Service Training

# Self-study Programme 357

# The Nivomat

Design and Function

The loading of a vehicle influences the ride comfort and driving stability to a great extent.
With this in mind, ride-height control systems have been and continue to be developed.
They have the task of actively reacting to the loading of the vehicle suspension.

Until now, these systems were optional extras in the higher vehicle classes or in luxury cars due to their complexity.

The NIVOMAT from ZF Sachs is a tested, compact system that can be easily integrated in existing vehicle concepts.

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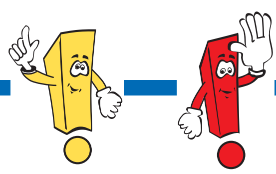
**NEW**

**Important Note**



**The self-study programme shows the design and function of new developments.**
**The contents will not be updated.**

For current testing, adjustment and repair instructions, refer to the relevant service literature.

# Contents

# Introduction

The Nivomat is a suspension system that automatically reacts to the load carried in the vehicle and adjusts the vehicle level to the current loading state. This means that the Nivomat raises the rear of the vehicle when loaded within its control limits so that the driving stability is maintained.
It therefore makes an essential contribution to the safety of the vehicle and its occupants.

**The advantages:**

- compact design,
- easy to install and retrofit,
- low cost,
- no electrical or hydraulic power requirement,
- no increased fuel consumption,
- load-sensitive suspension,
- prevention of damage to the underbody with heavy loads,
- bumpers remain in an ideal position even when the car is fully loaded.

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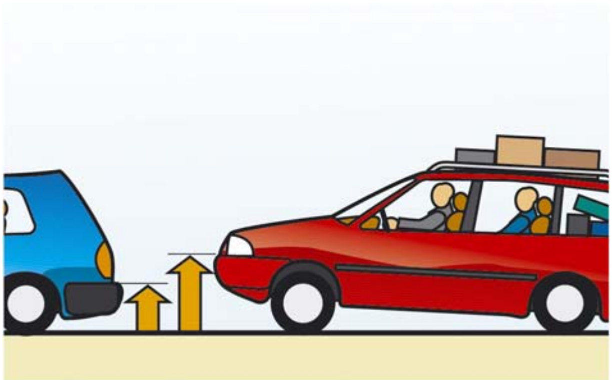
## Loading and vehicle behaviour

The vehicle behaviour is essentially determined by the weight and the weight distribution between the axles in addition to the speed and the environmental conditions. The ground clearance, driving stability, driving safety and aerodynamics are influenced negatively by an uneven weight distribution.

**Low ground clearance** S357_002

**Ground clearance**

If a vehicle is heavily laden, the springs will be compressed by the high vehicle weight and the vehicle level compared with the road will be reduced. Only a small amount of suspension travel is then available to compensate, for example, potholes. The underbody can be damaged.



**Unfavourable bumper position** S357_003

**Driving stability and driving safety**

When the car is carrying heavy cargo, the load is not distributed evenly between the front and rear axles. The front axle grip is reduced so that the drive, steering and braking forces are no longer transferred sufficiently.
In crash situations, the bumpers will also no longer be in an ideal position to absorb the collision.

**High air resistance** S357_004

**Aerodynamics**

Due to the unfavourable vehicle position when carrying heavy cargo, the air resistance and thus the fuel consumption is increased. Particularly at high speeds, the poor aerodynamic properties cause the driving stability to be reduced further.

## Explanation of terms

Before we look more closely at the design and the tasks of spring/damper systems in automotive engineering, we will explain the terms damping and suspension in order to differentiate them as much as possible.

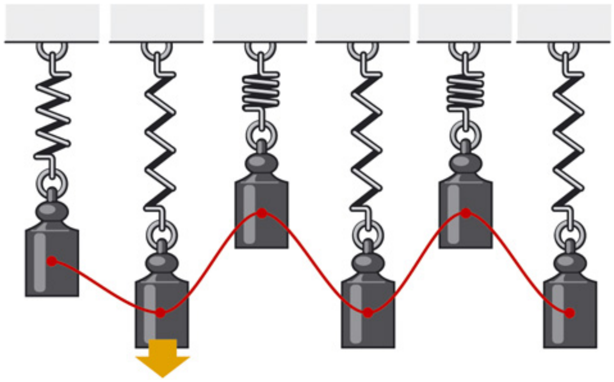
### Damping

The term damping originates from the theory of oscillation. In traditional mechanics, oscillation is the upward and downward movement of a mass that is attached to a mechanical spring. If you do not take external influences into consideration in an idealised observation, an EXCITED MASS would continue to oscillate infinitely (undamped oscillation).

In reality, there are, for example, friction influences from the surrounding air and from inside the metal structure of the spring. The friction that occurs "consumes" some of the vibration energy during each oscillation. This makes the oscillation weaker with each stroke until it finally stops as long as the spring mass system is not excited by bumps.
This is called a damped oscillation.

In many technical areas, it is necessary to amplify this damping behaviour with the appropriate design measures to prevent the development or build up of vibrations.
This is the task of damper systems used on the vehicle axles in automotive engineering. Among other things, they ensure that driving stability, driving safety and ride comfort are maintained.

**Undamped oscillation**
(ideal observation)

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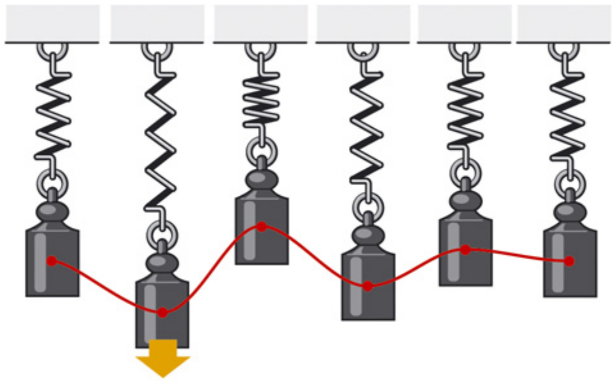
**Damped oscillation**

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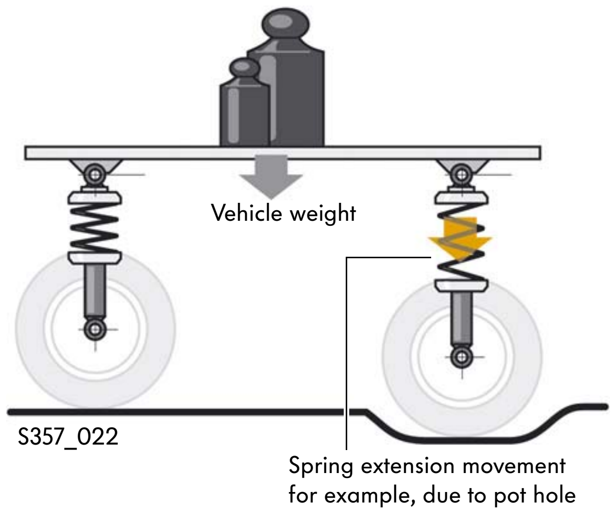
## Suspension



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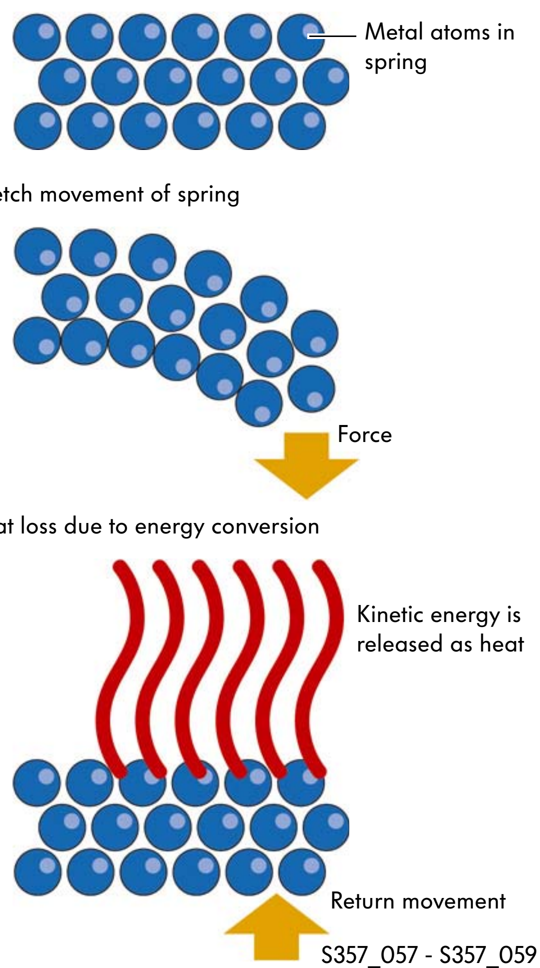
The task of the suspension is to carry the weight of the vehicle and absorb bumps caused by an uneven road surface. Pre-tensioning the springs ensures that none of the tyres lose contact with the ground, for example, when they travel over potholes. This is important so that on bad road surfaces drive, braking and steering forces can be transferred and the handling can be controlled.

**Damping effect on atom level**



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### Damping behaviour of mechanical springs

Depending on the type of spring used, a spring can also damp oscillations. The damping effect is usually small, however. This is due to the METAL ATOMS in the springs having a relatively fixed position and also wanting to maintain this position. The ATOMS need to be excited by an external force to leave their normal position and follow the extension movement of the springs. If the external force is no longer there, the metal atoms return to their original position.
At atom level with these movements, kinetic energy is converted into thermal energy. This is why springs become warm when they are extended and compressed in quick succession.

## Vehicle suspension systems

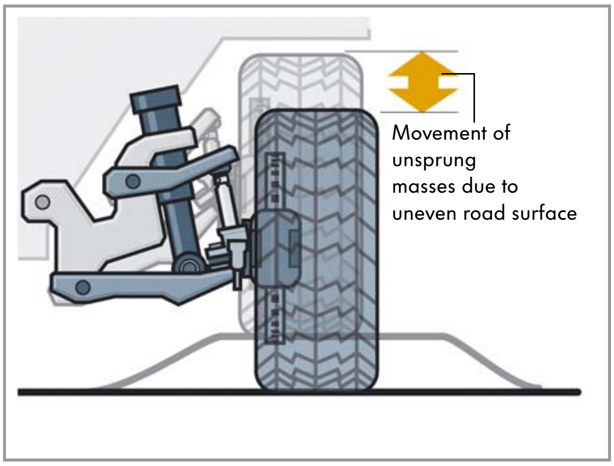
To achieve ideal interaction between suspension and damping, springs and suspension systems are used together.

In terms of physics, a vehicle is made up of unsprung and sprung masses.
The mechanical springs and the damper systems are partly among the unsprung masses.

**Unsprung masses**

This includes components that absorb the unevenness of the road with their movements. They are:

- the axles,
- the springs (partly),
- the wheel mountings,
- the brakes,
- the dampers (partly) and
- the wheels.

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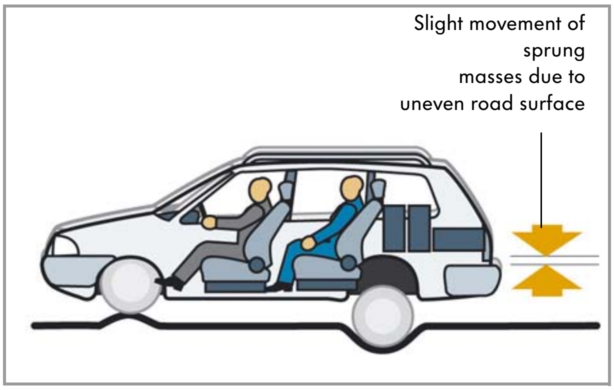
**Sprung masses**

These are all parts that are isolated from the uneven road surface by spring elements,
for example:

- the body,
- the occupants and
- the load.

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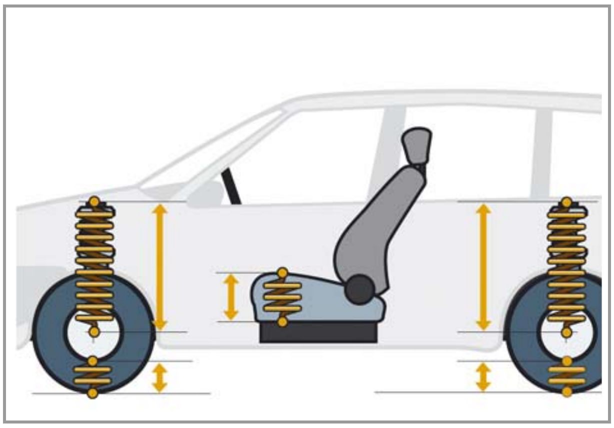
**Basic design**

Vehicle suspensions are usually made up of three spring elements:

- the tyres,
- the axle suspension and
- the seat springs.



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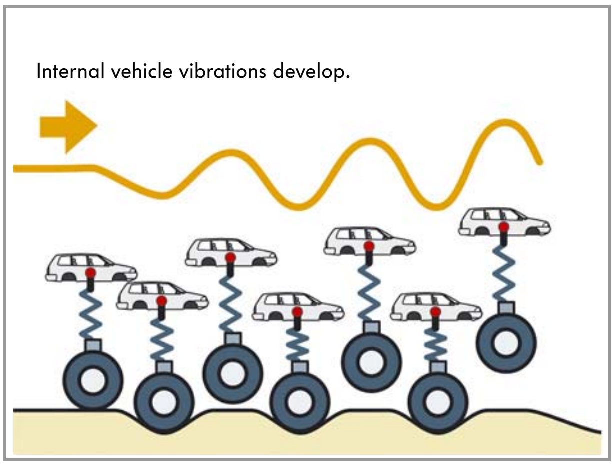
## Spring system tasks

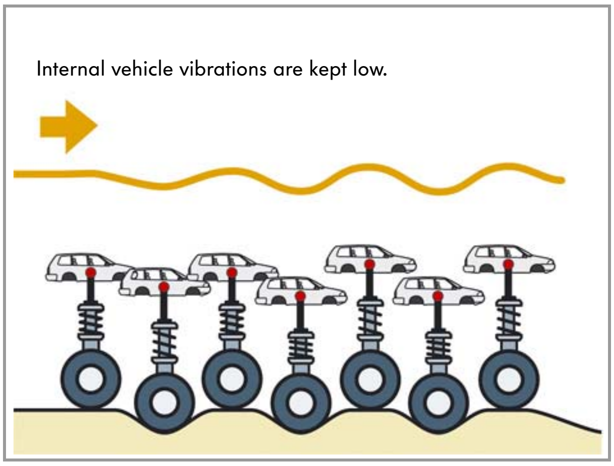
To illustrate the tasks of the suspension systems, we will look at the behaviour of a vehicle with a purely mechanical suspension without shock absorbers (undamped suspension) and a vehicle with a spring/damper system (damped suspension).




**Suspension without shock absorbers** S357_008

**Vehicle with undamped suspension**

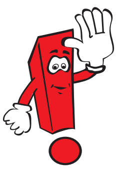
When an undamped suspension is used, the tyres start to bounce on successive road bumps and lose contact with the surface.
The vehicle body is subjected to increasing as well as overlapping oscillating and rolling movements that cause uneven grip. The vehicle is no longer controllable and becomes unstable.




**Suspension with shock absorbers** S357_009

**Vehicle with damped suspension**

The damping ensures that body and wheel vibrations that are caused by an uneven road surface are quickly absorbed. The grip of the tyres on the road is therefore maintained and the drive, steering as well as braking forces can be transferred.
The vehicle can also be controlled on bad road surfaces and is stable.



In the diagrams showing the behaviour of springs and dampers over the next pages, the mounting point on the body is taken as the fixed point. Therefore, when the springs are compressed, the upwards force, which compresses the springs or dampers, is shown as an arrow while the extension is shown as an arrow pointing downwards. The movement is therefore shown relative to the vehicle body.

# Vehicle Suspension Basics

## Types of suspension

The following suspension systems are distinguished:

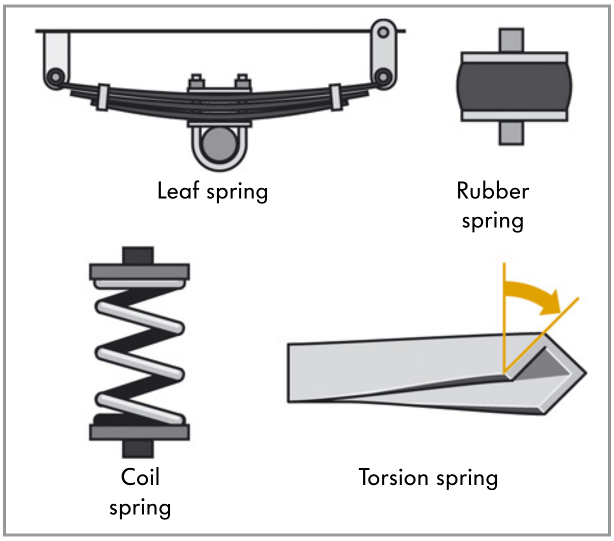
- Mechanical springs in the form of leaf, coil or TORSION SPRINGS made from steel or rubber spring elements,
- pneumatic suspension,
- hydropneumatic suspension and
- combinations of these systems, for example, a strut with pneumatic suspension and coil springs.

### Mechanical suspension

The mechanical springs on a vehicle above all have the purpose of carrying the mass of the vehicle.

#### Damping behaviour of mechanical springs

As described, mechanical springs usually have just a few damping characteristics.
It is not enough to damp the body vibrations sufficiently.

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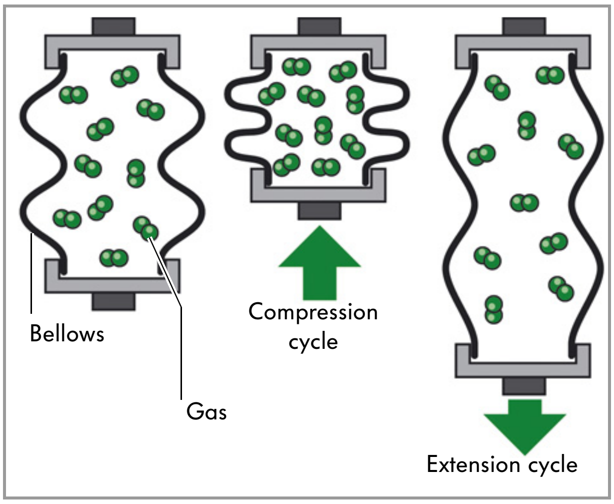
### Pneumatic suspension systems

A basic pneumatic spring consists of airtight bellows that are filled with a gas. The spring effect is based on the fact that gases can be compressed. This means that the bellows are pressed together by the vehicle mass.

#### Damping behaviour of pneumatic springs

Pneumatic springs also have a damping behaviour when the bellows are extended and contracted. This is due to the vibration energy being converted into thermal energy as the gas is compressed and expanded.

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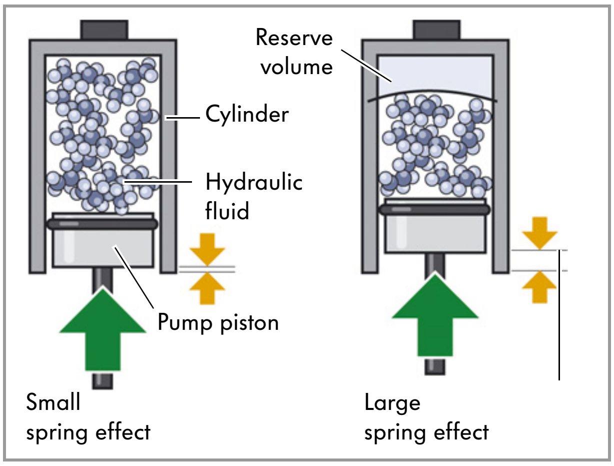


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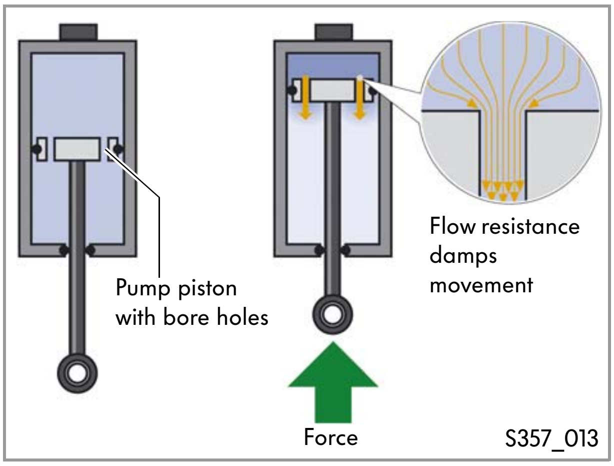
## Hydropneumatic suspension

As liquids cannot be compressed much, a purely hydraulic suspension system has only a very small spring effect. Hydraulic fluids are excellently suited, however, for achieving good damping behaviour. In order to use this property, cylinders and pump pistons are also filled with gas (gas-filled springs). The result is a hydropneumatic suspension that creates the spring effect by compressing the gas in the reserve volume.

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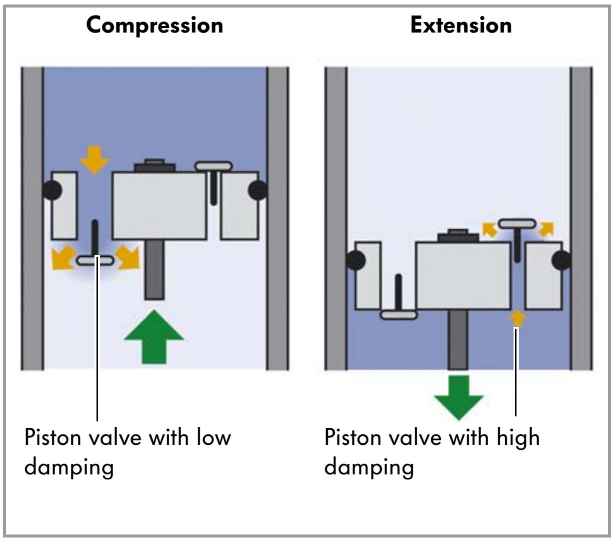
### Damping behaviour of hydropneumatic suspension

Due to the properties of the hydraulic fluid, these systems have a very high damping behaviour. The piston has small bore holes through which the hydraulic fluid needs to flow when the piston is moved by a force.

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Due to piston valves acting on one side with different cross-sections, the extension cycle is damped more than a compression movement. This is necessary because the mechanical springs on the strut (support springs) counteract the movement of the pump piston as it extends.

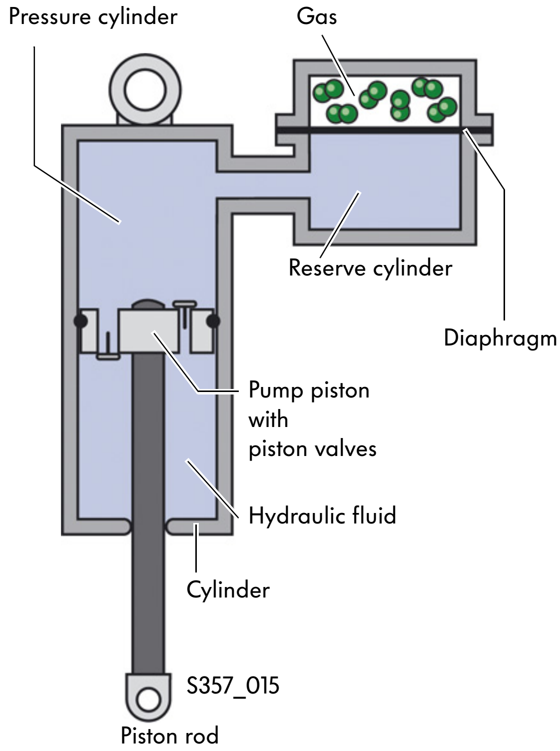
During compression, the supporting spring supports the movement of the pump piston. Therefore only a smaller level of damping is required for the compression movement.

# Vehicle Suspension Basics

## Shock absorbers

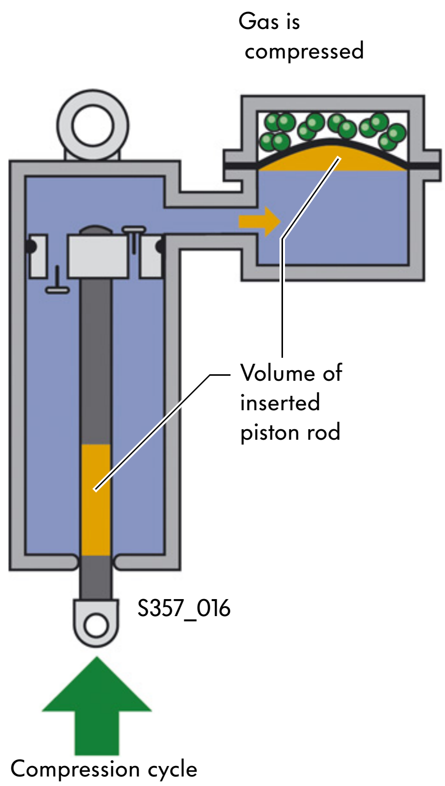
Today shock absorbers are the most frequently used damper elements in chassis suspension systems. Their task is, as the name suggests, to absorb vibrations caused by the uneven road surface fast enough and to the greatest extent possible so natural vibrations do not or rarely occur in the vehicle body.

Today's shock absorbers are usually designed as hydropneumatic systems.



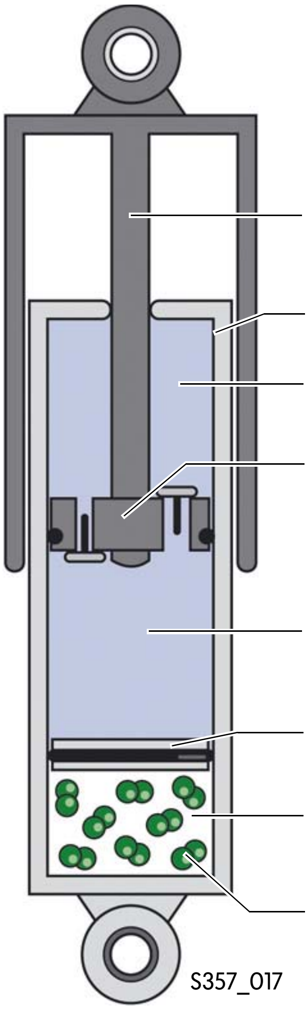

Among other things, the reserve chamber is used to hold the fluid that is pushed out of the pressure cylinder when the piston rod enters the working room during a compression cycle.

There are two types: single and twin-tube shock absorbers. The diaphragm shown here is not absolutely necessary. Depending on the type of shock absorber, the hydraulic fluid and gas are not separated or are divided by a separator piston.




To illustrate the basic principle more simply, the reserve cylinder is shown as an external chamber. Real shock absorbers usually have an integrated reserve cylinder.

## Single-tube shock absorber




**Design**

In the single-tube shock absorbers, the pressure cylinder and the reserve cylinder are combined in the same tube. Hence the name single-tube damper. To avoid bubbles forming in or foaming of the gas volume and hydraulic fluid, the two cylinders are separated by a sliding separator piston.

The reserve cylinder is filled with nitrogen gas. It has a pressure of approx. 20 to 30 bar depending on the manufacturer and design. The pressure cylinder where the pump piston moves is above the separator piston.

The damping effect, as described for the hydraulic suspension, comes from the pump rod only being able to travel in the pressure chamber as fast as the hydraulic fluid can flow through the piston valves from one side of the piston to the other. The piston valves ensure the different damping characteristics during the compression and expansion cycles.

**Advantages of single-tube damper:**

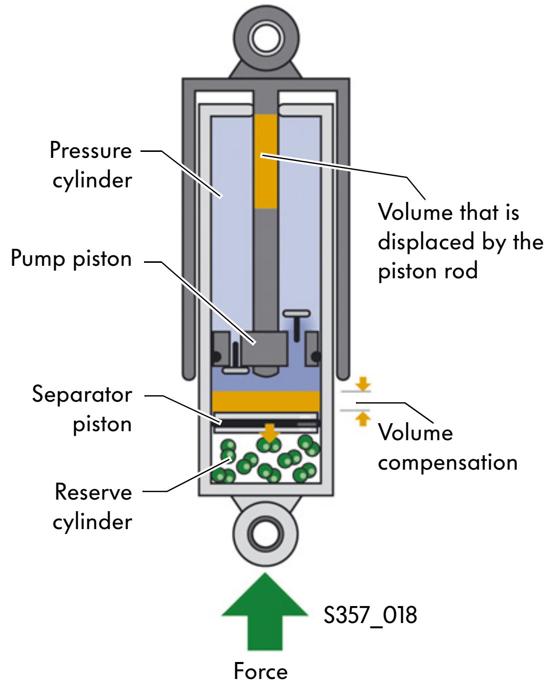
- good heat discharge,
- no danger of foaming,
- fast response and
- numerous mounting positions possible.

### Function

Due to the moving separator piston, the single-tube shock absorber has a pressure cylinder with variable volume.

When the pump piston is moved in the direction of the gas volume during a compression cycle, the piston rod is pushed into the hydraulic fluid. The volume of hydraulic fluid that is displaced by the piston rod moves the separator piston so that the pressure in the reserve cylinder is increased. This process is called volume compensation.

**Compression cycle**

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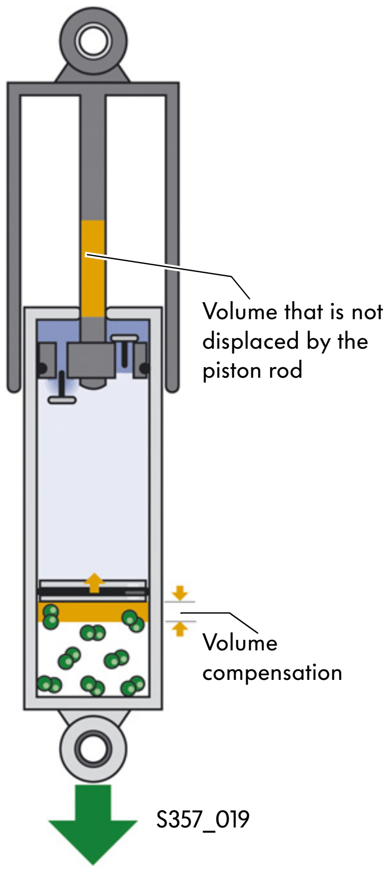
During the extension cycle, the piston rod is pulled far out of the pressure cylinder. As a result, it displaces less hydraulic fluid than before so the separator piston is now moved in the direction of the pump piston by the pressure of the gas volume.

**Extension cycle**

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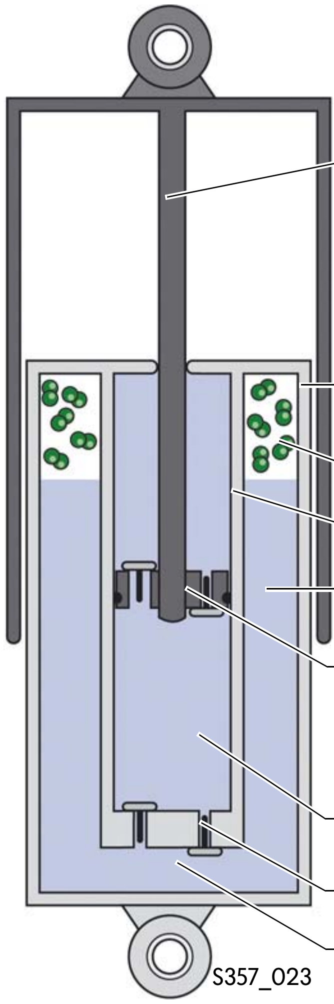
## Twin-tube shock absorber



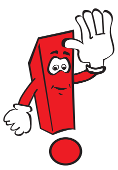

### Design

In a twin-tube shock absorber, the pressure cylinder and the reserve cylinder are accommodated in two pipes that fit inside each other. The pressure cylinder with the pump piston is in the inner tube.
The space between the outer tube and the inner tube is used as the reserve cylinder. This is where the gas and the hydraulic fluid for the volume compensation is located.

In a twin-tube shock absorber, nitrogen is used as the gas. It has a lower pressure than single-tube shock absorbers of approx. 3 to 8bar. The pressure cylinder and reserve cylinder are connected via valves at the bottom of the inner tube
so that the hydraulic fluid can flow back and forth between the two chambers.

### Advantages of twin-tube damper

- Low-cost construction
- Short length



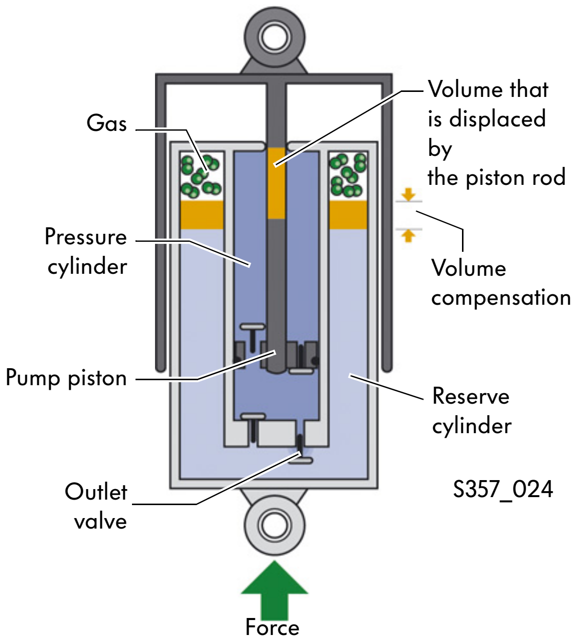
In order to show the design and functions more clearly, the twin-tube shock absorber proportions have been exaggerated widthways. Twin-tube shock absorber are in fact considerably slimmer in design.

### Function

Volume compensation should also occur during the compression and extension cycles in the twin-tube shock absorber since the piston rod displaces more or less hydraulic fluid.

During the compression cycle, the hydraulic oil that is displaced by the piston rod is pushed into the reserve cylinder via the base valve. The pressure in the reserve cylinder increases. As a result the gas is compressed until a pressure equilibrium is reached between the pressure cylinder, reserve cylinder and gas.

**Compression cycle**

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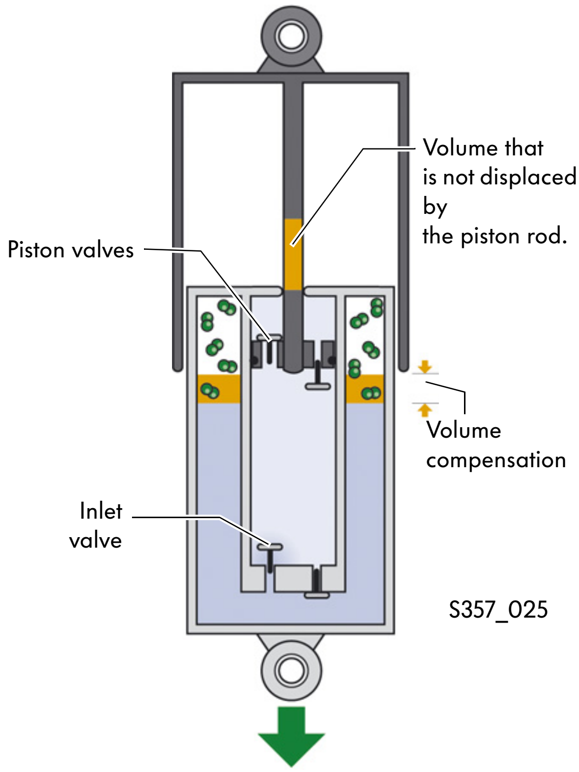
During the extension cycle, the piston rod is pulled far out of the inner tube. This means the piston rod displaces less hydraulic fluid so that the pressure in the pressure cylinder is reduced compared with the reserve cylinder. The inlet valve opens and hydraulic fluid flows out of the reserve cylinder into the pressure cylinder.
The gas expands between the inner and outer tube until a pressure equilibrium is reached between the pressure cylinder, reserve cylinder and gas.

The valves in the pump piston and the valves at the bottom of the inner tube ensure damping during the compression and extension cycles.

**Extension cycle**

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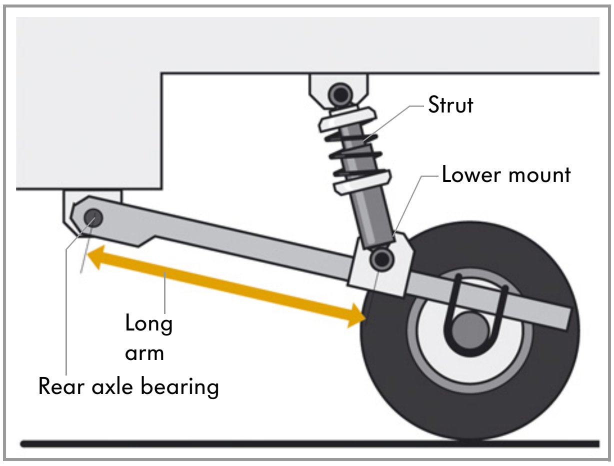
## What is ride-height control?

As described at the beginning of the self-study program, the vehicle load affects driving stability to a great extent. Ride-height control in the spring/damper system allows the vehicle height to be adjusted to different load states. As a result the driving stability, safety and ride comfort are also maintained with heavy loads.
There are different constructive approaches for creating a ride-height control system:

- changing the ratio of the springs,
- changing the lower mounting point of the shock absorber or
- a combination of these two approaches.



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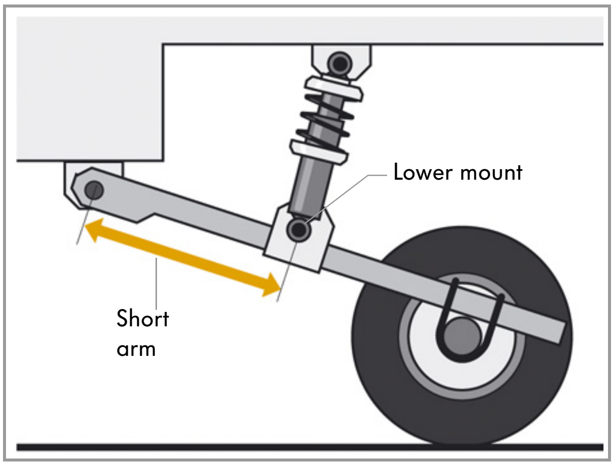
## Changing the spring ratio

The ratio of the springs is the distance between the rear axle bearing and the lower mounting point of the shock absorber in relation to the position of the wheel. An arm is attached to the rear axle bearing and the lower mount.



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This arm is shortened by mechanically moving the lower mount towards the rear axle bearing.
The shorter lever requires more force to compress the shock absorber above the rear axle.
This means that, with the same loading, the rear axle springs are not compressed as much as with the long arm.

# Basics of Ride-height Control

## Changing the lower mount of the spring

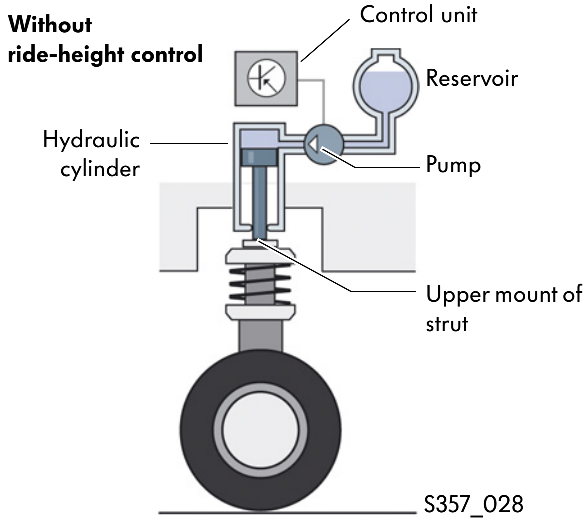
Changing the lower mount of the spring means that the lower mounting point of the strut is moved downwards in relation to the vehicle body using the corresponding design modifications. This changes the arm relationship between the rear axle bearing and strut in a similar way to the previous example.

There are three possible constructions for achieving this:

- Lowering the whole damper inn relation to the vehicle body,
- fastening the lower mount to a lever with torsion spring or
- increasing the spacing between the upper and lower mount of the shock absorber.

### Lowering the damper

In this approach, the upper mount of the shock absorber is not directly connected to the vehicle body, but to the piston of a hydraulic cylinder.
This is in turn attached to the vehicle body.

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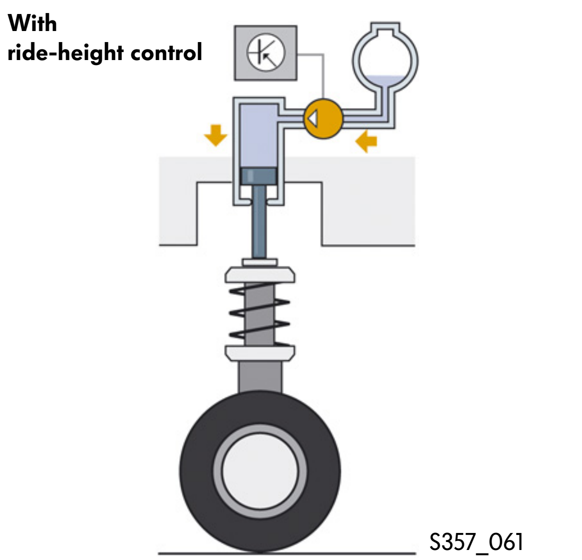
If the boot load is too high, the piston of this cylinder will be extended using a pump and the rear of the vehicle thus raised.

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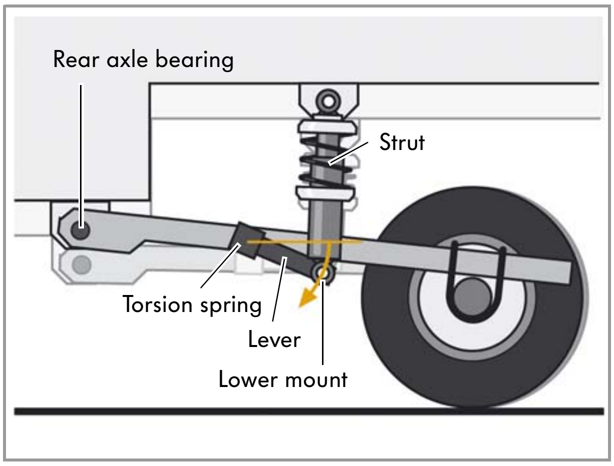

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## Using a torsion spring

In this case, the lower mount of the strut is connected to a torsion spring via a lever. The torsion spring is bolted to the rear axle. When the torsion spring is twisted by a heavy load, the arm between the rear axle bearing and lower mount is shortened. As a result the strut is not compressed so much with a full load.

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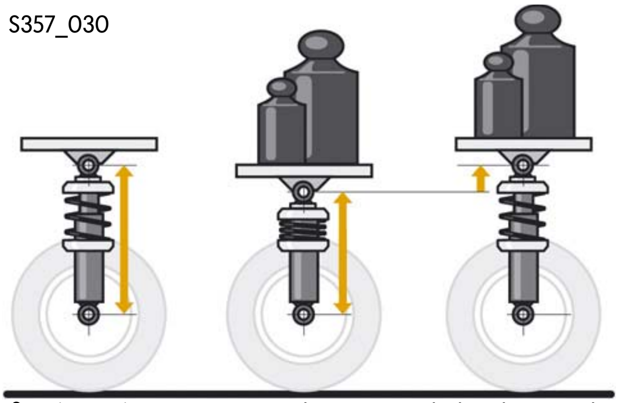
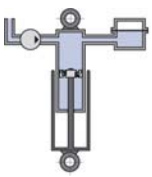


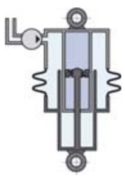

## Changing the spacing between the top and lower mount of the strut

The distance between the upper and lower mount point of the strut is changed depending on the loading of the vehicle. The compressed strut is simply pulled out.

This procedure can be achieved with three different construction methods:



1. The external supply of a hydropneumatic damper



2. The external supply of a pneumatic damper

3. A self-pumping hydropneumatic damper

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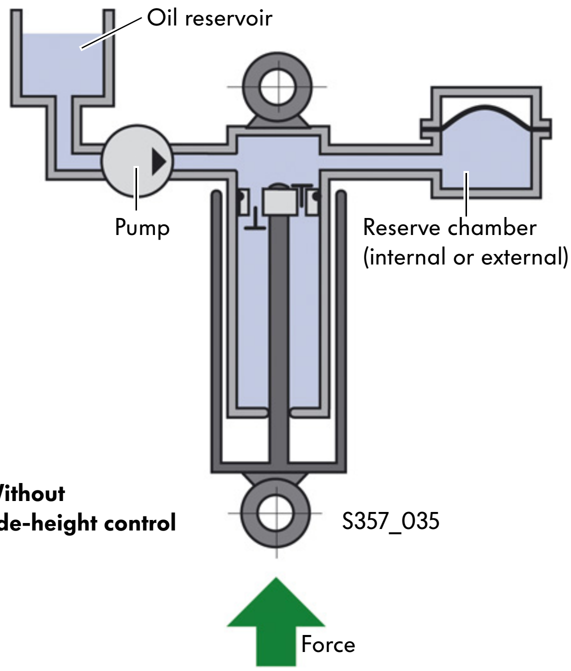
# Basics of Ride-height Control

**1. Hydropneumatic dampers with external supply**

This system is made up of an external oil reservoir, a hydraulic pump as well as the damper with reserve chamber and gas (gas-filled spring). The principle for controlling the ride height is to pump hydraulic fluid from the external oil reservoir into the pressure chamber using the hydraulic pump.




**Without ride-height control**

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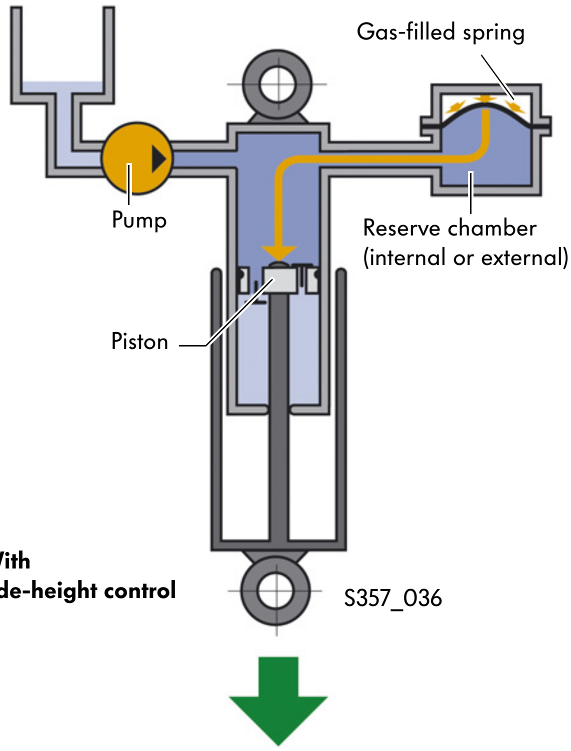
Since, due to the pump output, the pressure in the pressure chamber increases faster than the piston valves can reach a pressure equilibrium with the pressure chamber, there is a pressure difference between both areas of the pressure cylinder.
The resulting force extends the piston and is supported by the gas-filled spring.




**With ride-height control**

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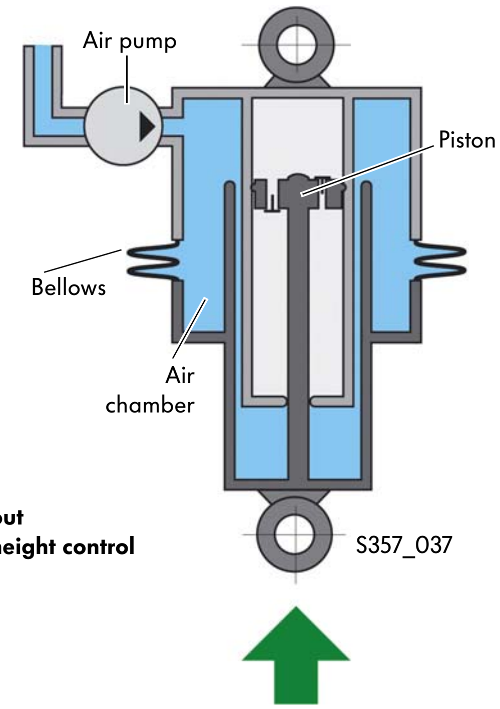
**Legend**

Low pressure

Pressure equilibrium / normal pressure

High pressure

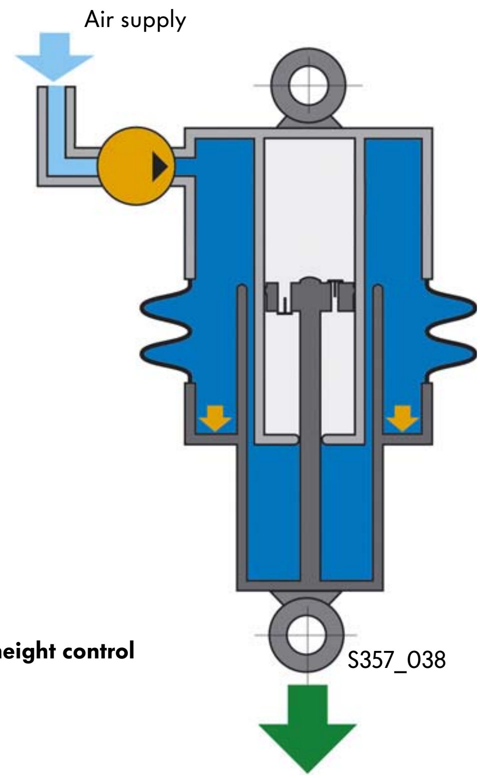



**Without**
**ride-height control**

S357_037

## 2. Pneumatic spring damper with external supply

The damper has a flexible air chamber with bellows and an external air pump that is connected to the surrounding air. In simple terms, the outside walls of the damper form a pneumatic cylinder with the walls of the air chamber.




**With**
**ride-height control**

S357_038

If the load is increased, air is pumped into the air chamber. As a result, the damper piston is drawn out of the pressure chamber so that the extension and compression path is also maintained with heavy loads.
In addition to the air pump, level sensors and an external electronic control unit are also required for this system.

**Legend**

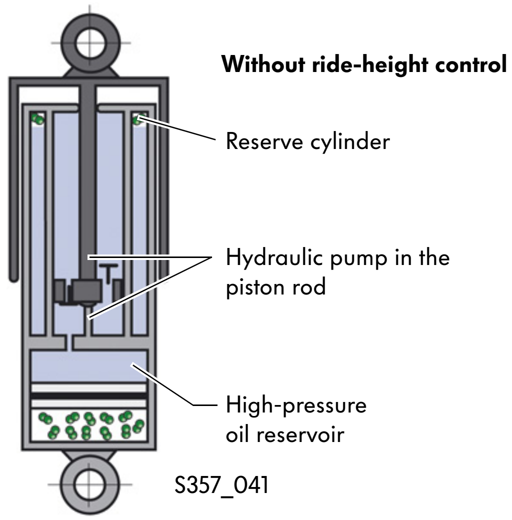
Air at normal pressure (1 bar)

Air at overpressure

# Basics of Ride-height Control

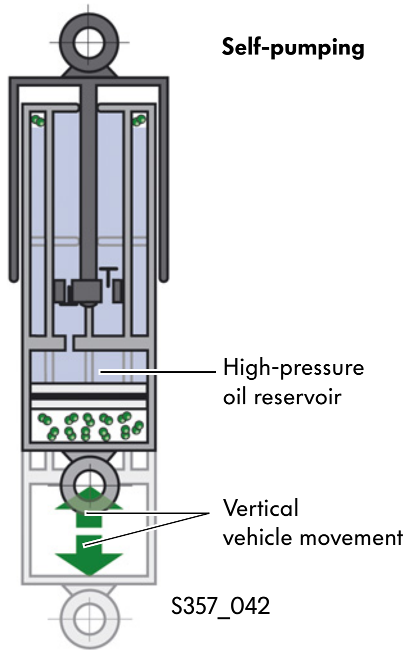
### 3. Self-pumping hydropneumatic damper

Self-pumping means that the damper automatically reacts to an increasing load and no additional components like external pumps or sensors are required for the ride-height control. Essential features of the self-pumping systems are a high-pressure oil reservoir separate from the reserve chamber and a mechanical hydraulic pump inside the piston rod.
All necessary parts are integrated in the damper.



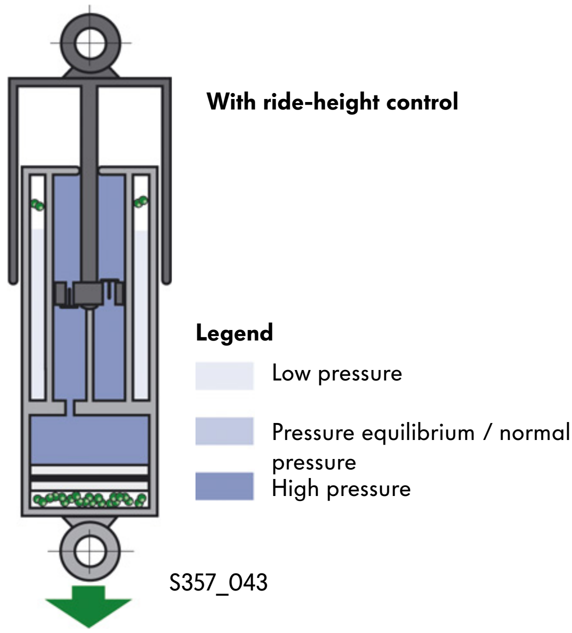

S357_041

The basic principle behind the self-pumping systems is to drive the integrated hydraulic pump with the vertical vehicle movement.
The pump movement causes hydraulic fluid to be transported from the reserve chamber into the high-pressure oil reservoir.




S357_042

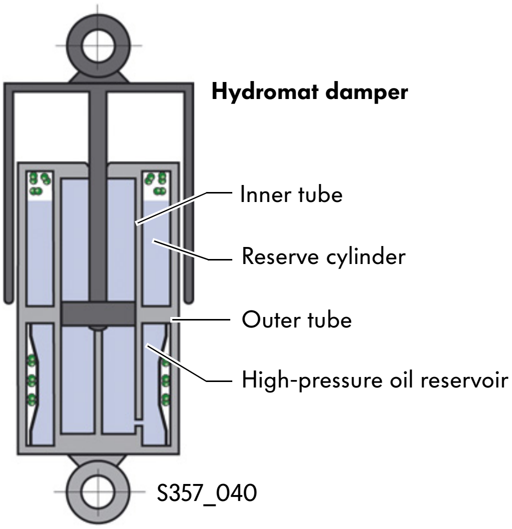
This process creates a higher pressure in the pressure chamber and high-pressure oil reservoir so that the gas-filling underneath the separator piston (gas-filled spring) is compressed more. The force is held by the separator piston causing the piston rod to be extended.




S357_043

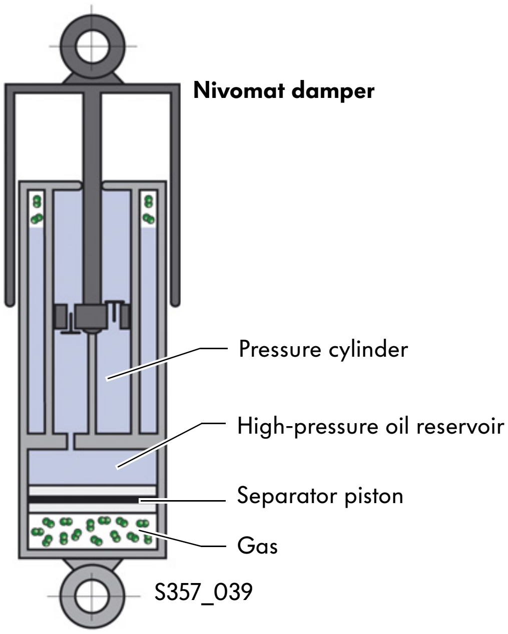
There are currently two different types of self-pumping hydropneumatic systems:

- Damper using the hydromat principle and
- dampers using the Nivomat principle.



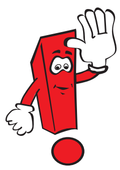
S357_040

The reserve chamber and the high-pressure oil reservoir are between the inner and outer tube in the hydromat system.
Thanks to the construction of the hydromat, it can be used in vehicle suspensions without additional mechanical coil springs (fully supported system).
However, the hydromat does require more space than conventional shock absorbers.



S357_039

Due to the arrangement of the high-pressure oil reservoir with separator piston above or below the pressure chamber, the Nivomat principle allows a very slim design compared with the hydromat.
The Nivomat is therefore an extremely compact and easy to install ride-height control system.
It replaces the conventional shock absorbers in the vehicle suspension, but also needs an additional mechanical coil spring (partly supporting system).



At the moment, the Nivomat principle is used as the ride-height control system at VOLKSWAGEN exclusively in vehicles without pneumatic suspension systems.
Over the following pages, we will therefore take a detailed look at the design and function of the Nivomat damper.

# Nivomat in the Passat

As we have said, the Nivomat is a compact ride-height control system. It is installed on the rear axle instead of the two normal hydropneumatic dampers.  The diameter of the Nivomat is larger than a conventional damper.
As each Nivomat adjusts itself automatically depending on the load, it is also possible to balance the rear axle if the loading on the left and right-hand side differs.
The basic features of the design are low pressure as well as high-pressure oil reservoirs and the internal mechanical hydraulic pump for the Nivomat.

## Design

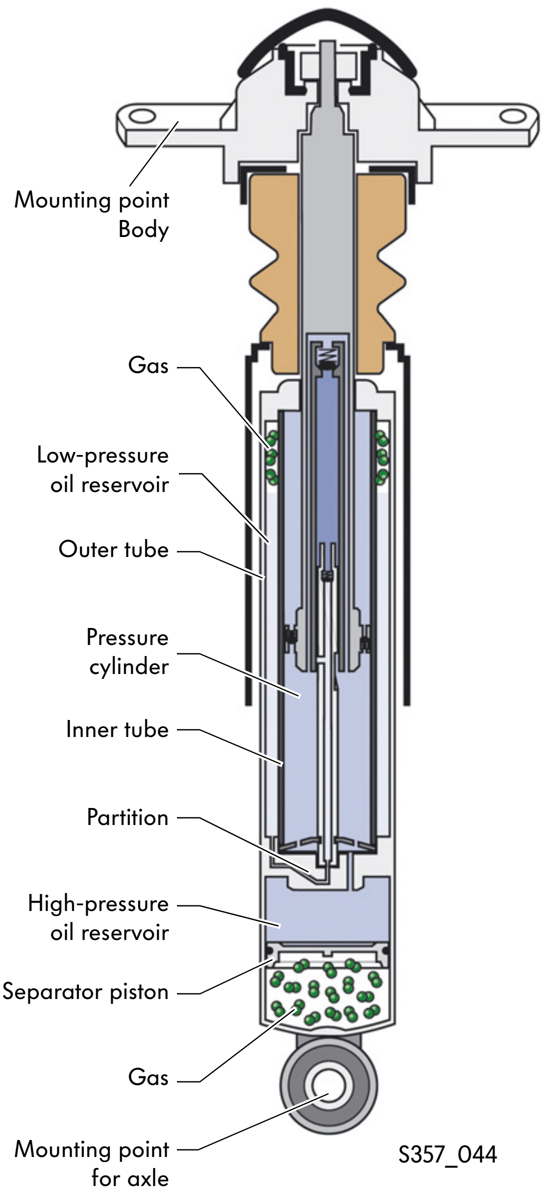
### Low-pressure and high-pressure oil reservoir

The Nivomat design is more or less a combination of single-tube and twin-tube shock absorber.
This means that, like single-tube shock absorbers, it has a separator piston and, like twin-tube shock absorbers, a inner as well as a outer tube with a reserve cylinder between them. The pressure cylinder is inside the inner tube.

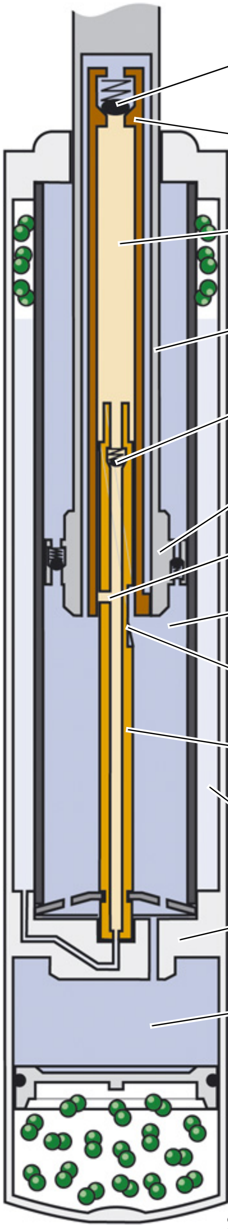
In the Nivomat, the reserve cylinder with oil reservoir and gas is not just used to compensate the volume of the piston rod, but also as the “supply cylinder” for the ride-height control. It is called the low-pressure oil reservoir.

The space with the separator piston underneath the partition also has a volume of gas and an oil reservoir. This is the high-pressure oil reservoir.

The ride-height control is achieved by the hydraulic pump pumping hydraulic oil from the low-pressure oil reservoir into the high-pressure oil reservoir into the high-pressure oil reservoir.



### Hydraulic pump



S357_045

It is driven by the compression and extension movement of the vehicle.
The special feature of the Nivomat compared with conventional shock absorbers is the hollow piston rod. A control sleeve has been pushed inside it with small spacing from the piston rod and is connected to the piston rod via the valve piston.
The control sleeve guides the pump rod, which is also hollow and connected to the partition at the other end. The space formed by the control sleeve and pump rod is the pump chamber. The oil supply for the pump runs via a bore hole in the partition that leads to the low-pressure oil reservoir.
At the top end of the pump rod, there is an inlet valve that allows oil to flow from the inner bore hole of the pump rod into the control sleeve.
The outlet valve, through which the oil flows from the pump chamber into the pressure cylinder and then into the high-pressure oil reservoir, is at the top of the control sleeve.

There is a spiral groove on the pump rod that works as a bypass.
Oil can flow back and forth between the pump cylinder and pressure cylinder when the spiral groove is opened to the pressure cylinder by the control sleeve.
Finally a drainage bore in the pump rod allows the oil to flow back from the pressure cylinder into the low-pressure oil reservoir via the partition.
The pump rod, control sleeve, inlet and outlet valve form the hydraulic pump for the Nivomat.

# Nivomat in the Passat

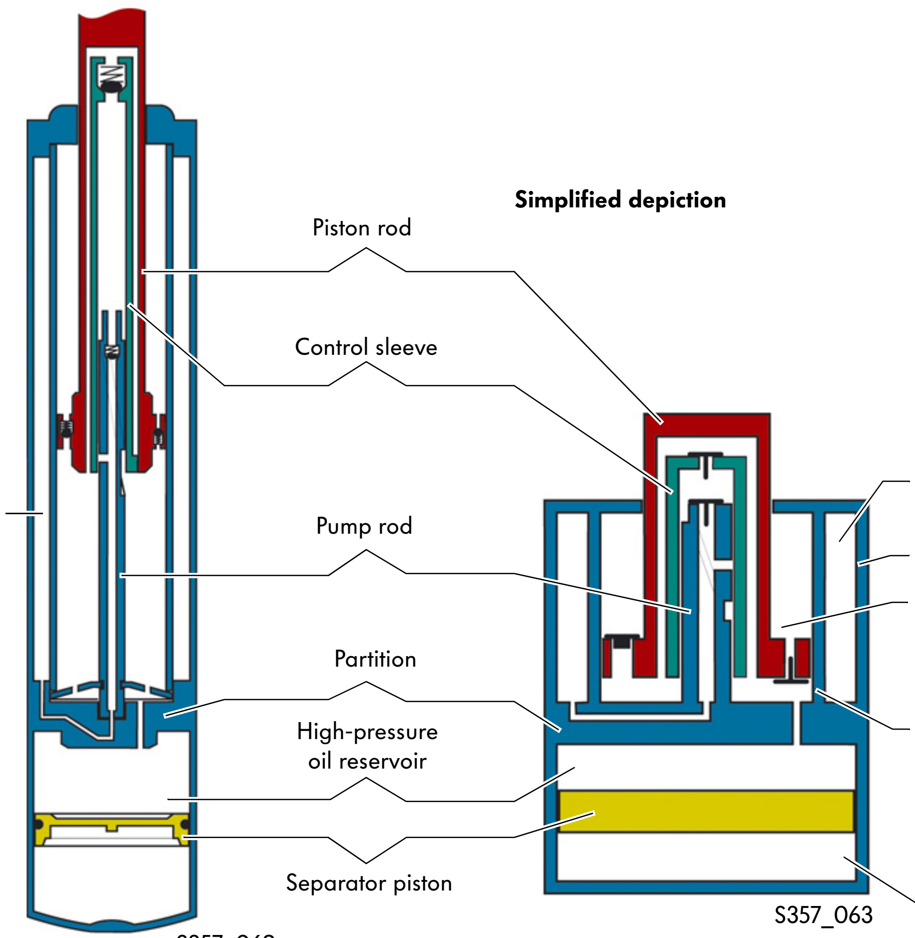
## Function

We will break the functioning of the Nivomat down into three sections:

- raising the vehicle level,
- holding the vehicle level and
- lowering the vehicle level.

Within these sections, we will show the procedures in very simplified diagrams of the Nivomat.

**Realistic depiction**



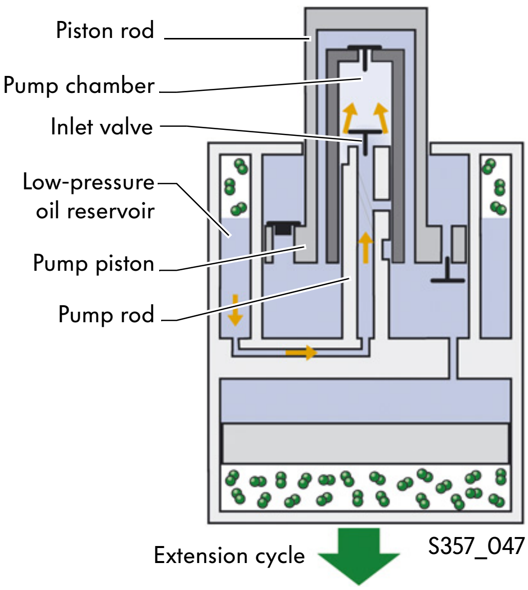

**About the diagram**

In the simplified diagram, the actual proportions of the individual components inside the Nivomat are exaggerated to make the operation of the pump rod inside the piston rod and the resulting oil flow easier to see.

## Raising the vehicle level

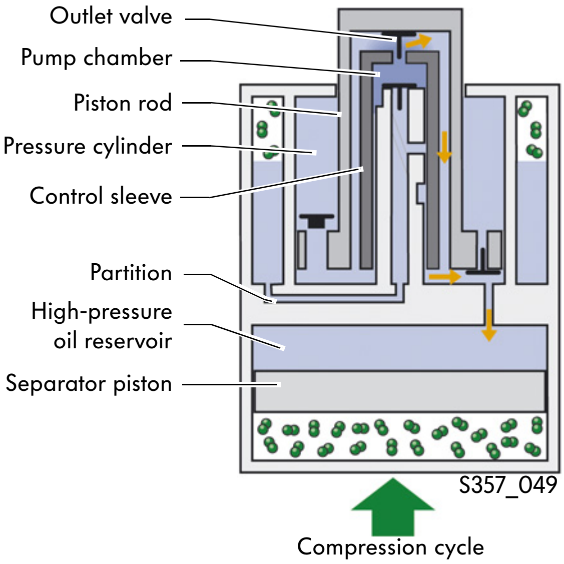
S357_046

When the boot is loaded, the rear of the vehicle is lowered as usual by the compression of the shock absorbers and coil springs.




S357_047

The Nivomat starts to work as the vehicle pulls away and compression and extension movements are caused by bumps on the road surface. During the first extension cycle, the Nivomat moves downwards away from the pump piston and piston rod. This increases the volume of the pump chamber and oil is drawn out of the low-pressure oil reservoir via the bore holes in the partition, the bore hole in the pump rod and the inlet valve in the pump chamber.




S357_049

The inlet valve closes during the next compression cycle. The oil in the pump chamber is now pushed out of the outlet valve into the space between the control sleeve and piston rod. From there it passes through the working chamber into the high-pressure oil reservoir.

**Legend**

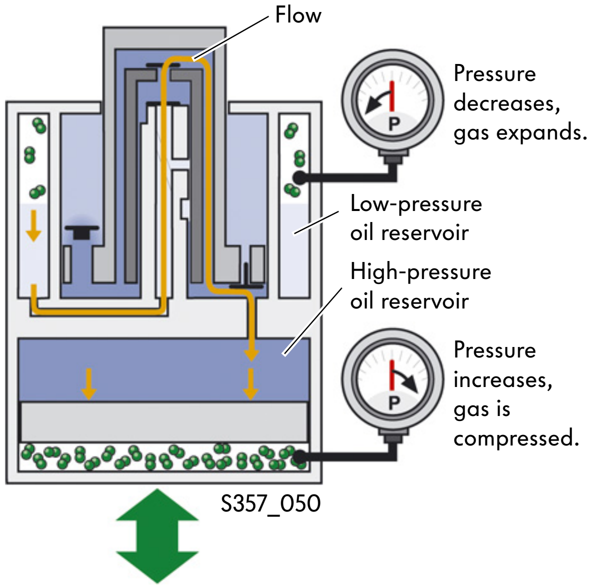
Low pressure

Pressure equilibrium / normal pressure

High pressure

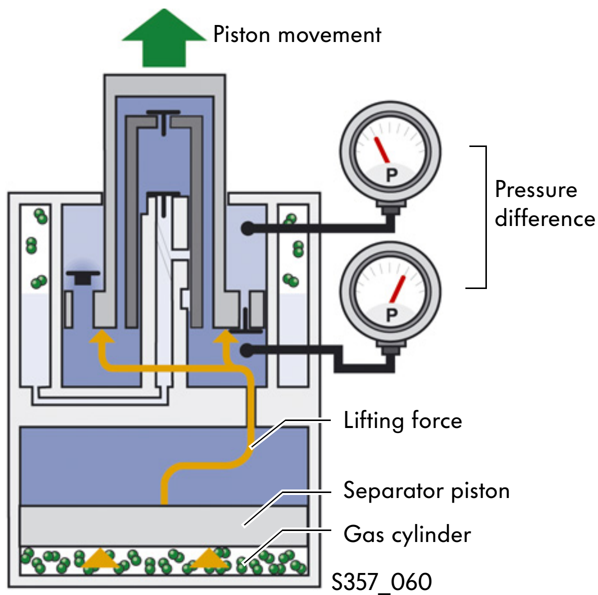
# Nivomat in the Passat

This means that due to the compression and extension cycles, oil is constantly pumped from the low-pressure oil reservoir into the high-pressure reservoir. As a result, the pressure in the low-pressure reservoir and the gas between the inner and outer tube expands. The pressure in the high-pressure oil reservoir increases and the separator piston is pushed in the direction of the gas. The gas underneath the separator piston is compressed.




S357_050

The lifting force that pushes the piston out of the Nivomat results from the pump pumping hydraulic fluid faster into the area under the piston than the fluid can flow through the piston valves in the upper section. This causes a pressure difference between the areas under and below the piston. The piston is pushed upwards out of the cylinder. The lifting force is supported by the separator piston and thus by the high gas pressure of the gas cylinder.




S357_060

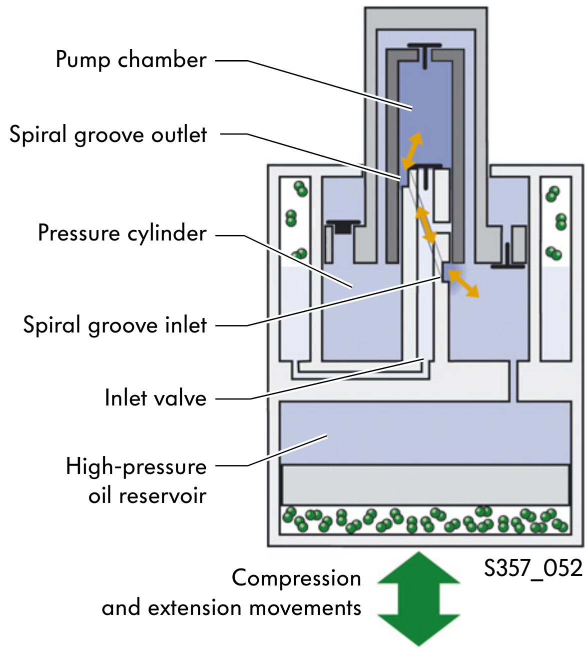
**Legend**

Low pressure

Pressure equilibrium / normal pressure

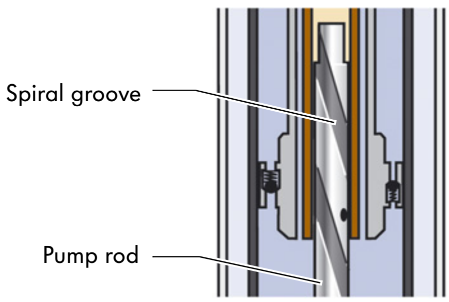
High pressure

**Holding the vehicle level**



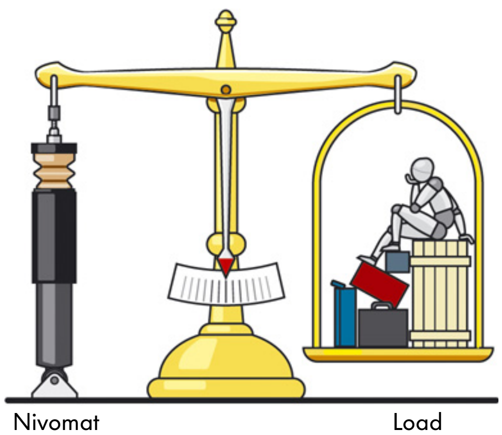
S357_052

When the target vehicle level is approached, the spiral groove reaches the pressure cylinder.
Now oil can flow back and forth between the pressure cylinder and the pump chamber. This means that no more oil is drawn in through the inlet valve during an extension cycle movement nor pumped into the high-pressure oil reservoir during a compression cycle movement.
The vehicle maintains the level reached even during further compression and extension movements.



S357_051

The spiral groove on the pump rod is designed so that it connects the pressure chamber to the pump chamber when the rear of the vehicle approaches the normal position. The spiral groove forms the boundary up to which the vehicle level can be raised.



S357_053

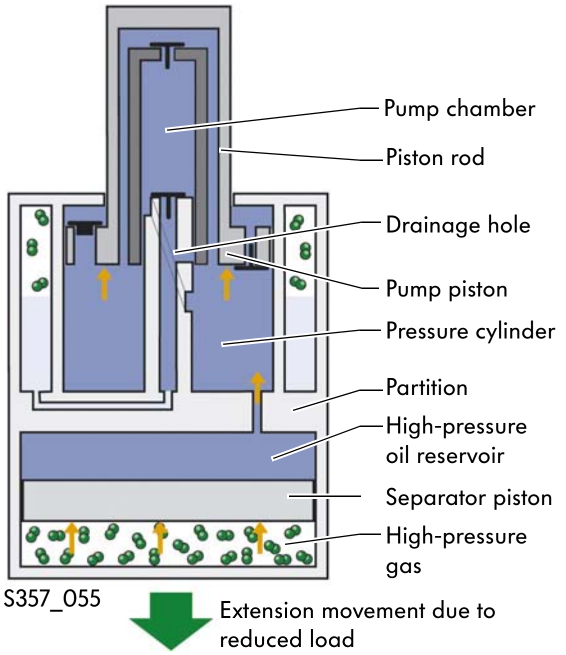
In this operating mode, there is a pressure equilibrium between the high-pressure gas, high-pressure oil reservoir, the pressure chamber and the pump chamber.

If the load is reduced, this balance has to be reached again.

# Nivomat in the Passat

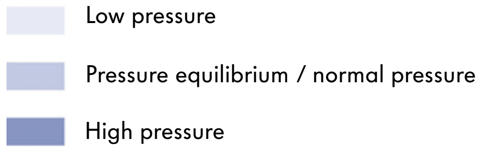
**Lowering the vehicle level**

When the vehicle is unloaded, the load on the rear axle is reduced. The mechanical springs on the axle draw the piston out of the pressure chamber during the extension cycle. This causes the pressure equilibrium that has been reached in the Nivomat between the high-pressure gas, the pressure chamber and pump chamber to be lost. The gas volume expands due to the lack of counter-pressure and supports the movement of the piston as the oil is pushed out of the high-pressure oil reservoir via the partition in the pressure chamber. The rear of the vehicle is raised.

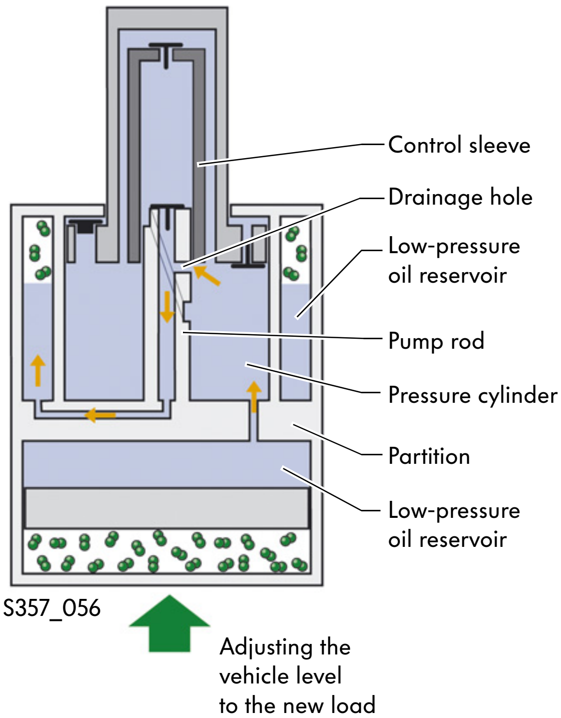



S357_055

**Legend**




The unloading causes the piston rod to be moved upwards with the piston and opening the drainage hole. Now oil can flow out of the high-pressure oil reservoir and the pressure chamber, through the bore hole in the pump rod and partition into the low-pressure oil reservoir between the inner and outer tube.




S357_056

## Workshop information

**Diagnosis**

When customers come with complaints, a visual inspection of the Nivomat should be carried out first of all. Drops of oil on the lower mounts indicate a faulty Nivomat. Faulty Nivomats should be replaced according to the repair instructions in ELSA.

If the customer notices the vehicle is leaning, this could have the following causes:

- incorrect tyre pressure,
- broken coil springs,
- faulty, leaking Nivomat

If the customer complains that the suspension is too soft, a test drive should be carried out in addition to the visual check.
The causes can be:

- incorrect, uneven tyre pressures
- overloading
- faulty anti-roll bars at front and rear including mountings
- worn steering bearings
- worn Nivomat mounting bearings
- faulty Nivomat

**Retrofitting**

Retrofitting on vehicles is possible as long as they are approved for the Nivomat system and the appropriate installation and repair instructions are available. It is important that the mounting points on the vehicle for using the Nivomat are the correct size.

The main advantage of the Nivomat system is that no additional components like sensors, pumps and control units nor electrical, hydraulic and pneumatic lines need to be fitted and connected.
The retrofit work simply involves replacing the shock absorbers on both sides of the rear axle with the correct Nivomats for the vehicle.
In addition, the coil springs on the axle need to be weaker as the Nivomat takes over part of the spring force of the coil springs in the complete suspension system.

Both conventional shock absorbers on the rear axle need to be replaced with Nivomats.
Make sure you follow the installation instructions.

# Service

### Repair and disposal

Faulty Nivomats should be disposed of according to the repair instructions in ELSA. Two holes should be drilled into the faulty Nivomat to release the pressurised gas and drain off the hydraulic fluid. Perform the work steps in the order specified in the repair literature.
Observe the specified spacing and drill bit size. The outer tube casing needs to be drilled through completely. Gas and oil spray will escape.

Once no more gas escapes after you have drilled the first hole and the Nivomat has been depressurised in the drilled area, make the hole bigger with a larger drill bit. Now hold the faulty Nivomat with the hole facing downwards over an oil tray and pump out the oil by moving the piston rod. Drill the second hole using the same procedure and drain the next section. Once you have completed the work, the empty Nivomat can be scrapped and the hydraulic fluid disposed of correctly.

# Glossary

### Atoms

The term atom was coined by the Greek philosopher Democritus around 400 B.C. Atom means indivisible and described what was then believed to be the smallest conceivable particle from which matter is made. Today we know that atoms are made from subatomic particles. At school, we learn that the structure is made up of a heavy nucleus and a light atomic shell. The nucleus is made up of protons (particles with positive electric charge) and neutrons (particles without electric charge). Electrons (particles with negative electric charge) orbit within the shell. The atomic number of the nucleus and shell needs to be balanced to obtain a uncharged atom. If this is not the case, an ion is involved.
Now even the elementary particles, i.e. electrons, protons and neutrons are being split into even smaller units. The aim is discover the smallest common universal particle and thus explain the structure and also the creation of all matter in the universe.

### Excited mass

If a mass or a particle is supplied with energy, for example, by an impact, increasing the overall energy of the mass, it is called an excited mass or excited particle in physics and chemistry.

### Metal atoms

Metals have a different atomic structure to salts like household salt, for example, or molecules like sugar, for example. In metals, the outer electrons are not tied to the individual metal atoms, but instead move freely in the metal as a cloud of electrons.
The mobility of the outer electrons causes metals to be conductive and creates their metallic shiny surfaces.

### Nivomat

Trademark of ZF Sachs for their shock absorber system with ride-height control.

### Torsion spring

Torsion is twisting along the longitudinal axis. A torsion spring or torsion bar is a spring element that is wound in a similar way to an elastic band. Torsion bars are used, for example, for anti-roll bars or in the steering.

# Test Yourself

**Which answers are correct?**
One, several or all of the answers could be correct.

**1. Which statement is correct?**

☐ a) The damping mainly supports the weight of the body.

☐ b) The damping prevents internal vehicle vibrations occurring.

☐ c) The damping ensures the necessary spring travel for stability and safety when the vehicle is carrying heavy loads.

**2. Which of the listed components are sprung masses?**

| | | |
|---|---|---|
| ☐ a) Body | ☐ b) Seats | ☐ c) Axles |
| ☐ a) Springs | ☐ e) occupants | ☐ f) Wheel mountings |
| ☐ a) Brakes | ☐ h) Wheels | ☐ i) Load |

**3. The damping effect of shock absorbers results from:**

☐ a) the mechanical springs in the shock absorbers converting work into heat.

☐ b) flow resistance occurring in the piston valve when the pump piston is moved.

☐ c) the movement energy of the vertical vehicle movement being consumed by the damper characteristics.

**4. What does volume compensation mean with shock absorbers?**

☐ a) The volume compensation adjusts the volume of the pressure chamber to the different load states.

☐ b) During volume compensation, the volume of hydraulic fluid displaced by the piston rod is collected in the reserve cylinder.

**5. The basic features of the Nivomat are:**

- [ ] a) separate low-pressure and high-pressure oil reservoirs,
- [ ] b) an integrated height sensor,
- [ ] c) a hollow piston rod for holding the pump rod,
- [ ] d) special piston valves with different damping characteristics.

**6. The internal hydraulic pump is used:**

- [ ] a) to pump hydraulic fluid into the low-pressure oil reservoir,
- [ ] a) to pump hydraulic fluid from the low-pressure into the high-pressure oil reservoir,
- [ ] a) to pump hydraulic fluid into the external oil reservoir,

**7. Once the ride height required for stability and safety has been reached:**

- [ ] a) the level sensor in the Nivomat prevents the vehicle level being raised again,
- [ ] b) the drainage bore hole in the pump rod prevents the vehicle level being raised again,
- [ ] c) the spiral groove in the pump rod prevents the vehicle level being raised again,
- [ ] d) the head valve in the control sleeve prevents the vehicle level being raised again,

**Answers**

1. b); 2. a), b), e), i); 3. b); 4. b); 5. a), c); 6. b); 7.c)



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❀ This paper was manufactured from pulp that was bleached without the use of chlorine.