STABILUS

Gas Springs

Technical Information

... technology gives comfort

Preface

In the early sixties, STABILUS became the first company in the world to develop the Gas spring for mass production. Since then, over 1.5 billion Stabilus gas springs have been produced. The first high volume applications were automobile doors and swivel chairs, whose comfort and reliability were enhanced by the properties of the gas springs. In the meantime, the gas spring has found its way into numerous technical applications in all branches of industry as an indispensable design element.

This brochure is mainly intended as an informative reference document for engineers and salesmen, as well as for technical college and university graduates, without actually claiming to be an instruction manual. The basic physical properties of the gas spring are highlighted, as they are of considerable interest to the design engineer. The subsequent description of the gas spring variants is subdivided according to their function and application. Hence the LIFT-O-MAT® gas springs are discussed first, followed by a description of the infinitely-variable BLOC-O-LIFT® locking gas springs; the STAB-O-MAT® / STAB-O-BLOC®.

The final portion of the information booklet describes the HYDRO-BLOC® locking elements, as well as a procedure for selecting the proper gas spring.
Due to the inherent flexibility of gas springs, the representation of all types and application options is beyond the scope of this brochure. Therefore, we will be focusing primarily on the most common gas spring variations.

STABILUS has set the standard for gas spring technology through our long-standing experience in development, production and industry consultation. The contents of this brochure is a reflection of our competence as the world market leader. We hope this brochure will prove useful to both old and new friends of our company.

Koblenz, January 2007
STABILUS GmbH

Contents

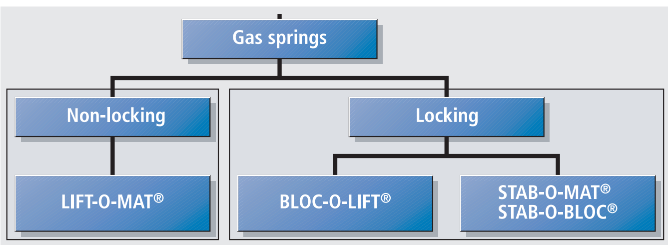
1. Gas Springs, Properties and Operation

Gas springs are primarily used to provide a counterbalance or force assistance, but can also be used to provide damping or an end-stop. In any case, gas springs are implemented to achieve a comfortable and reliable adjustment function, in addition to a leaving a clear mark of quality on the end product.

The gas spring's function is based on the potential energy of compressed gas, and compared to mechanical springs, offer the following advantages:

- a flat spring rate which means a relative constant force, even for high forces and over long strokes,
- compact construction
- straightforward and quick assembly
- a selectable linear, digressive or progressive characteristic, given a similar outer shape.
- damped motion control, definable over specific positions or over the full stroke.
- infinitely lockable
- rigid or elastic in locked position
- end stop function

Further gas spring functions can be realized using combinations of the above properties. Devices with dampened adjustment motion are frequently used in combination with end-position locking. A further variant is the design of devices with dampened motion and progressive spring characteristic etc. According to the function and application, STABILUS gas springs are subdivided into three types:



The LIFT-O-MAT® gas spring is primarily intended as an force element for position adjustment. Typical application examples in the automotive industry are gas springs which allow easy opening of Tailgates, Trunklids and Hoods.

The BLOC-O-LIFT® locking gas spring fulfils the same tasks as the LIFT-O-MAT®; however, the BLOC-O-LIFT® additionally allows infinitely-variable locking. Applications for the BLOC-O-LIFT® are the back adjustment in swivel chairs and the recline adjustment in hospital bedsSTAB-O-MAT® and STAB-O-BLOC® locking gas springs are used to adjust the height of swivel chairs. The supporting columns with these gas springs can withstand transverse forces and bending moments while providing infinitely-variable height adjustment and comfortable cushioning.

1.1 Physical Properties of the Ideal Gas Spring

In order to explain the basic function and physical properties of the gas spring on an understandable mathematical basis, an ideal model will be applied. Therefore, the influences of friction, flow and temperature will not be considered in this section. This ideal model can be applied to all varieties of the gas spring, regardless of the construction.

The gas spring is a closed system consisting of a pressure tube and piston rod with piston, as well as compressed Nitrogen (N2) as an energy source and a lubrication oil. Figure 1.1. shows a block diagram of the gas spring

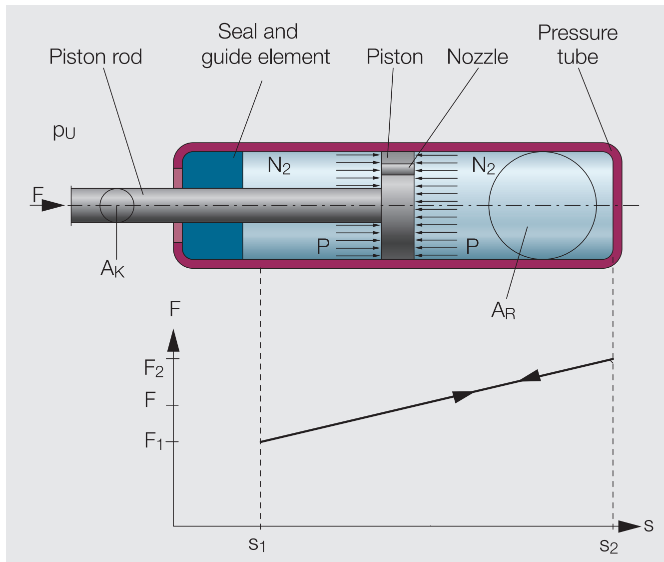


Figure 1.1: Diagram of the gas spring

1.1.1 Spring Force and Characteristic Curve of the Ideal Gas Spring

The piston rod with cross section AK is axially guided within the pressure tube as shown in figure 1.1. The cross section of the pressure tube is designated with AR (see figure 1.1.) A seal between the piston rod and pressure tube seals off pressurized gas p from the ambient pressure pU. A nozzle in the piston ensures that the pressure is the same on both sides of the piston.
Balancing the forces on the piston in any position yields:

$$F + p \cdot (A_R - A_K) - p \cdot A_R = 0$$

$$F = p \cdot A_K \qquad (1)$$

1. Gas Springs, Properties and Operation

The spring force F is thus the product of the inside pressure and the piston rod cross sectional area. In the extended position, the pressure of the gas spring (s=s 1) is p1. The resultant spring force in the extended position is:

$$F_1 = p_1 \cdot A_K$$

As the piston rod is pushed into the pressure tube, the gas volume is reduced by the volume of the inserted piston rod, resulting in an increase in pressure. Therefore, the gas spring in the compressed condition (s=s2) at pressure = p_2 will yield a spring force of:

$$F_2 = p_2 \cdot A_K$$

Both forces have been plotted on the diagram in figure 1.1 which illustrates a linear relationship. In the ideal gas spring, this characteristic curve applies to the compression and extension force of the gas spring.

The correlation between the change in pressure and volume is described by the following polytropic equation:

$$p \cdot V^n = \text{Constant} = p_1 \cdot V_1^n$$

The shape of the characteristic curve can be calculated using equation

$$F = p_1 \cdot A_K (V_1 / V)^n \qquad (2)$$

with $V = V_1 - A_K \cdot (s_2 - s_1)$

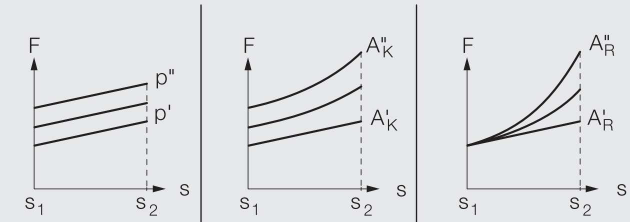
and $V_1 = A_R \cdot (s_2 - s_1)$

where V_1 is the compressible gas volume in extended condition, i.e. at the start of the stroke s_1 of the gas spring. $A_K \cdot s$ is the volume of the inserted piston rod.
Equation [2] indicates the parameters which influence the characteristic curve of the gas spring. They are as follows:

- the pressure of the filled gas p_1 ,
- the cross-section of the piston rod A_K ,the available gas volume V_1 or respectively the cross-section of pressure-tube A_R.

By varying the above factors in equation [2] we obtain the curve shown in figure 1.2. which illustrates the isothermal change of condition (n=1). This simplification is applicable if the gas spring is not actuated continuously, as the temperature of the gas during the compression of the piston rod is nearly constant.

If for example, pressure p_1, with which the gas spring is filled, is increased, an upward parallel displacement of the spring characteristic will occur. Larger diameter piston rods at identical filling pressures and tube geometry will also result in a force increase of the gas spring. Whereas the force increases in extended condition (s_1) increases linearly, the force in compressed condition (s_2) increase even further, because of the greater compressed piston rod volume. If pressure tubes of a smaller cross-section A_R are used, or if oil is added in the pressure tube, the gas volume V_1 will be reduced.



	Influence of filling pressure p1	Influence of the piston rod cross-section AK	Influence of the pressure tube cross-section
p_1	$p'_1 < p''_1$	const.	const.
$A_{K,R}$	const.	$A'_K < A''_K$, A_R = const.	$A'_R > A''_R$, A_K = const.
x	const.	x' < x"	x' < x"

Fig. 1.2: Spring characteristic dependent on different factors

The spring force in the extended condition remains unchanged. However, the rate of change in spring force increases, because of the greater reduction in gas volume during compression.

1.1.2. Force Ratio of the Ideal Gas Spring

In Fig. 1.2 force ratio x has been given as an additional parameter. It is a measure of the increase in spring force over the stroke of the gas spring independent from the shape of the curve. The force ratio x is defined as the ratio of the gas spring force at the compressed condition to force at the extended condition.

$$x = F_2/F_1 = V_1/V_2$$
$$x = V_1/(V_1 - A_K \cdot (s_2 - s_1)) \qquad (3)$$

For a force ratio x close to one, which is a result of a large pressure tube volume relative to piston rod volume, the characteristic curve is virtually a straight line. Compared to mechanical coil springs, the force increase over the travel of the spring is minimal.

Through differentiation of the spring force equation [2] we obtain with n = 1 spring rate c for:

$$c = dF/ds = p_1 \cdot A_K^2 \cdot V_1 / (V_1 - A_K \cdot (s_2 - s_1))^2 \ .$$

Given a linear spring characteristic curve, the spring rigidity can be calculated in a straightforward manner using the difference quotients of the spring characteristic:

$$c = \Delta F/\Delta s = F_1 \cdot (x-1)/(s_2 - s_1) \qquad (4)$$

1.1.3.Work of the Ideal Gas Spring

The potential energy stored during the compression of the gas spring is made available during extension as an output force capable of exerting work. The spring force corresponds to the surface area under the characteristic curve F(s), as shown in Fig. 1.3 :

with $dW = F \cdot ds$

and equation (2): $dW = p_1 \cdot A_K \cdot (V_1 / V)^n \cdot ds \qquad (5)$

Work W can be determined by integrating equation (5)

with n=1 (isothermal condition change) for any stroke position of the gas spring as follows:

$$W = -p_1 \cdot V_1 \cdot \ln(V_1/V)$$

For the characteristic in Fig. 1.3 the useful spring force W 2 in compressed position s=s 2 is:

$$W_2 = -p_1 \cdot V_1 \cdot \ln(V_1/V_2)$$

Note: there is less available work in a real gas spring due the effects of friction during compression and extension (see. Chap. 1.2.1).

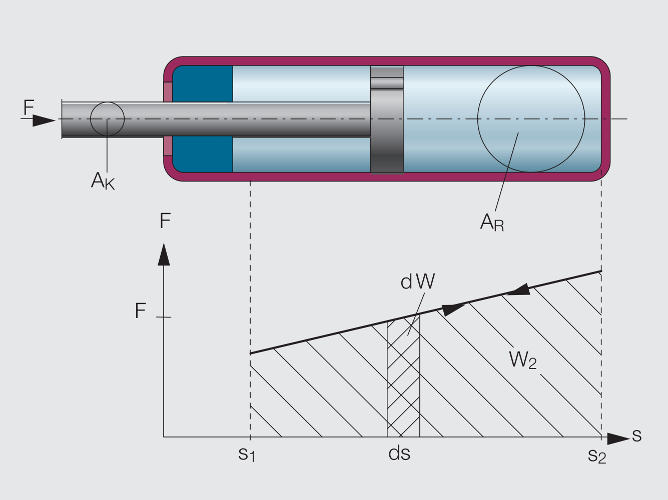


Fig. 1.3: Spring force of the gas spring

1.2 Technical Gas Spring Real

Up to this point, the influences of several factors had been ignored in the description of the ideal gas spring. The following explains the effect of the previously disregarded variables such as friction resistance, flow resistance in the piston nozzle and gas temperature on the function of the gas spring. The explanations of the technical gas spring are relevant to all discussed gas spring types.

1.2.1 Spring Force and Spring Characteristic of the Technical Gas Spring

Fig. 1.4 shows an example of the technical gas springs characteristic curve. At point B, the gas spring is fully compressed, At point A, full extended. Extension starts point B, where the extension force along line A-B is available to move the piston rod or the respective load on the piston road. To compress the piston rod, a force must be applied which is greater than frictional force, as well as the force along line A_B. The nature and magnitude of the friction force is dependent on the operation of the gas spring. If the piston rod is being compressed or extended, the dynamic friction force $F_{R\,dyn}$ will ensue, whereas in still condition, the static friction force $F_{R\,stat}$ is active. The differences are illustrated by the following discussion of measuring techniques.

Dynamic Measurement

From the fully extended position, the gas spring is compressed at a constant test velocity until fully compressed. The subsequent, automatic extension is controlled at the same constant velocity. During compression/extension, the force reaction is recorded, resulting in the characteristic curve. The difference between the extension and compression forces, as well as the technical gas spring and the ideal gas spring is analogous to Fig. 1.4 $\pm F_{R\,dyn}/2$.

This friction force occurs because of the sliding friction on the piston sealing ring and the seal and guide elements as well as flow resistance in the piston nozzle. The extent of the flow resistance is dependent on the measurement or actuation speed. Therefore, faster extension and compression speeds result in a higher dynamic friction whereas lower speeds incur minor dynamic friction. The flow resistance can be influenced by the shape and size of the flow path in the piston, thus allowing the resultant damping to be tuned to a specific application. (see Chap. 2.1).

The piston rod seal is constructed to achieve an optimum balance between minimum sliding friction and a long lifetime of the gas spring. The pressure of the seal exercised on the piston rod is dependent on the spring force, respectively on the filling pressure of the gas spring. Large extension forces require a strong pressure on the seal, to prevent gas loss and maintain the gas spring function over time and use.

In order to obtain reproducible measurements, specified measuring points (5mm from compressed and extended position as standard) have been designated, and the related force designations have been defined. (see Fig. 1.4) The measuring points and corresponding force values of the gas spring are specified in the relevant STABILUS gas spring drawing.

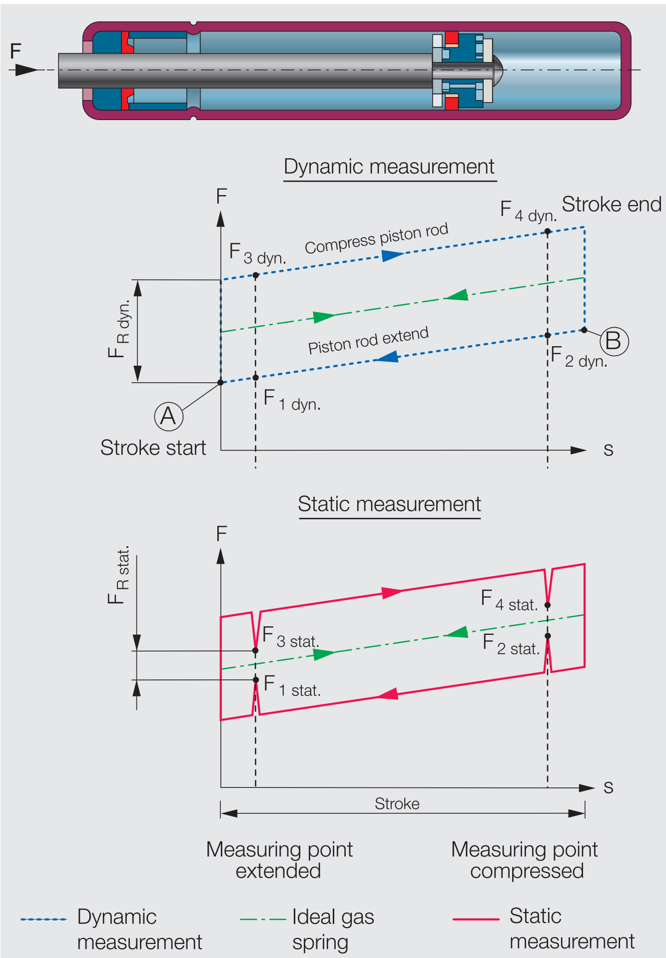


Fig. 1.4: Spring characteristic of the technical gas spring

Static Measurement

Similar to the dynamic measurement, the static measurement is performed with a constant speed. However, the motion is interrupted at the measuring points and the spring force is measured in a static condition. The difference between the compression and extension forces, as well as the difference between the ideal and technical gas spring, is $\pm F_{R\ stat}/2$. The friction force $F_{R\ stat}$ is caused by the static friction of the sealing elements. It is less than the dynamic friction, which is indicated for example by F1stat is greater than $F_{1\ dyn}$. Typically, when the extension force is discussed, it is the static force which is referred to. Both measurements are carried out at the standard temperature T0 =20°C. these measurements are used to describe all function values of the gas spring. To obtain reproducible measurement results, two stabilizing strokes are completed prior to the actual measurement stroke. The springs characteristics obtained from the first, second and third stroke (measurement stroke) are shown in Fig. 1.5.

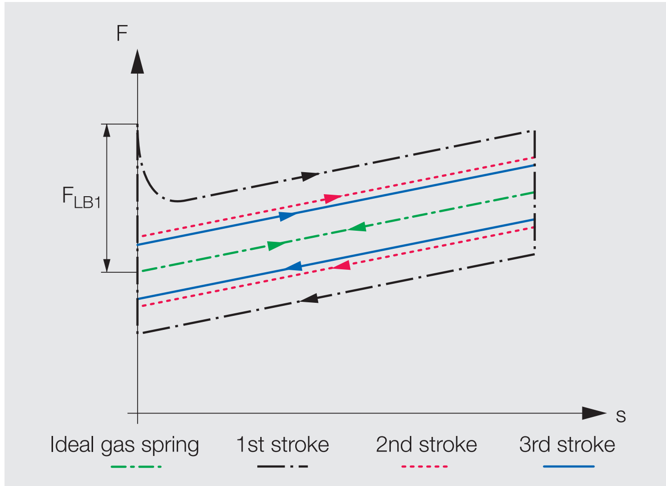


Fig. 1.5: Spring characteristic in the first, second and third stroke

The force peak at the beginning of the first stroke is designated as the break-away force F_{LB1}. It only occurs when the gas spring has not been used for a long while. During extended periods of unuse, the lubrication migrates away from under the sealing lip resulting in an increased static friction. As seen in the above chart, the second and third strokes have virtually identical function values and the break-away force has been fully eliminated.

Force Ratio (Spring Characteristic Curve)

As already stated in Chap. 1.1.2, the magnitude of the spring force is determined by the filling pressure, the force ratio and by the gas spring dimensions (pressure tube and piston rod cross-section). The force ratio value is normally situated in the range

$$1{,}01 < x < 1{,}6.$$

The bottom limit is obtained from an ideal gas spring geometry similarly to equation [3], the upper limit is a practical value based on component stability and reasonable safety factors.

1.2.2 Temperature Behavior of the Technical Gas Spring

In addition to friction and flow resistance, the gas spring forces are directly dependent on temperature, due to the compressed gas in the system. The dependency is can be derived as a first approximation of the ideal gas equation:

$$p(T)/p = T/T_0 = F(T)/F$$

The spring force of the gas spring in extended position and obtained at a random temperature is then:

$$F_1(T) = F_1 \cdot T/T_0$$

Where F_1 is the spring force at standard temperature T_0 =20°C (293 K). The force curves of a gas spring at temperatures $T = T_0$, $T > T_0$ and $T < T_0$ are shown in Fig. 1.6. In general, the gas spring is intended for a maximum operating temperature of 80°C. This accounts for the real properties of nitrogen (N_2) in respect to temperature and pressure changes. The force change of the gas spring as a function of pressure and temperature is also represented in Fig. 1.6.

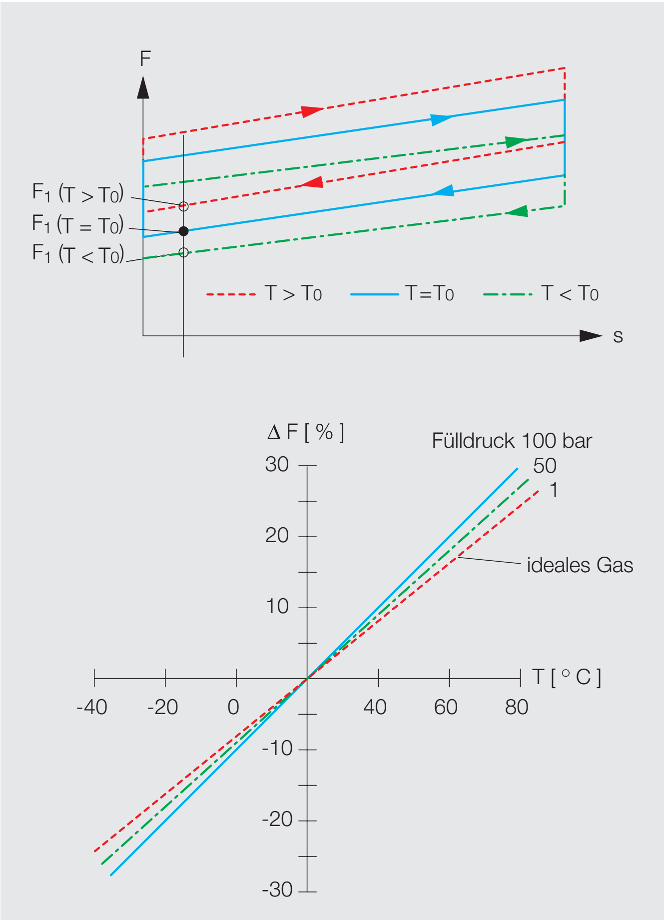


Fig. 1.6: Spring force change and spring force behavior at different temperatures

1.2.3 Lifetime of the Technical Gas Spring

Gas springs for e.g. automobile applications are designed in such a way that they can reach some 50,000 cycles via the whole stroke without problem. Which means a loss in spring force during endurance testing is of less than 10%.

It is also possible to equip the gas spring with special sealing system for special circumstances or requirements. In addition to the number of actuation cycles, the lifetime of the gas spring is also dependent on the natural permeability of the components. Applications with operating temperatures in the range of ambient temperatures have a positive effect on the life-time of gas springs. Generally speaking, the force loss depends on the current application (ambient temperature, environmental influences etc.) and the sealing elements used. The force loss of the STABILUS standard gas springs is less than eight percent of the specified output force during the first two years.

2. Gas Springs for Force Supply

The basic function of gas springs is to provide force support. In addition to lifting, gas springs can also be used for targeted damping of a movement with a defined speed. In addition, there are numerous other functions that these gas springs can perform to provide even more comfort and safety in the application.
This chapter provides an overview of the non-locking STABILUS gas springs, which are usually used in applications with only two end positions, such as doors and flaps that need to be moved comfortably from a closed to an open position (e.g., vehicle tailgate).
Fig. 2.1 illustrates the additional functions available, and at the same time, it provides a summary of the different product designations and variants of these gas springs.

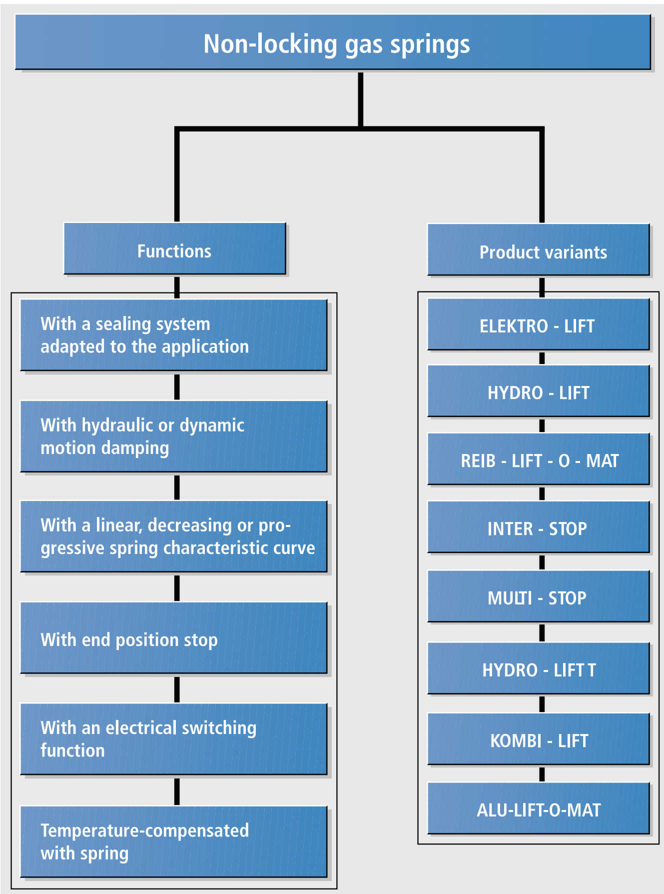


Fig. 2.1 Overview of STABILUS gas springs for force supply

2.1 STABILUS Gas Spring LIFT-O-MAT®

The LIFT-O-MAT® is the standard type of the STABILUS gas springs. Its name symbolizes its function, namely "lifting" something, such as a tailgate. However, this is only one of numerous application possibilities. It always provides force support, thus making the application more comfortable. In addition, it can also control the extension speed or the damping, depending on the function. Fig. 2.2 illustrates the structure and spring characteristic curve of a LIFT-O-MAT® gas spring in a diagram.

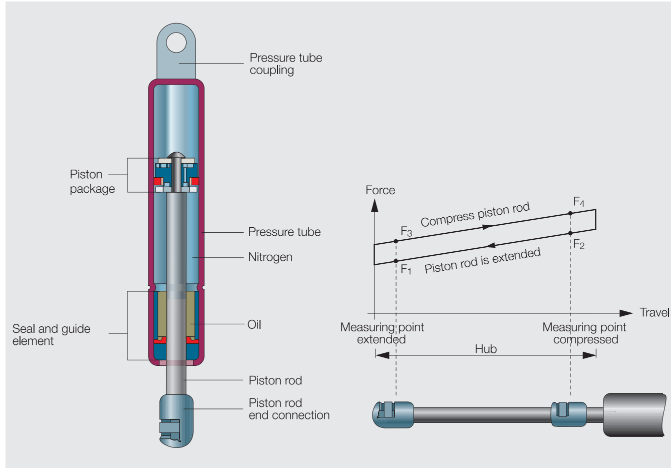


Fig. 2.2 LIFT-O-MAT®, structure and spring characteristic curve

Next is an overview of the major components of the LIFT-O-MAT® gas spring, since they play an important part in the core tasks of adjusting and damping. The adjustment or spring force is generated by the gas pressure inside the device; damping is generated by the piston package.

2.1.1 LIFT-O-MAT® Piston Package

In principle, a piston with a simple nozzle bore would be sufficient for hydraulic damping of a gas spring motion. On the one hand, this bore could get easily clogged and would not guarantee functional safety; on the other hand, it would be difficult to influence the damping characteristics. Therefore, STABILUS uses the STABILUS labyrinth piston shown in Fig. 2.3, the main component of the piston package, in all hydraulically damped gas springs.

The STABILUS labyrinth piston damps the motion of the piston when the gas spring extends, thus providing a defined speed. The extent of the damping depends on the length of the labyrinth channel that is passed through. It determines the flow resistance of the piston labyrinth. With a specific position of the piston bore, any extension speed desired can be set within a wide speed range. A "long flow channel" in the piston creates slow extension speeds due to the high flow resistance; a "short flow channel" provides for fast extension speeds.

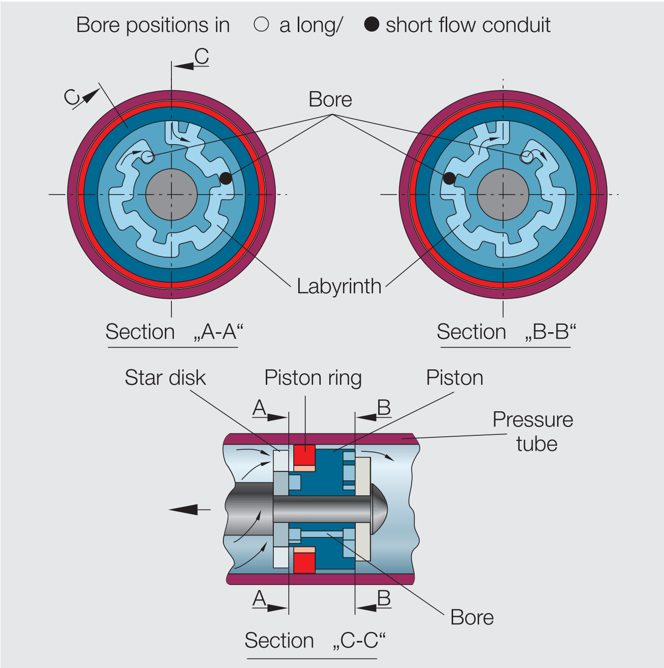


Fig. 2.3 Flow channel in the Stabilus labyrinth piston, gas spring extension-damped

The axially movable piston ring acts as a control element. In the example shown, the ring seals the free flow cross-section between piston circumference and pressure tube in the piston rod extension direction. The gas must now flow through the labyrinth (for example, see long flow channel in Fig. 2.3), before it reaches the pressure chamber on the opposite side. Compared with the undamped piston package (piston without a piston ring), the extension force, as well as the extension speed v of the gas spring, are reduced. In the compression direction of the piston rod, the piston ring fits onto the pinion-shaped disk (star disk), thus unblocking the flow cross-section between the piston circumference and the pressure tube. The gas can then flow through the piston unobstructed, so that the compression force remains the same compared with an undamped gas spring. With this piston package, the gas spring is extension-damped. Depending on the combination and arrangement of the piston package components, the functional properties, extension speeds, and spring curve characteristics of the gas spring shown in Fig. 2.4 will result.

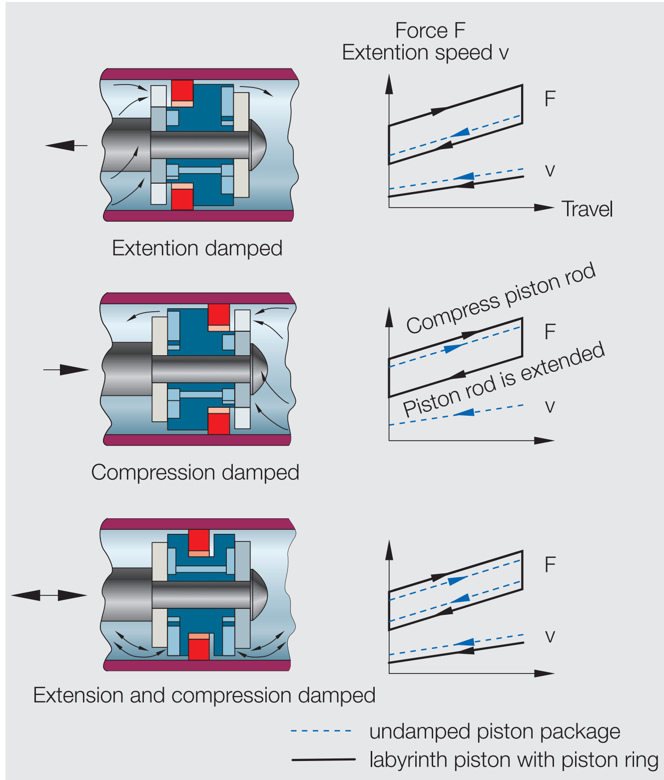


Fig. 2.4 Function of different piston packages

The piston required for the respective application can be selected from a wide range of piston models, so that the extension speed v and the force needed to compress the gas spring allow for comfortable adjustment of the application.

The extension speeds that can be selected range from 0.01 to 0.8 m/s. The adjustment of the application is nearly undamped, if the piston package of the gas spring is mounted without a piston ring. In this version, the LIFT-O-MAT® is used mainly to counterbalance weight. The extension speed of this model is significantly higher than in the damped gas spring. Therefore, a comfortable adjustment function requires special matching of the gas spring to the respective application. In addition to damping the adjustment motion, the piston package also limits the gas spring stroke in the extension direction, and it guides the piston rod in the pressure tube.

2.1.2 LIFT-O-MAT® Seal and Guide Element

Another support location for the piston rod is the guide element at the end of the pressure tube. Immediately behind it is the seal that prevents the pressurized gas from escaping, which inevitably would reduce the function. Depending on the mounting orientation of the gas spring, there are different seal systems to ensure the highest level of functional safety.

2. Gas Springs for Force Supply

Fig. 2.5 shows three gas spring variants, which only differ in the structure of their seal and guide elements. Variant I with the standard seal should preferably be in-stalled with the piston rod pointing down to ensure continuous lubrication of the seal with the lubricant accumulating in the seal. Variant II, however, has the STABILUS double seal system, which allows for mounting in any orientation. Even if the gas spring is mounted with the piston rod pointing upward, the oil enclosed between the seals ensures the lubrication of both seals. The second seal extends the life of the gas spring; therefore, this model is used in applications that require a high number of duty cycles.

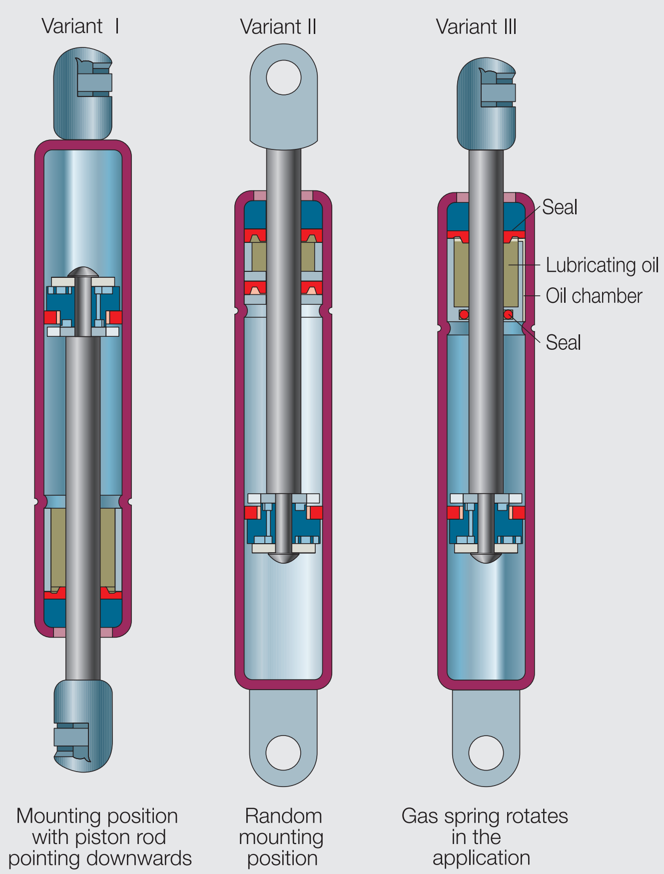


Fig. 2.5 LIFT-O-MAT® seal and guide element

Variant III has the **STABILUS oil chamber.** This variant is suitable for applications where the gas spring swivels when the application is adjusted, thus changing its position. If the gas spring is mounted with the piston rod pointing down, it fills up the oil reservoir, in which the oil flows along the free ring slot on the oil chamber jacket. If the gas spring then swivels, for example when the application is opened, and the piston rod points upward, there will still be enough oil in the reservoir to lubricate the seal.

All seal systems can be augmented by a "felt chamber" upon request. In that case, a felt ring impregnated with special grease provides additional lubrication of the piston rod across the entire stroke. This reduces the friction and breakaway force further, thus ensuring the optimum function of the gas spring even in sensitive applications.

Dust and contaminant deposits on the piston rod can have a negative impact on the life of gas springs. In environmental conditions that are less than optimal, a protective tube offers protection against contaminants, dust, moisture, or possible mechanical impact on the piston rod. In that case, a mounting orientation should be selected that prevents the protective tube from getting filled with contaminants or moisture.

In order to improve the functional safety and corrosion resistance even further, additional protective caps made of plastic protect the crimping and beading area of the gas spring against moisture, dust, and contaminants.

2.1.3 LIFT-O-MAT® End Fittings

A large variety of end fittings allows for fast and easy installation of the gas spring in the application. Fig. 2.6 shows a selection of Stabilus LIFT-O-MAT® gas spring end fittings, for mounting on the piston rod side or on the pressure tube side.

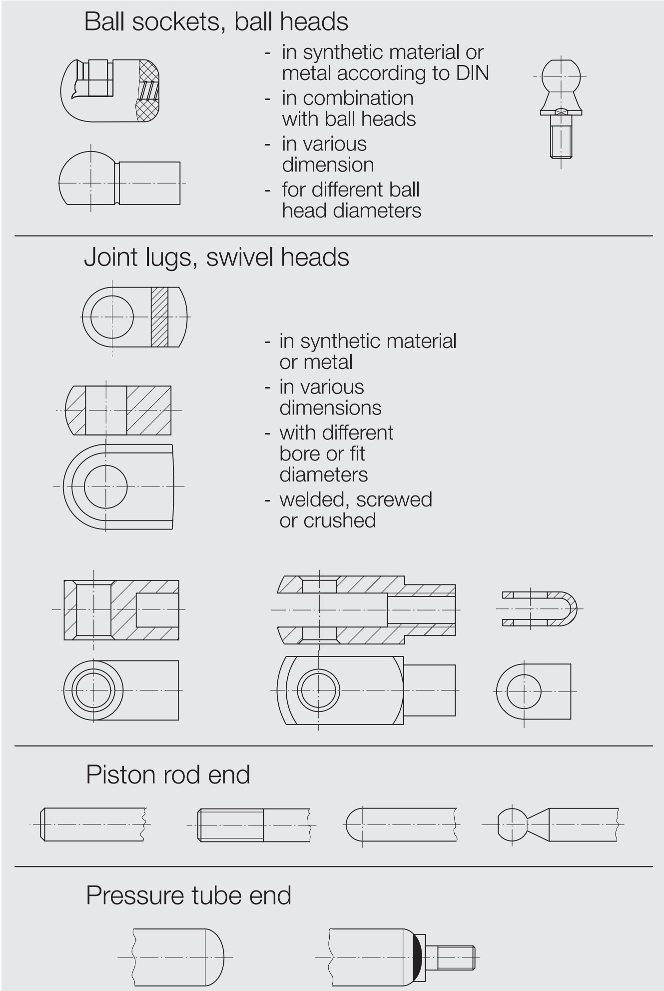


Fig. 2.6 Selection of LIFT-O-MAT® standard fittings

2.1.4 LIFT-O-MAT® Gas Spring with Hydraulic and Dynamic Motion Damping

To approach the end position comfortably, end position damping is provided in most application cases. Fig. 2.7a and 2.7b show the two principles that can be used for damping the piston rod motion: hydraulic and dynamic damping.

LIFT-O-MAT® with Hydraulic Damping

The LIFT-O-MAT® with hydraulic damping takes advantage of the flow resistance of the piston nozzle, which is lower in gas (see Fig. 2.7a, pneumatic damping range s2) than in oil (see Fig. 2.7a, hydraulic damping range s1). If the gas spring is mounted vertically with the piston rod pointing down, the oil accumulates at the seal and guide element of the gas spring. As soon as the piston dips into the oil when the piston rod is pushed out, the piston rod moves much more slowly. With a combination of different oils and labyrinth pistons, this braking effect can be customized to the application. The piston rod extension speeds that can be selected for hydraulic damping range from 0.01 to 0.35 m/s. The length of the hydraulic damping section is given by the amount of oil in the device. However, this damping effect can only be utilized in a vertical mounting orientation with the piston rod pointing down.

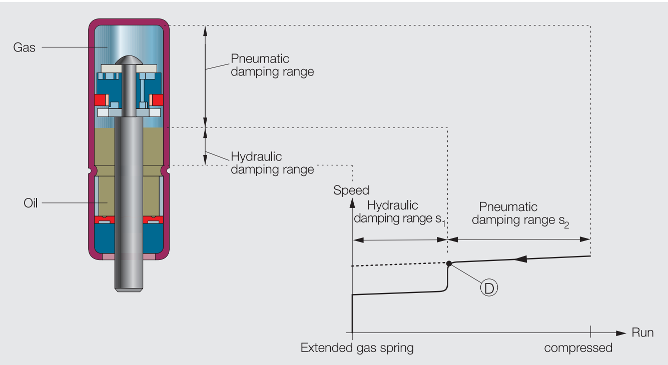


Fig. 2.7a LIFT-O-MAT® with hydraulic damping

LIFT-O-MAT® with Hydraulic Damping

Unlike hydraulic damping, the LIFT-O-MAT® with hydraulic damping can be mounted in any orientation. The extension speed of the gas spring is controlled by a longitudinal groove inside the pressure tube. In this case, the piston rod does not have a flow channel, so that the gas flows through the free groove cross-section when the piston rod is adjusted. By varying the groove geometry, it is possible to adjust the motion speed of the piston rod over the entire stroke, thus optimizing it to the respective application. Fig. 2.7b shows an example of the extension speed behavior of a gas spring with a groove cross-section that tapers off toward the end position of the stroke. The motion proceeds at a continuously decreasing extension speed, until the piston rod comes almost to a halt, thus ensuring a smooth stop of the application. When using this technology, damping in the compression direction is also possible; this can be useful in applications such as car hoods. Likewise, different groove geometries are possible, for example for damped approaching of interim positions.

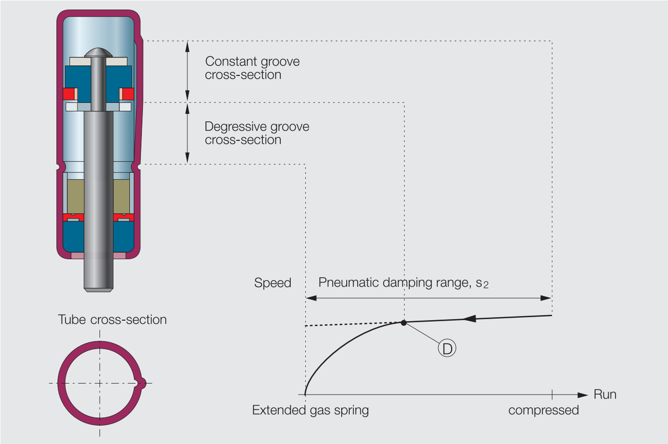


Fig. 2.7b LIFT-O-MAT® with dynamic damping

2.1.5 LIFT-O-MAT® with a Decreasing or Progressive Spring Characteristic Curve

Some applications do not require a linear, but a specially adjusted, stroke-controlled force supply. Such is often the case in end positions of applications that require disproportionately high or low spring forces relative to the main adjustment range. The LIFT-O-MAT® gas spring is particularly suited to this, since its spring characteristic curve can be easily customized to the application by simple addition of coil springs.

Progressive Spring Characteristic Curve

A coil spring between piston and pressure tube bottom creates a progressive spring characteristic curve, as shown in Fig. 2.8. The gas spring is supported by the force of the coil spring, which increases the gas spring force when the piston rod is compressed. This solution is suitable in cases where a particularly high extension force in the compressed position of the gas spring is needed.

Decreasing Spring Characteristic Curve

If the coil spring is placed between the piston and the seal on the piston rod, the gas spring force is reduced by the force of the coil spring. The result is a decreasing spring characteristic curve. The spring force of the extended gas spring is thus appropriately lower than the force of the standard gas spring.

The spring characteristic curves of both variants can be varied by selecting a different coil spring length (it determines the break point s3 of the spring characteristic curve) and the coil spring force (it determines the slope of the spring characteristic curve in break point s3). Often, a rubber cushion is used instead of the coil spring, so that in addition to the spring effect of the cushion, the end stop is damped when the piston rod is pushed in or out. A combination of both variants is also used.

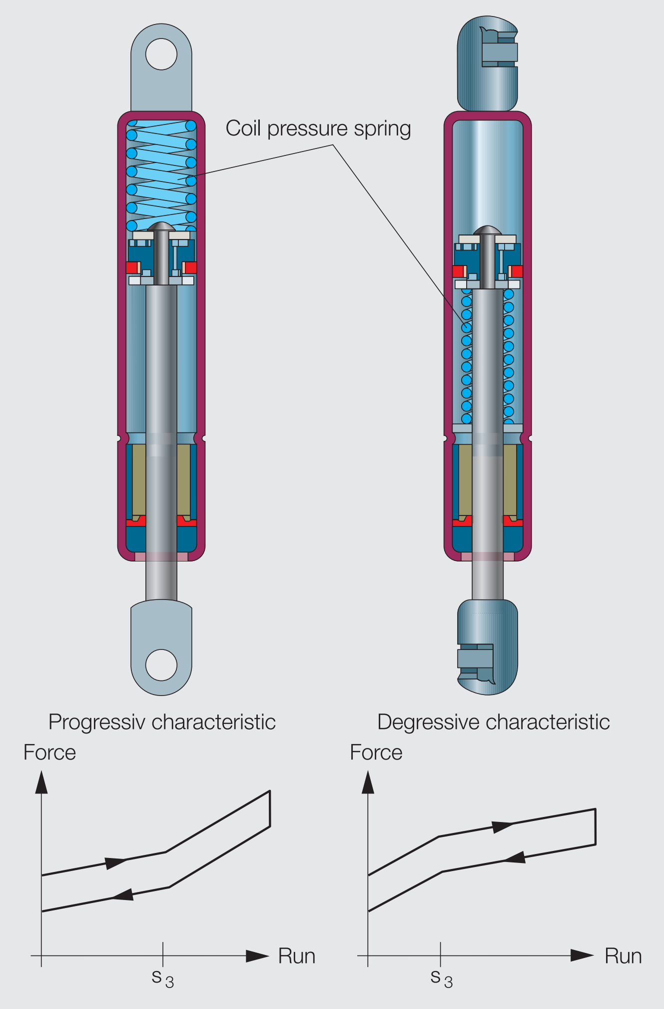


Fig. 2.8 LIFT-O-MAT® with progressive and decreasing spring characteristic curve

2.1.6 LIFT-O-MAT® with End Position Locking

If legal requirements demand safety precautions against unintentional adjustment, or if the gas spring is subjected to application forces that exceed its extension force, additional stop devices are the ideal solution.

With integrated, mechanical stop elements (see Fig. 2.9), the LIFT-O-MAT® can lock the application. A typical application example are mobile sales stands, in which the LIFT-O-MAT® can be used to open flaps, as well as a locking element against unintentional closing (e.g., under a heavy wind or snow load). If more than one gas spring is used in an application, it is usually sufficient to equip just one of the gas springs with the mechanical stop element.

The advantages of a mechanical end position lock in LIFT-O-MAT® gas springs can be put in a nutshell:
- Locking and unlocking directly in the adjustment element
- Additional protection against unintentional closing
- Absorption of external forces, such as wind and snow loads

STABILUS offers two gas spring variants with a mechanical stop element for locking forces of up to 3000 N max.

External Mechanical Locking

In this variant, a support tube is fitted on the piston rod end, which pivots out when the gas spring reaches the fully extended position. If the external load exceeds the gas spring force, the tube will support itself on the front side of the pressure tube, thus preventing the piston rod from compressing (see Fig. 2.9). To release the positional locking, the support tube must be removed from the locked position by pressing the button labeled "PRESS", at which point it swivels out. In addition to the locking function, the support tube offers protection against contamination of the piston rod.

Internal Mechanical Locking

The design of this locking function is similar to that of the ballpoint pen principle. As shown in Fig. 2.9, it is located in the pressure tube. The mechanical lock kicks in when the piston rod is pushed in slightly from the extended position.

To ensure that the positional lock does not release automatically, the load on the piston rod must be greater than the extension force of the gas spring; therefore, the spring force of this LIFT-O-MAT® gas spring should be lower than the external load exerted by the application. To release the locking, the piston rod should be pushed briefly into the direction of extension. Since the external load exceeds the extension force, the LIFT-O-MAT® compresses in a damped manner. A sticker on the gas spring shows the proper procedure. A major advantage of this variant compared with external end position locking is: Releasing the gas spring and adjusting the application can be don with one hand!

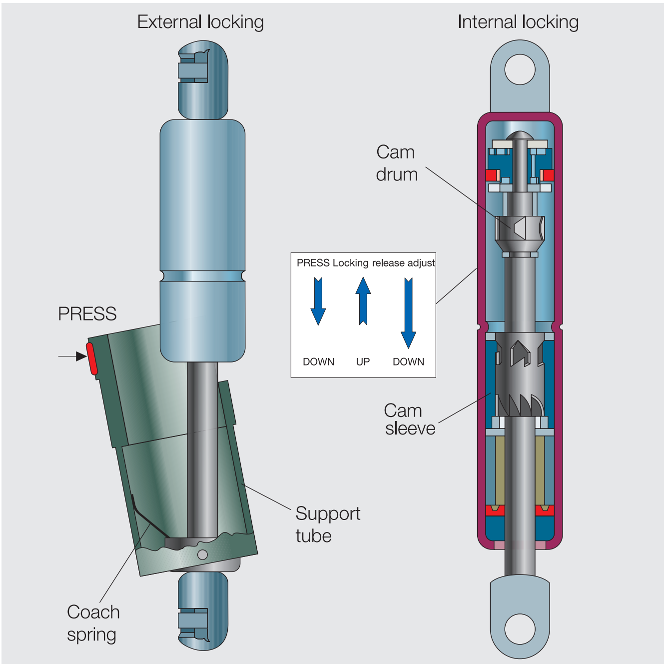


Fig. 2.9 LIFT-O-MAT® with external and internal end position locking

2. Gas Springs for Force Supply

2.1.7 LIFT-O-MAT® FR

In addition to force supply, some applications also require variable positioning capability over the entire adjustment range. The LIFT-O-MAT® FR (FR = friction) fulfills both requirements.

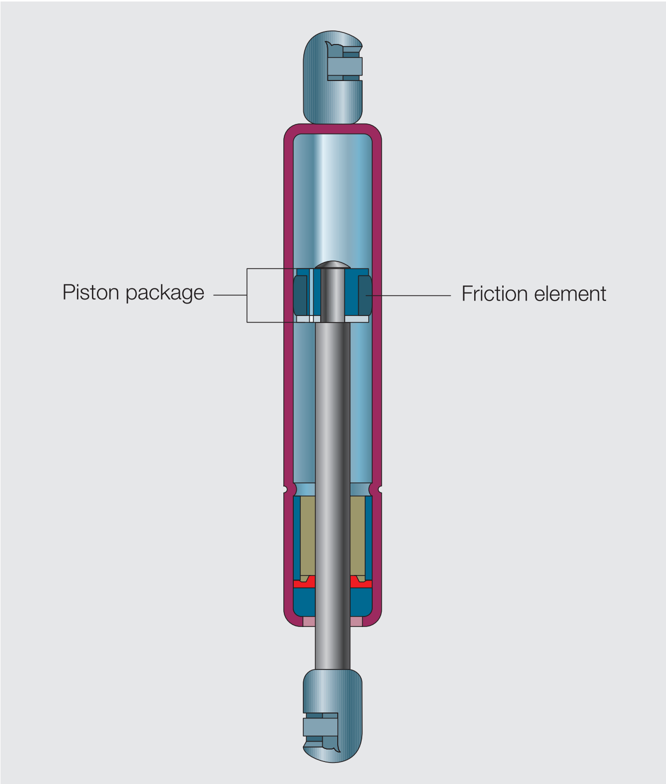


Fig. 2.10 LIFT-O-MAT ® FR, structure

The only difference to the LIFT-O-MAT® is a friction element integrated in the piston package, which increases the force for pushing in the piston rod. At the same time, this reduces the extension force of the gas spring. The spring characteristic curve of the LIFT-O-MAT® FR is therefore broader than that of the LIFT-O-MAT® gas spring (see Fig. 2.11).

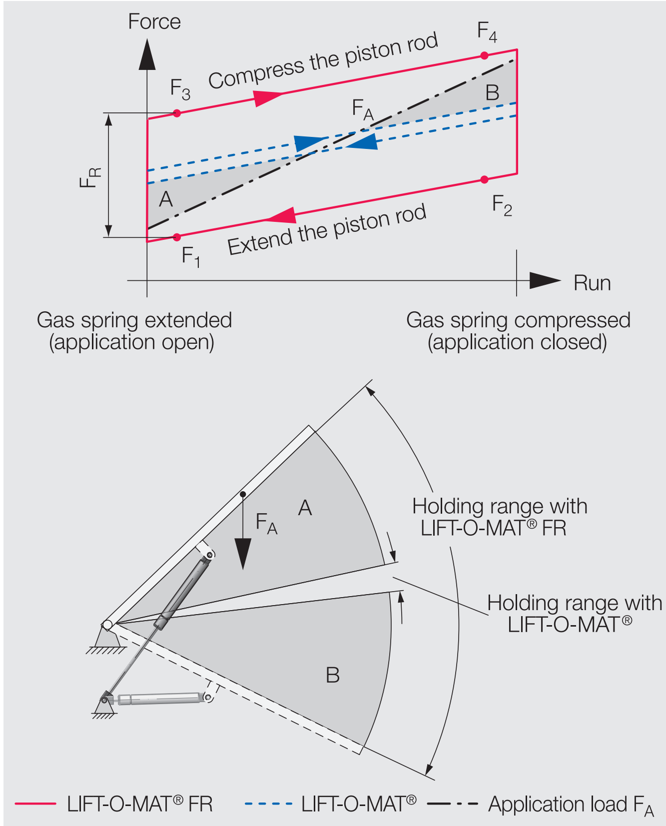


Fig. 2.11 LIFT-O-MAT® FR, spring characteristic curve and holding range of the application

If the characteristic curve of the application load $\mathbf{F_A}$ is within the spring characteristic curve of the LIFT-O-MAT® FR, the application can be variably positioned across the entire adjustment range. Due to the relatively low "holding force", the application can be opened and closed easily with minimal manual support. If a LIFT-O-MAT® gas spring were to be used for the application load curve shown, the application "holding range" compared with the LIFT-O-MAT® FR would be reduced. In ranges **A** and **B**, LIFT-O-MAT® ensures automatic opening or closing of the lid, whereas the LIFT-O-MAT® FR provides for fully variable positioning of the lid in these ranges.

2. Gas Springs for Force Supply

2.2 STABILUS Gas Spring HYDRO-LIFT®

Just like the LIFT-O-MAT® FR, the HYDRO-LIFT® provides force supply and fully variable positioning in the application. However, the piston of the HYDRO-LIFT® features a pressure valve on the back of the pis-ton. The valve prevents the gas exchange or the compression of the piston rod until the spring-preloaded seal releases the piston bore. Because of the spring-loading of the seal, the force needed to push in the piston rod is greater than the force of the regular LIFT-O-MAT® gas spring (see Fig. 2.12).

The compression force of the gas spring and/or the band width of the spring characteristics can be customized to the respective application by the right choice of valve coil spring.

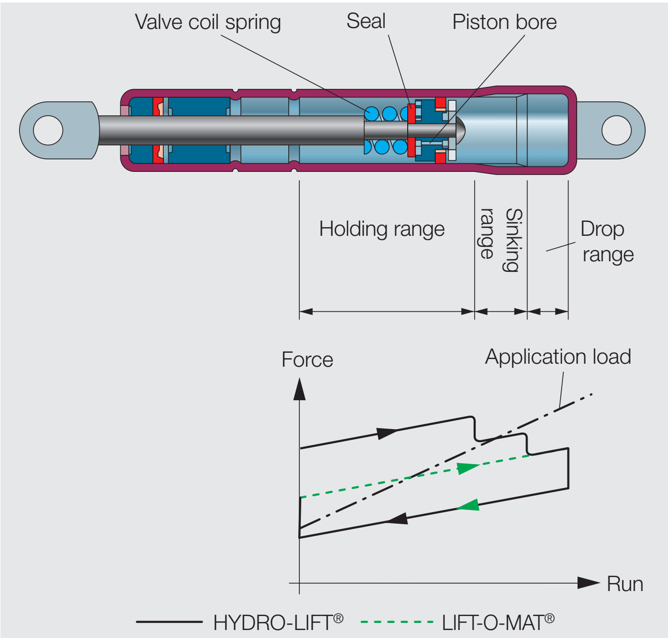


Fig. 2.12 HYDRO-LIFT® with "hold, sink, and fall range"

The extension force of the HYDRO-LIFT® is selected so that the piston rod in the application can only be extended with additional force (e.g., manual force required to open a lid). If the external load of the application is smaller than the compression force of the HYDRO-LIFT®, the lid remains in its position within the "holding range" (see Fig. 2.11).

Depending on the design of the HYDRO-LIFT®, the holding function can be active across the entire adjustment range (as in the LIFT-O-MAT® FR) or in one or more partial ranges of the application. In addition to the "holding range," Fig. 2.12 shows two other function ranges of the application. The "sink range" is achieved with one or more grooves in the pressure tube, which serve as piston bypasses, thus neutralizing the function of the pressure valve. The "fall range" is created by expanding the pressure cylinder cross section. If the piston reaches the "sink range" when the piston rod is pushed in, it reduces the gas spring force or the manual force needed to close the lid. In the "fall range", the lid then closes automatically.

2.3 STABILUS Gas Spring HYDRO-LIFT®-T

The opening and closing forces of a flap with gas springs are affected by the ambient temperature, due to laws of physics. At lower temperatures, the filling medium nitrogen contracts and the spring force decreases.

At higher temperatures, the filling medium expands and the spring force increases. The HYDRO-LIFT®-T was developed to keep the temperature influence as low as possible on the functional forces of a flap. This device is equipped with an additional, bimetal-controlled piston valve. At temperatures above +10°C, the valve is open. At temperatures below +10°C, the valve closes and increases the holding force. While achieving a safe holding force at temperatures as low as -30°C, this function allows for a lower extension force.

The overall lower force level relieves the coupling points of the gas spring, which makes closing with less effort much more comfortable.

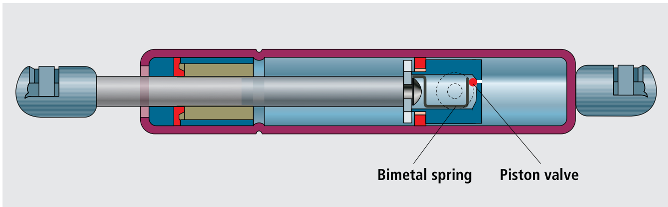


Fig. 2.13 Structure of HYDRO-LIFT®-T

2. Gas Springs for Force Supply

2.4 STABILUS Gas Spring KOMBI-LIFT

What makes the KOMBI-LIFT special are its two pre-settable positions of the extended length, which can be a helpful feature in applications such as tailgates of tall vehicles (vans), to prevent them from bumping into the garage roof or door. Short persons can limit the opening angle of the tailgate, making closing it easier.

To achieve this function, the KOMBI-LIFT has a switch on the piston rod, which opens or closes the valve in the piston. (see Fig. 2.14). The pressure tube has a groove that acts as a bypass in a certain range. Due to this combination, the KOMBI-LIFT is partly a locking and partly a non-locking gas spring – as the product name indicates.

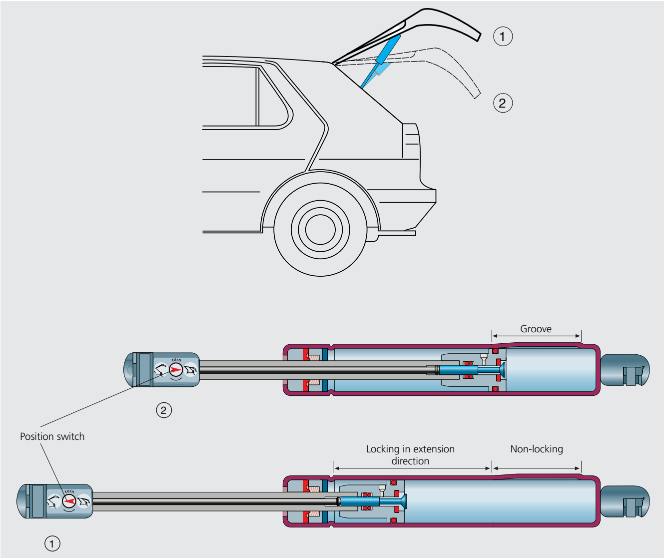


Fig. 2.14 Structure and application sample KOMBI-LIFT

If the valve remains open (switch position 1), the piston rod extends fully. However, if the valve is closed (switch position 2), the piston rod extends only partially, namely in the groove area. To extend it further, all that is needed is a change in switch position, which opens the valve. Due to the special design of the piston, the piston rod can be compressed without locking, regardless of the preset switch position.

2.5 STABILUS Gas Spring INTER-STOP

The INTER-STOP makes it possible to limit the opening angles of flaps, which is useful for tailgates in garages with low ceilings, or for hoods with a normal opening position and a service position. For this purpose, the function of a LIFT-O-MAT® with hydraulic damping is combined with the holding function of a HYDRO-LIFT. Unlike in the HYDRO-LIFT, the holding force of the INTERSTOP acts in the extension direction. Depending on the application, two different systems can be used:

INTER-STOP without Holding Range
In the first part of the stroke (range I), the INTER-STOP works like a gas spring with dynamic damping. The device stops smoothly at the holding point. With manual support in the opening direction, the valve in the piston opens, gas is exchanged between the function areas, and the holding point is overcome. The holding force must be chosen as to ensure the stop function at a temperature of 80°C. In the second part of the stroke (range III), the device acts like a normal gas spring and approaches the end stop in a damped motion.

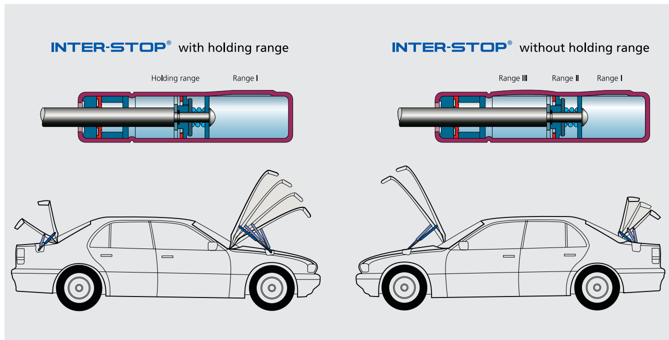


Fig. 2.15 Different opening functions of the INTER-STOP

The closing of a flap with INTER-STOP is the same as with a LIFT-O-MAT.

INTER-STOP with Holding Range
In the first part of the stroke, the device acts as described before. In the holding range, which is the latter part of the stroke, the piston valve is opened with additional manual effort, thus enabling continuos positioning of the flap until the end stop.

2.6 STABILUS Gas Spring ELEKTRO-LIFT

The ELEKTRO-LIFT has the same technical properties as the standard LIFT-O-MAT® . Equipped with a sliding contact at the piston, plastic end fittings, and an insulating plastic shrink-tube (see Fig. 2.14.), the ELEKTRO-LIFT can also conduct an electric current of 25 A max. at 12 V. Flat connectors provided at the piston rod and pressure tube ends act as electrical connections. Bare or interfering cable connections, such as cables to the rear window wiper or heater in the vehicle, can be omitted. In applications where the ELEKTRO-LIFT is to be used as a ground connector only, metal fittings can replace the plastic fittings.

In addition, the ELEKTRO-LIFT can assume a switch function, thus eliminating an additional electrical switch in the application. In that case, there is a plastic cap at the pressure tube end; when the piston rod is compressed, the switching contact lies on the collar of the cap. As soon as the switching contact touches the piston rod during extension, the electric circuit is closed. To set the switching point, this variant is available with an adjustable switching contact, for example for trunk lighting applications.

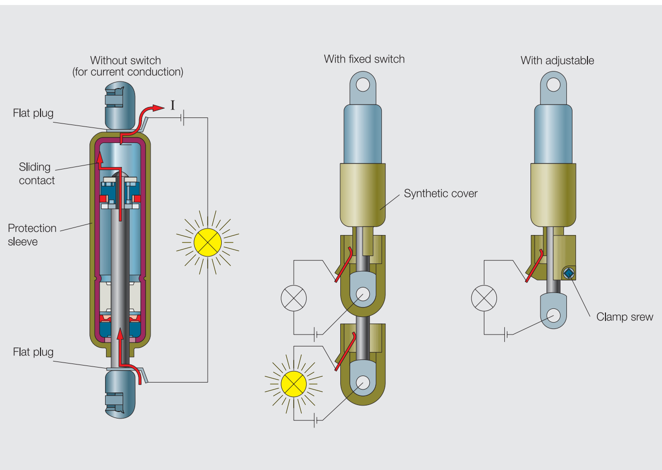


Fig. 2.16 ELEKTRO-LIFT, variants

2.7 Lightweight Design: Gas Springs with Aluminum Pressure Tube

To meet the need for weight reduction through lightweight design, Stabilus also offers gas springs with aluminum pressure tubes. Depending on the dimensions of the pressure tube, it is possible to achieve a weight reduction of up to 30% compared with conventional gas springs with steel pressure tube. Thanks to their bright polished metal surface, gas springs with an aluminum pressure tube feature an attractive high-tech design.

2.8 Gas Springs with Shrink Tube

In ELEKTRO-LIFT gas springs, the pressure tubes have been equipped with shrink tubing to insulate the steel pressure tube for many years now. This technology can also be chosen for special corrosion requirements. In addition to enhanced corrosion resistance, these materials improve the gas spring's resistance to certain chemical and mechanical stresses.

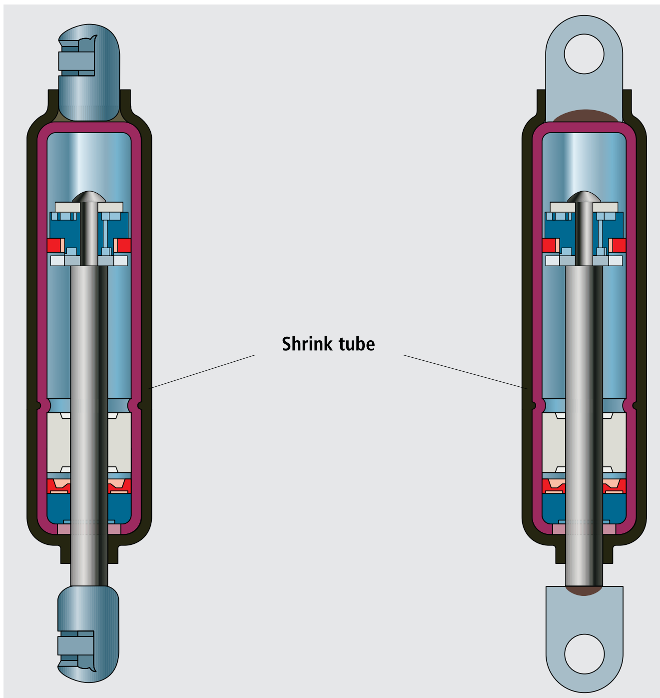


Fig. 2.17 Gas springs with shrink tube

2. Gas Springs for Force Supply

2.9 Tips on Installation and Use

As described in Fig. 2.5, the gas spring should be installed preferably with the piston rod pointing down, to ensure continuous lubrication of the seal with the lubricant accumulating in the seal.

If the gas spring is installed at a slope, the maximum slope depends on the oil fill amount. In that case, please notify us of the mounting orientation of the gas spring in your application. If the gas spring pivots around the horizontal during adjustment, the mounting orientation of the gas spring depends on the most frequent application end position.

In this application case, the gas spring should be equipped with an oil chamber system. If the piston rod points permanently upward in the application, a STABILUS gas spring with a double seal system shall be used.

Transverse forces may result in the premature wear of the gas spring. The mounting and actuation of the gas spring should therefore be free of transverse forces. If the gas spring needs to move in a 3-dimensional plane, ball joints (see Fig. 2.6) can be used as connecting elements to prevent jamming.

The design of the standard gas spring is chosen so it can be used in ambient temperatures of -30°C to +80°C. A brief exposure to 110° (max. 1 hour) is permissible. The gas spring is maintenance-free.

When mounting and operating the gas spring, please make sure that the piston rod in particular is protected from contaminants, paint, and damage. We have prepared a directive for the disposal of gas springs, which you can order. Please also follow our tips and hints on the correct installation of gas springs, which can be found in our Comprehensive Gas Spring Catalog, as well as on the Internet at www.stabilus.de

3. Gas Springs for Force Supply and Variable Position Lock

In addition to the above mentioned functional characteristics of the LIFT-O-MAT® gas spring, such as adjustment and damping, locking gas springs have the added property of infinitely variable position locks.

This property is achieved with a small-sized, integrated valve system to maintain the compact design of the gas spring. There are two basic types of locking gas springs. Fig. 3.1 provides an overview and shows the major areas of application.

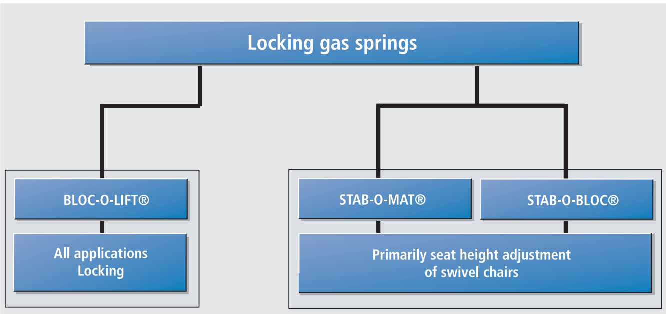


Fig. 3.1 Overview of locking gas springs from STABILUS

3.1 STABILUS Gas Spring BLOC-O-LIFT®

The theoretical principle of the BLOC-O-LIFT® gas spring was explained in Chapter 1. The structure and specialty of the BLOC-O-LIFT® gas spring is shown in Fig. 3.2. In the piston, a valve can be used to separate the two pressure chambers to the left and the right of the piston in a gas leak-proof manner. If the valve is opened by tappet actuation, the BLOC-O-LIFT® acts like a LIFT-O-MAT® gas spring and provides force supply:

The piston rod extends, damped by the gas spring force, or it can be compressed against the force of the gas spring. As soon as the valve tappet is released from the outside, the valve pin closes automatically due to the gas pressure acting on it. The gas exchange between pressure chamber 1 and 2 is interrupted and the piston or piston rod of the BLOC-O-LIFT® gas spring is locked. This way, BLOC-O-LIFT® can be locked in any stroke position.

Further criteria for locking gas springs, which need to be customized for the respective application, are, in addition to the extension force

- Actuation force
- Actuation range
- Damping
- Locking characteristics (spring-locking or rigid)

3.2 Valve Actuation Range and Damping

In addition to the BLOC-O-LIFT® spring characteristic curve shown in Fig. 3.2, there is also a valve force characteristic curve. The valve actuation force depends on the diameters of the piston rod, the valve pin, as well as the filling pressure of the gas spring. Since the diameter of the valve pin is the same, different piston rod diameters result in different actuation forces. For devices with a 10-mm piston rod diameter, they are approximately 20%; for devices with an 8-mm piston rod diameter, they are approx. 30% of the extension force of the gas spring. The actuation range depends on the design of the valve system and ranges from 1 to 2.5 mm (see Chapter 3.3).

The extension speed of the piston rod and the damping can be specified in the BLOC-O-LIFT® with different diameters of the nozzle bore in the piston. The BLOC-O-LIFT® shown in Fig. 3.2 should be installed with the piston rod pointing down, to allow the lubricant in the device to collect in the seal. If a gas spring is equipped with a double seal system similar to Fig. 3.4, it can be used in any mounting position.

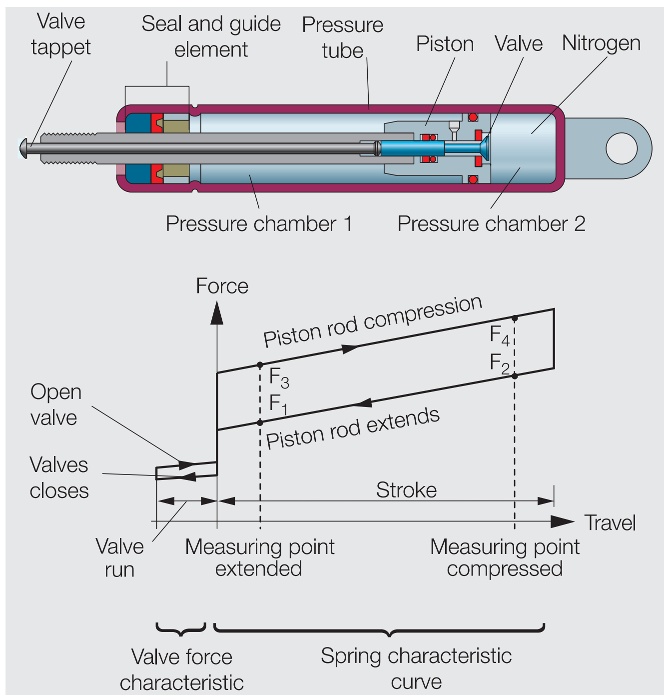


Fig. 3.2 BLOC-O-LIFT®, structure, valve function, and spring characteristic curve

3. Gas Springs for Force Supply and Variable Position Lock

3.3 BLOC-O-LIFT® Standard Actuation

Basically, there are two different valve designs: the sliding valve and the seat valve. Both types are shown in Fig. 3.3.

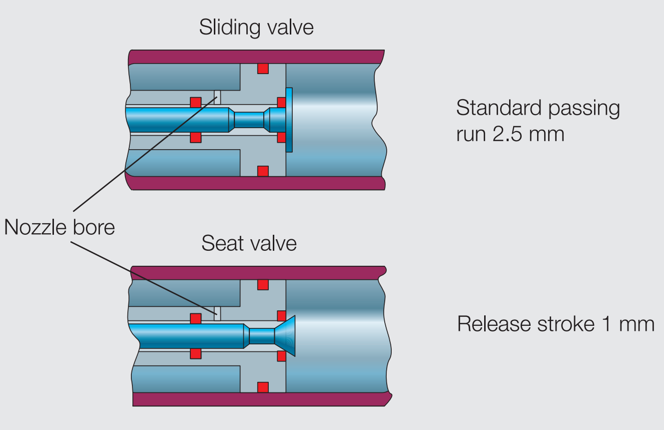


Fig. 3.3 BLOC-O-LIFT® standard and short actuation

Sliding Valve

The sliding valve is used in devices with standard actuation. The actuation range for opening the valve is a maximum of 2.5 mm. This design is resistant to pressure and tension; that is, the valve remains closed even when subjected to external pressure and tensile forces from the application.

Seat Valve

The advantage of this type lies in the very short actuation range (max. 1 mm) for opening the valve, which responds immediately when actuated and releases or locks the gas spring. Like the seat valve, the sliding valve is pressure-resistant. When subjected to high tensile forces, it opens, because due to the shape of the valve pin, the pressured area at the valve seat increases relative to the valve shaft area.

3.4 Locking Characteristics of BLOC-O-LIFT® Gas Springs

Depending on the application, rigid or spring-locking can be used. These characteristics can be achieved with the right structure of BLOC-O-LIFT® gas springs. When rigid-locking is chosen, the locking direction can be chosen as well. Furthermore, one differentiates between position-dependent and position-independent types.

3.4.1 BLOC-O-LIFT®, Spring-Locking

In certain applications, for example in the backrest adjustment of swivel chairs, springy, flexible locking is desirable. Fig. 3.4 shows a spring-locking BLOC-O-LIFT® gas spring. Because the filling gas can be compressed, a spring effect results even when the valve is closed.

First, the piston rod can be pushed in easily, but after a few minutes, it becomes harder to compress it against the increasing gas pressure. This physical effect can be compared to the function of an air pump with the air pump valve closed. Because of the filling pressure of the gas spring, the stroke of the gas spring with a closed valve is much smaller than the air pump stroke. The relative deflection of the spring under external load depends on the extension force of the gas spring, the piston rod diameter, and the respective position of the locked piston in the pressure tube. If the piston is near the pressure tube closed end, there will be a small deflection in the compressed direction and a comparatively large deflection in the extension direction. If the piston is locked in the medium range of the stroke, the spring compression and extension deflection will be the same.

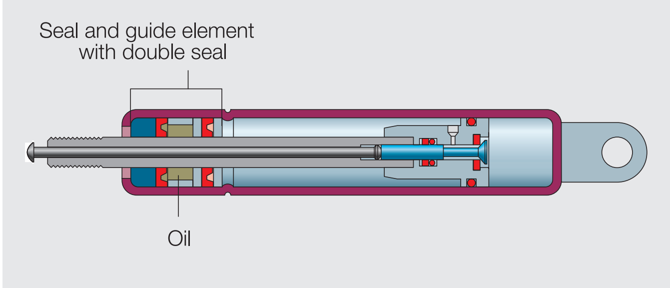


Fig. 3.4 BLOC-O-LIFT®, spring-locking with double seal

3.4.2 BLOC-O-LIFT®, Rigid-Locking

In numerous applications, for example in steering column adjustment or backrest adjustment in cars, rigid-locking is absolutely necessary. In principle, rigid-locking could be achieved by filling the pressure tube with oil that cannot be compressed. However, since the volume of the piston rod to be pushed in has to be displaced, the gas spring cannot be filled completely with oil; a certain gas volume must remain.

If the BLOC-O-LIFT® gas spring is installed with the piston rod pointing down, oil will collect above the piston because of gravity. However, if the piston rod cannot be mounted pointing down, a separating piston will ensure functional positioning of the oil. The resulting two types are explained hereafter:

3.4.3 BLOC-O-LIFT®, Position-Independent, Rigid-Locking

If the application is to remain rigidly locked when subjected to high external loads, rigid-locking BLOC-O-LIFT® gas springs are used. In this case, BLOC-O-LIFT® is equipped with a separating piston that separates the gas and oil chambers.

Whereas the gas chamber compensates the compressed piston rod volume and the oil expansion caused by the heat, the oil enables rigid locking. The separating piston can be placed as shown in Fig. 3.5, either on the piston rod or between piston and pressure tube end. In both cases, the working chamber of the piston is filled completely with oil. Since oil cannot be compressed, variant I is rigid in compression direction, variant II is rigid in extension direction when the valve is closed (see Fig. 3.5).

The maximum permissible oil locking force depends on the extension force of the gas spring and the device strength, taking into consideration all required safety factors.

If the piston is charged in the direction of the gas chamber while the valve is closed (variant I in extension direction, variant II in compression direction), then the BLOC-O-LIFT® is rigidly locked in this adjustment direction up to the respective gas locking force. Higher external forces will result in piston rod deflection, because the separating piston is displaced due to the external load and the gas volume is compressed. The gas locking force varies with extension force F1 and the charging pressure of the gas spring. The gas locking force/extension force ratio corresponds to the ratio of the separating piston/ piston rod cross-section; for design type I, it is approximately 4.5, for design type II, approximately 5.5. Both gas spring types can be used in any mounting orientation. While variant II does not require additional design elements for this purpose, variant I is equipped with the STABILUS double seal system, also shown in Fig. 3.5.

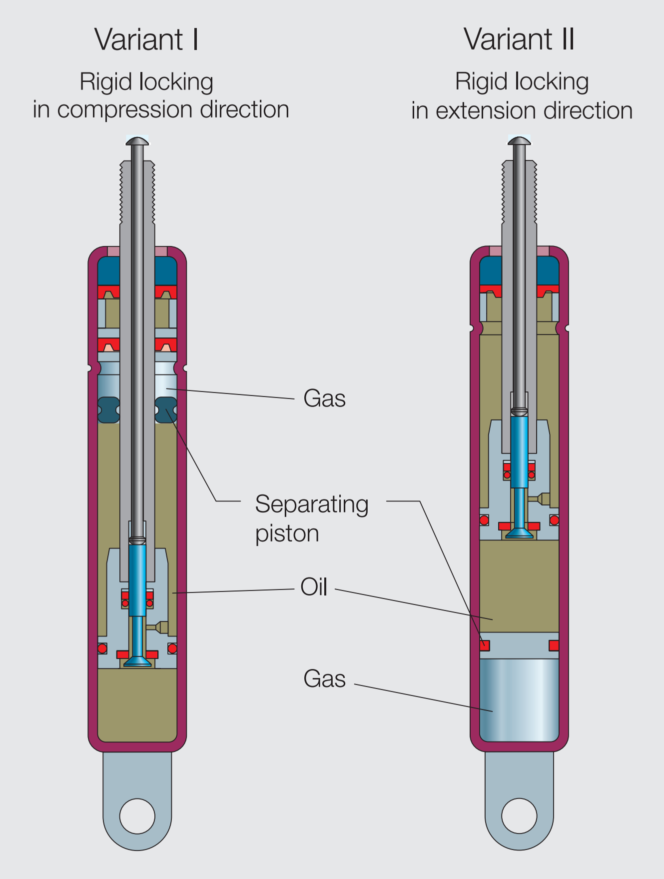


Fig. 3.5 BLOC-O-LIFT®, position-independent, rigid-locking in extension or compression direction

3.4.4 BLOC-O-LIFT®, Position-Dependent, Rigid-Locking

It is possible to achieve the function of the variant described in Fig. 3.5 less expensively, if the BLOC-O-LIFT® can be mounted in the application as shown in Fig. 3.6. Here, additional construction elements (e.g., separating piston) can be omitted.

If the gas spring is mounted with the piston rod pointing down, the oil in the device collects under the piston. This gas spring can then be locked rigidly in extension direction, as long as the piston is covered with oil. If the piston rod is pointed up, the gas spring can be locked rigidly in compression direction.

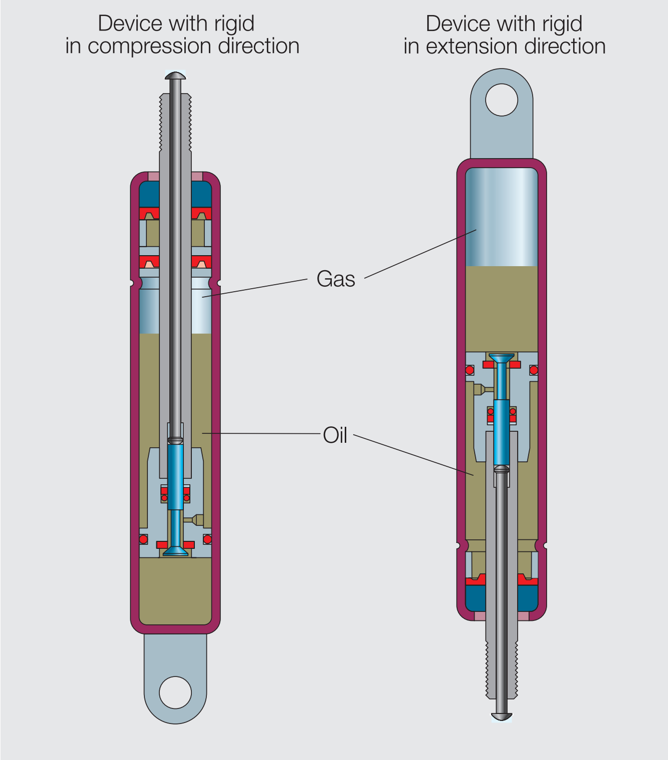


Fig. 3.6 BLOC-O-LIFT®, position-specific, rigid-locking in extension or compression direction

If the opposite load is applied to the BLOC-O-LIFT®, the piston rod will deflect when the external load exceeds the gas locking force. The oil and gas locking forces of these variants correspond to those devices with position-independent mounting orientation. Both variants can also be mounted at an incline. However, in this case, the adjustment range where the piston is covered with oil is smaller than when the gas spring is installed vertically. Thus, BLOC-O-LIFT® can only be locked rigidly in this limited stroke range. In addition, gas spring is equipped with a double seal system for lubrication of the piston rod seal.

3. Gas Springs for Force Supply and Variable Position Lock

3.5 Tips on Installation and Use

The notes in chapter 2.4 on the LIFT-O-MAT® also apply to the BLOC-O-LIFT® gas spring. The device description contains instructions on the installation position due to the different locking functions.

If oil-locking gas springs (see Chapter 3.4.2) are used in changing ambient temperatures, care should be taken that the gas spring can move freely on one end according to the thermal expansion of the oil, even when the gas spring is locked. A load on the gas spring beyond the locking force can result in destruction or malfunction of the spring. BLOC-O-LIFT® is locked safely when there is little play between the outer actuation system and the valve tappet while the valve is locked. To unlock the device, the valve tappet should be pushed in by the amount indicated on the gas spring drawing. The maximum valve stroke depends on the device design and is indicated in the gas spring drawing.

3.6 Stabilus Gas Springs STAB-O-MAT® and STAB-O-BLOC®

STAB-O-MAT® and STAB-O-BLOC® are spring-locking gas springs used in swivel chairs for suspension, variable locking, and damped height adjustment, even under eccentric loads. For this purpose, the pressure tube or the support tube of these devices are dimensioned to accommodate the transfer of bending moments. For both gas springs, the locking valve is located on the pressure tube end, as shown in Fig. 3.7. For this reason, a guide tube is necessary, which forms an annular gap between its outer diameter and the pressure tube inner diameter. The guide tube is located between the valve body and the seal and guide element. This pressure and guide tube combination of a gas spring is also called a double tube system. The piston of the STAB-O-MAT® or STAB-O-BLOC® is closed.

When the valve is open and the piston rod pushed in, the gas from pressure chamber 2 can flow through the annular gap into pressure chamber 1. With the valve closed, the spring deflection and the spring characteristics during extension and compression of the piston rod correspond to those of the spring-locked BLOC-O-LIFT® (s. Chap. 3.1.1). The extension force of the STAB-O-MAT® and STAB-O-BLOC® in the swivel chair application is usually between 300 N and 400 N. The damping effect during compression and extension is determined by the choice of the nozzle bore diameter.

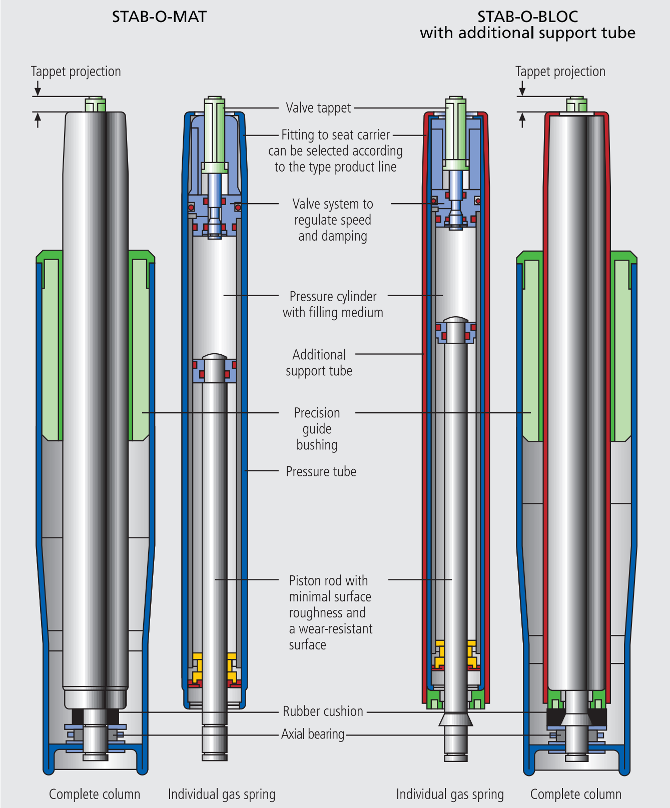


Fig. 3.7 STAB-O-MAT® and STAB-O-BLOC® structures

The difference between these two locking gas springs lies in their structure. The STAB-O-MAT® absorbs the loads resulting from the weight on the seat and bending moments (caused by uneven weight distribution on the seat) with the properly designed pressure tube; in the STAB-O-BLOC®, the functions of "suspension, damping, and adjusting" are performed by the internal pressure tube and the "transmission of bending moment" by the outer support tube.

Because of these properties, the STAB-O-MAT® is considered "self-supporting" and the STAB-O-BLOC® is "non-self-supporting." The combination of STAB-O-BLOC® with support tube is called "STAB-O-BLOC® Telescope." The STAB-O-BLOC® can be fastened in the support tube with a screw cap. This way, it can easily be replaced with other extension force variations, without having to change the support tube, which is fastened to the seat carrier. The strength of the taper at the end of the pressure or support tube, which is clamped into the seat carrier of the swivel chair, determines the bending moment that can be transmitted. STABILUS tapers are designed for reversed bending moments of up to 240 Nm (acc. to DIN 4550 and 4551). The permissible reversed bending stress for the respective taper dimensions can be found in the STABILUS gas spring product line catalog.

STAB-O-MAT® and STAB-O-BLOC® Telescope are available with the same forces and dimensions, so that they are interchangeable. The extended length of gas springs in standard devices is between 320 mm and 700 mm, with strokes ranging from 90 mm to 265 mm.

3. Gas Springs for Force Supply and Variable Position Lock

The connection geometry at the piston rod end is designed for the devices to be fastened to an outer tube, together with an axial ball bearing (see Fig. 3.8).

3.6.1 STAB-O-MAT® and STAB-O-BLOC® Valve Assemblies

The valve body of the STAB-O-MAT® and STAB-O-BLOC® can be equipped with a sliding or seat valve (compare BLOC-O-LIFT® Fig. 3.6). This will result in different valve strokes or actuation ranges and forces for releasing the gas spring. The following table 3.1 shows all actuation variations.

Characterization	Actuation range [mm]	Actuation force ca. [%] of F1	Application in	Ø Piston rod [mm]
Standard actuation	2,5 1,7	30 28	STAB-O-MAT® STAB-O-BLOC®	10 8
Short actuation	1,0	20	STAB-O-MAT®	10
Reduced actuation	1,7	17	STAB-O-MAT® STAB-O-BLOC®	10 10

Table 3.1 Valve and Actuation Variations

The standard tappet height (see Fig. 3.7) is 6.0 mm for the STAB-O-BLOC®, 6.5 mm for the STAB-O-MAT® gas springs. To limit the play between the release mechanism in the seat carrier and the actuator pin of the gas spring, all actuator variants are available with an adjustable tappet (can be set with a screw).

3.6.2 STAB-O-MAT® and STAB-O-BLOC® Columns

STAB-O-MAT® and STAB-O-BLOC® Telescope and an outer tube are combined into a swivel chair column. Fig. 3.8 shows a gas spring column with a standard outer tube, with the gas spring shown in the compressed and extended position.

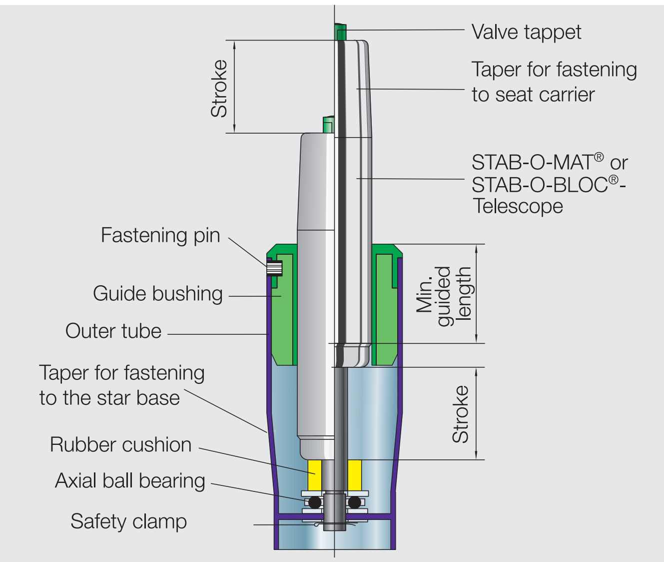


Fig. 3.8 STAB-O-MAT® and STAB-O-BLOC® columns, structures with standard outer tube

A taper at the outer tube end ensures easy mounting and safe attachment of the gas spring columns to the star base of the swivel chair. The STAB-O-MAT® and STAB-O-BLOC® Telescope are secured to the outer tube with a safety clamp at the piston rod end. The pressure or support tube end is then pointed up, for fastening to the respective opposite taper of the seat carrier. The valve tappet is easily accessible for the release systems on the seat carrier. In the compression direction of the gas spring, the external load is supported by the axial ball bearing secured to the end of the piston rod, which simultaneously ensures a slight rotation of the seat carrier. In the one-piece version, the bearing is a captive unit, thus contributing to easy installation or removal of the gas spring. The rubber cushion positioned between the pressure tube end and the axial bearing is a soft stop in the lowest seat position, when the gas spring is compressed and cannot deflect any further. For optimized guidance when adjusting and swiveling the gas spring or the seat carrier, the outer tube has a fitted guide bushing. The length of this bushing is designed to transmit the bending moments that are led into the pressure or support tube safely to the outer tube. The stroke and extended length of the gas spring, as well as the length of the outer tube, must therefore be matched. The piston rod of the gas spring is then free from transverse forces and bending moments. The required guided length of the gas spring when extended (see Fig. 3.8) depends on the gas spring stroke. The effective length should be at least 70 mm.

Additional column versions are available to increase the ease of gas spring adjustment and bounce properties of the swivel chair; they are described in the following sections.

3.6.3 STABILUS Outer Tube with Bottom Spring

Special seating comfort can be achieved if, in addition to a rubber cushion, a coil compression spring (shown in Fig. 3.9) is integrated in the outer tube. This spring is connected to the piston rod of the gas spring via flexible coupling.

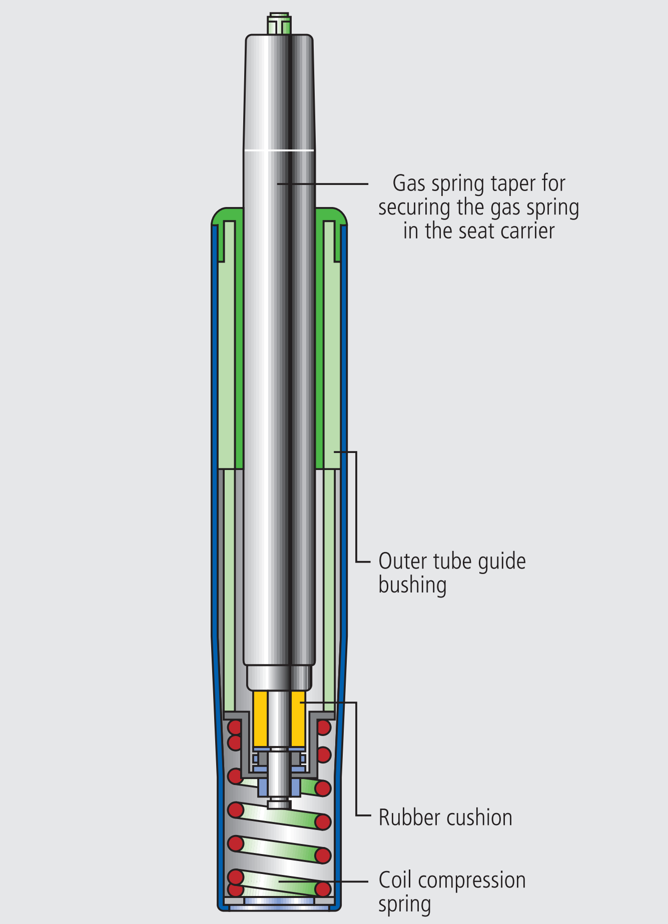


Fig. 3.9 STABILUS swivel chair column with bottom spring

If the piston rod is compressed and the gas spring cannot deflect further, a coil compression spring provides an additional bottom spring function. In all other stroke positions of the gas spring, the gas spring and the coil compression spring act together, which ensures pleasant resilience when the gas spring is locked. As an alternative to the coil spring, special end position buffers can be used, which also offer more comfort in the lowest seat position.

3.6.4 STABILUS Telescope Outer Tube

The height adjustment of STAB-O-MAT® and STAB-O-BLOC® gas springs is usually limited by the required guided length in the outer tube. An increased adjustment range automatically results in a longer outer tube, thus causing the lowest seat position to be higher.

The STABILUS Telescope Outer Tube solves this problem. For this purpose, a telescoping tube is integrated in the outer tube. While the gas spring is guided in the telescope tube, the telescope tube is guided in the outer tube (see Fig. 3.10). It extends as soon as the pin on the gas spring reaches the guide bushing during adjustment of the gas spring.

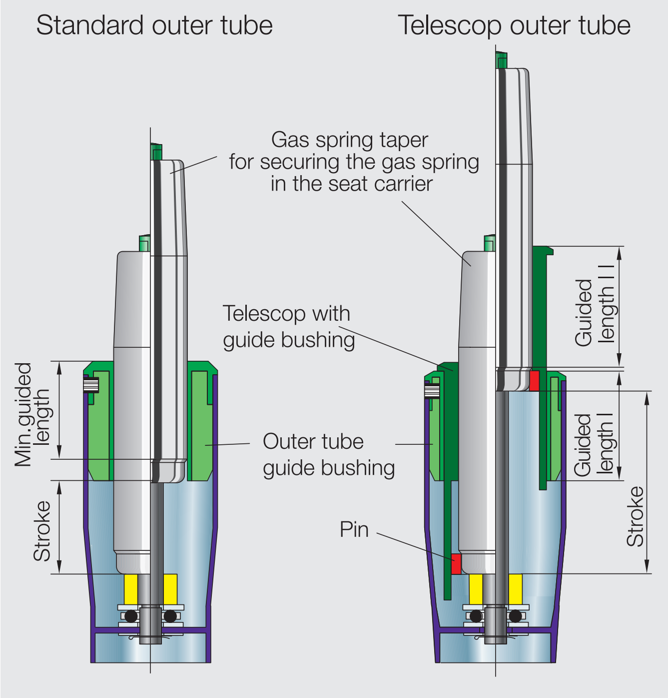


Fig. 3.10 STABILUS swivel chair column with standard and telescope outer tube, structure

3.6.5 Multi-Function Column

It is not always desirable that swivel chairs remain at the set height, but return to a certain position upon removal of the load. The MULTI-FUNCTION COLUMN not only returns to the highest seat position, but also swivels back to the starting position. This ensures an appearance of "neatness" at all times. Naturally, all other functions of variable seat adjustment are still available in the MULTI-FUNCTION COLUMN. The MULTI-FUNCTION COLUMN is especially suited for conference room chairs and special chair applications, for example in theGerman Parliament in Berlin or the European Parliament in Strasbourg.

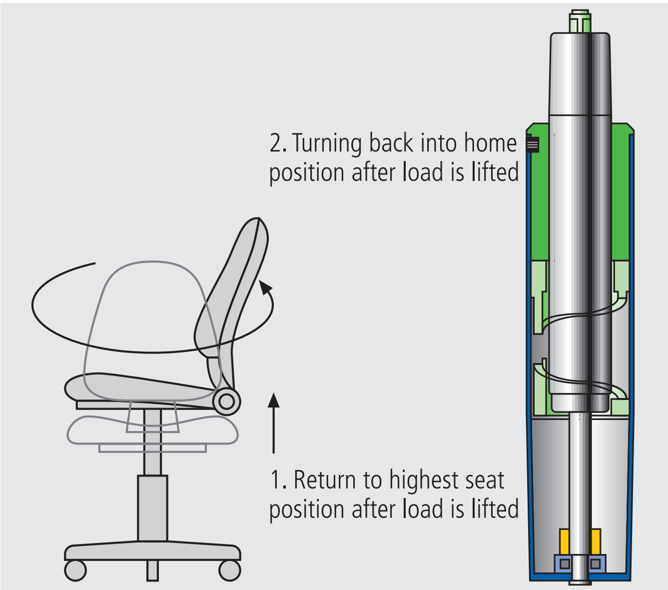


Fig. 3.11 Multi-function column NEW

3. Gas Springs for Force Supply and Variable Position Lock

3.6.6 Non-Twisting Column

In certain applications, swivel chairs should not turn, either due to the situations or facilities they are used in. This can be ensured with non-twisting columns. At the same time, all advantages and the full comfort of the variable locking height adjustment functions of the STAB-O-MAT® and STAB-O-BLOC® columns are available.

3.6.7 Column with Additional Stop Function

The telescope column with stroke-controlled stop function protects stools and task chairs for standing/seated workstations in a specific range against accidental rolling away. Above a defined actuation point within the stroke range, a rubber stopper rebounds out of the column when a load is applied by the user of the chair, thus preventing the chair from rolling away. Below this actuation point, the stopper remains in and the chair can be used and adjusted like a normal swivel chair.

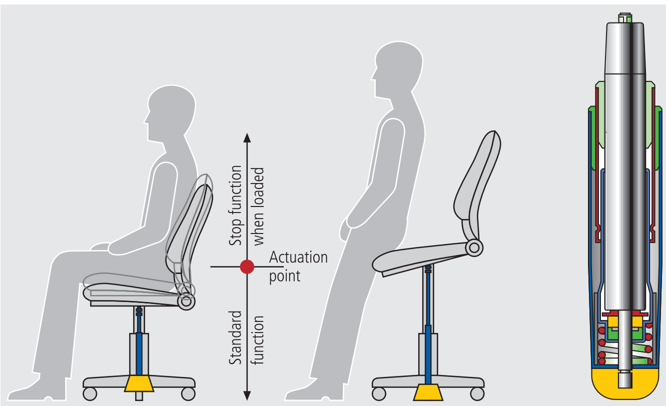


Fig. 3.12. Column with additional stop function NEW

3.6.8 Tips on Installation and Use

The mounting orientation of the STAB-O-MAT® and STAB-O-BLOC® Telescope is determined by the respective end fittings. The taper at the pressure or support tube end is attached to the opposite taper of the seat carrier. The outer tube taper is installed in the respective opposite taper of the star base. The piston rod of the gas spring should always point down. Please follow the strength classes and taper dimensions given in the STABILUS Gas Spring Catalog, as well as the respective standards (e.g., DIN 4551 for office swivel chairs in Germany).

To protect the piston rod from transverse force and bending moment loads or jamming, the pressure tube of the gas spring shall be properly guided in the guide bushing of the outer tube. The piston rod end is attached to the outer tube bottom, allowing for some radial play. When using STABILUS gas spring columns, both are automatically guaranteed.

When mounting the multi-part axial bearings, the assembly sequence according to the drawing shall be followed. The swivel chair can then be swiveled noiselessly and comfortably. For further application hints see Chap. 2.9.

3.7 STABILUS Actuation Systems for Locking Gas Springs

The actuation system consists of an actuation element, for example on the seat carrier, the release head on the gas spring, and – for " remote control" – a Bowden cable as the transmission element between actuation element and release head. The choice of actuation element is usually determined by the free installation space and the customer's wishes regarding form and function.

The various types of STABILUS release heads are shown in Fig. 3.13. Also shown is a universal actuation element for BLOC-O-LIFT® gas springs.

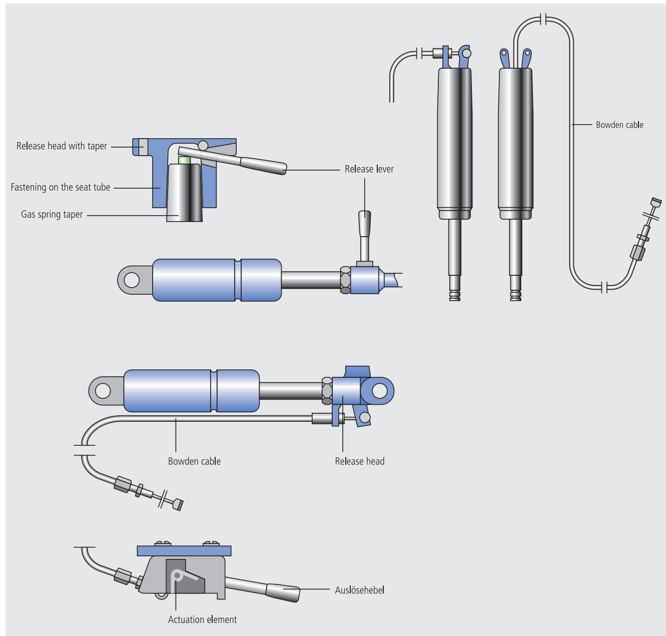


Fig. 3.13 Stabilus release heads and actuation element

The release head or valve tappet of the BLOC-O-LIFT® gas spring can be operated by release lever or Bowden cable. Both release head types are screwed onto the piston rod and secured with a nut. They also contain the piston rod-side connection to the application, which allows for a compact design and easy installation of the gas spring. The Bowden cable is installed by placing the sleeve on the jib of the actuation head.

The design of the release head of the STAB-O-BLOC® / STAB-O-MAT® gas spring is designed to include the release head in the pressure tube taper. It can be removed any time by releasing the fastening clamps. The lever and Bowden cable lengths depend on the respective application. Dimensions, strengths, and installation tips for the actuation systems are included in the STABILUS specifications. Depending on the installation situation, radial guidance of the Bowden cable might be more favorable. There is a special configuration available for this as well.

4. STABILUS Locking Elements without Extension Force: HYDRO-BLOC®

Damped adjustment and infinitely-variable locking are the characteristic functional properties of the HYDRO-BLOC®. This construction type does not have an extension force and is thus most suitable for applications that do not require any force support but damping and infinitely-variable locking. Application examples are found in the automobile industry for the length adjustment of the steering column and in furniture as an adjustment element for backrests as well as for seat inclination adjustment.

Fig. 4.1 shows the structure of the HYDRO-BLOC®. The HYDRO-BLOC® differs from the BLOC-O-LIFT® in its inner structure. The piston of the device is arranged in such a way that in addition to a piston rod pointing outwards it has room for a gimbal fixed compensation piston rod. The use of a compensation piston rod results in the components of the internal pressure of the device being mutually eliminated in the axial direction. The piston rod thus has no resultant output force.

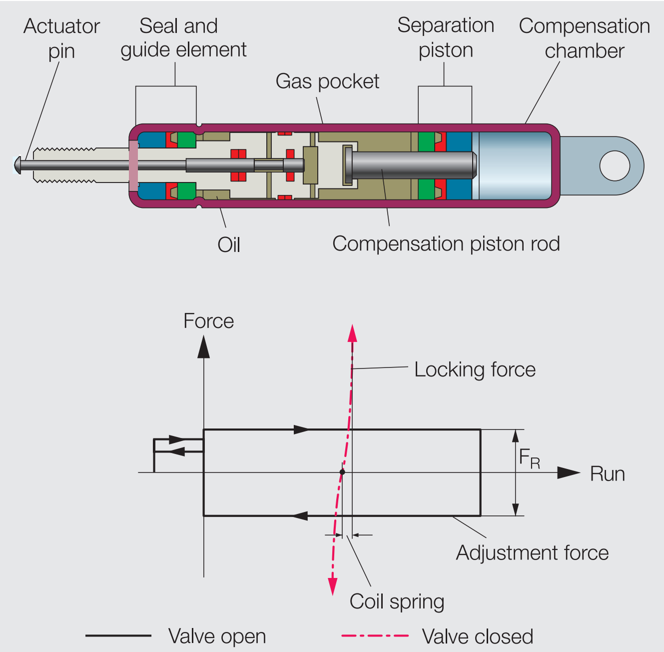


Fig. 4.1: HYDRO-BLOC®, structure and characteristic

To adjust the HYDRO-BLOC® it is only necessary to overcome the friction force of the seal elements and flow resistance of the piston nozzles, as shown in the characteristic curve in Fig 4.1.

The friction is slightly greater in this construction type than in the BLOC-O-LIFT® because of the additional seal required for the compensation piston rod. The damping of the adjustment motion may be determined by varying the nozzle diameter as is the case for the BLOC-O-LIFT®. The separation piston separates the pressureless compensation chamber from the piston work chamber. The compensation chamber only serves to accept and protect the compensation piston rod when adjusting the device in the compression direction. To compensate for the change in oil volume during temperature changes the work chamber contains a pressurised gas pocket. When the valve is closed the HYDRO-BLOC® consequently behaves similarly to the gas-locked BLOC-O-LIFT® (see Fig. 3.3). However, the spring effect in the HYDRO-BLOC® is considerably less because of the relatively small gas pocket, so that it locks rigidly in both adjustment directions. The valve release force is approx. 125 N, the valve stroke is 2.5 mm. Fig. 4.2 shows another construction of the HYDRO-BLOC®. The constructions differ in the separation piston support. Whereas the separation piston of the HYDRO-BLOC® shown in Fig. 4.1 is positioned against the radial groove, the coil spring shown in Fig. 4.2 supports the separation piston.

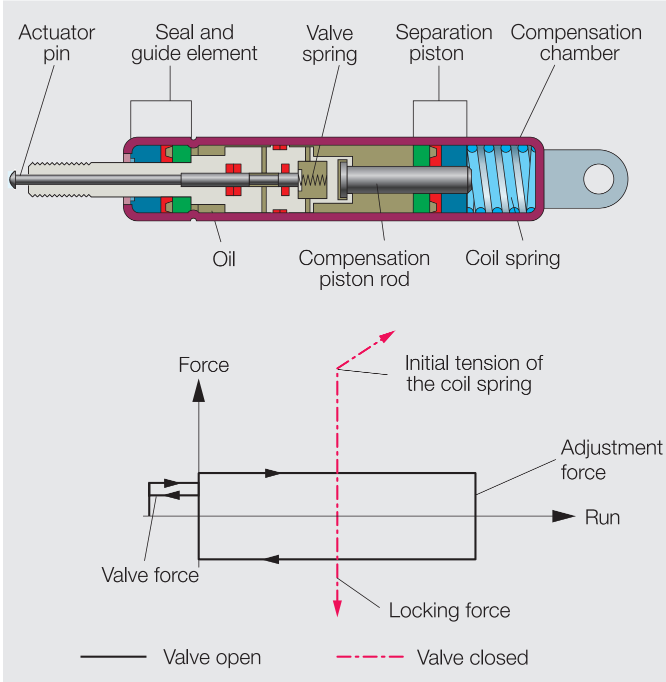


Fig. 4.2: HYDRO-BLOC® with the initial tension on the coil spring of the separation piston

The temperature-dependent oil expansion is compensated by the coil spring, a gas pocket in the work chamber is not necessary. This is why the device is rigid in both adjustment directions when the valve is closed. It is only when the external load exceeds the initial tension force of the coil spring that the piston rod can be compressed. On this device variant the valve released force is mainly determined by the force of the valve spring. It is approx. 100 N, and the valve stroke 3.5 mm.

Both device models can be installed in any position; the preferred installation position for the HYDRO-BLOC® shown in Fig. 4.1 is horizontal. For more tips on installation and application see chapter 3.5. The release heads for BLOC-O-LIFT® gas springs shown in Fig. 3.3 can also be used for HYDRO-BLOC®.

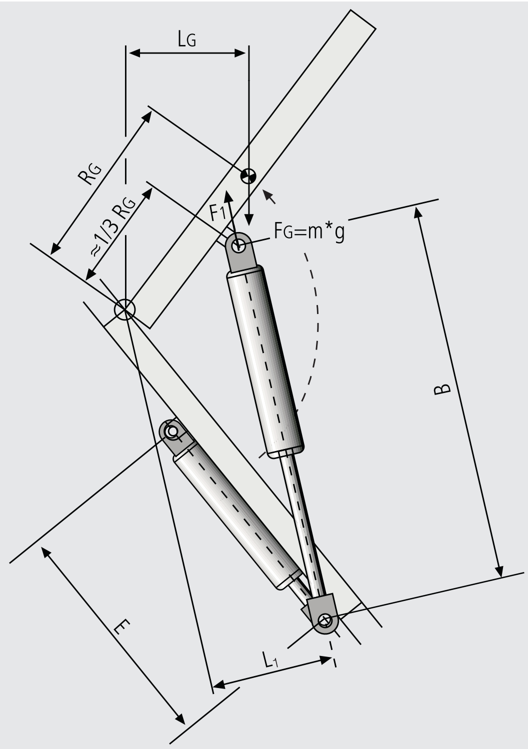
5. Gas Spring Range and Mounting Situation

You can select your gas springs from the STABILUS gas spring type programmes. They include numerous variants related to stroke **A**, extended length **B**, thrust force $\mathbf{F_1}$ and connection techniques of the STABILUS gas springs.

The determination of dimensions **A** and **B** required for the application as well as the necessary thrust force $\mathbf{F_1}$ of the gas spring occurs in most cases by straightforward estimating techniques. **A** particularly comfortable opening and closing behaviour of the application is obtained when the required gas spring and its connection points are obtained by simulation calculation using the STABILUS mounting proposal programme.

5.1 Estimation of Extension Force F_1

Fig. 5.1 gives a schematic representation of a random flap (e.g. a machine hood, cupboard door, loader ramp etc.) in opened and closed position. All the dimensions and forces required for estimating techniques are listed.



Min.stroke $A = B - E$ Extension force $F_1 = \frac{F_G \cdot L_G}{n \cdot L_1} \cdot R$

A	:	Stroke of the gas spring	[mm]
B	:	Extended length of the gas spring	[mm]
E	:	Compressed length of the gas spring	[mm]
F_1	:	Extension forceof the gas spring	[N]
F_G	:	Weight force of the application in the centre of gravity	[N]
g	:	Acceleration due to gravity 9,81	[m/s^2]
L_1	:	Vertical distance bearing/deformation axis F_1	[mm]
L_G	:	Vertical distance bearing/deformation axis F_G	[mm]
R_G	:	Radius bearing/centre of gravity	[mm]
m	:	Mass (weight) of the application	[kg]
n	:	Number of gas springs	[/]
R	:	Reserve force factor 1,2 ... 1,3	[/]

Fig. 5.1: Stroke and extension force of a gas spring to open a flap

The extended length **B** can be chosen in such a way that the gas spring serves as a stop when opening the flap. The required minimum thrust **A** of the gas spring is then the result of the difference between the extended and compressed length **E**.

The stroke or the extended and compressed length can be graphically represented by measuring a correct scale drawing or using trigonometric functions. The gas spring stroke should also take into account the length tolerance of the application and gas spring.

Extension force $\mathbf{F_1}$ of the gas spring can be calculated on the basis of the moment balance on the application pivot bearing.
The extension force is measured in such a way that the flap remains open. Moreover, force reserve factor **R** is included in the calculation equation in Fig. 5.1.

For **R**=1 the force balance is obtained from the weight force of application $\mathbf{F_G}$ (in the centre of gravity) and of the thrust force of gas spring $\mathbf{F_1}$. The flap is then suspended. The greater the selected force reserve factor, the greater will be the "manual force" required to close the application.

As a general rule the force reserve factor is of between 1.2 and 1.3. For ambient temperatures of more than 30°C **R** may be smaller, for ambient temperatures of less than 10°C **R** should be greater (see Chap. 1.2.2). The rigidity and weight of the application determine number **n** of the required gas springs. Large, flexible flaps usually require two gas springs to prevent the tilting or sagging of the application.

5.2 Calculation of the Manual Force Characteristic, Simulation, Calculation

To assess or optimize the adjustment function of an application the extent of the necessary manual forces is considered over the full adjustment range of the application. The manual force characteristic for opening and closing the application can be determined through simulation in the STABILUS mounting proposal programme.

The goal of the simulation calculation is to obtain the optimal arrangement of the gas spring or extension force and spring characteristic in combination with the optimal connection points in the application. The optimum depends on the relevant function. For instance gas springs in vehicle tailgates are measured to ensure that the application requires no further manual force once the application has opened slightly and that during closing the tailgate automatically snaps in the lock.

Other applications require the immediate opening or extension of the gas spring (e.g. swivel chair-backrest), other applications must be maintained in a specific position (e.g. top part of a sun bed etc.). All these different requirements can be represented in the manual force behaviour. The drafting of a mounting proposal is done by STABILUS or STABILUS agents.

5. Gas Spring Range and Mounting Situation

The necessary indications for processing the mounting proposal of an application with a rotating joint are given in drawing SK 0902FP in annex 6.2. If the application is activated with a four-bar hinge, the plans are also required in addition to the geometrical description of the fourbar hinge.

Fig. 5.2 shows the result of the simulation calculation based on the example of an application drawing from Fig. 5.1. The left side of the picture shows the kinematic representation of the application. The elements and forces used are numbered.

Rod 2 is used as a replacement representation of the tailgate and is connected to the pivot bearing. The tailgate is represented in open and closed condition, the suspension angle on the bearing is of 90°. The gas spring as shown as element 3 in which the position of the gas spring connections are marked by circles on the piston rod and pressure tube. In addition to the components of the application, the operating forces such as the weight force of tailgate $\mathbf{F_G}$ (4) and manual force $\mathbf{F_H}$ (5) for opening and closing the flap are shown according to their position and direction.

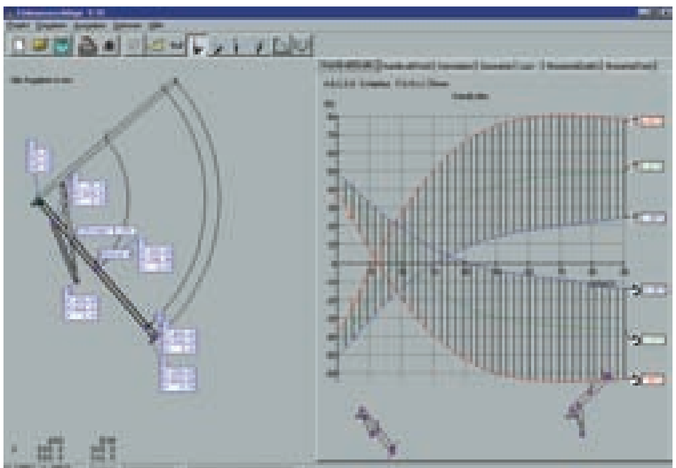


Fig. 5.2: Result of the simulation calculation, kinematic and manual force characteristics

The paths in which these forces act over the full range of the application are represented as arcs. The manual forces for opening and closing the application can be calculated at different positions along the arc. The manual force characteristics of the application are shown on the right side of the picture in Fig. 5.2. The characteristics are identified by characters and the legend is located in the top picture corner.

At the origin of the abscissa (0°-opening angle) the flap is closed, the gas spring is compressed. Positive manual forces mean that the application requires that manual force be applied to achieve adjustment. For negative manual forces the moment of the gas spring is sufficiently large such that the application can adjust automatically.

In the example (see Fig. 5.2) manual force characteristic **E** indicates the opening behaviour of the flap at nominal $\mathbf{F_1}$ and at an ambient temperature of the gas spring. To open the flap from a closed position the manual force is initially of approx. 45 N. During the further opening process the manual force decreases gradually, because of the increasing lever action of the gas spring, until the intersection point with the abscissa (approx. 20° opening angle) is reached. As from this point the manual force becomes negative.

The flap now opens now automatically up to the stop (90° opening angle). Manual characteristic **B** describes the closing process from an open position of the application (90° opening angle). Hence some 33N manual force are required to start the closing process of the flap. After the intersection of the characteristic with the abscissa the manual force becomes negative, so that the flap automatically falls in the lock. The intersection of the characteristic with the abscissa is mainly dependent on the connection points of the gas spring, thrust force $\mathbf{F_1}$ and spring characteristic x as well as on the ambient temperature of the application.

The example in Fig. 5.2 shows the characteristics at 80°C and -30°C in addition to the manual force characteristic at ambient temperature. These characteristics also take into account the tolerance of extension force $\mathbf{F_1}$ of the gas spring, so that he minimum and maximum manual forces of the application can be illustrated off. The manual force at the start of characteristic C (90° opening angle) is also called the "holding force" of the application, because it represents the force reserve for holding the flap open at the lowest ambient temperature (here: -30°C) and bottom extension force tolerance. The force reserve should be at least 45 N. The values on which this example is based are listed in the data sheet of the mounting proposal (see Fig. 5.3).

5. Gas Spring Range and Mounting Situation

STABILUS GMBH

M o u n t i n g p r o p o s a l N o .: Example DEMOFM01

Author	STABILUS
Customer	User
Project	Example
Application	Tailgate

		X	Y	Z
1	Bearing	0.0	0.0	0.0

2 STAB Length = 922.0

3 GAS SPRING

Connection	Position	X	Y	Z
Pressure tube	Start angle	77.7	-124.1	0.0
	End angle	123.8	78.1	0.0
Piston rod	Start angle	200.0	-416.0	0.0
	End angle	200.0	-416.0	0.0

PARTS NUMBER:

F_1	= 400
Compressed	= 300.00
Extended	= 500.00
Stroke	= 200.00
X	= 1.20

Number per application 2

4 FORCE : FG

Position	X	Y	Z
Start angle	300.0	-350.0	0.0
End angle	348.9	301.2	0.0

VALEU	= 210.0
Upper tolerance	= 0.0
Bottom tolerance	= 0.0

5 FORCE : FH

Position	X	Y	Z
Start angle	600.0	-700.0	0.0
End angle	697.9	602.5	0.0
Start angle	550.0	-650.0	0.0
End angle	648.1	552.3	0.0

manuel forces look diagram

Start angle	-50
End angle	90

Units :		
	lengths	(mm)
	forces	(N)
	moments	(Nm)
	angles	(degres)

Fig. 5.3: Data sheet of the STABILUS mounting proposal programme

The performance characteristics of the STABILUS mounting proposal programme are briefly summarised below:

- Variation of the connection positions of the gas springs,
- Variation in the extension force and hysteresis,
- Variation of the spring characteristic,
- Random characteristic (linear, degressive, progressive),
- Calculation of random constructions of single and four-bar hinge systems,
- Compliance with building length tolerances,
- Compliance with force tolerances,
- Compliance with the operating temperature range.

For requests concerning the drafting of a mounting proposal please refer to drawing 10014184 in annex 6.2.

6. Appendix

6.1 Used Symbols and Units

A_R Pressure tube cross-section (Y inside) [mm 2]
A_K Piston rod cross-section [mm 2]
c Spring rigidity [N/mm]
F Spring force of the gas spring [N]
F_1 Extension force at the stroke start* of the gas spring [N]
F_2 Extension force at the stroke end* of the gas spring [N]
F_3 Compression force at the stroke start* of the gas spring [N]
F_4 Compression force at the stroke end* of the gas spring [N]
F_D Gas or oil blocking force in the pressure direction [N]
F_H Manual force [N]
F_{LB} Break-away force [N]
F_R Friction force of the gas spring [N]
F_Z Gas or oil blocking force in the pull direction [N]
L_B Solid length of the coil spring [mm]
n Polytropic exponent [/]
N_2 Nitrogen [/]
p Overpressure of the gas in the pressure tube [N/mm 2]
p_1 Overpressure in the extended gas spring [N/mm 2]
p_2 Overpressure in the compressed gas spring [N/mm 2]
p_U Ambient pressure (approx. 0.1 N/mm 2) [N/mm 2]
s Stroke, range of spring of the gas spring [mm]
s_1 Stroke start (extended gas spring)/Hydraulic damping range [mm]
s_2 Stroke end (compressed gas spring)/Pneumatic damping range [mm]
s_3 Tappet of the coil spring [mm]
T Temperature [K]
T_0 Standard temperature (293 K = 20°C) [K]
v Extension speed [m/s]
V Gas space or free pressure tube volume [mm 3]
V_1 Gas space at stroke start [mm 3]
V_2 Gas space at stroke end [mm 3]
W Spring force [Nmm]
W_2 Spring force at stroke end [Nmm]
x Spring characteristic F 2 /F 1 [/]

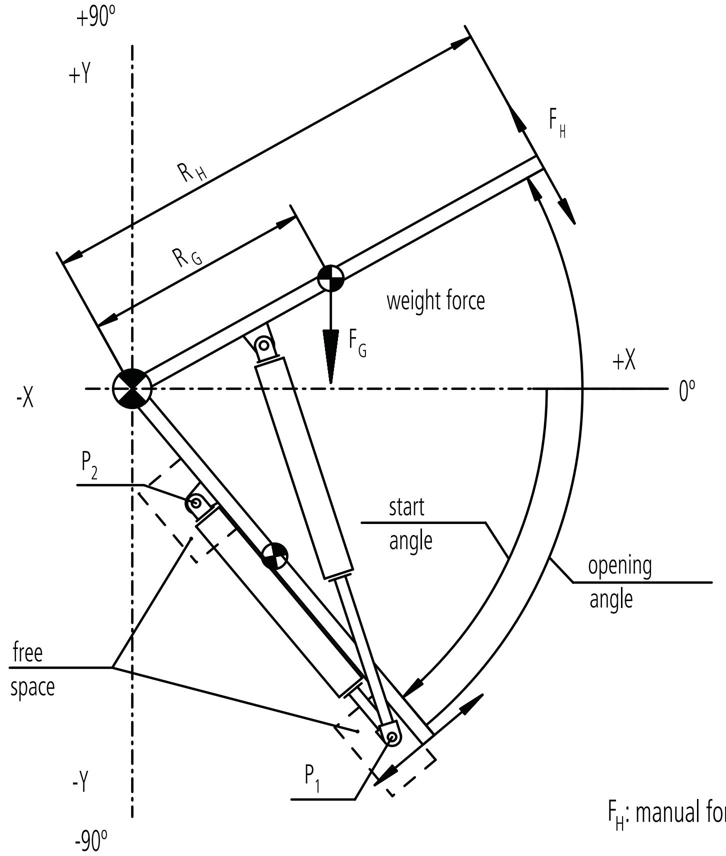
*: for standard devices 5 mm after stroke start and 5 mm before stroke end

6.2 Worksheet 10014184

For internal and external use

DE

Data sheet Programme: mounting	Document No. 10014184 Ident. Doc.: SK 0902FP



STABILUS recommends a minimum manuel force of 20 N at -30° C at open position. Is the calculated manuel force below 20 N, the agreement of the customer is needed.

<u>confirmation of the customer</u>

F_H: manual force for opening or closing

Customer:.......... Project:.......... Anwendung:..........

gas spring:	x [mm]	y [mm]	free space ± X [mm]	± Y [mm]
P_1 (flap):				
P_2 (frame):				

start angle: [GRAD]	weight force F_G: [N]
opening angle: [GRAD]	number of the gas springs: [/]
manual force radius R_H: [mm]	temperature:
radius bearing R_G: [mm]	from to [°C]

last edition:

signed:	authorization:	last change:

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