Pneumatics and Hydraulics

PNEUMATIC ACTUATORS

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Review of the last lecture

- Air distribution
- Sizing pipe systems
- Flow resistance
- Pipe material and Piping layout
- Water separators and service units
- Compressed air filter
- Compressed air regulators

Outline

- Compressed air lubricator and removing oil
- Maintenance of air service units
- Pneumatic actuators

Compressed air lubricator

As a general principle cylinders with heat-resistant seals must not be supplied with lubricated compressed air, since the special grease which forms the original lubrication would be washed out.

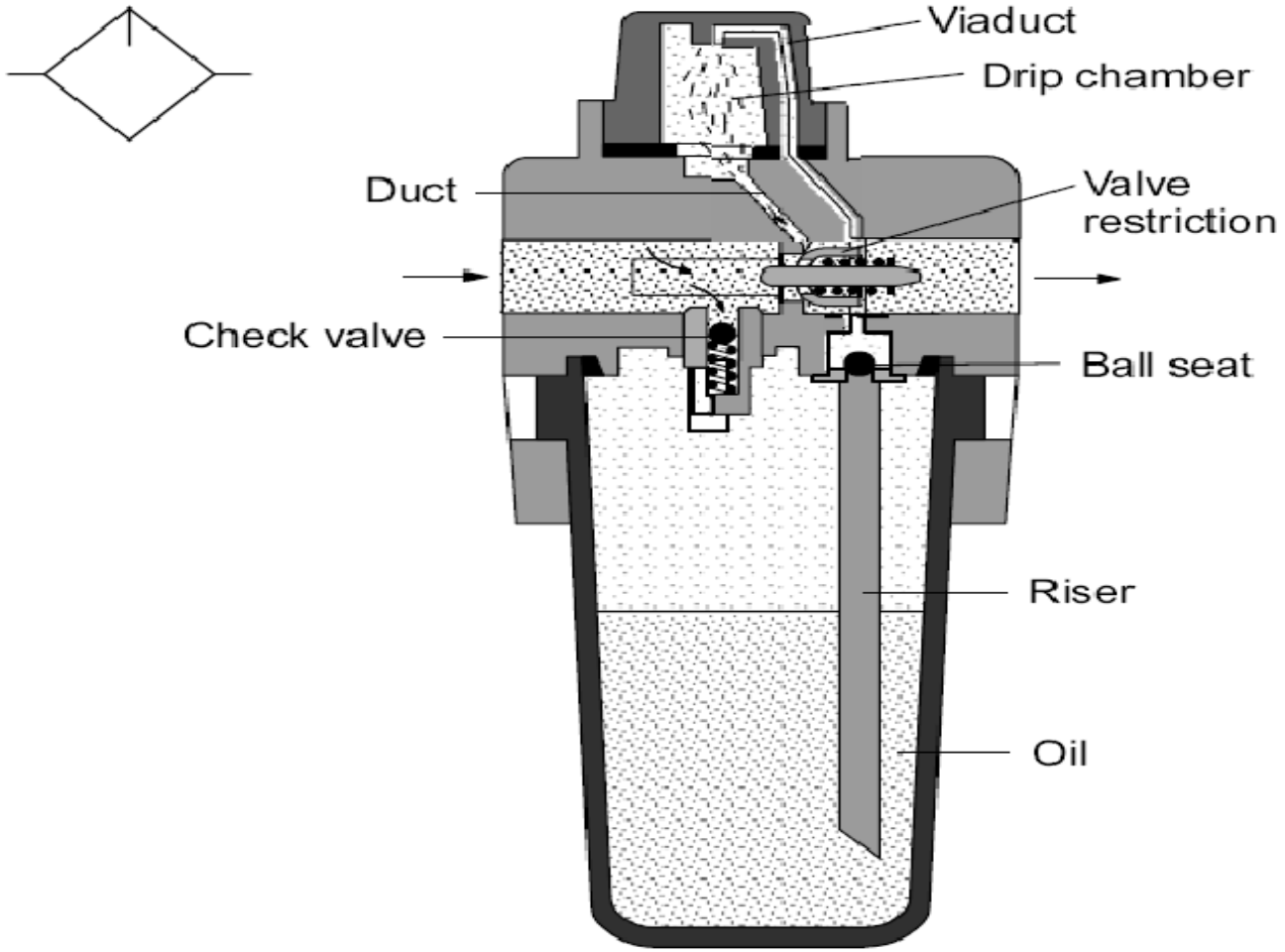
Lubrication of the compressed air by means of mist lubricators may be necessary in certain cases:

- Where extremely rapid oscillating motions are required
- With cylinders of large diameter, lubricators should where possible be installed only directly upstream of the consuming cylinders.

Operational principle

- The compressed air passing through the lubricator causes a pressure drop between the oil reservoir and the upper part of the lubricator.
- The pressure difference is sufficient to force the oil upwards through a duct where it then drips into a nozzle which can be seen through an inspection glass.
- Here the oil is atomized and taken up by the air stream to a greater or lesser extent.

Operational principle



Checking the oil dosage

It is possible to check the oil dosage as follows:

- A reference value for oil dosage is a quantity of 1 to 10 droplets per cubic meter of compressed air.
- The correct metering can be checked as follows: A piece of white cardboard should be held at a distance of approximately 10 cm from the exhaust port of the power valve of the cylinder which is furthest away from the lubricator.
- If the system is then allowed to operate for some time, it should be possible to see only a pale yellow color on the cardboard.
- Dripping oil is a clear sign of over lubrication.

Removing oil

- Up to a few years ago, the general view was that the oil discharged by the compressor could be used as a lubricant for the power components. Now it has been recognized that this is not the case.

- As the level of heat produced in the compressor is very high, the oil is carbonized and the oil vapor exhausted.

- This leads to an abrasive action on cylinders and valves, and service is considerably reduced.

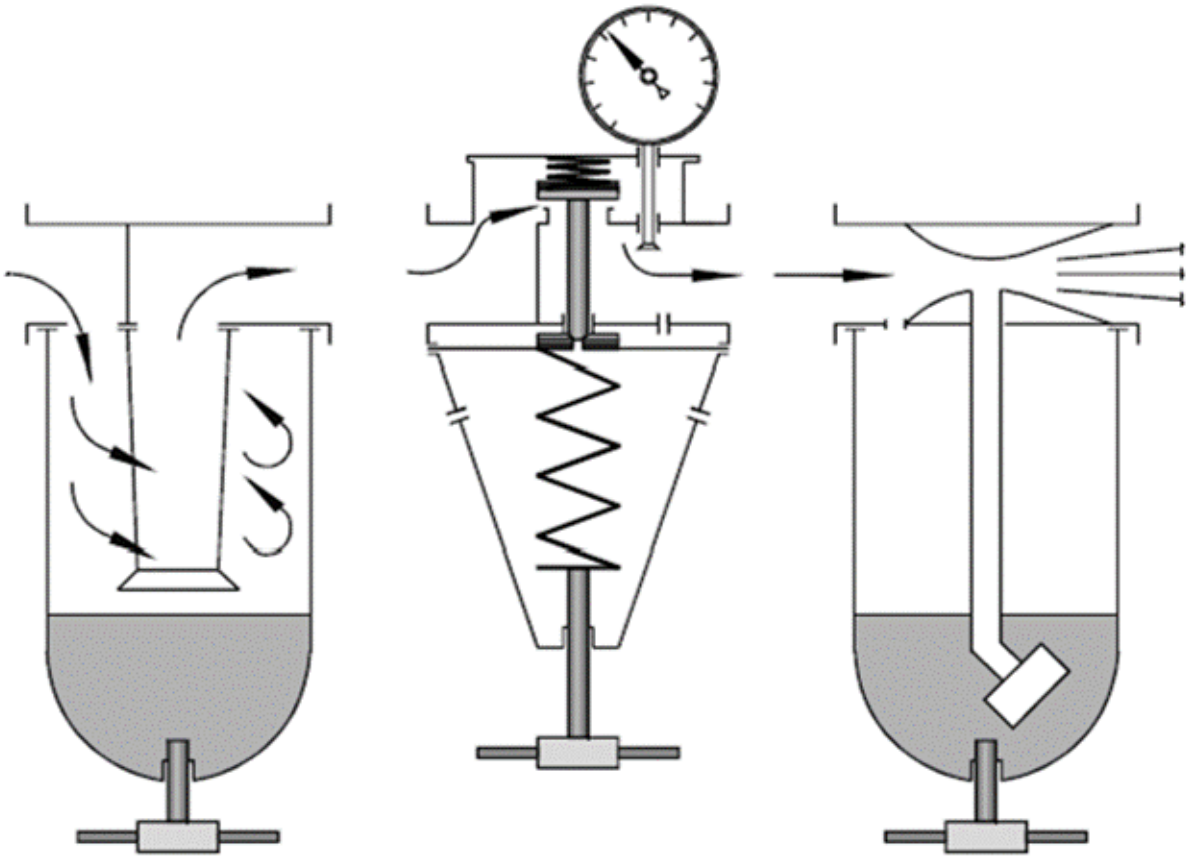
- A further problem is that oil is deposited on the inner walls of the pipes and is eventually absorbed in an uncontrolled way into the air flow.
- This fact alone makes controlled and effective distribution impossible.

Removing oil

- A pipe which has become contaminated in this way can no longer be cleaned without dismantling.

- A further disadvantage is gumming, which means that after a system has been at a standstill for some time (after weekends and public holidays), lubricated components do not function correctly.

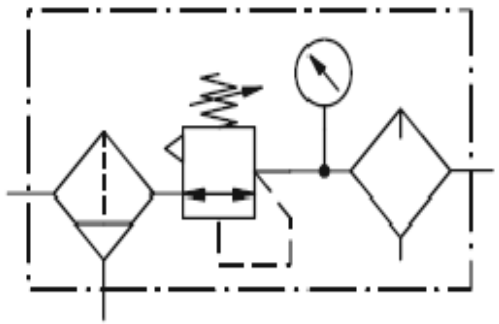
Service unit

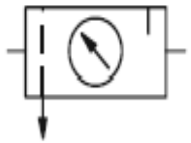


detailed symbol

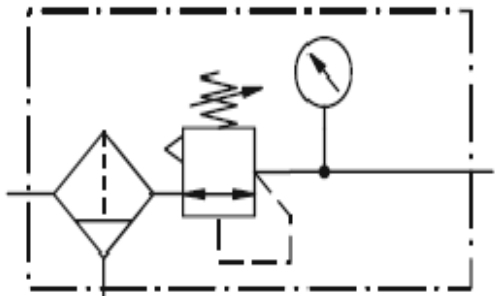
simplified symbol

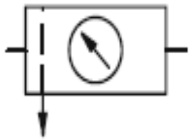
With lubricator





Without lubricator





Service unit

The following should be observed with service units:

- The total air throughput in m^3/h determines the size of the unit. If the air throughput is too high, a large pressure drop occurs in the units.
- The values specified by the manufacturer should be observed.
- The working pressure may not exceed the value stated on the service unit. The ambient temperature should not exceed 50 °C (maximum values for plastic bowls).

Maintenance of air service units

The following routine service measures are necessary on a regular basis:

- Compressed air filter: The condensate level has to be checked regularly, as the level indicated in the sight glass must not be exceeded.
- If the level is exceeded, this can result in the accumulated condensate being drawn into the air supply lines.
- The excess condensate can be drained using the drain cock on the sight glass.

- The filter cartridge must also be checked for contamination and cleaned or replaced if necessary.

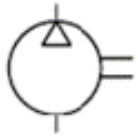
Maintenance of air service units

- Compressed air regulator: This requires no servicing, provided it is preceded by a compressed air filter.
- Compressed air lubricator: If fitted check the oil level in the sight glass and top up, if necessary, to the level indicated.
- The plastic filter and lubricator bowl must not be cleaned with trichloroethylene. Only mineral oils may be used for the lubricator.

Maintenance of air service units

Supply

– Compressor with fixed capacity



– Air reservoir with T junction

– Pressure source

Service equipment

– Filter — Separation and filtration of particles

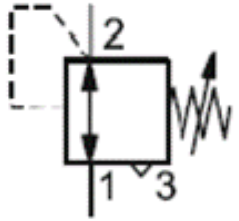
– Water separator, — Manually operated

– Water separator, automatic

– Lubricator — Metered quantities of oil passed to the air stream

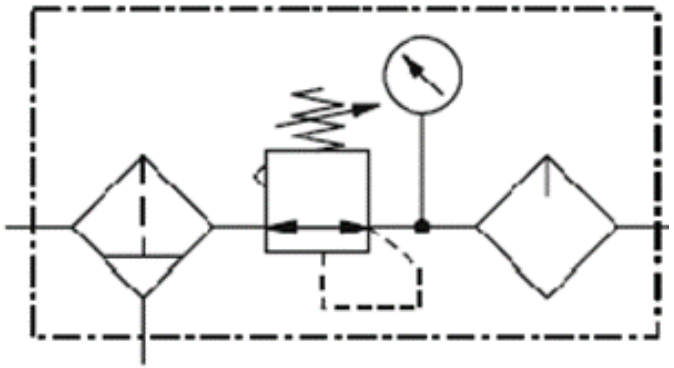
Maintenance of air service units

– Pressure regulator — Relieving type - vent hole for excess upstream pressure - adjustable

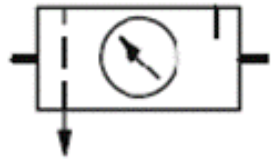


Combined symbols

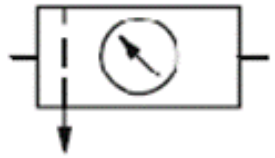
– Air service unit — Filter, Regulator, Gauge, Lubricator



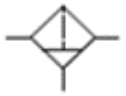
Simplified air service unit

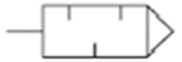
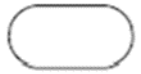


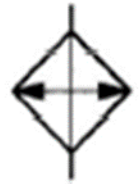
Simplified air service unit without lubricator

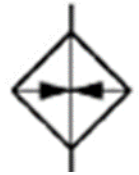


Maintenance of air service units

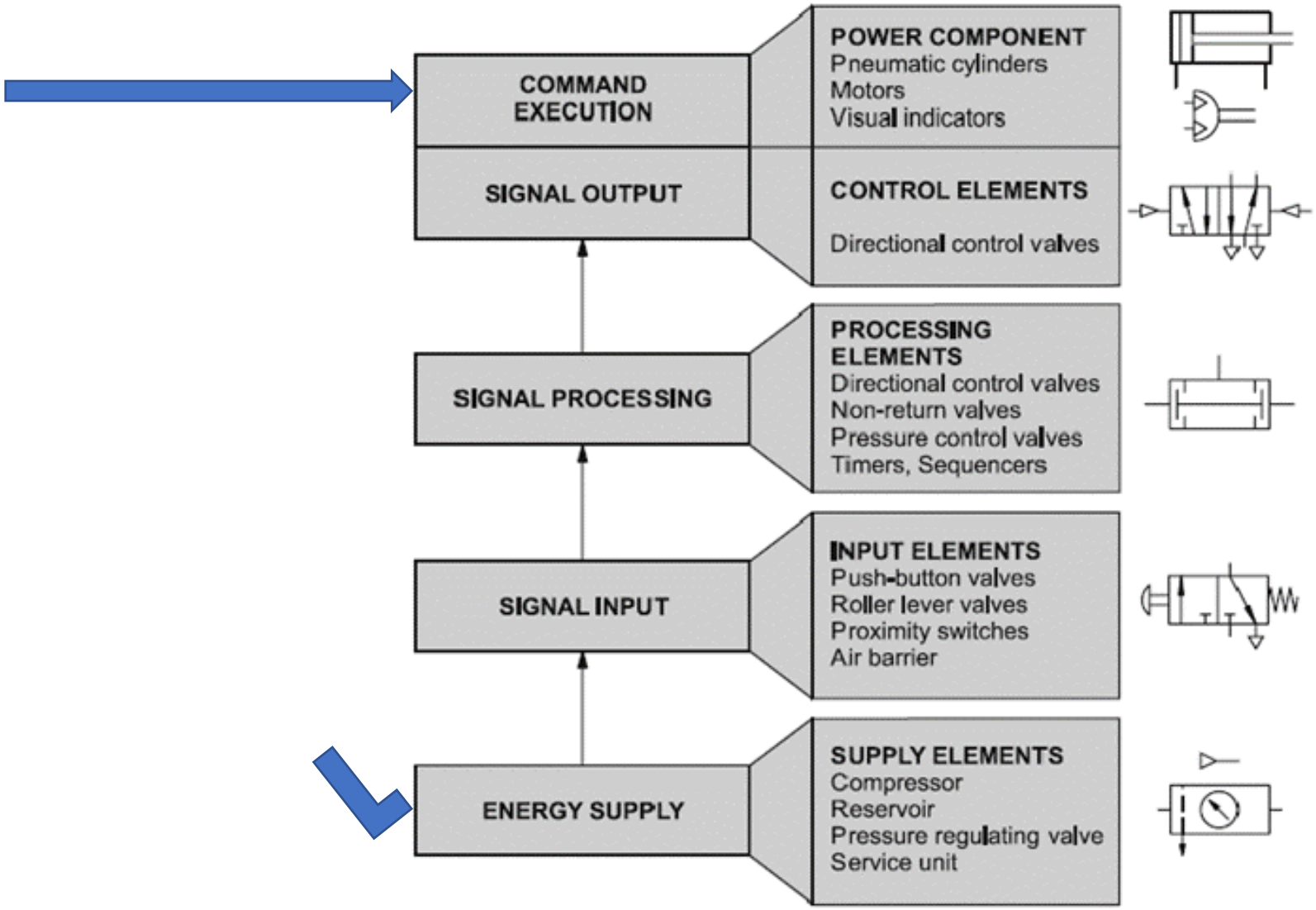
Symbol	Designation	Explanation
	Filter	Device for removing contaminants
	Water separator	Manually operated
		With automatic draining
	Filter with water separator	This device is a combination of filter and water separator
		Manually operated
		With automatic draining
	Air drier	Device in which the air is dried (e. g. by means of chemicals)
	Lubircator	Device in which a small amount of oil is added to the air flowing through for lubricating connected devices
	Pressure gauge	
	Pressure source	

	Silencer
	Vessel (air reservoir)

Cooler 

Heater 

Structure and signal flow of pneumatic systems



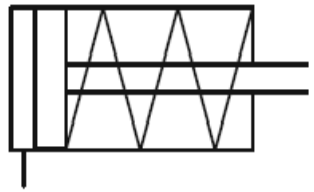
PNEUMATIC ACTUATORS

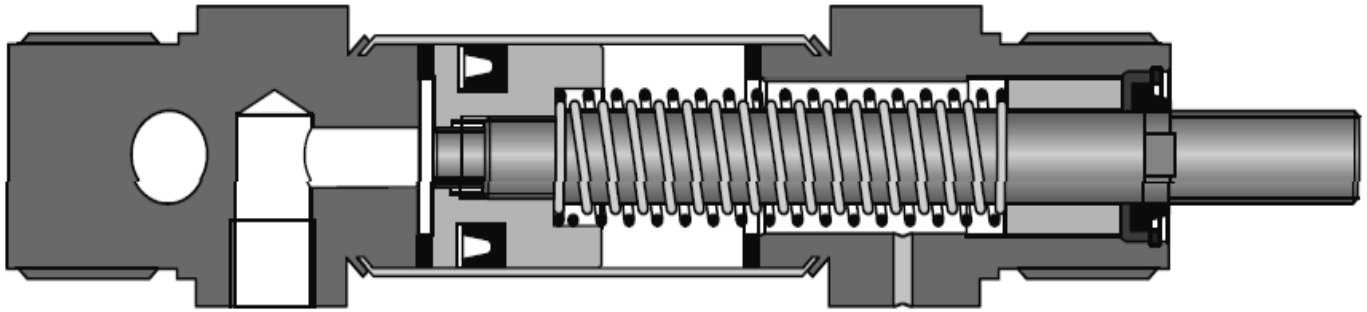
- An actuator is an output device for the conversion of supply energy into useful work.
- The output signal is controlled by the control system, and the actuator responds to the control signals via the control element.
- The pneumatic actuator can be described under two groups, linear and rotary :
- Linear motion: Single-acting cylinders and Double-acting cylinders.
- Rotary motion : Air motor, Rotary cylinders and Rotary actuators.

Single-acting cylinders

- With single-acting cylinders compressed air is applied on only one side of the piston face. The other side is open to atmosphere.
- The cylinder can produce work in only one direction.
- The return movement of the piston is effected by a built-in spring or by the application of an external force.
- The spring force of the built-in spring is designed to return the piston to its start position with a reasonably high speed under no load conditions.

Single-acting cylinders





Single-acting cylinders

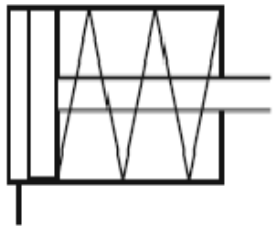
- For single-acting cylinders with built-in spring, the stroke is limited by the natural length of the spring.
- Single-acting cylinders are therefore only available in stroke lengths of up to approximately 80 mm.
- The construction and simplicity of operation of the single-acting cylinder makes it particularly suitable for compact, short stroke length cylinders for the following types of applications:

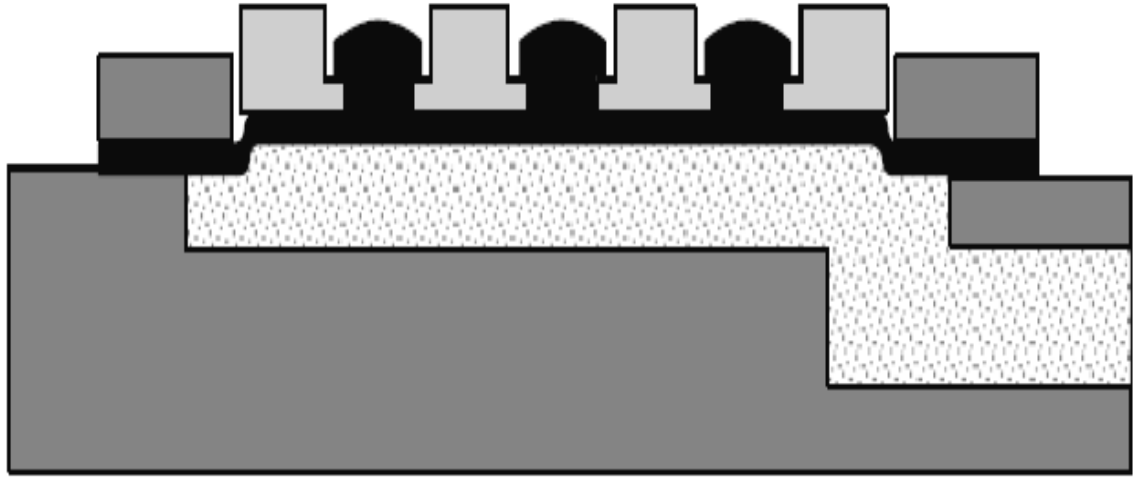
a. Transferring
b. Branching
c. Clamping
d. Ejecting

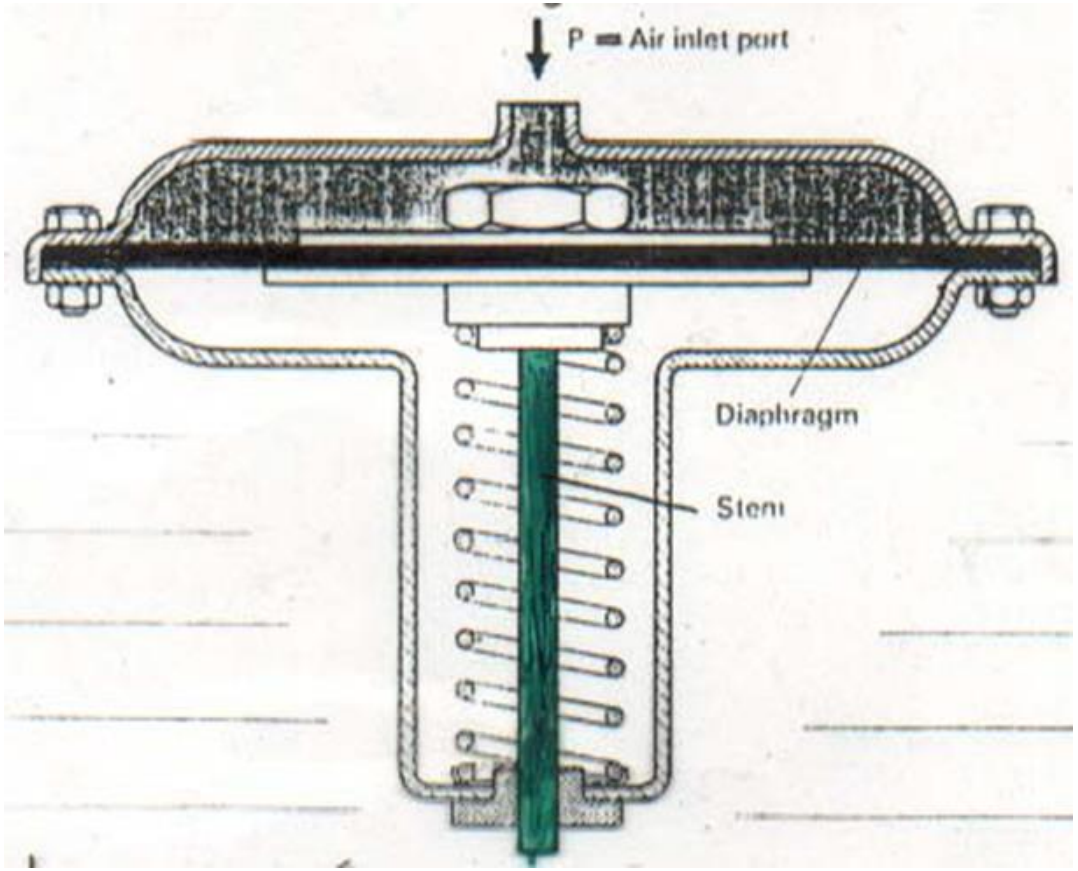
Single-acting cylinders construction

- The single-acting cylinder has a single piston seal which is fitted on the air supply side. Sealing is by a flexible material that is embedded in a metal or plastic piston (Perbunan).
- During motion, the sealing edges slide over the cylinder bearing surface. There are varying designs of single-acting cylinders including:
- Diaphragm cylinder
- Rolling diaphragm cylinder
- Bellow cylinder
- Tube cylinder (fluid muscle)
- With a diaphragm cylinder, a built-in diaphragm made of rubber, plastic or metal performs the task of the piston.
- The piston rod is mounted centrally on the diaphragm. There is no sliding seal, but merely friction as a result of the tensile stress of the diaphragm.
- They are used in short stroke applications, for clamping, embossing and lifting operations.

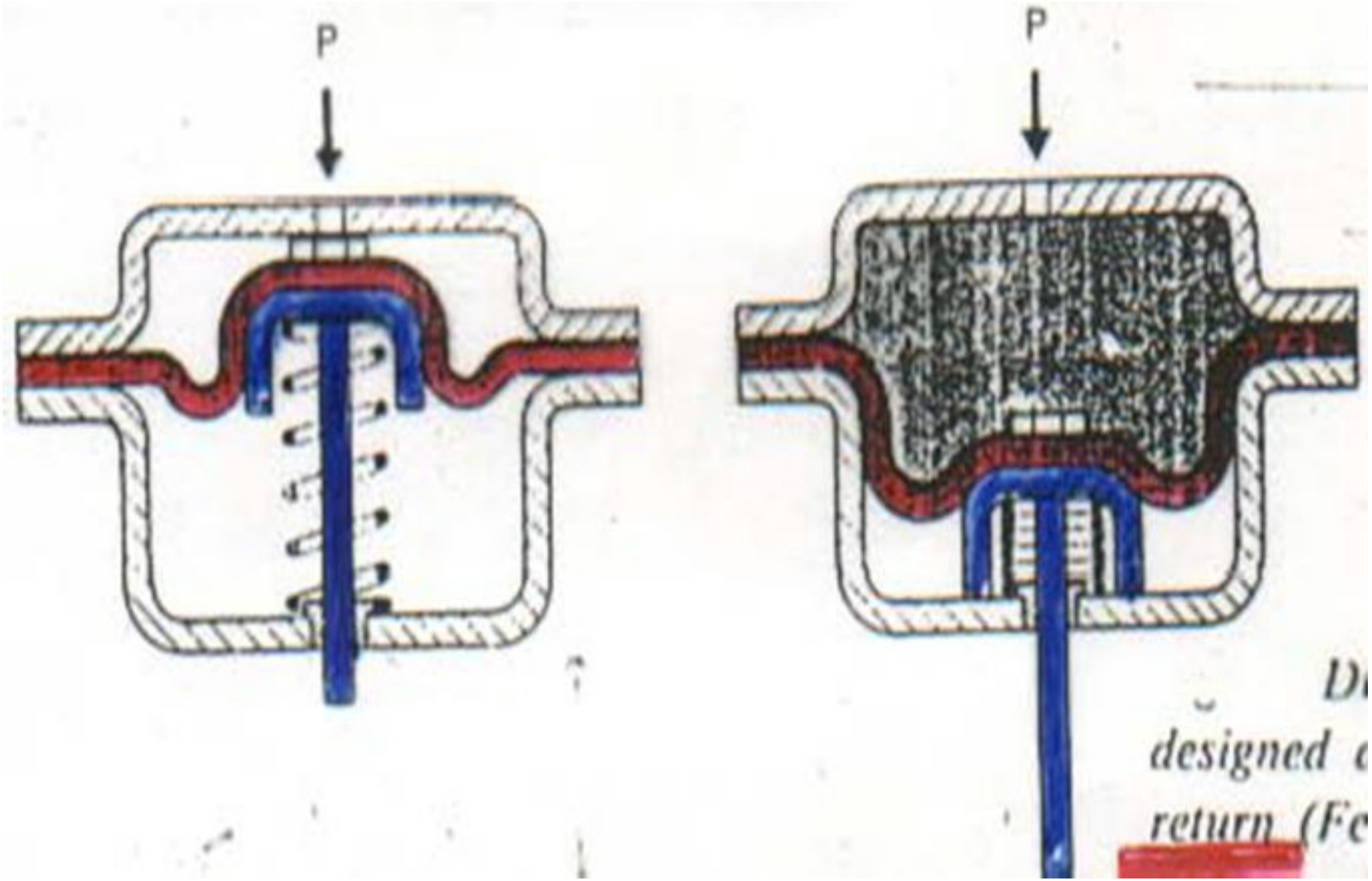
Diaphragm cylinder







Rolling diaphragm cylinder



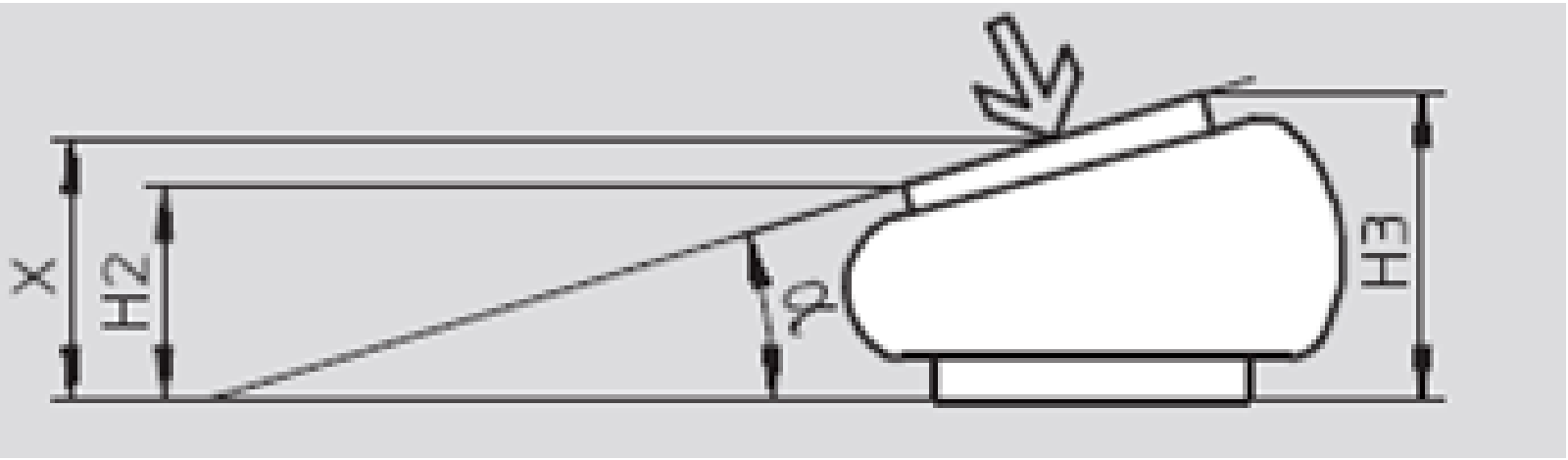
Rolling diaphragm cylinder

Bellow Cylinder

- Bellows cylinders function both as driving and pneumatic spring components.
- The simple design consists of two metal plates with a ribbed rubber bellows.
- Bellows cylinders are single-acting drives that do not require spring returns, as the reset is performed through the application of external force.
- Rolling bellows have a different stroke/force characteristic to conventional bellows and can cover a wider stroke range in relation to installation height.

Bellow Cylinder

- Bellows cylinders may only be driven against a workpiece, or they must be equipped with stroke limiting stops at the stroke ends, because the bellows would otherwise be overloaded.
- A resetting force is required in order to press the bellows cylinder together to its minimum height. As a rule, this is achieved through the applied load.
- The stroke of the bellows cylinder can be made to describe a circular arc, in which case the indicated tilt angle α must not be exceeded.



Bellow Cylinder

Diameter
145 ... 385 mm

Stroke length
60 ... 230 mm

General technical data							
Size	145	165	215	250	325	385	
Pneumatic connection	G⅛	G¼	G¾	G¾	G¼	G¼	
Mode of operation	Single-acting						
Design	Bellows						
Type of mounting	With female thread						
Mounting position	Any						

Operating and environmental conditions		
Operating medium		Filtered compressed air, lubricated or unlubricated
Operating pressure	[bar]	0 ... 8
Ambient temperature	[°C]	−40 ... +70

Diameter
80 and 100 mm

Stroke length
105 and 110 mm

General technical data		
Size	80	100
Pneumatic connection	G⅜	
Mode of operation	Single-acting	
Design	Rolling bellows	
Type of mounting	With female thread	
Mounting position	Any	

Operating and environmental conditions		
Operating medium		Filtered compressed air, lubricated or unlubricated
Operating pressure	[bar]	0.9 ... 8.0
Ambient temperature	[°C]	−40 ... +70

Tube Cylinder (Fluid Muscle)

- Fluidic Muscle is a tensile actuator which mimics natural muscular movement.
- It consists of a contraction system and appropriate connectors.
- The contraction system is formed by a pressure-tight length of rubber hose, sheathed in high-strength fibers.
- The fibers create a rhomboidal pattern with a three-dimensional grid structure.
- When internal pressure is applied, the hose expands in its peripheral direction, thus creating a tensile force and a contraction motion in the muscle's longitudinal direction.

Tube Cylinder (Fluid Muscle)

- Tube Cylinder (Fluid Muscle)
- The usable tensile force is at its maximum at the start of the contraction and then decreases in a virtually linear manner as a function of stroke.
- Fluidic Muscle is intended for use as a tensile actuator only.
- The expansion in the peripheral direction cannot be used for clamping purposes, since external friction could cause damage to the muscle.

The applications of Fluidic Muscle are as follows:

- Single-acting actuator
- Pneumatic spring

Tube Cylinder (Fluid Muscle)

Advantages:

A. High initial force and acceleration:

1. Initial force up to 10 times higher than a conventional cylinder of the same diameter
2. Highly dynamic response, even at high loads.

B. Judder-free operation:

1. No mechanical parts moving against one another
2. Completely jolt-free with extremely slow movements

Tube Cylinder (Fluid Muscle)

C. Simple positioning:

1. Controlled by means of pressure using the simplest technology without displacement encoders.

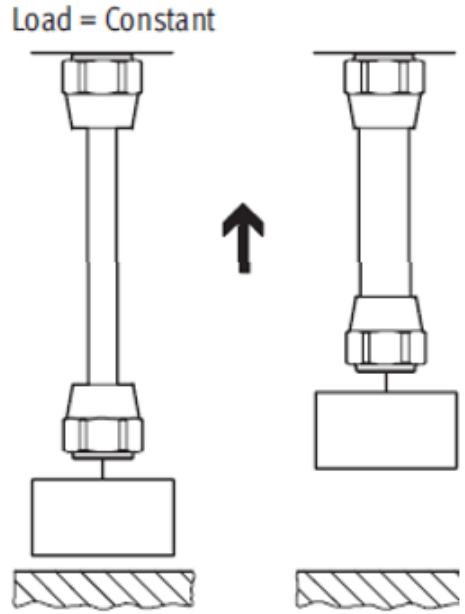
D. Hermetically sealed design:

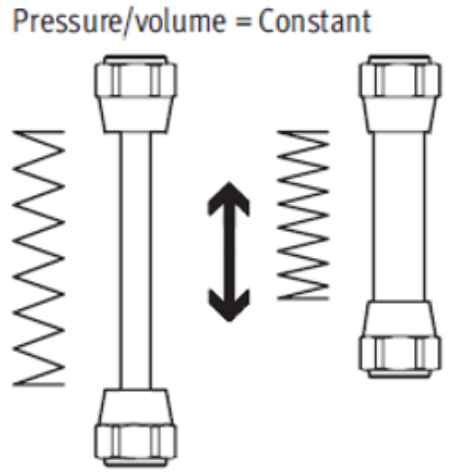
1. Separation between operating medium and atmosphere.
2. Ideal for dusty and dirty environments.
3. Robust design.
4. Zero leakage.

Tube Cylinder (Fluid Muscle)

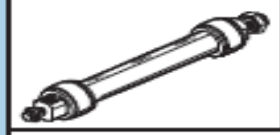
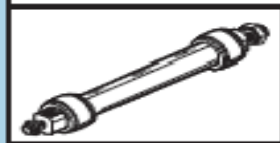
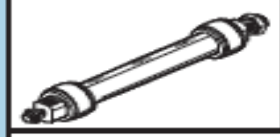
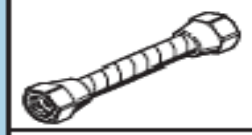
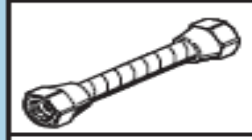
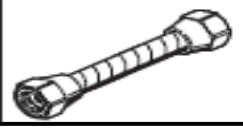
- In the simplest case, Fluidic Muscle operates as a single-acting actuator against a constant load.
- Fluidic Muscle behaves like a spring with a changing external force.
- **Disadvantages:**

1. If the muscle is fed with compressed air and the volume blocked, the pressure in the muscle can increase significantly when the external force is varied.
2. The service life of the Fluidic Muscle depends on the contraction, the operating pressure and the Temperature. High operating frequencies or high loads can lead to a temperature rise.
3. The service life of the fluidic muscle is between 100000 and 10 million switching cycles for typical applications.





Tube Cylinder (Fluid Muscle)

Function	Version	Type	Inside dia. [mm]	Nominal length [mm]	Lifting force [N]	Max. permissible pretensioning	Max. permissible contraction	Operating pressure [bar]
Single-acting, pulling	Fluidic Muscle with pressed connection							
		DMSP	10	40 ... 9000	0 ... 630	3% of nominal length	25% of nominal length	0 ... 8
		DMSP	20	60 ... 9000	0 ... 1500	4% of nominal length	25% of nominal length	0 ... 6
		DMSP	40	120 ... 9000	0 ... 6000	5% of nominal length	25% of nominal length	0 ... 6
	Fluidic Muscle with screwed connections							
		MAS	10	40 ... 9000	0 ... 630	3% of nominal length	25% of nominal length	0 ... 8
		MAS	20	60 ... 9000	0 ... 1500	4% of nominal length	25% of nominal length	0 ... 6
		MAS	40	120 ... 9000	0 ... 6000	5% of nominal length	25% of nominal length	0 ... 6

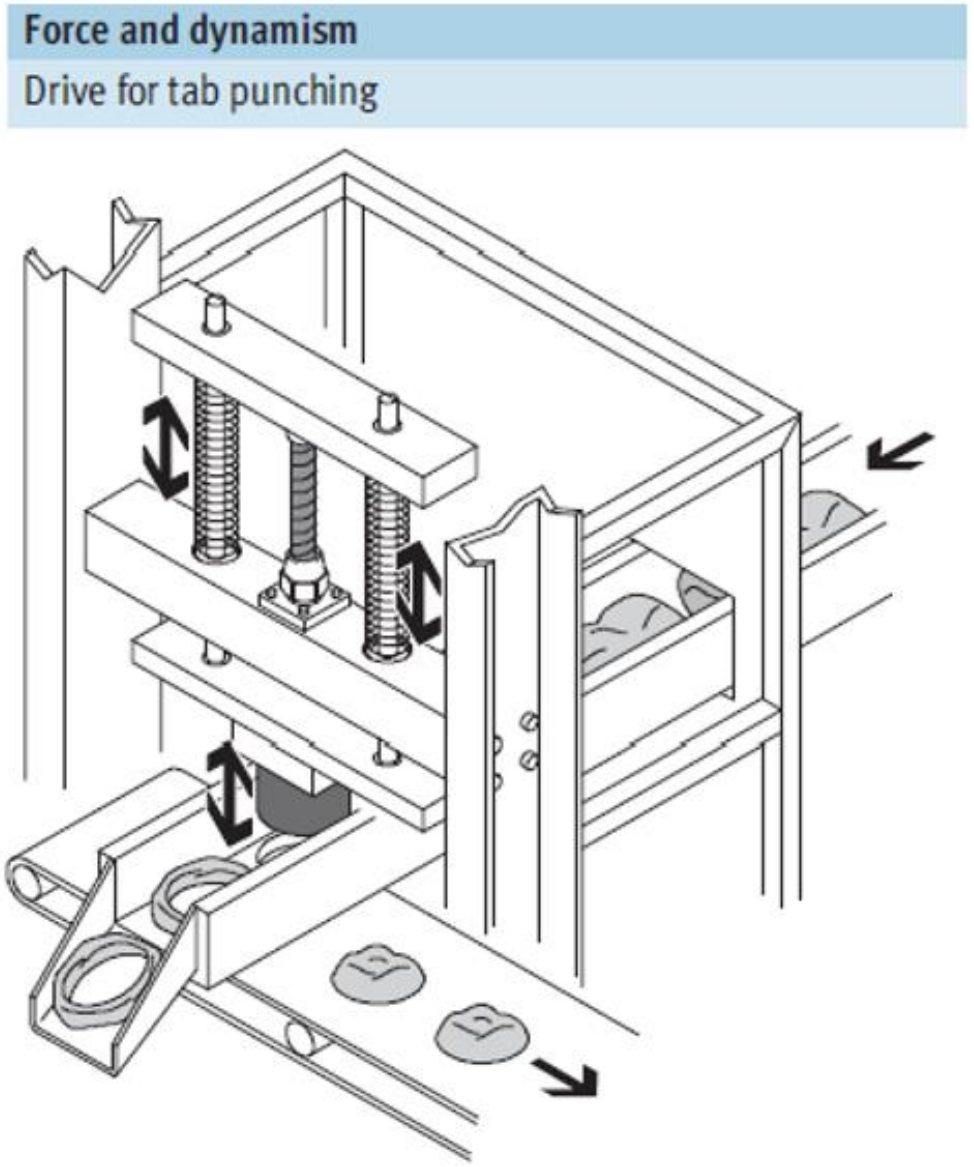
Tube Cylinder (Fluid Muscle)

General technical data				
Size		10	20	40
Pneumatic connection		G1⁄8	G1⁄4	G3⁄8
Design		Contraction membrane		
Mode of operation		Single-acting, pulling		
Internal dia.	[mm]	10	20	40
Nominal length	[mm]	40 ... 9000	60 ... 9000	120 ... 9000
Max. additional load, freely suspended	[kg]	30	80	250
Max. permissible pretensioning[1)]		*3% of nominal length*	*4% of nominal length*	*5% of nominal length*
Max. permissible contraction		25% of nominal length		
Max. hysteresis		≤ 3% of nominal length	≤ 2.5% of nominal length	
Max. relaxation		≤ 3% of nominal length		
Repetition accuracy		≤ 1% of nominal length		
Max. perm. offset of connections		Angle tolerance: ≤ 1.0°		
		Parallelism tolerance: ± 0.5% (up to 400 mm nominal length), ≤ 2 mm (from 400 mm nominal length)		
Type of mounting		With accessories		
Assembly position		Any (an external guide is required if lateral forces occur)		

Operating and environmental conditions				
Size		10	20	40
Operating pressure	[bar]	0 ... 8	0 ... 6	
Operating medium		Filtered compressed air, lubricated or unlubricated (other media upon request)		
Ambient temperature	[°C]	−5 ... +60		

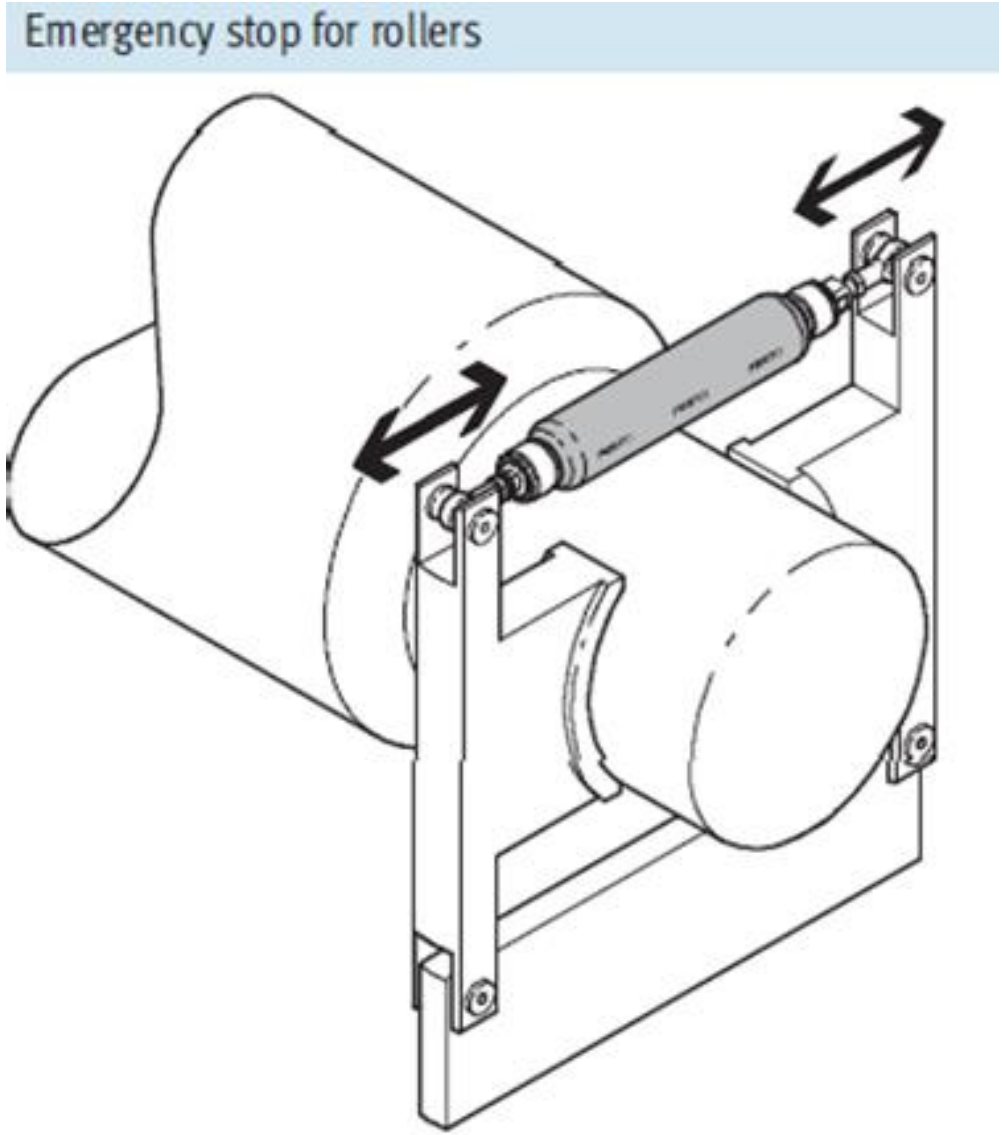
Tube Cylinder (Fluid Muscle)

- Very high cycle rates are possible with the muscle, on the one hand because of its low weight and on the other because it has no moving parts (e.g. piston).
- The simple construction – one muscle pretensioned using two springs – replaces a complicated toggle lever clamping system using cylinders. This makes a frequency increase of 3 to 5 Hz possible.



Tube Cylinder (Fluid Muscle)

- The fluidic muscle is setting new standards in applications that require fast response times.
- The emergency stop for rollers demands both speed and force. Long machine downtimes in the event of malfunctions can thus be prevented.

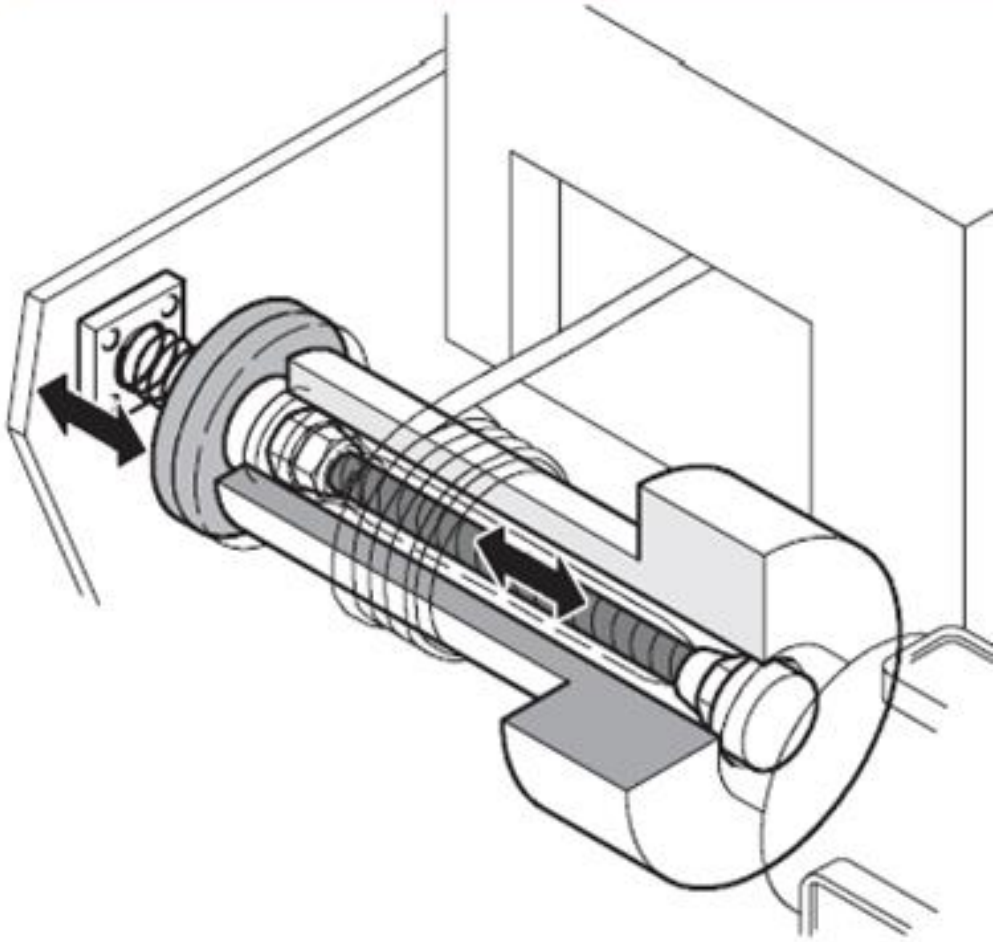


Tube Cylinder (Fluid Muscle)

- The friction-free muscle allows uniform and gentle braking of the pay-out reel, ensuring highly precise winding at constant speed.
- Control is provided by a proportional control valve whose signals are regulated via force sensors.

Judder-free movements

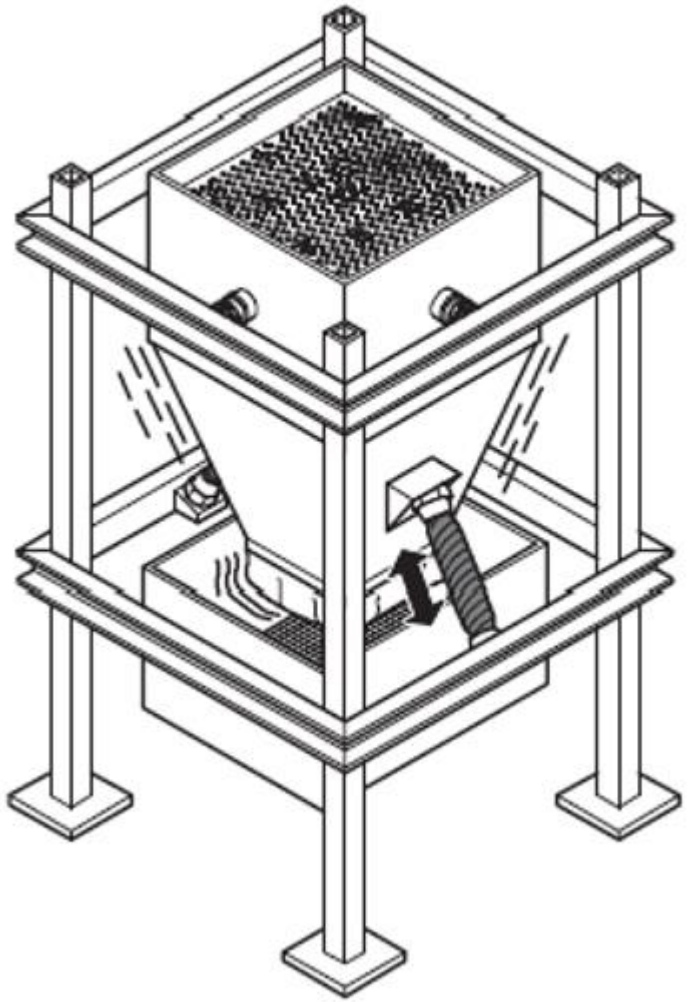
Brake actuator for rewinding equipment



Tube Cylinder (Fluid Muscle)

- Hoppers and silos are susceptible to the problem of parts jamming during feeding.
- Fluidic Muscle facilitates stepless regulation of a pneumatic shaker between 10 and 90 Hz, thereby guaranteeing continuous delivery.

Drive for a vibratory hopper



Tube Cylinder (Fluid Muscle)

- Approximate intermediate positions? No problem with pressure regulation.
- The workpieces can be raised or lowered as required by pressurizing or exhausting the muscle via a hand lever valve.
- Muscle lengths up to 9 m facilitate various types of application