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# Foreword

The Collection of Transparencies is conceived for the basic material of the TP100 Pneumatic Technology Package. The transparency collection and technology package form part of the Learning System for Automation from Festo Didactic GmbH & Co.

The transparencies are designed from a didactical and methodological point of view. For each transparency, there is a short accompanying text that provides the speaker with a quick overview of the contents. More information you will find in the textbook Pneumatics.

## Syllabus

- Physical fundamentals of pneumatics
- Function and application of pneumatic components
- Designation and drawing of pneumatic symbols
- Drawing of pneumatic circuit diagrams in accordance with standards
- Representation of motion sequences and operating statuses
- Direct and indirect stroke-dependent controls
- AND/OR logic functions of the input signals
- Time-dependent control system with time-delay valve
- Pressure-dependent control system with pressure sequence valve
- Troubleshooting with simple pneumatic control systems

The text pages contain a complete picture of the transparency with additional explanations and designations which the speaker can enter on the transparency during instruction.

The advantages of this concept are:

- The speaker can add to the transparencies step by step during the presentation
- Instruction is livelier
- The text pages supplied reduce preparation time

## New!

### Electronic presentation

The enclosed CD-ROM contains all the overhead transparencies and accompanying text of this edition in an electronically presentable form in the files „Pneumatics\_transparencies.pdf“ and „Pneumatics\_text.pdf“. In addition to the screen presentation, which can be made in any order, the contents can be printed out and text and graphics can be used for your own training preparations, insofar as the functionality of the required Adobe® Acrobat® Reader permits this. This freely distributable software is available on the CD-ROM in the currently valid English version for Windows 95/98/NT for installation in the directory „Acrobat\_Reader“. Please start the file „rs405eng.exe“ and follow the subsequent dialogue.

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## The Structure of Pneumatic Systems

Signal flow

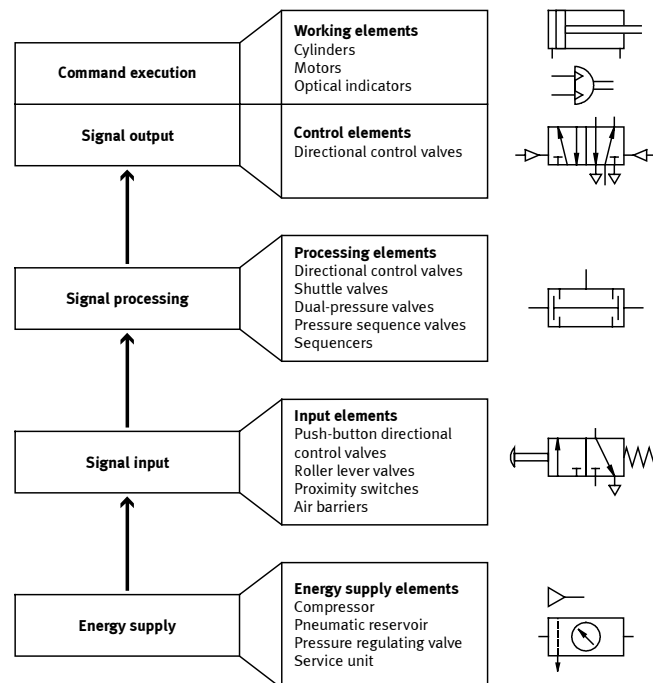
- From bottom to top

Control chain

- S P A principle: Sensor, processor, actuator
- I P A principle: Input, processing, output

Energy supply

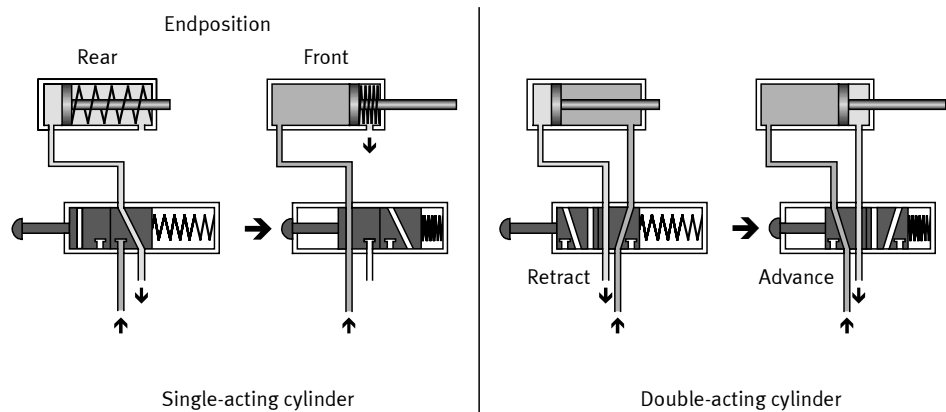
- Through tubing or piping





### Direct Actuation of Cylinders

Single-acting cylinders	<ul style="list-style-type: none"> <li>• Perform work in only one direction</li> <li>• Return position via spring</li> <li>• Air supply port, vent hole</li> </ul>
3/2-Way valve	<ul style="list-style-type: none"> <li>• 3 Working ports, 2 switching positions</li> <li>• Manually actuated, spring return</li> </ul>
Double-acting cylinder	<ul style="list-style-type: none"> <li>• Performs work in both directions</li> <li>• 2 air supply ports</li> </ul>
5/2-Way valve	<ul style="list-style-type: none"> <li>• 5 Working ports, 2 switching positions</li> <li>• Manually actuated, spring return</li> </ul>





## Symbols for the Power Supply Section

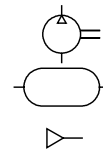
Symbols in accordance with DIN ISO 1219 "Fluid Technique – Graphical Symbols and Circuit Diagrams"

The triangle indicates the flow direction.

In general, the symbols for pneumatics and hydraulics are the same.

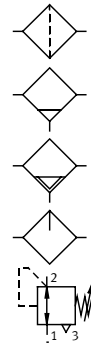
### Energy Supply

- Compressor with constant displacement volume
- Pneumatic reservoir
- Pressure source



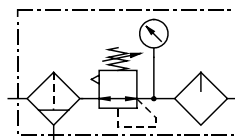
### Maintenance

- Filter
- Water separator with manual actuation
- Water separator with automatic condensate drain
- Lubricator
- Pressure regulating valve with relief port, adjustable



### Combined Symbols

- Air service unit  
Consisting of  
Compressed air filter,  
Pressure regulating valve,  
Pressure gauge and  
compressed air lubricator



Simplified representation  
of a service unit



Simplified representation  
of a service unit without  
compressed air lubricator



### Directional Control Valves: Ports and Switching Positions

Directional control valves are used as

- Control elements
- Processing elements or
- Input elements

Written title: 2/2-Way valve

Spoken title: Two-slash-two way valve

Port identification: By numbers

Open position/Normally open position

Closed position/Normally closed position

┌ Number of ports  
└ Number of switching positions

2/2-way valve, normally open position



3/2-way valve, normally closed position



3/2-way valve, normally open position



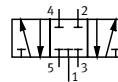
4/2-way valve  
flow from 1 → 2 and from 4 → 3



5/2-way valve  
flow from 1 → 2 and from 4 → 5



5/3-way valve, mid-position closed



### Port designations

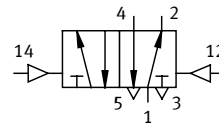
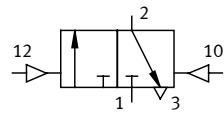
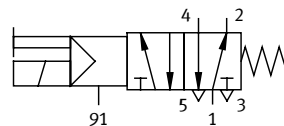
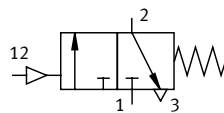
Port designation in accordance with DIN ISO 5599-3 "Fluid Technology – Pneumatics, 5-Way Valves"

#### Working ports

- 1          Supply port
- 2, 4      Working ports
- 3, 5      Exhaust ports

#### Pilot ports

- 10        Signal applied blocks flow from 1 to 2
- 12        Signal applied opens flow from 1 to 2
- 14        Signal applied opens flow from 1 to 4
- 81, 91    Auxiliary pilot air



## Types of Actuation

Symbols in accordance with DIN ISO 1219 "Fluid Technology – Graphical Symbols and Circuit Diagrams"

The symbols for the types of actuation are drawn directly on the valve symbols.

### Selection

Depending upon system requirements

- Manually actuated
- Mechanically actuated
- Pneumatically actuated
- Electrically actuated
- Combined types of actuation

### Purpose

- Actuate
- Reset
- Center

<b>Manual actuation</b>	– General	
	– Pushbutton operated	
	– Lever operated	
	– Via lever with detent	
	– Foot pedal operated	
<b>Mechanical actuation</b>	– Stem actuated	
	– Roller actuated	
	– Roller actuated only in one direction	
	– Spring actuated	
	– Spring centered	
<b>Pneumatic actuation</b>	– Direct pneumatic actuation	
	– Indirect pneumatic actuation, piloted	
<b>Solenoid actuation</b>	– Single-solenoid operation	
	– Double-solenoid operation	
<b>Combined actuation</b>	– Double solenoid valve, piloted, with manual override	

## Non-return, Flow Control and Pressure Control Valve

Non-return valves

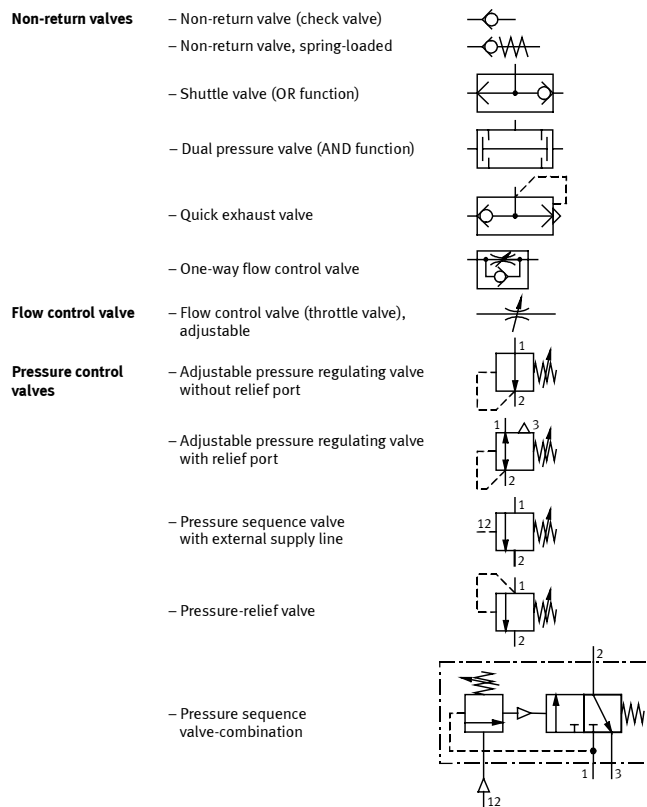
Non-return valves contain a non-return valve as basic element

Pressure control valves

Types of pressure valves:

- Pressure regulating valves
- Pressure sequence valves

Sloping arrow: denotes an adjustable valve



## Symbols for the Principle Working Elements

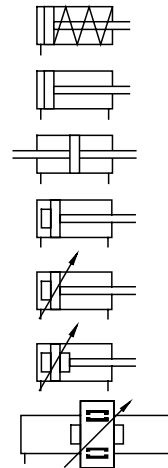
The symbol is represented with the advance motion to the right in the system circuit diagram

Single-acting: Performs work in one direction  
 Double-acting: Performs work in both directions

Sloping arrow over piston: denotes adjustable end position cushioning

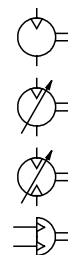
### Linear Actuators

- Single-acting cylinder
- Double-acting cylinder
- Double-acting cylinder with through piston rod
- Double-acting cylinder with single, non-adjustable cushioning
- Double-acting cylinder with single, adjustable cushioning
- Double-acting cylinder with adjustable cushioning at both ends
- Rodless cylinder with magnetic coupling



### Rotary Drives

- Air motor, constant displacement, rotation in one direction
- Air motor, variable displacement, rotation in one direction
- Air motor, variable displacement, rotation in both directions
- Pneumatic rotary motor



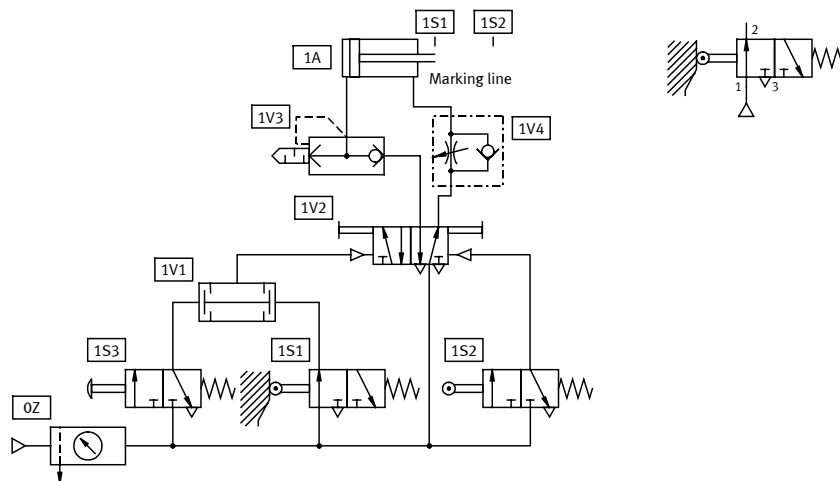
### Component designation

System number	<ul style="list-style-type: none"> <li>Beginning with 1</li> <li>Is used only if the entire switching circuit consists of more than one system</li> </ul>
Circuit number	<ul style="list-style-type: none"> <li>Components of energy supply, accessories 0</li> <li>Fluid circuits; Number assignment per cylinder 1, 2, ...</li> </ul>
Component designation	by letter <ul style="list-style-type: none"> <li>Working elements A</li> <li>Compressors P</li> <li>Sensors S</li> <li>Valves V</li> <li>Other components Z</li> </ul>
Component number	<ul style="list-style-type: none"> <li>Beginning with 1</li> <li>Continuous numbering of the same types of component</li> </ul>

Numbers assigned from left to right and from bottom to top

Actuated input elements:

Identified by the representation of a switching cam



### Direct and Indirect Actuation

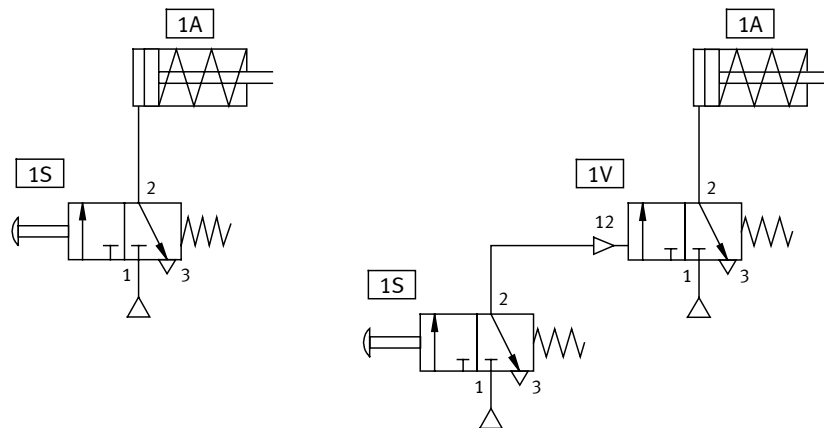
3/2-way valve: so that the piston chamber can be vented for the return stroke

Direct actuation

- Simplest possibility
- Input element = Control element

Indirect actuation

- Usual type of actuation
- For cylinders with large diameters
- In case of large distance between input element and working element







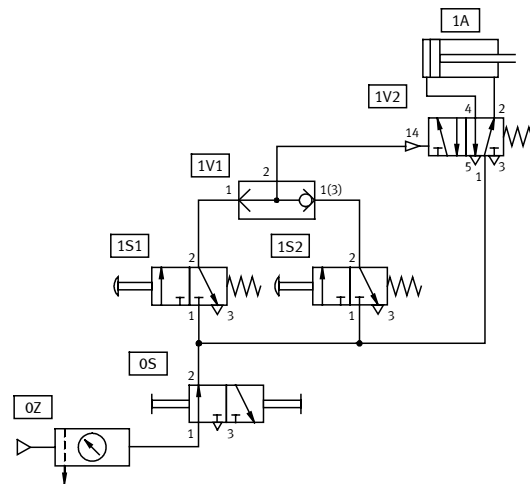
### Circuit Diagram: Shuttle Valve (OR Function)

Problem description

The piston rod of a double-acting cylinder is to advance if one of the two pushbuttons is actuated. The piston rod is to return when the pushbutton is released.

Assignment

Complete the valve symbol 1V1.  
Explain the functioning of the control.



### Circuit Diagram: 5/2-Way Double Pilot Valve (Speed Control)

#### Problem description

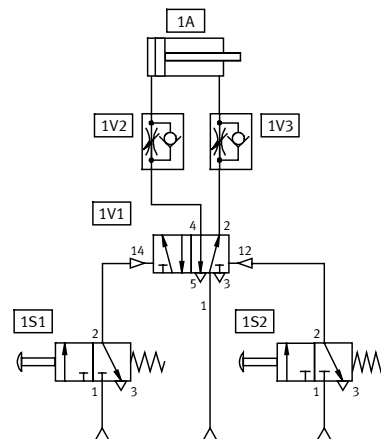
The piston rod of a double-acting cylinder is to move out upon manual actuation of a 3/2-way valve. The piston rod is to remain in its extended position until a second valve is actuated. After actuation of the second valve, the piston rod then moves back into its initial position. The piston speed should be adjustable in both directions.

#### Assignment

- Complete the circuit diagram.
- Explain the functioning of the control.

#### Flow control

- Supply air flow control
- Exhaust air flow control



### Circuit Diagram: Quick Exhaust Valve

Increases the piston speed of cylinders.

The flow resistance of the exhaust air is reduced.

Single-acting cylinder

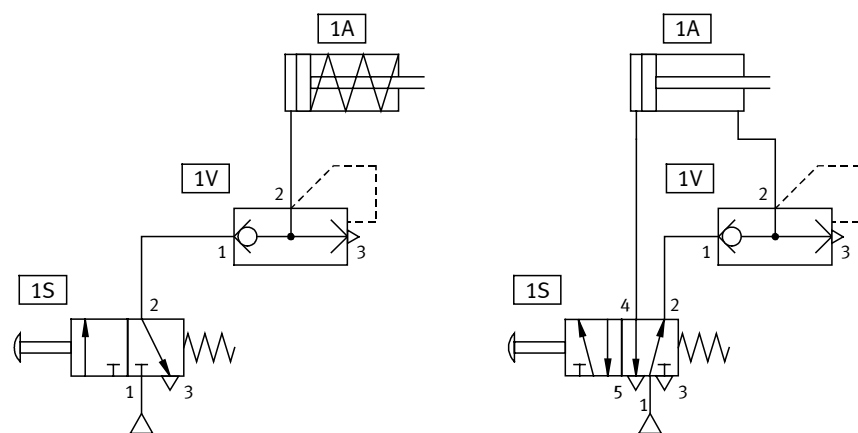
- The spring forces the piston into the retracted end position more quickly.

Double-acting cylinder

- The supply air forces the piston into the forward end position more quickly.
- The counter motion is not affected.

Installation

- Directly on the cylinder
- With a short piece of tubing



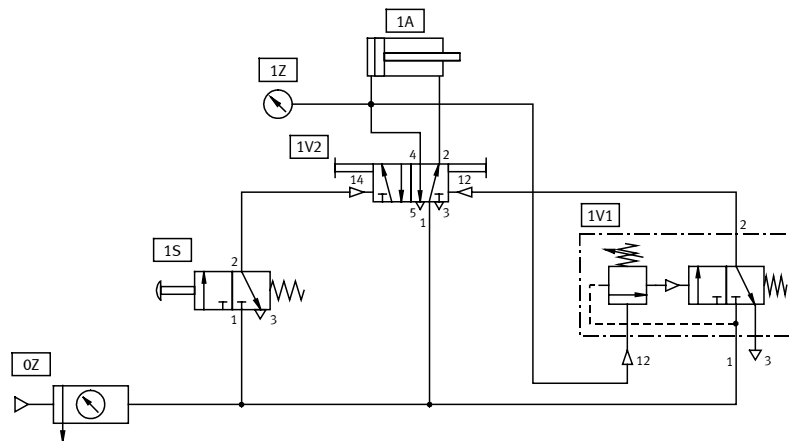
### Circuit Diagram: Pressure Sequence Valve

#### Problem Definition

A workpiece is to be stamped with an embossing stamp. The embossing stamp is to advance and stamp the part when a pushbutton is actuated. After reaching a preset pressure value, the embossing stamp is to retract automatically. The maximum embossing pressure should be adjustable.

#### Function

- When valve 1S is actuated, the control element 1V2 switches and the piston rod of cylinder 1A advances.
- When the piston rod strikes the workpiece, the pressure begins to rise.
- When the pressure in the piston chamber reaches the value preset on pressure sequence valve 1V1, the 3/2-way valve built into valve 1V1 switches.
- The control element 1V2 switches and the piston rod of cylinder 1A retracts.



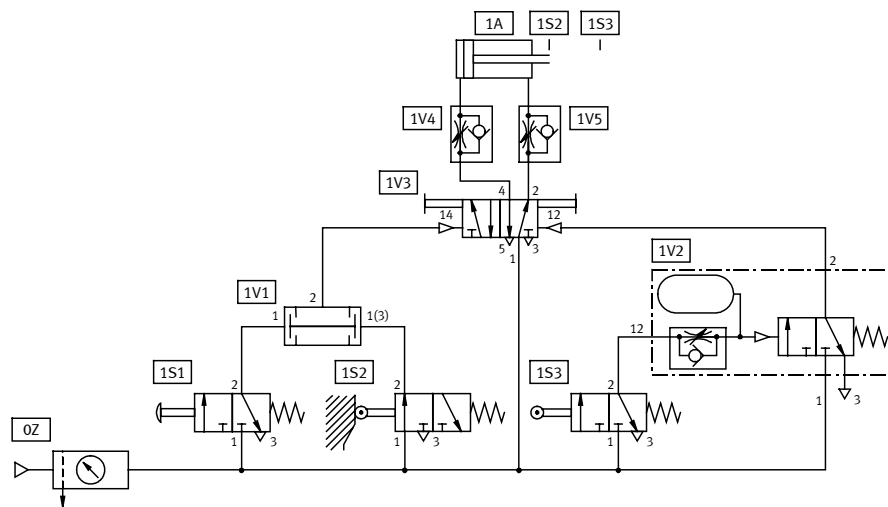
### Circuit Diagram: Time Delay Valve

#### Problem Description

A double-acting cylinder is used for the pressing and gluing of components. By actuating a pushbutton, the piston rod of the pressing cylinder slowly advances. When the pressing position is reached, the pressing force should be maintained for a time of approx. 6 seconds. After expiry of this time, the piston rod automatically retracts into its initial position. A re-start is possible only when the piston rod is located in its initial position.

#### Function

- If a signal is present at both inputs of the dual pressure valve 1V1, the control element 1V3 switches and the piston rod of cylinder 1A advances.
- When actuated, roller lever valve 1S3 sends a signal to the pilot port 12 of the time-delay valve 1V2.
- When the preset time has expired, the 3/2-way valve built into Valve 1V2 switches.
- The control element 1V3 switches and the piston rod of cylinder 1A retracts.



### Circuit Diagram: Coordinated Motion

#### Problem Description

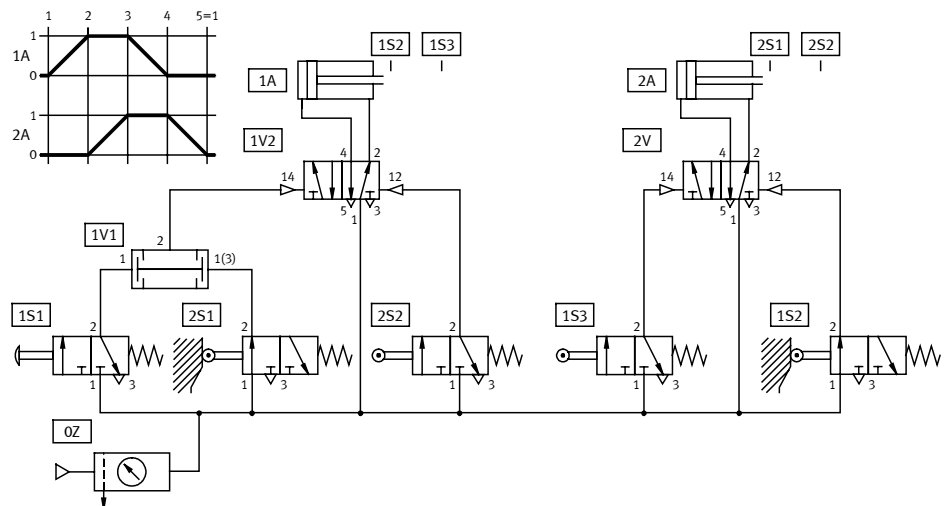
Two double-acting cylinders are used to transfer parts from a magazine onto a slide. After pressing a pushbutton, the first cylinder pushes the part out of the magazine. The second cylinder transports the part onto the slide. After the transfer is completed, the first cylinder then retracts followed by the second cylinder.

#### Function

- Pressing pushbutton 1S1 switches the 5/2-way double pilot valve 1V2 and the piston rod of cylinder 1A advances.
- In the forward end position, the piston rod of cylinder 1A actuates limit switch 1S3. The 5/2-way double pilot valve 2V switches and the piston rod of cylinder 2A advances.
- In the forward end position, the piston rod of cylinder 2A actuates limit switch S2S. The control element 1V2 switches and the piston rod of cylinder 1A retracts.
- In the retracted end position of cylinder 1A, the limit switch 1S2 is actuated and control element 2V switches. The piston rod of cylinder 2A retracts and actuates limit switch 2S1 when it reaches its retracted end position.
- The initial position has then been reached.

#### Note

In this motion sequence, no signals overlap.



### Circuit Diagram: Overlapping Signals

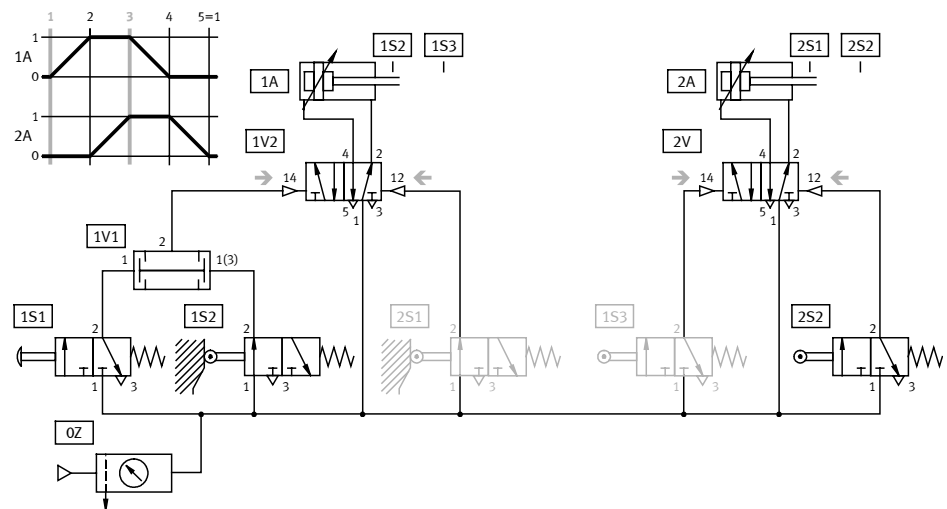
If signals are applied simultaneously to the two pilot ports of a double pilot valve, the switching of the valve is prevented. This is called signal overlapping. The signal first applied is dominant.

Possible Solutions  
Signal suppression

- Differing control surfaces
- A pressure regulator built into a pilot line

Signal Switchoff

- Roller lever valve with idle return
- Signal shortening
- Reversing valve
- Sequencer





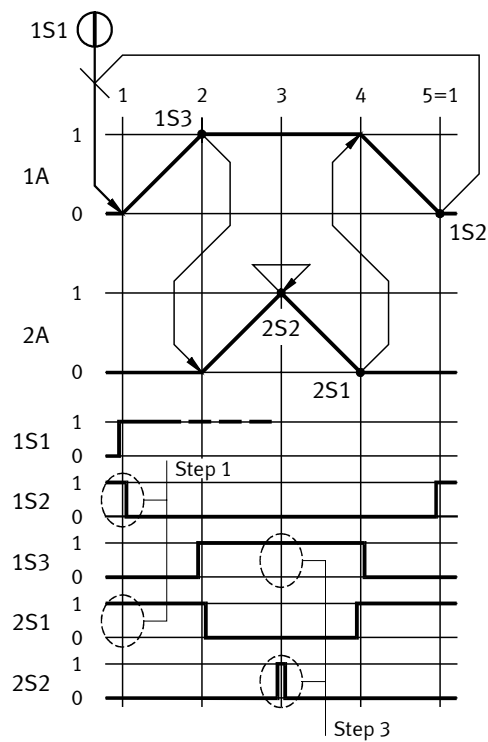
### Function Diagram: Overlapping Signals

#### Step 1

- Start button 1S1 is actuated; a signal is applied at both inputs of the dual pressure valve 1V1.
- A signal is applied to pilot port 14 of the control element 1V2.
- The control element 1V2 cannot switch as a signal is also applied to pilot port 12 by actuating the limit switch 2S1.

#### Step 3

- The extended piston rod of cylinder 2A actuates the limit switch 2S2 and a signal is applied to pilot port 12 of control element 2V.
- The control element 2V cannot switch as a signal is applied to the pilot port 14 by actuating the limit switch 1S3.



### Circuit Diagram: Roller Lever Valve with Idle Return

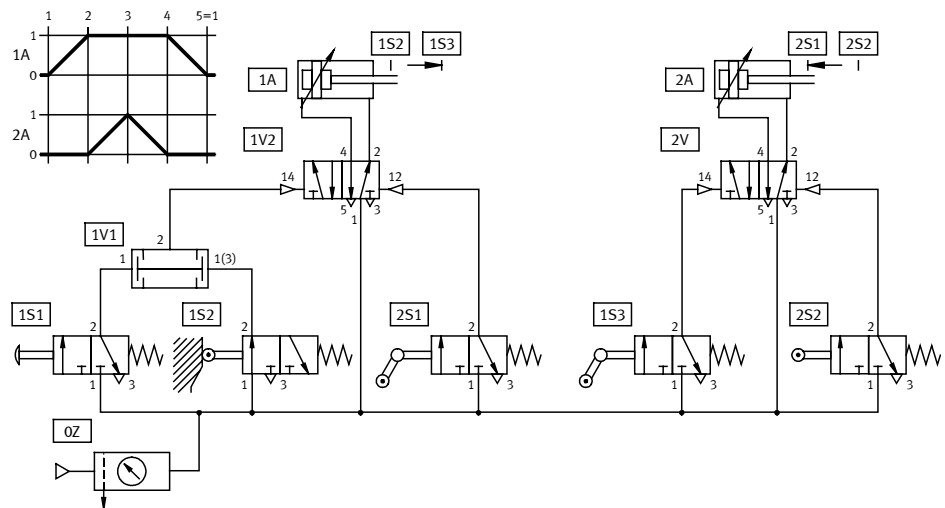
Overlapping signals are eliminated through roller lever valves. The roller lever valve with idle return switches only when the roller lever valve with idle return is approached from a certain direction. Overtravel in the opposite direction produces no signal.

#### Representation

- Valve symbol with type of actuation: via a roller, working in only one direction
- Marking lines on the cylinder with arrow to the left or right

#### Problem

- Switching cam of the cylinder travels over the roller lever and the end position is not detected.
- Signal from the valve is available for only a short time.



### Circuit Diagram: Reversing Valve

Overlapping signals are eliminated by using reversing valves.

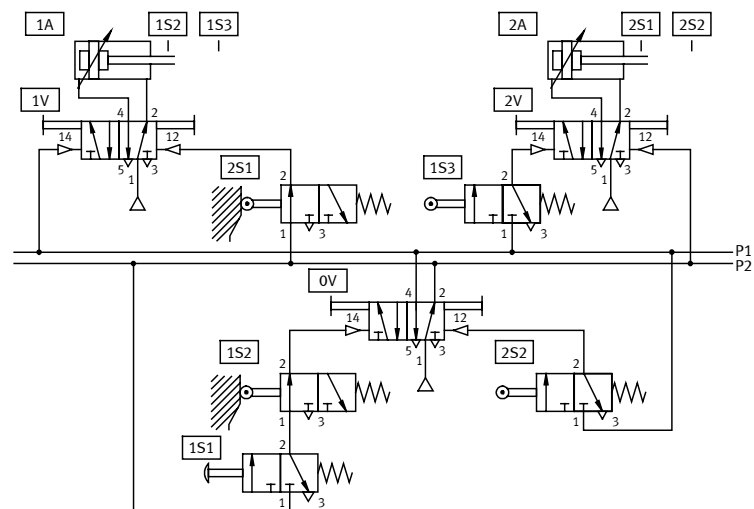
A 5/2-way double pilot valve (auxiliary memory) is installed as the valve.

Basic idea

- Signals are active only when they are required.
- Signals are not always further transmitted.
- Input elements are not always supplied with air.
- Distribution lines P1, P2

Switching diagram design based on the block form method

Greater operational reliability compared with roller lever valves with idle return



### Types of Compressor

The selection of a compressor depends upon the working pressure and the required air quantity.

#### Reciprocating piston compressor

The piston draws air in through the suction valve during the downward stroke, compresses it during the upward stroke and pushes it out through the pressure valve.

Pressure: Single-stage up to approx. 600 kPa (6 bar)  
Two-stage up to approx. 1500 kPa (15 bar)

#### Screw compressor

The air drawn in through the suction nozzle is moved axially through two impellers at high speed to the pressure side.

Pressure: Up to approx. 1000 kPa (10 bar)

#### Radial flow compressor

Through rapidly rotating blades, the air is accelerated radially. The kinetic energy of the air is converted into pressure energy.

Pressure: With multi-stage design up to approx. 1000 kPa (10 bar)

#### Sliding vane compressor (Rotary compressor)

Sliding vanes in an eccentrically located rotor divide the compressor chamber into closed cells. By reducing the size of the cells during the revolution, the air is compressed.

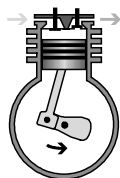
Pressure: Single-stage up to approx. 400 kPa (4 bar)  
Two-stage up to approx. 800 kPa (8 bar)

#### Axial compressor

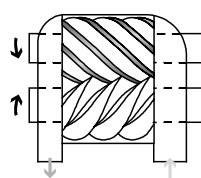
Through rapidly rotating blades, the air is accelerated radially. The kinetic energy of the air is converted into pressure energy.

Pressure: Up to approx. 600 kPa (6 bar)

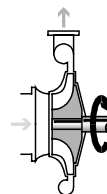
Reciprocating piston compressor, single stage



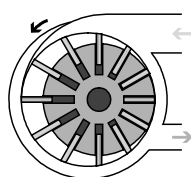
Screw compressor



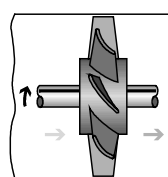
Radial-flow compressor



Sliding vane compressor (Rotary compressor)

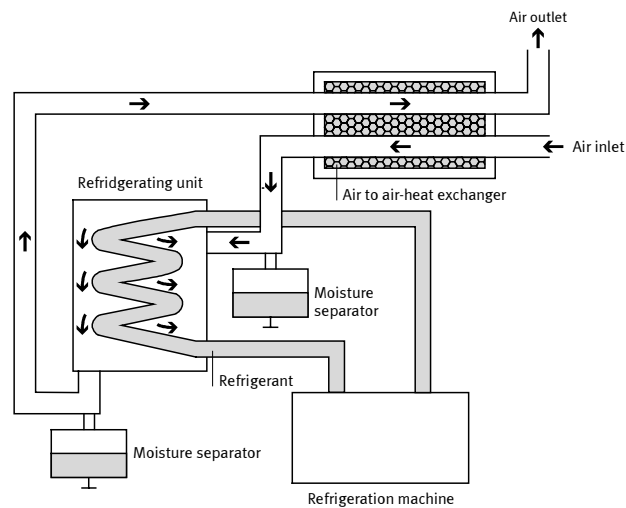


Axial compressor



### Air Drying: Refrigeration Drying

Dewpoint	Identifies the temperature at which the relative humidity has reached 100%. If the temperature is lowered further, the water vapor contained in it begins to condense.
Pressure dewpoint	<p>The temperature at which air under pressure has a relative humidity of 100%.</p> <p>With refrigeration drying, a pressure dewpoint between +2 °C and +5 °C is reached.</p> <p>The most frequently built dryer, works reliably and has low maintenance costs</p>



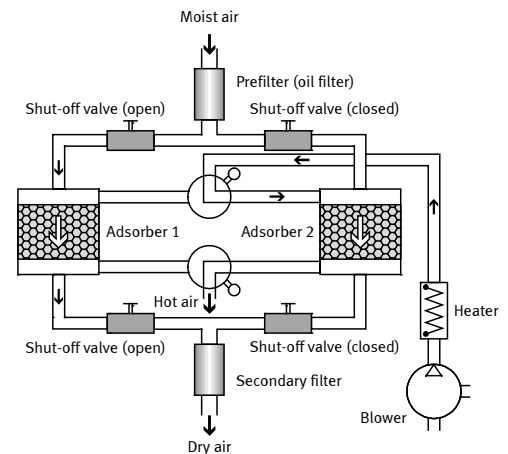
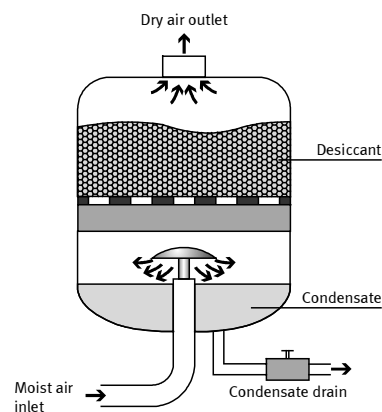
### Air Drying: Absorption Drying and Adsorption Drying

#### Absorption

- To bring gases or dissolved materials into a solid or liquid state
- Chemical process
- Moisture from the air combines with a desiccant, which becomes liquid and must be replaced
- High operating costs, simple installation, no external energy requirement

#### Adsorption

- To deposit gases or dissolved materials on the surface of a solid body
- Physical process
- Moisture from the air deposits on the porous surface of the desiccant
- Regeneration through hot air flow
- Pressure dewpoints down to  $-90\text{ }^{\circ}\text{C}$  possible



### Compressed Air Filter

The compressed air flows from left to right through the compressed air filter.

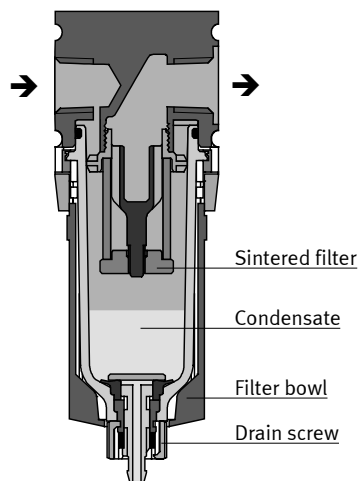
A baffle plate rotates the air.

Through the centrifugal force, water droplets and solid particles are removed.

The precleaned air flows through a filter insert.

Filter fineness

Standard filter:	5 $\mu\text{m}$ to 40 $\mu\text{m}$
Fine filter:	1 $\mu\text{m}$
Micro filter:	0.01 $\mu\text{m}$

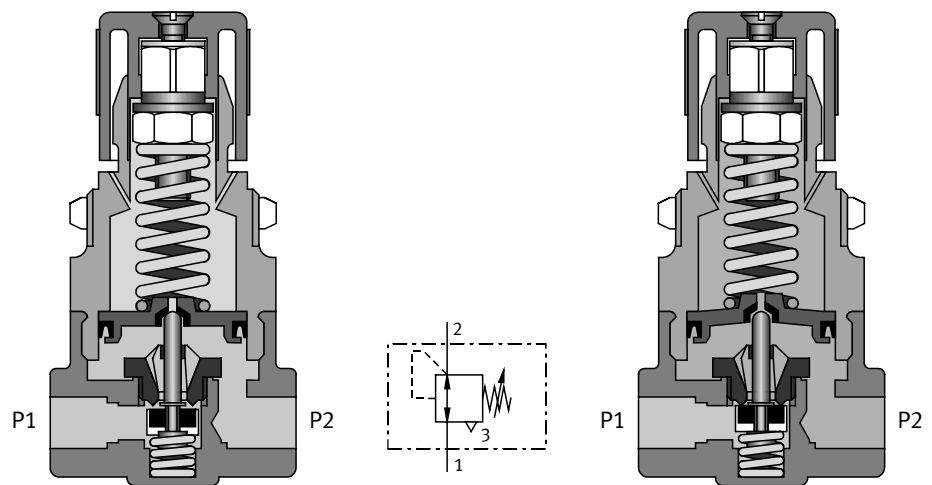


### Pressure Regulating Valve with Relief Port

The pressure regulating valve holds the working pressure largely constant, independent of pressure fluctuations in the network and the air consumption.

The inlet pressure must always be higher than the working pressure.

If the working pressure increases, for example, in case of a load change on the cylinder, the compressed air can escape through a vent hole.





## Compressed Air Lubricator

### Function Principle

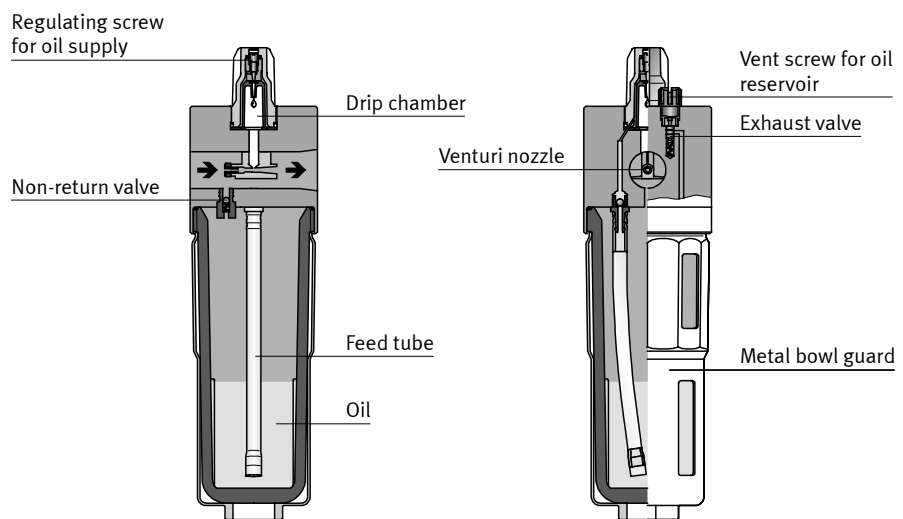
- The compressed air lubricator works on the Venturi principle.
- The compressed air flows through the lubricator.
- A vacuum is created at a narrowing in the flow channel.
- This causes oil to be drawn out of a reservoir through a feedpipe.
- The oil enters into a drip chamber, is atomized by the airflow and then transported further.

### Lubricate compressed air only

- In the case of extremely rapid motion sequences
- In the case of cylinders with large diameters

### Problems

- Malfunction of components
- Increased environmental damage
- Seizing of components after lengthy downtimes



### 3/2-Way Valve: Ball Bearing Seat, Normally Closed Position

3 Working ports, 2 switching positions

Unactuated

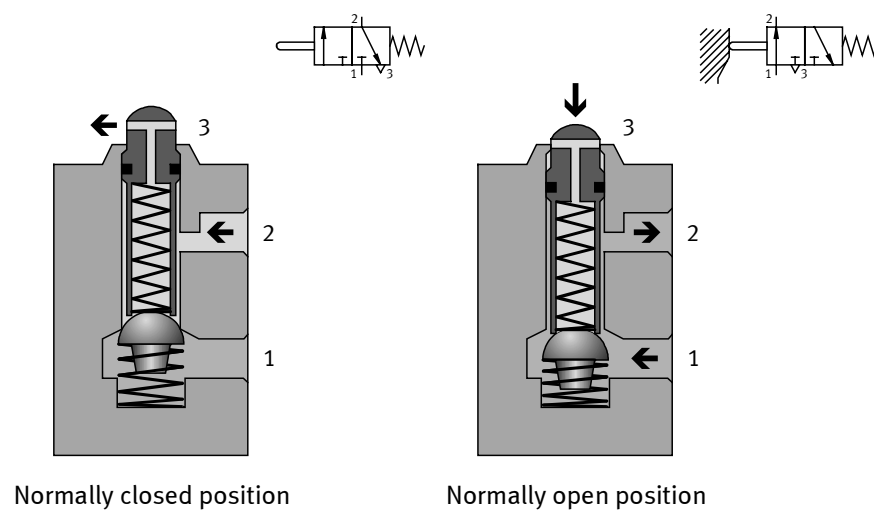
A spring-loaded hemispherical seal blocks the flow of air from the air supply port 1 to working port 2. Working port 2 is connected with exhaust port 3 via the stem.

Actuated

Initially, exhaust port 3 is blocked, then the flow from port 1 to port 2 opens.

Features

- Switching without overlap
- Simple, low-cost design
- Small size



### 3/2-Way Valve: Disk Seat, Normally Closed Position

3 Working ports, 2 switching positions

Unactuated

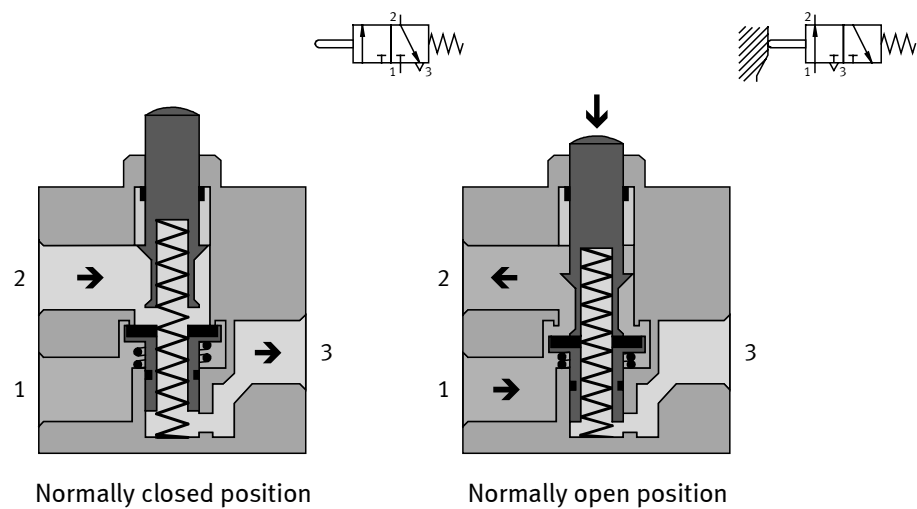
A spring-loaded disk seal blocks the flow of air from air supply port 1 to working port 2. Working port 2 is connected with exhaust port 3.

Actuated

Initially, exhaust port 3 is blocked, then the flow from port 1 to port 2 opens.

Features

- Switching without overlap
- Larger flow cross-section with shorter actuation stroke
- Insensitive to dirt
- Long service life



### 3/2-Way Valve: Disk Seat, Normally Open Position

3 Working ports, 2 switching positions

Unactuated

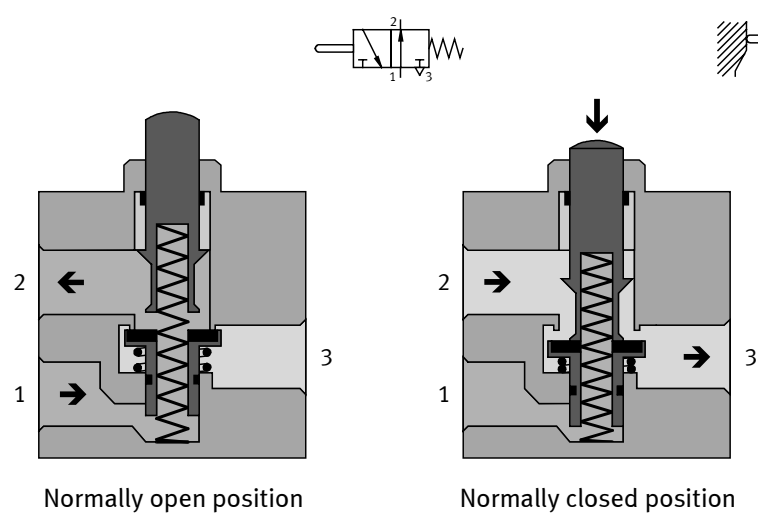
A spring loaded disk blocks exhaust port 3. Air supply port 1 is connected with working port 2.

Actuated

Initially, air supply port 1 is blocked, then the flow from port 2 to port 3 opens.

Features

- Switching without overlap
- Larger flow cross-section with shorter actuation stroke
- Insensitive to dirt
- Long service life



### 3/2-Way Single Valve, Normally Closed Position

3 Working ports, 2 switching positions

Unactuated

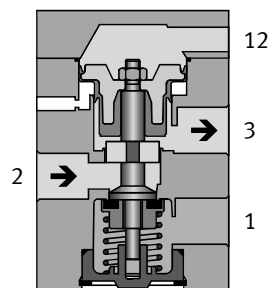
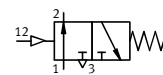
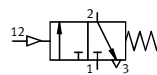
A spring-loaded disk blocks the flow from air supply port 1 to working port 2. Working port 2 is connected with exhaust port 3.

Actuated

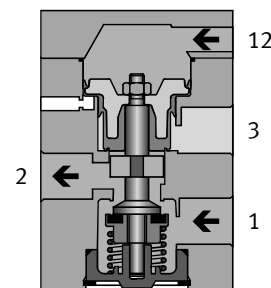
Initially, a pneumatic signal at pilot port 12 blocks exhaust port 3, then opens the flow from port 1 to port 2.

Sizing of the pilot piston area

Select the area in such a way that the valve disk is lifted reliably from the seat with the same pressure on ports 1 and 12.



Normally closed position



Normally open position

### Pilot Control

Pilot control valves are used to reduce the actuation forces.

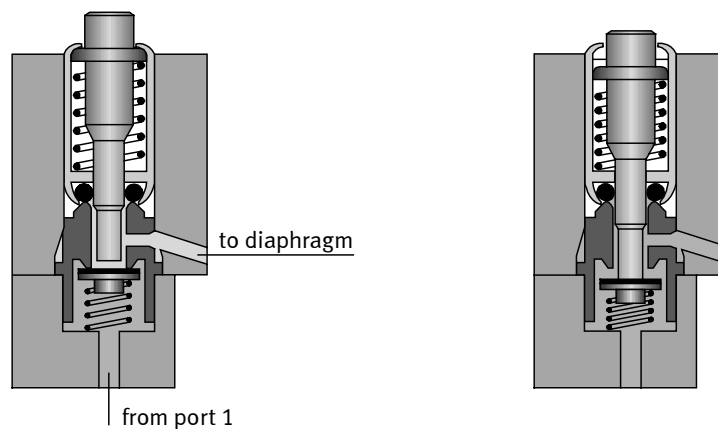
They are composed of 2 valves:

- The pilot control valve (3/2-way valve) with small nominal bore and
- The main valve

A small diameter air duct connects the air supply port 1 of the main valve with the pilot control valve.

When the stem of the pilot control valve is actuated, compressed air flows to the pilot piston of the main valve and the main valve switches.

The pilot control valve is vented through the guide sleeve of the stem.



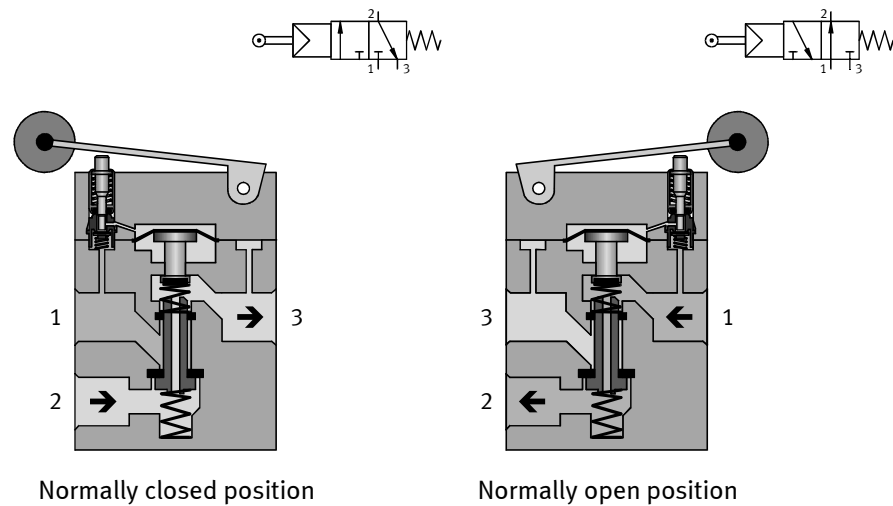
### 3/2-Way Roller Lever Valve, Pilot Actuated

3 Working ports, 2 switching positions

The roller lever is actuated, for example, by the switching cam on a cylinder.

Reduced actuation force through pilot control

Conversion from normally closed position to normally open position by exchanging ports 1 and 3 and repositioning the upper part of the housing by 180°.



### 4/2-Way Valve, Disk Seat

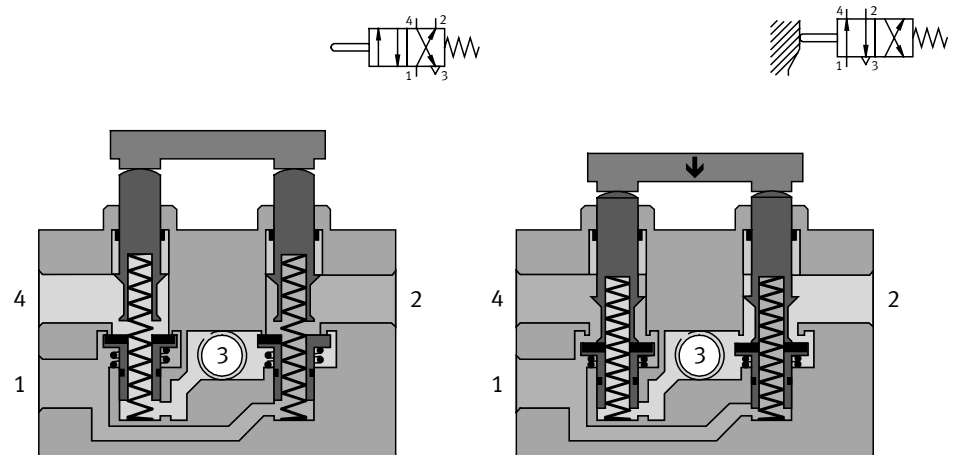
4 Working ports, 2 switching positions

Valve with two pilot pistons

Combination of two 3/2-way valves

- A 3/2-way valve in the normally closed position
- A 3/2-way valve in the normally open position

4/2-way valves are used to actuate double-acting cylinders.





### 4/3-Way Valve, Mid-Position Closed, (flat slide valve)

4 Working ports, 3 switching positions

Flat slide valves are mostly actuated manually as other types of actuation can only be implemented with difficulty.

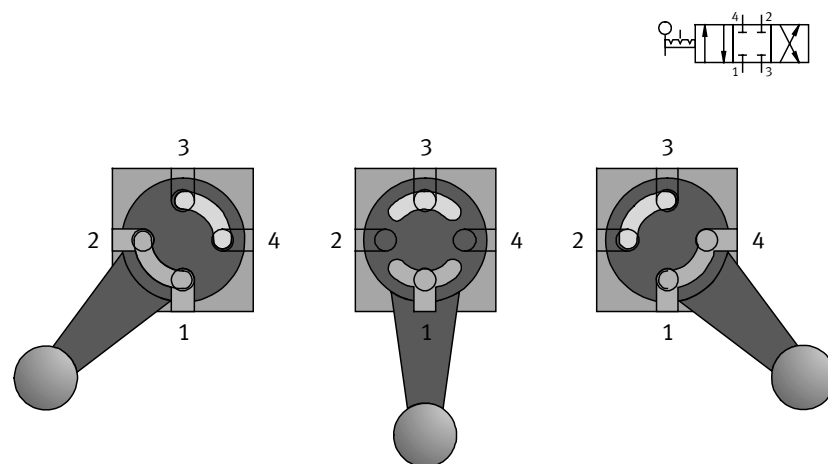
By rotating two disks, the flow channels are connected with, or isolated from each other.

Mid-position closed

- The piston rod of a cylinder can be stopped in any position within its stroke range
- Exact fixing of the position is not possible
- Because of the compressibility of the compressed air, the piston rod assumes different positions when the load changes

Mid-position exhausted

- The piston rod of the cylinder can be moved into any desired position via an external force.



### 5/2-Way Double Pilot Valve, Pneumatically Actuated, Both Sides

5 Working ports, 2 switching positions

The valve has a memory function. A short signal (pulse) is sufficient for actuation.

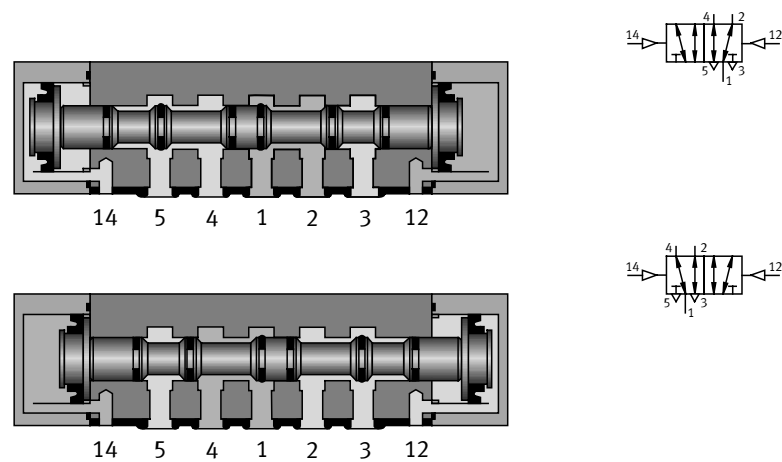
A pneumatic signal applied to pilot port 12 causes flow from port 1 to port 2.

A pneumatic signal applied to pilot port 14 causes flow from port 1 to port 4.

If signals are applied to both pilot ports, the first signal that arrives is dominant.

#### Features

- For actuation of double-acting cylinders
- Large actuation distances
- Small actuation forces



### 5/2-Way Double Pilot Valve, Suspended Disk Seat

5 Working ports, 2 switching positions

The valve has a memory function. A short signal (pulse) is sufficient for actuation.

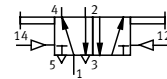
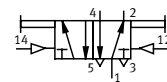
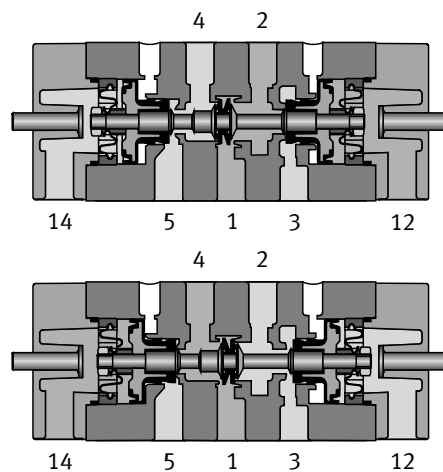
A pneumatic signal applied to pilot port 12 causes flow from port 1 to port 2.

A pneumatic signal applied to pilot port 14 causes flow from port 1 to port 4.

If signals are applied to both pilot ports, the first signal that arrives is dominant.

#### Features

- To control double-acting cylinders
- Shorter actuation distances in comparison with longitudinal spool valves



### 5/3-Way Valve, Pneumatically Actuated, Both Sides

5 Working ports, 3 switching positions

A pneumatic signal applied to pilot port 12(14) causes flow from port 1 to port 2(4).

If there is no signal applied to the pilot ports, the valve piston is centered in its mid-position by return spring.

Mid-position closed

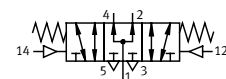
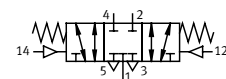
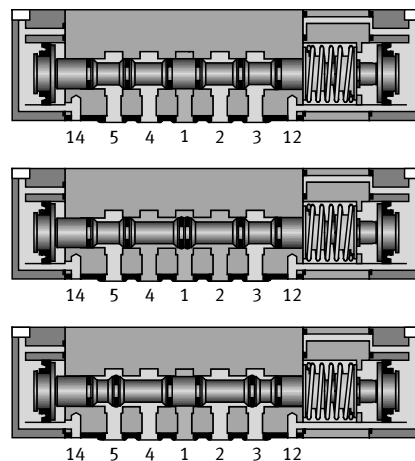
- The piston rod of a cylinder can be stopped in any position within its stroke range.
- Because of the compressibility of the compressed air, the piston rod assumes different positions with load change

Mid-position pressurised

- The piston rod of the cylinder moves outward with reduced force (area ratio, piston area/piston annular area).

Mid-position exhausted

- The piston rod of the cylinder can be freely moved into any desired position by an external force.



### Dual-Pressure Valve (AND Function)

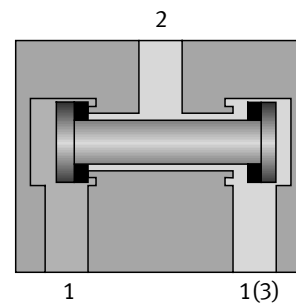
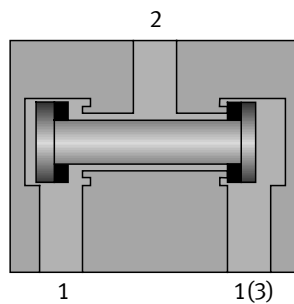
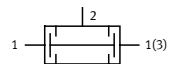
The dual pressure valve is used for the logic AND connection.

Compressed air signals applied to the inputs 1 and 1(3) produce a signal at output 2.

With no signal at all or only one input signal, no output signal is produced.

Output signals

- In case of time differences between the input signals, the signal arriving last reaches the output.
- In case of pressure differences between the input signals, the signal with the lower pressure reaches the output.



### Shuttle Valve (OR Function)

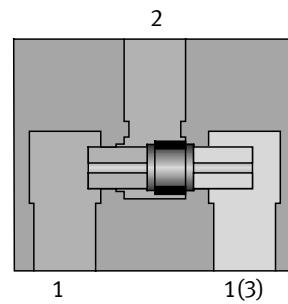
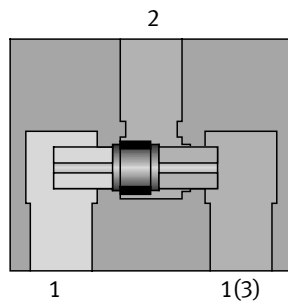
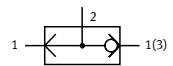
The shuttle valve is used for the logic OR connection.

Compressed air signals applied to input 1, input 1(3) or to both inputs produce a signal at output 2.

If there is no input signal, there is also no output signal.

Output signals

If signals are present at both inputs, the signal with the higher pressure reaches the output.



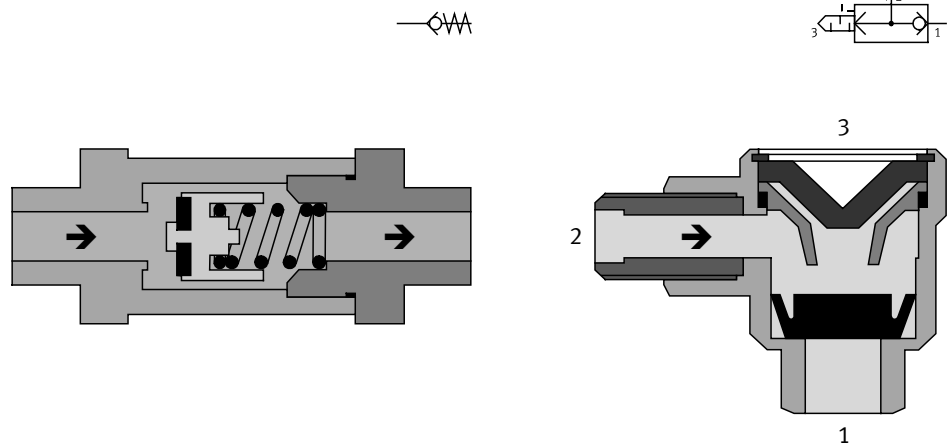
### Non-return Valve and Quick Exhaust Valve

#### Non-return valve

- Releases the flow in one direction
- Blocks the flow in the opposite direction
- The sealing body lifts from its seat when the force of the compressed air is larger than the pretensioning of the spring.

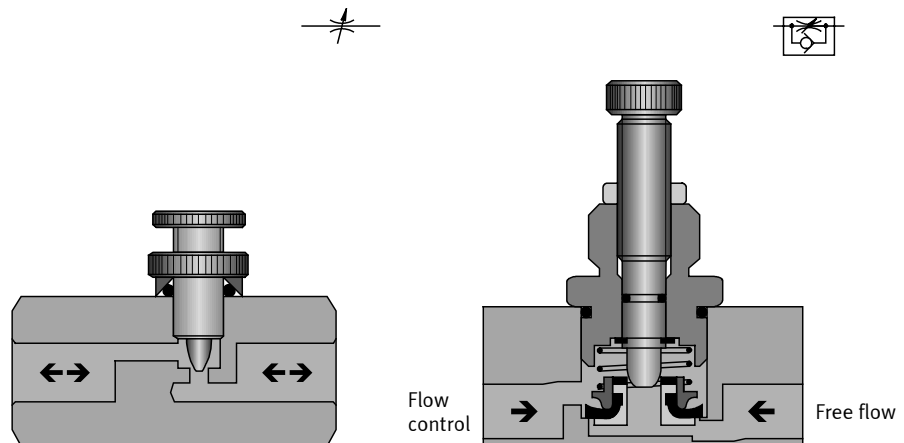
#### Quick exhaust valve

- Is used for quick venting of working elements
- The piston speed of a cylinder can be raised to almost the maximum possible value because the flow resistance at the exhaust is reduced during motion.
- Installation directly on the cylinder or as close as possible to the cylinder



### Flow Control Valve and One-Way Flow Control Valve

Flow control valve	<ul style="list-style-type: none"> <li>• Influences the volumetric flow of compressed air</li> <li>• Most flow control valves can be adjusted; the adjustment can be set.</li> <li>• Never close flow control valves completely.</li> </ul>
One-way flow control valve	<ul style="list-style-type: none"> <li>• Valve combination of a flow control valve and a non-return valve</li> <li>• Permits free flow in one direction, but the compressed air can only flow through the cross-section set in the opposite direction</li> <li>• Installation directly on the cylinder or as close as possible to the cylinder</li> </ul>
Applications	<ul style="list-style-type: none"> <li>• Supply air or exhaust air throttling of cylinders</li> <li>• Setting of signal delays</li> </ul>







### Pressure Sequence Valve

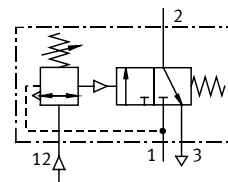
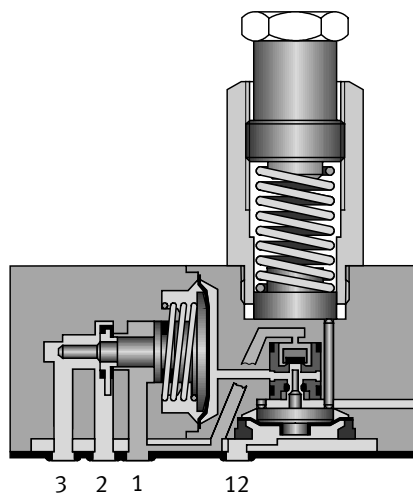
If the pressure at pilot port 12 exceeds a certain adjustable value, the 3/2-way valve actuated switches; compressed air is present at working port 2.

The 3/2-way valve switches back when the pressure at the pilot port is less than the preset value.

#### Application

A pressure-dependent signal is necessary for the further switching within a control system.

Example: Clamping pressure of a cylinder.



### Time Delay Valve, Normally Closed Position

#### Valve combination

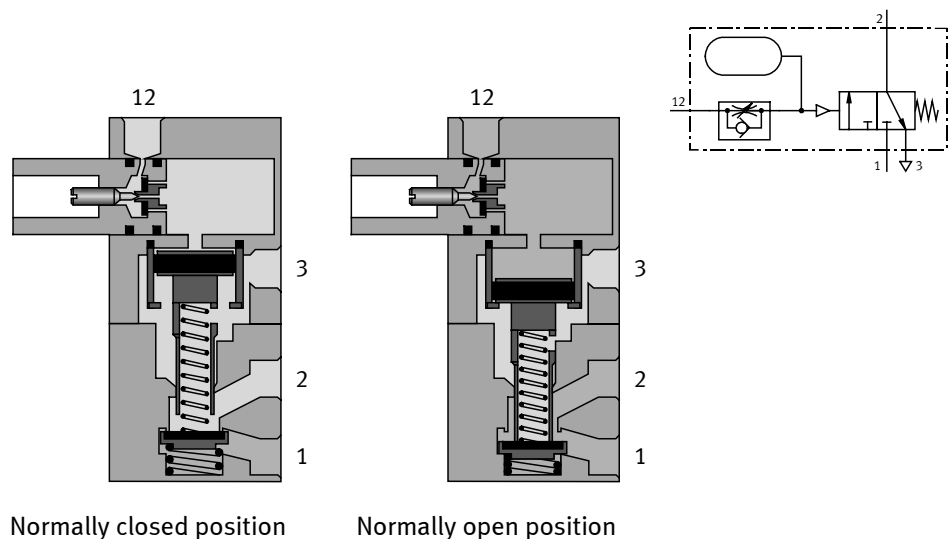
- A one-way flow control valve
- A compressed air reservoir and
- A 3/2-way pneumatic valve

#### Function

- Compressed air flows from pilot port 12 through the adjustable throttle into the compressed air reservoir.
- Depending on the throttle setting, more or less air flows into the compressed air reservoir per unit time.
- When the necessary pilot pressure has built up, the piloted 3/2-way pneumatic valve switches; compressed air is present at working port 2.
- If the pilot signal is removed, the 3/2-way pneumatic valve moves back immediately.

#### Application

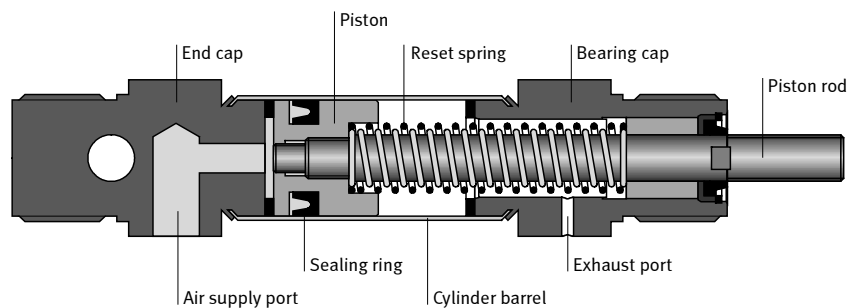
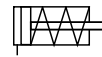
- Circuits with switch-on delay time behaviour
- Circuits with switch-off delay time behaviour
- Circuits with signal shortening
- Circuits with signal lengthening



### Single-Acting Cylinder

Pneumatic drives have the function of converting the energy stored in compressed air into kinetic energy.

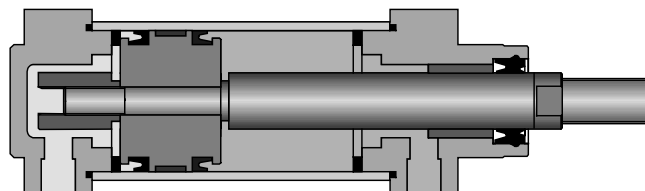
Function	<ul style="list-style-type: none"> <li>• In single-acting cylinders, compressed air is applied to only one side of the piston. The cylinder can perform work only in this direction (working stroke).</li> <li>• The piston returns through a built-in spring or external force (return stroke).</li> </ul>
Actuation	3/2-way valve
Types	<ul style="list-style-type: none"> <li>• Piston cylinder</li> <li>• Membrane cylinder</li> <li>• Rolling membrane cylinder</li> </ul>



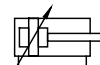
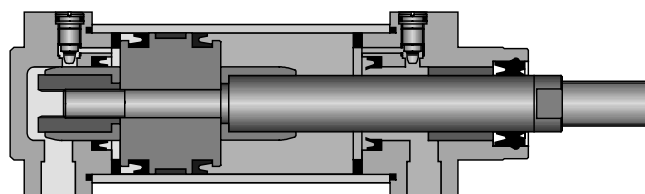
## Double-Acting Cylinder

Function	In the case of the double-acting cylinder, compressed air is applied to the cylinder from both sides. The cylinder can perform work in both directions.
Piston force	In the case of cylinders with a piston rod on one side, the advance stroke force is greater than the return stroke force (ratio piston area/piston annular area).
End position cushioning	Is used with large moving masses to avoid hard impact of the piston in the end positions. A cushioning piston interrupts the direct exhaust air path. The air must flow through a small, often adjustable cross-section.
Actuation	5/2-way valve, 5/3-way valve
Types	<ul style="list-style-type: none"> <li>• Piston cylinder</li> <li>• Cylinder with through piston rod</li> <li>• Tandem cylinder</li> <li>• Multi-position cylinder</li> </ul>

Double-acting cylinder



Double-acting cylinder with adjustable endposition cushioning



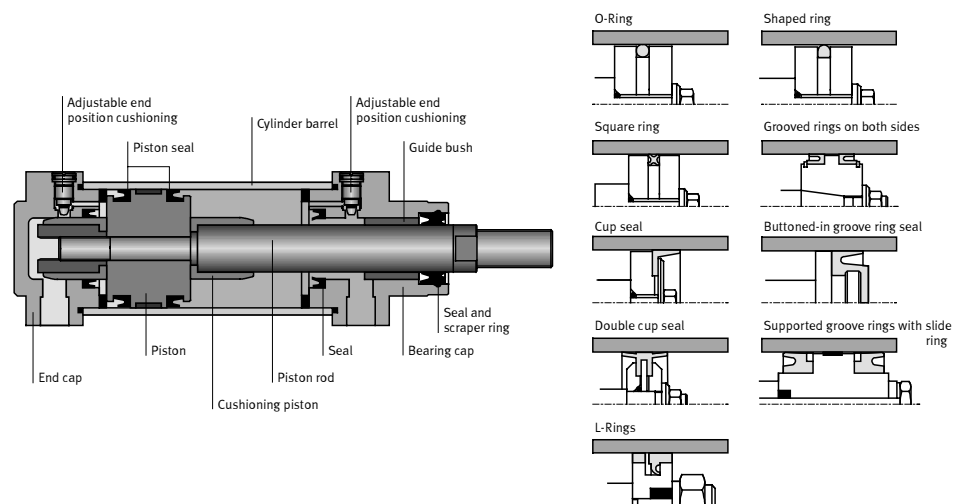
## Cylinder Construction and Types of Seal

### Construction

- Cylinder barrel
- End and bearing cap
- Piston with seal
- Piston rod
- Bearing bush
- Scraper ring
- Connection parts
- Seals
- Return position spring (only single-acting cylinder)

### Types of seal

- Function:  
Seal chambers from each other
- Installation criteria:  
Dimensions, precision fit, friction force, service life, chemical resistance
- Materials:  
Perbunan, Viton, Teflon



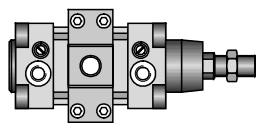
### Types of Mounting

The type of mounting is determined by the attachment of the cylinder to a fixture or machine.

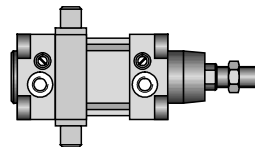
Through additional parts (modular principle), the cylinder can be converted for another type of attachment.

#### Advantages

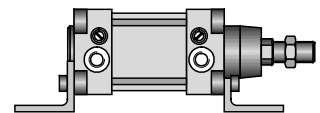
- Reusability
- Simplification of inventory-keeping
- Cost savings



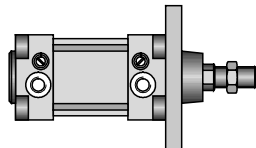
Centre swivel flange



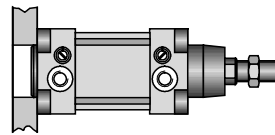
Rear swivel flange



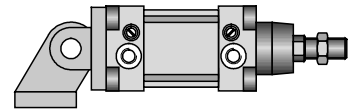
Foot mounting



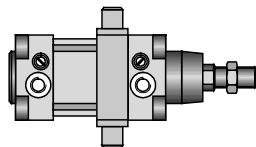
Front flange



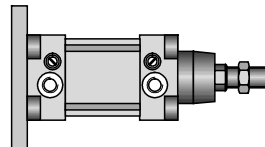
Rear mounting



Swivel flange



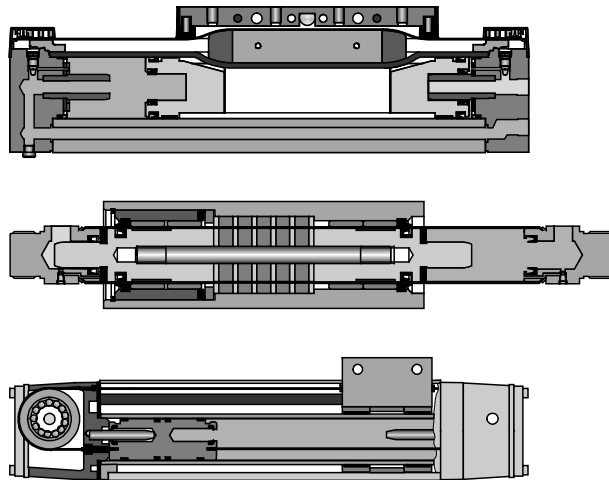
Front swivel flange



Rear flange

### Rodless Cylinder

Function	Compressed air is applied to rodless cylinders from both sides. The cylinder can perform work in both directions.
Piston force	Is equally large in both directions
Actuation	5/2-way valve, 5/3-way valve
Features	<ul style="list-style-type: none"> <li>• Short installation length (in comparison with standard cylinders)</li> <li>• No danger of bending of the piston rod.</li> <li>• The movement is guided over the entire stroke length.</li> <li>• Stroke length up to 10 m possible</li> </ul>
Types	<ol style="list-style-type: none"> <li>1. Sealing band cylinder with slotted cylinder barrel</li> <li>2. Cylinder with magnetically coupled slide</li> <li>3. Belt or cable pulley cylinder</li> </ol>





### Rotary Cylinder and Swivel Drive

#### Rotary cylinder

- The piston rod has a tooth profile. This tooth profile drives a gear.
- The linear movement of the piston is converted into the rotary movement of the gear.
- Angle of rotation:  
0° to 360°
- Torque:  
Approx. 0.5 Nm to 150 Nm at 600 kPa (6 bar) operating pressure, depending upon piston diameter

#### Swivel drive

- The compressed air drives a vane.
- The movement of the vane is transmitted directly to the drive shaft.
- Swivel angle:  
From 0° to 270°
- Torque:  
Approx. 0.5 Nm to 20 Nm at 600 kPa (6 bar) operating pressure, depending upon the size of the swivel vane

