PORSCHE

The closed air suspension system of the Porsche Panamera

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Dipl.- Ing. Torsten Nitschke, responsible project engineer for the Panamera air spring system, Dr. Ing h. c. F. Porsche AG

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- Components
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- Control unit and software development process
- System functionality and controller strategy
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Comfort

Performance	Driving pleasure and emotion	Efficiency

- the best possible driving performance and superior traction
- great driving pleasure and agility
- maximum driving safety and superb handling
- excellent driving comfort and the familiar day-to-day usability

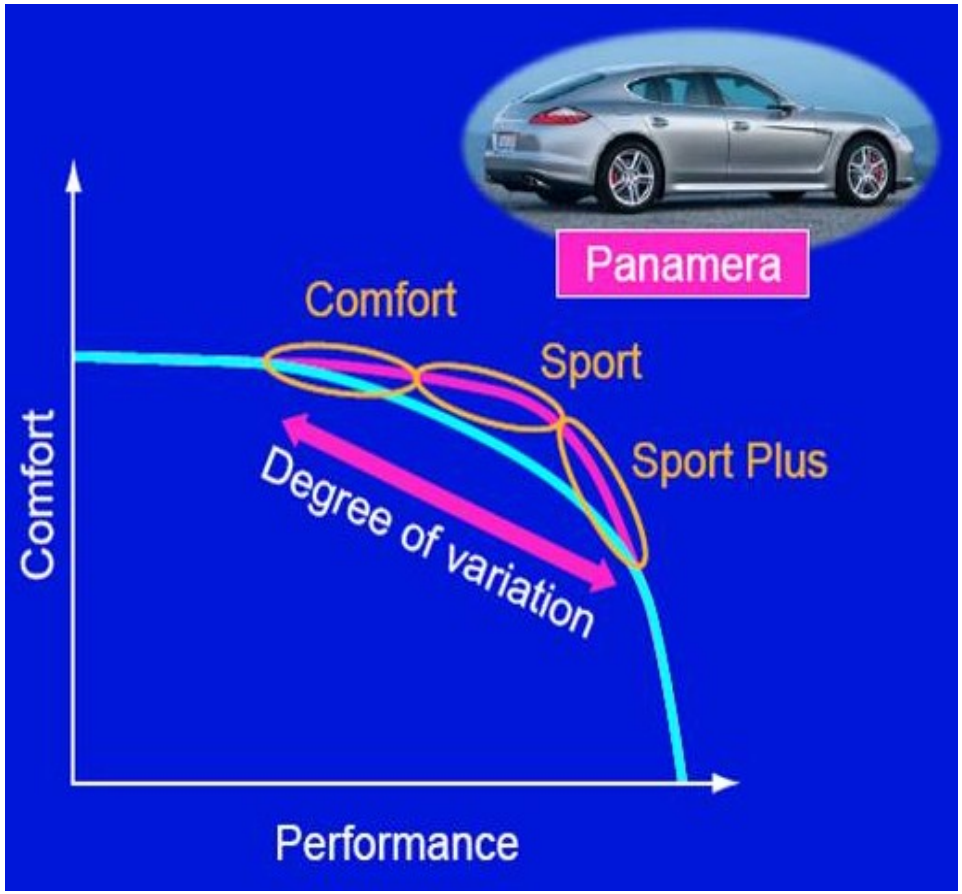


fig. 1: variation of suspension set up

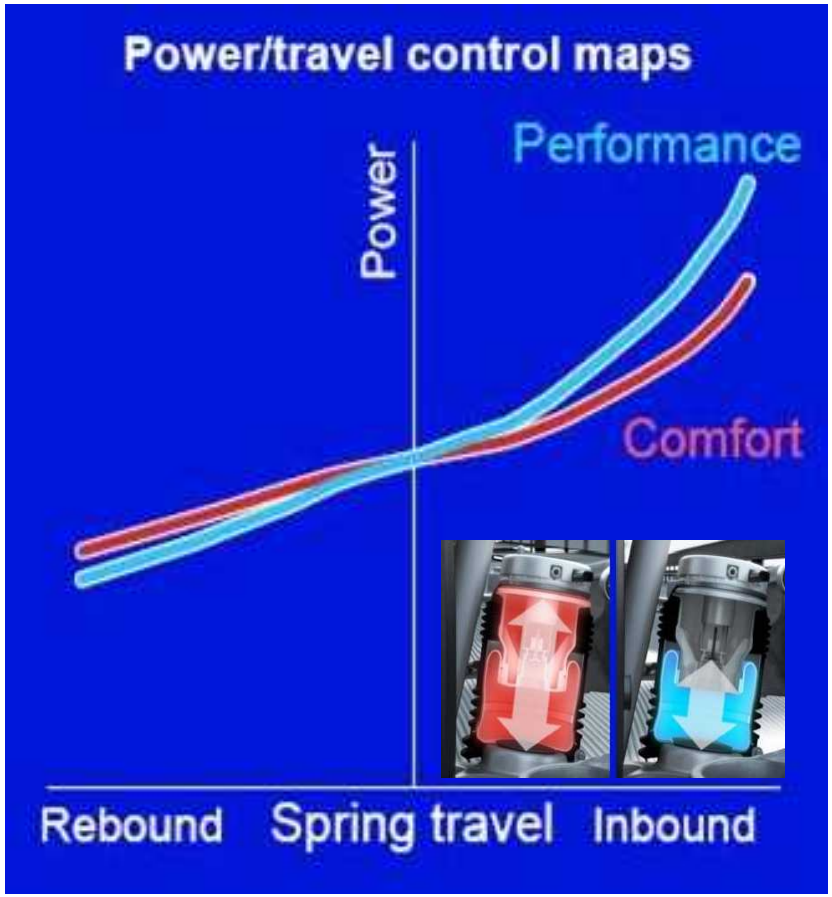


fig. 2: variation of spring rate

Operation and function

fig. 3: interieur Panamera

fig. 4: operation panel

- Comfort => shock absorber comfort + normal vehicle level + soft spring rate
- Sport => shock absorber sport + normal vehicle level + soft spring rate
- Sport Plus => shock absorber performance + low vehicle level + hard spring rate

Operation and function

Lift level : + 20 mm above normal vehicle level

Normal vehicle level

Low level : - 25 mm below normal vehicle level

fig. 5: various vehicle levels

Components

- front air spring strut with additional air volume and PASM shock absorber,
- separate rear air spring with additional air volume and PASM shock absorber
- air supply system with compressor, pressure sensor and pneumatic valve block
- 5.2 litre air reservoir
- wheel travel sensor on each corner
- two front and one rear acceleration sensor
- temperature sensor
- Electronic Control Unit (ECU)

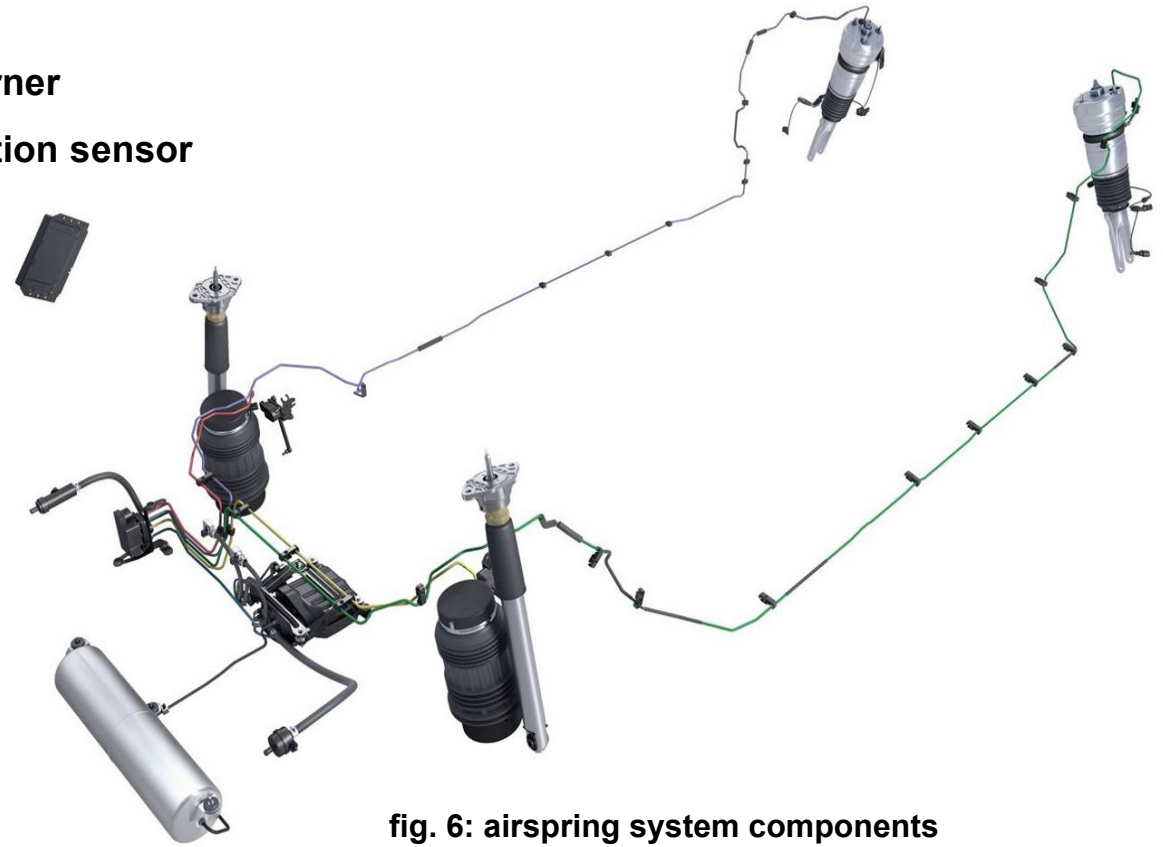


fig. 6: airspring system components

The closed air supply system

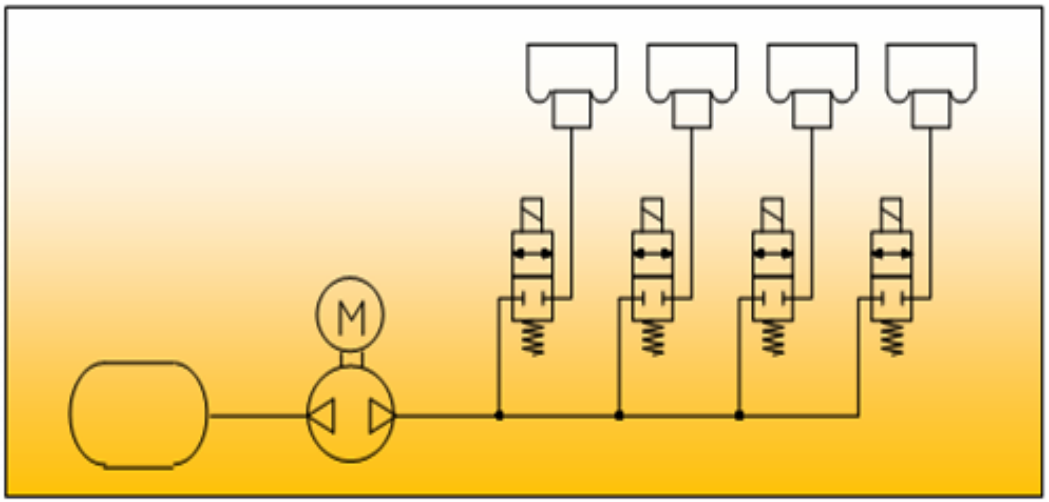


fig. 7: pneumatic scheme of the closed system

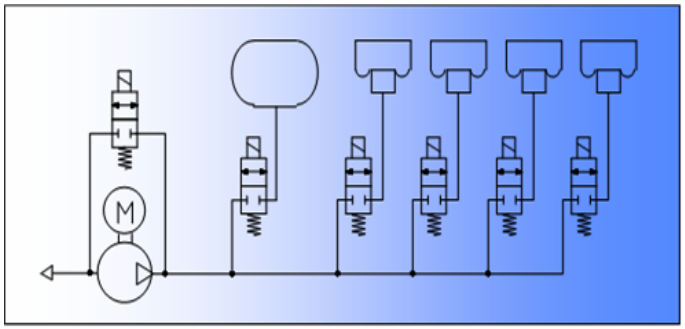


fig. 8: pneumatic scheme of the open system

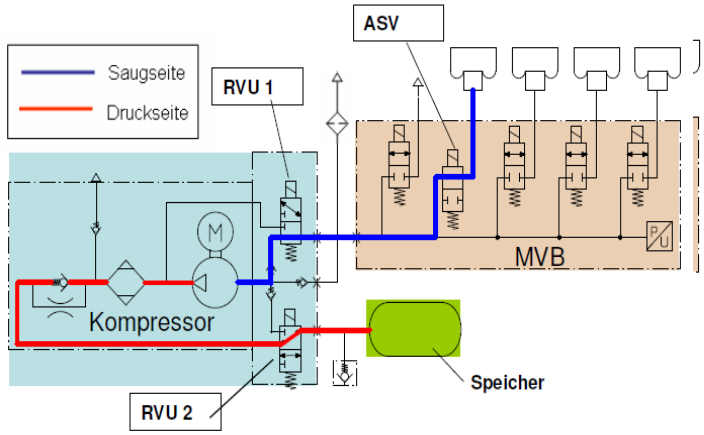


fig.9b: scheme air spring fitting

Advantages of the closed compared to the open air supply system:

- energy consumption reduced by around 60%
- compressor operating time reduced by 75%
- high adjusting speed v > 4mm/s
- weight savings of around 1kg
- less costs due to smaller components

Control unit and software development process

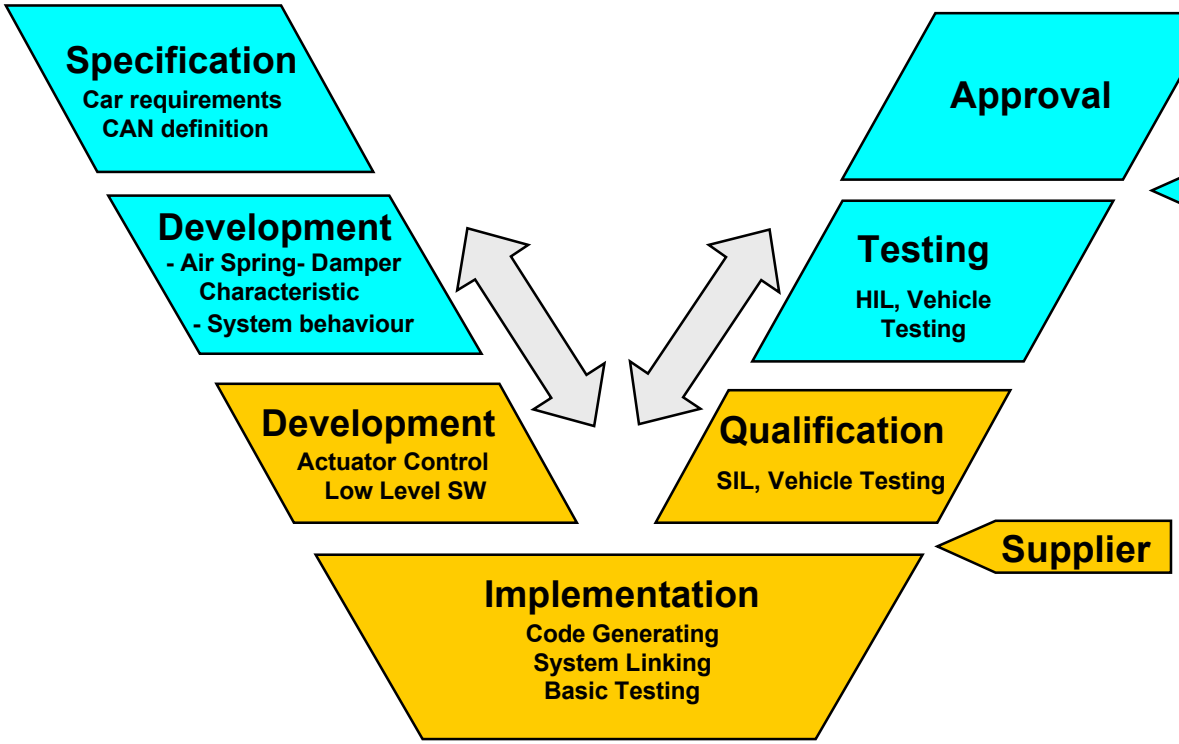


fig. 10: V- development scheme

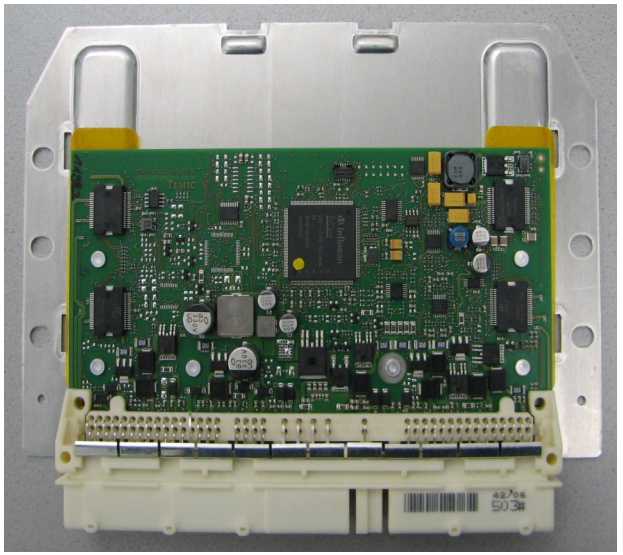
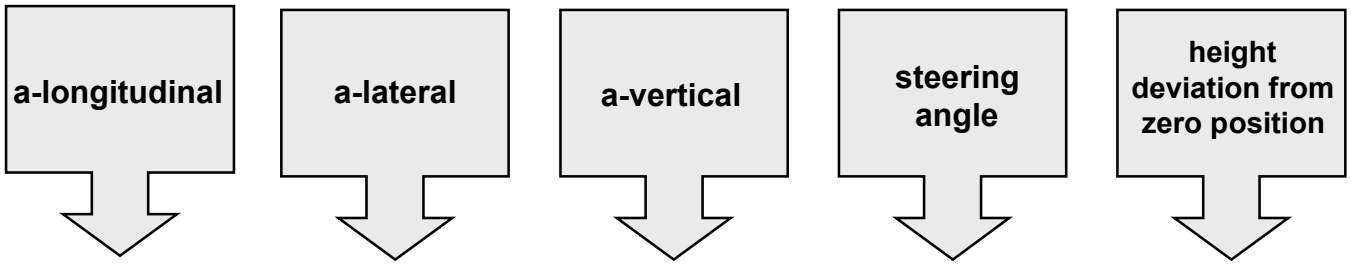
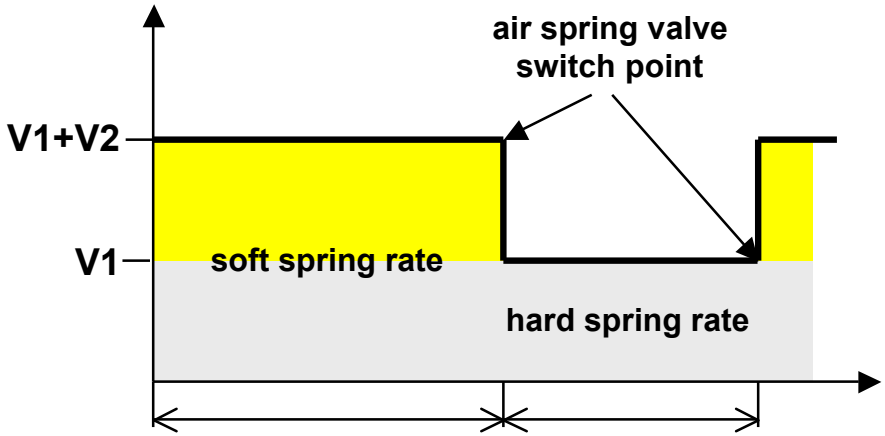


fig. 11: ECU Hardware

System functionality and controller strategy

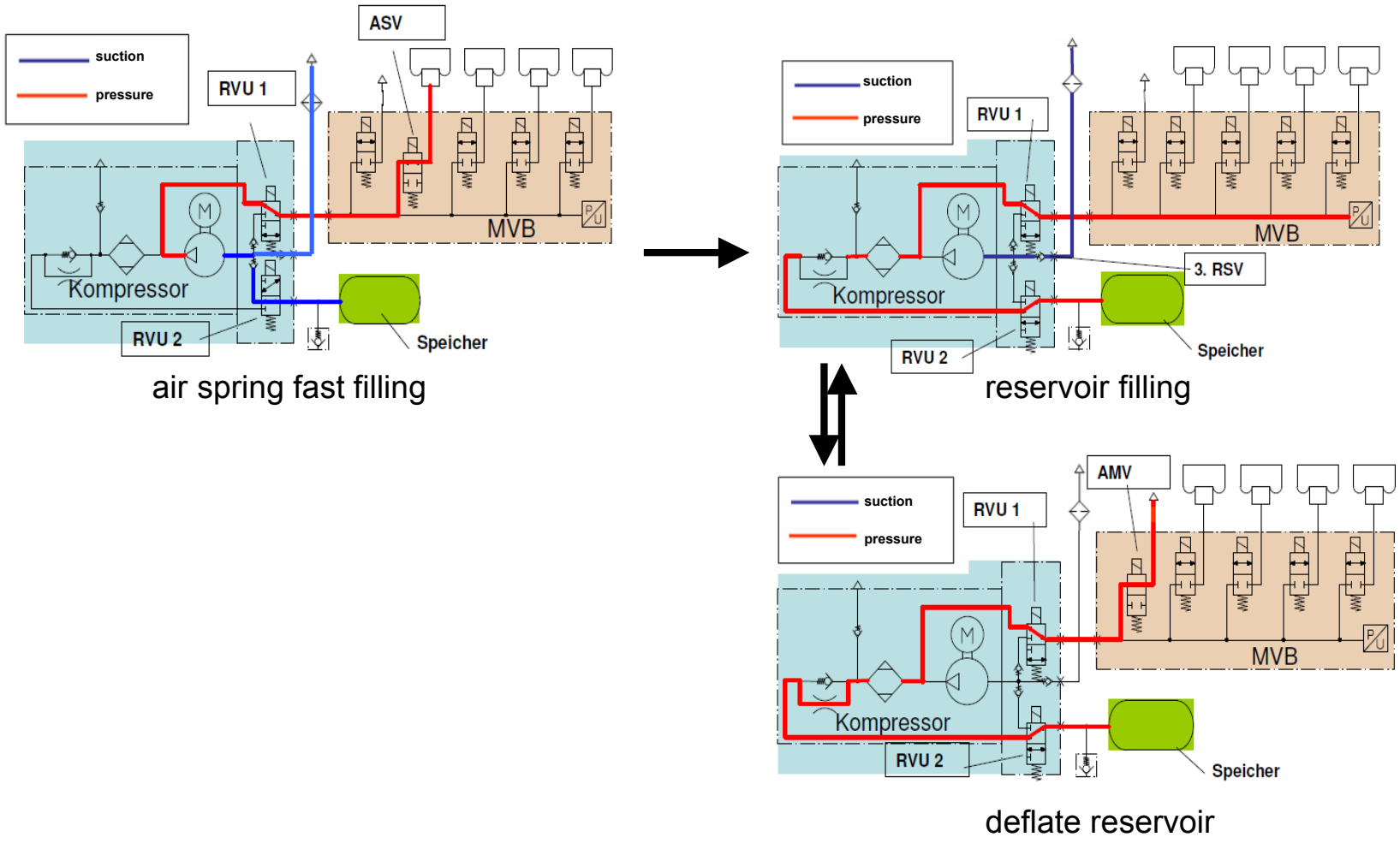
- Spring rate switch point





System functionality and controller strategy

• Air leakage compensation



System functionality and controller strategy

- **Diagnostics and fault detection**

fig. 12: PIDT-Tester

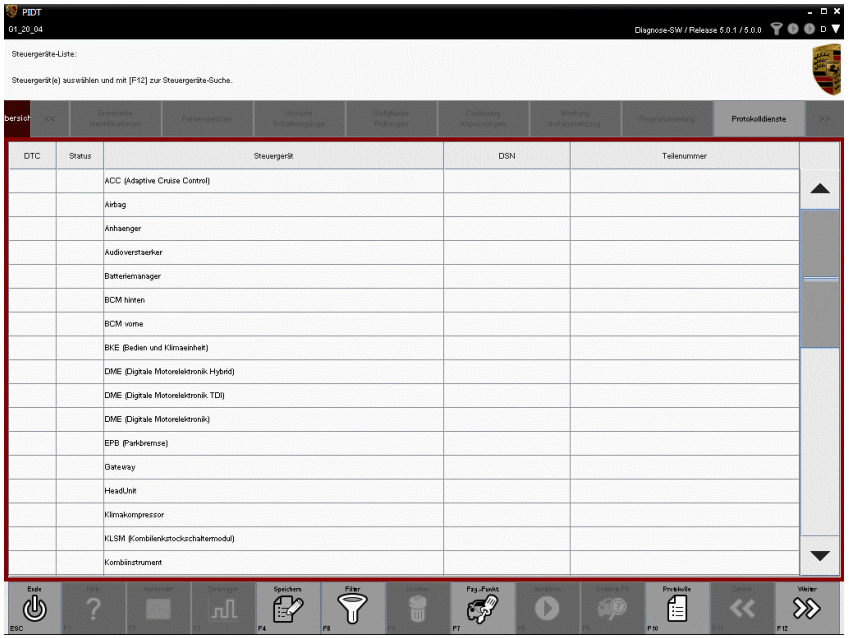


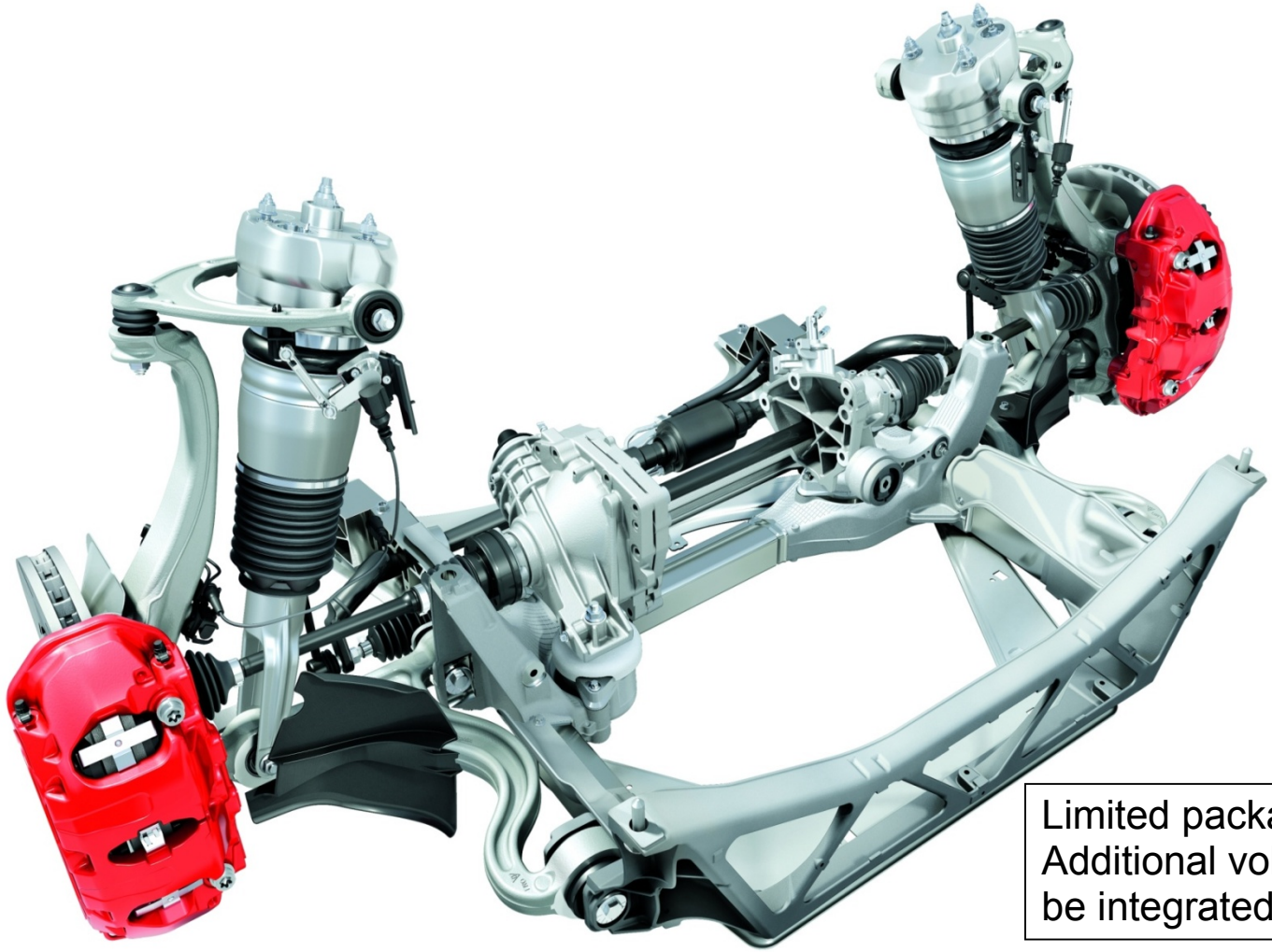
fig. 13: user interface

Handing over to Continental AG

The new air spring design of the Porsche Panamera

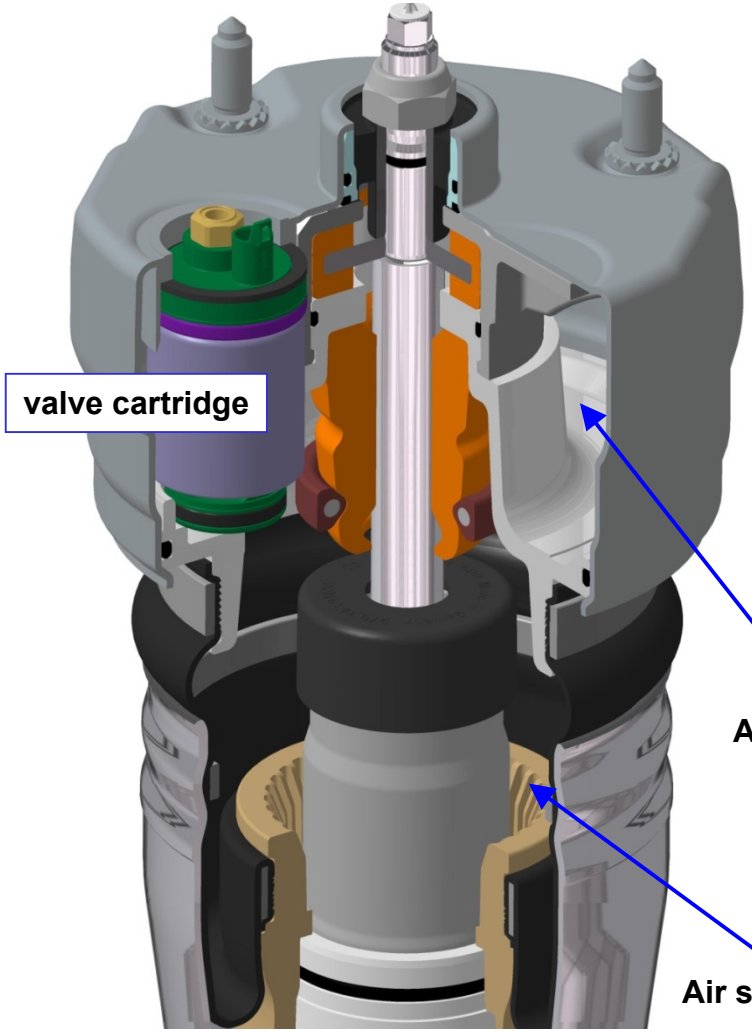
Andreas Nessel
Stuttgart, 22.06.10

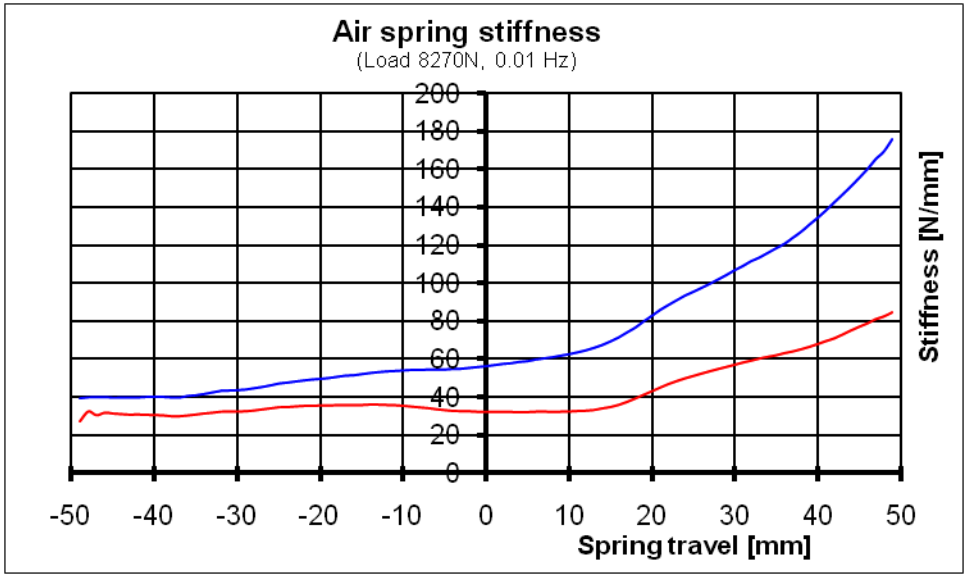
Panamera front axle – Package of air struts



Limited package space
Additional volume and valve must be integrated into the air spring

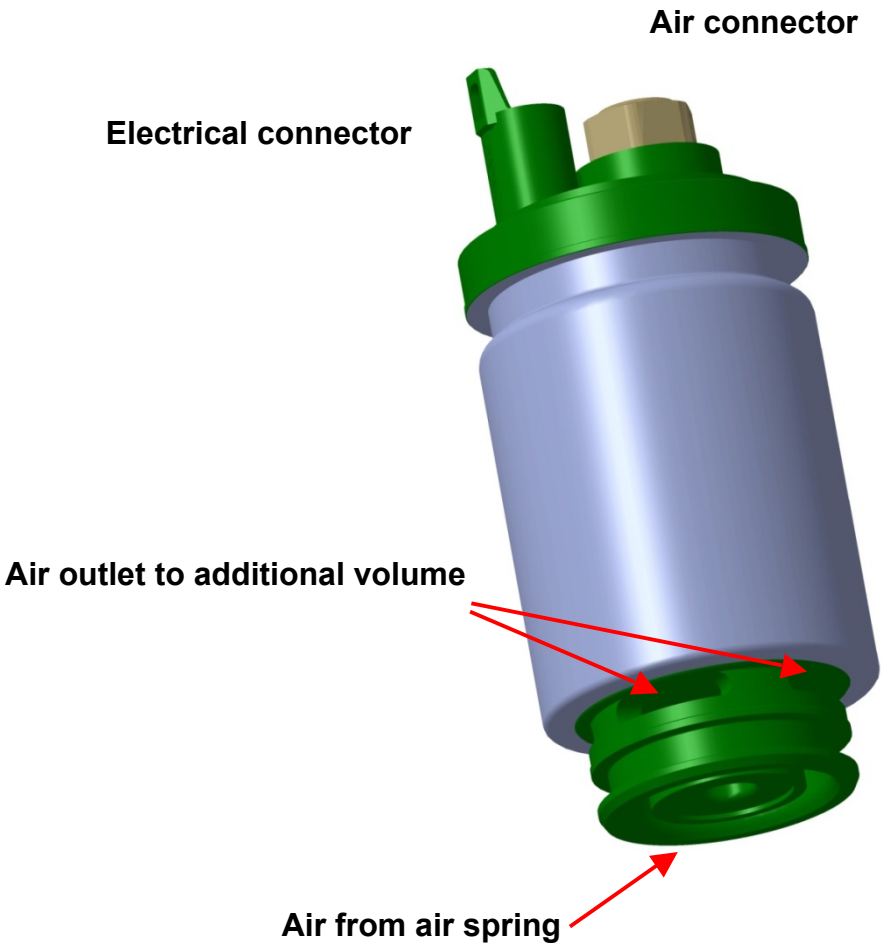
Integration of addition volume





Switch to sport plus mode by separation of the additional volume

Addition volume valve

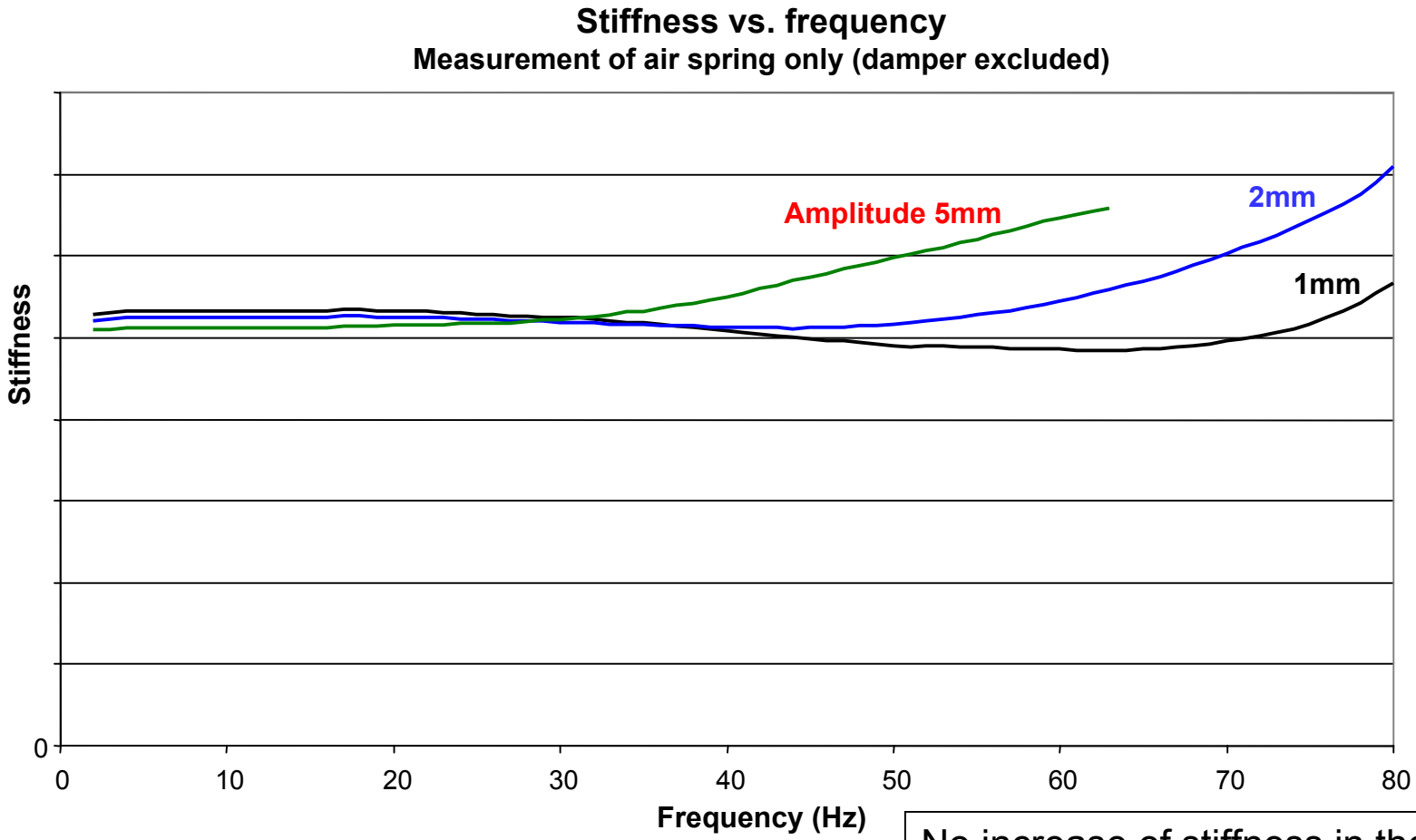


Technical data:

- Nominal opening diameter 12mm
- Mass 370g
- Diameter 40mm
- Switch time < 100ms
- Integrated air spring filling

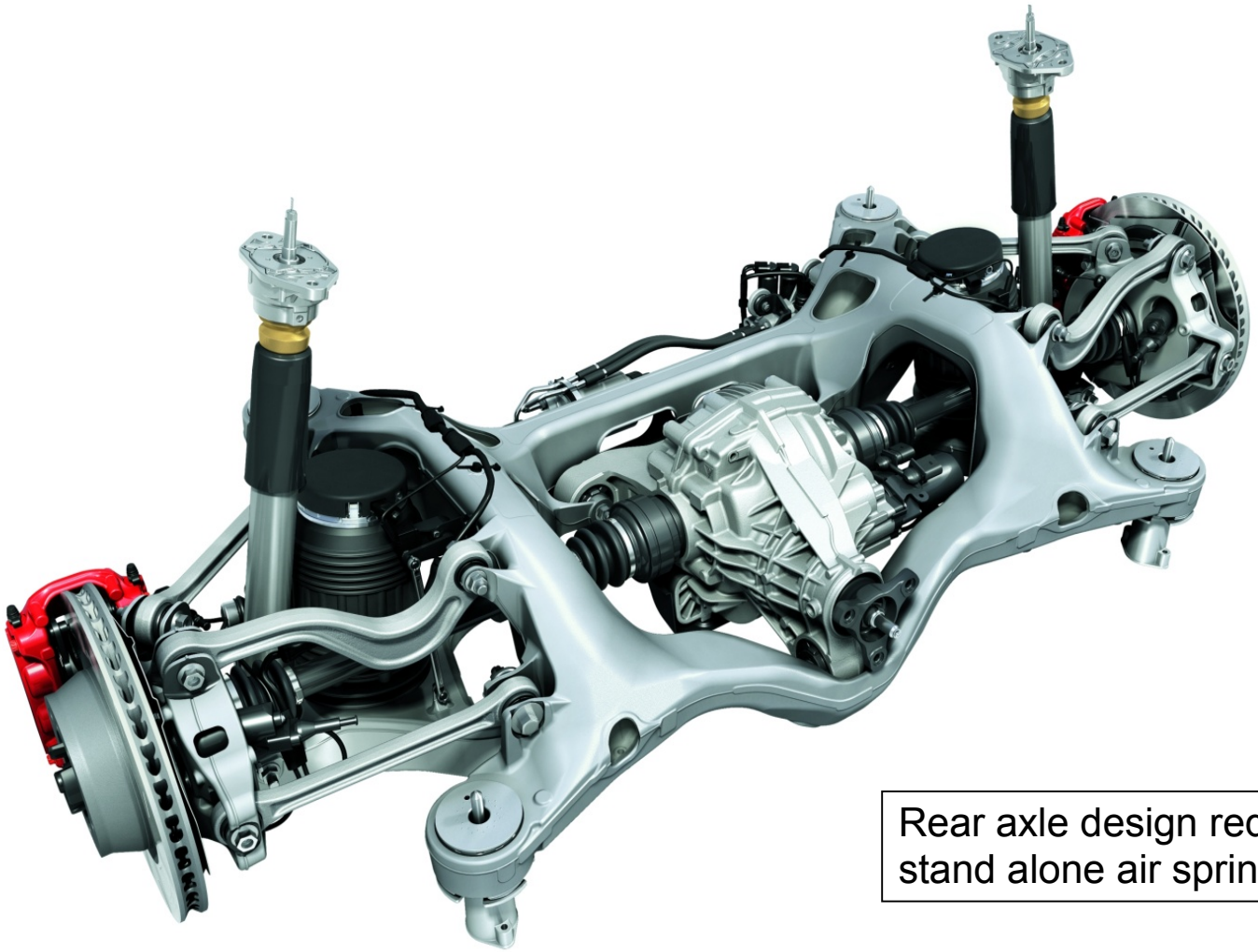
Development of a new valve to meet the weight and packaging targets

Dynamical behavior of the front axle air spring



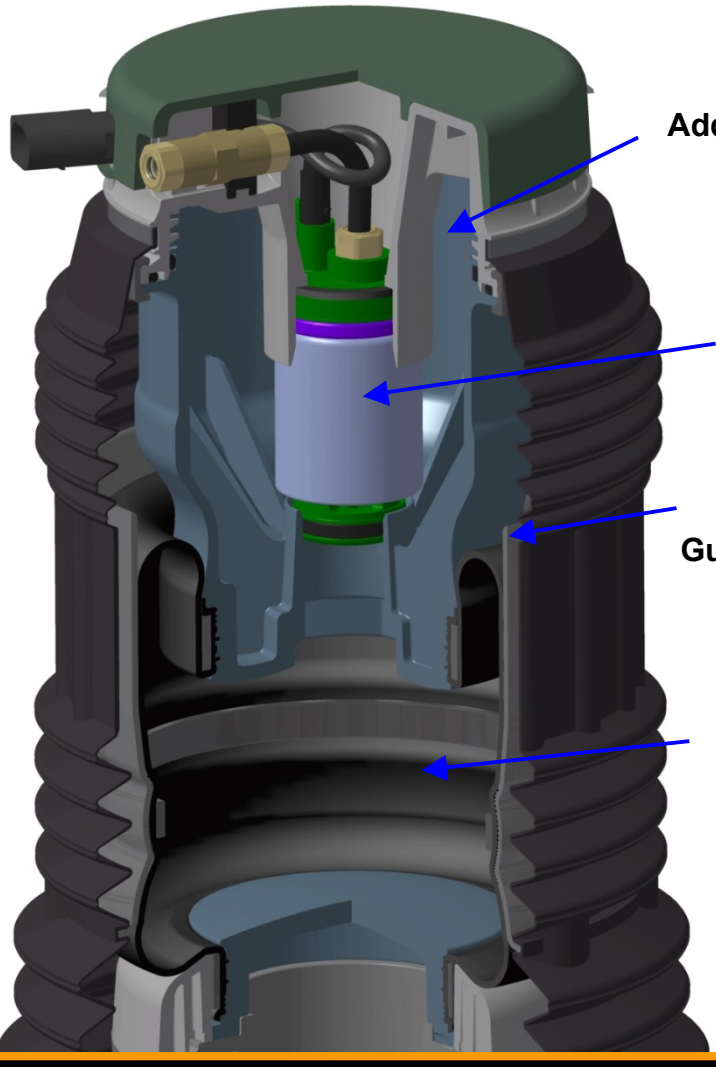
No increase of stiffness in the frequency area relevant for ride comfort

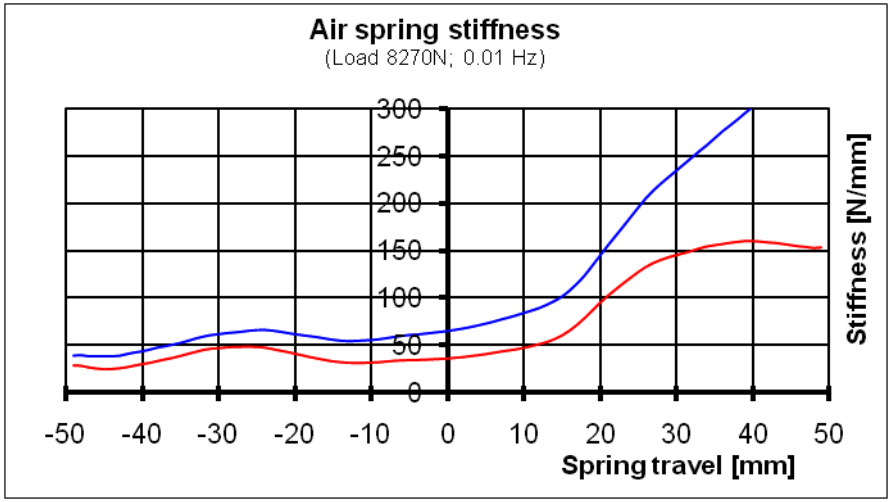
Panamera rear axle – Package of air springs



Rear axle design requires stand alone air spring

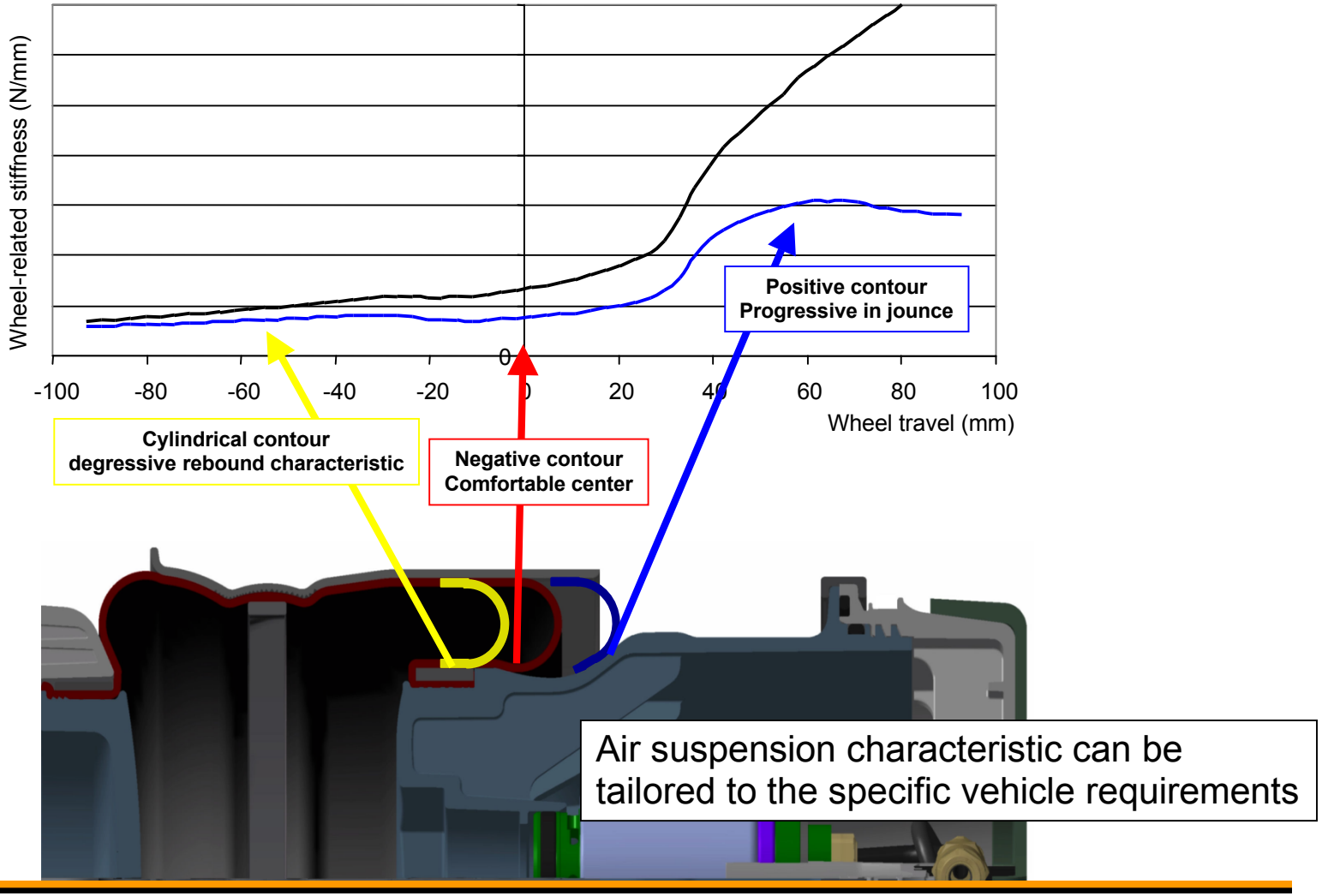
Design of rear axle air spring



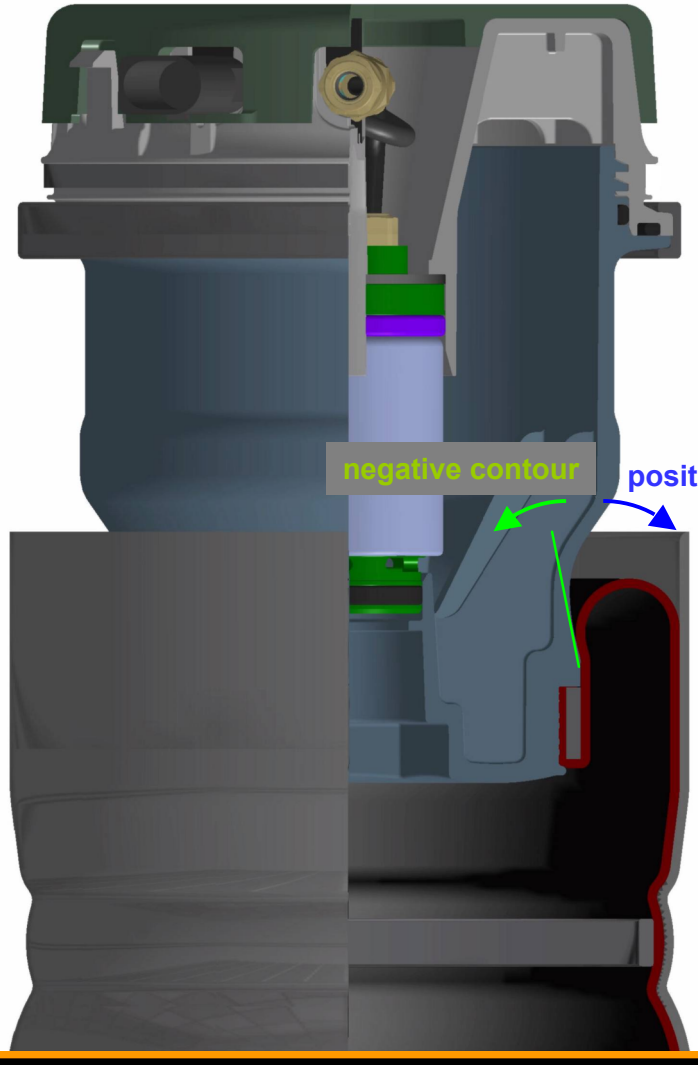


Switch to sport plus mode by separation of the additional volume

Influence of piston contour on air spring characteristics



Piston contour

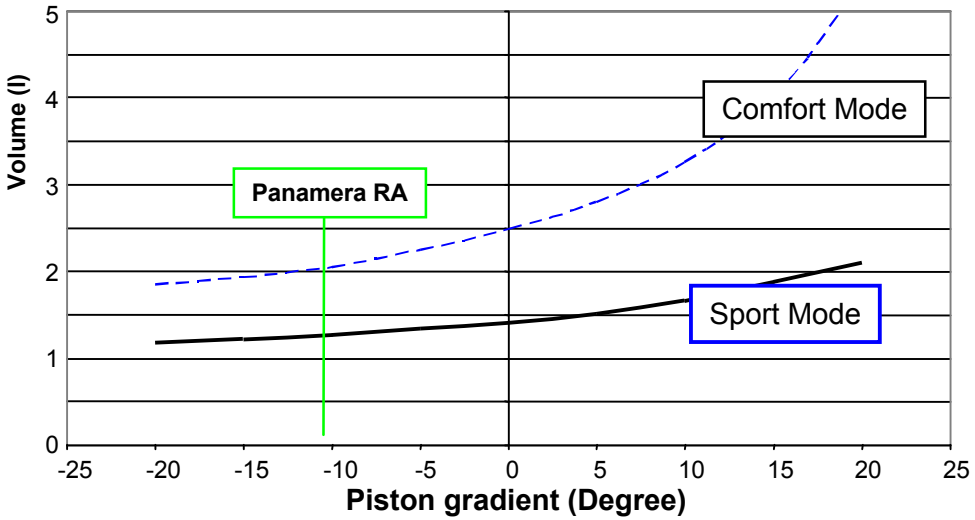


Negative piston contour

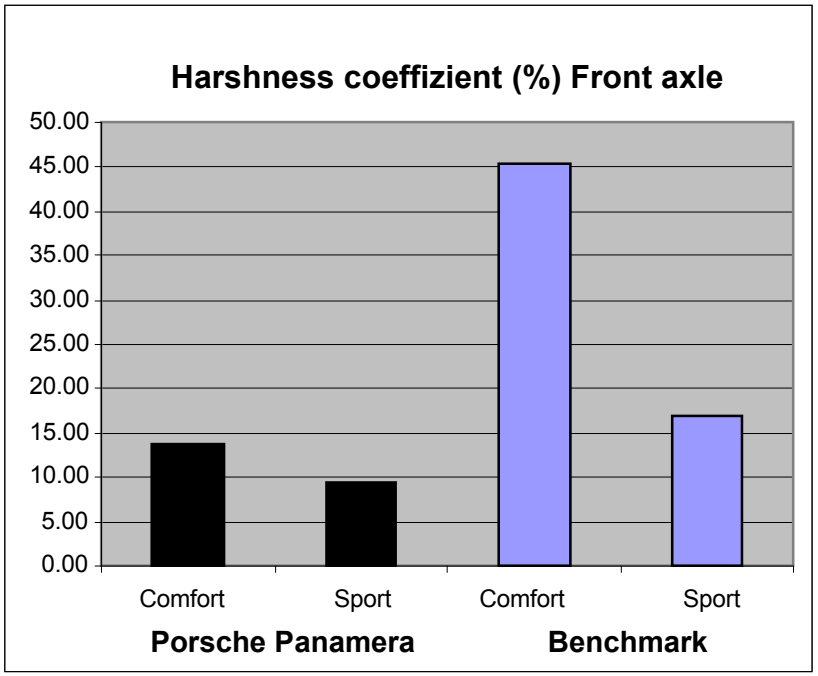
=> Reduction of stiffness

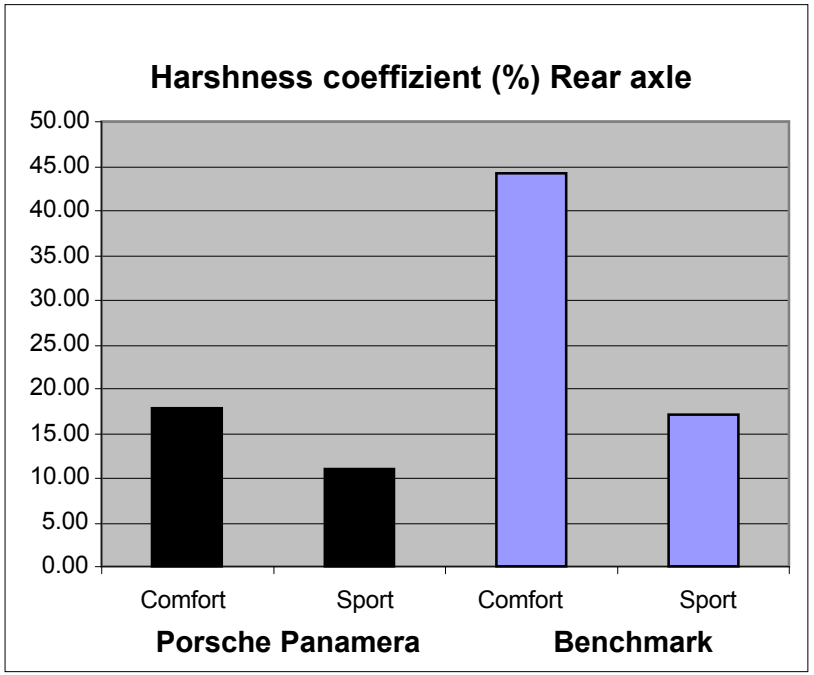
=> Lower air spring volume required for given stiffness

Required air spring volume vs. Piston gradient



Benchmarking of air spring related harshness





$$HarshnessCoefficient = \frac{c_{0,1} - c_{25}}{c_{25}} \cdot 100\%$$

Low harshness due to bellow design

Summary

Switchable rate air springs…

…enable the driver to select between sportive and comfortable characteristic.

…influence the steering behaviour in the direction of a more agile handling in the sport mode.

A compact design enabled by…

…a new developed smaller valve and the integration of the additional volume into the air spring module.

…reduction of required air spring volume by appropriate piston contour design.

Outstanding air spring comfort achieved by…

… using outer guiding tubes, for the Porsche Panamera the very first time for a stand alone air spring module on the rear axle.

…using bellows with comfort supporting harshness properties.

Questions and Discussion

Thank you for your attention