Suspension Components and Systems



For Passenger Cars

Safety and Comfort: Suspension Components and Systems for Passenger Cars

The demands placed on suppliers in the automotive sector are changing dramatically. Increasingly, suppliers are being called upon to integrate components into complex systems – a development task that can only succeed on the basis of close partnerships with vehicle manufacturers. The future will bring continued demands for reduced fuel consumption, emissions, weight and installation space, along with enhanced comfort, safety, and driving dynamics. To meet these goals, innovative solutions and new products are essential.

ZF Sachs has taken responsibility here, demonstrating expertise in generating comprehensive solutions with its intelligent suspension systems. In doing so, it consistently pursues a systems approach in developing and manufacturing new products and technologies that represent real advances. Together with ZF, it provides overall solutions that meet the demands of overall systems. One example: As a suspension specialist and manufacturer of electric drives, ZF Sachs can also implement the full range of strategies for ride-height control and electronic damping systems, and thus offer production-ready solutions today for the vehicles of tomorrow.

Available Dampers

Damper dimensions that ZF Sachs offers as either standard or optional:

Piston Ø (mm)	Piston rod Ø (mm)						
	11	13	15	18	20	22	25
27	TT	TT	e	Strut	Strut		
30	MT TT	TT			Strut		
32		TT	TT	e	e	Strut e	Strut
36	MT	MT	i	TT e i	e	Strut i	Strut i
40			i	e i			
45	MT	MT					

MT = Monotube damper
TT = Monotube damper
Strut = Suspension strut

e = CDCe with external valve
i = CDCi with internal valce

■ = Standard
□ = Option

Product Range of Suspension Components and Systems for Passenger Cars

BasicLine

Basic damping operations

The BasicLine from ZF Sachs – this means clear standardization of monotube dampers, twin-tube dampers, and suspension struts. Its worldwide standardized development and production processes and its uniform product specifications deliver on the promise of basic damping operations. The BasicLine's underlying principle is a modular system of components that ensure the optimum cost/performance level – demonstrated millions of times.

Product solutions BasicLine

- Monotube Damper
- Twin-Tube Damper
- Suspension Strut

CustomizedLine

Individual customer demands and additional damping functions

Based on a modular system, the CustomizedLine meets customer-specific wishes. The development work behind this line has produced stronger individualization and a greater focus on vehicle adaptation. In addition to monotube dampers, twin-tube dampers, and suspension struts, this product range also includes modules. The CustomizedLine also features additional damper functions that offer appreciable added value for vehicle makers and end consumers. The constant focus of these products is to combine superior driving comfort, safety, and dynamics.

Product solutions and additional functions CustomizedLine

- Customer-Specific Dampers and Modules
- HID – High Impact Damping
- Vario – Stroke-Dependent Damping
- Sensitive Damping Control – Amplitude Selective Damping
- Nivomat – Leveling System
- CDC – Continuous Damping Control Dampers

ActiveLine

Active suspension systems

The ActiveLine covers all controllable damping systems. These systems communicate with the vehicle's other safety systems; they continuously respond to current vehicle data and thus ensure that damping is adjusted to the actual driving situation. With its electronic damping systems, ZF Sachs sets new standards in safety, comfort, and driving dynamics. For car makers, these systems not only offer new potential for networking within the vehicle but also reflect the vehicle's value on the market.

Product solutions and additional functions ActiveLine

- CDC – Continuous Damping Control System Technology
- Active Roll Stabilization

EcoRide

Preserving the environment with lightweight design

The EcoRide product range is part of the CustomizedLine and ActiveLine. It encompasses all the solutions that make an effective contribution to reducing damper weight. Examples include the use of hollow piston rods, aluminum tubes, and plastic components. The EcoRide product range also includes environmentally friendly production processes.

Product solutions and additional functions EcoRide

- Lightweight Design with Steel, Aluminum, and Plastic
- Production Processes that Preserve the Environment

Shock Absorbers

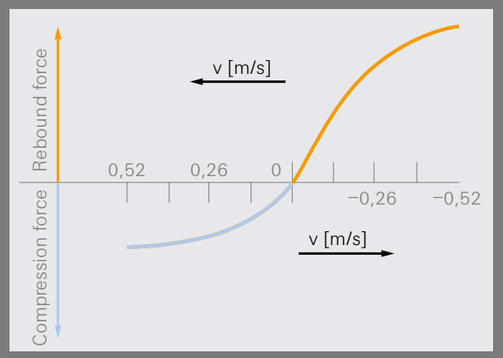
The task:
High demands are placed on vehicle damping systems. Shock absorbers have to minimize vibrations and post-oscillation in the vehicle body generated by uneven road surfaces. They also have to ensure that the wheels are in constant contact with the road. Both these tasks have a crucial impact on driving safety and comfort. While taut damping characteristics increase driving safety, comfort declines. The reverse also applies: Soft damping increases comfort but reduces safety. To achieve both optimum comfort and optimum safety, sophisticated technical solutions are required.

The technology:
In monotube dampers, the floating separating piston forms an absolutely leakproof separation between the oil and the gas. The damping valves for rebound and compression are located on the piston. The piston rod and seal are especially important components because the pressurized system must remain perfectly sealed under dynamic loads. The Viton seal is applied to the piston rod by means of mechanical pre-loading and high internal pressure. Both materials and geometry have been optimized to minimize friction. Twin-tube dampers require lower gas pressure levels; 6-8 bar are enough to ensure precision damping as well as low noise levels even at high compression speeds.

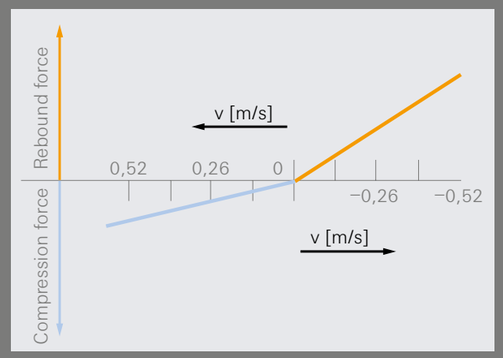
Damping force and characteristic curves
A shock absorber's damping force generally depends on the piston speed. As the piston speed increases, so too does the damping force. The degree to which this takes place is defined by valves. The design, arrangement, and combination of valves allow all the desired and/or optimum damping characteristics (curves) to be attained for different applications.

A damper's characteristic curve can be shown as a force/speed (F-v) diagram. Shock absorbers from ZF Sachs can feature degressive or linear characteristic curves as well as combinations thereof.

Characteristic curve degressive

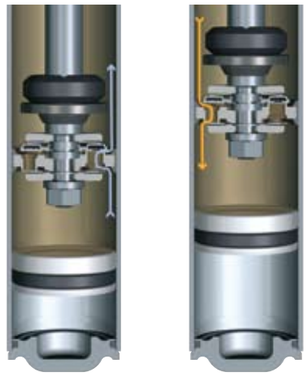


Characteristic curve linear



The Monotube Principle

When the piston rod moves in (compression), the floating separating piston compresses the gas cushion by the amount of oil corresponding to the volume of the piston rod. When the piston rod retracts (rebound), the nitrogen gas pressure pushes back the separating piston. Vibrational damping in both directions takes place via the multi-stage piston valve.



Compression Rebound

The Twin-Tube Principle

Compression Rebound

When the piston rod moves in (compression), some of the oil flows from the lower operating chamber through the piston valve into the upper operating chamber. A quantity of oil corresponding to the volume of the piston rod is thereby pushed through the base valve into the compensation chamber. When the piston rod retracts (rebound), the piston valve takes over the damping function, while a quantity of oil corresponding to the volume of the piston rod flows back through the base valve.

Suspension Strut Principle

The structure of the suspension strut corresponds to that of the twin-tube damper. In addition to damping, it also takes care of wheel positioning together with the track control arms, and thus ensures that steering movements are transmitted to or implemented by the wheels. It also absorbs the support spring forces via the spring seat, and supports lateral forces that arise especially when braking, accelerating, and taking curves. Given these forces as well as the demand for minimal weight, the suspension struts are optimally adapted to individual vehicle models. In order to reduce friction, the bearing surfaces of the piston rod guide and the damper pistons feature special elements such as slide bushings as well as PTFE sheeting and coatings. ZF Sachs provides the best solutions for all classes of vehicles.

Customer-Specific Dampers and Modules

The technology:
ZF Sachs is a leader in the development and production of damper and suspension strut modules. High demands are placed on these modules: They have to ensure that vehicles run safely, comfortably, and quietly. Individual components have to meet high functional requirements, yet at the same time show a reduction in weight. Development, production, installation, and logistics from ZF Sachs fulfill the highest demands for cost-effectiveness and efficiency while also meeting uncompromising global quality standards. One example is the suspension strut module with wheel control, which consists of many individual components. Flawless interplay between the constituent parts is of paramount importance for the system's operation and life span. The interaction between the individual components and rubber-to-metal parts, supporting springs, axial bearings, and dampers is a decisive factor in making sure that chassis systems (steering, braking, damping) operate smoothly. Damper and suspension strut modules are used on the front and rear axles of passenger cars from compacts to luxury sedans.

Suspension Strut Module

Improved comfort and steering performance
- Lower undesired lateral forces
- Optimization of load distribution in the spring seat
- Minimal friction in suspension strut and mounts

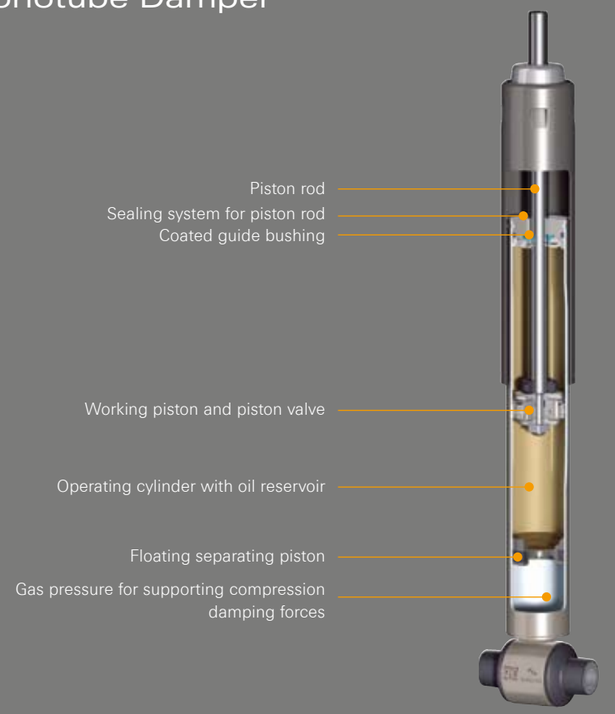
Greater driving comfort
- Multi-directional support bearing
- Support bearings feature different longitudinal and lateral degrees of stiffness
- Rubber-to-metal part design (ring eye rubber joints and support bearings) optimized to reduce secondary stiffness

Reduced tolerances
- Smaller ride-height differences
- Reproducible, low system friction

Optimized design of support bearing properties
- Low installation height for longer wheel/damper stroke
- Enhanced functioning due to individually adjusted stiffness (X, Y, and Z directions)

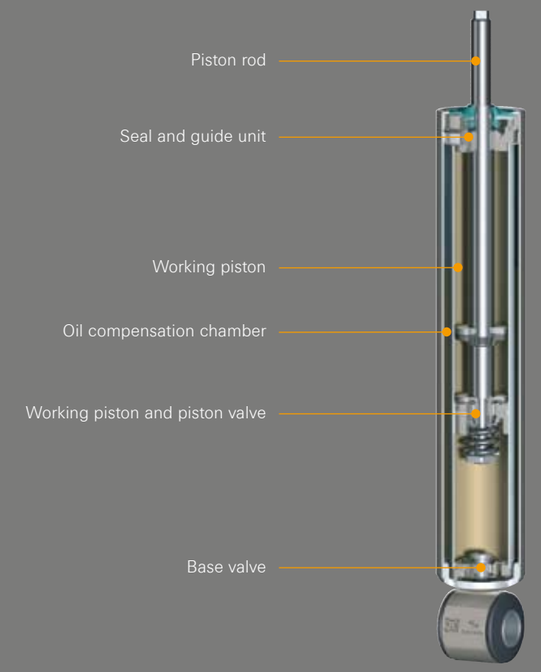
Lower weight
- Components optimized by FE analysis
- Targeted material selection

Monotube Damper



Benefits
- Lower noise levels
- Precise damping even for the smallest, high-frequency axle movements
- Any installation position thanks to separation of oil and gas
- No oil foaming
- Low weight

Twin-Tube Damper



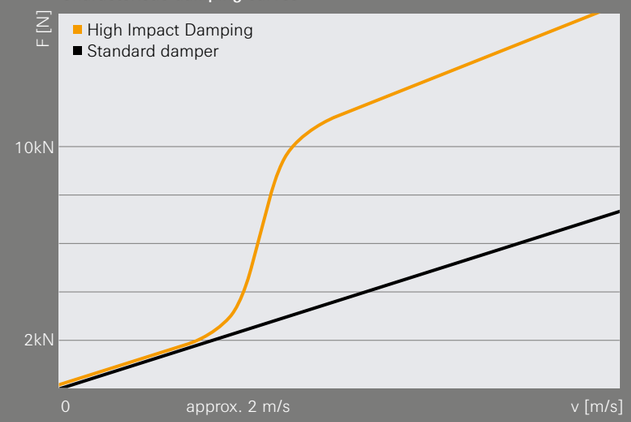
Benefits
- Low friction
- Greater ride comfort
- Variable curve configuration thanks to multi-stage piston and base valves
- Short installation lengths

HID – High Impact Damping

The technology:

Elevated levels of excitation from the road surface that exceed 2 m/s generate strong forces both inside the damper and on its external attachments. The consequences can include deformation in the wheel suspension area and premature failure. The only way to prevent these negative forces is to use additional struts which in turn mean greater costs and increased vehicle weight. With its High Impact Damping, ZF Sachs offers a technology that ensures comfort and safety even for high levels of excitation from the road surface. High Impact Damping is a further development of passive damper technology. It uses a speed-dependent hydraulic overload mechanism to generate high damping forces and to reduce the dome forces. The additional operational unit on the base valve, or on some vehicle models on the piston valve, allows high forces to be absorbed. This damper can be used in all vehicles, and can also be combined with the CDC electronic damping control system.

Characteristic damping curves



For defined damper speeds of more than around 2 m/s, HID optimizes the absorption of forces compared to standard dampers.

Benefits

- Reduced dome forces (typically minus 30 %)
- Minimal additional installation length (approx. 15 mm)
- No effect on normal vehicle performance
- Reduced vehicle weight
- Greater driving comfort due to less vehicle body acceleration

Vario Damper

The technology:

Vario dampers are available in monotube or twin-tube design. Control grooves in the cylinder tube create a hydraulic bypass which enables stroke-dependent damping. Mechanically formed in the cylinder tube of the shock absorber, the hydraulic bypass affects the piston valve. The piston travels over the bypass groove depending on the damper position and stroke.

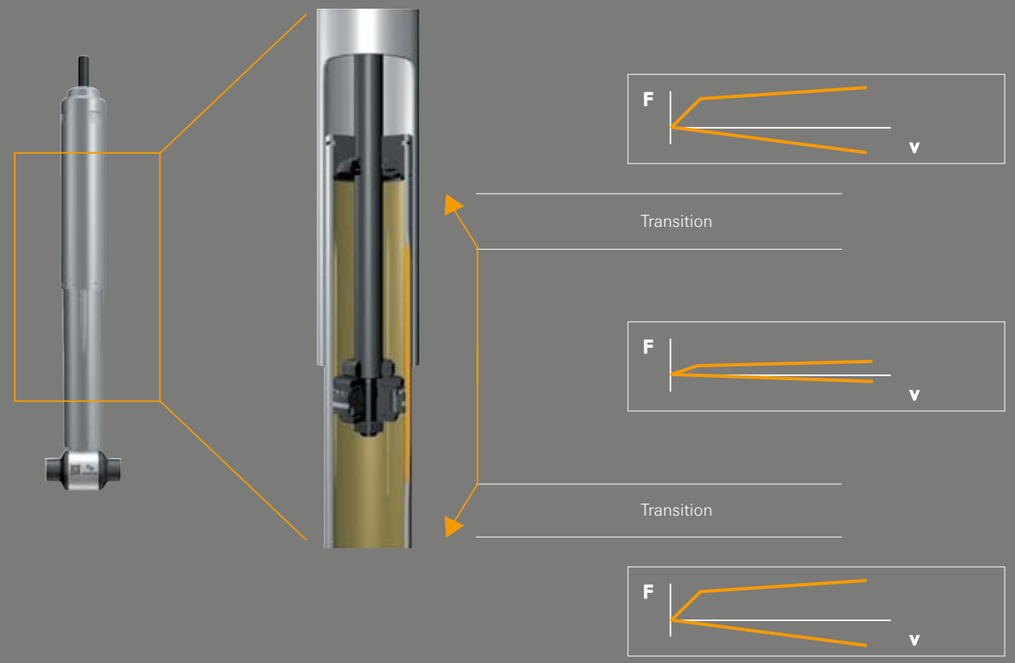
When oil flows over the groove, hydraulic resistance is reduced and therefore the damping force as well. Vario technology is used in vehicles that have to carry a wide range of different loads, yet still meet the highest comfort and safety standards.

Stroke-dependent damping from ZF Sachs

When the piston travels over the bypass groove, driving comfort is enhanced. Outside the groove range, damping forces are considerably greater – which means a plus for driving safety. Careful design of the transition profile between the groove and the smooth part of the cylinder prevents abrupt changes in damping forces.

Benefits

- Enhanced comfort
- Economical
- Can be integrated in standard dampers
- No control elements needed
- Can replace existing dampers



Sensitive Damping Control

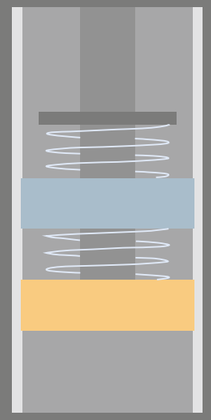
The technology:
Sensitive Damping Control represents a further evolutionary development of today's dampers. It stands for a combination of agile and comfortable driving. Sensitive Damping Control is a self-contained damping system that greatly reduces the target conflict of axle/body damping, without having to provide the entire functional range of an electronic system. ZF Sachs' solution is based on distributing the damper characteristics over two valves. A second valve on the piston rod is suspended between springs, which allow for a certain play depending on the vehicle model. While the standard valve handles small excitations, damping forces from both valves are available for larger disturbances.

Sensitive Damping Control is a way to enhance driving comfort without any loss in driving safety. It is used in passenger cars from compacts to upper mid-sized vehicles. There is still room for comfort to be heightened in this sector without risking safety. For minor excitations, body vibrations in sports-oriented vehicles can also be dampened without any loss in comfort. Commercial vehicles represent yet another area of application. Sensitive Damping Control is especially effective in enhancing comfort in buses and vans.

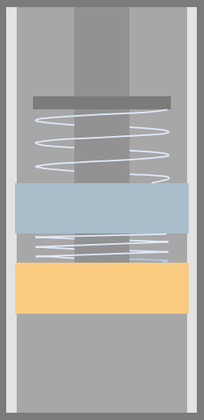
Sensitive Damping Control

Benefits
- Optimum road contact
- Greater comfort with no loss in safety
- Improved insulation of vehicle body against high-frequency road-based excitation
- Compensates for loss in comfort for run-flat and low-profile tires
- No electronic control system

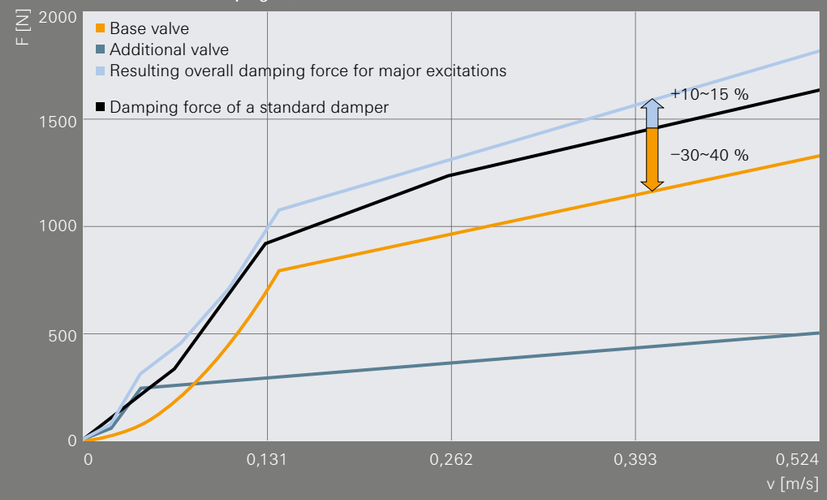
Sensitive Damping Control operating principle



Sensitive damping from ZF Sachs
One of the valves is fixed on the piston rod and thus continuously dampens motion. The other valve is suspended between two springs, which allow for play depending on the axle ratio and adjustment philosophy. At full stroke, the movable valve also contributes to the overall valve characteristics and thus increases damping for the body and/or axle to the level required.

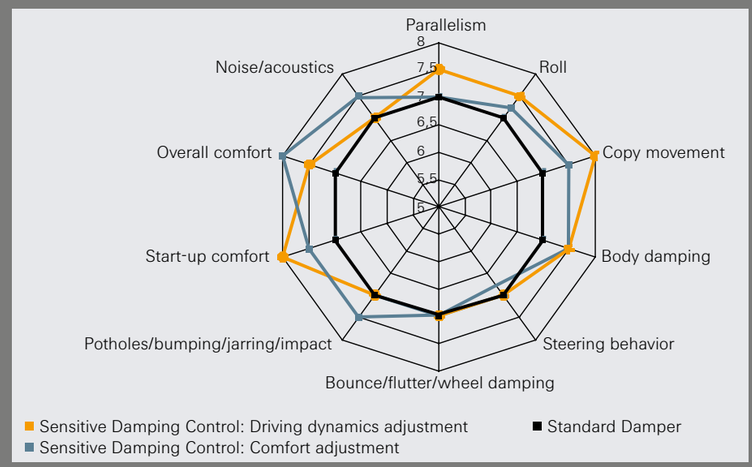


Characteristic damping curves



For strong excitations from the road surface, the second valve increases the damping force, which exceeds the properties of a standard damper and makes a significant contribution to driving safety. When damper excitation is low, driving comfort is increased.

Comparison of Sensitive Damping Control vs. standard dampers



A comparison with standard dampers clearly shows the numerous advantages of amplitude selective damping. Especially with respect to start-up comfort and copy movements, Sensitive Damping Control shows a definite improvement – and thus helps boost overall comfort.

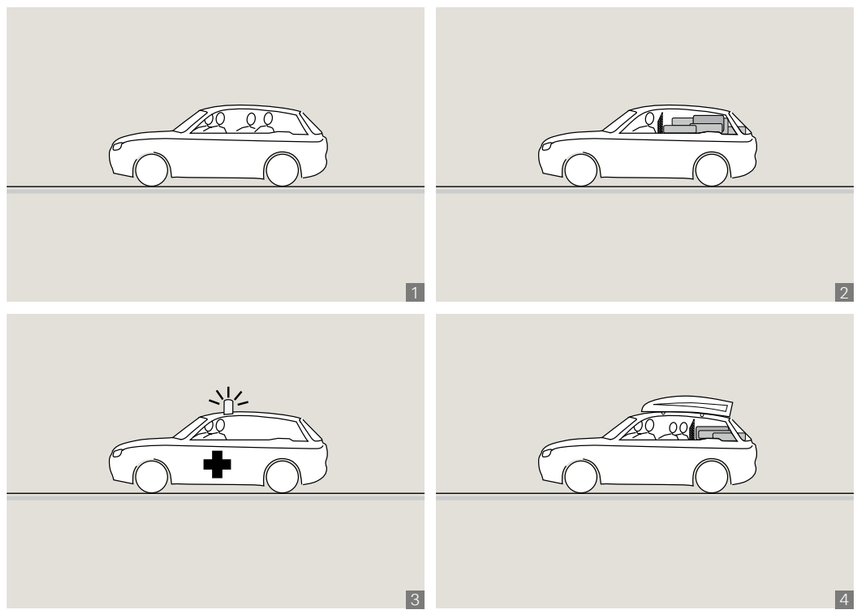
Nivomat – Always at the Right Height

The task:
Constant heavy or changing loads, as well as trailer dynamics, place high demands on both vehicle and driver. Extra weight on the rear axle shifts the center of gravity, and exerts a major impact on driving performance in the process. In critical situations, the vehicle can be very difficult to control, while inconsistent responsiveness makes driving comfort nearly impossible. Other consequences can be expensive. Fuel consumption rises, and tire wear increases due to uneven power transmission. Greater strain is also placed on the axle as a whole. The Nivomat, the leveling system from ZF Sachs, counters the negative effects of loads. There are many vehicle applications, especially in mid-sized classes, such as station wagons, vans, SUVs and sedans that offer the Nivomat as an option. The Nivomat is available as a damper, spring damper, suspension strut, or suspension strut module.

The technology:
The Nivomat is installed on the rear axle in place of a conventional damper. Fully automatically and without additional electronic systems, this compact device pumps the vehicle up to its optimum ride height after only a few meters. The Nivomat takes the energy needed to do so from the relative movements of the wheel and vehicle body. For every load condition, this maintenance-free system sets the ideal vehicle height, thus ensuring a safe and comfortable drive.

Nivomat: Clear advantages for all load situations

1. Transporting passengers
2. Transporting goods (sample products, tools)
3. Special vehicles (police, ambulance, fire department, roadside assistance, service technicians)
4. Family trips (major load shifts, such as with roof racks)



Benefits

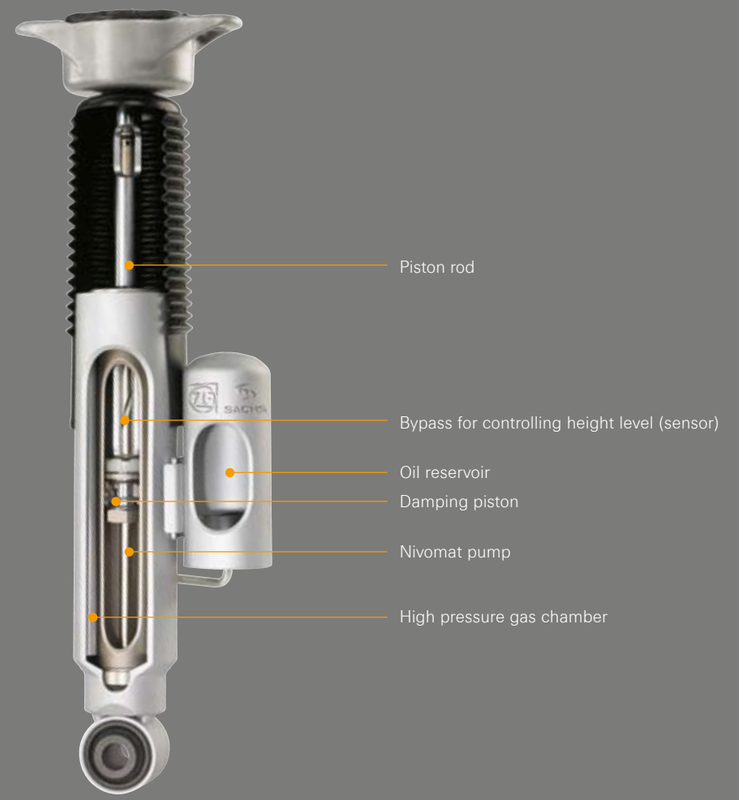
Greater safety
- Safe handling thanks to constant vehicle height for all load conditions
- Constant axle height makes driving on bumpy surfaces safer

Better comfort
- Responsiveness doesn't become fuzzy under high axle loads
- Less driver fatigue

More economical
Reduces costs
- Less wear on tires and axle
- Lower fuel consumption due to better aerodynamics

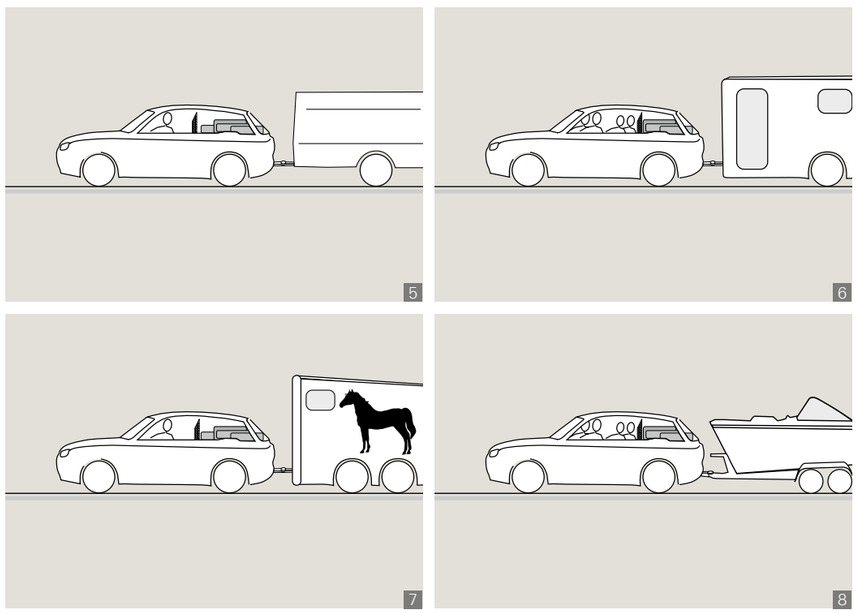
Reliable
- No additional on-board electronics; Eliminates possibility of system failures

Environmentally friendly
- No additional energy required for pump operations
- No additional CO_2 emissions



Stabilizes couplings for all trailers

5. Goods
6. Motor homes
7. Horses
8. Boats



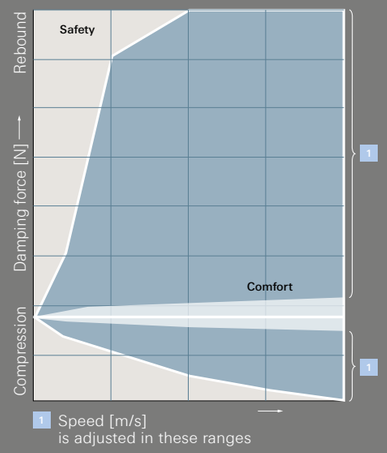
Active Suspension Systems

The task:
Over recent decades, electronic systems have substantially enhanced the operation of vehicle mechanical functions – and the field of damping technology is no exception. Development work on the next generation of vehicles is focusing to an ever greater degree on active and semi-active damping and suspension systems. With its electronically controlled damping systems, ZF Sachs is setting new standards in driving safety, comfort, and dynamics. One of the strengths at ZF Sachs is that it supplies not only components but also entire systems including both hardware and software. ZF Sachs is also a leading module supplier of active chassis systems such as roll stabilization and spring mount adjustment. Many of the major vehicle manufacturers rely on the systems expertise of ZF Sachs for their high-end products. Today's mid-sized and high-end vehicles feature a number of active electronically controlled systems that have thus far operated largely independently of each other. In order to further resolve the compromise between driving safety, comfort, and dynamics, the automotive industry is increasingly seeking to integrate individual systems. ZF Sachs is superbly prepared for this development and will play an active role in shaping it.

CDC® – Continuous Damping Control

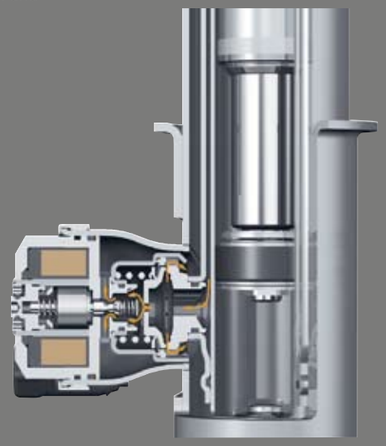
The technology:
CDC is an electronic damping system that noticeably increases driving safety, comfort, and dynamics by adjusting damping forces optimally for each individual wheel. A control unit calculates the requisite damping forces within milliseconds, and adjusts the dampers just as quickly. Vehicle sensors monitor values such as body, wheel, and lateral acceleration, and use them to generate the ideal damping forces for each individual wheel on a continuous basis. The CustomizedLine includes the CDC actuators; the ActiveLine goes beyond the actuators to offer the entire system consisting of actuators, sensors, hardware, and software.

Variable Damping



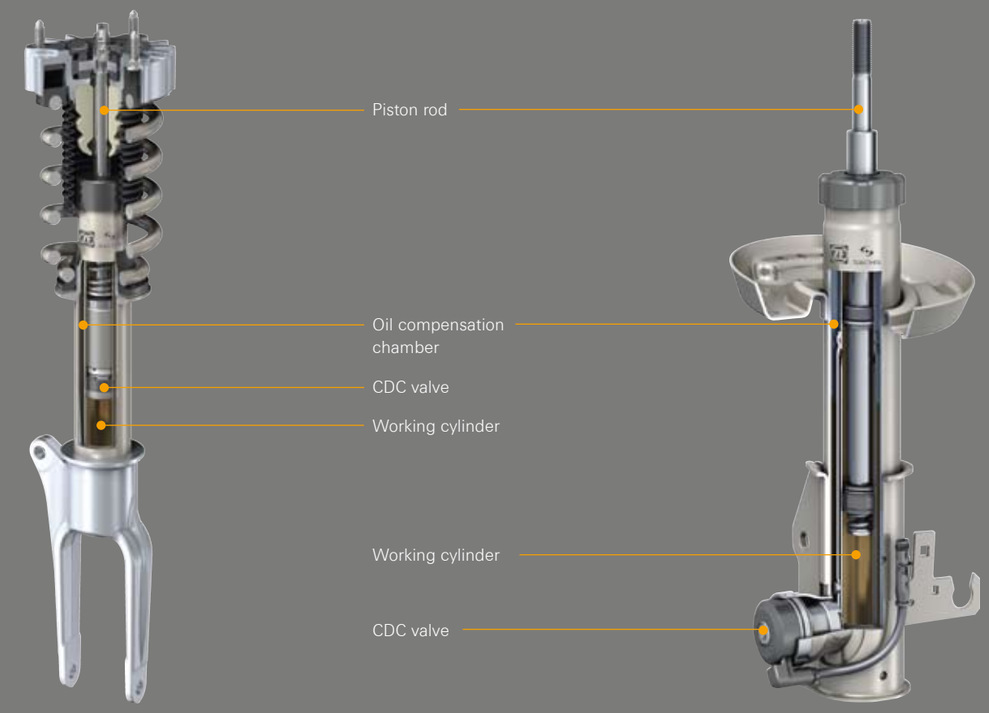
1 Speed [m/s] is adjusted in these ranges

Optimum comfort, superior safety
This graph of characteristic curves shows the range in which CDC can continuously vary damping forces in compression and rebound.



The core of the CDC damping system is the proportional valve. Depending on its position, the opening for oil flow is expanded (soft damping) or constricted (firm damping).

CDC Overview: Actuators



CDC damper with internal valve

CDC

CDC damper with external valve

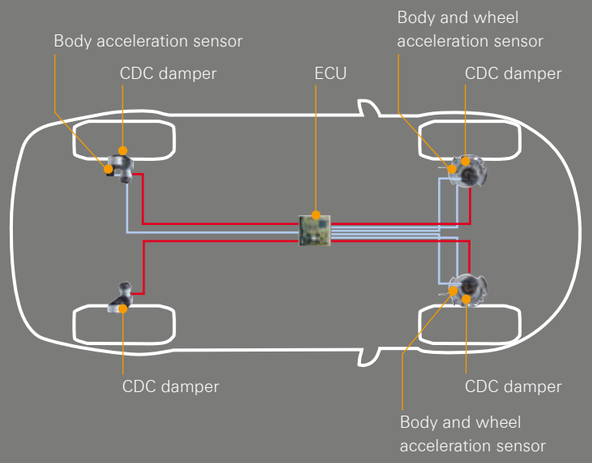
EcoRide features
- Cylinder tube, container, axle attachment, and top mount housing made of aluminum
- Hollow piston rod

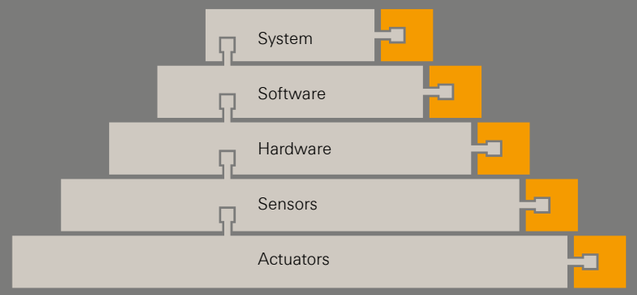
Benefits
- Greater safety thanks to optimized wheel damping
- Enhanced driving comfort and dynamics
- Reduced roll, pitch, and vertical motion
- Shorter braking distances thanks to better road contact
- Continuous adjustment in real time

CDC damper with two external valves

CDC Overview: System

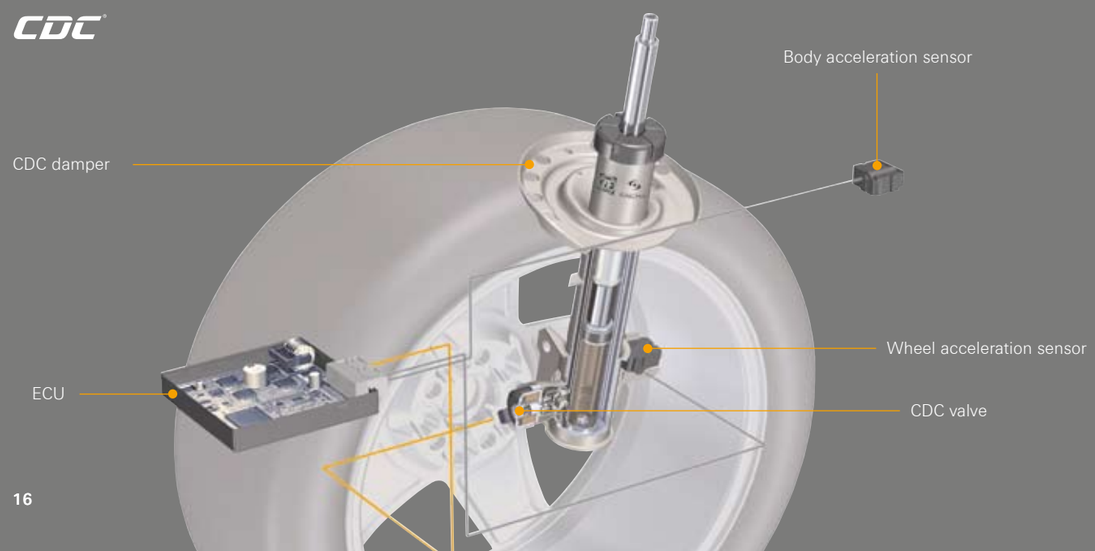
The CDC system
A sensor is located on each of the front axle's two dampers. Three additional sensors are located in the vehicle body. The sensor data is compiled and processed by a central control unit that adjusts the damping forces within milliseconds.



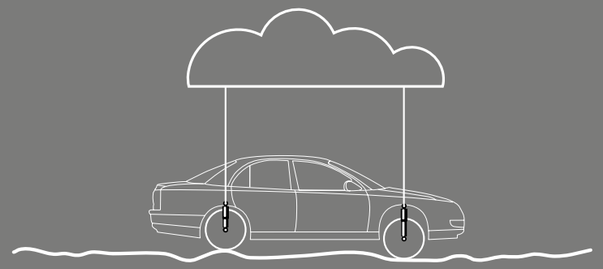


Actuators, sensors, hardware, and software are linked to form the CDC system technology. New solutions are continuously being developed in the individual subfields which generate added value for the overall system – providing considerable benefits to vehicle makers and end consumers alike.

CDC Overview: Actuators, Sensors, and Hardware



CDC Overview: Skyhook Control Strategy (Software)



Benefits
- Damping forces are only increased in the direction of motion where they are needed
- Damping forces are adjusted with targeted precision
- Optimum wheel damping
- More degrees of freedom in vehicle tuning
- Integrated fail-safe strategy

The technology:
Damping forces for each wheel are individually controlled for the directional movements of wheel and body. Thus they always provide the best possible compensation for vehicle body movement relative to a stationary center position. The skyhook principle keeps the vehicle body as stable as possible, independent of driving and road conditions. The control strategy seeks to calm vehicle body movement, as if the moving vehicle were connected to a hook fixed on the sky. As a result, the body moves along like a sedan chair parallel to the sky – as if were "hanging from the heavens".

A comparison with passive dampers clearly shows the advantages of CDC with a Advanced Skyhook control strategy. Considerable advantages result for each of the dimensions shown.

	Conventional	ZF Sachs Advanced Skyhook
Elevation	0	+++
Stability	0	+++
Comfort	0	+++
Traction	0	++
Handling	0	+++

Comparison of CDC Advanced Skyhook control strategy vs. conventional dampers

ICD – Intelligent Controlled Damper

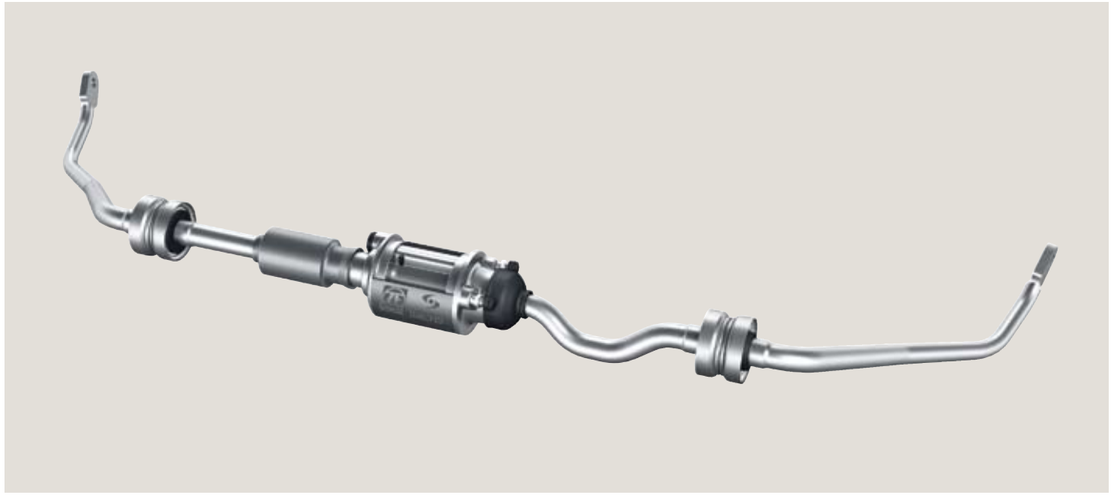
The technology:
Further development work in the direction of mechatronics is yielding a number of advantages. The entire damping control system, for example, can be run by ICD modules. These modules eliminate the need for a central control unit, because the dampers and sensors are part of the local bus system and receive the necessary vehicle data via a connection. Different systems can be designed to interact with damper control.

Benefits
- Lower damping force tolerances yield functional system benefits
- Elimination of wiring and plug connections saves costs and increases overall system reliability
- Easy and quick exchange of sensor and system information
- Easier interfaces with other chassis systems; generates new chassis functions

Active Roll Stabilization

The technology:
Active hydraulic roll stabilizers from ZF Sachs enable dynamic driving while increasing both safety and comfort. These units generate stabilizing forces on the front and rear axles to minimize or completely eliminate roll movements in the vehicle body during curves. They enable optimal turn-in and load alteration performance. When the vehicle is moving straight ahead, the electronic control unit adjusts the damping level to ensure softer, more comfortable suspension properties. Copy movement in the vehicle body is reduced, which gives the vehicle greater agility and cornering predictability throughout the entire speed range.

Active roll stabilization systems are used in mid-sized and high-end vehicles.

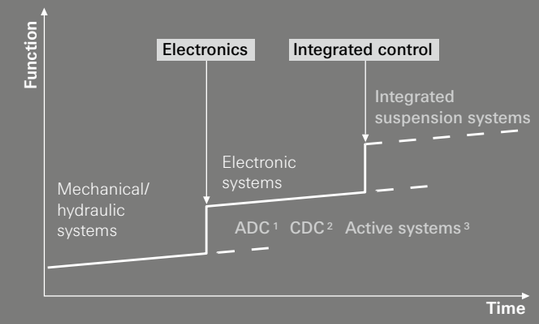


Hydraulic roll stabilization

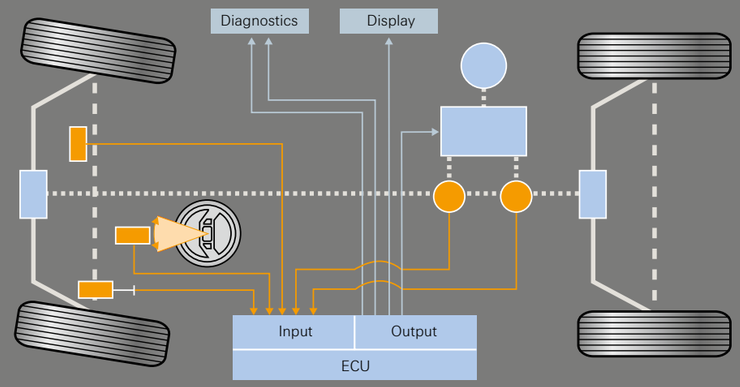
Benefits
- Minimizes roll movement
- Improves turn-in and load alteration performance
- Decouples wheel movement in straight-ahead driving

Integrated Chassis System

The task:
The next dimension in chassis development will feature greater driving safety, comfort, and pleasure – these are the demands that the market will place on cars of the future. The road to these new developments will be paved by “by-wire” technologies. Especially in the chassis, intelligent individual systems such as brakes, steering, suspension, damping, and wheels will increasingly make use of complex mechatronic strategies. The potential for the future – especially in the chassis – is based on linking and integrating individual systems. The goal of this development process is an integrated and largely “dry” drive-by-wire chassis. This process places new demands on technology, but also and especially on the quality of the partnership between vehicle manufacturers and system suppliers.



1 ADC: Adjustable Damping Control from ZF Sachs
2 CDC: Continuous Damping Control from ZF Sachs
3 Possible modules from ZF Sachs for active chassis systems and their linkage (roll stabilization, spring mount adjustment, and pneumatic suspension)



The technology:
Integrated suspension systems
ZF Sachs will actively shape these developments. With its CDC electronic damping system, ZF Sachs has established convincing systems expertise over a period of many years, and thus continuously created a foundation for the future. Our engineers are working intensively to advance CDC technology. This means making ongoing improvements and innovations in sensor, actuation, and electronic systems, as well as expanding existing damper parameters. An additional goal is to achieve the best possible interaction between damping systems and other subsystems and control units.

Experience as a development partner – for complex spring/damper units with steel or pneumatic spring design as well as for key active chassis system modules that control vehicle body movements – makes ZF Sachs the ideal partner for developing the integrated chassis systems of the future.

Preserving the Environment with Lightweight Design

A major challenge in chassis technology is the search for new ways to make individual components even lighter while continuing to meet the ever more sophisticated demands of the market. Lightweight design for the automotive industry strives to meet the sometimes conflicting demands for greater safety and comfort, lower fuel consumption, and high recyclability.

Cost-effectiveness:
There are various “intelligent lightweight design” strategies to reduce damper weight: One way is to use lighter or alternative materials, such as plastic, aluminum, magnesium or high-strength steel. Another option is to use finite element methods to optimize dimensions and component design. Thanks to expert utilization of the latest methods and processes, such as cold-pressing lightweight components, ZF Sachs is a specialist in large-scale series production and strategic development projects such as the 1-liter car. Lightweight design is one of the core areas of expertise at ZF Sachs.

Intelligent lightweight design utilizes the weight-saving potential in outer tubes, spring seats, cylinder tubes, piston rods, stabilizer mounts, top eye and brackets. It can reduce vehicle weight by as much as four kilograms, at only moderate additional cost.

Lightweight features
- Hollow piston rod in suspension struts
- Micro-alloyed steels for outer tubes and add-on parts such as retaining bars and spring seats
- Weight-optimized add-on parts
- Cold-extruded aluminum outer tubes with strength-optimized, variable wall thicknesses
- Lightweight design with high-strength steel, component weight similar to aluminum but with moderate additional costs
- Plastic joints

Monotube damper

EcoRide features
- Aluminum outer tube
- Plastic ring eye

CDC damper with internal valve

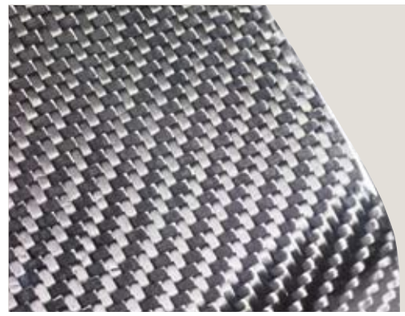
EcoRide features
- Cylinder tube, outer tube, axle attachment, and top mount housing made of aluminum
- Hollow piston rod

Ultra-lightweight McPherson strut with integrated wheel carrier

EcoRide features
- CFRP wheel carrier
- CFRP piston rod
- FGRP spring
- Top mount plastic model

The EcoRide product range also features environmentally friendly processes. One example is the elimination of energy-intensive procedures such as welding. Some of the environmentally harmful paint work can also be eliminated. Although the technologies used for this range are cutting edge, customers can be sure of the products’ reliability for it is verified in both theory and practice.

Methods and Tools:
Before the product is created, an innovation process takes place in which new ideas are generated and evaluated. To develop the strategies and products needed to ensure mobility now and in the future, and to be a reliable partner for our customers in the automotive industry worldwide, ZF Sachs invests continuously in design, simulation, testing, and configuration of suspension systems. Project management systems at ZF Sachs ensure optimum development times. Cutting-edge development tools ensure the quality of development results in the product range EcoRide.



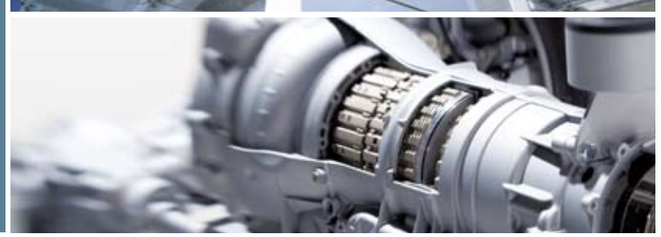
Company

ZF is a leading worldwide automotive supplier for Driveline and Chassis Technology. With total sales of euro 12.5 billion in 2008 and 61,156 employees at 125 production companies in 26 countries, ZF is among the top fifteen companies on the ranking list of the largest automotive suppliers worldwide.

ZF Sachs is the Powertrain and Suspension Components division of the ZF Group. For more than 100 years, ZF Sachs has been a renowned partner of the automotive industry. Our products are not only used with traditional applications in cars, commercial vehicles, rail, construction and agricultural technology but also in motorsports.

Leading technology, quality and service are integral parts of the company's strategy. By implementing a company-wide "Global Performance System", known as GPS, ZF Sachs has adapted to international market requirements. The objective is to promote customer-supplier relations by means of process orientation, innovation, flexibility, and standardization. GPS as a Corporate Mission Statement represents improved cost management, employee commitment, and increased productivity at a global scale.

In the corporate group:
ZF Sachs AG is a partner of vehicle makers worldwide for the development and production of powertrain and suspension components. A variety of R&D and systems advantages arise for vehicle makers in conjunction with the divisions of the ZF Friedrichshafen AG corporate group. Examples include suspension strut modules or complete axle systems.



Powertrain and Suspension Components

Powertrain Components
Strategic Business Units and Product Program

Clutch Systems PC	Dual Mass Flywheel, XTend – Clutch Cover with wear compensation, Clutch Discs, Multi Disc Clutch, Actuation System, Mechanical Torsional Damper, Actuators for Automated Manual Transmissions
Active Launch Systems	Torque Converter for PC, CV and Construction Vehicles, Dual Wet Clutch, HCC – Hydrodynamically Cooled Clutch
Clutch Systems CV	Single and Dual Disc Clutches, XTend – Clutch Cover with wear compensation, Dual Mass Flywheel, ConAct – Pneumatic Actuation System, Torsional Damper
Electric Drives	Electric Drives and hybrid modules for PC, CV and Construction Vehicles

The continuous advancement and integration of components and modules into complex systems are one of the demanding tasks of the Powertrain division. Automotive manufacturers are aiming at lower fuel consumption and reduced CO_2 emissions with simultaneously enhanced comfort. New converter concepts, optimized dual mass flywheels, hydrodynamic launch systems, and the intensive development work on the hybrid modules make a considerable contribution to achieving the automotive industry's targets.

Suspension Components
Strategic Business Units and Product Program

Conventional Dampers PC	Monotube and Twin-Tube Damper, Suspension Strut, Stroke-Dependent Damping, Sensitive Damping Control – Amplitude Selective Damping, HID – High Impact Damping
Active Suspension Systems PC	Nivomat – Leveling System, CDC – Variable Damping System, Active Roll Stabilization, Monotube, Twin-Tube, Steering Damper and Suspension Forks for Motorcycles, Damper and Clutches for Racing
Damper Systems CV/Railway	Monotube and Twin-Tube Damper, Air Spring/Damper Module, CDC and PDC – Variable Suspension Systems, Cabin Damping for CV, Agricultural and Construction Vehicles, Primary-, Secondary- and Yaw Dampers for Rail Vehicles

The optimization of conventional shock absorbers as well as the integration and networking of intelligent dampers in complex and adjustable chassis systems determine the processes of the Suspension division. Increased safety, comfort, and driving dynamics are the market requirements to be met in all vehicle classes. ZF Sachs allows for a new dimension in the field of suspensions by providing innovative products, such as the CDC electronic damping system, or the amplitude-selective damping system Sensitive Damping Control.

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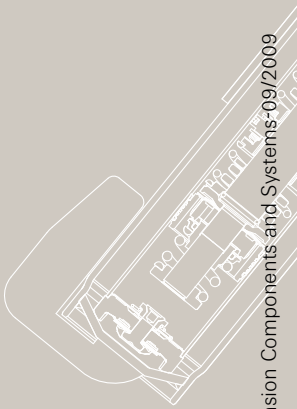

Driveline and Chassis Technology