

White Paper:

Four Myths About Pneumatics – And One Key Advantage

Why pneumatic actuators pay off in the water industry

FESTO



This white paper has the following aims:

- To examine reservations that are frequently mentioned in connection with pneumatics: are pneumatic actuators really more easily damaged, expensive over their lifetime and higher on energy consumption compared to electric actuators? The reality is more complex.
- To provide concrete tips and hints for users in the water industry: why a lifetime calculation is a good idea, how leakage can be avoided – and some of the advantages of pneumatics that may not be obvious at first glance.

Executive summary

High wear, costly maintenance, high energy costs: a whole series of myths is perpetuated about pneumatic actuators, however they do not stand up to closer examination.

In fact, not only are pneumatic actuators very easy to install, they also require almost no maintenance. If problems do occur, troubleshooting and simple repairs are possible without the need for a specialist. These days, leaks are no longer something that must be tolerated: they can be located and fixed without any great effort. Studies that postulate compressed air losses and associated costs are from a time when companies were not as concerned with energy efficiency.

Pneumatic actuators are generally regarded as being inexpensive to purchase, but are suspected of being expensive to operate: an exact lifetime analysis frequently shows that this is not the case – even less so in water business, where switching cycles are comparatively infrequent. Every operator can and should do their own calculations of lifecycle costs for their application. The higher energy requirement is another myth: the detailed calculation shows that the pneumatic actuator actually has a better energy footprint than an electric actuator.

Pneumatics – well-known and yet (in some cases) unknown

Pneumatics has been a tried-and-tested actuator technology for process valves for decades, and is almost universal in a number of industries. For example, pneumatic actuators are standard in many areas of chemistry as well as in pulp and paper production, mining and pharmaceutical production plants. In other industries, however, decision-makers are still reluctant when it comes to planning new plants or renovating existing ones. Which actuator technology is the right one?

There are a number of myths perpetuated about pneumatics, which make it appear less advantageous as an actuator technology in the process industry than other alternatives. In some cases this has to do with misconceptions or outdated calculations. In other cases it is because disadvantages that play a role in certain applications and industries are transferred to the specific case. That is why a closer look is always worthwhile: what exactly is the application?

The white paper puts four widespread assumptions under the microscope and takes a cold, hard look at whether there is any truth to them, based on current knowledge. This much we can say: in all cases the answer is not what it seems at first glance. For the operators, it is worthwhile taking a closer look behind the facade of the first impression – and a cool, calculated look at the costs incurred, the areas of use and the specific advantages that lie in the corresponding application.

Myth one:

Pneumatics means more components. As a result, the technology has increased wear and therefore requires more costly maintenance.

A pneumatic system requires a whole range of components for compressed air generation: these include a compressor, a dryer and an air reservoir. In addition, pipes, tubes and valves are required to transport and switch the compressed air to the relevant actuators. At first glance, it seems that the number of accessories and therefore also the cost of maintenance as well as the risk of wear is multiplied. An electric actuator looks almost sleek in comparison: here, all the components are under a single hood.

➤ The white paper examines four myths about pneumatics:

- High wear and complicated maintenance
- Poor energy efficiency
- High lifecycle costs
- Leakage

A number of these myths are based on long-outdated calculations. Operators are recommended to take a cold, hard look at the current realities.

➤ Pneumatics is virtually maintenance-free when used in the water industry – down to the compressor. When it comes to equipment, the overall structure of a pneumatic system is no more complicated or delicate than the structure of electric actuators.

The compressor only needs to be maintained once a year

However: compressed air generation is only required once. A compressor can supply several hundred actuators simultaneously without any problems. The average municipal water treatment plant, for example, will normally have between 50 and 200 actuators. And while screw-type compressors designed for high, continuous demand are required for the pneumatic actuators in large-scale industrial applications, reciprocating compressors are used in water management; these are handy devices that can, for example, be transported on a pallet. This is because the compressed air consumption in water treatment plants is relatively low. Many process valves only need to be switched once a day. This means that the compressor is also low maintenance – it only needs to be maintained once a year.

The pneumatic actuator itself is a technology based on just a few components (see Figure 1). It acts directly on the shut-off device and only needs a piston and piston rod to set the power generated by compressed air in motion. Pneumatic actuators are also resistant to vibration and lubricated for life. All this also means that a pneumatic actuator is completely maintenance-free. “For example, our actuators have a minimum service life of one million switching cycles,” says Dr. Wolfgang Rieger, Global Key Account Management Process Industry. This means that many water and wastewater treatment plants can be operated without maintenance for many years, even if the number of switching operations is high. While a distinction is made between control actuators and pure valve actuators when it comes to the design of electric actuators, the robust pneumatic actuator covers both areas with ease. This is made possible by its long service life. Another advantage is that the pneumatic actuator has a continuous output capability, so it does not need cooling-off phases as rest periods like an electric actuator. To put it another way – a pneumatic actuator is more durable in every respect.

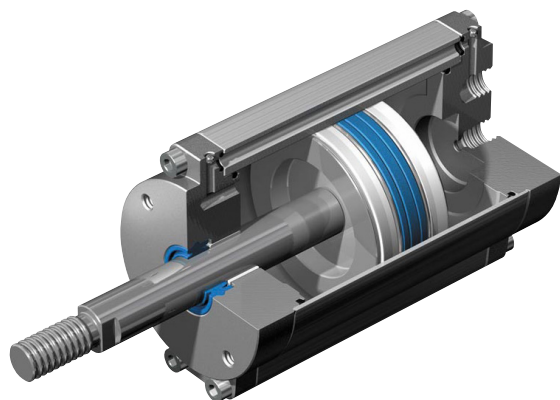


Fig. 1: Sectional view of a pneumatic linear actuator

More components? It is a question of perspective

The more closely one looks at the inner workings of the respective actuator technology, the clearer it becomes that “more components” is a question of perspective: although compressed air generation by pneumatics does need various components as described, the electric motor with its individual parts including gear unit, control unit and electrical connection is undoubtedly an inherently complex structure that involves correspondingly more work (that can only be done by specialists) when faults and defects do occur.

That leaves only the lines that need to be laid from the air reservoir to the individual actuators: the most practical variant for a compressed air network these days is a ring line. Distribution of the compressed air to the actuators then takes place using tubing and push-in fittings. These are not only flexible, but also quickly assembled and maintenance-free – and therefore no more complicated than an electrical line. Comparisons often stretch the complete pneumatic infrastructure chain from the compressed air preparation to the actuator, while only looking at the actuator itself when it comes to the electric actuators. They neglect the associated and necessary infrastructure, for example for energy transmission to the actuator itself, on the electrical side.

➤ Pneumatic actuators have a certain energy loss – but no more than alternative actuator types. Other calculations are based on outdated methods. Leaks are mostly minimal these days and also easy and cheap to locate and fix.

Myth two:

The efficiency of pneumatics is extremely low. Most of the energy used is lost as heat. Added to this is the energy lost due to leakage.

Plant operators are cost-conscious for good reason: municipal wastewater treatment plants consume on average some 4,400 GWh of electrical energy per annum. This accounts for around 20 percent of the electrical energy consumption of an average local authority. There is a lot of savings potential here, and more and more local authorities and operators are becoming aware of the topic and listening attentively when it comes to energy efficiency – or waste.

Outdated conceptions based on a long-obsolete study

The result of a study from the 90s cemented the idea in many minds that pneumatic actuators are only 7 percent efficient – which would mean that 93 percent of the energy generated by the compressor is lost. However, the study (published by Ilmberger/Seyfried, BWK, 1994) was already lacking substantiated information at the time of publication. From today's point of view, however, the 24-year-old study can definitely be considered irrelevant since it was carried out on the basis of an outdated system.

The fact is that compressed air systems, as well as other systems, have a certain energy loss, starting with the compressor through the refrigeration dryer to the consumer connection. A recent study based on a modern system (EnEffAH – Energieeffizienz in der Produktion im Bereich Antriebs- und Handhabungstechnik [Energy Efficiency in Production in the Field of Actuator and Handling Technology], 2012) comes to the conclusion that the total energy input results in 42.1 percent usable efficiency (see Figure 2 – page 7).

Energy efficiency: fully competitive

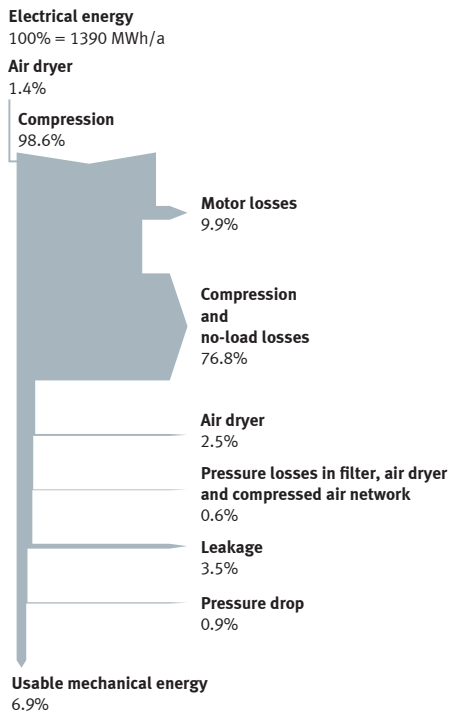
The comparison with electric actuators shows that modern compressed air systems are fully competitive as regards efficiency. This is due to the fact that electric actuators also have to put up with energy losses, for example due to self-locking gear units: in order to throttle the speed of an actuator with 1,400 revolutions to 30 to 60 turns per minute (the usual speed for precise opening and closing of a process valve in everyday operation), gear units with comparatively poor efficiency are used. On average, the usable power of the electric actuator is therefore ultimately 40 percent (difference between absorbed effective electrical power and delivered mechanical power). The seemingly “poor energy efficiency” of pneumatic actuators is therefore revealed as at least equivalent to its rival on closer examination.

“These days leaks are not something you have to put up with”

There are also different numbers in circulation for leakage, which are no longer tenable from today's perspective. An example of a study frequently quoted here is “Druckluft effizient” [Compressed Air, Efficiently], (publisher: VDMA), which came to the conclusion in 2005 that compressed air losses of 30 percent were not unusual. “That might have been the case at the time,” says Dr. Wolfgang Rieger. Reasons for this include some manufacturing companies not even having the topic of energy efficiency on their radar and paying little attention to the topic. This has changed fundamentally. Today more than ever, the focus is on monitoring compressed air consumption and on leakage detection – and their importance is increasing. Large companies now have their own energy management systems and take regular measurements. Festo itself also often performs system checks in companies.

“There will always be small leaks,” says Rieger: “But the latest modern components are so effective at containing them that they are not cost-relevant.” Added to this in the meantime is modern support technology such as a service unit with integrated sensors. Using pressure sensors and flow sensors, it can detect when compressed air consumption ceases. Then it switches off automatically and measures the compressed air drop at standstill. “This is an easy way of detecting and locating leaks,” says Rieger. “These days leaks are no longer something you have to put up with, you can fix them quickly and easily. The corresponding measuring technology is available on the market for around EUR 2,000.”

Outdated statement (1994)



Modern compressed air system

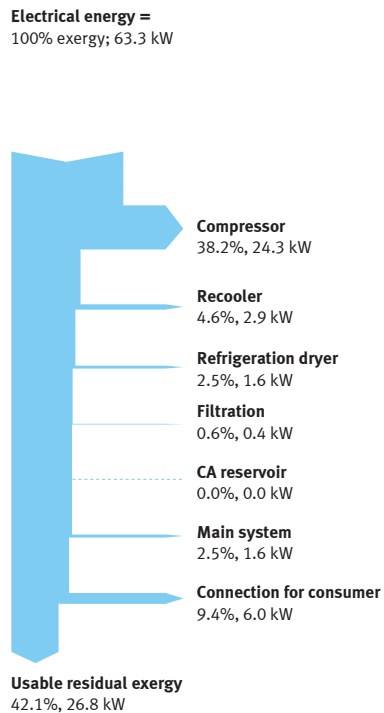


Fig. 2: Comparison of compressed air systems – from generation to application

Myth three:

Pneumatics may be cheaper to purchase, but are expensive calculated over the lifetime.

In comparisons of the different actuator alternatives between pneumatic, electric and hydraulic actuation, the prejudice persists that although pneumatics may be cheaper at first glance, the costs are much higher when calculated over the lifecycle. However, it actually depends very much on the application. An industry segment that uses its actuators at peak performance in continuous operation causes completely different operating costs in both pneumatics and electrics than a water or wastewater treatment plant that opens or closes its actuators and process valves on average once a day. In the case of the latter, the operating costs are negligible compared to the investment costs.

On the one hand, this means that lifecycle costs are necessarily highly individual. Plant operators would do well to inform themselves in advance and do their own calculations. This is possible using the calculation tool of the German Electrical and Electronic Manufacturers' Association – ZVEI¹, for example, which makes it easy to perform a comparative evaluation of alternative technologies in terms of lifecycle costs.

¹ Online calculation tool ZVEI:
www.zvei.org/themen/energie/energieeffizienz-rechnet-sich-lifecycle-cost-evaluation-lce/ (access March 2018)

Sample calculation: What does it cost to automate a water treatment plant?

Nevertheless, a sample cost comparison can already provide a lot of information. For that reason, the new construction of a filtration system at a municipal water treatment plant is assumed to be representative here. The equipment consists of seven multi-layer filters and seven active carbon filters with 84 automated process valves. To calculate the investment costs, the following factors are taken into consideration:

- Actuators and accessories
- Actuation components up to the fieldbus interface
- Energy supply components (in the case of pneumatic actuators, this means the compressor with dryer and air reservoir; in the case of electric actuators, it means the control cabinet elements for energy transfer and the fuses)
- Assembly and commissioning

Note: We take the list prices of Festo as well as list prices of current providers for the electric actuator as a basis for the comparison.

This results in an investment of about EUR 222,000 for the pneumatic actuator and EUR 310,000 for the electric actuator. This result is not surprising: pneumatic actuators have a reputation as being the cheaper variant in terms of investment.

What about the operating costs? For this we must first calculate the anticipated compressed air consumption, which is the result of the number of process valves, the size of the actuators and the number of actuation operations per day. The compressed air costs are within a certain range depending, among other things, on how efficiently the actual compressors actually work. With state-of-the-art energy-saving equipment, the optimum prices are 1.5 cent per standard cubic meter (cent/Nm³). If old screw-type compressors are used, the prices can quickly increase to 10 cent/Nm³.

According to the EnEffAH study, the average compressed air costs are currently 2 cents/Nm³, including the costs for maintenance and repairs. We assume 14 cents per kWh for the energy price of electric actuators, calculated based on the actuator speeds and process valve operating times required for the example. In the comparison at hand, the consumption costs for the pneumatic actuators therefore come to EUR 104 a year, while the costs for the electric actuators come to EUR 146 a year.

This is an interesting result in many respects: firstly, the energy costs in both cases are of an order of magnitude that is negligible for the operation of a water treatment plant. Apart from this, even in this comparison the costs for compressed air are below the follow-up costs for electric actuators – in fact significantly so.

➤ The water industry generally works with very low compressed air consumption. This also reduces the proportion of operating costs compared to the investment costs. In the example shown here of a typical water treatment plan, pneumatics beats electromechanics on price in all categories. Plant operators are recommended to calculate the anticipated lifecycle costs in advance and do a cost comparison.

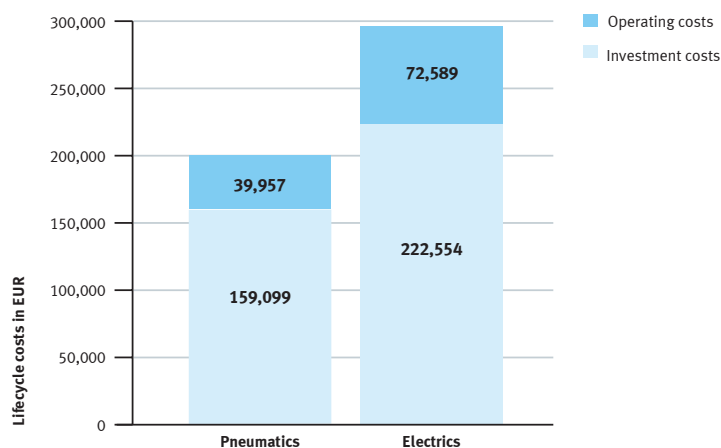


Fig. 3: Comparison of the lifecycle costs of pneumatic and electric actuator technology

Operating costs: More likely 20 to 30 percent of the investment costs

In order to now calculate the total cost of ownership (i.e. the costs of a system over its entire lifecycle), we will use a comprehensive study in cooperation with the Braunschweig University of Technology as an example. The 2007 study examined the filter system of a water treatment plant with two small compressors for the pneumatic actuator. The pneumatic quarter turn actuators are controlled via eight valve terminals, there is a total of eight closed filters involved: seven butterfly valves that work in open and closed mode and a regulated plunger valve for controlling the entire process. It has been assumed for the electrical solution that the actuators are actuated centrally by the control cabinets and an emergency generator ensures that energy is available at all times. “The results of this study are still relevant today,” says Rieger: “Current calculations coincide with the results from that time.”

As with the example mentioned in the paragraph above, the pneumatic solution is unsurprisingly cheaper when it comes to investment costs: around EUR 159,000 compared to around EUR 222,000 for the electric actuator. For the energy costs in operation, it is assumed that the filter is flushed once a week (this involves opening all the process valves once and then closing them again). The result is a comparatively short operating time that is, however, representative of the industry and its applications.

Extrapolated over the entire lifecycle with a return of three percent (as recommended within the framework of investments in the water industry), the total cost of ownership comes to approximately EUR 200,000 for the pneumatic system and EUR 295,000 for the electric valve actuator system. Also included in this incidentally are the costs for inspection and maintenance as well as the final dismantling during the disposal phase. The investment costs are therefore much higher in this example, the follow-up costs are just 20 to 30 percent. The total cost of ownership for the pneumatic solution is therefore almost a third lower.

Energy costs are low in comparison with other industries

The widespread assumption that pneumatics is only cheaper in terms of the procurement costs is therefore unequivocally refuted for the example at hand. What is much more crucial, however, is that even if the parameters change, it does not change the fact that in view of the short operating times in water management, the energy costs are much lower compared to other industries. Not only can pneumatic actuators therefore demonstrate their technical strengths here, they also score in terms of total cost of ownership. In the current example, the TCO is one third lower.

Add to this the fact that the optimization potential for compressed air consumption is not even close to exhausted yet today. Energy efficiency modules or the new possibilities of digitalization and big data analytics will make energy conservation easier. It is very likely that further innovations will follow here in the future. In view of the low costs, subsequent automation may even be worthwhile.

Myth four:

Pneumatic components like tubing are complicated to install and additionally susceptible to leakage.

The connection between the solenoid valve and actuator is today established via a tubing/push-in fitting combination. The right combination is available for every application. All these combinations have one thing in common: they are easy to lay and reliable to install. The tubing is inserted into the fitting with a simple movement and held securely by a stainless steel retaining claw that does not damage the surface. Vibration and pressure surges are safely absorbed in this way. A sealing ring guarantees a perfect seal between the tubing and fitting. The complete installation can be performed without the need for a specialist.

QuickStar series push-in fittings – features

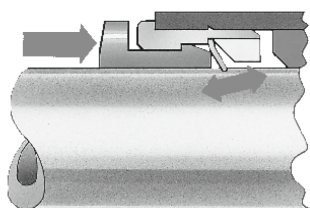


Fig. 4: Simply “plug and work”
Installation without specialists

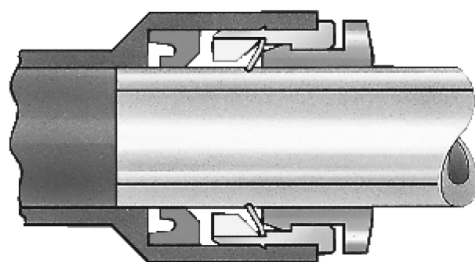


Fig. 5: Reliably connected:
The nitrile rubber sealing ring guarantees a perfect seal.

Current components are robust and easy to handle

The still perpetuated fear that the combination of tubing and push-in fitting is susceptible to leakage is unfounded these days, especially in view of the variety of products and high-quality components. The combination is even suitable for vacuum.

“Modern combinations need no further monitoring and checking,” says Rieger. “Apart from the regular maintenance of the compressor, no further steps are required. It really does follow the motto ‘fit and forget’.” Festo examined compressed air systems in water treatment plants after an operational life of ten years and performed leakage measurements. “The systems are still as good as new,” says Wolfgang Rieger: “There was no difference compared to the condition during commissioning.”

➤ Laying tubing is easy and intuitive with modern components. Fears about increased workload are outdated and unfounded. The material is also very robust and requires no further attention over its service life.

An advantage that is often overlooked: reliability

The ideal system is one that always runs – without problems, without interruptions and without failures. But every plant operator knows that this is ultimately a utopia. Most systems combine too many complex factors to run their whole lifetime without any problems. Whether the “human factor”, i.e. a mistake by an employee, or even completely external, also unpredictable influences, such as the failure of the electrical energy supply and the weather.

Pneumatic actuators demonstrate a strength in this context that some planning engineers do not even think about in advance: they are extremely resistant to a large number of these incalculable factors – and are comparatively easy to repair or switch using emergency supplies.

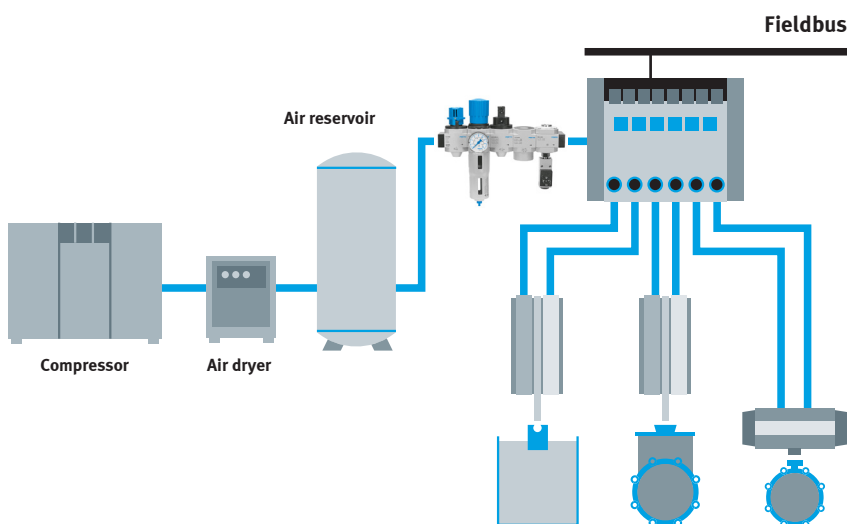


Fig. 6: The air reservoir is an integral part of compressed air generation and always offers a reserve in the event of power failure.

Flexible response to unpredictable situations

Take power failure, for example: compressed air is available even if the power fails. In addition to the compressor, an air reservoir is ultimately also always available. This makes it easy to bridge power failures – depending on the required consumption, the compressed air can still be used for some time even if there is no power supply.

Electric actuators are equipped as standard with a handwheel for emergencies. However, it is seldom practical to use in an emergency because opening or closing the process valves requires several hundred rotations. If, in addition, several actuators need to be operated simultaneously, appropriate personnel is required but not usually available. The alternatives are emergency generators or batteries, however they make the infrastructure much more expensive and also require maintenance.

Pneumatic actuators permit a flexible response to a number of common unpredictable situations in water management: for example, if a gate valve temporarily needs more power due to deposits that have collected on a slide gate over time, this can be very easily achieved by increasing the pressure. Every pneumatic actuator has these power reserves; they normally work at 5 to 6 bar, but can be easily increased to 8 bar. Electric actuators, on the other hand, generally work at a fixed rotational speed. If they encounter a blockage, they switch off. “A Festo customer, a municipal wastewater treatment plant, had this problem frequently with rain overflow basins,” says Rieger: “Whenever it happened, a team had to be deployed to perform the complex task of getting the gate valve moving freely again.”

If a defect actually occurs at any point in the actuator, an initial check can be performed without the need for specialists: “Pneumatic actuators generally work with 24 V control technology, so anyone can open the door of the control cabinet and look inside,” says Rieger. Leaks can be identified or seals replaced without any in-depth knowledge – unlike with the electric actuator, where an electrician must be consulted whenever a failure occurs. Quite apart from the fact that pneumatic actuators are much more robust overall because of their comparatively simple structure, they are overload-proof, cannot overheat, and do not need either motor protection or cooling-off phases.

Conclusions

On closer examination, all myths associated with pneumatic actuators prove to be untrue or outdated. Pneumatic actuators are easy to install and extremely low maintenance, and offer an efficiency that is comparable with their competitors. In some cases, the lifecycle costs in the water industry are below those of comparable electric actuators. Minor repairs can be performed by the operator. Pneumatic actuators are therefore a worthwhile alternative for the water industry.

➤ Pneumatic actuators are very resistant to the common unpredictable situations in everyday operation: they have a reserve in case of power failure, can mobilize power reserves if needed and do not require a specialist for minor repairs.

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