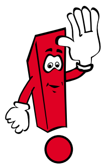
Vibration damper control

The damper control system registers the condition of the road surface and the movements of the vehicle via four wheel acceleration sensors and three body acceleration sensors.
The characteristics of the individual vibration dampers are adjusted according to the calculated damping requirements.
In this case, the dampers function as semiactive components during bump and rebound cycles.

Continuous damping control is based on vibration dampers whose characteristics are electrically adjustable.
These vibration dampers are integrated in the air spring struts.
Damping force can be set depending on the characteristic map via the proportional valve built into the vibration damper.
As a result, it can adapt the damping force to the driving situation and road condition within milliseconds.

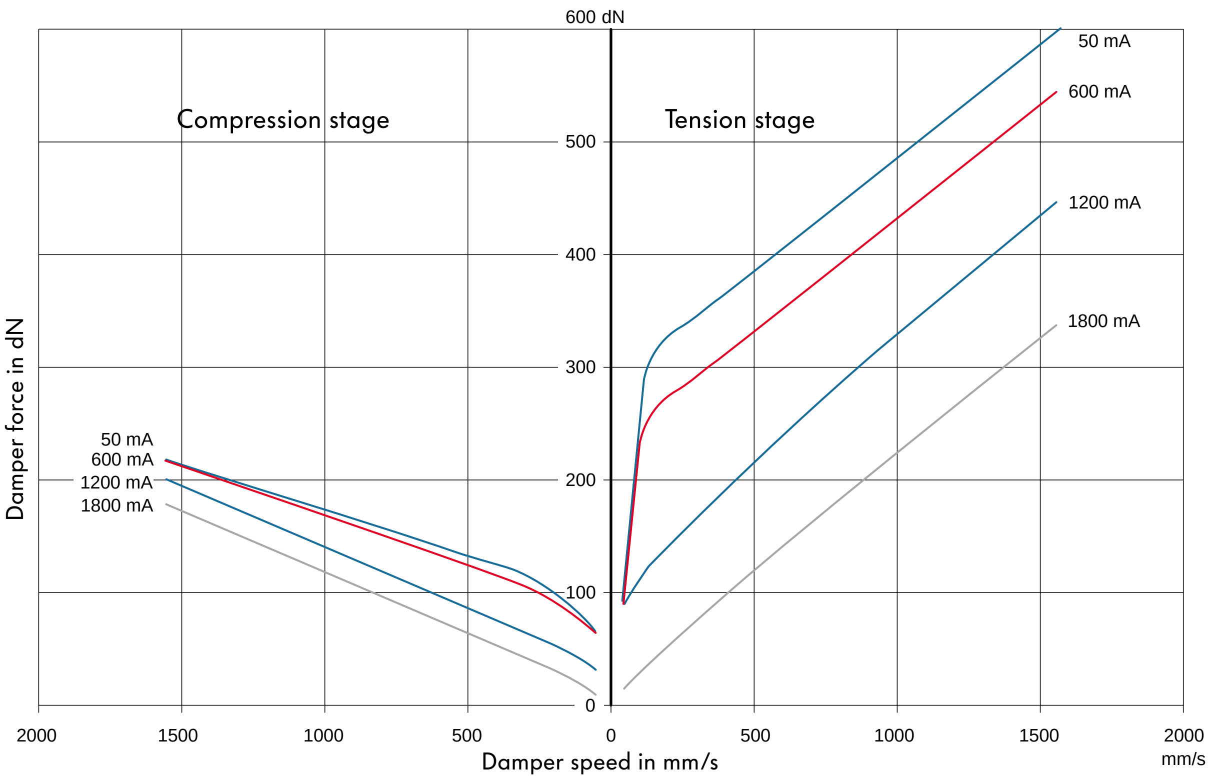
The control always attempts to set the damper force according to the so-called "skyhook control strategy".
The damper is adjusted depending on the vertical acceleration rates of the wheels and the vehicle body.
Ideally, damping would be controlled as if the vehicle body were suspended by a hook in the sky and were hovering above the road almost without any interfering movements.

Maximum driving comfort is achieved in this way.



Firm damping is achieved by low control rates.
Soft damping is achieved by high control rates.

Characteristic map of damper force in Phaeton front axle

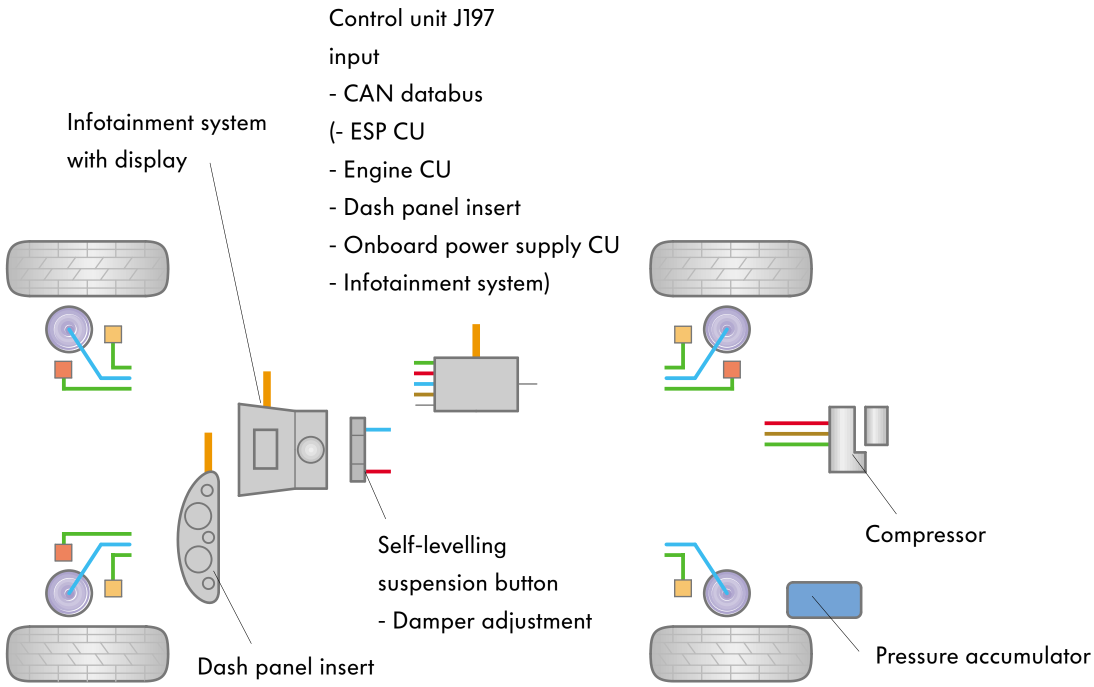


275_022

System description

Diagram of the suspension system with controlled dampers

The system diagram below highlights the relationships with other vehicle systems as well as display and operating elements.



275_025

Air spring strut with electrically adjustable damper

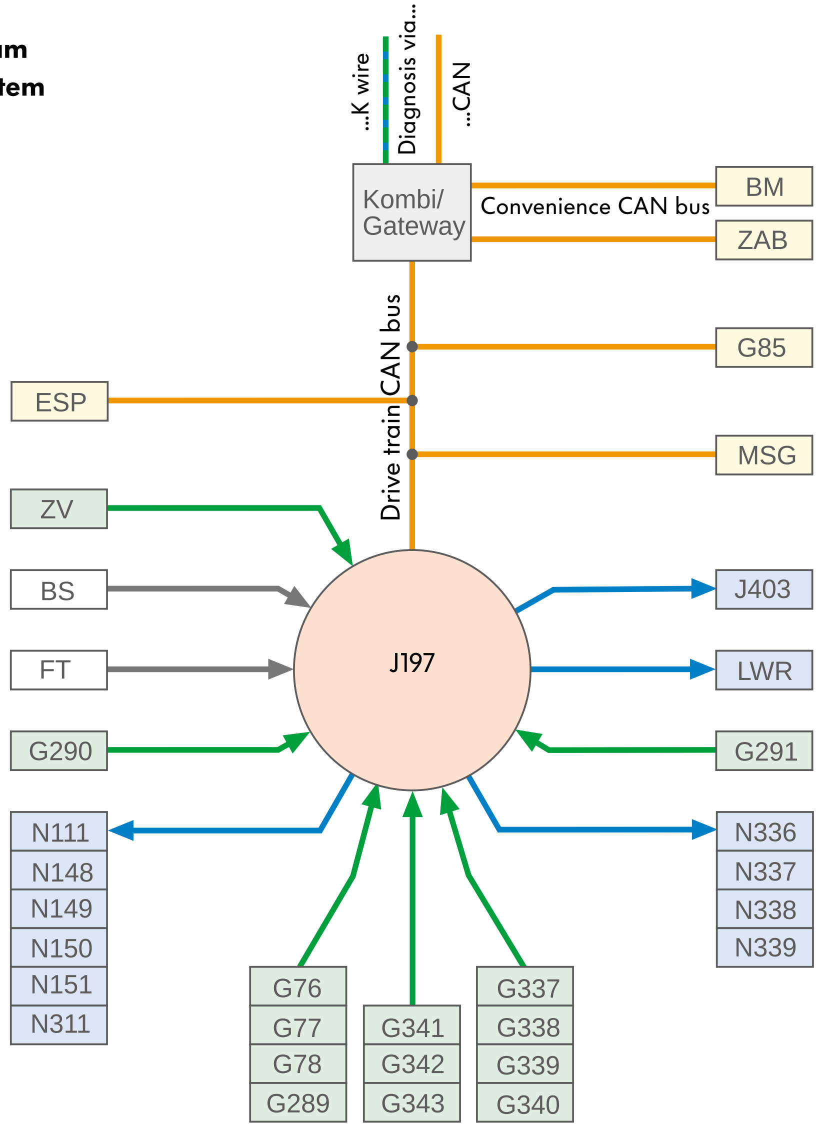
Connection via CAN bus

Wheel acceleration sender

Connection via onboard power supply

Body acceleration sender

Schematic diagram of the overall system



275_023

Legend

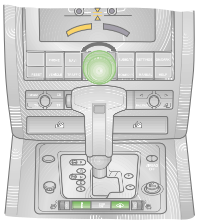
BM - Battery management
BS - Status signals T.30, T.15
ESP - Electronic Stability Programme
FT - Self-levelling suspension button and damper adjustment button
G76...78, ... G289 - Vehicle level senders
G85 - Steering angle sender
G290 - Compressor temperature sender, self-levelling suspension
G291 - Self-levelling suspension system pressure sender
G337 ... G340 - Wheel acceleration sender
G341 ... G343 - Body acceleration sender
J197 - Self-levelling suspension control unit
J403 - Self-levelling suspension compressor relay
Combi - Dash panel insert
HRC - Headlight range control
MSG - Engine control unit
N111 - Drain valve
N148 ... N151 - Damper adjustment valve
N311 - Self-levelling suspension pressure accumulator valve
N336 ... N339 - Damper adjustment valve
ZAB - Infotainment
ZV - Door/bonnet/bootlid signal

System description

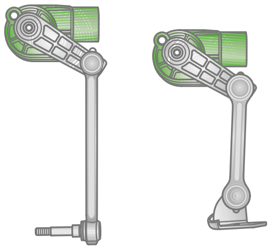
System overview

Sensors

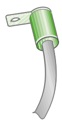
Damper adjustment button E387
Self-levelling suspension button E388



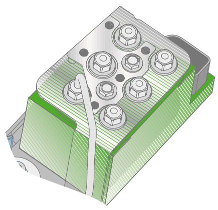
Vehicle level sender, front and rear
G76, G77, G78, G289

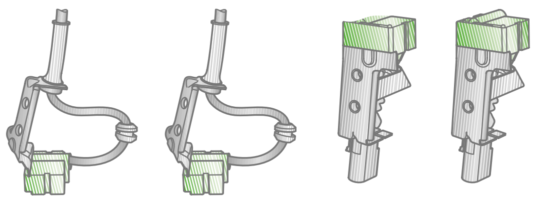


Compressor temperature sender G290

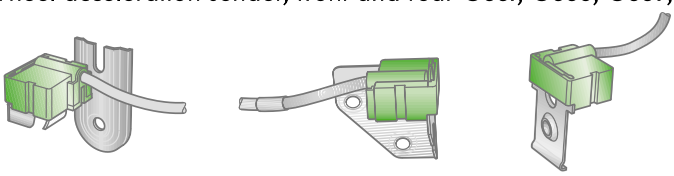


Self-levelling suspension system
pressure sender G291
(integrated in solenoid valve block)



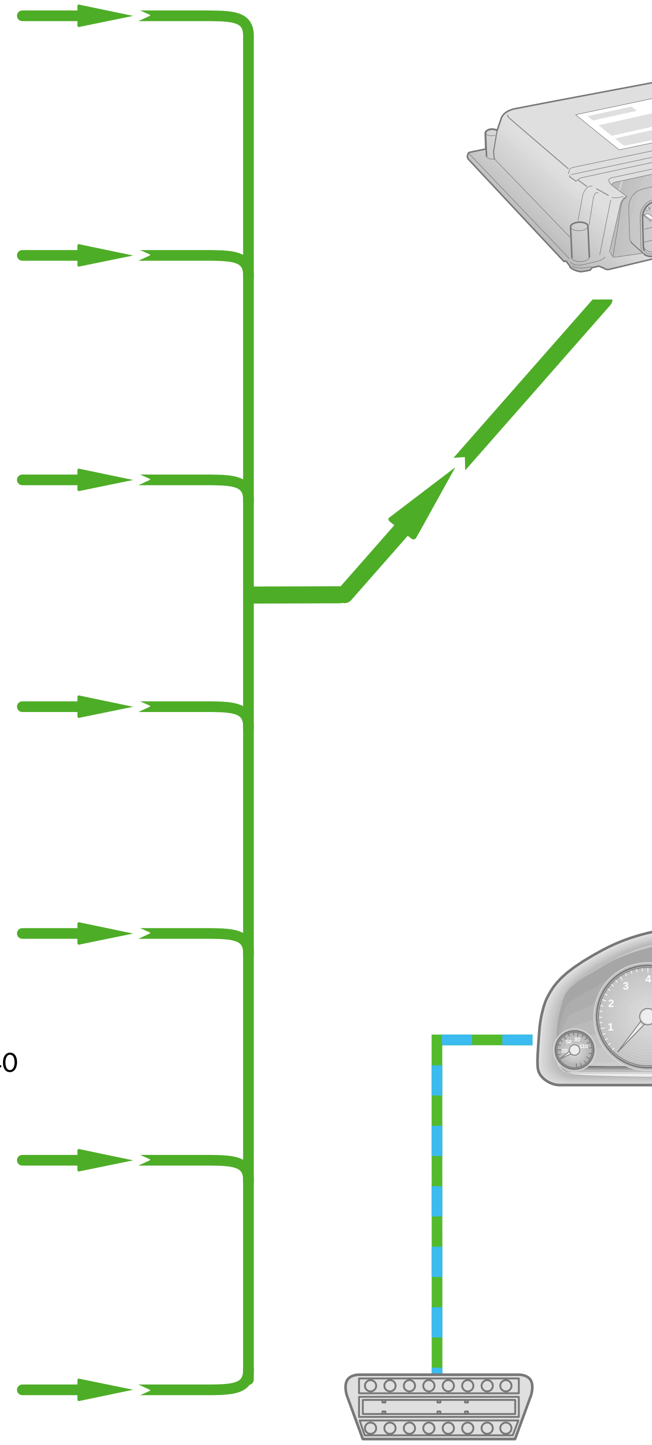


Wheel acceleration sender, front and rear G337, G338, G339, G340

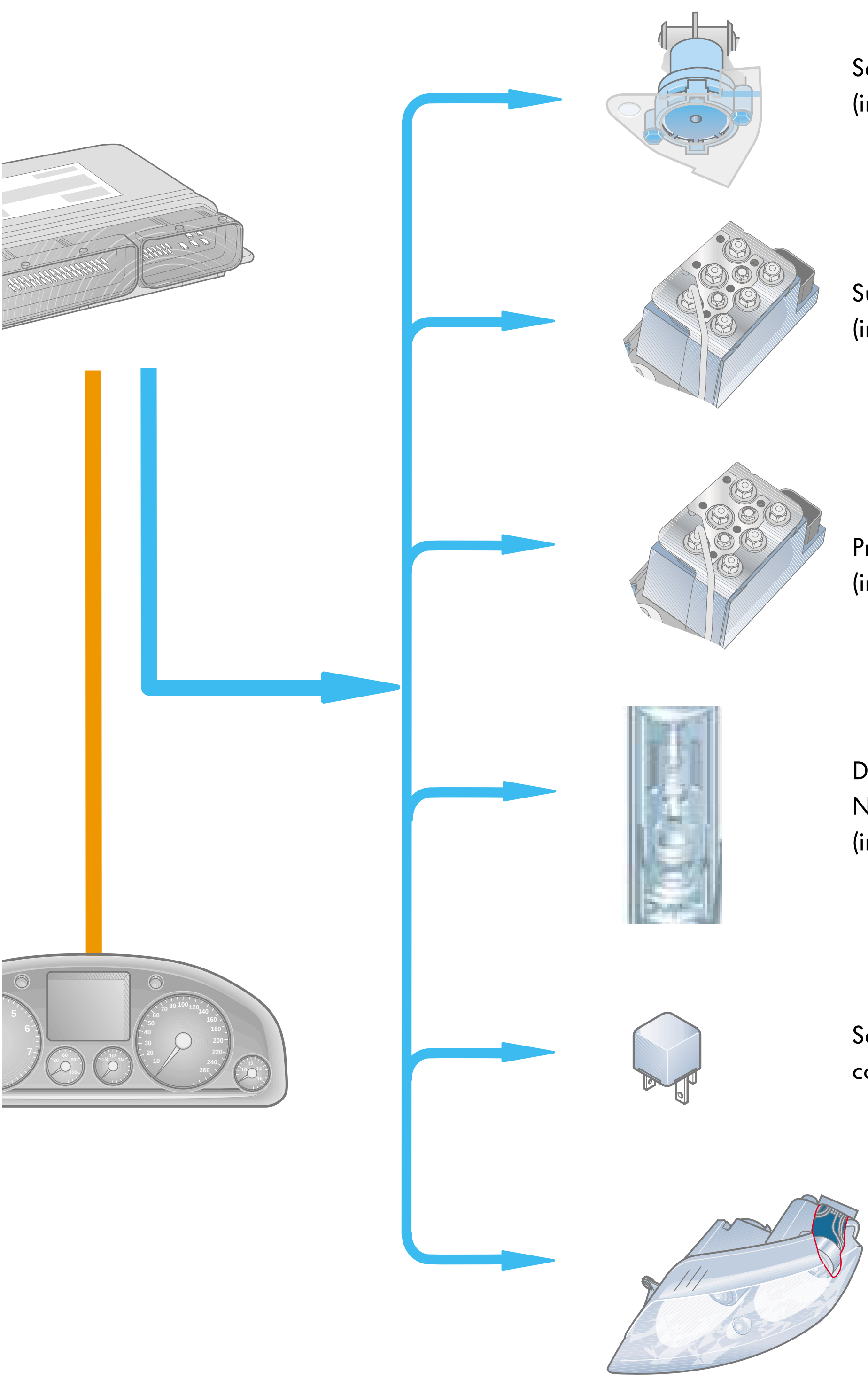


Body acceleration sender G341, G342, G343

Auxiliary signals: Signal for doors/bonnet/bootlid contact



Actuators



Self-levelling suspension drain valve N111
(integrated in solenoid valve block)

Suspension strut valves N148, N149, N150, N151
(integrated in solenoid valve block)

Pressure accumulator valve N311
(integrated in solenoid valve block)

Damper adjustment valves
N336, N337, N338, N339
(integrated in air spring struts)

Self-levelling suspension
compressor relay J403

Gas discharge lamp control units with HRC
J567 and J568 integrated in the headlights

275_026

Design and function

Self-levelling suspension control unit J197

This control unit is located in the luggage compartment on the left-hand side behind the side trim. It is bolted behind the relay and fuse carriers.

As a central control unit, it has the following tasks:

- to control air suspension and the vibration dampers,
- to monitor the overall system,
- to diagnose the overall system, and
- to communicate via the CAN databus (drive train CAN databus).

275_083

The self-levelling suspension control unit has a redundant processor design (dual processors); the air spring algorithm runs primarily on the first processor and damping control runs primarily on the second processor.

Air spring struts

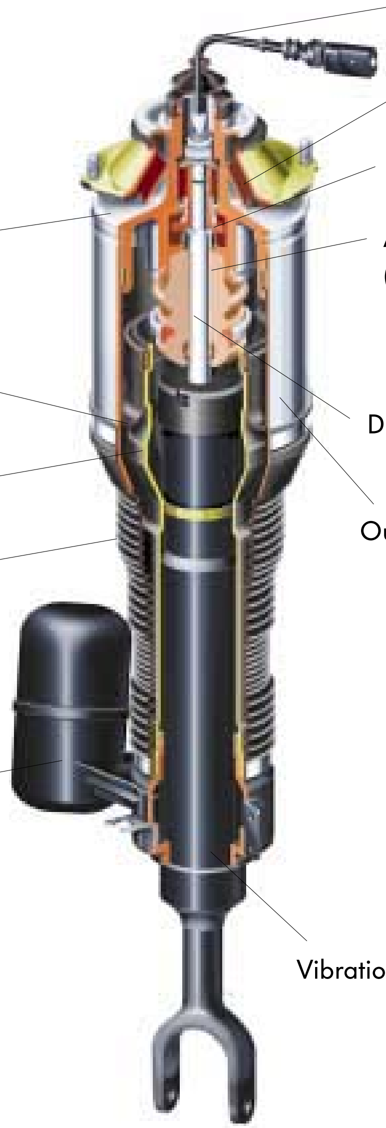
Air spring struts with externally guided, two-layer air spring gaiters are used on the front and rear axles.

The air spring gaiter is arranged concentrically around the gas-filled shock absorber (twin-tube gas-filled shock absorber).

The small wall thickness of the air spring gaiter provides excellent suspension response.
The desired spring rate is achieved by combining the roll piston contour, the outer guide and an auxiliary accumulator directly attached to the strut.

Different auxiliary accumulators are used on the front axle and rear axles.
The accumulator on the front axle - recognisable as a small cylinder - has a capacity of 0.4 litre and the ball accumulator on the rear axle has a capacity of 1.2 litre.

Strut, front axle



275_027a

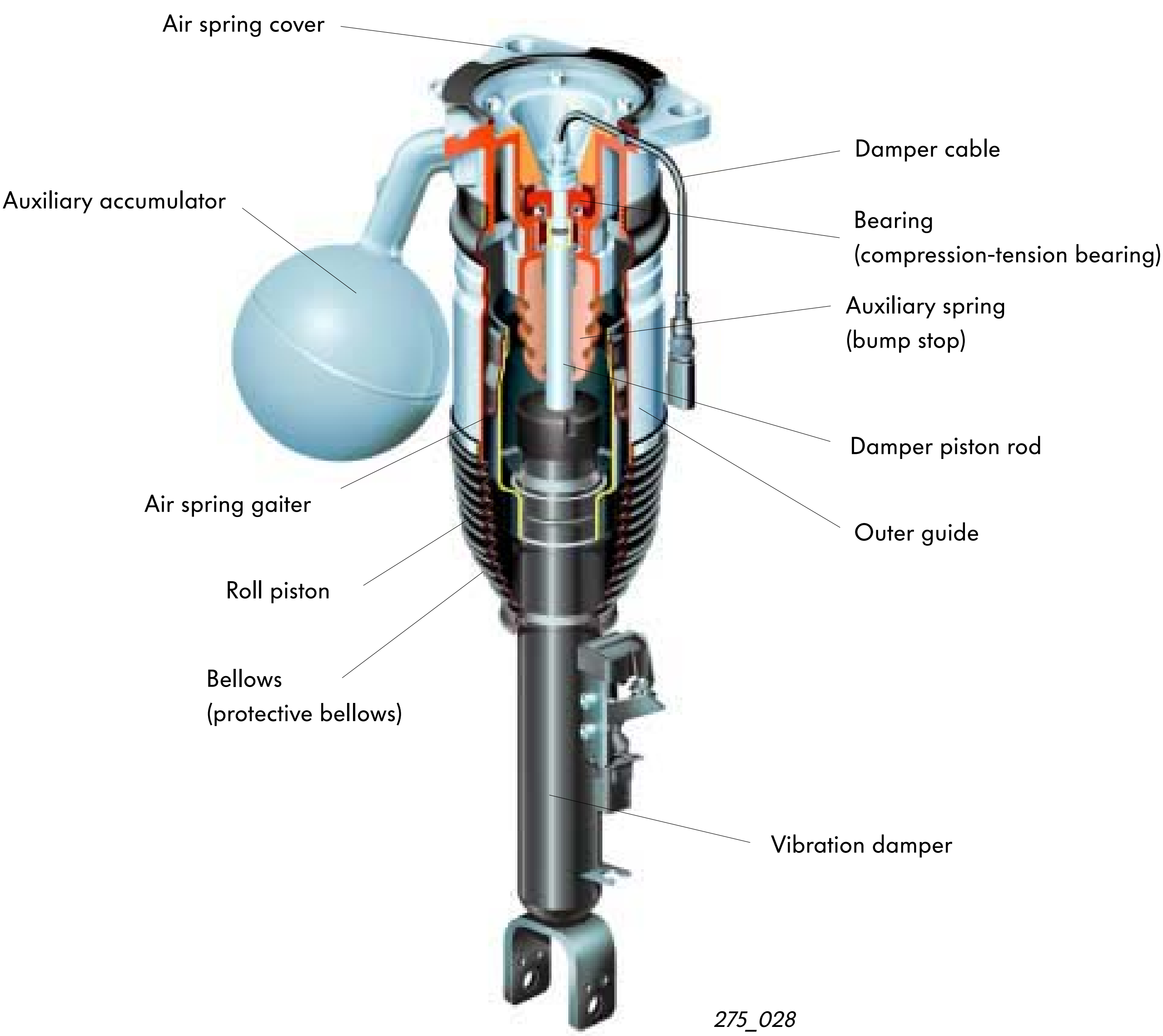
Design and function

The struts are designed to minimise the effect of transverse forces on the dampers. The special design of the strut support bearing on the front axle and the cardanic acting hydro-mounted version on the rear axle help reduce the effects of transverse forces on the dampers.

Residual pressure maintaining valves are mounted directly on the air connection of each air spring strut.
They maintain a residual pressure of about 3.5 bar in the air spring strut. This permits easy assembly and mounting of the components.

The outer guide protects the air spring gaiter against soiling and damage besides its function of guiding the air spring gaiter and bellows.

Strut, rear axle



275_028

Damper adjustment valve

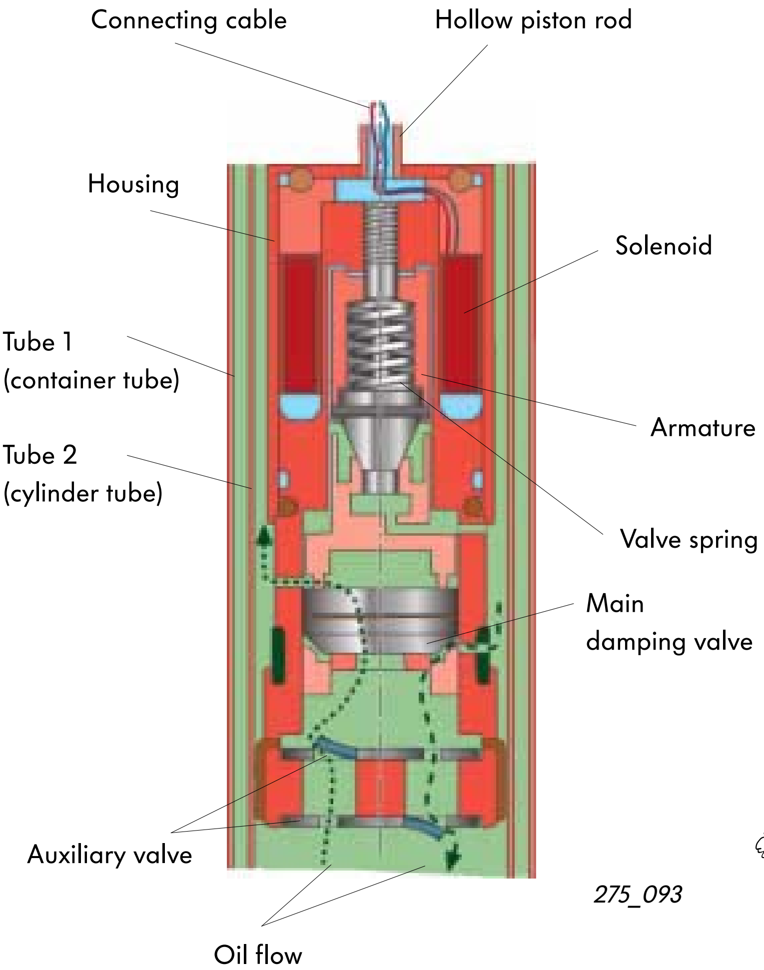
The CDC twin-tube gas-filled damper is adjustable over a wide range of damping forces via an electrically controlled valve integrated in the piston.
The oil flow through the piston valve, and hence the damping force, can be adapted to momentary demand within a few milliseconds by varying the electric current flowing through the solenoid.

The wheel acceleration senders mounted on each damper generate signals which, together with the signals supplied by the body acceleration senders, are used to calculate the required damper setting.

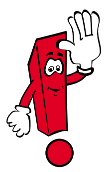
Since the system can rapidly detect and control tension and compression stages, it permits adjustment of the damping force required for the momentary driving situation.

The driving situation dependent maps are stored in the self-levelling suspension control unit.

Example of a piston valve



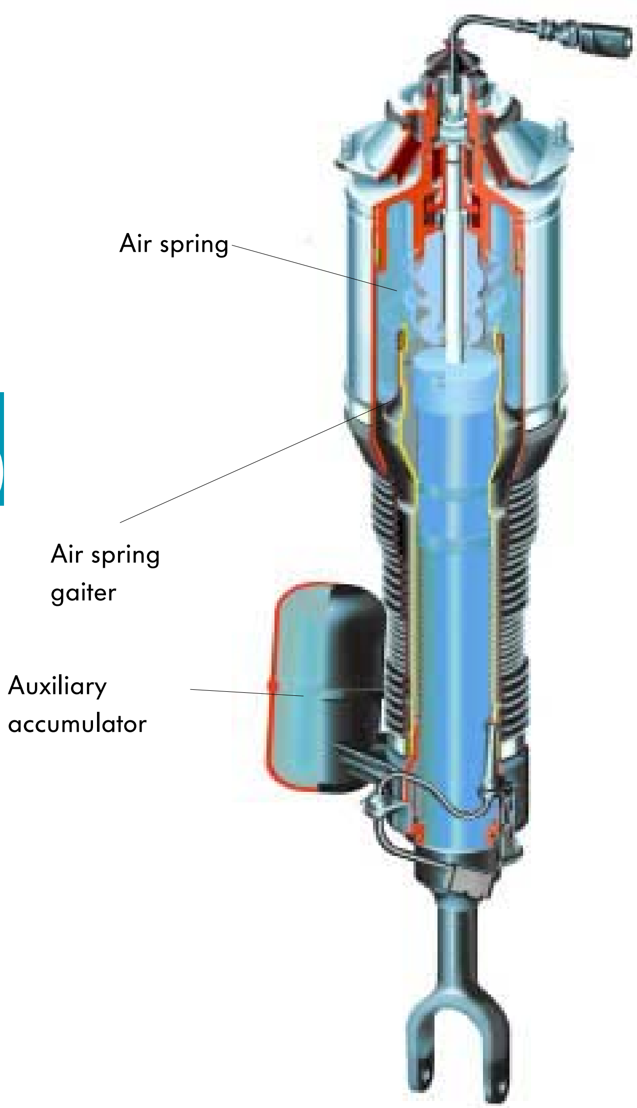
275_093



In certain driving dynamic states - e.g. longitudinal and/or transverse dynamics - the "skyhook control" is deactivated and the dampers are controlled by other dynamic modules.

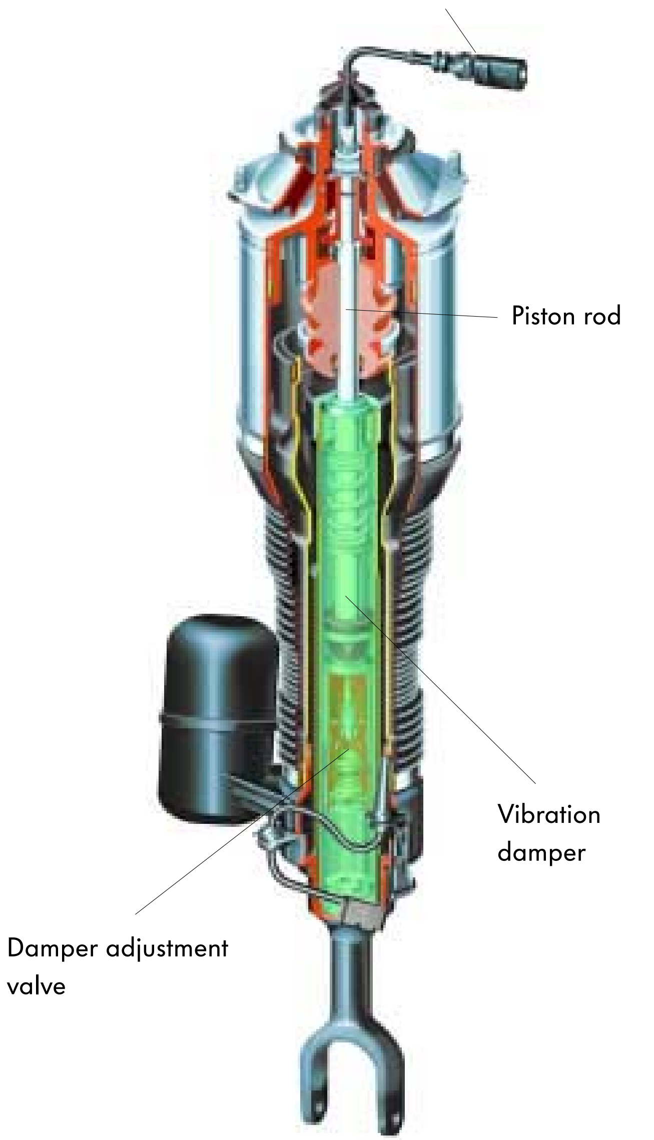
Air spring strut, front axle

Air spring part (blue)



275_086

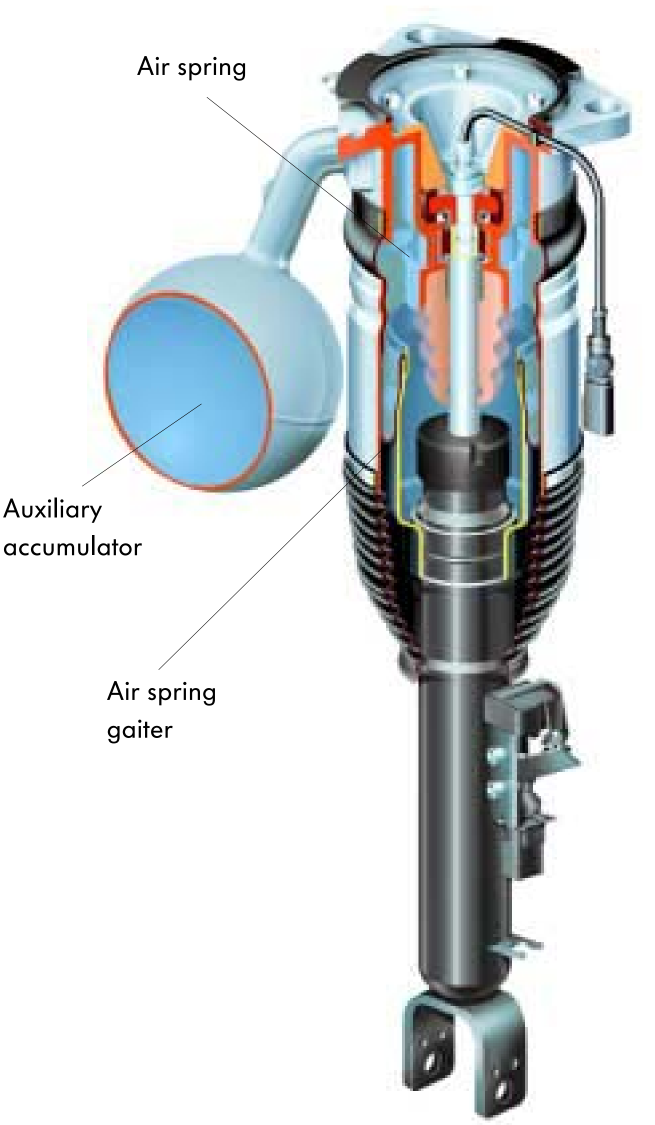
Damper part (green)



275_084

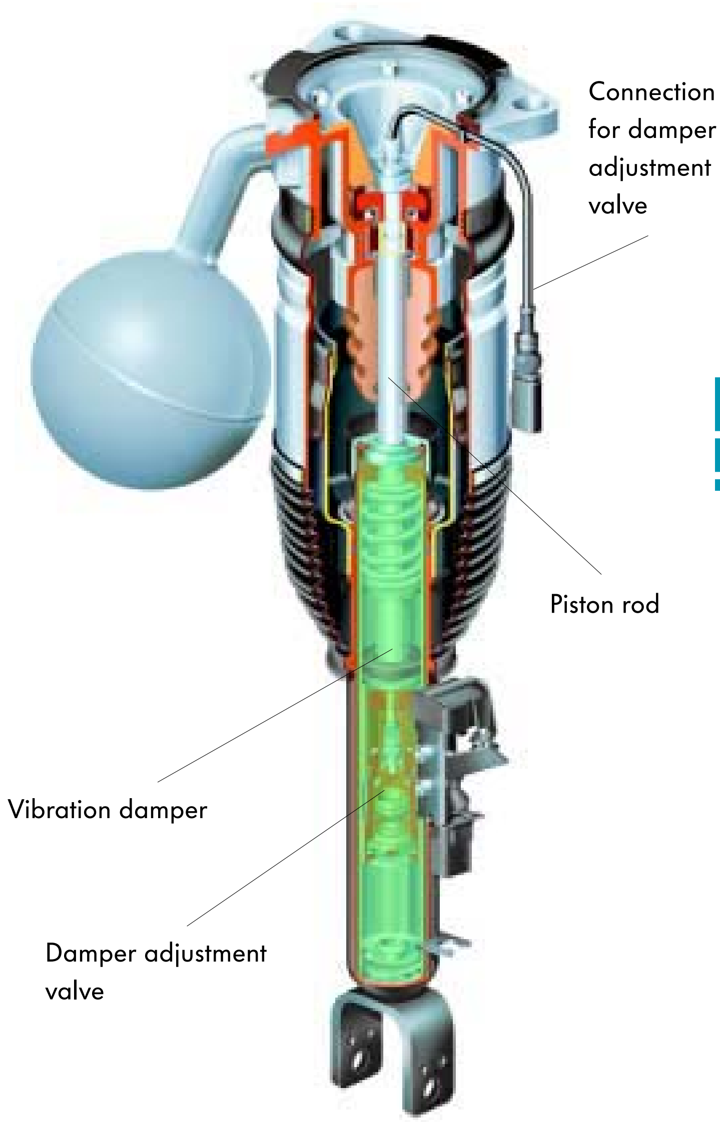
Air spring strut, rear axle

Air spring part (blue)



275_087

Damper part (green)



275_085

Design and function

Air supply unit

The air supply unit (ASU) is a compact unit. It is mounted to the underbody on an anti-vibration mounting in the spare-wheel well adjacent to the activated charcoal filter.

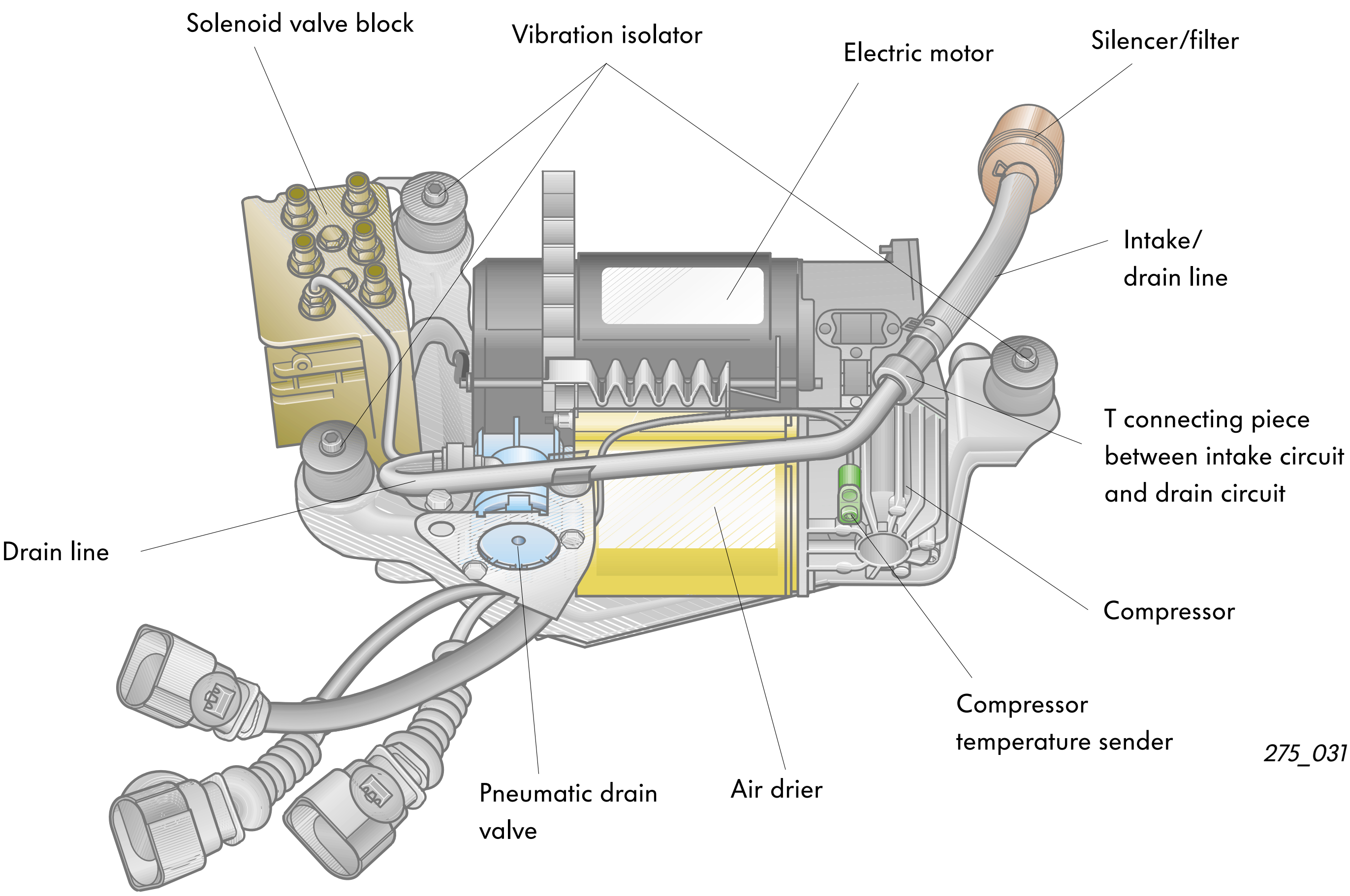
A plastic cover with vents provides protection against soiling.

The compressor is supplied with air via the luggage compartment. Air is drawn in via the silencer/filter, cleaned and discharged.

A temperature sender protects the compressor against overheating and ensures availability of the air supply for the air suspension in all climatic and driving conditions.

The air supply unit comprises:

- the compressor unit with
  electric motor,
  dry-running compressor,
  air drier,
  residual pressure maintaining unit,
  maximum pressure limiter,
  drain circuit/valve,
  silencer with air filter,
  compressor temperature sender
  (temperature sender for overheating protection),
  pneumatic drain valve with pressure relief valve and
- the solenoid valve block with
  control valves for each air spring strut and for the pressure accumulator as well as
  an integrated pressure sender for monitoring the pressure accumulator.



275_031

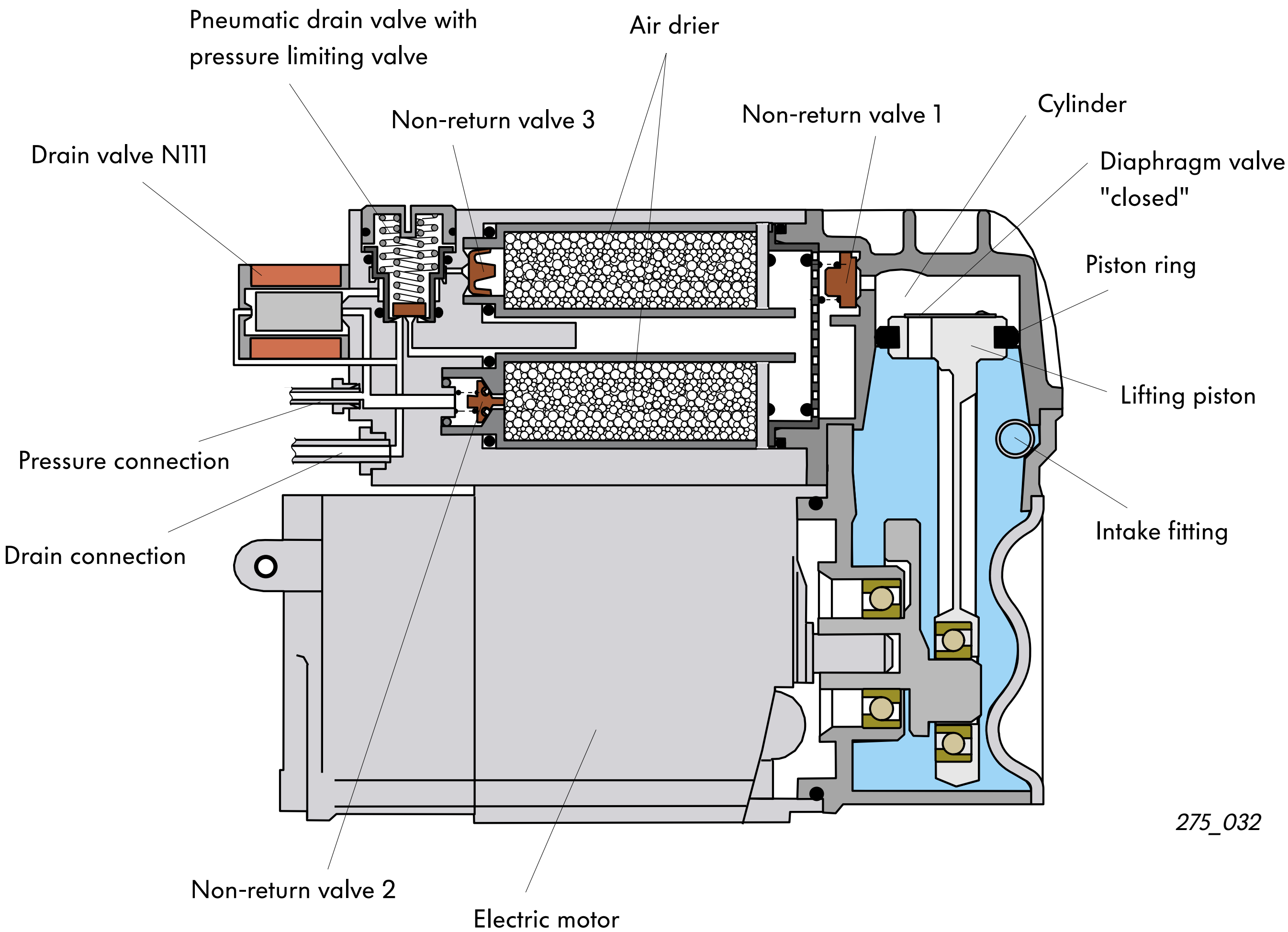
Compressor unit

Compressed air is produced by means of a single-stage piston compressor with integrated air drier.
To prevent soiling of the gaiters and the air drier (drier cartridge), the compressor is designed as a so-called dry-running compressor.

Lifetime-lubricated bearings and a piston ring made of PTFE (polytetrafluorethylene) ensure a long service life.

The drain valve N111, a pneumatic drain valve with pressure limiting valve and 3 non-return valves are integrated in the air drier housing.

To protect the compressor against overheating, it is switched off if excess temperature occurs.



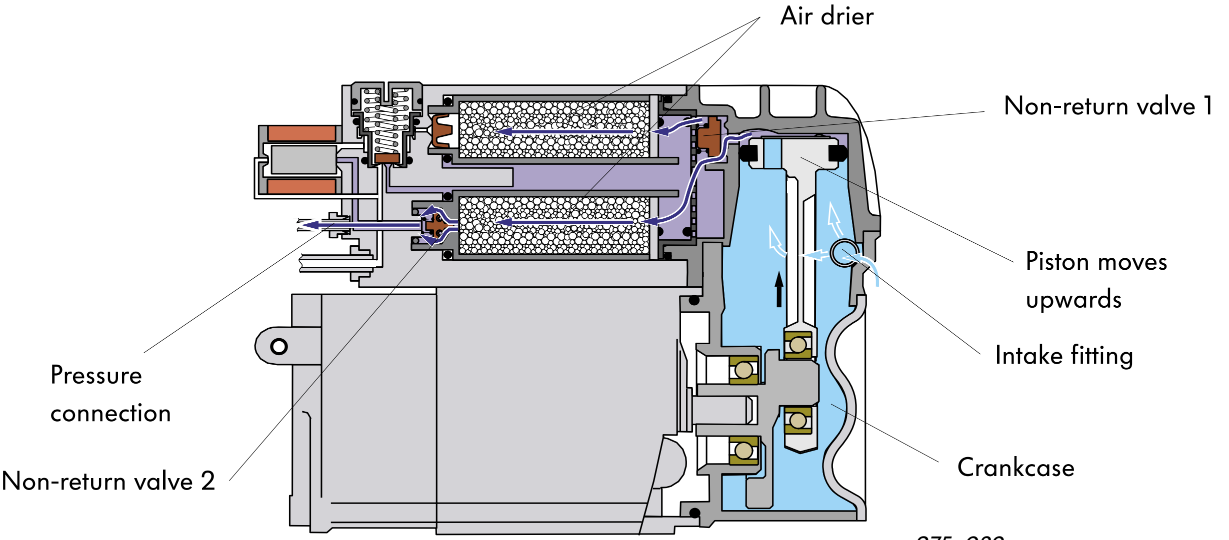
275_032

Design and function

Intake/compression cycles

During the upwards movement of the piston, air is drawn into the crankcase through the intake fitting via the silencer/filter. Air in the cylinder is compressed above the piston and flows into the air drier via non-return valve 1.

The compressed and dried air flows via non-return valve 2 and the pressure connection to the valves and the pressure accumulator.



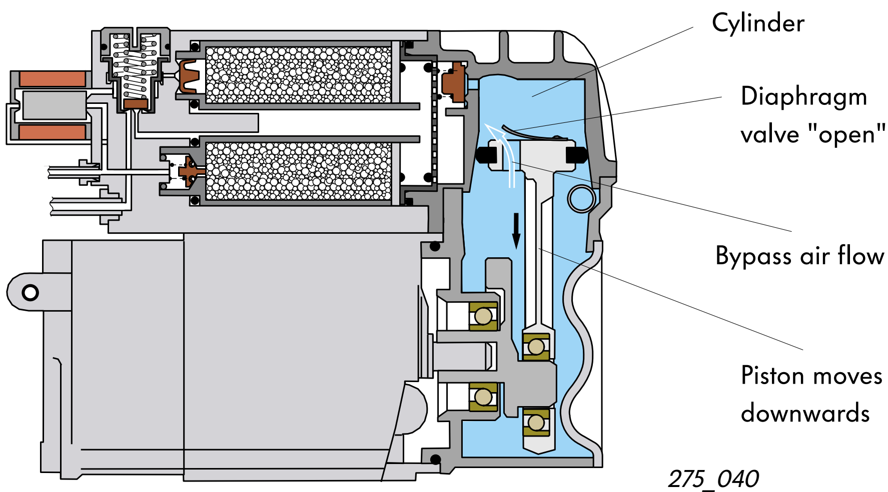
275_039

Bypass air flow

During the downwards movement of the piston, air drawn into the crankcase bypasses the diaphragm valve and flows into the cylinder.

Fill/lift cycles

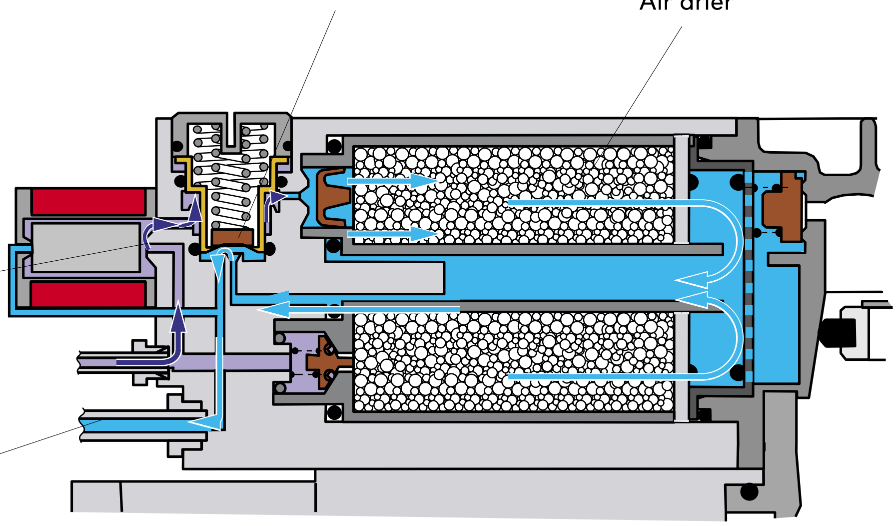
To fill the springs (i.e. raise the vehicle), the control unit activates the compressor relay and the air spring valves at the same time.



275_040

Drain/lowering cycles

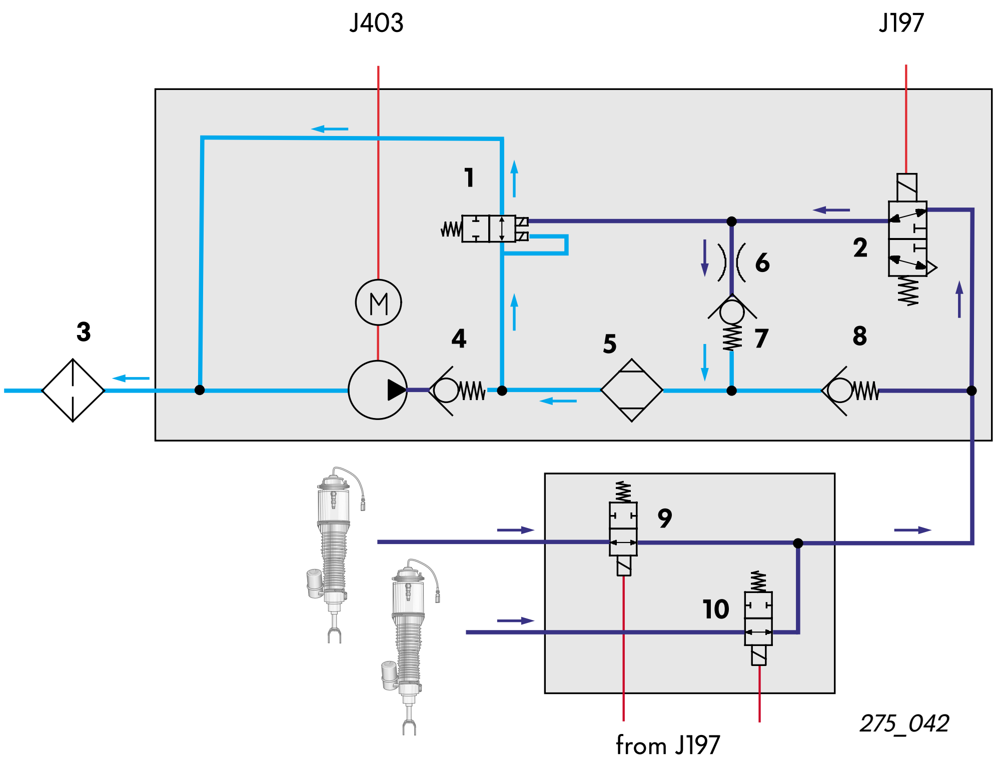
Suspension strut valves N148 and N149 and drain valve N111 are activated (open) during the drain cycle. The air spring pressure flows towards the pneumatic drain valve and from there into the spare-wheel well in the luggage compartment via the air drier, the pressure limiting valve and the silencer/filter.



275_041

Pneumatic diagram of "drain" cycle
(example: rear axle)

1 - Pneumatic drain valve
2 - Electric drain valve N111
3 - Silencer/filter
4 - Non-return valve 1
5 - Air drier
6 - Drain restrictor
7 - Non-return valve 3
8 - Non-return valve 2
9 - Suspension strut valve N148
10 - Suspension strut valve N149



275_042

Pneumatic drain valve

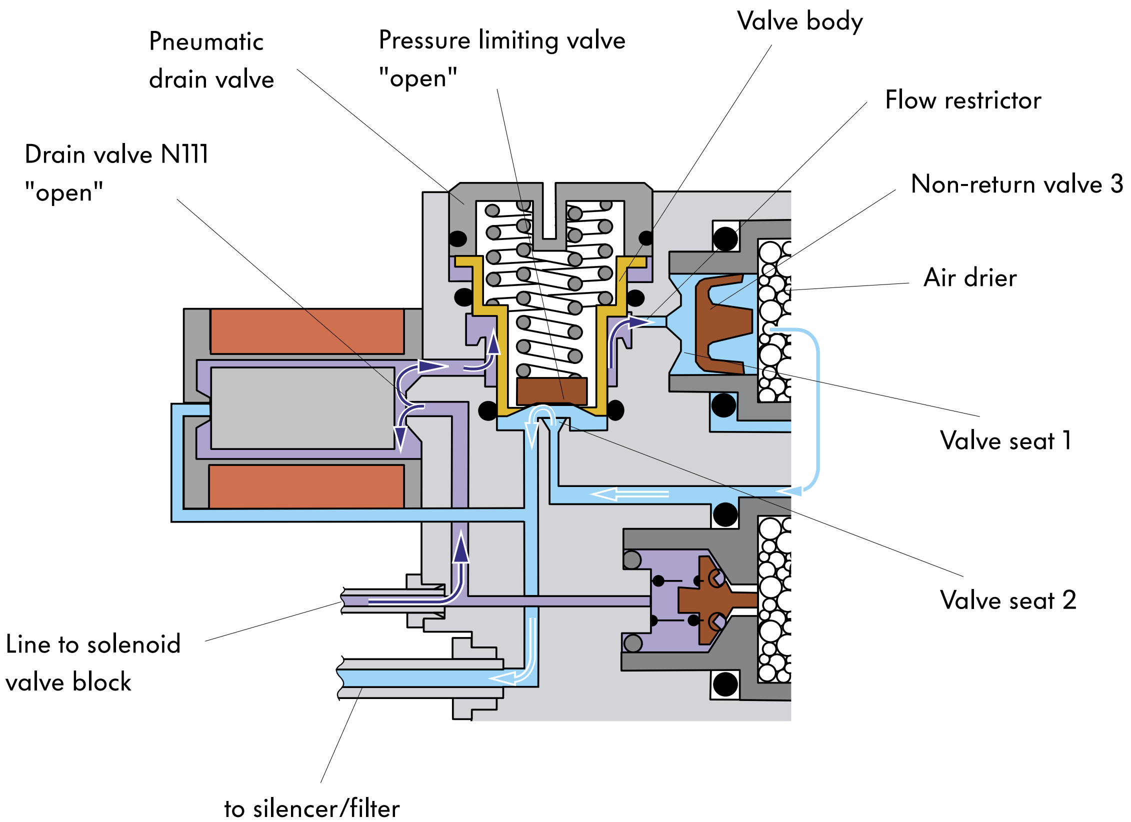
The pneumatic drain valve performs two functions:

– residual pressure maintenance and
– pressure limitation.

To prevent damage to the air springs (air spring gaiter), a specific minimum pressure of > 3.5 bar (residual pressure) must be maintained.
The residual pressure maintenance function ensures that pressure in the air spring system does not drop below 3.5 bar during pressure relief (except in the case of leaks which occur upstream of the pneumatic drain valve).

When an air spring pressure of > 3.5 bar is applied, the valve body lifts against the spring force of the two valve springs and opens valve seats 1 and 2. The air spring pressure is now admitted into the air drier via the flow restrictor and non-return valve 3. After passing through the air drier, the air bypasses the valve seat of the pressure limiting valve and the drain filter in the spare-wheel well in the luggage compartment.

A sharp decrease in pressure downstream of the flow restrictor leads to a reduction in relative atmospheric humidity, thereby increasing the amount of moisture absorbed by the "waste air".

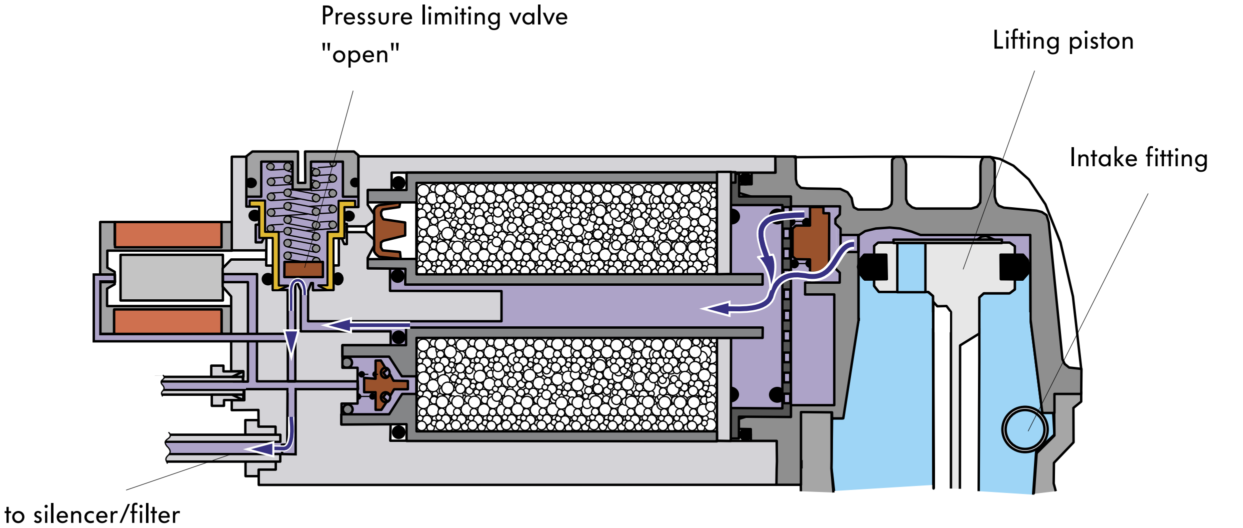


275_043

Pressure limiting valve

The pressure limiting valve protects the system against excessively high pressures, e.g. if the compressor fails to cut out due to a defective relay contact or a defective control unit.

In this case, the pressure limiting valve opens against the spring force when the pressure exceeds approx. 20 bar, and air conveyed by the compressor escapes via the filter.



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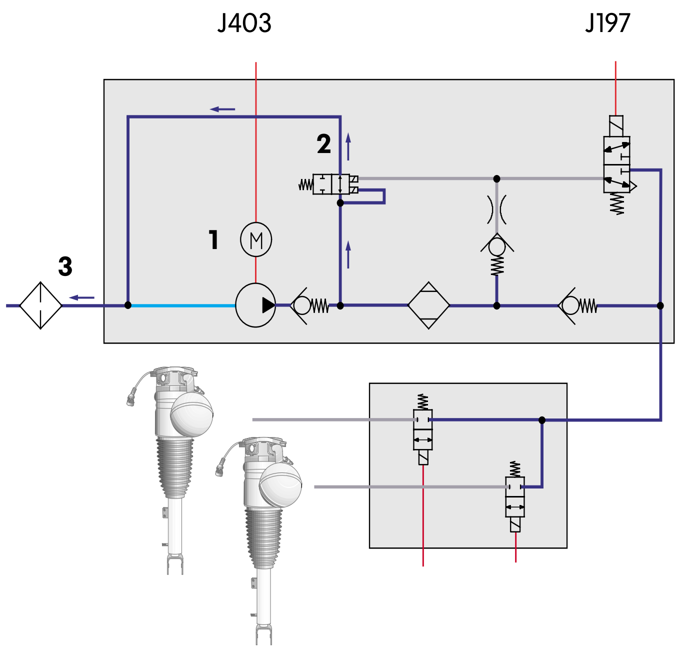

1 - Compressor
2 - Pneumatic drain valve with pressure limiting valve
3 - Silencer/filter

275_044a