Occupant protection system on the new Audi A5

The Technical Development Team of Audi AG was tasked with developing a high-quality occupant protection system. Compliance with current legislation and consumer protection tests is only one of the many safety requirements. In addition analyses of actual accidents in road traffic were included into the development process. Audi's in-house requirements presented additional challenges to the development team.

The occupant protection system on the Audi A5 comprises the following components and systems:

- Airbag control unit
- Driver airbag, two stage
- Front passenger airbag, adaptive
- Front side airbags
- Head airbags (sideguard)
- Crash sensors for front airbag (upfront sensors)
- Crash sensors for side impact detection in the doors
- Crash sensors for side impact detection in the C-posts
- Front belt tensioner with switchable belt force limiter
- Battery disconnect
- Seat belt reminder for driver and front passenger
- Seat belt switch, driver and front passenger side
- Seat occupied recognition feature in the front passenger seat
- Driver and front passenger seat position detection
- Backguard

The vehicle is optionally available with a key switch for deactivating the front passenger front airbag with associated warning lamp.

Due to the various requirements and statutory market regulations incumbent upon vehicle manufacturers, equipment can vary, particularly for the US market.

Legend:

E24 Driver side belt switch
E25 Front passenger side belt switch
E224 Airbag disabling key switch, front passenger side (optional)

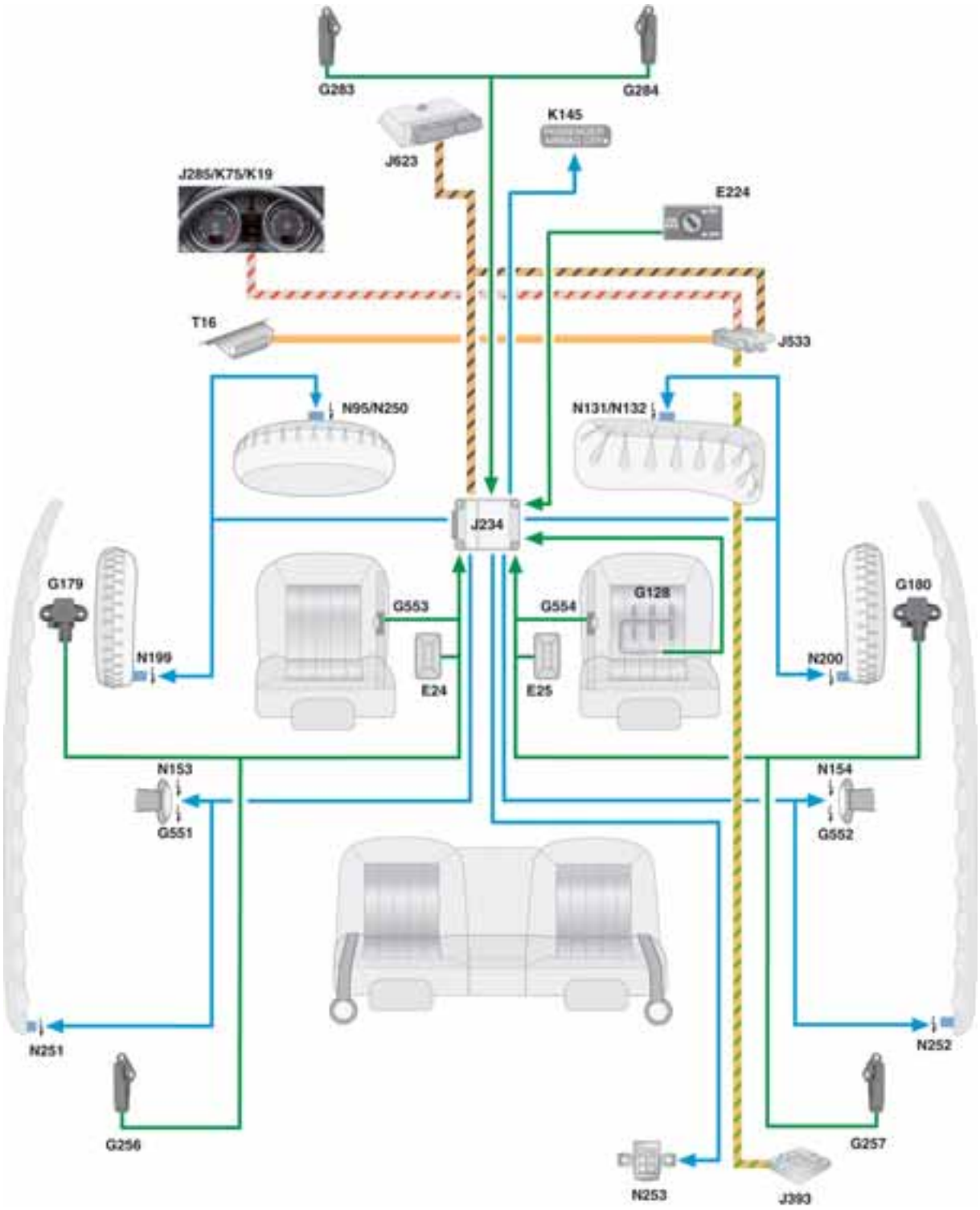
G128 Seat occupied sensor, front passenger side
G179 Side airbag crash sensor, driver side (driver door)
G180 Side airbag crash sensor, front passenger side (front passenger door)
G256 Rear side airbag crash sensor, driver side (C-post)
G257 Rear side airbag crash sensor, front passenger driver side (C-post)
G283 Driver side front airbag crash sensor (left front end)
G284 Front passenger side front airbag crash sensor (right front end)
G551 Belt force limiter, driver side
G552 Belt force limiter, front passenger side
G553 Seat position sensor, driver side
G554 Seat position sensor, front passenger side

J234 Airbag control unit
J285 Control unit with display in dash panel insert
J393 Convenience system central control unit
J533 Data bus diagnostic interface (Gateway)
J623 Engine control unit

K19 Seat belt warning system warning lamp
K75 Airbag warning lamp
K145 Passenger airbag off warning lamp (optional)

N95 Airbag igniter, driver side
N131 Front passenger side airbag igniter 1
N132 Front passenger side airbag igniter 2
N153 Driver seat belt tensioner igniter -1-
N154 Front passenger seat belt tensioner igniter -1-
N199 Side airbag igniter, driver side
N200 Side airbag igniter, front passenger side
N250 Driver side airbag igniter -2-
N251 Driver side curtain airbag igniter
N252 Front passenger side curtain airbag igniter
N253 Battery isolation igniter

T16 Connector, 16-pin, diagnostic port


G283
G284
J623
K145
J285/K75/K19
E224
T16
J533
N95/N250
N131/N132
J234
G179
N199
G553
G554
G128
G180
E24
E25
N200
N153
G551
N154
G552
N251
N252
G256
G257
N253
J393

392_010

Airbag control unit J234

The airbag control unit J234 and the electronics integrated therein basically have the following main tasks:

- Collision detection (front, side, rear)
- Evaluation of all input information
- Defined deployment of the belt tensioners, airbags and battery disconnect
- Defined deployment of the second airbag stage (driver side)
- Control of the adaptive front passenger front airbag
- Belt force limiter control
- Seat belt reminder control
- Continuous monitoring of the complete airbag system
- Independent energy supply via capacitor for a defined period of time (up to 200 ms)
- Fault indication via failure warning lamp
- Storage of fault and crash information
- Indication of a collision event to other system components via powertrain CAN bus

The airbag control unit is integrated within the powertrain CAN data bus so it can exchange information with other control units.

An airbag control unit can only be replaced using a VAS tester and the "Guided Fault Finding" or "Guided Functions" application.

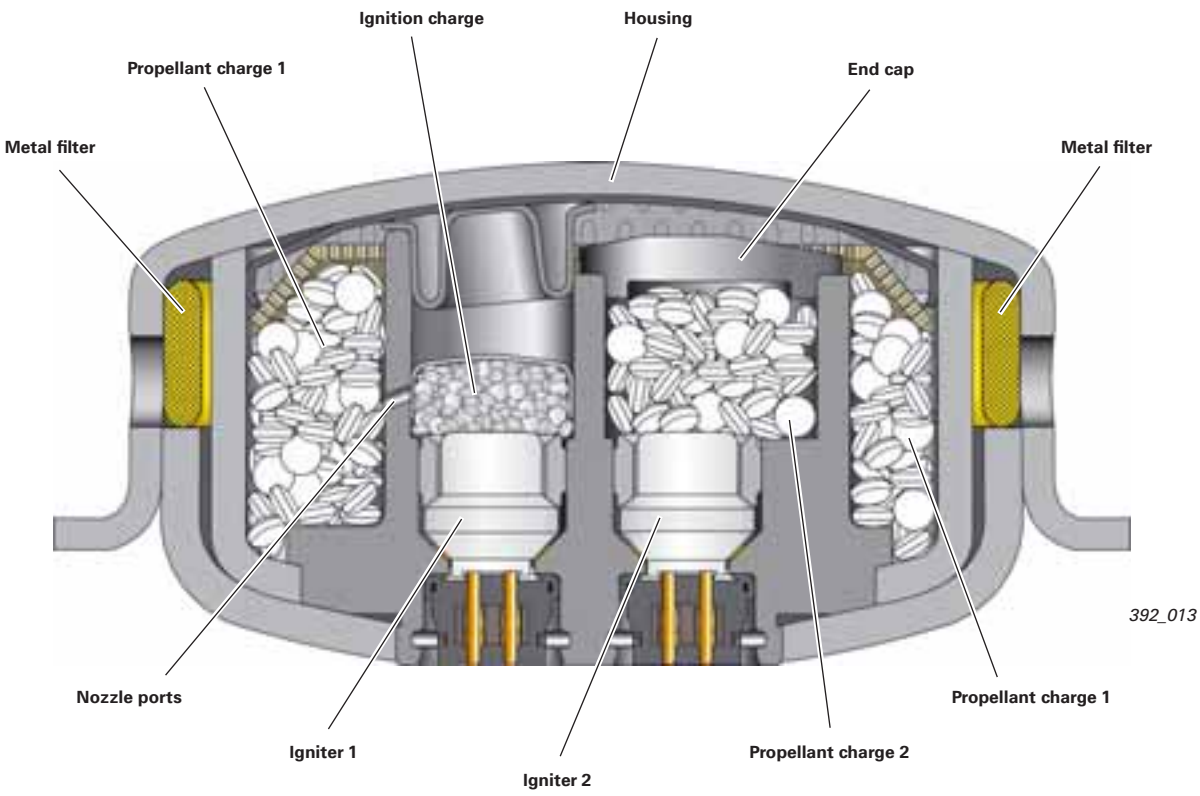
392_012

Airbag igniter, driver side N95
Driver side airbag igniter -2- N250

As with other Audi models, the Audi A5 is equipped with a two-stage driver front airbag.
The airbag control unit J234 is capable of adapting the interval between the two ignition stages depending on the accident severity and type.

In any event, both propellant charges are ignited. This prevents the propellant charge from remaining active after the airbag has deployed.

Schematic diagram of the gas generator



Igniter 1 activated by the airbag control unit J234 fires ignition charge. The actual propellant charge 1 is ignited via nozzle bores.
If the gas pressure produced by the burn-off of propellant charge 1 exceeds a predefined value, the gas generator housing deforms thereby opening the path via the metal filter to the airbag. The airbag unfolds and is inflated.

On expiration of a predefined interval, the airbag control unit J234 energises the igniter 2. which directly ignites the secondary propellant charge. When a set pressure is exceeded, the developing gas lifts the cap off the second-stage chamber and flows through the stage 1 combustion chamber and into the airbag.

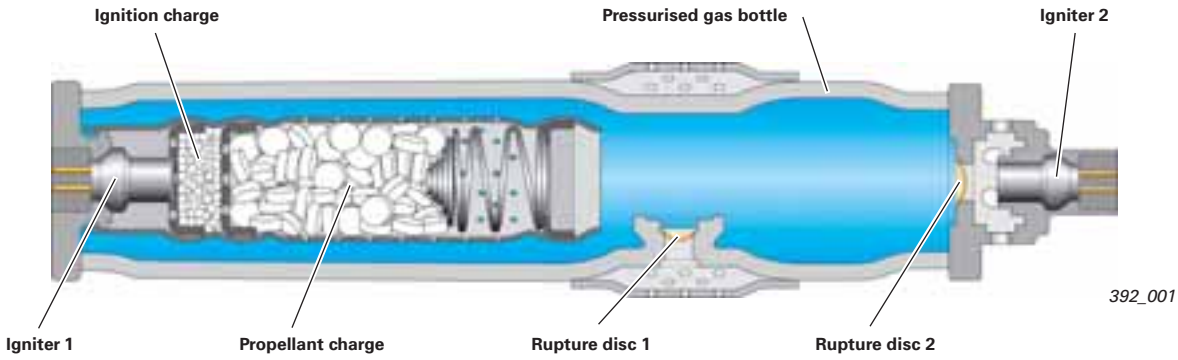
Front passenger side airbag igniter 1 N131
Front passenger side airbag igniter 2 N132

The Audi A5 is the first vehicle in the Audi model range to be equipped with an adaptive front passenger airbag. It takes the form of a single-stage hybrid gas generator with a second discharge port.

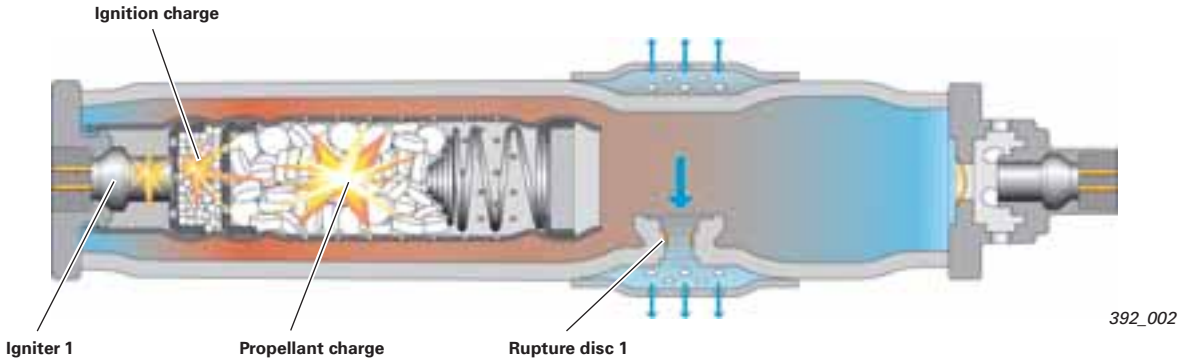
This type of gas generator allows variable degrees of inflation of the front passenger airbag.
The airbag control unit J234 determines the interval between activation of the two igniters based on accident severity and front passenger seating position.

The pyrotechnic propellant charge which is activated by airbag control unit J234 is integrated in the pressurised gas bottle. The so-called cold gas in the pressurised gas bottle is pressurised to approx. 400 bar and is a mixture of approx. 95 % argon and approx. 5 % helium.

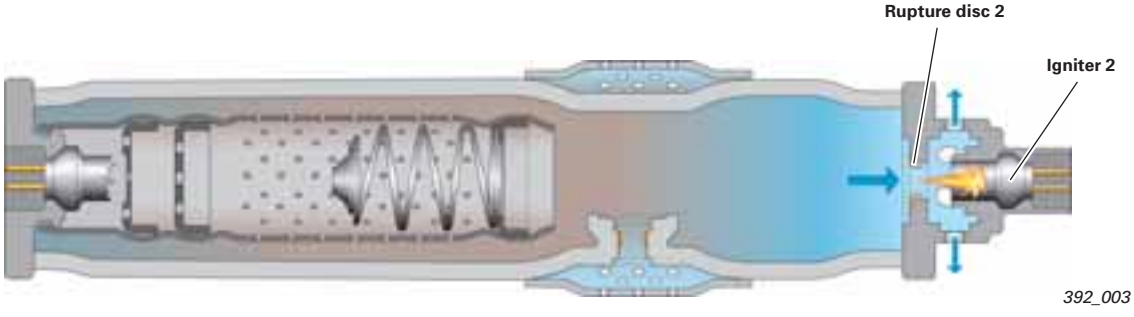
The schematic diagrams below show the gas generator.



The ignition charge fired by igniter 1 ignites the actual propellant charge. The pressure inside the pressurised gas bottle increases, bursting rupture disc 1 at a certain pressure. The gas mixture inflates and unfolds the airbag.



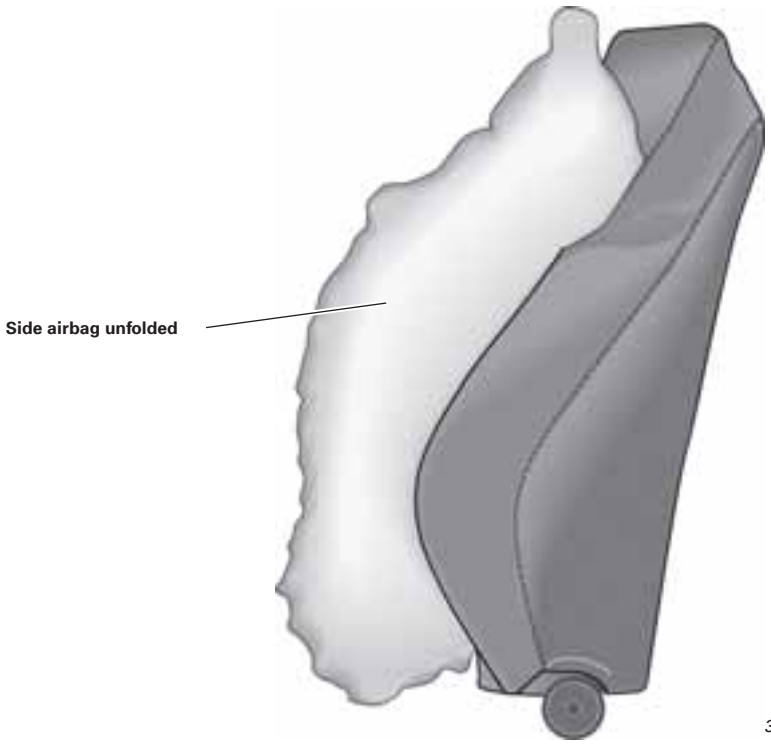
After a defined interval, the airbag control unit J234 activates igniter 2. A targeted pressure pulse from igniter 2 causes rupture disc 2 to burst. A portion of the remaining gas from the pressurised gas bottle now flows into the atmosphere, and no longer into the airbag.



Side airbag igniter, driver side N199
Side airbag igniter, front passenger side N200

The side airbags are so-called "Soft Cover Modules". In these modules, the plastic case which encloses the entire airbag module has been replaced by a textile sleeve.

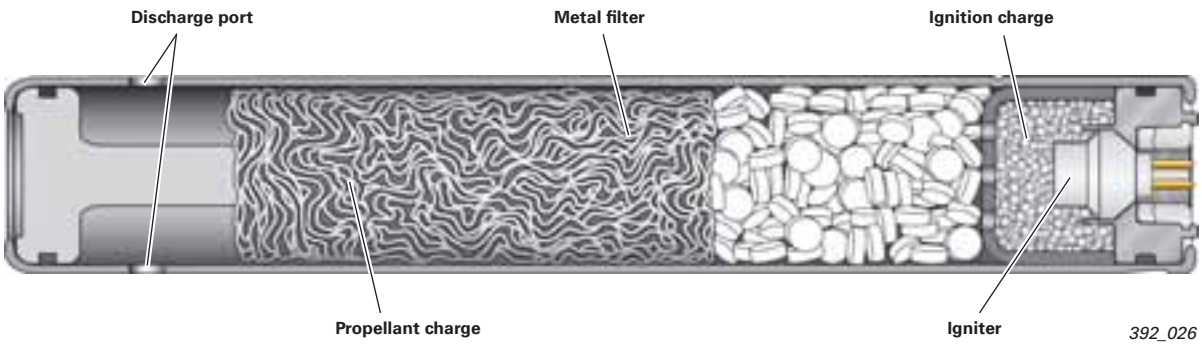
The soft surface of the textile sleeve allows better integration of the airbag module in the seat back. The lower weight of the sheath is a further advantage.



392_025

The airbag control unit J234 energises the corresponding side airbag igniter. The ignition charge fired by the igniter in turn ignites the actual propellant charge. The developing gas is cleaned by the metal filter and cooled down, unfolding and inflating the airbag.

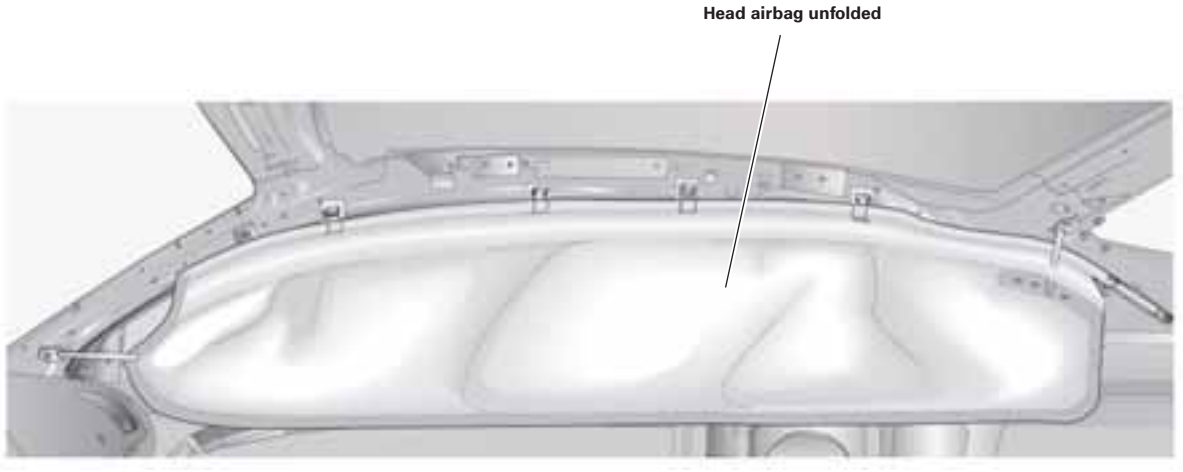
Schematic diagram of the gas generator



392_026

Driver side curtain airbag igniter N251
Front passenger side curtain airbag igniter N252

The head airbags on the Audi A5 extend from the A post to the C post and therefore cover almost the entire side window area.
This method of installing the airbags ensures that the occupants are well protected in the event of a side impact.

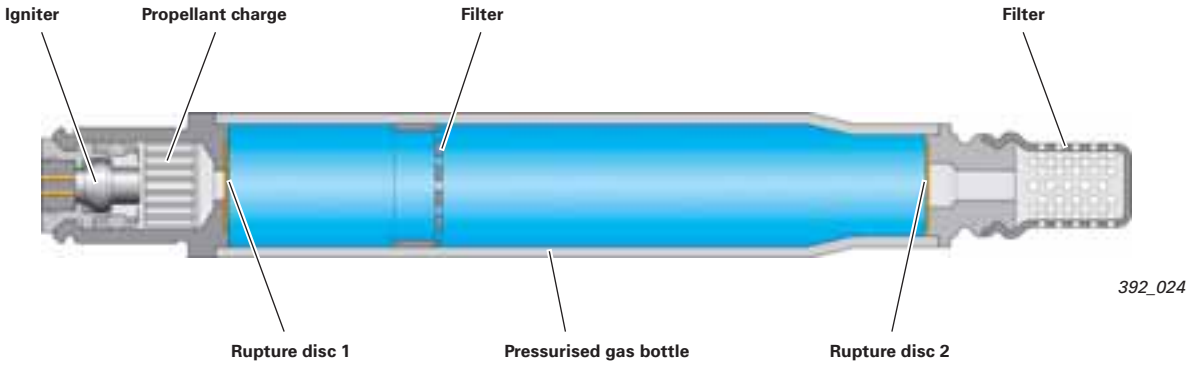


392_023

A hybrid gas generator performs the task of inflating the head airbag. A pressurised gas bottle is filled with compressed gas. The gas is pressurised to approx. 450 bar and is approx. 95 % argon and 5 % helium.

The igniter is activated by the airbag control unit J234. The propellant charge is ignited as a result.
The combustion of the propellant charge produces a gas pressure which causes the rupture disc 1 to burst. The gas pressure expands inside the pressurised gas bottle and causes rupture disc to break at a defined pressure. The gas mixture flows through the filter into the airbag.

Schematic diagram of the gas generator



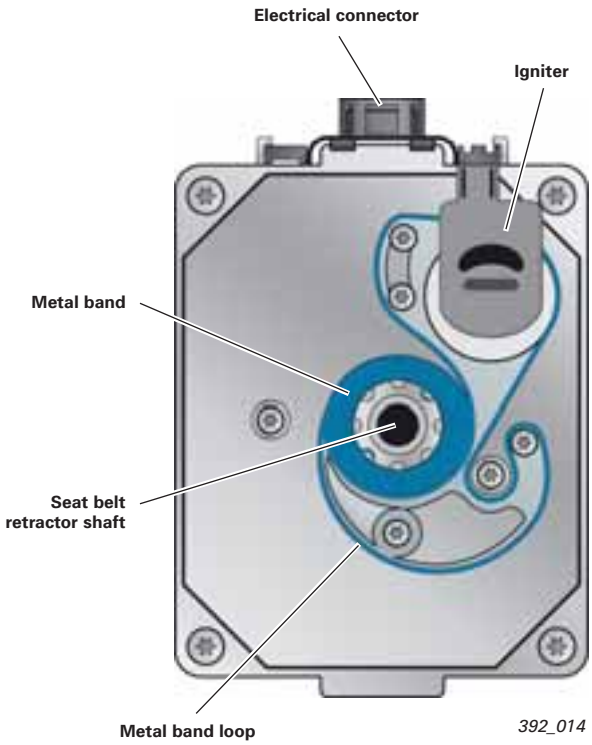
392_024

Driver seat belt tensioner igniter -1- N153
Front passenger seat belt tensioner igniter -1- N154

The Audi A5 is equipped with driver and front passenger belt tensioners. So-called band tensioners are used on all models world-wide.

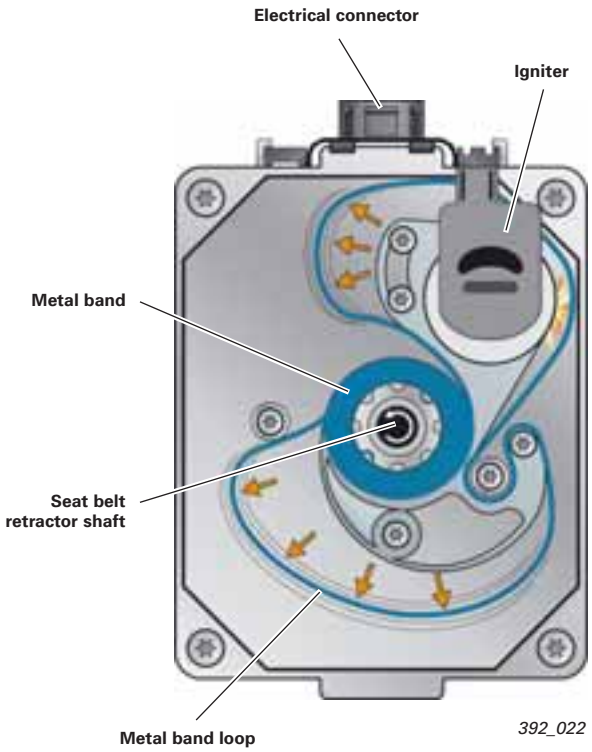
The schematic diagrams below show the principle of the belt tensioner.

A metal band is wrapped around the seat belt retractor shaft.
Both open ends are connected to the seat belt retractor shaft.
The closed end is looped around the belt tensioner igniter.



392_014

If the igniter is ignited by the airbag control unit J234. The loop of the metal band enlarges due to the evolving pressure.
The movement of the metal band exerts a pull on the seat belt retractor shaft, which thereupon begins to rotate tensioning the seat belt.



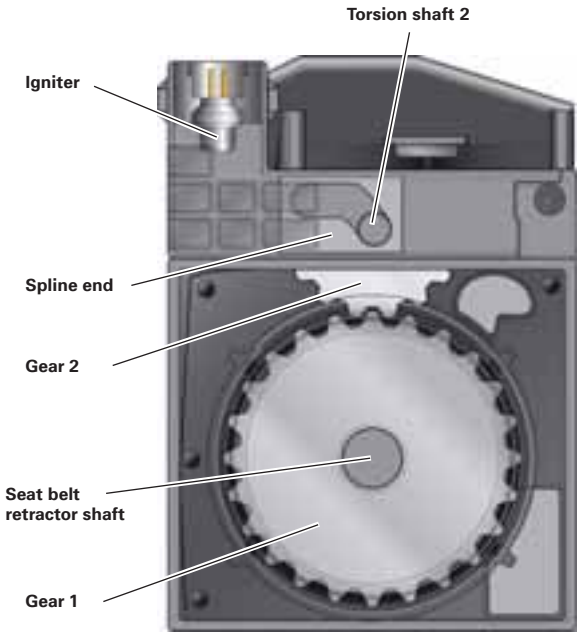
392_022

To reduce the pressure losses, the housing cover surface between which the metal band moves is coated with a film of silicone.

Belt force limiter, driver side G551
Belt force limiter, front passenger side G552

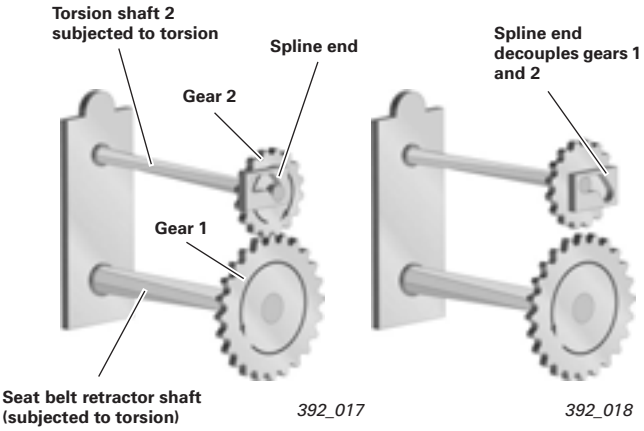
The front inertia-reel seat belts have a two-stage belt force limiter.
In the event of a collision, the belt tensioners (band tensioners) are ignited first.
The belt tensioner retracts the seat belt as far as possible. The inertia-reel seatbelt subsequently blocks the seat belt retractor shaft and prevents the seat belt from unwinding, which would otherwise occur due to the forward motion of the vehicle occupants.
If the occupant's body now moves further forwards due to deceleration, the belt force limiter will allow limited unwinding of the seat belt upwards of a defined force.

The schematic diagrams on the right show the principle of the belt force limiter.



392_015

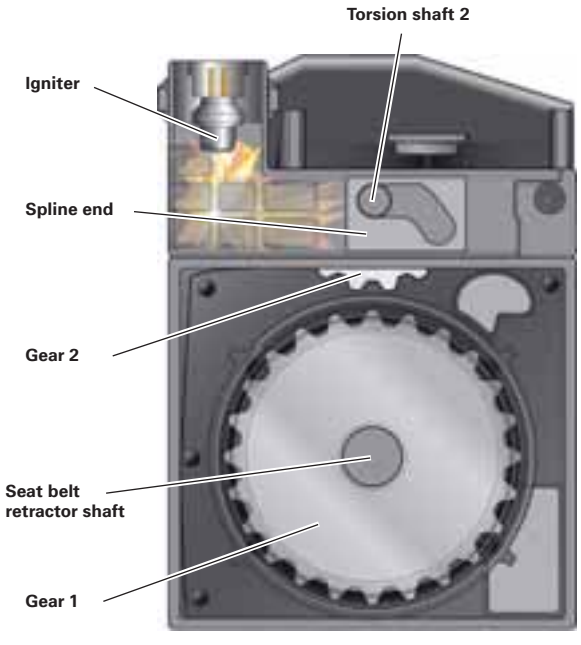
The seat belt retractor shaft is designed as a torsion shaft and is connected to torsion shaft 2 via gears 1 and 2. Both torsion shafts are subjected to torsion (high belt force).



392_017 392_018

Depending on accident severity and seating position, the airbag control unit J234 decides when the belt force limiter igniter is activated.
The second torsion shaft is decoupled.
The seat belt retractor shaft now counteracts by itself the seat belt unwinding force (low belt force level).
To ensure a good level of occupant protection, the belt tensioner, belt force limiter and front airbags work in concert with one another.

In a side or rear collision, the belt force limiter igniters are not activated.



392_016

Seat position sensor, driver side G553
Seat position sensor, front passenger side G554

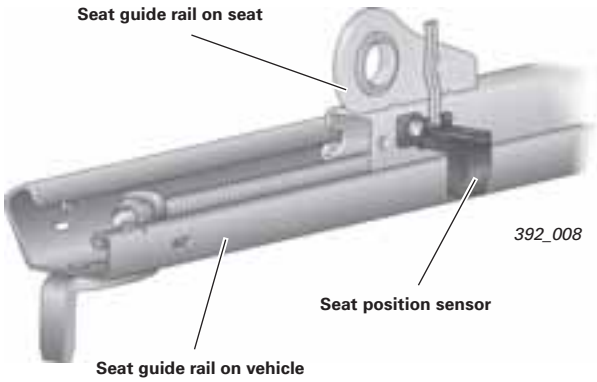
The driver and front passenger seats on the Audi A5 are equipped with seat position sensors G553 and G554. They are of the type Hall sensor. Based on the power consumption of the seat position sensors, the airbag control unit J234 is able to determine whether the seats are located in the front third or in the rear two thirds of the seat adjustment range. The airbag control unit J234 uses this information to activate adaptivity of the belt force limiter and the front passenger airbag to the correct timing.

If the seat is in the front third of the adjustment range, the airbag control unit J234 can activate igniter 2 of the adaptive airbag earlier than if the seat was in the rear two thirds of the adjustment range.

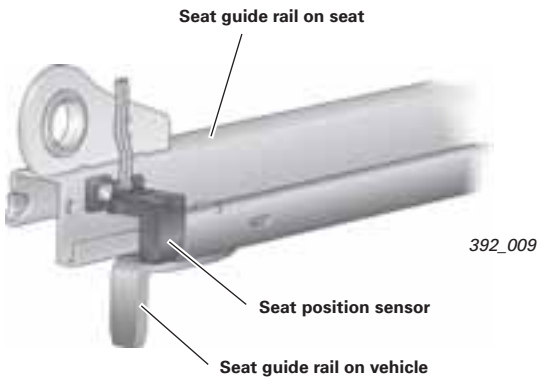
The earlier ignition of the second igniter makes the airbag softer and allows smaller individuals to sink into the airbag in a controlled fashion.
The belt force limiter igniters G551 and G552 are also activated earlier. Thus, the restraint systems are adapted to the accident situation and seat position.

Again, the following rule of thumb applies:
A correctly adjusted seat, correct seating position and a correctly fastened seat belt are the basic requirements for effective occupant protection.

The seat position recognition sensors work in conjunction with the seat rails mounted on the tunnel side.
If the seat occupied recognition sensor is located above the seat guide rail attached to the vehicle, its power consumption is approx. 5 - 7 mA.
The airbag control unit J234 determines that the seat is in the back position.



If the seat is pushed forward and the seat position sensor moves beyond the seat guide rail attached to the vehicle, the power consumption of the sensor increases to approx. 12 - 17 mA.
The airbag control unit J234 determines that the seat is in the front position.



Battery isolation igniter N253

The battery isolation igniter N253 disconnects the vehicle battery from the starter and alternator in the event of a collision.

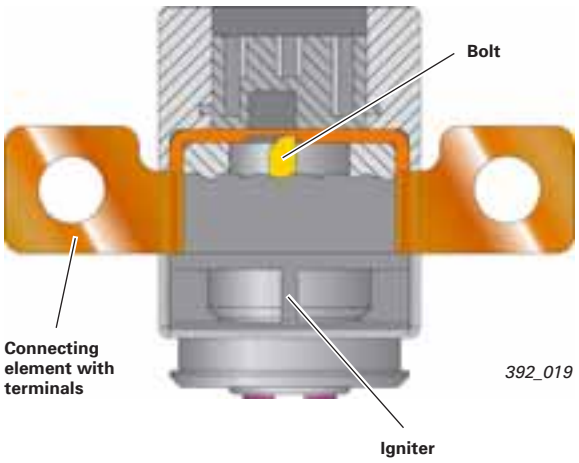
Use is made of a pyrotechnic component, which is activated by the airbag control unit J234 upon deployment of the airbag in an accident of high severity.

In the event of a rear collision, only the belt tensioners and the battery isolation igniter are activated.

If the pyrotechnic propellant charge is ignited, the resultant gas pressure displaces the bolt of a piston and disconnects the two terminals.

After activation, the battery isolation igniter must be replaced.

Battery isolation igniter



The battery isolation igniter N253 is located in the main fuse box directly on the battery in the boot of the Audi A5.

Supplements to the occupant protection system for specific markets

To bring the Audi A5 into compliance with the statutory and market-specific requirements of several countries, the occupant protection system can be equipped with additional functions and components.

Possible additional systems are:

- seat occupied recognition sensor, front passenger side
- knee airbags
- adaptive driver airbag
- rear belt tensioner (ball-gear)
- seat belts with "child seat restraint" function (front passenger seat and rear seats)

Seat occupied recognition, front passenger side

The front passenger seat occupied recognition system is also used in other Audi models, e.g. Audi Q7. However, the component parts of the system have been adapted to suit the Audi A5.

The system basically comprises the following components:

- Seat squab
- Sensor mat for seat occupied recognition
- Pressure sensor for seat occupied recognition G452
- Seat occupied recognition control unit J706

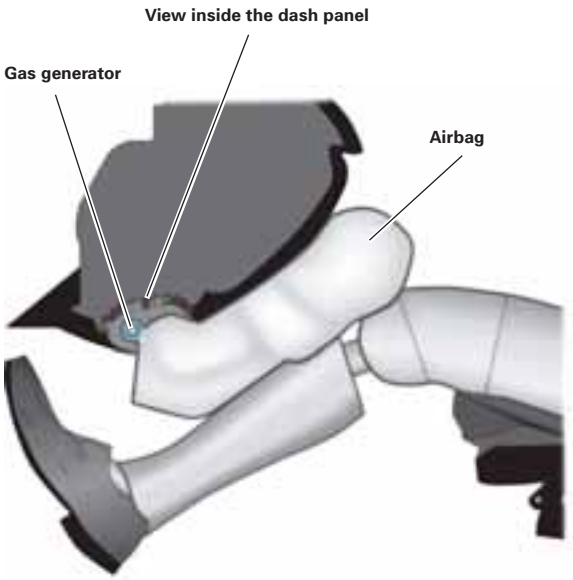
} These components form a single unit and must not be separated from each other.

- Front passenger side belt switch E25
- Seat belt force sensor for seat occupied recognition G453
- Front passenger side airbag deactivated warning lamp K145 (PASSENGER AIRBAG OFF)
- Airbag control unit J234

Knee airbag igniter, driver side N295
Knee airbag igniter, front passenger side N296

Ignited knee airbags allow the occupants to participate earlier in vehicle deceleration.
On the driver side, the knee airbag can be found in the footwell trim panel below the dash panel.
On the front passenger side, the knee airbag can be found behind the glove box lid.

Hybrid gas generators are used as gas generators.



392_020

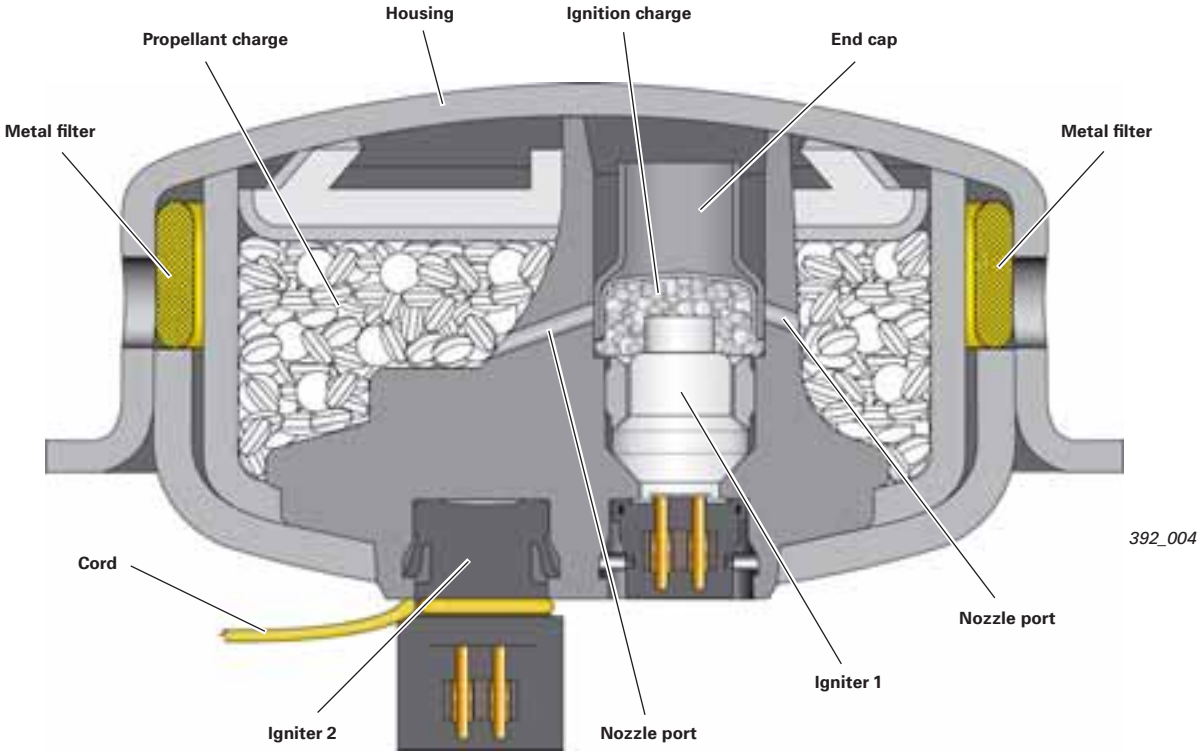
Airbag igniter, driver side N95
Driver side airbag igniter -2- N250

In several markets the Audi A5 is equipped with an adaptive driver airbag.
It is a single-stage solid fuel generator with an additional igniter.

The airbag control unit J234 activates igniter 1.
The ignition charge is thus ignited.

The actual propellant charge is then ignited via nozzle ports. If the gas pressure produced by the combustion of the propellant charge exceeds a defined value, the gas generator housing deforms thereby opening the path via the metal filter to the airbag. The airbag unfolds and is inflated.

Schematic diagram of the gas generator

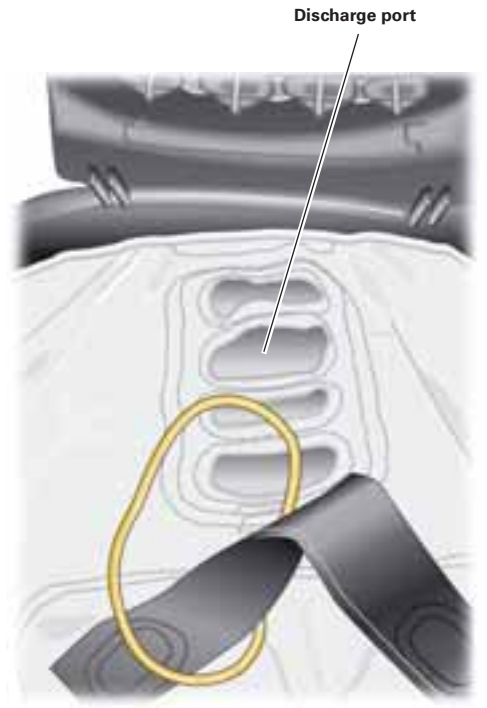


An additional igniter, driver side airbag igniter -2- N250. is attached to the back of the airbag. A cord which seals an additional discharge port is wrapped around this igniter.

As long as the cord is held in place by the igniter, this discharge port is sealed.

392_007

The airbag control unit J234 activates igniter 2.
The igniter housing ruptures and the cord is released.
The volume of the airbag increases by approx. 4 litres and the additional discharge port is opened.
Now more gas can escape through this discharge port when the occupant sinks into the airbag.
The airbag is "softer" for the occupants.



392_006

The vehicle airbag's gas generator is floating-mounted in a rubber ring, depending on model.
This allows vibrations to be minimised at the steering wheel.