector was also covered in soft leather. It is fitted quite simply by pulling it over the roll bar and attaching it at the rear. To ensure rear visibility when the softtop is closed, the centre section can be folded forwards by opening two press studs and zip fastenings.

4.3 Hardtop

The hardtop is another part of the extensive standard equipment. The development goals for the hardtop were its optical integration into the overall styling, the exclusivity of the materials, excellent safety standards and easy operation. The prioritisation of the requirements led to the following technology being used:
- aluminium space frame
- PU foam system with glass fibre
- PU coating to act as the exterior skin.

As a result of choosing this technology it was possible to ensure maximum safety and give the designer plenty of freedom. This freedom allowed the designer to give the Z8 a "Coupé character" when fitted with the hardtop, Figure 20. This was achieved by so-called "finning" with integrated forced ventilation and a heated rear screen that has been moved forwards. When the hardtop is fitted the heated rear screen is contacted automatically. The inside of the hardtop is laminated with a high quality interior headlining (acoustic décor) in a sandwich design to give the Z8 with its hardtop excellent acoustics. The relative lightweight hardtop (28 kg) can be fitted with ease by two people. After placing the hardtop on the car it is secured at the front in the leather-covered roof frame using two 90° rotary locks and at the rear using two "single lever locks", one at each side of the hardtop.

4.4 Air Conditioning

The constantly changing temperatures and air flows in a roadster would result in permanent adjustment if an automatic controller were to be used. Therefore a manual control has been provided for the air conditioning system, **Figure 21**.

The system has a recirculation mode and also has an integrated microfilter. This means that a pleasant interior climate can be provided when the softtop is closed or the hardtop fitted.

Figure 17: The MIR (multi-informations radio) is behind the flap

5 Electrical System

The typical BMW vehicle electrical system has been adapted for the Z8, **Figure 22**. The systems communicate using CAN and k-bus systems. This also means that it was possible to offer a full range of equipment for the Z8, which contains every possible function, designed to improve safety, comfort and luxury. Some examples of these function include radio and infra red remote controls, central locking with hotel locking function, electric softtop control (_ automatic), Tempomat, alarm system with interior sensors, electric windows, electric seat adjustment, CD changer, telephone/mobile phone and, of course, a navigation system.

5.1 Navigation System

The MIR, (multi-information radio) is a highly integrated unit containing the radio (audio), the navigation system with speech control and directional arrows, as well as the telephone/mobile phone controls and the external temperature display. The navigation system offers the same functions and accuracy as the established BMW system.

5.2 Aerial

To comply with the design requirements of the Z8, the rod aerial normally used on roadsters has been eliminated. Instead a bumper aerial for radio and telephone reception was developed. It was a particular challenge to achieve the required reception levels and freedom from interference.

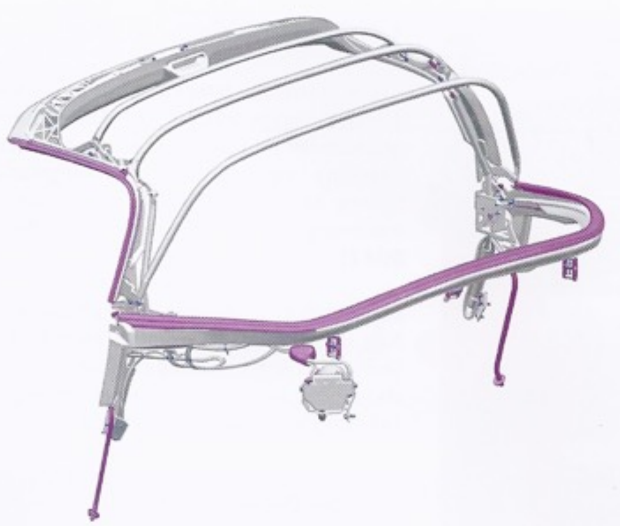


Figure 19: Softtop ribbing with hydraulic components and tighteners

Figure 20: Hardtop

Figure 18: Boot

5.3 Lights

The main headlights with xenon gas discharge technology guarantee outstanding even and wide road illumination even in poor weather. This considerably enhances road safety, **Figure 23**.

The front direction indicators, the rear indicators, the reversing light, the brake lights and the third brake light all feature neon technology, **Figure 24**. This is an innovative new idea in this constellation.

Short response times, stylistic freedom, clear visibility and a long service life were the reasons that this technology was used. The direction indicators integrated in the side "gills" feature optical fibre technology and are an optical reminders of the legendary BMW 507, **Figure 25**.

5.4 Interior Security

In an open-top car, surveillance of the interior is particularly useful. A motion sensor recognises any movement in the interior within 30 seconds of being armed and triggers an acoustic warning. In addition the typical BMW systems such as the alarm system, electric immobiliser and the tilt alarm sensor also protect the Z8.

5.5 Audio System

The audio system is a genuine highlight within the equipment in the Z8. It comprises a CD changer, a 250 W amplifier and 10 speakers offering four times 40 W and six time 15 W for top hi-fi pleasure. The speakers are housed in the A pillar, the top shoulders, the rear side shoulders and, with correspondingly large volume, in the floor of the car under the seats. This helps achieve a special sound. The bass reproduction is excellent for an open-top car and generates a sound that is independent of the car.

6 Engine and Powertrain

The engine and powertrain are designed to emphasise the elegant and dynamic impression of the vehicle and also offer sports-minded customers power and torque in excess. Control comfort is also at the highest level.

6.1 Engine

The DOHC 5-litre V8 4V fully-aluminium engine developed by BMW Motorsport, **Figure 26**, with its high torque and power potential is the ideal power source for the Z8. As it is mounted behind the front axle, it allows excellent weight distribution for enhanced handling.

The following development features:
- high revving sports engine with a maximum speed of 7000 rpm
- power output 294 kW / 400 bhp at 6600 rpm
- maximum torque 500 Nm from 3800 to 5200 rpm
- 85% of the maximum torque is available at just 1500 rpm
- double-camshaft variable valve timing (DOVANOS: two adjustable camshafts on each row of cylinders)
- lateral flow cooling
- electronic throttle valve control (EDR)
- accelerator pedal recognition switch for sport and comfort settings
- BMW's own digital engine management system (MS S52)
- lateral acceleration controlled oil supply for extreme cornering manoeuvres
- oil/water heat exchanger
- thermal oil level sensor (TOG)

ensure that the Z8's engine meets the highest demands in terms of
- performance
- response
- handling
- fuel consumption and
- emissions (EU3/TLEV).

The cutaway model in **Figure 27** offers an insight into the engine design. The inlet camshafts are driven by a duplex roller chain. A single roller chain drives the outlet camshafts. By using conical valve springs it is possible to achieve a maximum engine speed of 7000 rpm. The adjuster pistons on the four camshafts are supplied with an oil pressure of 100 bar by one radial reciprocating pump for each row of cylinders and allow the camshafts to be adjusted continuously over a range of 54° CA (inlet) and 39° CA (outlet), controlled by the characteristic map. The high system pressure makes for very short adjustment times (> 250 ms) with minimum installation space. The valve overlap characteristic map used for the Z8 is shown in **Figure 28**.

The variable valve timing allows the optimisation of the following areas in particular:
- high torque even at low and medium engine speeds
- lower fuel consumption and raw emissions due to the internal exhaust gas recirculation (EGR) system
- faster catalytic converter heating
- lower combustion noise
- residual gas minimisation at idling speed, thus creating greater smoothness.

The DOVANOS system, together with the intake pipe length of 424 mm, makes the torque/power properties shown in **Figure 29** possible.

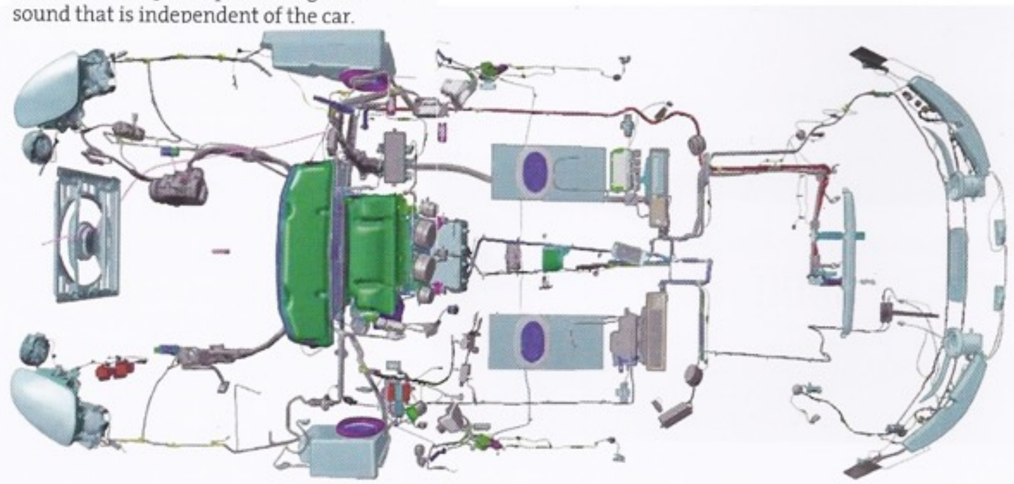


Figure 22: Full electrical/electronic system components

The fresh air supply is regulated by electronically controlled individual throttle valves (50 mm in diameter). Two tension struts transfer the rotary motion of the DC motor with a reduction gear, which is positioned between the rows of cylinders, to the throttle valves for cylinders 3 and 6, from where the other throttle valves are synchronised from shaft to shaft. The servo motor only requires 120 ms to fully open the throttle valves, which means that it also satisfies sporting requirements.

Using the throttle valve progression switch, which can be selected by the driver, the engine response can be adapted to the specific pedal adjustment, **Figure 30**. The almost linear vehicle response in the comfort setting allows the driver to control the engine torque sensitively over the entire pedal range, whilst in the sports setting the very sporting character of the vehicle once again comes to the fore, particularly from a standing start.

To ensure that the oil supply is maintained even when cornering at extreme speeds, the oil that collects at the outer curve of the cylinder head and the oil sump due to centrifugal force is drawn off by two suction pumps controlled by solenoid valves and supplied to the partitioned oil sump. The DSC sensor records the level and direction of the lateral acceleration, the sensor signal is evaluated and the switch valves are actuated (if the acceleration exceeds 0.8 g) by the engine management system. The system remains functional even if the DSC function is switched off by the driver.

The Z8 has a so-called seam pipe radiator. This is particularly notable for its high structural and compressive strength, as well as its improved heat transfer properties.

In order to achieve a high torque at low engine speeds, the exhaust system has a twin pipe design and a defined cross-response point behind the tri-metallic coated metal substrate catalytic converter. Two lambda and two monitor sensors regulate and monitor the function of the catalytic converter.

The centre and rear silencers take the form of absorption dampers to minimise throughflow losses.

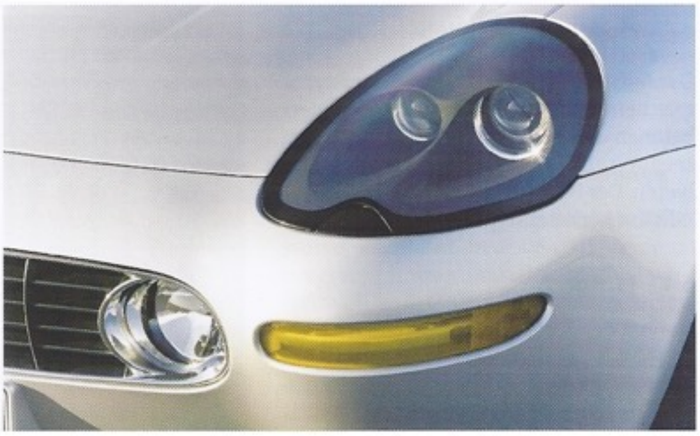


Figure 23: Main headlights with Xenon technology, parking light; high beam headlights in the kidney grilles and neon direction indicators

Figure 24: Rear light units with direction indicators, reversing and brake lights in neon technology. Rear fog light and reversing lights

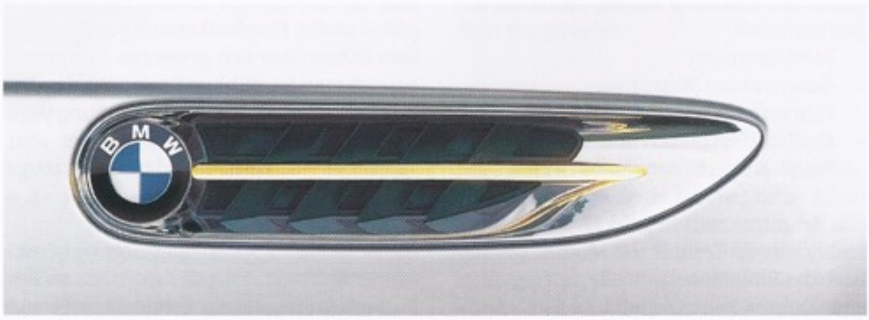


Figure 25: Gills with centre light rod with optical fibre technology, to indicate direction (light intensity reduces from front to rear)

6.2 Gearbox

The 6-speed manual gearbox was designed for the requirements of a high-performance sports car. The main development points listed below

- optimisation of the aluminium casing structure (weight and rigidity)
- increase in the specific gearing strength (shot peening, process-optimised heat treatment processes)
- sporting gear ratios to suit the engine characteristics
- high-performance synchronisation packages (triple cone version)
- use of high-performance roller bearings
- rolled bearing seats
- optimised oil supply measures
- reinforced gearshift elements
- defined air guidance to cool the gearbox oil
- filled with durable oil for its entire service life

mean that the lightweight gearbox is compact and offers short gearshift distances, extreme precision and requires low maintenance.

To achieve constant clutch pedal force with harmonious pedal force characteristics over the entire service life of the system, a self-adjusting single disc dry clutch with an additional spring is used. The dual mass flywheel compensates for engine vibrations and thus results in a marked improvement in the powertrain acoustics.

6.3 Propeller and Output Shafts

To meet the demands of the tight sporting character of the car, particular value was attached to achieving an optimised design with optimised weight and strength in the development of the propeller and output shafts, resulting in high torsional strength. Together with the equally tight axle mounting bearings, this means that a spontaneous response can be achieved when the load is increased.

6.4 Rear Axle Differential

The compact rear axle differential has been optimised in terms of its noise and strength by the use of hypoid gearing. The rear axle differential cover has cooling ribs to cool it, which, together with airflow elements, achieve optimal heat dissipation over the entire operational range. In order to achieve excellent performance and a harmonious overall drive tuning, the gear ratio was set at 3.38 : 1.

6.5 Fuel Supply System

The fuel supply system was developed to comply with the latest US fuel evaporation regulations. It is used all over the world with a returnless fuel system. One of the main aims of the development was to integrate existing components from the group module system into a new fuel supply system concept, **Figure 31**. The fuel tank (HDPE) produced by co-extrusion (6 layers) with an integrated expansion tank has a useful capacity of 73 litres. The acoustic goals were achieved by using a complete, two-piece noise-reducing hood.

As a result of the raised tank position resulting from the overall package, a two-piece filler tube placed in the tank was developed to ensure safe refuelling. Fuel leaks when the filler pump nozzle is switched off are prevented by a mechanical non-return valve at each end of the filler tube.

An active charcoal filter collects the fuel vapour that occurs during refuelling and while the vehicle is in motion. The vapour is returned to the combustion process by an engine management system.

The fuel lines, which are designed for a system pressure of 5 bar, are made of aluminium in the underbody area and stainless steel in the engine compartment. To facilitate servicing and installation, the joints have been fitted with quick-release connectors.

7 Chassis

The Z8 would not be a typical BMW sports car if its designers had not given it a chassis that satisfies the highest of demands, **Figure 32**. These include

- precise handling
- very good straight line control
- tight spring/damper setting typical of a roadster
- direct road contact and response
- eager partial load characteristics
- foreseeable and easily manageable vehicle reactions in the limit range
- very high stability in all driving conditions
- good long journey comfort.

The low centre of gravity of the vehicle, its large track widths, the axle load distribution of 50/50 percent and the extremely rigid body structure all go together to provide ideal conditions for meeting these requirements.

The use of aluminium not only helps to keep the non-sprung masses low, it also offers excellent handling characteristics without compromising the high safety standards of the car in terms of strength.

As a result of this excellent design, the bump steering properties of the Z8 remain neutral and free of interfering load cycle reactions well into the limit range. This means that the Z8 offers very good traction and safe handling even when the stability control system (DSC III) is inactive.

7.1 Front Axle

The front suspension of the Z8 is a double link MacPherson strut axle with rack and pinion steering, aluminium control arms and aluminium tension struts. This axle principle, which has already proven very successful on 5-Series and 7-Series BMW models, was modified to suit the handling requirements of a roadster. The main focus was maximum lateral force absorption and excellent straight line handling. Together with the responsive steering, this results in very precise handling and rolling comfort previously unheard of in this vehicle class.

The front axle mounting is a welded aluminium construction made of extruded sections and plates. It supports all the parts of the front axle and is bolted to the Z8's body at six points. The control arm, a forged aluminium part, has two ball joints to ensure precise wheel control during sporty driving. To minimise vibrations on the front axle there is an optimally adjusted, hydraulically damped rubber bearing in the aluminium torsion strut.

MacPherson struts with a barrel spring mounted at an angle to the damper axis operate on the front axle to minimise friction forces. Gas pressure dampers with separate spring/damper mountings are used to guarantee the best possible response from the dampers, whilst a stabiliser is mounted directly onto the MacPherson strut to minimise the rolling angle. The slight raise in the axle load when the car is loaded and the tight springs mean that a spring compression distance of 70 millimetres has been achieved.

7.1.1 Steering

The power-assisted rack and pinion hydraulic steering positioned in front of the centre of the front wheels on the Z8 is partly responsible for the excellent steering

Figure 26: Engine compartment

Figure 27: Sectional view of engine

characteristics and precision of the car. With a variable steering gear ratio of 45 to 52.5 millimetres stroke per steering wheel revolution, the Z8 requires only three turns of the steering wheel from lock to lock.

The steering train, with an aluminium corrugated tube deformation element, has two universal joints that ensure direct response and underline the sporting character of this vehicle.

7.1.2 Steering Column

The main aim in the development of the steering column, in addition to producing an attractive, ergonomic design of the interior components and satisfying ever higher comfort requirements, was to maintain the high level of active and passive safety.

The Z8's steering column is infinitely adjustable in the axial direction using an electric motor and is based in principle on the version used in the current 7-Series. As a result of a completely new vehicle structure and a changed installation position, the steering column has been further optimised in terms of its energy absorption capacity in the even of a crash.

As a result of the planned interior design, it was decided from the very beginning that the steering lock had to be redeveloped. Behind the ignition lock with a separate starter button in the instrument panel there is a combination of a well-tested mechanism and the very latest electronics. The security for the steering column demanded by law is provided by locking the steering column locking plate into an element of the slip clutch, The release procedure, actuated by an electric motor, cannot be started until the correct key has been inserted into the steering lock and the code transfer has taken place between the chip in the key and a control module in the car. As a result of the styling elements defined in the list of specifications, the development of the steering wheel and integrated airbag represented a very special challenge.

By using aluminium and magnesium and after extensive FEM calculations, an optimum combination of weight and the required strength was achieved. The first use as standard of a two-stage gas generator in the driver's airbag means that it is possible to offer an innovative system with the best possible safety effect concealed behind a puristic appearance.

7.2 Rear Axle

At the rear, the roadster has a so-called integral 4 axle, a multiple control arm principle patented by BMW, which is also used in 5-Series and 7-Series cars. By using ball joints in the swinging arm and traction strut, the considerably higher longitudinal and lateral acceleration forces generated by the car can be handled with ease. The rear axle is supported by large rubber mountings to insulate it from disturbing vibrations on the body. MacPherson struts are also used, but with central springs. Here, too, the tight tuning of the gas pressure dampers and springs allows a spring compression distance of 80 millimetres. Despite the sporting design, very good rolling comfort has also been achieved on the rear axle as a result of the sophisticated elastokinematics that allow a defined longitudinal suspension of the wheel with very high lateral rigidity.

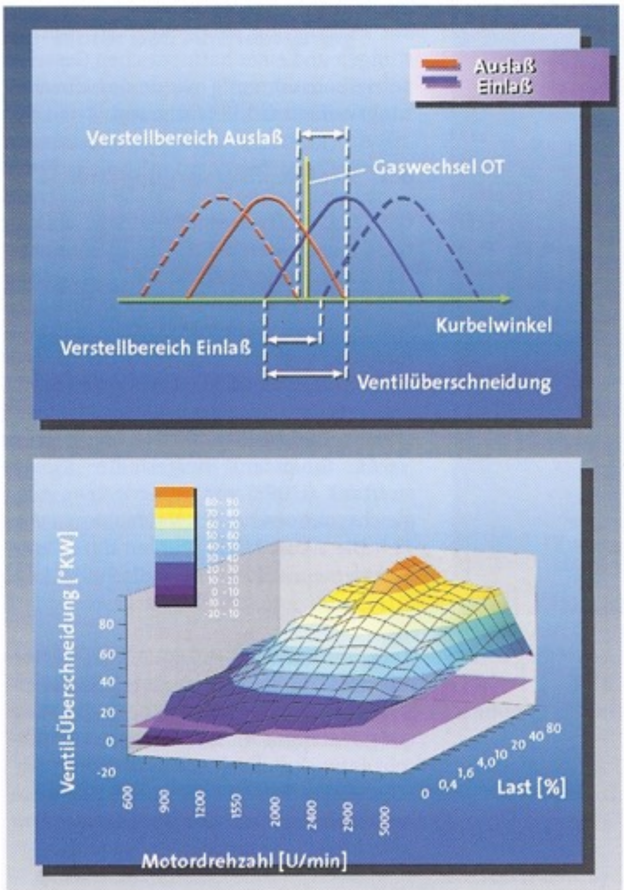


Figure 28: Map of interferences

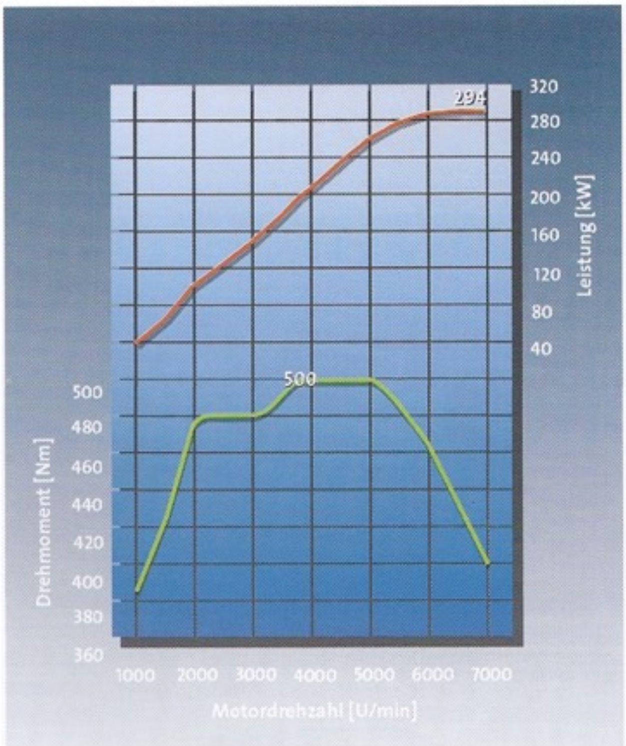


Figure 29: Torque and p

Figure 30: Variable gas pedal identification

7.3 Wheel Brake and Parking Brake

The Z8 is fitted with the front axle and rear axle brake power distribution system that is used as standard by BMW. The braking system has been designed to satisfy the requirements of a roadster by adjusting the large braking system to suit the specific demands of a sports car. The ventilated brake discs have a diameter of 334 mm at the front and are 32 mm thick, whilst the corresponding rear disc dimensions are 328 mm and 20 mm respectively. With these dimensions, even when the brakes are applied suddenly, good thermal stability is assured. Twin piston floating callipers are used on the front axle with single piston floating callipers on the rear axle. In order to make the brake discs look attractive through the open wheel styling throughout their entire service life, they have been coated in full with "Geomet" in a silver finish. A black zinc cobalt coating is used to protect the surface of the brake callipers to meet both quality and optical requirements. The parking brake is a double-servo drum brake with a diameter of 180 mm and is integrated in the rear disc brakes.

7.3.1 Brake Actuation

The brake actuation, including the pedal unit, is also based on the standard components of the 7-Series. Fitted with a 9"/10" brake booster and a staged tandem main brake cylinder with diameters of 26.99 mm / 20.64 mm, the Z8 has an extraordinarily effective brake actuation system. The tandem main brake cylinder is designed for use with the DSC III system.

Many of the details used on the brake actuation system and the pedal unit and wheel brakes have been tailored to the needs of the Z8. The aim of this was to highlight the efficiency of the braking system over the full range of requirements by means of a tight pedal feel, short pedal distances, a precise pressure point and thermally stable brake pads.

7.4 Wheels and Tyres

The Z8 is fitted with so-called Run-Flat tyres on die cast aluminium wheel rums with an extended hump (EH) rim contour; at the front the tyres are 245/45 R 18 96 W on 8 J x 18 EH2 wheels and at the rear the tyres are 275/40 R 18 99 W on 9 J x 18 EH2 wheels.

The design principle of these tyres is based on reinforced tyre walls with additional insert strips and extremely heat-resistant rubber compounds.

The seat of the tyre on the rim in a non-pressurised situation is ensured by the use of wheels with an EH rim contour that has been specially developed for this tyre type, with the tyre seat contour being identical with the well-known H2 wheel, which means that conventional tyres can also be fitted.

In the event of a puncture, regardless of the payload, the car can be driven at a maximum speed of 80 kph over a distance of at least 250 km.

To show the driver that the air pressure has fallen in one of the tyres the car is fitted with a flat rolling indicator (tyre pressure warning system). This system evaluates the wheel speeds using ABS sensors; if the air pressure falls, the rolling circumference of the tyre is reduced, so that wheel speed difference caused by this can be identified by the tyre pressure warning system and the driver is notified acoustically (by a gong) and optically (by a warning light) that the car has suffered a puncture. A warning is given if the tyre pressure falls by between 0.5 and 0.8 bar from the nominal pressure, depending on the status of the car, a level which is sufficient when Run-Flat tyres are used.

As a result of the Run-Flat tyres and the tyre pressure warning system, the Z8 does not need to carry a spare wheel.

7.5 Control Systems

The anti-locking brake system (ABS) with integrated Cornering Brake Control (CBC) is specially designed for the needs of this high performance car.

CBC is one of the standard features. This new system automatically controls the pressure in the various brake cylinders while the car is cornering, so that the Z8 always remains precisely on track.

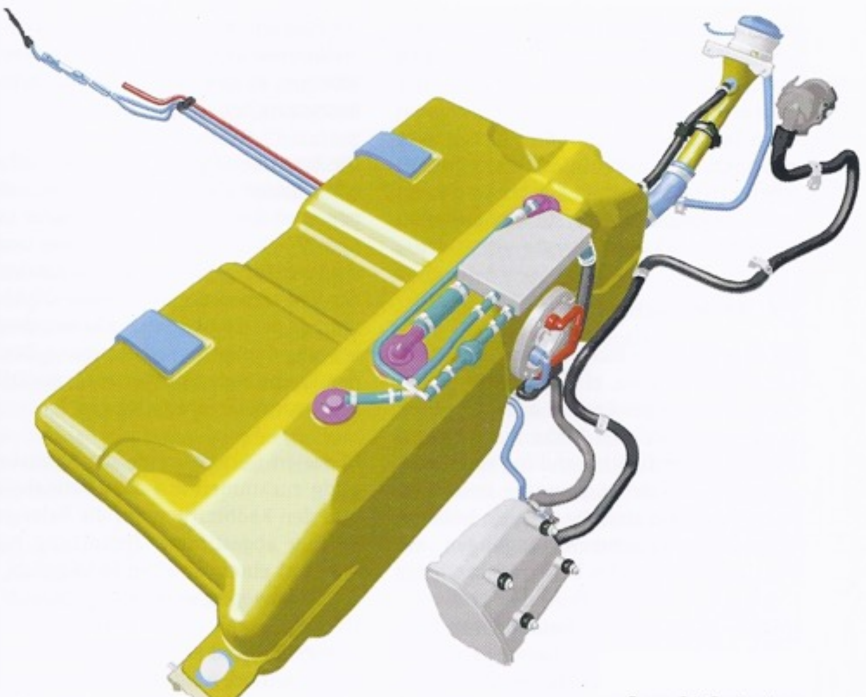


Figure 31: Fuel system

Whereas the ABS does not cut in unless the wheels are about to lock in an emergency braking manoeuvre, CBC is activated automatically during less extreme manoeuvres. CBC therefore makes braking while cornering even safer. From a technical point of view, this system controls the braking force while the car is cornering so that any oversteer or understeer is neutralised.

Of course, the Z8 also has the latest generation of dynamic stability control, DSC III, a further development of ABS and ASC+T (Traction Control System). Whilst ASC only controls the longitudinal slip of the wheels, DSC III also registers and improves the resulting lateral dynamic forces as necessary, in order to adjust to the lateral dynamic driving style.

For example, if oversteer or understeer occur on a slippery road surface, the DSC III system will decelerate the rear wheel on the inside or outside of the corner automatically and if necessary will do the same to the inside or outside front wheel, thus sta-

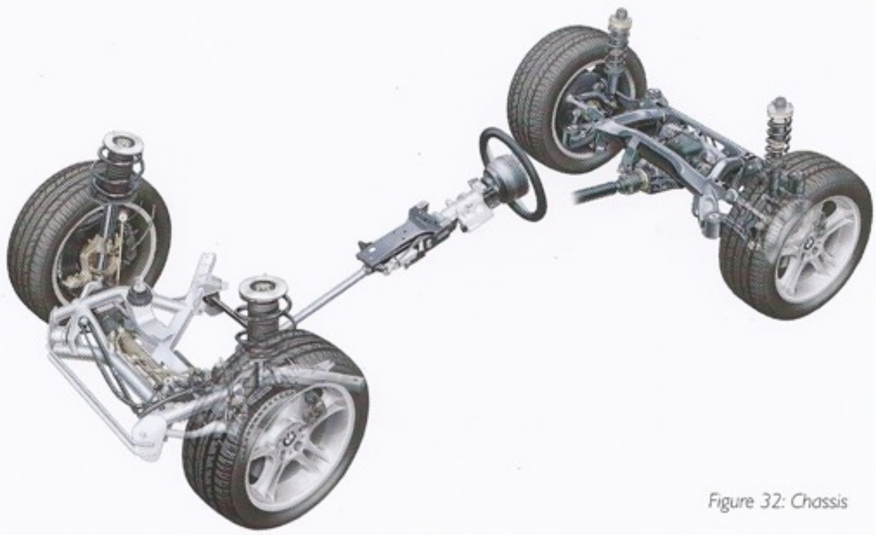


Figure 32: Chassis

bilising the whole car. Even a less experienced driver will therefore be able to hold the car on the right line. A light in the cockpit shows if the car is currently in the control range, indicating that the limit of the car's stability has been reached.

The yawing moment control system GMR also plays a role in this. This system ensures that the Z8 is stabilised automatically by building up a counter yawing moment. The individual wheels are then braked as required in the event of a possible unstable vehicle situation.

The DSC III system has been specially designed for the Z8 to maintain the high level of agility of this sporting roadster despite electronic intervention – even though it can be deactivated by the driver at any time using a switch. On the one hand, the high performance potential of the car should not be affected too adversely, while on the other hand a Z8 driver should never lose respect for this performance potential.

The fact that this finely tuned compromise has been a resounding success is shown by a lap time on the legendary 20 kilometre Nürburgring north circuit. A Z8 whose DSC III system was switched off managed to complete this course in a highly respectable 8 minutes 15 seconds, while the same car with activated DSC III only required a marginally longer time. The engine drag moment control system (MSR) is operational on the Z8 even if the DSC III has been deactivated.

7.6 Dynamic Tuning and Handling Criteria

A level of dynamic tuning of kinematics, elastokinematics and control systems has been achieved that covers every possible angle in terms of handling properties and active driver safety. Even in highly dynamic manoeuvres, the car can be handled safely and easily. In braking manoeuvres after fast cornering and after the driver has taken his foot off the pedal suddenly, the response always remains predictable and controllable, **Figures 33 and 34**. The sporting character of the Z8 compared to a luxury top class saloon car is demonstrated on the basis of a "stationary cornering" manoeuvre, **Figures 35, 36 and 37**. The considerably steeper steering moment gradient with a simultaneously higher steering force level enhances the response to the driver. The very low rolling angle means lower wheel load shifts when cornering, which leads to a high lateral dynamic cornering potential. The wheel stroke change also demonstrates the very symmetrical rolling properties of both front and rear axles.

8 Acoustics and Vibration Comfort

In developing the Z8 as an emotionally attractive sports car, the main aim of the acoustics development was to underline this character. A conscious effort was made to deviate from the standard comfort-oriented acoustics tuning used in BMW saloon cars. No compromises were accepted in terms of body rigidity and vibration comfort.

8.1 Vibration Characteristics of the Body

For open top cars, the high rigidity of the body is extremely important for handling and comfort. Values of 23 Hz for the initial torsion and 21 Hz for initial beaming can only be achieved by the consistent use of calculations and experimental modal analysis over the entire period of development.

This meant that the typical quiver vibrations suffered by open top cars have been prevented to a large extent without the use of body stabilisers, which increase the weight of the vehicle.

8.2 Body Acoustics / Aero-acoustics

The rigid space frame concept means that there is practically no need for anti-drumming measures of the body plates, thus reducing the weight of the car. Special attention was paid to the acoustic design of the rear ventilation system integrated in the hardtop.

Special attention was also paid in the development of this high tech roadster to minimising draughts in the interior of the car when driving with the soft-top open. Extensive tests were performed in an aerodynamic wind tunnel for this purpose using a measurement dummy fitted with thermistor sensors to allow the wind speeds in the sensitive areas of the face, neck and upper arms to be measured. This has resulted in an interior climate that provides a phenomenal level of comfort when driving with the soft-top open, even at high speeds.

The wind noise development of the car was conducted in the BMW acoustic wind tunnel. One of the main areas of the development was ensuring the optimal air flow around the soft-top with reduced excitation of the areas prone to flutter.

To prevent drumming noise caused by the high level at frequencies around 20 Hz, which represent a massive loss of comfort to passengers in the car, a special foil with high damping properties was developed for the rear screen. Highly effective acoustic materials are also used for the exterior material for the soft-top and the interior headlining, **Figure 38**.

8.3 Sound Development

At the very start of the development phase it was clear that the image of the Z8 should be supported by a thrilling sound. Using the target sounds defined by very latest methods of sound engineering, what was needed was a powerful, sporting tone. The complete dual pipe exhaust system has rear silencers with a short pipe length for this purpose.

The volume of the middle silencer is designed to emphasise the deep sound that is typical of a V8 engine. The heavy dependence of the sound on the load was another aim of the development. Whilst the Z8 has a low interior noise level when it is driven in comfort mode, in sports mode it develops a powerful sound as it approaches the limits of its performance, **Figure 39**. The car complies with all relevant international exterior noise regulations.

8.4 Component Acoustics

For the harmonious tuning of the overall acoustic concept, it is necessary to reduce the noise that is not expected by the customer to a level where it is no longer a disturbing feature. For a team of experts from various departments this meant that a large number of additional details were optimised, of which the following are just a few examples:
- encapsulated fuel tank to prevent noise caused by pumping, fuel flow and slopping
- newly developed engine fan with considerably reduced rotational noise
- encapsulated soft-top hydraulic unit.

9 Quality Management

The aim of this quality work is the early identification of potential problems, the integration of defects in existing systems and their elimination as quickly as possible.

All the components of the car, in particular all the interior and exterior equipment and electrical components, were studied to ensure they were absolutely true to size in accordance with the CAD version by means of test cubing (milled CAD version of a body completely in aluminium).

Together with the suppliers, the individual components were tuned to the body to ensure that they were suitable for installation. The process of fine tuning was repeated in the various phases of the car's development with the inclusion of suppliers and their subcontractors.

The quality work on the vehicle as a whole was based on the integration subject areas of acoustics, sealing and knocking and creaking noises. In addition, functional testing work is conducted during assembly, as are dynamic tests with subsequent driving assessments.

The vehicle audit with the weekly problem meeting makes the current quality status transparent. Systematic defects and individual defects were sent to the relevant departments (development, supplier or assembly) to produce a solution. By constantly monitoring individual actions it was possible to implement the solutions at a very early stage.

This meant that, on the basis of the same high test criteria that are used on our mass production cars, a small-series production car has been developed that achieves top quality values within the automotive industry today whilst complying with the elementary components from the product design process and the production process. Experience in applying these measures has shown that identifiable potential defects and product risks in the early phase account for almost 100% of later customer complaints.

The Z8 is the result of the work of all those involved in the process, who have done a successful job in the service of the company and to the satisfaction of our customers.

10 Repair Procedures, Guarantee of Part Availability

Taking into account the high requirements of aluminium and the fact that production numbers will be lower than for large-series production, a maintenance concept has been developed that is based on the following criteria:

- maintenance of the enhanced relationship between the customer and dealer
- coverage for all servicing topics, including accident repairs, by existing BMW dealers
- solution of the repair requirements specific to the use of aluminium.

The highly limited ability of aluminium components with regard to straightening, aluminium welding, riveting and gluing are some of the main elements that must be taken into account.

The expected low frequency of use (< 1% of the vehicle stock), however, means that it is not sensible to enable all BMW dealers to carry out this work. The following action has therefore been taken:

- establishment of the expected level of accidents (max. approx. 1% of structural damage)
- definition of focal markets
- preparation of the dealer organisation for the Z8, including training for working with aluminium.

The above concept has been implemented and includes the following core points:

- completion of all servicing work, repair work to the mechanical systems, electrical systems, electronics, body equipment, body exterior skin, order acceptance and dealing with body structure damage by every BMW dealer
- accident damage to the body structure is to be repaired in regional centres that have all the special equipment and appropriately trained personnel.

Repair work can be accepted and the repair order processed by the BMW dealer, so that, as far as the customer is concerned, there is no difference to the normal procedure.

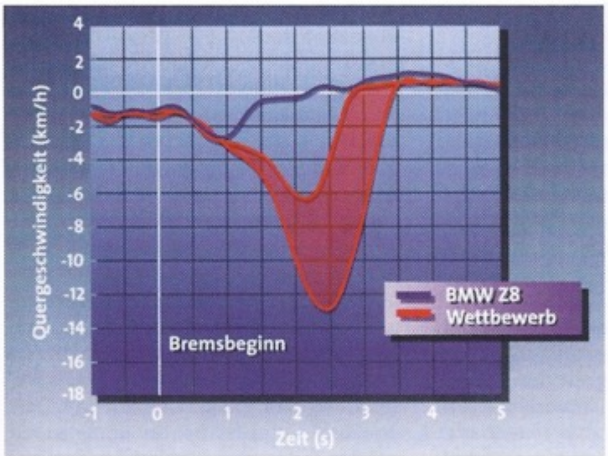


Figure 33: Braking while cornering

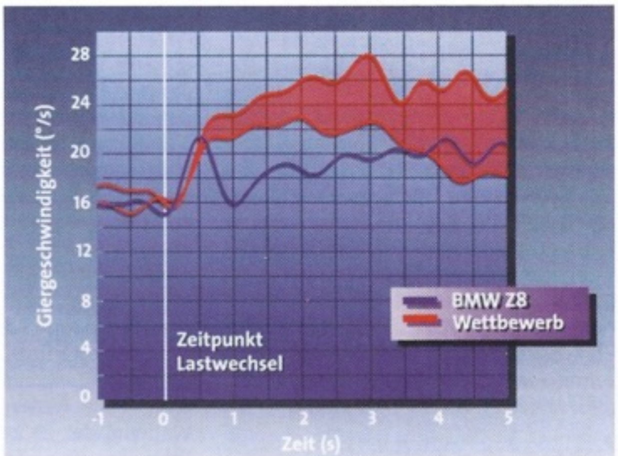


Figure 34: Load reversal while cornering

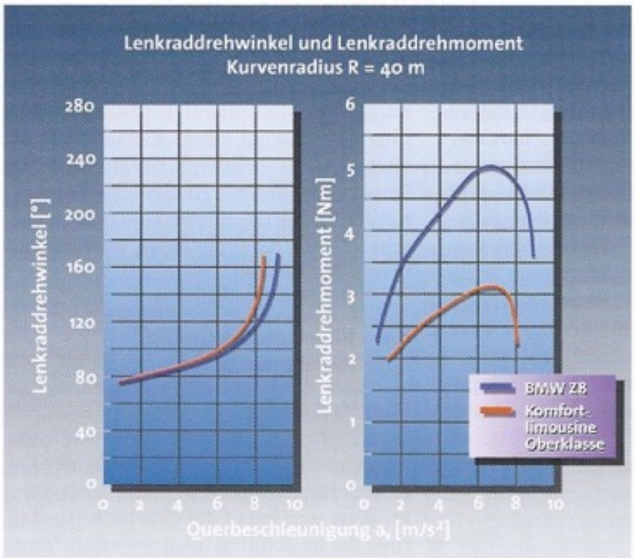


Figure 35: Steering wheel angle and torque

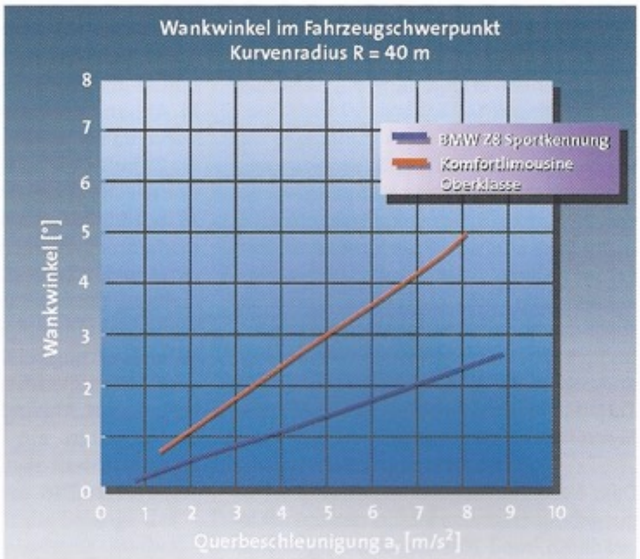


Figure 36: Roll angle versus lateral acceleration

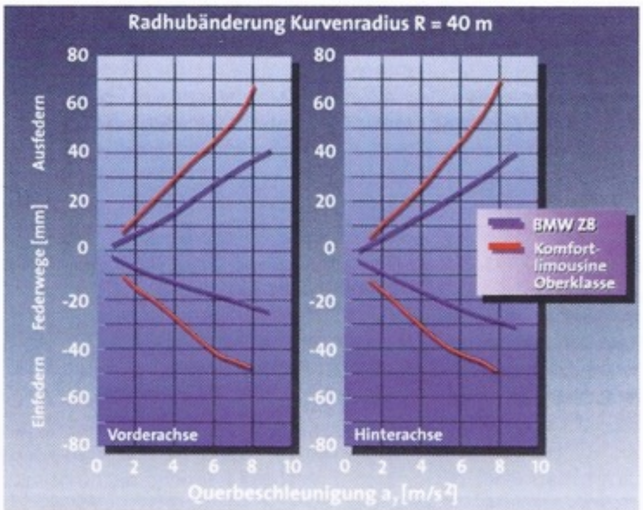


Figure 37: Strut changes versus lateral acceleration

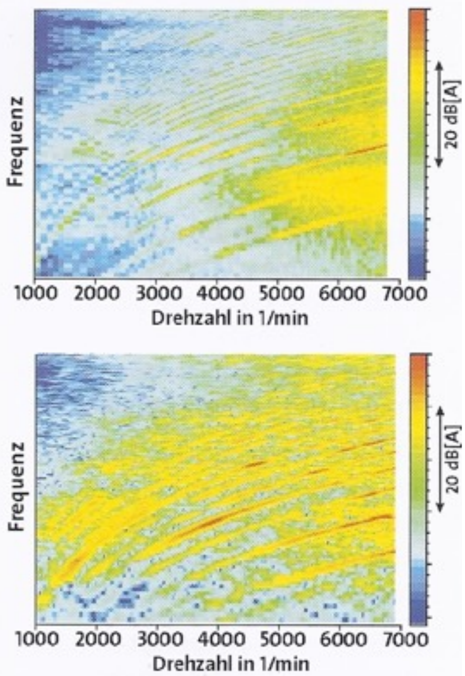


Figure 39: Noise development at low and at full engine load

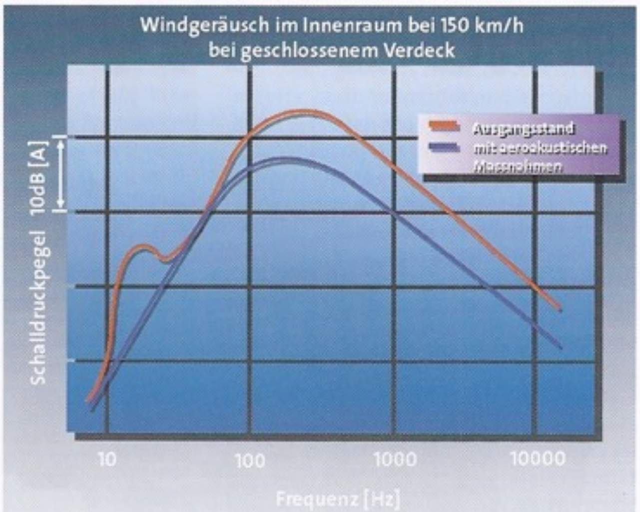


Figure 38: Wind noise with and without aero-acoustical measures