

Development history

An idea that triggered a revolution

13 years of development involving pioneering work in numerous fields

Automotive engineers as blasters and canaries as testers

250 crash tests and seven million kilometres of testing

Airbags that protect against side impacts since 1995

A wide area around the proving ground at Stuttgart-Untertürkheim was cordoned off. Crouching behind thick walls, the Mercedes-Benz engineers waited with bated breath. Not a sound could be heard, not a breeze stirred the air. All of a sudden there was an ear-splitting bang. Shreds of fabric and plastic flew everywhere, causing birds to flutter nervously from the trees. The engineers emerged from their sanctuary behind the walls, jumping for joy: the "explosives" had gone off just as planned. The Mercedes-Benz safety experts had just taken another step towards reaching their ultimate goal: the car airbag.

"We used missile technology", remembers Helmut Patzelt, one of the founding fathers of the airbag and an expert in pyrotechnics. "A missile receives its thrust from discharged gas, and we applied this very principle. The only difference is that we trapped the gas – in an airbag."

It was with this type of triggering test that Mercedes-Benz began to develop the idea of the airbag in 1967, prompted by two developments which affected traffic policy: the rapidly spiralling number of accidents during the sixties (also see page 13) and a resultant series of new laws in the USA, one of which prescribed an automatic occupant protection system for every car in the USA from 1969 onwards. "We can no longer tolerate unsafe automobiles", said the then US President Lyndon B. Johnson, making car safety a matter for decision at the top level.

And so it was that previously ignored inventions – for which patent applications had been submitted by the German Walter Linderer and the American John W. Hedrik as early as 1953 – suddenly took on a whole new meaning. "A folded, deployable receptacle which inflates automatically in the event of danger" was a fascinating idea yet, at that time, the technology required to make it happen simply did not exist. This was the cue for the automotive engineers to commence their explosive experiments. In 1970 the pressure on the developers increased when the newly formed US highway-safety authority stipulated that driver airbags would be a legal requirement for all new cars – starting as early as January 1, 1973.

The airbag becomes a bone of contention

No sooner had it been made a requirement than the airbag became the subject of a long-running dispute. "The airbag will kill more people than it saves", claimed the new critical voices entering the debate in the USA. As a consequence, the introduction date was put back until 1976. And even after that, the production launch had to be postponed on several other occasions. The airbag – was it all really just a lot of hot air? Hansjürgen Scholz, the then project manager for passive restraint systems at Mercedes-Benz, remembers only too well: "When a fatal accident involving an airbag occurred in the USA in 1974, most of those involved deserted the project like a sinking ship." All of a sudden the Mercedes developers were left on their own without any outside support. Other German manufacturers also failed to see the potential of the life-saving airbag at the time.

Those who advocated the airbag philosophy at Mercedes-Benz were very much left to their own devices. But they were not about to give up. "We had recognised the enormous potential of the air cushion. And we were not going to throw away our trump card", says Professor Guntram Huber, the former director of development for passenger car bodywork at Mercedes-Benz, who would later be awarded the "Safety Trophy" by the American Department of Transportation for his role in the introduction of the airbag. And so it was that, in 1974, Mercedes-Benz decided to go ahead and develop the airbag for

production, regardless of happenings in the US market. What is more, it would be aimed at the world market. Airbags have only been a requirement in the USA since 1993, not 1973.

Page 3

The technological challenges that had to be overcome when developing this innovation, which finally led to the unveiling of the world's first driver airbag in December 1980, were immense. A new product had to be created entirely from scratch. Problems that required solutions included the sensor-triggered deployment mechanism, the gas generation process, the tear-resistance of the airbag fabric, the effects on health and hearing, functional reliability and the issue of how to prevent unintentional activation. Given the intrepid test methods employed – they were, after all, based on missile technology – the authorities were quick to offer resistance, at first putting the triggering mechanism used to inflate the airbag in the same category as fireworks. For this reason, all those involved in the development of the airbag had to attend an explosives course. Following initial tests with liquid gas cylinders, the breakthrough was finally achieved by using a solid fuel for firing the airbag.

Toxicologists also had their say, querying the emissions left behind in the car after deployment of the airbag. But the developers were able to allay these fears as well, since the solid fuel pressed into tablet form – consisting of sodium azide, calcium nitrate and sand – left behind predominantly non-hazardous nitrogen gas and small quantities of hydrogen and oxygen.

Crash tests with canaries

In their efforts to overcome the technical hurdles before them, many of the ideas the engineers came up with were highly unconventional. Since the sound of the deploying airbag was above the pain barrier but only lasted for ten milliseconds, the effect on the eardrums could not be clearly ascertained at first. The engineers therefore installed a cage containing 15 canaries in the test car to determine the harmful effects of the noise, gas emissions and air pressure during deployment of the airbag. Not only did all the canaries

survive the test, they also remained their usual lively selves. Yet another step in the right direction.

Page 4

Some 250 crash tests on complete vehicles, around 2500 sled tests and thousands of component tests provided the airbag pioneers with invaluable knowledge to help the airbag on its way to full series production.

The primary concern in all the tests was stopping the car airbag from deploying unintentionally – a horror scenario for the developers. In early tests, the airbag would sometimes go off when the vehicle was at a standstill, meaning that the engineers also had to develop the electronic system from scratch. The sensor only had a few milliseconds in which to deploy the airbag – still very much a utopian idea in those days. As if that were not enough, the sensor had to be able to function reliably for several years at extremely low and very high temperatures with constant fluctuations in humidity.

Some 600 test cars took part in road tests, off-road trials and rally events, clocking up in excess of seven million kilometres, in order to ensure that the sensor could perform its vital, life-saving function. In addition, the engineers, technical experts and office staff had to put themselves in the firing line, sitting at the wheel to gauge the effects of the airbag in an emergency, all under the watchful eye of the project team who recorded the results. Last but not least, another issue which had to be resolved before the first airbag was allowed to see the light of day in a production car in December 1980 was disposal, in other words what to do with the airbag when the car reached the end of its life.

From airbag to windowbag

Following the world premiere of the driver's airbag in an S-Class Saloon, the specialists in the Mercedes safety development department set about building upon their lead, using their know-how to further develop the airbag idea. Hence the front-passenger airbag was introduced in 1988. Then, in 1992, all Mercedes models were fitted with a driver's airbag as standard. A front-passenger airbag has been part of the standard specification since 1994.

A further milestone in passenger car safety was achieved in 1995 when the sidebag made its debut in the E-Class following a development period of around ten years. The side airbag threw up new challenges for the

developers, since it only had 20 milliseconds in which to deploy following a crash whereas a front airbag enjoyed the comparative luxury of around 40 milliseconds. Needless to say, the development of the side airbag involved a considerable amount of work and was not without its handicaps. Yet despite this, the Mercedes engineers took up the stiff challenge, quickly recognising the importance of further improving occupant safety. "The sidebag was and remains a key addition to the other side protection measures such as the use of sturdy door locks and door hinges, the installation of special tubular sections in the doors and the incorporation of lateral bodyshell reinforcements", says Dr Luigi Brambilla, the then head of airbag and seat belt development at Mercedes-Benz.

The next milestone in airbag history – the windowbag – was achieved in 1998. In the event of a side impact, it inflates across the side windows to form a curtain, its large dimensions providing a wide area to protect the heads of both the front occupants and the rear passengers. Windowbags can prevent the head from hitting the side window, roof pillars or roof frame and are also capable of catching any fragments of glass or other objects propelled into the interior following a collision or subsequent roll-over, which constitute an additional injury hazard.

Side airbags are activated by the central control unit based on signals received from additional satellite sensors positioned on the crossmembers beneath the rear seats. In the new S-Class, new pressure sensors rapidly send the control unit precise information about any side collision in the door area. These sensors respond immediately when the air between the door's outer skin and interior panelling is compressed upon impact.

Since the design of Cabriolet and Roadster models makes it impossible to install windowbags, Mercedes-Benz has also developed a side airbag which protects both the head and the upper body. This head/thorax bag, as it is known, is located in the front seat backrest and deploys within a matter of milliseconds following a side impact, forming an asymmetric air cushion whose upper edge spreads further upwards when inflated, thus reducing the

risk of the occupant's head hitting the side window or coming into contact with any objects which penetrate the car interior. At the same time, the lower section of the head/thorax bag inflates between the door and the occupant, creating a large-surface protective shield for the chest area.

Two-stage triggering

Page 8

The front airbag has also developed into a highly complex and sensitive electronic system – a high-tech product that adapts to suit the seat occupant and the accident situation, responding accordingly before the driver has even had time to fully register any precarious accident situation. This lightning-fast reaction time is down to electronic triggering sensors and newly developed gas generators which allow the front airbags to deploy in two stages, depending on the severity of the accident: in the event of a minor frontal collision, the ECU only fires one chamber of the two-stage airbag gas generators. As a consequence, the airbags are deployed with a lower internal pressure. However, if the control unit detects a severe frontal impact, it also fires the second chamber of the gas generator to produce a higher internal pressure, thus affording the seat occupant the ideal level of protection for the accident situation in hand.

The system is able to differentiate in this way thanks mainly to additional up-front sensors and new algorithms programmed into the airbag control unit, made possible as a result of an increase in the system's performance and computing power.

Personalised safety for large and small front passengers

Equipment on board the new S-Class includes a computer which, as well as gauging the severity of the accident, also takes into account the size of the front passenger for the first time. If the sensor system housed in the seat upholstery detects a small front passenger, it initially only triggers the first airbag stage, depending on the type of accident, meaning that less air is injected into the airbag. If the system senses a larger front passenger, however, both airbag stages are triggered. This enhanced technology sees Mercedes-Benz launching a new trend in safety engineering: a restraint system which operates based on individual, occupant-specific parameters to provide passengers with an even higher level of protection than was previously possible (also see page 17).

Mercedes models also contain automatic child-seat and front-passenger recognition systems which enable the ideal airbag response given the situation in hand: as soon as a rear-facing child seat equipped with a transponder is fitted on the front-passenger seat, the front-passenger airbag is disabled, since it is surplus to requirements when it comes to protecting younger front passengers. Similarly, the front airbag, sidebag and belt tensioner on the front-passenger side are deactivated when the seat is not occupied.

Occupant protection before impact

In 2002, the PRE-SAFE[®] anticipatory occupant protection system ushered in a new era in passenger car safety. The innovative system, only available from Mercedes-Benz, further enhances the effectiveness of the seat belts and airbags by identifying situations which might turn into accidents and preparing the occupants and vehicle for a possible collision. As a precaution, PRE-SAFE[®] tensions the front seat belts, moves the front-passenger seat into the optimum position and, if applicable, automatically closes the sunroof. These preventive pre-crash measures ensure that the occupants are in the best possible sitting position should an impact occur, allowing the seat belts and airbags to do their job as effectively as possible.

Tests carried out by the Mercedes engineers on the new S-Class show just how effective the PRE-SAFE[®] functions are: inflatable air cushions housed in the seats of the Saloon support and hold the driver, front passenger and rear occupants in the ideal position before an imminent accident, thus considerably limiting the dangerous oscillating motion of the upper body. As a result, the distance between the shoulder and the door's interior panelling is increased, enabling the sidebag to offer even better protection in the event of an impact. PRE-SAFE[®] also enhances the effectiveness of the windowbag: if an accident seems likely, the side windows are closed in order to facilitate deployment of the windowbag in the event of a side impact or roll-over.

