Camloc
Motion Control

More than just a manufacturer of Gas Springs and Dampers

Technical Guide – Edition 2.0:
Gas Spring Mounting

Summary

Following on from "Technical Guide – Edition 1: Gas Spring Overview", this whitepaper provides the reader with in-depth technical insight into gas spring mounting. Covering a wide variety of areas including 'handling forces', 'mounting positions and gas spring sizing', 'mounting orientations', 'mounting – crossover, self-rise and self-close', 'mounting – practical application' and 'mounting - dampers'; provides ample knowledge for projects requiring aid with motion control.

1.0 Handling Forces

1.01 Handling Forces Introduction

The primary function of a gas spring is to lift and support an object in a safe and controlled manner. For the designer and end-user of an application, the handling forces are the most important consideration; these are the human and mechanical interactions the spring has with an application.

Handling forces can be categorised as either a System or Ergonomic force, and can be related back to the **P1-P4** chart (discussed in Technical Guide – Edition 1: Gas Spring Overview), seen in figure one:

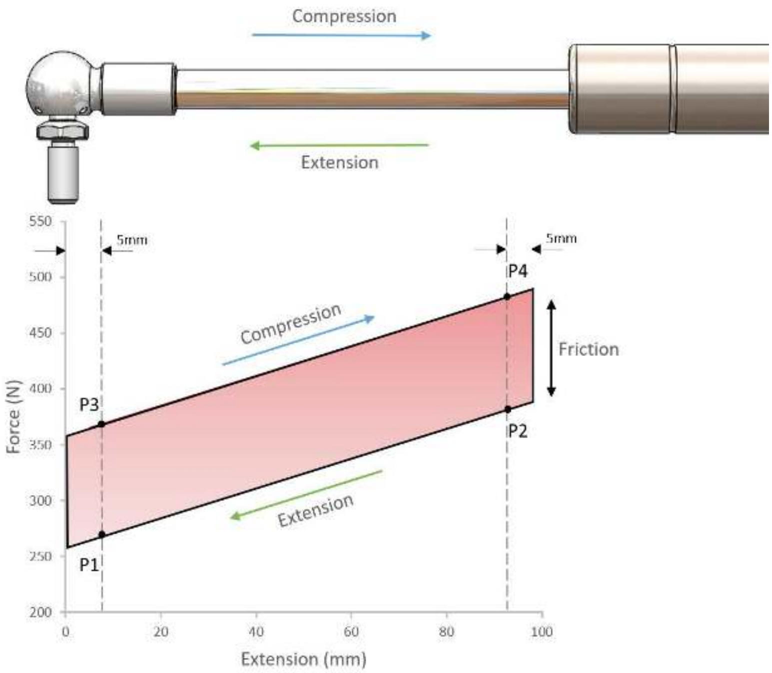

Figure One: Idealised P1-P4 Force/Displacement Graph

1.02 System Forces

The **P1** and **P4** points of the chart are System Forces which can be calculated and must be taken into consideration by the designer of the application.

P1 – This is the force required to keep the application fully open, e.g. a car tailgate being held in open position.

P4 – This is the maximum load the system will experience. The spring is reaching full closure in the compression direction, the bracket and the hinge design must be capable of withstanding this force.

1.03 Ergonomic Forces

The **P2** and **P3** points are Ergonomic Forces. These are the subjective forces that the end user will assess the gas springs performance by.

P2 – This is the key handling force when lifting a lid, it dictates when you have reached an in-balance position. In the example of the car tailgate, the tailgate is shut and the end user is opening the tailgate; the target for this is to be less than 60N.

P3 – This is the key handling force when closing a lid, this is the force required to close when the spring is fully extended, the target for this is to be 60N or less.

2.0 Mounting Positions & Gas Spring Sizing

2.01 Mounting Points Overview

There are two mounting points for a gas spring, the 'fixed' and 'moving' mounting points.

As the names suggest, the fixed mounting point remains fixed, whereas the moving mounting point rotates through an arc as the application opens and closes.

As a rule of thumb when positioning a gas spring, Camloc start with the moving mounting point approximately 1/3 the length of the lid from the hinge as shown in figure two below:

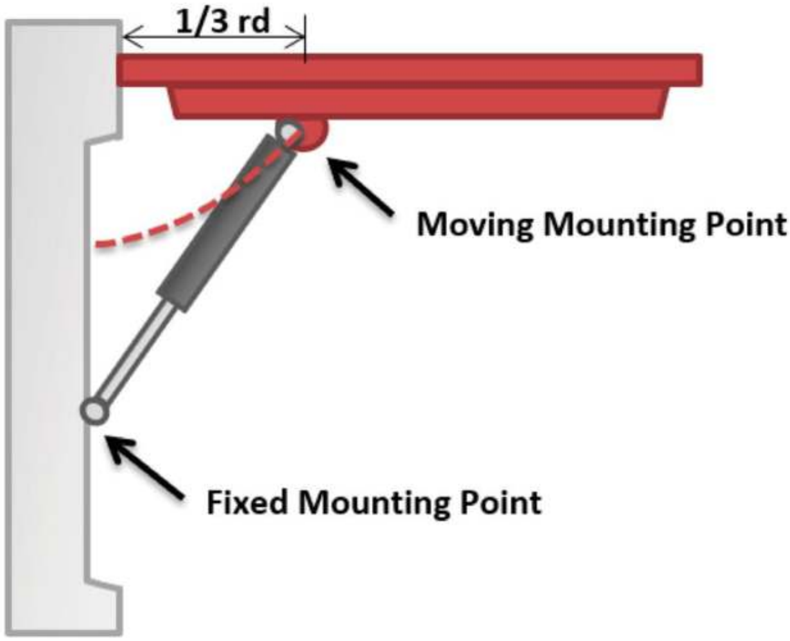

Figure Two: Typical Gas Spring Positioning

This provides an extremely rough guide as to where to place a gas spring, but if this is developed further it will also give an indication of the size of the spring required.

2.02 Simple Moment Balance

If we begin by considering the application to be a simple moment balance without a gas spring involved, in basic mechanics terms the application can be considered as a second-class lever.

The application is pivoted at point A, the lid weighs 50kg (G) and the centre of mass is equi-distant at a length of L between pivot A and somebody holding the lid up at point B.

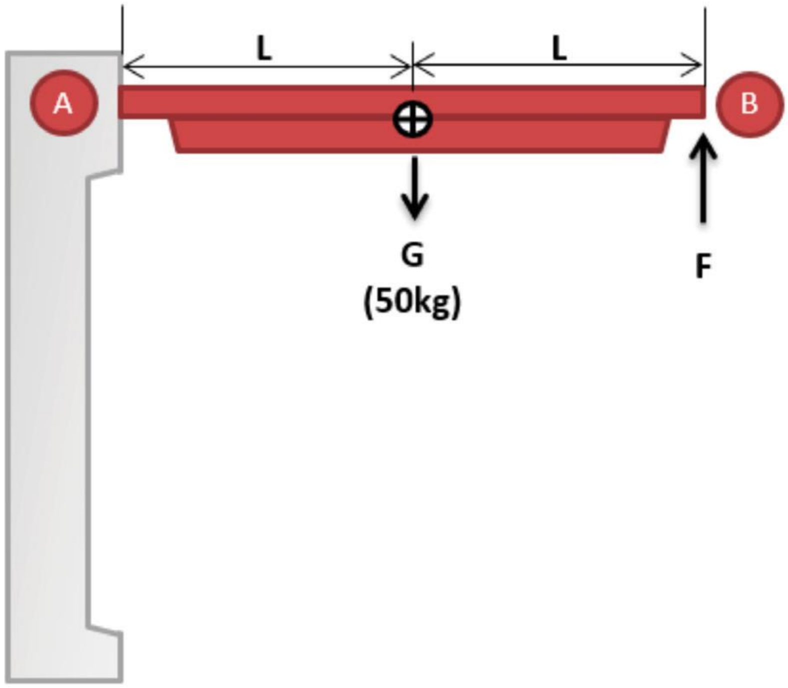

Figure Three: Simple Moment Balance A

To calculate the upward force (F), an individual must apply to keep the lid horizontal and in balance, using the formula below:

$$\sum M_A = 0$$

$$G.L - F.2.L = 0$$

$$F = {}^{G}/_{2}$$

$$F = 25kg\ (245N)$$

Taking this a step further, if the centre of mass is moved further to the right (away from the pivot), no longer being equi-distant along the hatch; the centre of gravity (XG) is now 0.8m from point A, with the total length of the hatch (Z) being 1.2m.

What is the upward force (F2) to point B required to keep the hatch open?

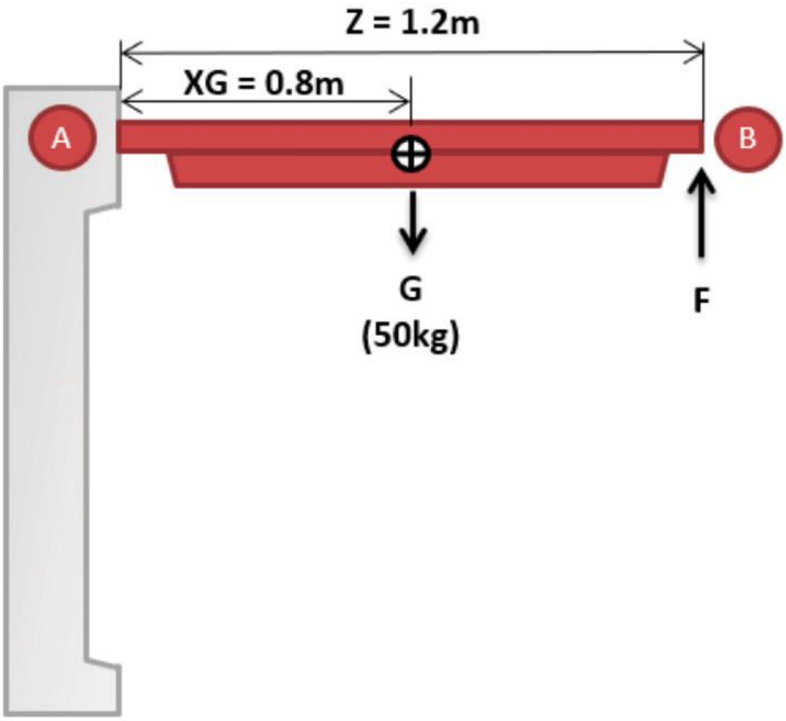

Figure Four: Simple Moment Balance B

This can be determined with the following equation:

$$\sum MA = 0$$

$$G.XG - F.Z = 0$$

$$F = {G.XG}/{Z}$$

$$F = {(50 \times 9.81) \times 0.8}/{1.2}$$

$$F = 327N\ (+82N\ increase)$$

Both solutions are simple because all forces are perpendicular to the beam and there is no gas spring involved. By including a gas spring, the problem becomes more complex.

2.03 Simplified Gas Spring Application

For the remainder of this section, we will refer to the following diagram and list of terms:

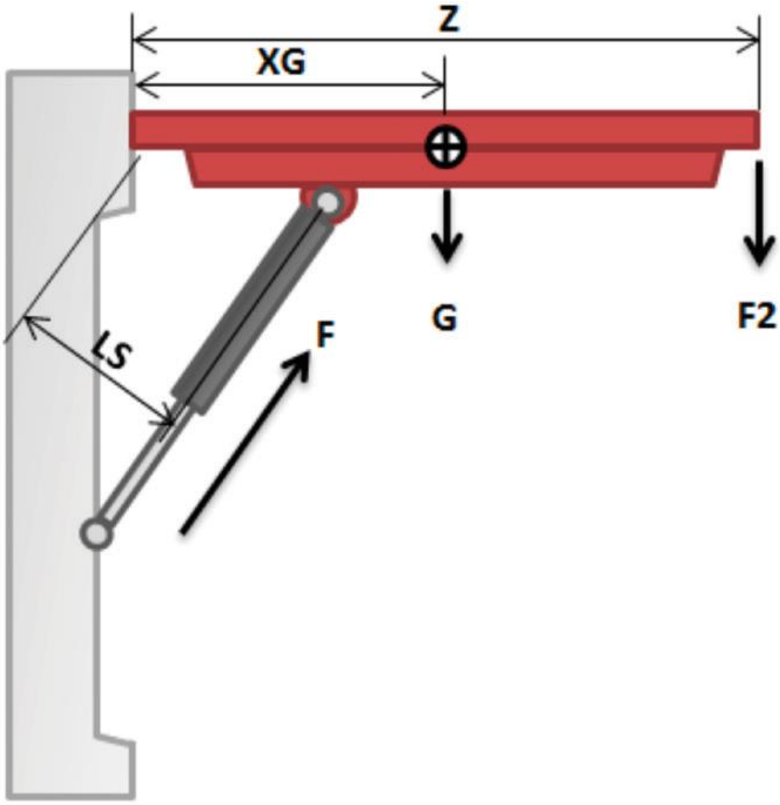

Figure Five: Simplified Gas Spring Application

Z = Length of the Lid (m)
XG = Centre of Gravity (m)
LS = Radius of Gas Spring Force (m)
F1 = Opening Force (N)
G = Mass of the Lid (N)
F2 = Closing Force (N)
n = Number of Gas Springs

Including a gas spring to the earlier example, the size of the gas spring required can be estimated using the following (simplified) formulas. These use the principle of the line of action of a force.

To calculate the forces involved, two terms in particular should be taken into consideration:

LS – Radius of the gas spring force (m), this is the distance between point A and the centre line of the gas spring.

n – Number of gas springs per application (normally two).

The formulas are used to give an estimate of the minimum required force for a specified mounting geometry.

They will not provide optimum mounting positions and a better solution may be found using specialist software.

2.04 Opening Force Calculation

The force required to hold the lid open (F1) can be calculated using the formula:

Gas Spring Force (F1) = Mass of lid x Centre of Gravity / Radius of Force x Number of Springs

$$F1 = \frac{G \times XG}{LS \times A}$$

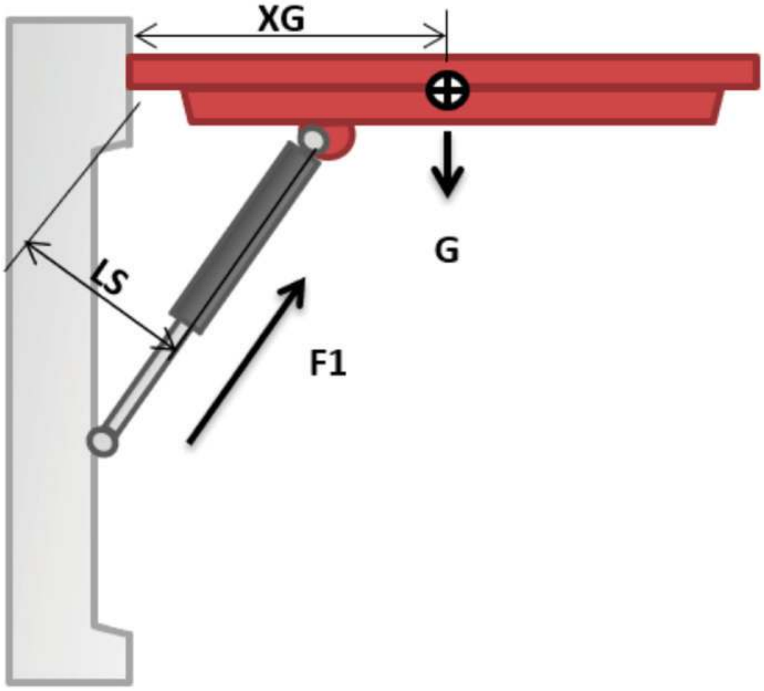

Figure Six: Gas Spring Force (F1)

2.05 Closing Force Calculation

Similarly, the force required to close the lid (F2) can be calculated using the formula:

Closing Force F2 = Number of Springs x Spring Force F1 x Radius of Force / Lid Length

$$F2 = \frac{A \times F1 \times LS}{Z}$$

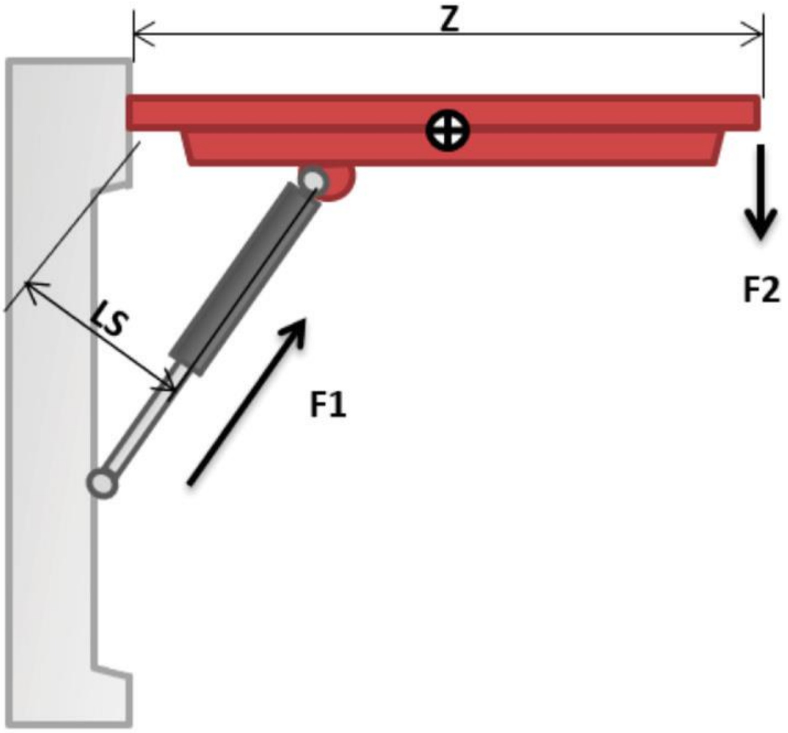

Figure Seven: Closing Force F2

2.06 Worked Example

Calculation of the opening and closing forces can be achieved using the values below:

Opening Force (F1)

F1 = (50 x 9.81) x 0.8 / 0.25 x 2
F1 = 784.8N

Closing Force (F2)

F2 = 2 x 784.8 x 0.25 / 1.2
F2 = 327N

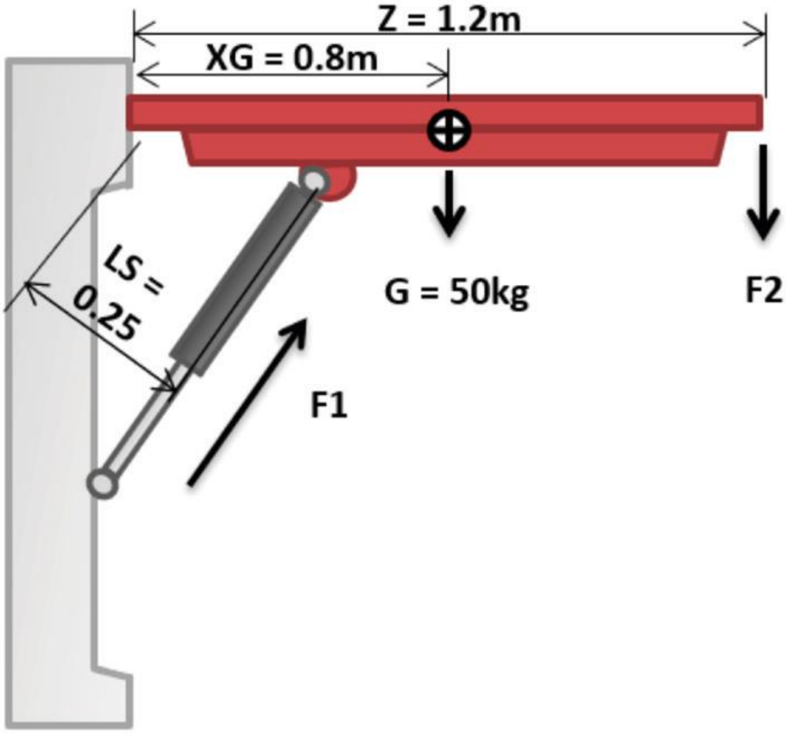

Figure Eight: Opening and Closing Forces

2.07 Changing the Moving Mounting Point

What happens to the forces when the gas spring mounting position is altered? Assuming the above example is the 'mid-point' and the radius of the gas spring force is moved either side of this by 50mm:

Moving the moving mounting point 50mm towards the hinge (i.e. LS becomes 0.2m):

F1 = 981N (+197N increase)
F2 = 327N (no change)

Moving it 50mm further away from the hinge (i.e. LS becomes 0.3m)

F1 = 523.2N (-261N decrease)
F2 = 523.2 N (+196N increase)

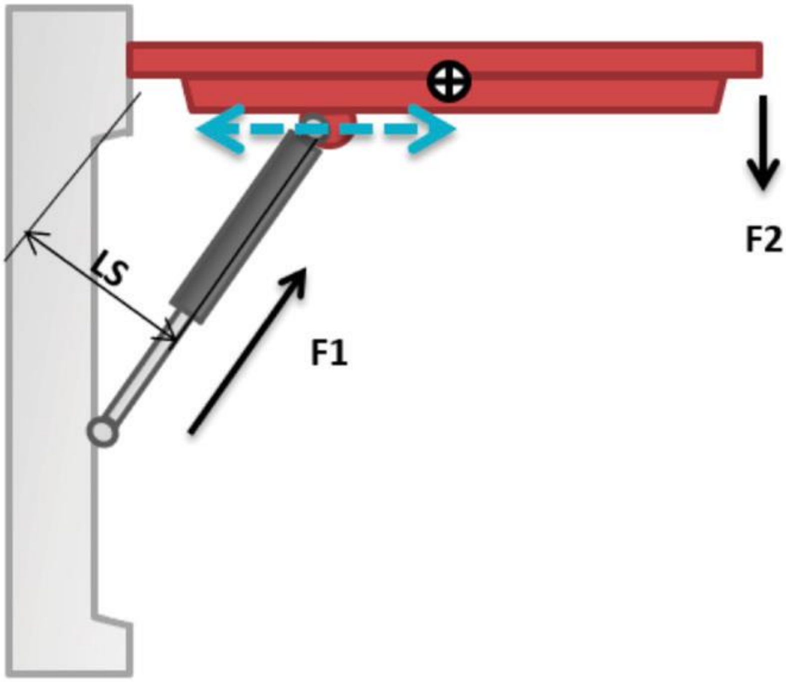

Figure Nine: Changing the Moving Mounting Point

The calculations show that the closer towards the hinge the moving mounting point gets, the higher the opening force required. Whereas, moving it further away the opening force reduces, but the closing force increases.

2.08 Changing the Centre of Gravity

If the centre of gravity moves nearer or further from the hinge, this will also affect the opening and closing forces.

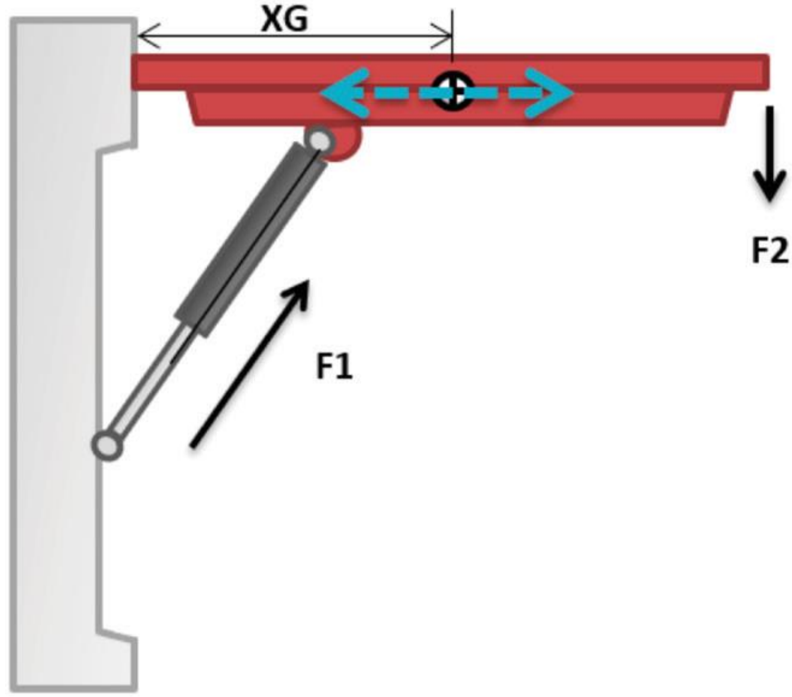

Figure Ten: Changing the Centre of Gravity

Moving the centre of gravity 0.2m towards the hinge (i.e. XG becomes 0.6m)

F1 = 588N (-196N decrease)
F2 = 245N (-82N decrease)

Moving it further away from the hinge (i.e. XG becomes 1.0m)

F1 = 981N (+197N increase)
F2 = 408N (+81N increase)

3.0 Gas Spring Mounting: Mounting Orientations

3.01 Mounting Orientations Overview

There are two differing mounting orientations available to the designer, these are ‘Push Up’ and ‘Flip Over’ mounting.

In both cases, the spring should always be mounted “rod down” when in the fully closed position to ensure proper lubrication of the seal package.

As a general rule, Camloc’s preferred mounting is the ‘Push Up’ design orientation.

3.02 Push Up Design

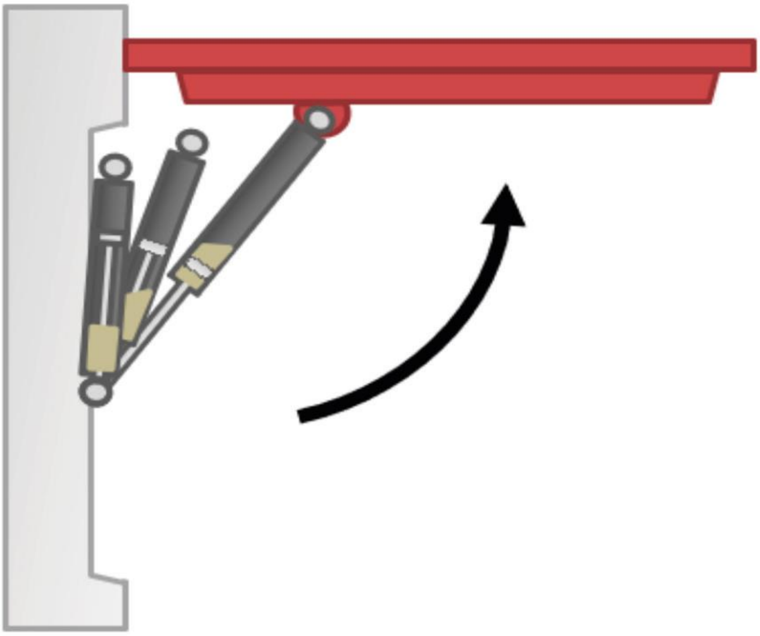

Figure Eleven: Push Up Design Example

Identification

This type of mounting can be identified by the fact that the end at the lowest point of the gas spring when closed, remains in its lowest position when fully open.

It can also be identified by the moving mounting point being located closer to the hinge than the fixed mounting point.

Rod-Orientation

Unless a means is utilised to lubricate the rod, then the spring should always be mounted rod down to ensure proper lubrication of the main seal.

The main drawback of this mounting position is the additional strength required in the application being lifted, particularly the hinges.This is due to increased cantilever of the lid from the gas spring support.

Damping

The major advantage with this type of mounting and rod down orientation is that it provides consistent damping at the end of the stroke. This is due to oil always being at the bottom of the tube; thus, damping will always occur at the same point in the lift cycle

3.03 Flip-Over Design

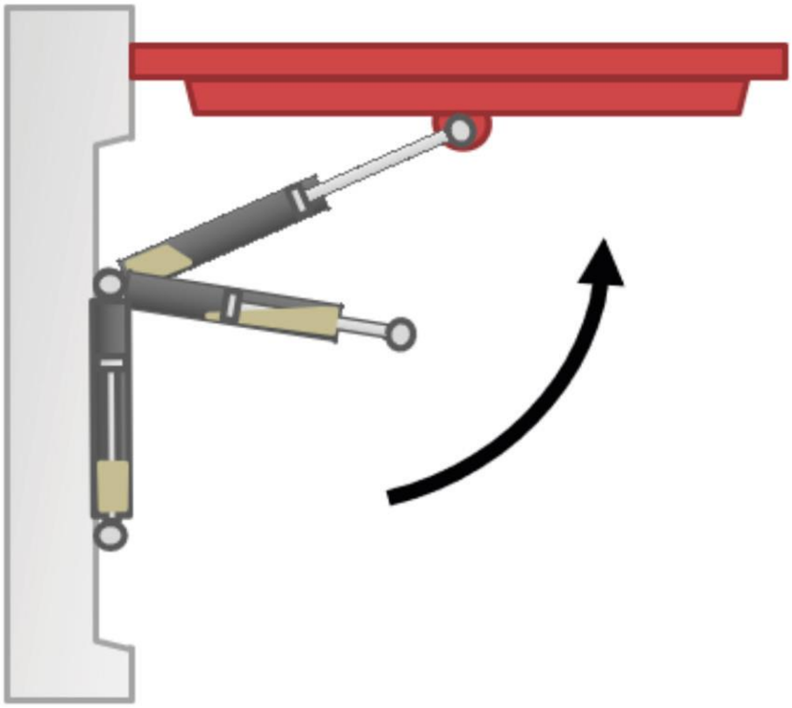

Figure Twelve: Flip-Over Design Example

Identification

This type of mounting can be identified by the end at the lowest point of the gas spring when closed, rotates to the highest point when fully open.

It can also be identified by the moving mounting point being located further away from the hinge than the fixed mounting point

Rod Orientation

Unless a means is utilised to lubricate the rod then the spring should always be mounted rod down to ensure proper lubrication of the main seal in the closed position.

Damping

The main drawback of this mounting position is the lack of damping control throughout the stroke.

At the start of the stroke, the oil is at the bottom around the main seal. As the spring passes the horizontal position the oil begins to run down the tube towards the tube end.

Along this point it will meet the piston moving up through the tube.
When the piston meets the oil, the extension of the spring will be slowed until the oil has passed through. At this point, the extension speed will increase and will reach the end of the stroke with no damping.

The advantage of this design is that it places less strain on the hinges than the push up design.

4.0 Mounting: Crossover, Self-Rise & Self-Close

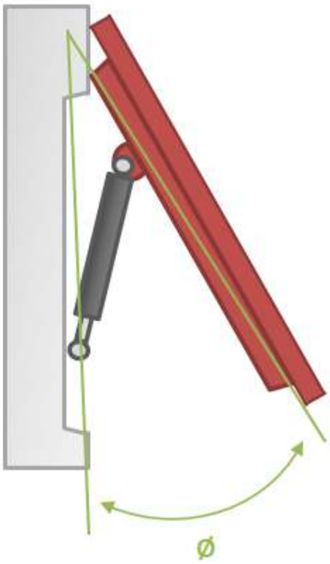

Figure Thirteen: Crossover Example

4.01 Crossover

Crossover is the point at which the gas spring takes over the lifting action (or gravity takes over to close).

This will normally be around 10° to 30° from fully closed.

In practice, this will vary by several degrees between opening and closing, due to factors such as friction of the internal components of the spring, hinges and end connectors.

4.02 Self-Rise & Self-Close

Self-rise is the angle at which the gas spring will lift the lid without any assistance from the operator. Similarly, self-close is the angle at which the lid will close without any assistance.

In most cases, it is undesirable to have the lid open without any operator input (referred to as “instant lift”). This behaviour is unpredictable to the operator and can allow the lid to open without any warning, in instances where the P1 force increases above nominal due to elevated ambient temperatures, for example.

4.03 Effects of Temperature on Handling

As discussed in "Technical Guide – Edition 1: Gas Spring Overview", temperature not only affects the output force of the gas spring, but also the handling forces.

The following graphs show how a spring behaves on an application at 20°C and then again at 65°C.

As is seen in figure fourteen, at 20°C crossover occurs at an opening angle of around 7°, with the handling forces being acceptable in both opening and closing.

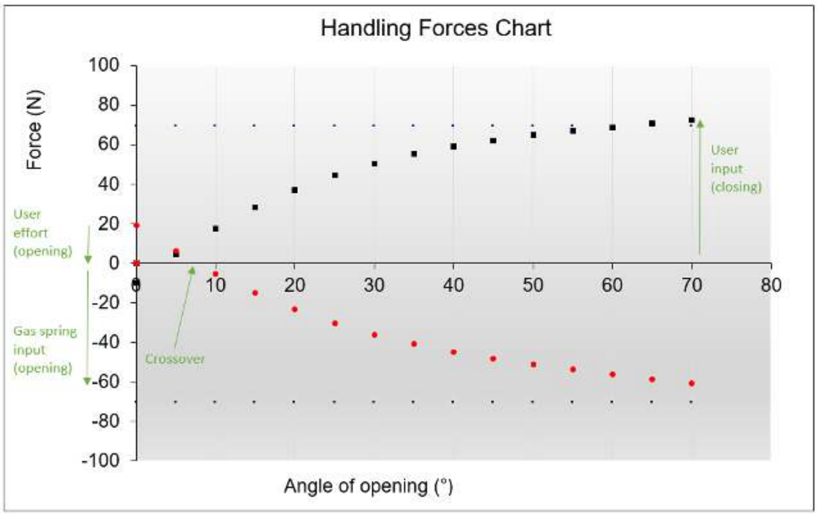

Figure Fourteen: Crossover at 20°C

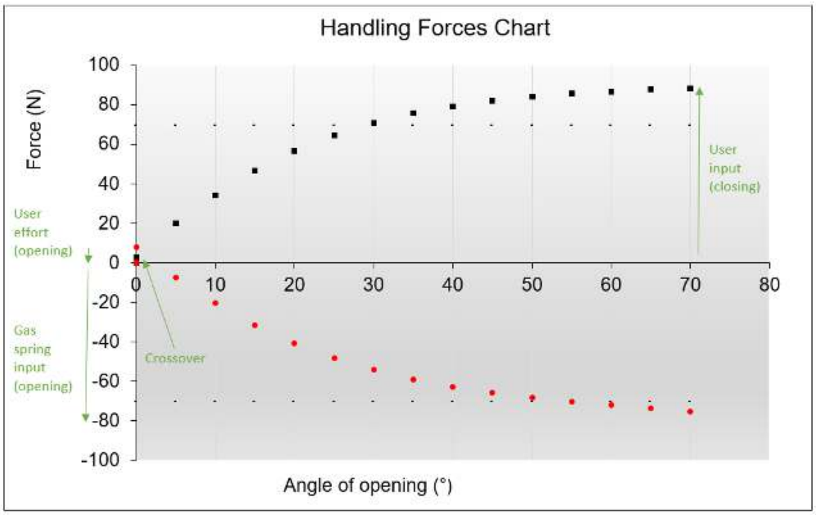

Figure Fifteen: Crossover at 65°C

However, when the ambient temperature increases to 65°C (for example, in the case of an engine cover application), lift will occur almost instantaneously.

This behaviour is unpredictable to the operator, in some cases proving dangerous.

It is also evident that handling effort to close the application increases.

For these reasons it is important that understanding of what the ambient and 'normal' operating temperatures of an application will be, so if necessary, a suitable compromise can be made in handling performance.

5.0 Mounting: Practical Application

5.1 Unused Stroke

When positioning a gas spring, Camloc's preference is to allow 10mm of unused stroke.

The reason for this is to allow for the stack up of manufacturing tolerances in the application, preventing the gas spring from bottoming out before the lid is fully closed.

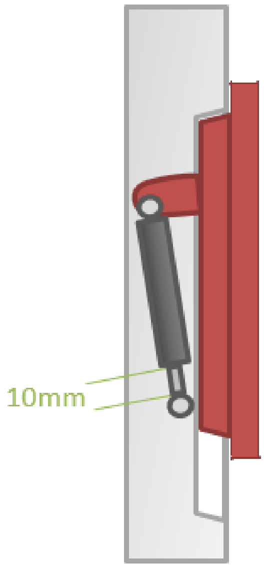

Figure Sixteen: 10mm of Unused Stroke Example

5.2 Preventing Instant Lift

Positioning the moving mounting point so that it creates an over-centre condition when the lid is closed will aid in reducing instant opening of the lid.

Figure seventeen highlights two examples; one of a spring position which will lead to instant lift (on the left) and one which is over-centre and will reduce the potential of instant lift (on the right).

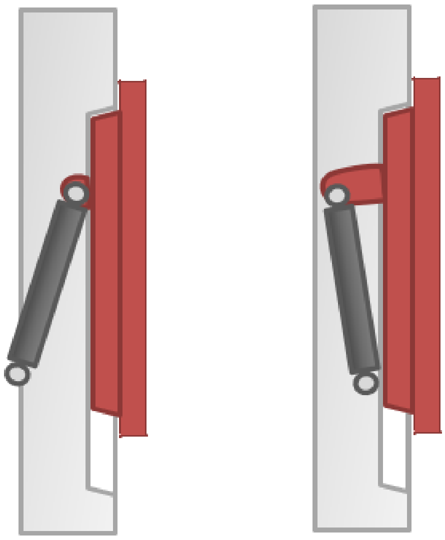

Figure Seventeen: Preventing Instant Lift Spring Position Example

5.3 Reducing Handling Forces

To help reduce handling forces, the following strategies can be used:

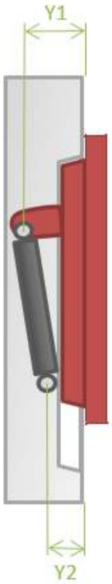

Figure Eighteen: Reducing Handling Forces Example

- Move the mounting point Y1 closer towards the pivot by reducing the stroke.
- Consider whether the opening angle could be reduced.
- Move fixed mounting point Y2 to a more suitable location.

6.0 Mounting: Dampers

6.01 Mounting: Dampers – Overview

Should dampers be mounted rod up or rod down? The answer to this is dependent on whether the damper is a compression or extension damper; each having specific orientations and should be mounted as follow:

Figure Nineteen: Extension Damper (Left) & Compression Damper (Right)

6.02 Extension Dampers

Extension dampers should be mounted 'rod down' to ensure consistent damping throughout the stroke.

Mounting the damper 'rod up' will result in little or no damping.

6.03 Compression Dampers

Compression dampers should be mounted 'rod up' to ensure consistent damping throughout the stroke.

Mounting the damper 'rod down' will result in little to no damping.

Lubrication of the main seal is not a problem due to the high volume of oil used in the damper.

More than just a manufacturer of Gas Springs and Dampers

Camloc Motion Control Ltd
15 New Star Road
Leicester
LE4 9JD

Tel: +44 (0)116 274 3600
Email: info@camloc.com

Camloc Motion Control Ltd, design and manufacture engineered gas spring and damper solutions to the latest ISO 9001 industry standards.

It works closely with customers at every stage. From initial design through to product testing, manufacture and distribution, to ensure its products deliver precise movement control solutions to suit individual requirements.

Continuous investment in staff and the latest hardware keeps it at the forefront of the industry, ensuring it continuously adopts the latest manufacturing processes and successfully problem solve for its customers.

Utilising nearly 30 years of industry experience, Camloc delivers high quality products that cover a wide range of industry sectors.