

White Paper: Considerations for choosing pneumatic guided drives and slides

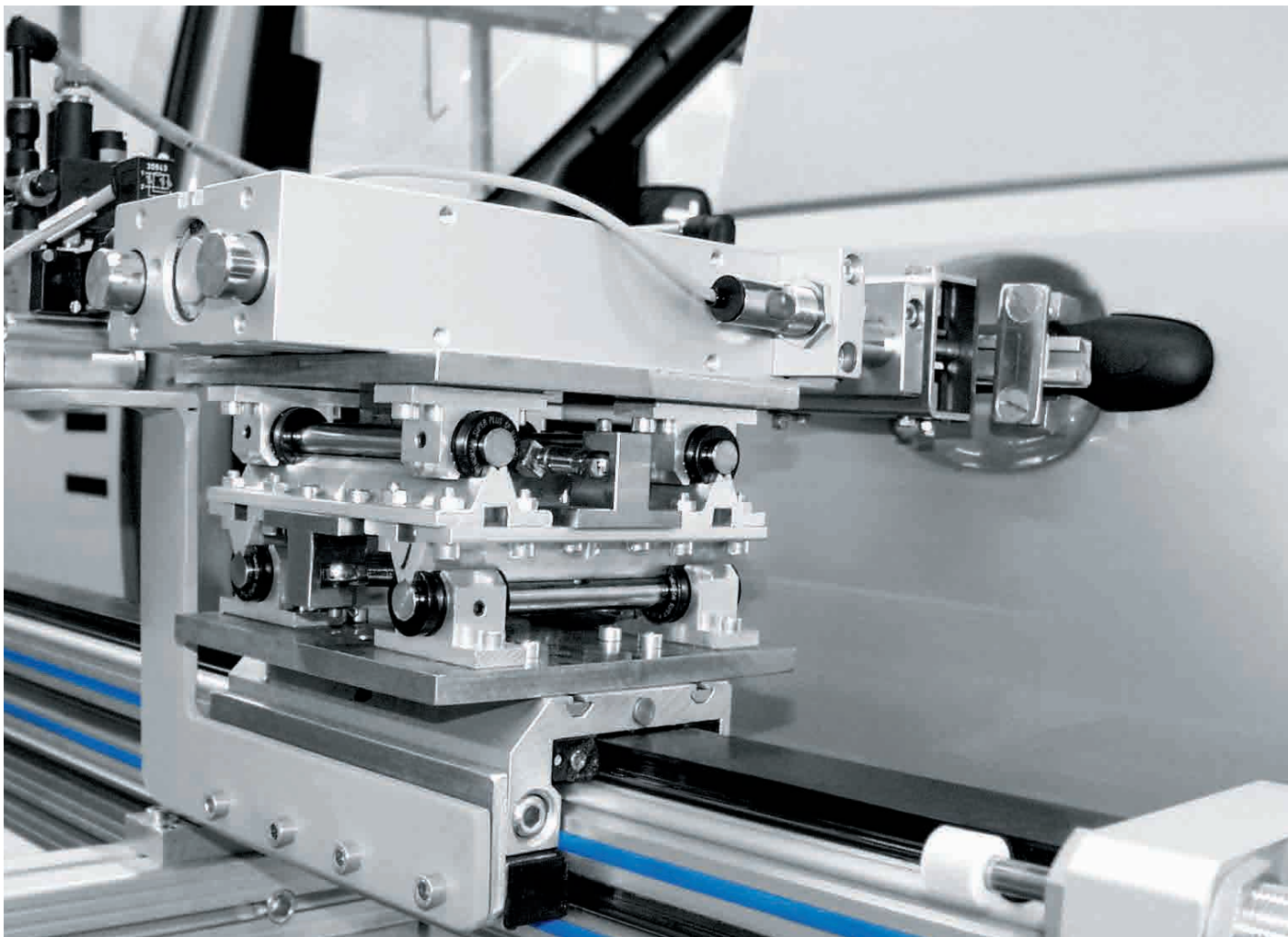


This whitepaper includes information on:

- How pneumatic guided drives and slides work
- Pneumatic or electric? Where pneumatic excels
- Guided drive or slide? Which to choose
- Customization possibilities: bearings, cushioning and more
- Models for special situations
- Sizing the drive or slide for your application

Executive Summary

Pneumatic guided drives and slides are the work horses of industrial automation. They are a well-proven concept, adaptable to a growing range of applications where the particular benefits of adding guidance result in superior performance. They are a cost-effective choice as well, with many variants and configuration options to assure great reliability and longevity.



Introduction: The guiding principle

Pneumatic guided drives maintain complete stability where a standard drive might not. Pneumatic guided slides provide greater stability and precision where a standard drive might not, which is critical in many pick-and-place functions. For both styles of actuator, adding stabilization for the piston rod tends to ensure better performance and a longer service life than non-stabilized alternatives. The market for guided drives and slides is growing as more engineers become aware that it is easier and more convenient to buy a single product which combines the benefits of linear movement and guiding than buying both functions separately (Figure 1).

➤ Stability and having to purchase just one component are enough reasons to decide in favour of an integrated, guided solution.

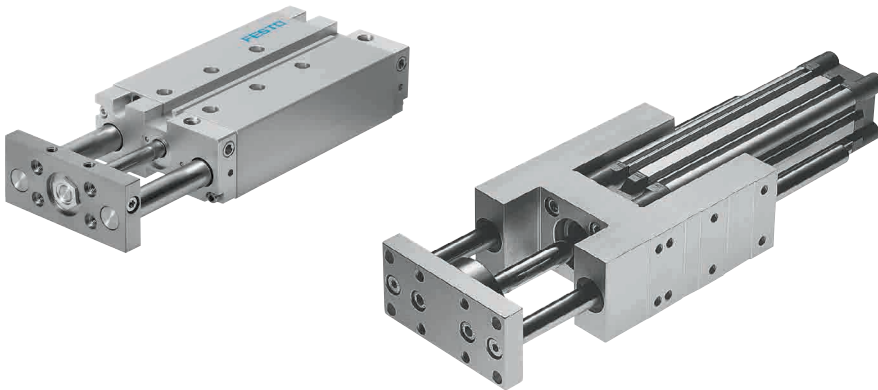


Figure 1. A guided drive like the Festo DFM (left) includes integrated guide rods and requires no assembly while a guide unit like Festo's FENG plus a standard cylinder (right) requires assembly.

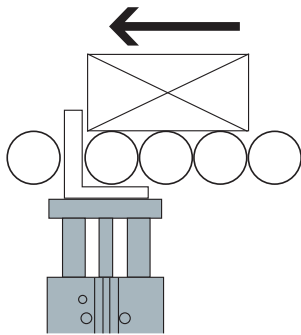
Guided drives for stability

In a standard pneumatic drive, the piston rod creates linear motion. It can freely rotate as it extends and retracts. In many industrial applications, that rotation is immaterial, but if the function requires stability – such as maintaining a stamping tool perfectly parallel to the item being stamped – it's undesirable. Additionally, where the piston rod is applying force to an object, the resistance it meets can create a lateral force or torque against the entire actuator assembly. If, for example, the actuator is positioning a circular saw cutting through wood, the external forces subjected to the actuator with the piston rod extended can produce deflection and result in an imperfect cut causing excessive wear on the saw and cylinder.

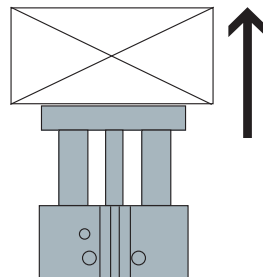
➤ Guided cylinders are extremely stable as the guide rods are supported by a series of bearings and connected using a transverse yoke.

Pneumatic guided drives have just one piston, with the integrity of the piston ensured by two integrated guide rods. These guide rods are typically running on sets of bushings or ball bearings to provide stability. The guide rods and piston attach to the yoke assembly that holds any tooling, preventing the piston from twisting or turning if lateral force is applied, assuring excellent operational stability. These drives are found in widespread use in applications involving lifting, pressing, pulling, pushing, clamping, stopping, restraining, holding, cutting, separating – and much more (Figure 2). They come in many sizes and variants, can hold almost any tooling, deliver stroke lengths up to 400 mm, are extremely robust and can apply great force where required.

Stopping



Lifting



Pushing

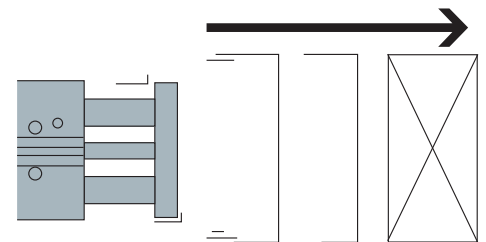


Figure 2. Examples of functions performed by guided drives.

Guided slides for precision

Guided slides excel in tasks where great precision and repeatability are essential: such as in assembling electronics or small auto parts, in food and beverage or in dispensing applications in other process sectors. Guided slides are typically constructed with single or dual piston rods and a guiding rail running on a series of precision ball bearings in the slide housing to achieve a precise movement and great repeatable accuracy, even when exposed to lateral loads and torque (Figure 3). Guided slides provide linear motion, whether fixed horizontally or vertically. They make excellent tools attached to a gantry, such as a dual axis (X, Z) and are combinable in pick-and-place or piggyback configurations, often without adapters. In duplex applications, a compact mini-slide with a small attached mechanical gripper or a vacuum cup to perform the task typically can deliver a repetition accuracy of 0.01 mm and linearity and parallelism within the 1/100 mm range over millions of cycles. Guided slides come in a large range of sizes with multiple mounting options and many damping choices to assure optimum cycle times with minimum vibration to the machine. In apples to apples comparisons – with identical piston bore size and stroke length – they are the largest and heaviest of the options with built-in piston guidance, a function of the wide flat guide they use to deliver highly precise motion.

➤ Guided slides are extremely precise and have excellent repeat accuracy – for a period of many years.

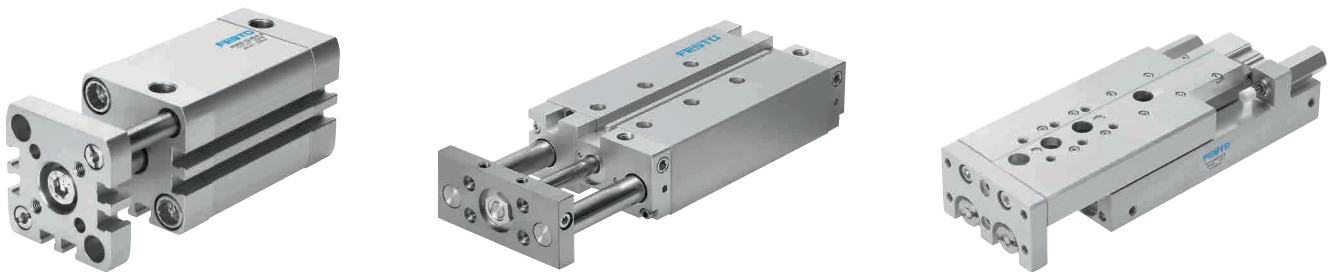


Figure 3. From left to right, a non-rotating drive, guided drive and guided slide.

Assuming the same bore diameter (20 mm) for the piston rod and the same stroke length (50 mm), the guided slide has the largest profile (Figure 4). The guided drive fits in between.

➤ Increased stability and increased precision need space, usually lengthwise.

Size Comparison – 20 mm bore/ 50 mm stroke

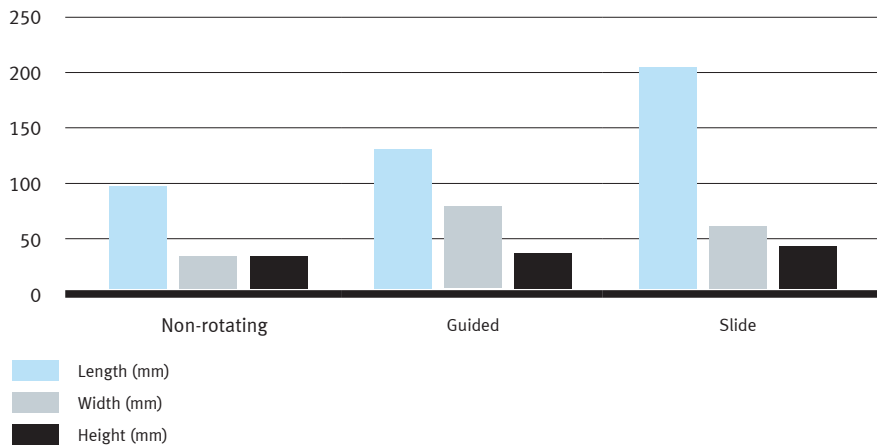


Figure 4: Size comparison.

Again, using base models of a non-rotating cylinder, guided drive and guided slide with the same piston bore size (20 mm) and stroke length (50 mm) and an identical extended force of 188N as the basis of comparison (Figure 5), the non-rotating drive has a force to weight ratio of 65%, the guided drive 16% and the guided slide 15%. Adding guidance adds more weight relative to the non-rotating drive to provide added stability.

Weight to Linear Force Comparison – 20 mm bore/ 50 mm stroke

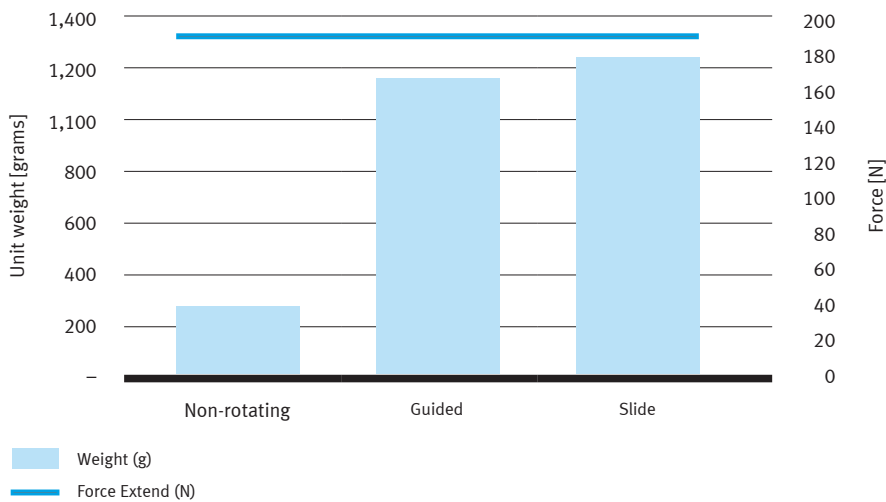


Figure 5: Weight to linear force comparison.

Limitations of alternatives to guided actuators

Non-rotating cylinders and combinations of external guide units and standard cylinders are often considered as alternatives to pneumatic guided drives and slides. In some circumstances, they are suitable, but not in most. While non-rotating drives and cylinders with non-rotating piston rods are less expensive, guided drives and slides are more robust and precise – built to handle more significant lateral loads and torque. In the performance of the same function, per Figure 6, the non-rotating drive will have the greatest amount of deflection from bearing clearance and lateral force.

➤ Cylinders with protection against rotation are more cost-effective, but have higher deflections in the advanced end position.

Type	Piston diameter [mm]	Piston stroke [mm]	Deflection in total [mm]*
Non-rotating cylinder	20	50	0.15
Guided drive	20	50	0.12
Guided slide	20	50	0.05

*Total deflection (f) is the sum of deflections from bearing clearance (f_1) and lateral force (f_2).

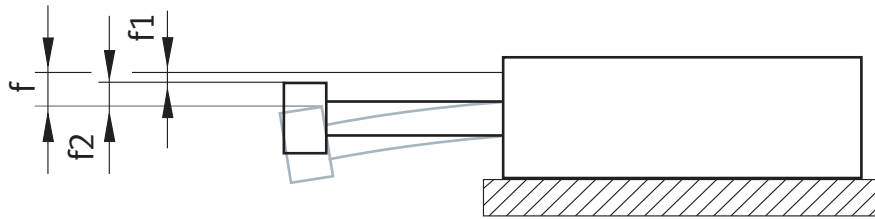


Figure 6: Deflection.

The external guide unit/standard cylinder combination can be configured with a wider range of cylinders than guided drives, but is usually more expensive. Comprised of two separate components, it requires additional engineering and assembly. In pick-and-place applications in electronics, a compact unguided cylinder with its free rotating piston might be considered, but won't assure the consistent positioning and orientation of chips the way a guided mini-slide can.

Pneumatic versus electrical guiding

Pneumatic and electric guided drives and slides can perform similar missions but have different strengths. With a properly scaled, well-maintained compressed air system, pneumatic drives will deliver higher force density and speed for a significantly lower installed and operating cost, and a longer service life. Looking strictly at the actuator, comparing similar pneumatic and electric mini-slides (for example, Festo's DGSL and EGSL respectively), the pneumatic version has a more compact length and faster positioning time, while the electric offers gentler stopping and starting, a programmable drive profile and constant and precise speeds. As a general rule, pneumatic drives and slides take up less space. Today, new energy management and compressed air diagnostic technologies can optimize compressed air usage and reduce unscheduled maintenance downtime, reinforcing a positive economic case for pneumatic actuators.

➤ Pneumatic versus electric: pneumatic force and speed or a programmable drive profile and precise, electric speed control?

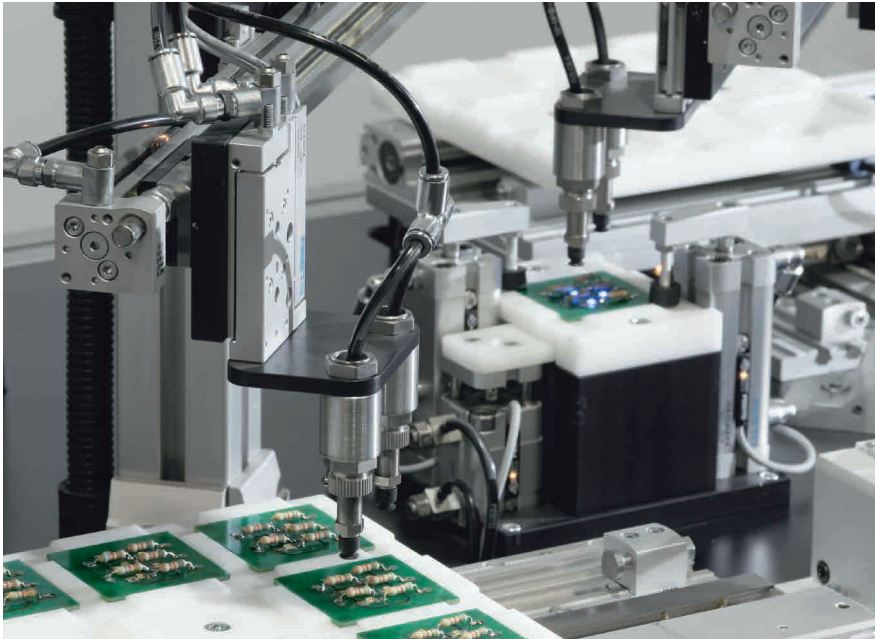


Figure 7: Precise placement using mini-slides

Value considerations in drive selection

Relative efficiency is a prime consideration in making the right engineering choice among potentially suitable pneumatic drives with guiding.

The example in Figure 7 shows the relative price comparison of a non-rotating cylinder, guided drive and guided slide – all base models with the same piston diameter (20 mm) and stroke length (50 mm) – and the percentage of guide utilization capacity when subjected to identical offset loading conditions. The non-rotating cylinder for the purpose of this example is at 100% guide utilization. It is at its limit and in this example, would be a sub-optimal choice in terms of its ability to handle offset loading. The guided slide is the most expensive of the three, and with just 12% guide utilization over-performs for this application. The guided drive achieves 54% guide utilization and while it's about two and a half times the cost of the non-rotating cylinder, it provides the best cost-performance solution of the three options.

Decisive factor in selection:
definition of the requirements
for precision in relation to the
moved load

Relative Price % vs Guide Utilization Comparison – by Type

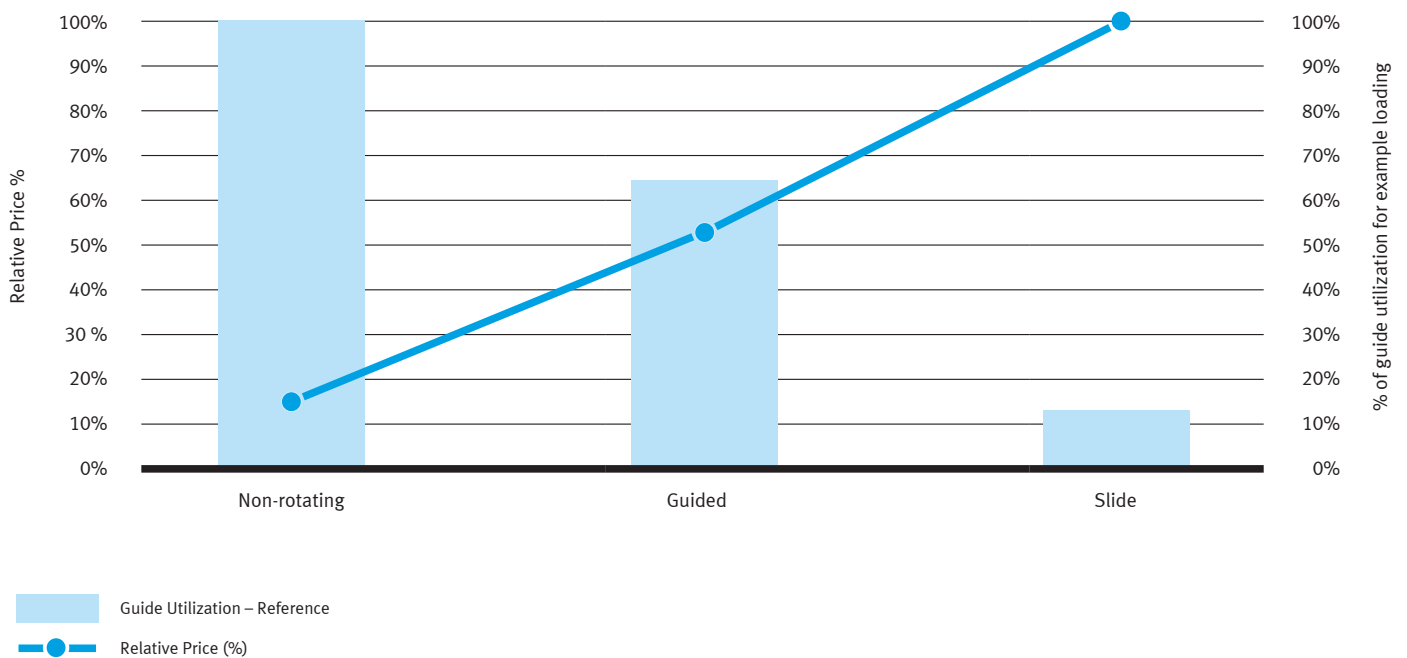


Figure 8: Relative price % vs guide utilization comparison by type.

Guided drives for all scenarios

The proliferation of pneumatic guided drives and slides reflects their suitability for an extraordinary range of tasks. These actuators are available in base (off the shelf) and specialty or customizable models, in metric and inch versions. Representing as much as 50% of the market for guided drives, base models are a cost-effective solution that are suitable for a large majority of applications. Most are maintenance free and require little or no assembly. Many are available with a choice of plain-bearing guide for high rigidity or a recirculating ball bearing guide for applications involving torque loads. Base models are extremely versatile and take up less space for the force they deliver than the alternatives. These basic drives come in many sizes, with many piston diameter and stroke length combinations. Stroke lengths up to 200 mm are generally considered standard products. Larger versions with stroke lengths of up to 400 mm are available. These larger versions include a choice of damping and end cushioning options, including manually adjustable and in some models, self-adjusting air cushioning.

There also are specialty models and variants for dry food and splash zones, clean room and ATEX applications, and variants with heat resistant designs. Hygienic drives for food and pharmaceutical applications provide the same ease of cleaning and corrosion resistance as standard hygienic cylinders as well as NSF-H1 compliant lubrication. Hygienic guided drives have a smooth, clean design that will not allow water, dirt or dust to collect on the unit.

Options when choosing standard guided drives:

- Cylinder/slide
- Ball bearing/plain bearing
- Yoke/yoke slide
- Adjustable/self-adjusting cushioning

Additionally:

- Food
- ATEX
- Cleanroom
- Resistant to heat

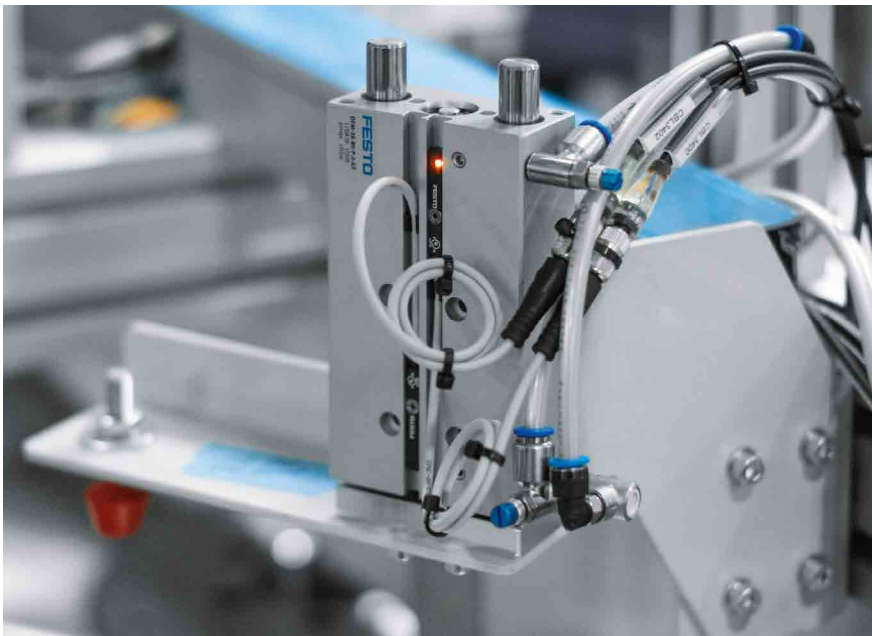


Figure 9: The DFM base model series is Festo's most popular pneumatic guided drive.

Many of the same benefits of large guided drives are available in mini-guided drives where short stroke length and less force are sufficient and space is at a premium. Particularly compact models can offer stroke lengths of just 5-30 mm.



Figure 10: Two Festo DGSL mini-slides mounted on an EGC electric axis in the side loading unit of a state of the art packaging machine

➤ Miniaturisation for guided drives:

- Compact models
- Short stroke
- Limited force

Guided slides offer similar variety

Guided slides offer similar variety with both standard and specialty models and options that can be optimized for most applications. The range includes base models with stroke lengths up to 200 mm and multiple cushioning options, flat and slim designs, as well as ultra-compact models as small as 8 mm wide with 1-10 mm stroke lengths. The latter is ideal for small pick and place and other short stroke applications. The compact DGST is Festo's newest basic guided slide series, and like the existing DGSL line, comes in a wide range of sizes and stroke lengths. The development of ever more compact guided slides reflects the trend in industry, especially electronics assembly, towards miniaturization – requiring guided mini-slides and micro-slides that can perform with the same high precision, excellent repeatability and long service life of larger actuators.

Choosing the right drive, slide

Software like Festo's pneumatic sizing tool (found in the company's online catalog under the blue "Engineering" tab) supports customers in the selection and configuration of pneumatic products. Customers can enter their application parameters, factors such as the load to be moved, the distance and speed and the operating pressure, and they are provided with suitable product recommendations as well as an idea of the type of cushioning that meets their needs – from a simple bumper type or shock absorber to manually adjustable or self-adjusting air cushioning. That sizing tool also addresses bearing guide utilization, providing an indication of whether plain bearing or ball bearing styles would be better-suited to their operating requirements.

➤ The selection tools for guided drives from Festo will guide you to the right decision.

In summary

Demand for pneumatic guided drives and slides is growing steadily, reflecting the further expansion of automation and improvements in actuator design. These actuators are an excellent choice wherever compressed air energy is available. They are cost competitive, easy to configure and install, often maintenance free and robust, ensuring a long service life. They are versatile, available in a huge range of piston sizes and stroke lengths, with base models to suit most applications and specialty variants for many others. Their guiding capability is already designed and built in, so minimal if any assembly is required. It's no exaggeration that there is a guided drive or slide for almost any application requiring great stability and/or precision with unbeatable repeatability.

	Not-rotating drives	Guided drives	Guided slides
Price	+++	++	+
Size	+++	++	+
Weight	+++	++	+
Resistance to torque loads	+	++	+++
Accuracy	+	++	+++
Mounting flexibility	++	+++	++

Figure 11: Drives with guiding: relative price, specifications, assembly and performance attributes.

Contributors:

Darren O'Driscoll
Product Management – Pneumatic Drives
Festo Inc., Canada

Michael Guelker
Product Management – Pneumatic Drives
Festo Corp., USA

Thomas Martin
Product Management – Pneumatic Drives (Slides)
Festo AG & Co. KG., Germany

Julian Beckler
Product Management – Pneumatic Drives (Guided and Rotary)
Festo AG & Co. KG., Germany