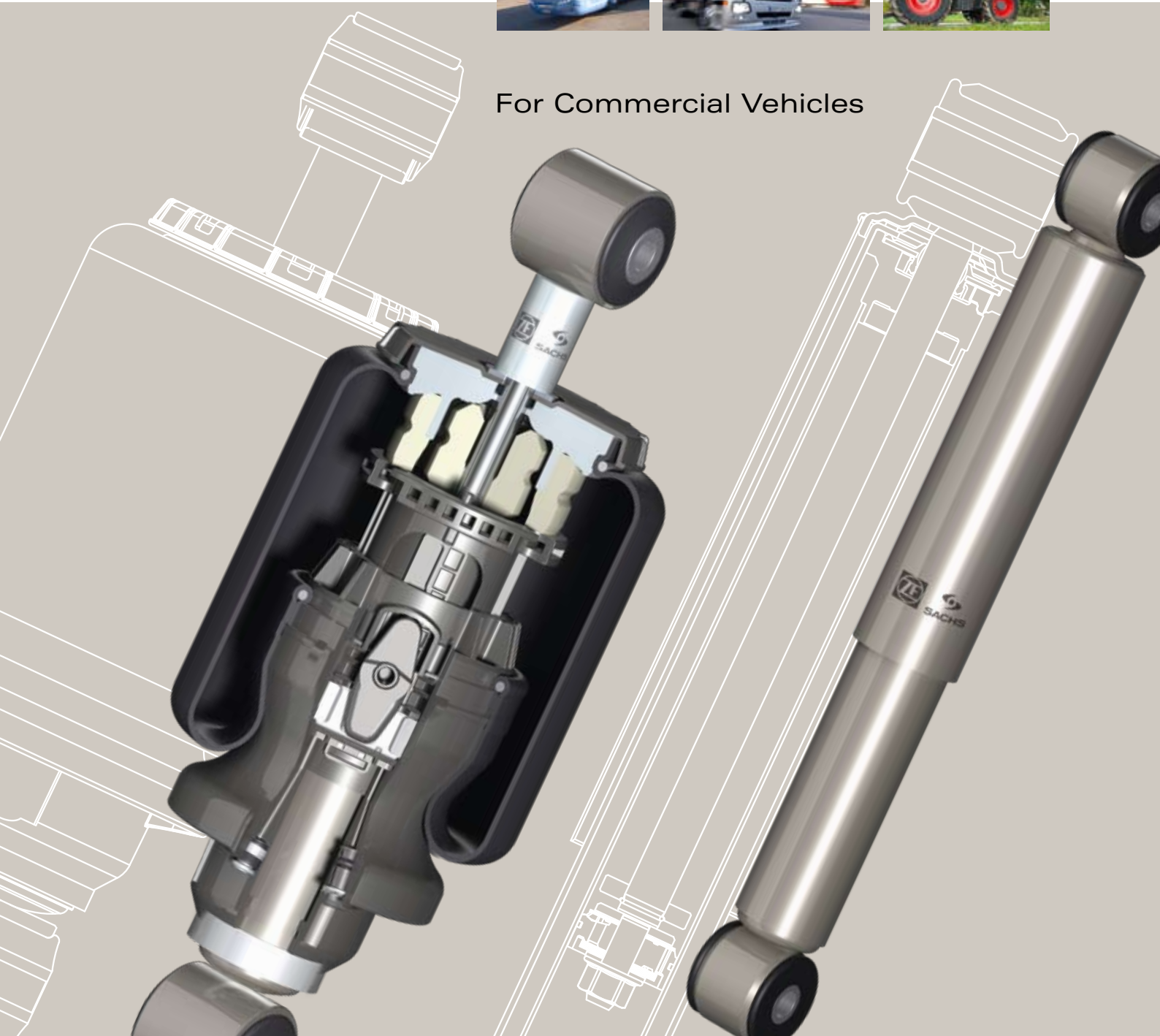


Suspension Components and Systems



For Commercial Vehicles

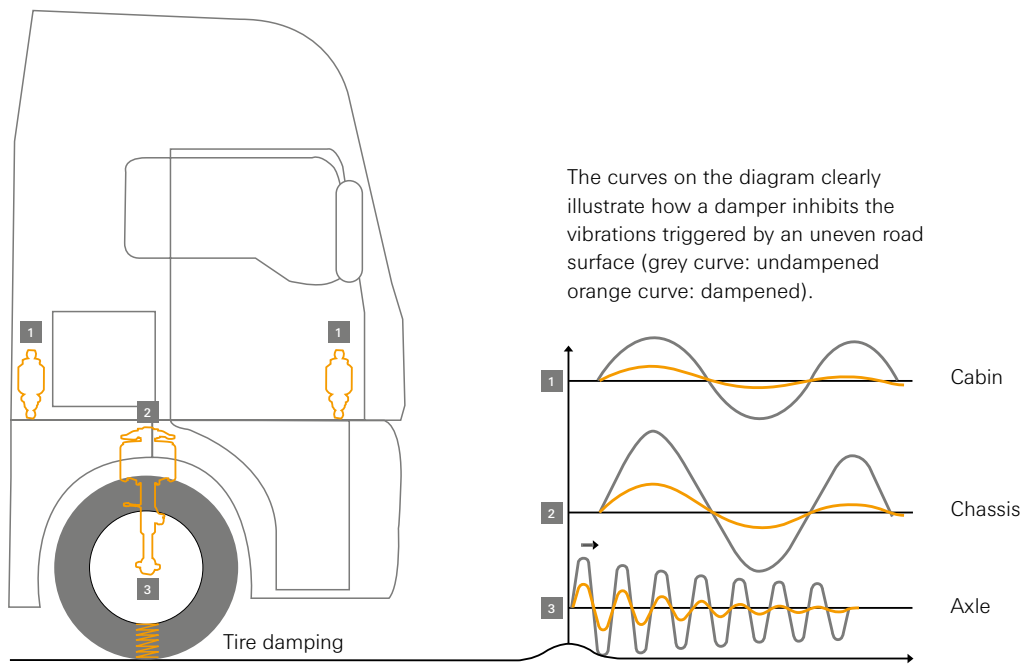


Vibration and Motion Damping from ZF Sachs: Safe, Comfortable and Economical

ZF Sachs develops and produces vibration and motion dampers and modules for commercial vehicle suspension and cabin mounts for commercial vehicle manufacturers worldwide. ZF Sachs demonstrates its expertise in the development of comprehensive solutions through intelligent systems. ZF Sachs consistently strives to advance its systematic approach in the development and production of new products and technologies for noticeable added value. As a suspension expert, ZF Sachs offers a wide range of concepts for primary suspension and cabin damping, allowing us to implement sustainable, road-ready solutions.

Quality, innovative power, secure supply, on-demand delivery, life-cycle costs and service – these are the watchwords that define our work at all locations. ZF Sachs vibration and motion dampers are reliable in a wide range of usage conditions and are a valuable contribution to our customers' success.

Vibration and Motion Damping in the Vehicle



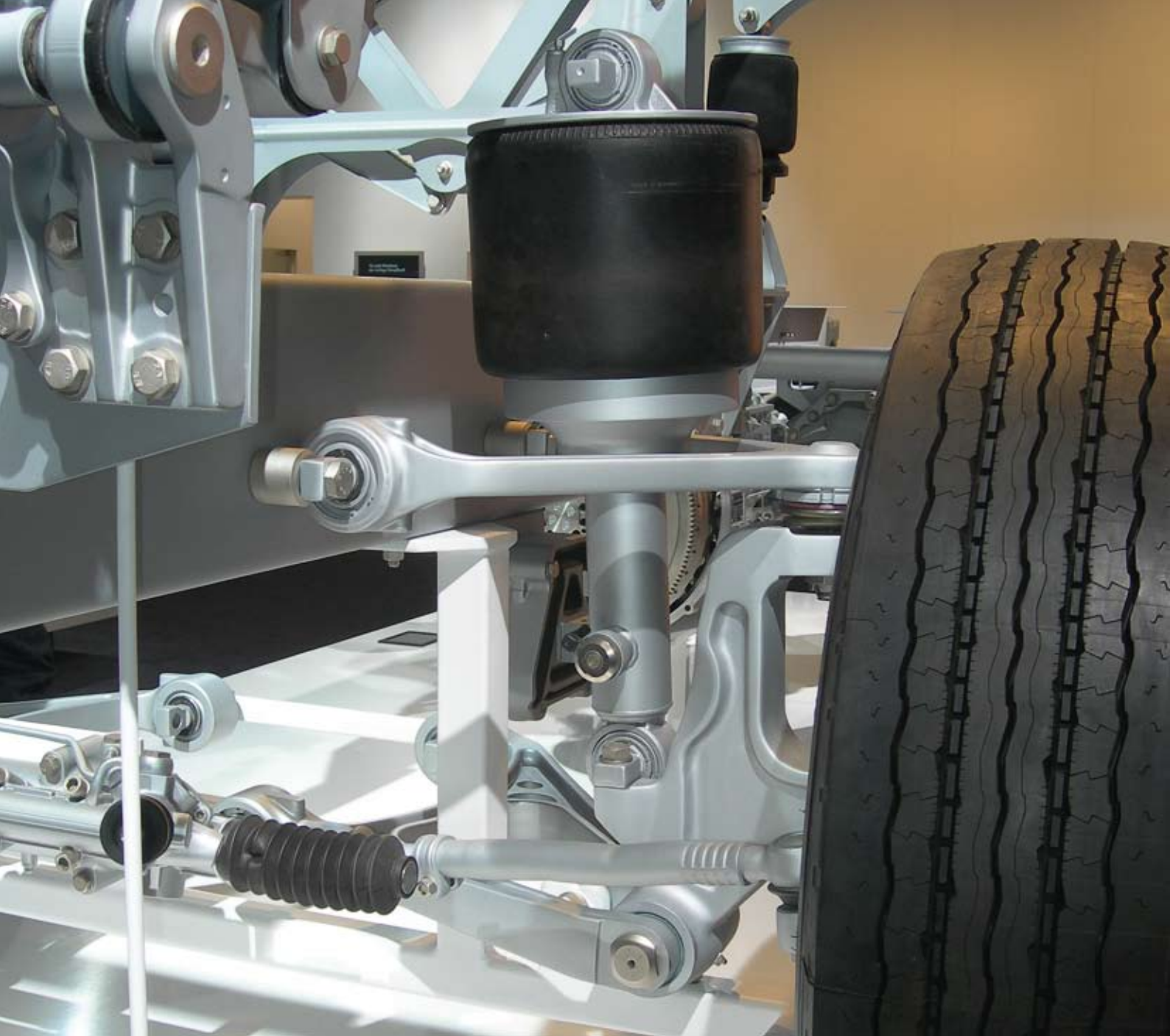
Product Range

Primary Suspension

Monotube Damper	Monotube dampers are used in the rear axles of vans.
McPherson Suspension Strut Module	In addition to its damping function, in vans the suspension strut module performs wheel control and transmits steering movements in conjunction with the the track control arms.
N-Damper	N-dampers are the standard axle dampers for medium and heavy commercial vehicles as well as buses.
Horizontal Damper	Horizontal dampers are primarily used in trailers and semi-trailers or as steering dampers.
Air Spring/Damper Module	Air spring/damper modules are used for innovative axle concepts for heavy commercial vehicles and buses.
VARIO Damper	VARIO technology is ideal for vehicles with high comfort standards.
CDC® – Continuous Damping Control	The electronically controlled damping system CDC® provides ideal damping in every situation.

Cabin Damping

Horizontal Damper	Horizontal dampers are used for the cross stabilization of cabins.
Steel Spring Module	The steel spring module is used in all types of commercial vehicle cabins. It can be combined with a manual spring base point.
Air Spring Module	Air spring modules significantly increase driving comfort in trucks, tractors and specialty vehicles.
CALM® – Cabin Air Levelling Module	The CALM® Cabin Air Levelling Module is an air spring module with integrated level regulation. There are no more external components for height sensing and equalization.
CDC® – Continuous Damping Control	The electronically controlled damping system CDC® provides the cabin with ideal damping in every situation. In particular, pitching movements are reduced significantly.



Vibration and Motion Damping for the Primary Suspension

The springs and shock absorbers compress when a vehicle is driven over bumps on the road. The impact that would otherwise jolt the vehicle is absorbed by the springs. They allow the wheel to follow the uneven course of the road while keeping the vehicle body as still as possible. The springs then release the energy they accumulate by rebounding.

In order to dampen the oscillation interplay thus generated between primary suspension and body as quickly as possible, the chassis is equipped with vibration and motion dampers. Sprung and unsprung masses vibrate in different frequency ranges. The vibration and motion dampers in the vehicle suspension system largely prevent body motion and post-oscillation, thus ensuring continuous road grip, which in turn enables good tracking and braking. Damping therefore plays a decisive role in driving safety and comfort.



Damper sizes

The selection of the ideal damper size depends on the forces of inertia and the entire suspension system as they determine the required damping forces. In addition, the length and diameter define the heat dissipating surface. The larger the damper, the larger the surface and the higher the thermal stability.

Vehicle category	Van						Special application
	Light trucks						
	Heavy trucks and buses						
Damper sizes	S27	S30	N30	N36	N45	N50	T70
Rebound [N]	3,500	4,500	6,000	11,000	16,000	20,000	30,000
Compression [N]	1,500	1,200	1,800	3,500	6,000	10,000	20,000

Maximum permissible nominal damper power for a piston speed of 0.52 m/s.

Monotube Damper

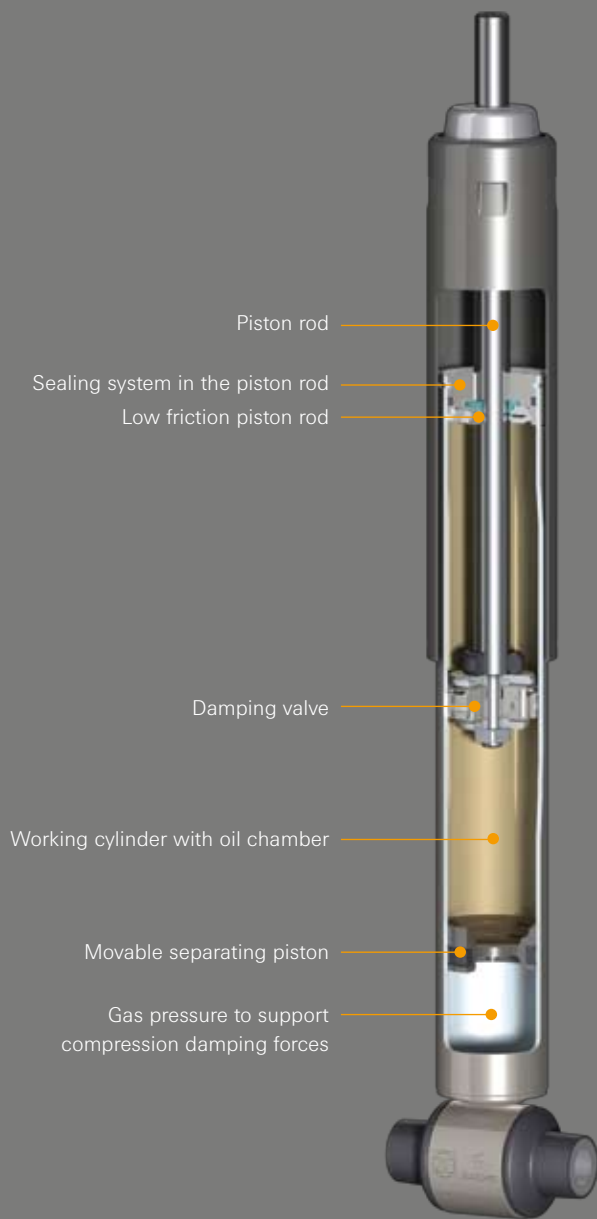
In monotube dampers, oil and gas are separated by the moveable separator piston. The damping valves for rebound and compression are mounted on the piston. The piston rod and seal are central components because the pressurized aggregate must be sealed securely. The Viton seal is mounted on the piston rod using mechanical prestressing and internal pressure. Friction is minimized using geometry and material optimization.

Benefits

- Lower noise levels
- Precision damping even for the smallest, high-frequency axle movements
- Any installation position thanks to separation of oil and gas
- Light weight

Application

For vans, the monotube damper is used on the rear axle.



McPherson Suspension Strut Module

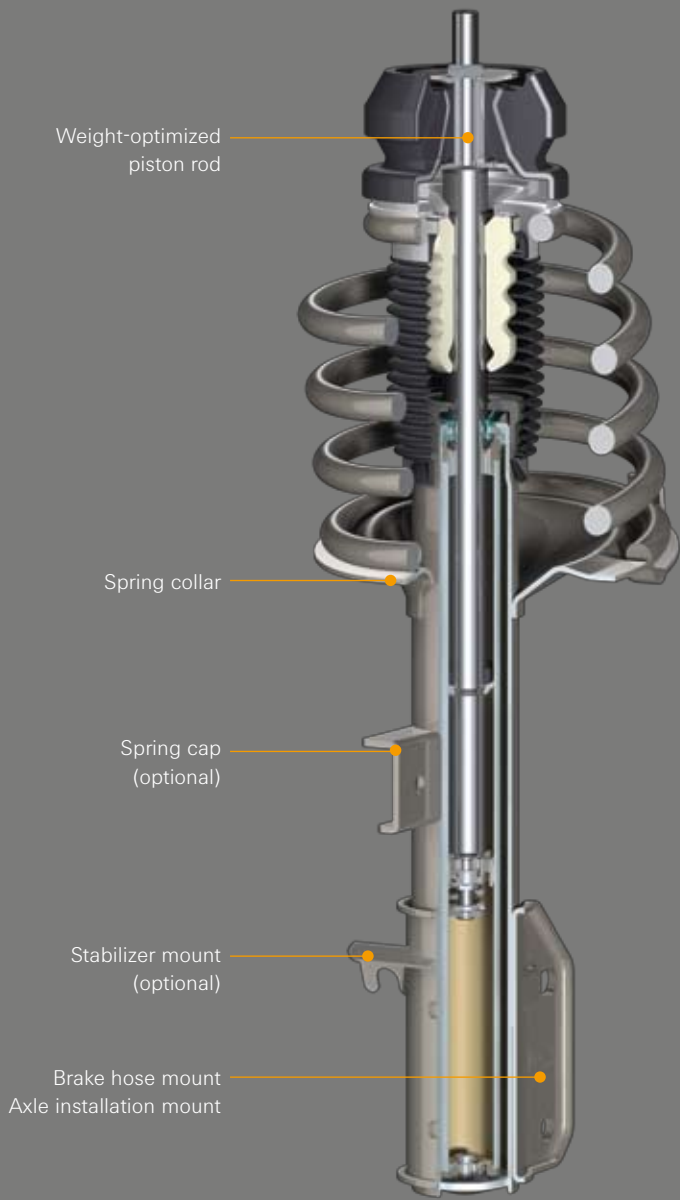
ZF Sachs offers individual concepts for suspension strut modules. The core of the suspension strut is a twin-tube damper. In addition to its damping function, it works together with the the track control arms to perform wheel control and thus the support or transmission of the steering movement. It also absorbs the forces of the load-bearing spring via the spring cap and counteracts transverse forces, which occur in particular during braking, acceleration and steering. Considering these forces and the requirement for minimal weight, the suspension strut is optimized for the respective vehicle.

Benefits

- Robust design especially suited for vans
- Friction-optimized guide and piston for superior responsiveness to excitation
- Lateral force compensation for greater ride comfort
- Separate transmission of spring and damping forces for greater comfort
- Optimized weight

Application

The McPherson suspension strut module is used on the front axles of vans.



N-Damper

The N-Damper was specially developed for modern pneumatic and parabolic springs, and has proven itself both in long-haul trucks and under extreme conditions on rough terrain.

N-Dampers from ZF Sachs operate on a twin-tube principle. When the axle encounters sudden loads, the piston rod moves in (compression). This pushes a quantity of oil corresponding to the volume of the piston rod through the damping base valve into the outer tube, while the annular volume of oil is pushed from the lower into the upper working chamber through the piston valve.

When the axle load is released, the piston rod retracts (rebound). The annular volume flows back through the piston valve and a quantity of oil corresponding to the volume of the piston rod is sucked from the oil reservoir in the outer tube through the base valve.

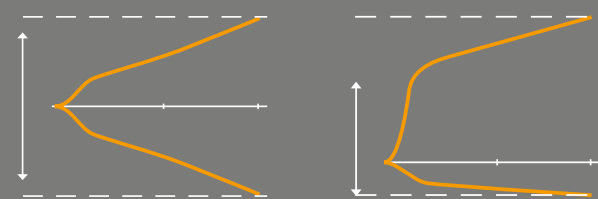
Benefits

- Long service life
- Greater ride comfort
- Low friction
- Multi-stage piston and base valve
- Ideal for modern air spring designs
- Even greater comfort with VARIO technology

Application

The N-Damper is used in all trucks, buses, and trailers.

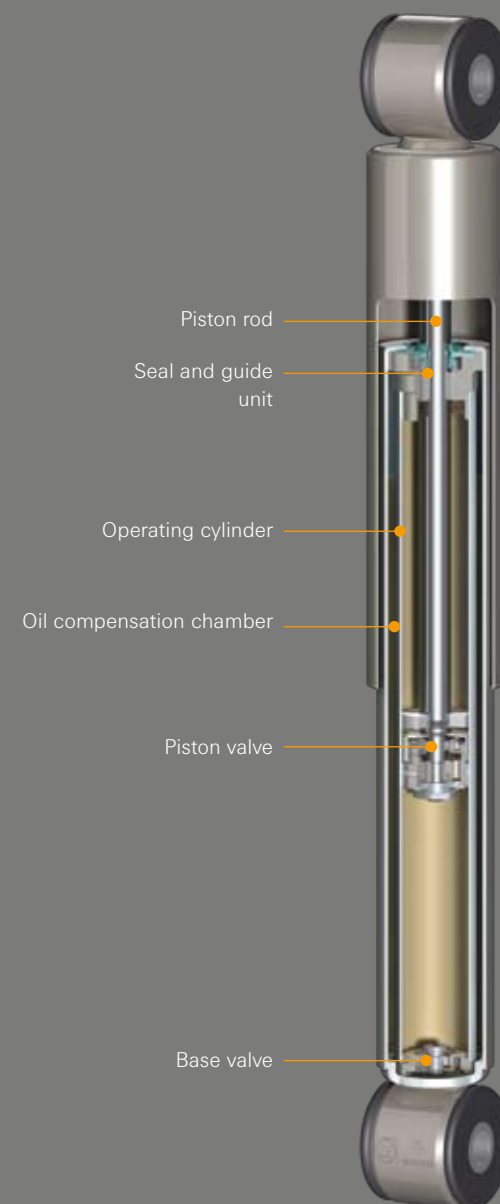
Damping force and characteristic curves



Progressive-linear characteristic curve for leaf-sprung vehicles

Degressive characteristic curve: ideal for parabolic and air suspension vehicles thanks to the patented piston system

In general, the damping force of the shock absorber depends on the piston speed: The damping force increases with increasing piston speed. The valves define to which extent this happens. The special design, arrangement and combination of the valves make it possible to achieve all desired damping characteristics that are required and ideal for the respective use. The damping force characteristic is individually adjusted for each vehicle series. The characteristic is defined in close cooperation with the vehicle manufacturer so that full driving stability is guaranteed even when the vehicle is fully loaded.



Horizontal Damper

There is an upper limit for the design height of truck loading areas. Therefore, the load volume can only be increased by using a lower chassis. In the respective axles, the vertical movement of the wheel is therefore redirected into an almost horizontal motion of the damper.

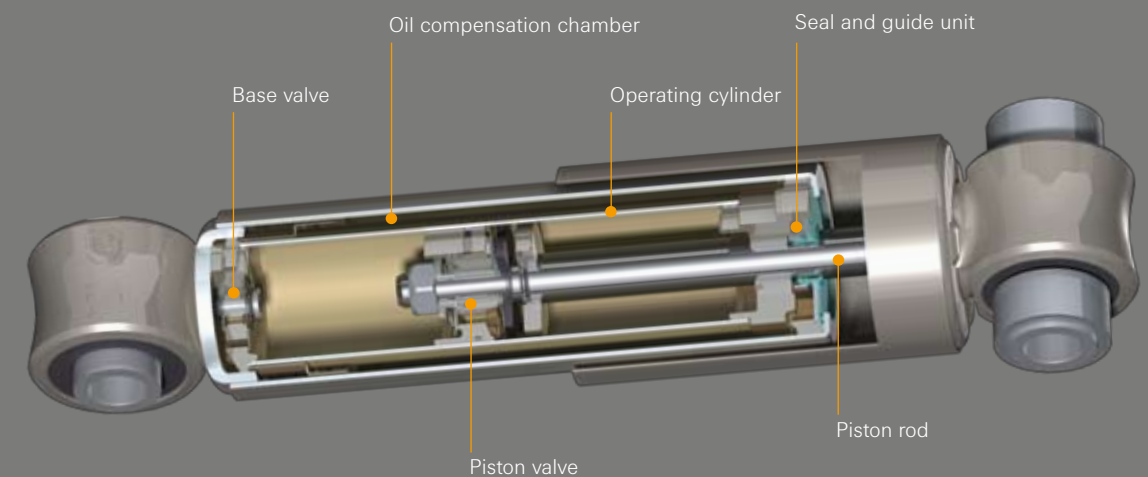
This specially developed damper ensures that the oil flow meets these requirements even when it is almost horizontal and that even vehicles with low chassis can be damped safely. The functional principle here is the same as for a twin-tube damper.

Benefits

- Long service life as part of the N-Damper kit
- Increased load volume
- Safe damping even in an almost horizontal position

Application

The horizontal damper is used above all in towed vehicles such as semi-trailers and trailers.



Air Spring/Damper Module

The air spring/damper module is an alternative to the conventional design with an adjacent damper and air spring on the axle. It is a compact unit consisting of both an air spring and a damper.

By reducing the number of individual components and therefore saving installation space, the air spring/damper module takes a major step toward accommodating the new demands placed on the front axle. The design is similar to spring carrier solutions in cabin mounts; air spring/damper modules thus provide ideal conditions for the intelligent axle designs of the future.

VARIO Damper

Stroke-dependent Damping

Vario dampers can feature monotube or twin-tube designs. Control grooves in the cylinder tube, which create a hydraulic bypass, are used to implement stroke-dependent damping. The hydraulic bypass works on the piston valve. It is mechanically formed in the cylinder tube of the shock absorber.

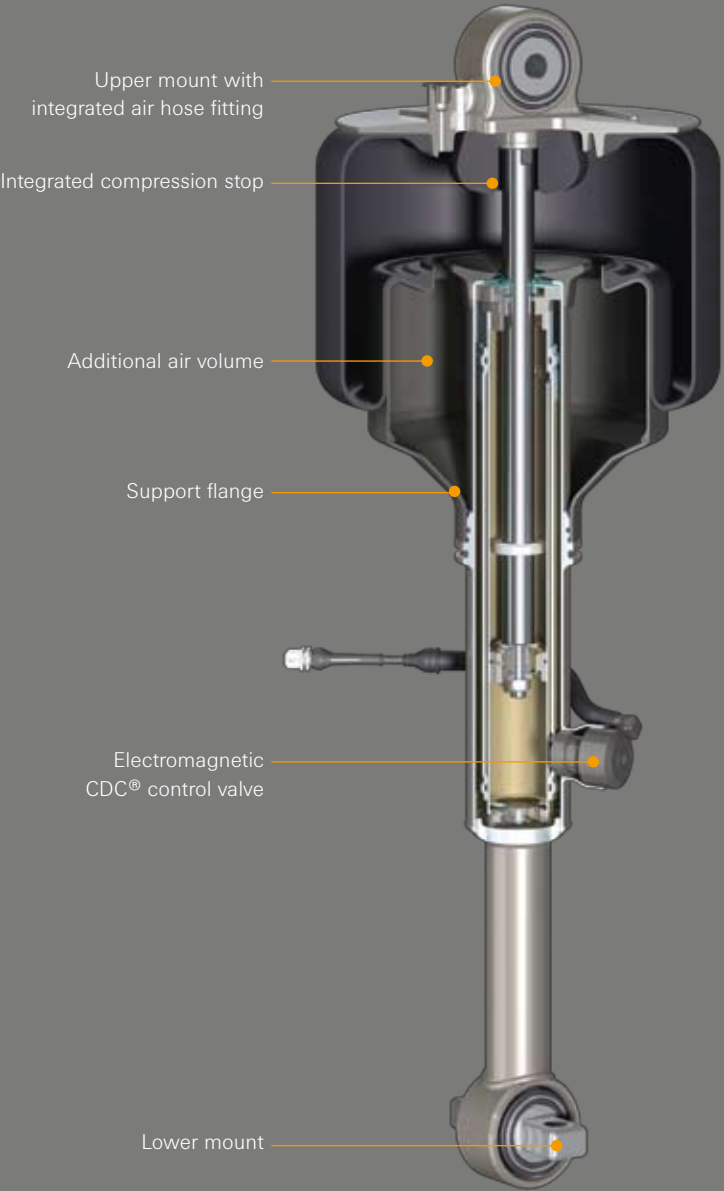
The piston travels over the control groove depending on the damper position and stroke. When oil flows over the groove, hydraulic resistance is reduced and therefore the damping force as well. The damping forces are significantly higher outside of the grooves – for even more driving safety. Abrupt force surges in the vehicle damping are avoided by ensuring that the transition between the groove and the smooth part of the tube is designed appropriately.

Benefits

- Improved roll stability – especially important for high centers of gravity
- The corresponding axle kinematics yield larger suspension ranges for supporting trailers and semi-trailers.
- Less installation space required
- Combining the spring and damper allows for a wider spring track
- Ideal dimensioning of the outer contours of the bellow and piston enables high axle loads to be supported
- The air spring/damper module can be combined with CDC® variable damping systems

Application

Air spring/damper modules are used in commercial vehicles for individual wheel suspensions as well as for conventional suspensions on the front axle.

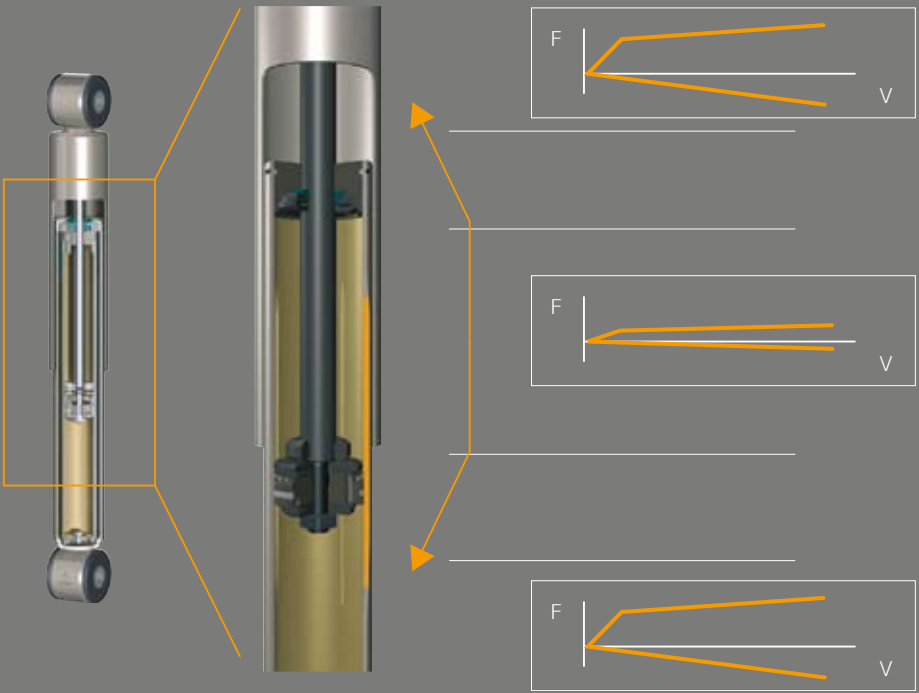


Benefits

- Enhanced comfort
- Economical
- Can be integrated into standard damper
- Can replace existing damper
- No control elements needed

Application

VARIO technology is used primarily on cabin mounts in trucks and on axles in buses to improve comfort. It also has numerous applications in vans and light-weight trucks.



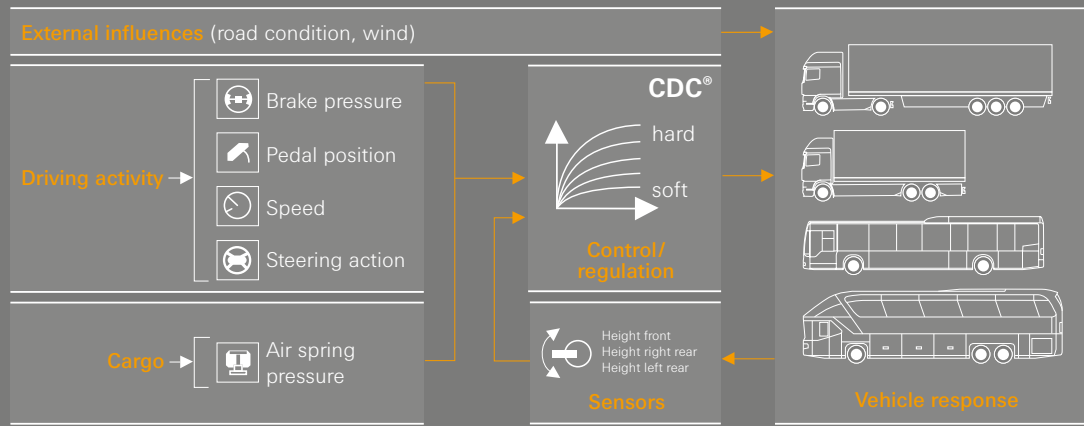
CDC® – Continuous Damping Control

Ideal Damping in Every Situation

CDC® – Continuous Damping Control – is the electronically controlled damping system from ZF Sachs. A control system constantly monitors all influences on the driving situation such as load conditions, driver actions, and vehicle movements, and adjusts for the optimum damping force.

With CDC®, the vehicle remains stable and easy to control even in critical situations. Damage to cargo and packaging are minimized and less physical strain means that drivers can better concentrate on his primary task – driving.

CDC® control cycle (example)

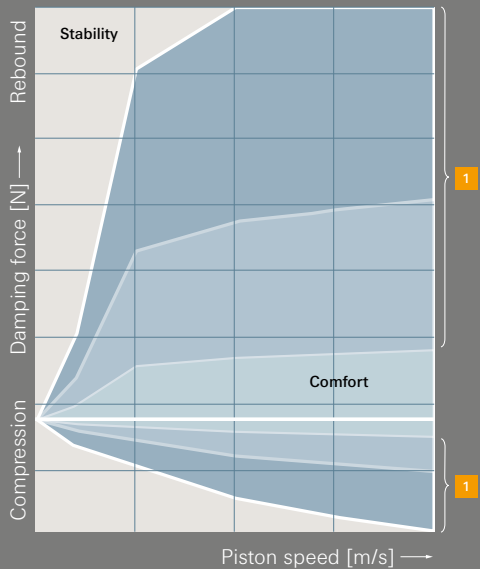


CDC® system

The CDC® damper is embedded in an intelligent suspension control system, which consists of the CDC® damper, a sensor system, and a control unit.

- The vehicle's sensor system monitors the driving situation at all times. The control unit uses the sensor data on the CAN bus as the basis for regulating the dampers.
- The core of the CDC® damper is its electromagnetically controlled proportional valve. Depending on the damping requirements, the oil aperture is expanded (soft damping) or contracted (hard damping). The control unit constantly recalculates and readjusts the valve settings.
- The continuously variable number of valve positions and the rapid adjustment of damping forces enable variable adjustment of the damper rate within milliseconds.

Variable damping

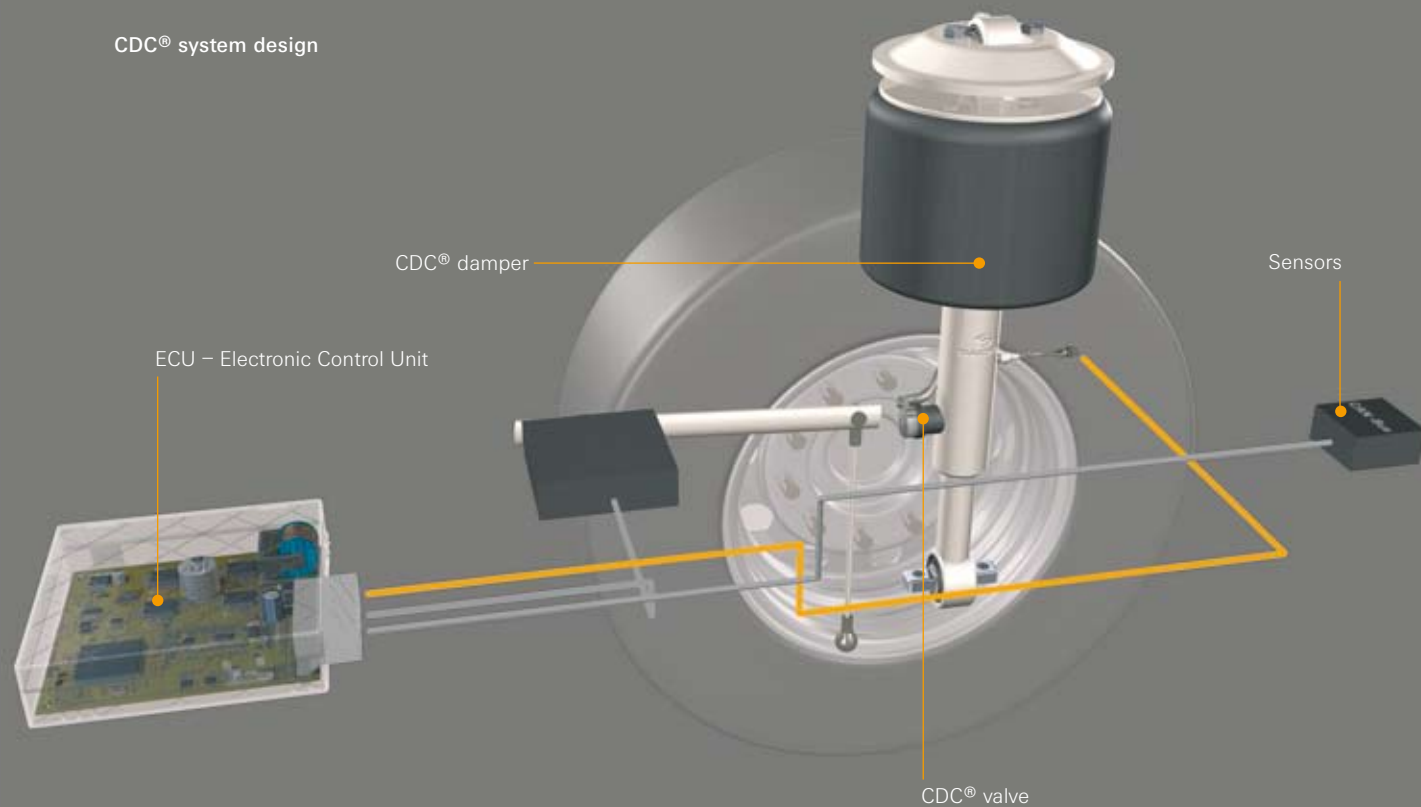


1 Adjustments are made in these ranges



Electromagnetically controlled proportional valve

CDC® system design



Upon request, ZF Sachs will develop and supply a complete CDC® system consisting of damper, sensors and control unit.

Ahead of the Pack with CDC®

Benefits

■ Safety

The vehicle remains stable and easy to control even in demanding situations.

■ Greater safety and better handling in critical maneuvers:

1. Braking: Potentially shorter braking distances
2. Lane changes: Better control and handling due to lower roll angle
3. Steering: Less steering angle
4. Acceleration: Less pitching, better wheel control

■ Less damage to cargo and packaging

Cargo remains securely fixed on load floor

■ Vehicle wear

Vehicle components are subjected to less stress; maintenance costs decrease

■ Driving comfort

Reduced vehicle body and seat acceleration; CDC® lowers driver fatigue and thus enhances performance; passengers have a more pleasant trip

■ Road protection

Reduction in damage caused by dynamic loads

■ Cost-effectiveness

Vehicle components are subject to less wear, maintenance costs sink, tire wear is reduced; potentially lower insurance premiums

Recommended Applications



High centers of gravity
Upright cargo, animal transports



Liquid transport
Milk collectors, all kinds of tank vehicles
Fuel, gas, chemicals



Extreme load differences and variations
Container transporters, construction material transporters, delivery vehicles



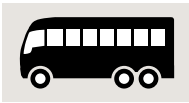
Transport of highly sensitive goods or assemblies
Electronics, glass, tiles



Moving or suspended loads
Meat, clothing



Emergency and support vehicles
Fire department, technical services, ambulances



Touring buses

Vehicle performance improvement with CDC®

Driving maneuver	Crtiterion	Tractor and trailer conventional damping	Tractor and trailer variable damping
Vertical dynamics			
Sinusoidal elevation	Seat acceleration	100 %	46 %
Good motorway	Trailer acceleration	100 %	73 %
Longitudinal dynamics			
Braking	Braking time	100 %	97 %
Start-up	Pitch angle	100 %	45 %
Lateral dynamics			
Sudden steering angle change	Roll angle	100 %	89 %
Double lane change	Limit speed	100 %	108 %

IKA/FKA measurement results on semi-trailers



Compared to conventional dampers CDC® improves driving dynamics by all relevant criteria.

CDC® on the Test Track

Handling and stability

Simulation of a dangerous driving situation on a test track: a double lane change at 34 km/h, well below the speed limit for urban areas.

Two fully-loaded trucks were compared. While the vehicle on the left is outfitted with conventional shocks, the vehicle on the right has the CDC® electronically-controlled suspension. The vehicle with damping control shows a noticeably less pronounced roll angle. The vehicle handles the series of curves with ease. The truck with conventional suspension nearly reaches its tipping point. The driver has great difficulties keeping the vehicle stable.



Conventional damping



Variable damping

Comfort and cargo protection

Comparison of two semi-trailers with and without variable damping: Vehicles were driven over a rough road surface at a constant speed of 30 km/h for 80 meters. While from the outside no differences were perceptible, the high-frequency vibrations had markedly different effects on the cargoes of the two vehicles.



Cargo with conventional suspension



Cargo protection with damping control

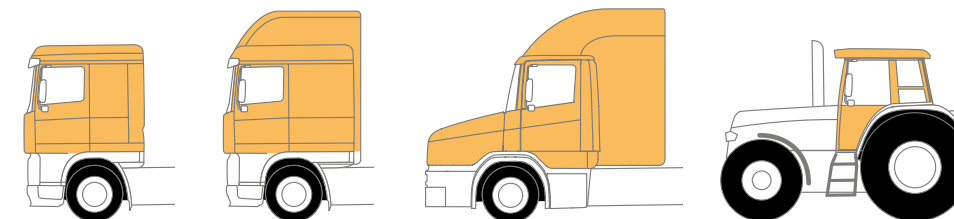


Vibration and Motion Damping for the Cabin

ZF Sachs vibration and motion dampers for the driver's cab provide greater safety, comfort, and stability. Greater comfort levels reduce driver fatigue, increasing performance and thereby driving safety.

Driving comfort in commercial vehicles is considerably enhanced by separating the damping and suspension systems for the cabin from those of the chassis. Because different types of vehicles are used for different applications, their cabins differ in size, equipment, and weight. Each different cabin design requires an individual spring/damper solution.

ZF Sachs offers a range of products from horizontal dampers (nearly horizontal installation position) to monotube and twin-tube dampers, steel-spring and air-spring modules and CALM® Cabin Air Levelling Module to CDC® variable damping.



For all cabin designs and sizes, ZF Sachs offers the optimum solution for damping and mounting

Steel Spring Module

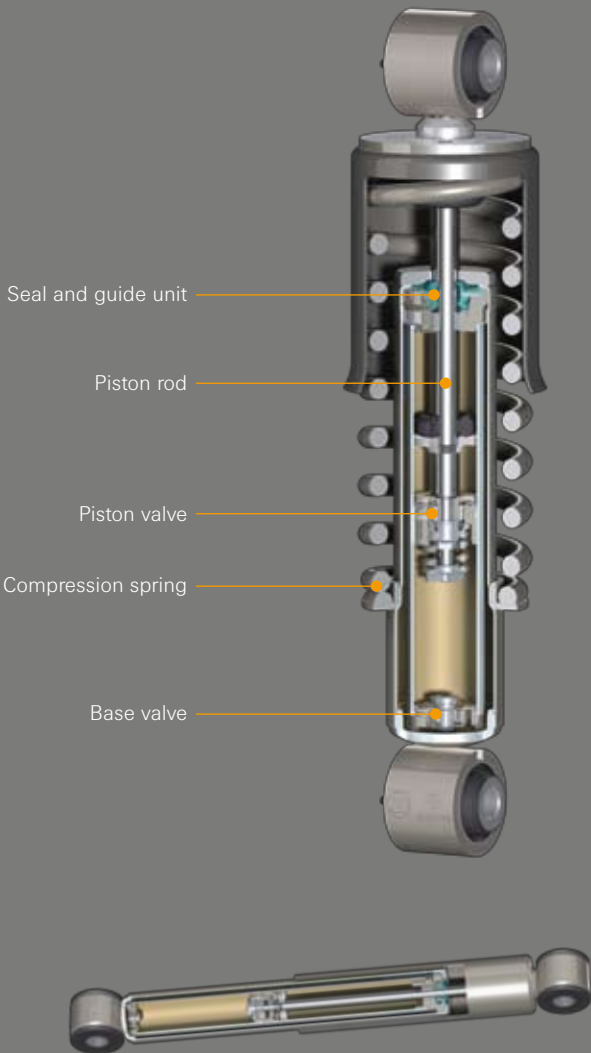
The steel spring is mounted concentrically on the damper, with linear or progressive characteristics depending on the application. The cabin level is independent of the system and is therefore not controlled. It depends on the load. Different cabin weights require the steel spring suspension to have different load carrying capacities to maintain ride-height levels. This is achieved by using different spring characteristics or by mechanical height adjustment.

- Benefits**
- Functions independently of other systems, such as compressed air supply
 - Outstanding cost/benefit ratio
 - Less installation space required
 - Robust construction enables rough-terrain applications, such as for construction vehicles

Application
The steel spring module is used in all types of commercial vehicle cabins, especially when robustness is a priority, such as with construction and delivery vehicles, tractors and specialty vehicles with low load variation.



The same spring/damper modules can be used for different cabin weights by adjusting the spring base point.



Horizontal dampers reduce the infamous "cabin trembling" syndrome and thus increase safety and comfort.

Air Spring Module

Pneumatic suspension enables the cabin's ride-height to be regulated. It balances out load differences resulting from different cabin designs and compensates cabin movements while the vehicle is operated. Because high suspension comfort is based on a low natural frequency, drivers' cabs – especially in medium and heavy-duty vehicles – are equipped with pneumatic suspension.

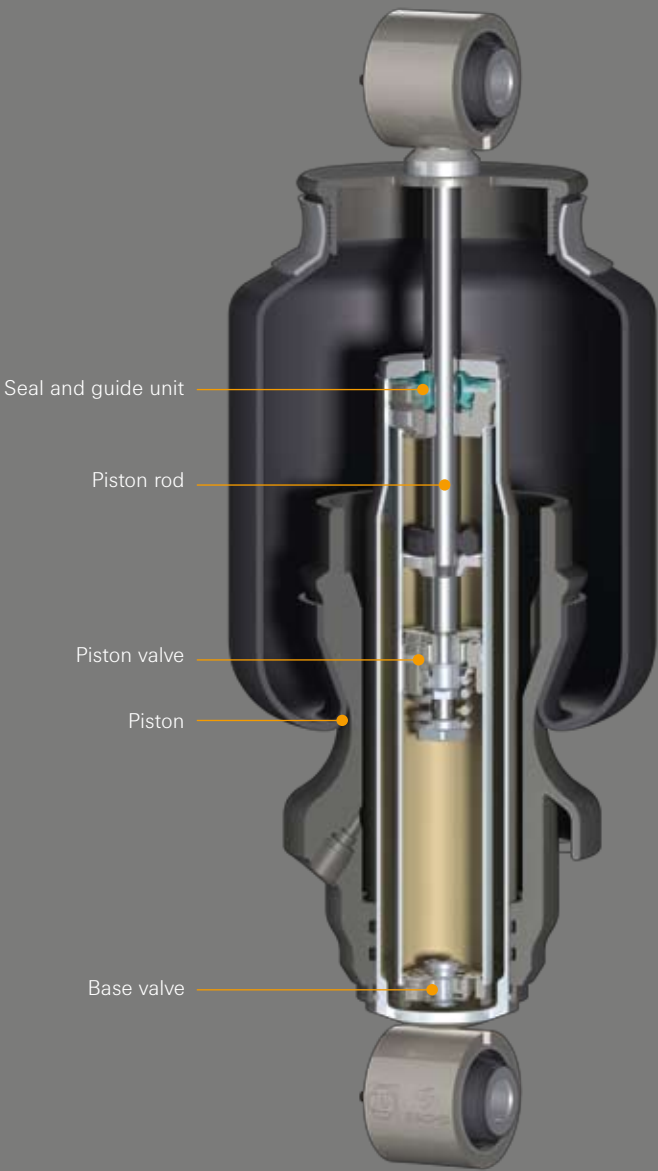
Interior pressure of 5 bar in the air spring bellows allows for carrying forces of between 2,000 and 4,000 N. A special roller contour for the air spring yields low spring rates in the level position, but a very strong progression in the stroke end positions. The cabin remains stable at markedly higher levels of driving comfort.

- Benefits**
- Level compensation for different cabin equipment/loads
 - Constant comfortable natural frequency
 - Greater driving comfort
 - Less installation space required

Application
The air spring module is used for drivers' cabs with high comfort requirements and a wide range of loads, especially for trucks, tractors, construction vehicles, and specialty vehicles.

The steel spring and air spring modules in comparison

Requirements	Steel springs	Air springs
Hydraulic damper or suspension strut with concentrically mounted spring element	■	■
Typical cabin natural frequency	1.8 - 3.0 HZ	1.0 - 1.4 HZ
Low natural frequency in the level position and strongly progressive characteristics in the stroke end positions	qualified	66%
Dampers with VARIO design (bypass groove in the cylinder tube) with stroke-dependent characteristics	■	■



CALM® – Cabin Air Levelling Module

With CALM® (Cabin Air Levelling Module), ZF Sachs has developed a unique air spring/damper module for the cabin with integrated ride-height control. CALM® hardly differs from conventional air spring/damper modules in visual terms. Ride-height is no longer controlled via an external valve but rather directly in CALM®.

This eliminates the need for a whole series of additional external components. The valve regulates the pressure in the air springs and thus maintains a constant cabin level. In the meantime, CALM® has proven its worth under the toughest conditions – including in construction vehicles and tractors. Even there, drivers need not give up the benefits of a cabin with pneumatic suspension.

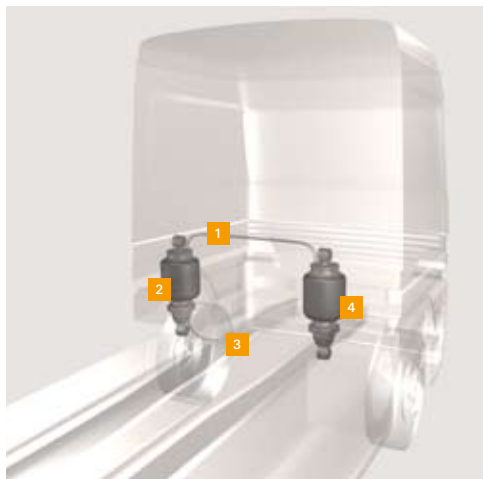
Benefits

- Damping and pneumatic suspension with integrated ride-height control
- Reduced susceptibility to external influences such as dirt and impact
- Modular construction
- Less installation space required
- No adjustment during installation
- Fewer individual parts

Application

CALM® is used in all types of air-sprung cabins that require high comfort levels and are subject to a wide range of different load conditions. Areas of application include trucks, tractors, construction vehicles, and specialty vehicles.

The CALM® solution



Design

- 1 Air supply
- 2 CALM®
- 3 Air inlet line
- 4 Conventional air spring module

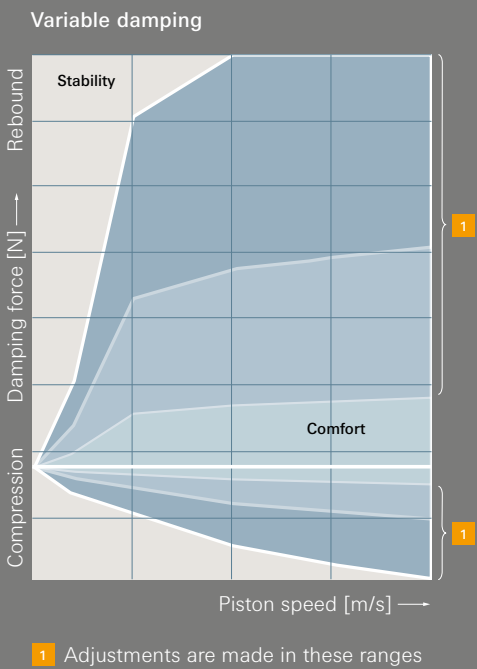
External components for ride-height control have largely been eliminated.



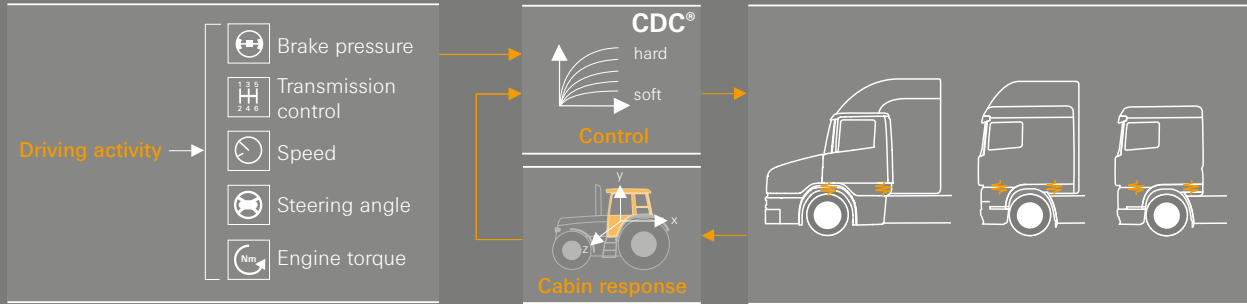
CDC® – Continuous Damping Control

CDC® eliminates the need to choose between comfort and stability in the cabin as well as in the vehicle itself. It solves the conflicting demands for higher suspension and damping comfort on the one hand, and on the other hand for a solid connection between cabin and body during abrupt load alterations (start-up, braking maneuvers) and on curves.

The control system uses data from the vehicle's sensors to adjust damping forces to the optimum level within milliseconds. For simple straight-ahead driving on average-quality roads, it lowers damping forces so the cabin suspension can be soft and comfortable. But as soon as cabin vibrations change due to lane changes, braking maneuvers, or gear shifts, for example, CDC® keeps the cabin stable by hardening the damping forces in a targeted manner. The system also contributes to efficiency by enabling reduction of gear-shifting times and thus the interruption of traction force.



CDC® control cycle (example)



International Presence and
Market Leadership

Worldwide: Suspension Components
and Systems for Commercial Vehicles

ZF Sachs is the preferred partner for conventional shock absorbers, modules and systems worldwide. All reputable commercial vehicle manufacturers place their trust in ZF Sachs expertise.

Our global presence ensures customer reach and high responsiveness. Our development, sales, production and logistics experts work constantly to provide solutions for our customers. Using our intelligent, universally applicable system modules, we can economically and flexibly implement specific requirements for ZF Sachs products with minimal response times. Our wealth of expertise in the field of vehicle calibration can be called upon anywhere in the world. Our plants and branches are so tightly interconnected that we can ensure the highest quality standards in every market. Perfectly calibrated suspension components and systems give our customers a decisive edge over the competition.

Millions of times over – daily – worldwide.

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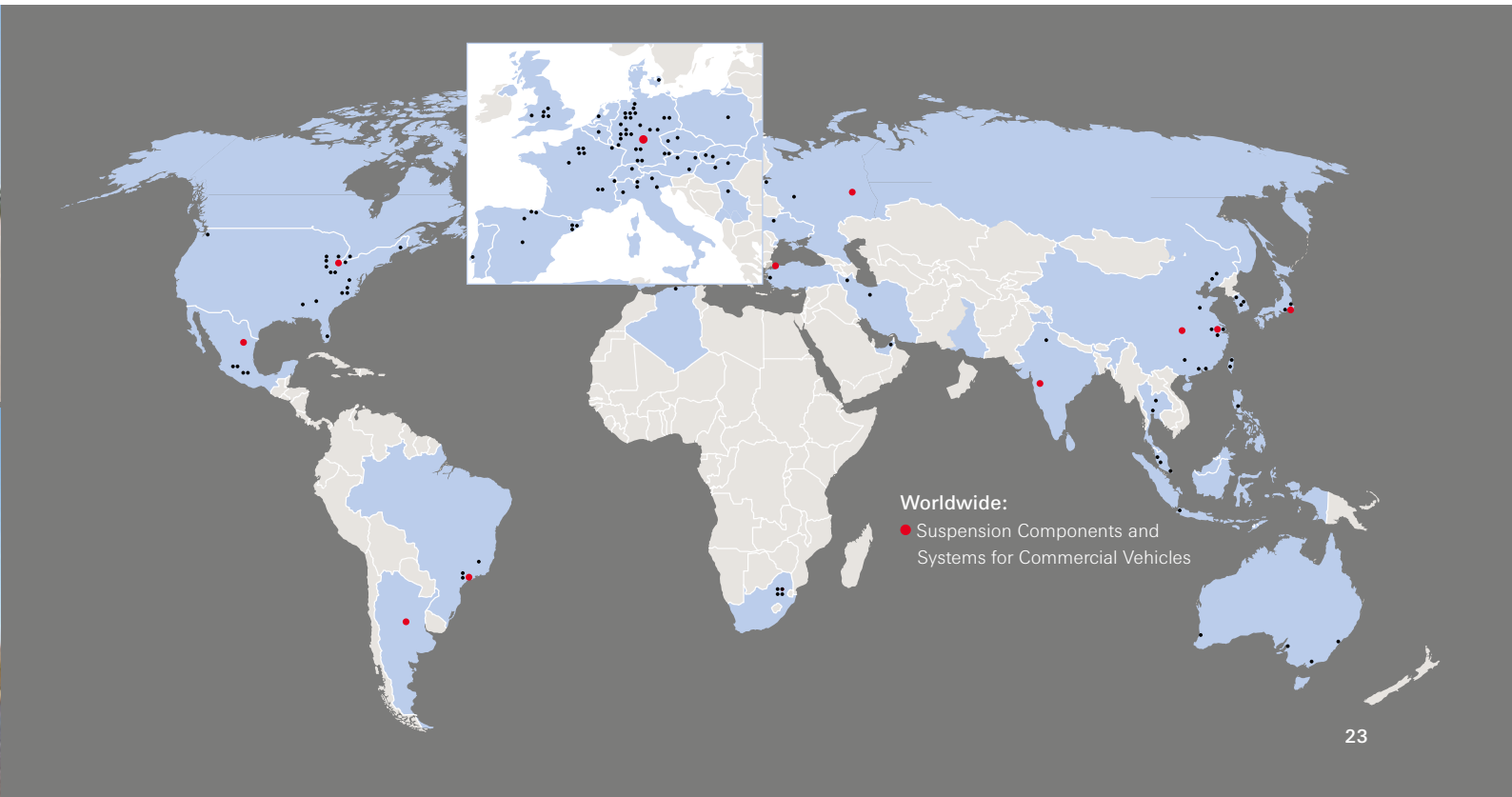
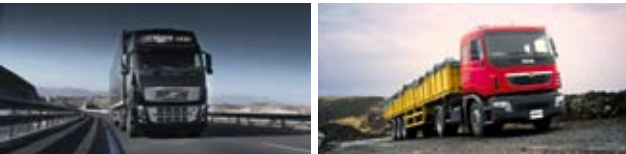
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