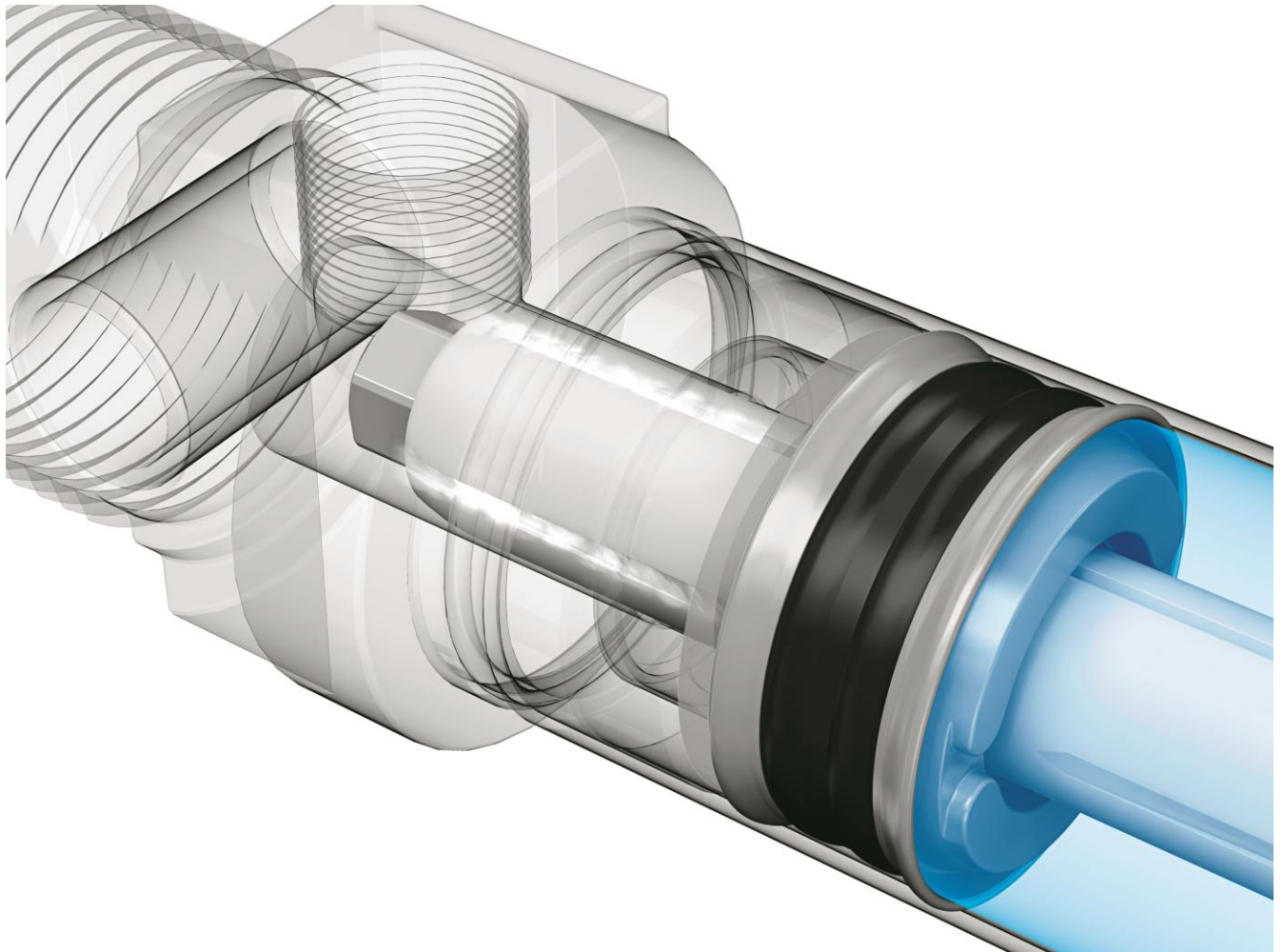


## White paper

# More productivity with optimally cushioned pneumatic cylinders

**FESTO**



**With the right end-position cushioning, you can significantly increase the efficiency of your entire pneumatic system.**

**When used to its full effect, it can improve cycle times and even reduce the size of the components used.**

**And all this for the simple reason that good end-position cushioning decreases the impact forces generated by changing loads and extreme dynamic stress – factors that play a crucial role in defining the travel time and speed of pneumatic cylinders.**

**This white paper has information on:**

- **The benefits of end-position cushioning systems** in pneumatic drives
- **The latest end-position cushioning technology** for pneumatic cylinders
- **Different cushioning solutions – an overview**
- **Advantages and disadvantages of cushioning technology** – overview table

## Benefits of end-position cushioning systems

One of the fundamental aims of today's manufacturing industry is to increase productivity while reducing costs. This means that cycle times in production have to be as fast as possible. As a result, the travel speeds and energy in the end positions of pneumatic drives are very high. End-position cushioning is therefore needed to minimise the impact of the piston and to reduce wear and shock. The latter is crucial in ensuring that as few rejects as possible are caused by shock.

## The latest technology

There are various ways of cushioning pneumatic drives. They differ greatly in their mode of operation and performance. These are some of the important types of cushioning:

- Mechanical and elastic cushioning. Operational principle: coil springs or elastic buffer materials cushion the impact at the end position.
- Pneumatic and servopneumatic cushioning. Operational principle: braking effect generated by air compression or a controlled counter-current of air.
- Hydraulic cushioning systems. Operational principle: braking effect generated using viscous fluids such as oil.

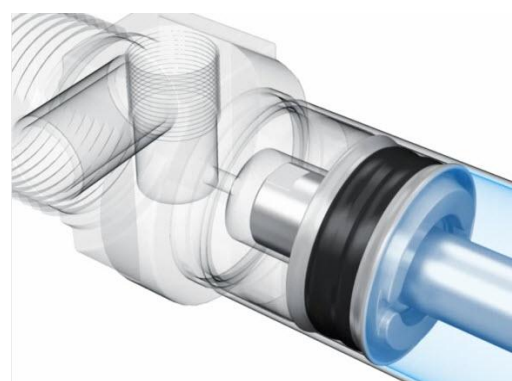
Elastomer buffers and pneumatic cushioning types are well established particularly in automation technology and in plant and machine building because of their price and cushioning performance. They are the types most commonly used in practice. In order to ensure that the cushioning performance is as effective as possible, it is important to select the most suitable type of cushioning for the application in question. This white paper focuses on the best performing and most cost-effective end-position cushioning technologies for pneumatic cylinders:

- Elastic buffer cushioning P
- Adjustable pneumatic end-position cushioning PPV
- Self-adjusting pneumatic end-position cushioning PPS
- Combination of adjustable and self-adjusting pneumatic end-position cushioning PP1
- Self-adjusting pneumatic end-position cushioning PPP as special design
- Servopneumatic end-position cushioning Soft Stop

## Elastic buffer cushioning

The term "elastic buffer cushioning" (P-cushioning) refers to the elastic cushioning rings that are integrated either as part of the cylinder piston or in the end position. They are made of elastomer.

Elastic cushioning elements reduce the impact forces and the volume of the impact made when the piston reaches the cylinder end position. However, only a small amount of kinetic energy can be absorbed. As such, P-cushioning is particularly suited to slow operating speeds, low loads and applications with short working strokes.



Inside view of a cylinder with elastomer P-cushioning

As the hardness of elastomer materials differs, the performance of P-cushioning varies depending on the manufacturer or the type of drive.

Elastic P-cushioning is a simple yet effective standard solution for end-position cushioning in pneumatic cylinders.

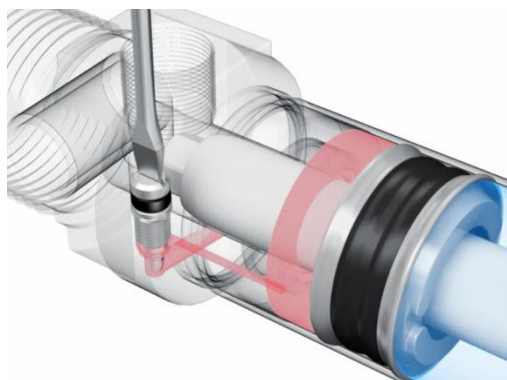


Example of elastic buffer cushioning: the short-stroke cylinder ADN from Festo with elastomer P-cushioning

More: [www.festo.com/catalogue/adn](http://www.festo.com/catalogue/adn)

### Adjustable pneumatic cushioning PPV

When the dynamic forces and loads are larger, additional cushioning is required in order to prevent the drive and system from being overloaded. Machine and plant builders therefore often use the adjustable pneumatic cushioning system PPV.



Inside view of a cylinder with PPV cushioning. Adjusting screws and air compression are shown in red.

The way it works is as follows: with each working stroke, a mechanism traps a specific volume of air

in the end position. This air is compressed to generate a braking effect. The exhaust air flow can be controlled using an adjusting screw, allowing manual adjustment of the braking effect.

The following factors affect the cushioning characteristics and need to be taken into account when manually adjusting PPV end-position cushioning systems: the moving mass, the piston speed, the acceleration of the piston, the working pressure and the friction in the cylinder.

If adjustable end-position cushioning systems are adjusted by experienced personnel in line with the application at hand, optimum cushioning can even be achieved for applications with very high energy absorption, i.e. combinations of high loads and speeds. If the system is adjusted poorly or not at all, the cushioning quality is still better than that of P-cushioning, even though it is far below the potential optimum level. It may be necessary to readjust the cushioning after a certain number of cycles in order to maintain optimum cushioning performance in the long term.

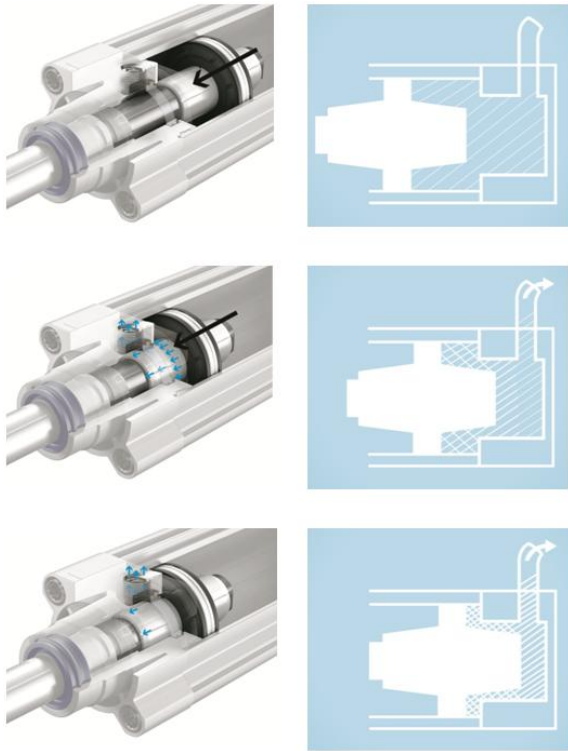


Example of an adjustable end-position cushioning system: integrated into the standard cylinder DSBC-PPV from Festo with PPV cushioning

More: [www.festo.com/dsbc](http://www.festo.com/dsbc)

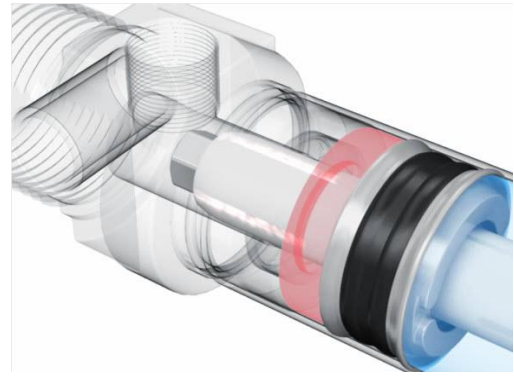
### Self-adjusting pneumatic cushioning PPS

Self-adjusting cushioning PPS for pneumatic cylinders also compresses air to generate a braking effect. Unlike PPV cushioning, though, the exhaust air flow control of compressed air is altered depending on the stroke.



Inside view of a pneumatic cylinder with self-adjusting end-position cushioning PPS moving into the piston end position. Left: the black arrows show the direction of movement of the piston; the blue arrows show the movement of air in the cylinder. Right: air compression and exhaust direction (white hatching and arrows)

The patented operational principle: the exhaust air escapes through the slots in the cushioning boss. The cross-section of this exhaust method is altered by the cushioning stroke. This allows the end-position cushioning PPS to adjust automatically to the different energy levels generated by changing loads and speeds. PPS cushioning even reacts to changes in parameters such as friction and working pressure, and ensures optimum cushioning without the need for manual adjustments. PPS automatically minimises the effect that acceleration forces and shock have on machine components and workpieces. As there is no need for manual adjustment, PPS saves the system operator valuable time – and thus costs – during installation and maintenance of the drives. A positive side-effect of this is the increased process reliability and protection against faulty settings.



Inside view of a cylinder with self-adjusting cushioning PPS: venting slots replace the adjusting screw in the cushioning boss.

### Advantages of PPS cushioning

Compared to PPV cushioning that has been adjusted poorly or not at all, self-adjusting cushioning PPS always provides better quality cushioning. However, its performance reaches its limits when the energy absorption (extreme combinations of speeds and loads) is very high. In such cases, the cushioning performance is not as good as that of well-adjusted end-position cushioning PPV. However, the biggest advantage that PPS has over other types of end-position cushioning technology is that it provides optimum cushioning results for most speed/load combinations (approx. 80% of all industrial applications). This makes it a very good solution for a wide range of applications in all industrial sectors. As PPS is easy to clean and has no dirt traps (Clean Design), it is becoming increasingly popular in the food industry.



Self-adjusting pneumatic cushioning: the standard cylinder DSBC-PPS from Festo adjusts itself automatically, so it doesn't need an adjusting screw.

More: [www.festo.com/pps](http://www.festo.com/pps)

### **PP1 – a combination of PPS and PPV (Special design)**

PP1 is always recommended in situations that demand extremely fast travel. This design combines the features of the adjustable pneumatic cushioning PPV with the self-adjusting pneumatic cushioning PPS, and has an additional adjustable bypass for PPS to improve the cushioning performance. When the bypass is closed, this combination of technologies thus acts as a simple pneumatic cushioning system PPS. One of the great advantages of this hybrid design over PPV cushioning is that it is much easier to adjust manually. In addition, PP1 does not usually require readjustment. This end-position cushioning system is a relatively new development with great potential. PP1 is currently only available as a special design.

### **Self-adjusting pneumatic cushioning PPP (Special design)**

End-position cushioning PPP is a pressure-sensitive pneumatic cushioning system that is used in very special applications. When conditions are extremely demanding and the above end-position cushioning systems are not powerful enough, PPP can be used to achieve very good cushioning. When the load/speed combination changes or there are pressure fluctuations in the working air, it ensures optimum end-position cushioning. Like the other pneumatic end-position cushioning systems, PPP generates its braking effect by compressing a trapped volume of air. It automatically adapts to changes in load and offers a greater power spectrum than the PPV.

The patented operational principle is as follows: the flow rate required to dissipate the energy is regulated automatically by a specially shaped spring-ball system. The cross-section of the cushioning is adjusted depending on the buffer pressure.

As it is a special design, PPP is adapted by the manufacturer to suit the individual customer's application. This makes it a costly end-position cushioning system. Machine and plant builders

also need to plan accordingly for the development time when designing their projects.

### **Servopneumatic cushioning Soft Stop**

Servopneumatic cushioning systems can regulate the cushioning process directly. Using a displacement encoder, a proportional valve and an electronic end-position controller, the approach to the end positions of the pneumatic cylinder is controlled electronically. A counter-current of air is channelled in at specific, predefined positions to brake the piston. The end-position controller regulates the air flow rate through the proportional valve. This method produces excellent cushioning characteristics. The end-position controller automatically compensates for fluctuations in the supply air and dynamic loads. Servopneumatic end-position cushioning is very effective, but the number of additional components required makes it expensive. It is mainly suitable for applications with very high cycle rates, strokes of more than 300 mm and loads greater than 10 kg.

## Choosing the right end-position cushioning technology

The search for the right end-position cushioning technology for a machine or system is often difficult – and sometimes never even begun. But it is worth the effort.

There are a great many factors that play a role. Moving loads, travel speeds, the combination of the two, cylinder size and length and horizontal and vertical alignment are all important. On top of this, the decision is made even more difficult by reciprocal dependencies.

It is therefore not just a question of finding the right technological solution, but also of taking into account the requirements of the individual application. The selected end-position cushioning technology should come as close as possible to fulfilling the requirements of the application. Ultimately, the application defines the solution. There is no "one-size-fits-all" solution.

In spite of this often highly complex problem, it is still possible to provide a general recommendation for an end-position cushioning solution for many industrial applications. The scope of the self-adjusting end-position cushioning PPS reliably meets the needs of most industrial applications. What's more, compared to alternative end-position cushioning methods it provides financial, planning and industry-specific benefits, such as Clean Design for the food industry.

Each type of cushioning technology has advantages and disadvantages that need to be weighed up. There is a suitable solution for both standard applications and special requirements. The latter may require a specialist end-position cushioning system, which would necessitate a certain amount of development work. However, searching for the right solution may be easier than it seems – thanks to the self-adjusting cushioning PPS, which combines a number of advantages.

The PPS Check is now a quick and easy way to provide clarity. From now on you can choose the right cushioning for any application on your smartphone using PPS Check.



Finding PPS Check is easy:  
Simply enter [www.festo.com/app](http://www.festo.com/app) in your smartphone's browser, then click **PPS Check**.

The table on the following pages should help you to choose the right technology. It provides an overview of the advantages and disadvantages of the types of cushioning technology described in this paper. As optimum end-position cushioning depends on a number of factors, the recommended applications in the right-hand column have been kept deliberately vague. To ensure that the choice of end-position cushioning technology for individual and special applications is the right one, it is best to obtain professional advice. This calls for a partner with experience in automation technology, professional technical expertise and a thorough understanding of the processes and preferences of plant and machine builders. This is the only way to achieve greater efficiency and maximum productivity.

Author:

Michael Rau  
Product Development Standard Drives  
Festo AG & Co. KG

Holger Buisson  
Product Management Standard Drives  
Festo AG & Co. KG

Technical consultation  
Tel: +49 (0)711 347-3000  
Fax: +49 (0)711 347-2190  
Email: [technikservice@de.festo.com](mailto:technikservice@de.festo.com)

Technology	Advantages	Disadvantages	Applications
<b>P-cushioning: elastic buffer cushioning</b>	<ul style="list-style-type: none"> <li>• Low costs</li> <li>• Available from all manufacturers (standard solution)</li> </ul>	<ul style="list-style-type: none"> <li>• Moderate cushioning characteristics</li> <li>• High operating noise level</li> </ul>	<ul style="list-style-type: none"> <li>• Suitable for small loads and low speeds (low impact forces)</li> </ul>
<b>PPV: adjustable pneumatic cushioning</b>	<ul style="list-style-type: none"> <li>• Optimum cushioning for many applications</li> <li>• Very high energy absorption</li> <li>• Low operating noise level</li> <li>• Available from many manufacturers (standard solution)</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in load profile require manual adjustment (pre-adjustment and readjustment)</li> <li>• Additional maintenance costs, staff time and effort for adjustment</li> <li>• Risk of malfunctions caused by incorrect adjustment/manipulation</li> </ul>	<ul style="list-style-type: none"> <li>• Suitable for many combinations of loads and speeds</li> </ul>
<b>PPS: Self-adjusting pneumatic cushioning PPS</b>	<ul style="list-style-type: none"> <li>• Consistently high quality of cushioning in the end position</li> <li>• Automatic adaptation to changes in load</li> <li>• Lower price than PPV</li> <li>• Low operating noise level</li> <li>• Saves time and costs during installation, operation and maintenance</li> <li>• Tamper-proof and protected against malfunction</li> <li>• Synchronous use of multiple cylinders is very easy Easy to clean</li> </ul>	<ul style="list-style-type: none"> <li>• Not designed for special applications such as those with very long strokes and very high loads (high impact forces)</li> </ul>	<ul style="list-style-type: none"> <li>• Suitable for most load/travel speed combinations (medium impact forces, approx. 80% of all industrial applications)</li> <li>• Advantageous for synchronous use of cylinders</li> <li>• Replaces unadjusted and poorly adjusted end-position cushioning systems PPV without any problems and provides better cushioning</li> <li>• Useful for applications requiring intensive cleaning, e.g. in the food industry (Clean Design)</li> </ul>

Technology	Advantages	Disadvantages	Applications
<b>PP1: a combination of PPS and PPV</b>	<ul style="list-style-type: none"> <li>• Extends the performance range of PPS with that of PPV</li> <li>• Cushioning automatically adjusts within certain limits</li> <li>• Easy to adjust</li> <li>• Readjustment usually not necessary</li> <li>• Increased cushioning performance with opened bypass</li> </ul>	<ul style="list-style-type: none"> <li>• No larger range for self-adjustment</li> <li>• Adjustment required for maximum performance</li> <li>• Only available as special design</li> </ul>	<ul style="list-style-type: none"> <li>• Suitable for special industrial applications with demanding end-position cushioning requirements</li> </ul>
<b>PPP: self-adjusting special design</b>	<ul style="list-style-type: none"> <li>• Optimum cushioning for high loads and speeds</li> <li>• Automatically adapts to changes in load</li> <li>• High dynamic and system stability</li> <li>• Very stable when dealing with fluctuations in supply pressure</li> </ul>	<ul style="list-style-type: none"> <li>• Costly</li> <li>• Long development time</li> <li>• Only available as special design</li> </ul>	<ul style="list-style-type: none"> <li>• Suitable for very extreme conditions with special requirements in terms of moving load and speed for the drive</li> </ul>
<b>Soft Stop: Servopneumatic cushioning</b>	<ul style="list-style-type: none"> <li>• Optimum cushioning thanks to adjustability</li> <li>• Self-adjustment with adaptive controller</li> <li>• Two user-definable mid-positions in addition to the end positions</li> <li>• Easy selection of travel times and components thanks to selection software</li> <li>• Actual position and detailed system diagnostics via fieldbus</li> <li>• Rapid availability</li> </ul>	<ul style="list-style-type: none"> <li>• Costly</li> <li>• More hardware requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Suitable for applications with high cycle rates, loads greater than 10 kg and strokes of more than 300 mm</li> </ul>

**Table: Overview of the different end-position cushioning technologies**