PNEUMATIC DRIVES

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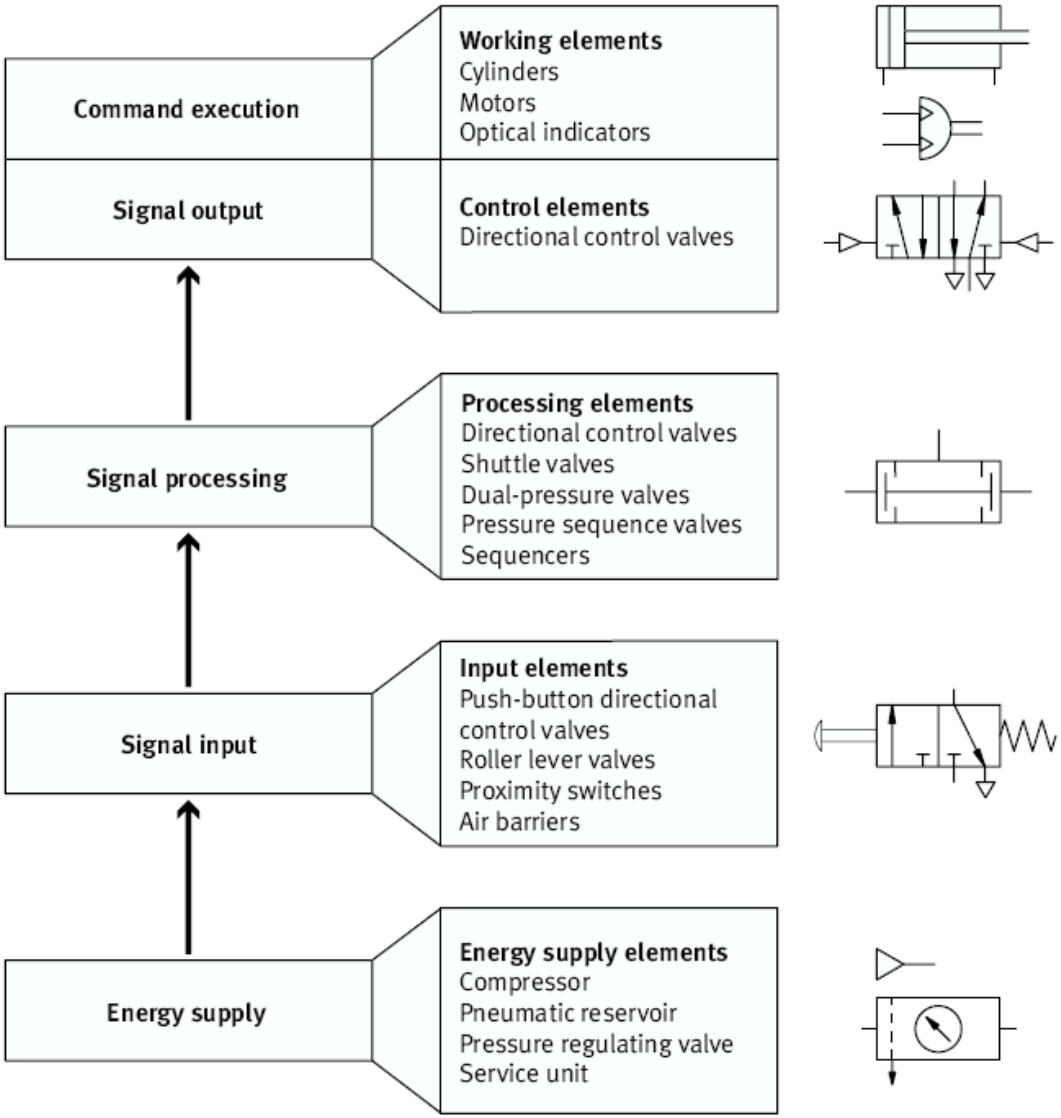
Basic mean for automation
of sewing machine

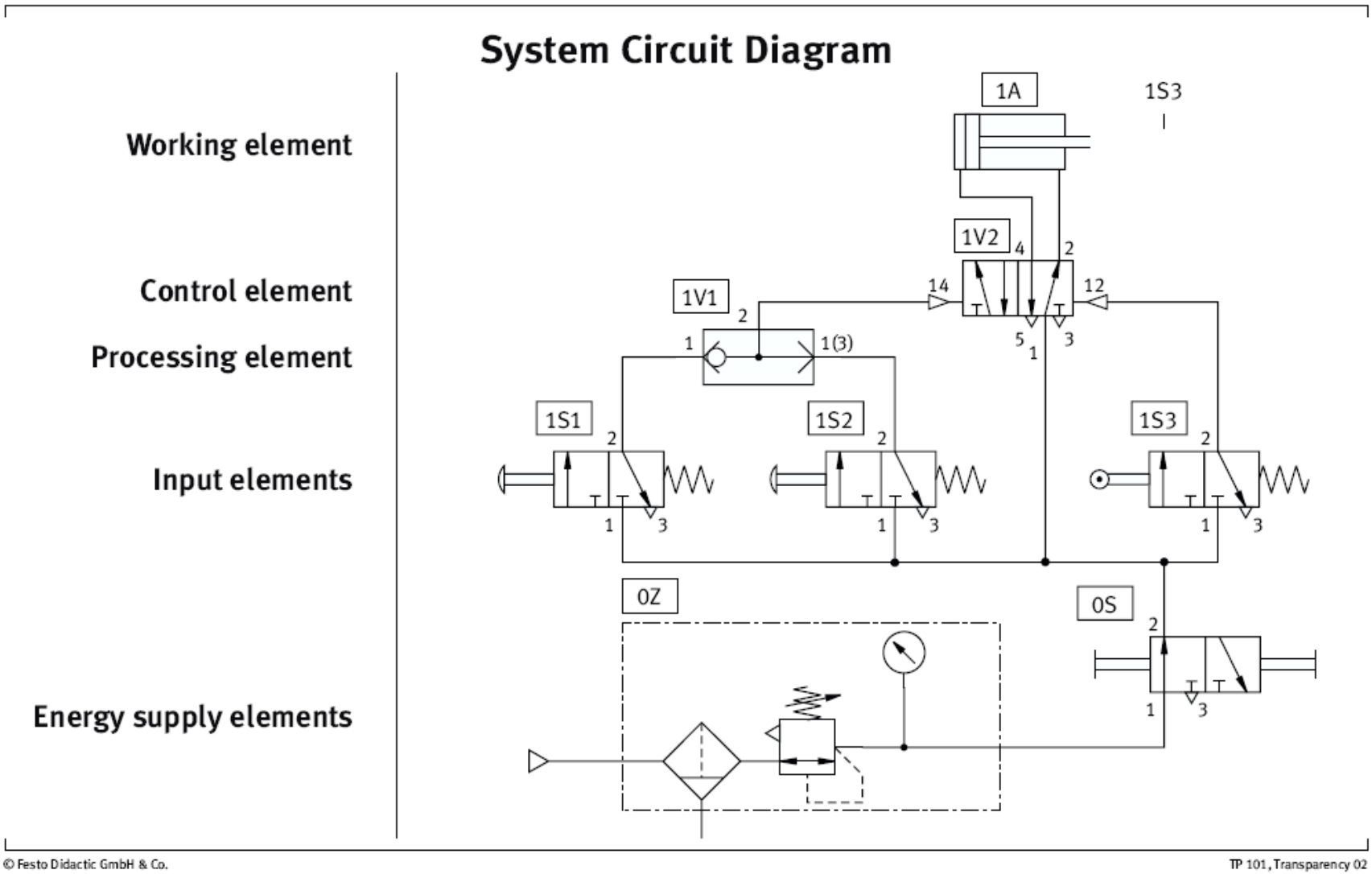
Pneumatic drives

- Properties of pneumatic drives
  - Speed: 8 m/s (common speed 2-3 m/s)
  - Air pressure: 0,6 MPa (defines a force $F = S*p$)
  - Power < 1kW

The Structure of Pneumatic Systems



System Circuit Diagram

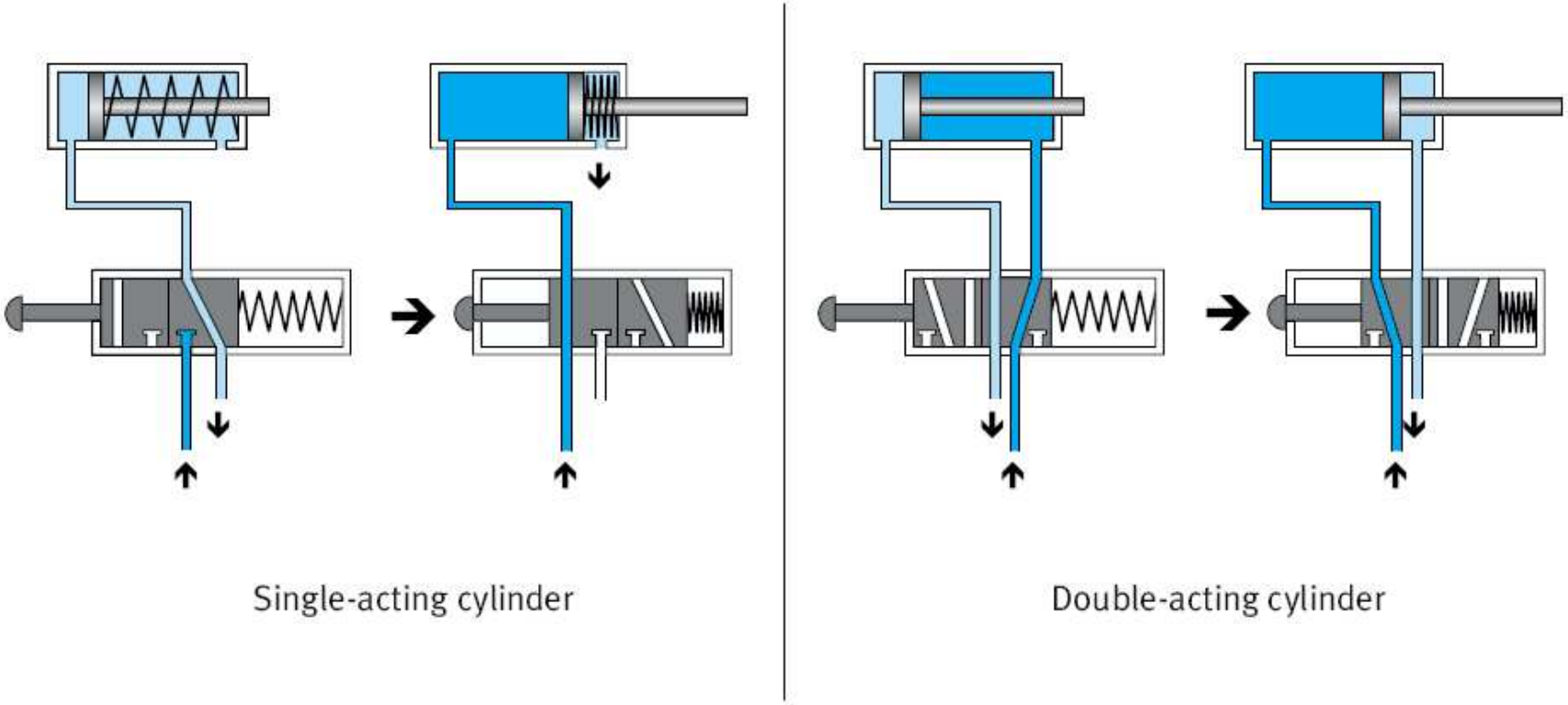


Pneumatic drives

- Division according to the element converting the pressure to force or deflection:
  - With membrane
  - With piston
  - Special
- According to the way motion is generated
  - Single-acting
  - Double-acting
- According to the path of the output element
  - Linear
  - Swivel
  - Rotary
- According to the signal
  - Continuous (proportional)
  - Discontinuous

Type of drives used in practice (seminars)

Direct Actuation of Cylinders



- The double-acting cylinder has two working ports and can therefore create a force during extending and retracting the piston (hence the naming).
- The single-acting cylinders, however, can produce a force in one direction only. The retraction is done here by a return spring.

PISTON FORCE calculation for linear engines

THEORETICAL PISTON FORCE is given by:

$$F_{th} = A \cdot p$$

where F_{th} - theoretical piston force [N, kp]

A - piston area [m^2, cm^2]

p - working pressure [Pa, bar]

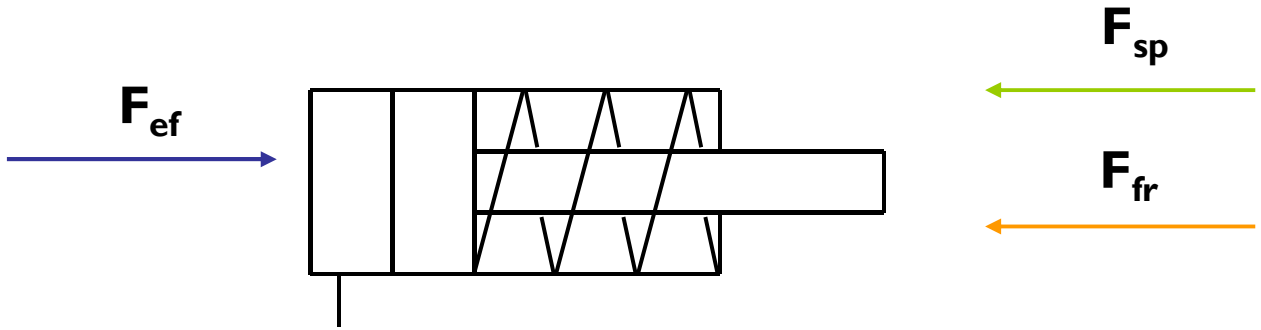
Pneumatic piston drives achieve considerable forces - tens of kN.

Piston force

- However, EFFECTIVE PISTON POWER is important for practice
- Frictional resistances must be taken into account in its calculation
- Under normal operating conditions, frictional forces can amount to 3 - 20% of the total derived force
- The single-acting cylinder has a significantly worse efficiency simply because the piston force has to work against the return spring
- Assume an efficiency of 0.95 for double-acting cylinders and 0.8 for single-acting cylinders

Effective force – single-acting cylinder

$$F_{ef} = A \cdot p - F_{fr} - F_{sp}$$



Force analysis of a single-acting cylinder

Where

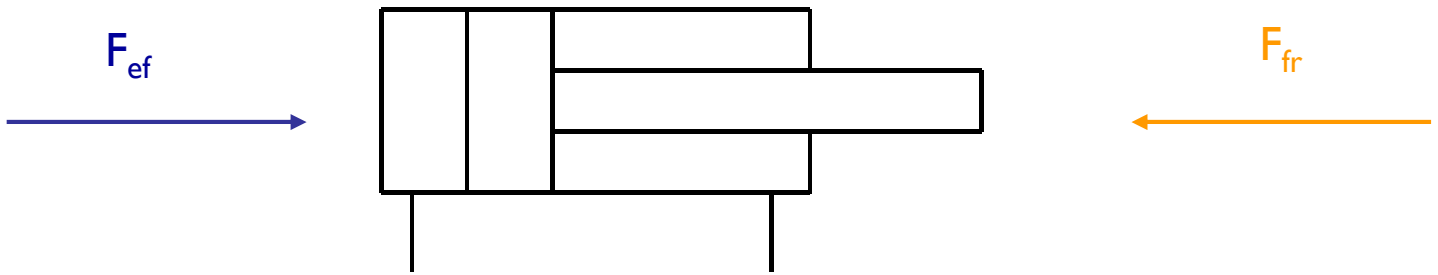
F_{ef} effective force

F_{fr} frictional resistance force

F_{sp} return spring force

Effective force – duble-acting cylinder

$$F_{ef} = A \cdot p - F_{fr}$$



Force analysis of a double-acting cylinder

Where

F_{ef} effective force

F_{fr} frictional resistance force

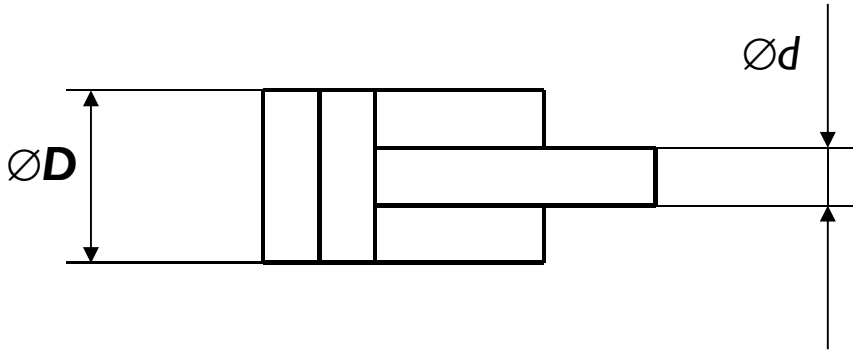
Effective force – duble-acting cylinder RETRACTION MOVEMENT

$$F_{ef} = A' \cdot p - F_{fr}$$

Where

$A = \frac{D^2 \cdot \pi}{4}$ - effective piston area [m^2]

$A' = \frac{(D^2 - d^2) \cdot \pi}{4}$ - effective piston area on the piston rod side [m^2]



p working pressure [Pa]

F_{ef} effective force [N]

F_{fr} frictional resistance force [N]

D inner diameter of the piston [m]

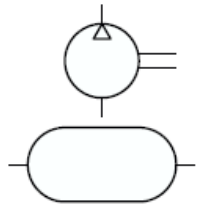
d piston rod diameter [m]

Symbols for the Power Supply Section

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

Energy Supply

– Compressor with constant displacement volume

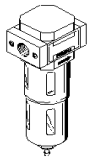


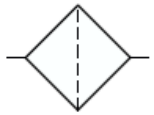
– Pneumatic reservoir

– Pressure source

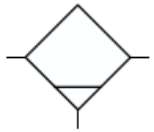
Maintenance

– Filter

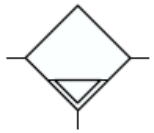




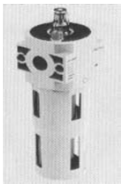
– Water separator with manual actuation



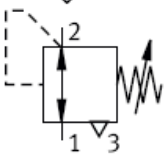
– Water separator with automatic condensate drain



– Lubricator



– Pressure regulating valve with relief port, adjustable



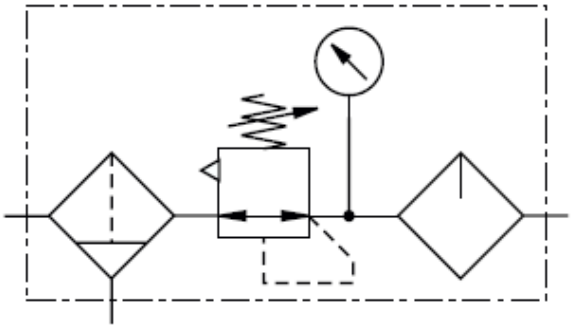
- The triangle indicates the flow direction.
- In general, the symbols for pneumatics and hydraulics are the same.

Symbols for the Power Supply Section

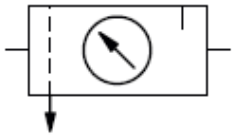
Combined Symbols

– Air service unit

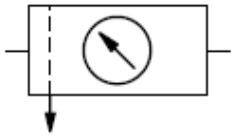
Consisting of
Compressed air filter,
Pressure regulating valve,
Pressure gauge and
compressed air lubricator



Simplified representation
of a service unit



Simplified representation
of a service unit without
compressed air lubricator



Directional Control Valves

Directional control valves are used as
- Control elements
- Processing elements or
- Input elements

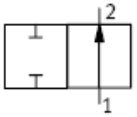
Written title: 2/2-Way valve
Spoken title: Two-slash-two way valve
Port identification: By numbers

Open position/Normally open position
Closed position/Normally closed position

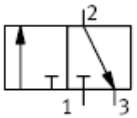
Directional Control Valves:
Ports and Switching Positions

Number of ports
Number of switching positions

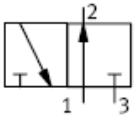
2/2-way valve, normally open position



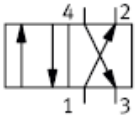
3/2-way valve, normally closed position



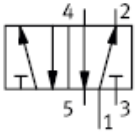
3/2-way valve, normally open position



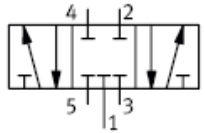
4/2-way valve
flow from 1 → 2 and from 4 → 3



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



5/3-way valve, mid-position closed



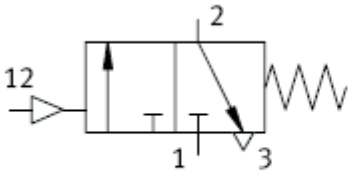
Port designations

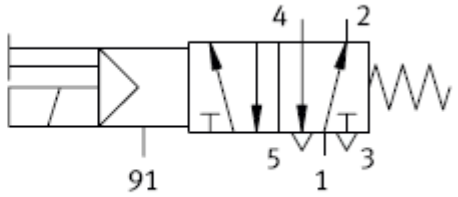
Working ports

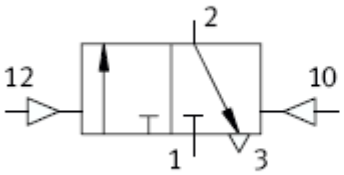
- 1 Supply port
- 2, 4 Working ports
- 3,5 Exhaust ports

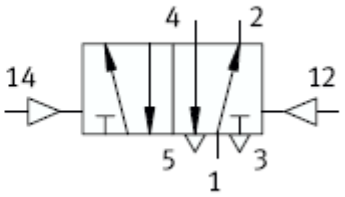
Pilot ports

- 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



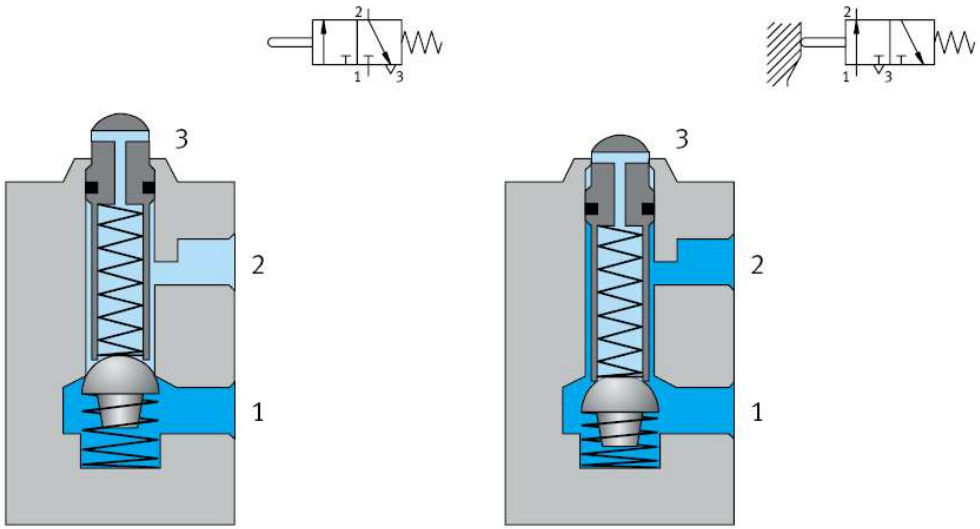




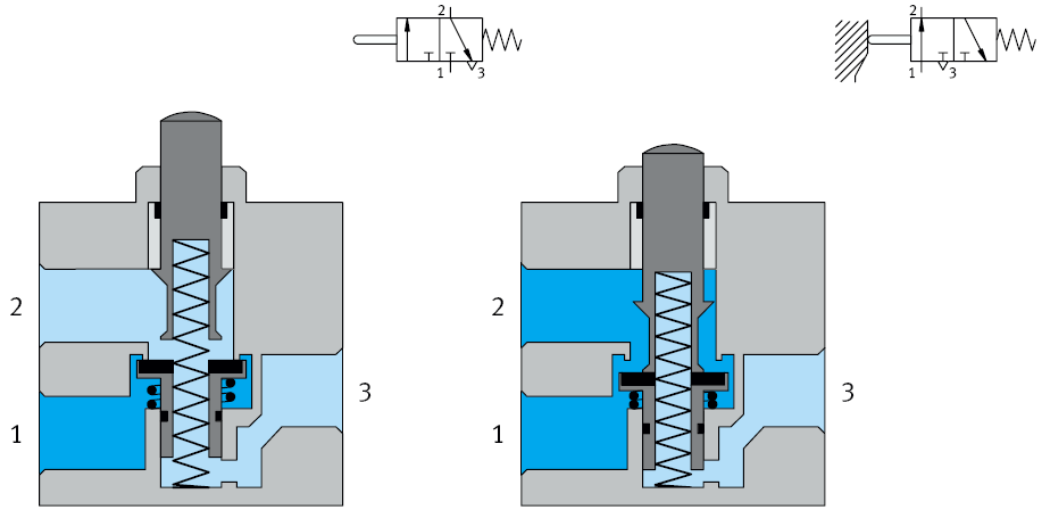


Example of 3/2-Way Valve

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

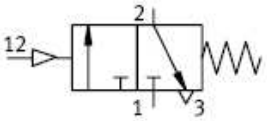


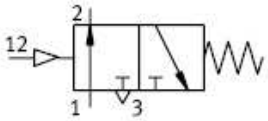
3/2-Way Valve: with Disk Seat, Normally Closed Position

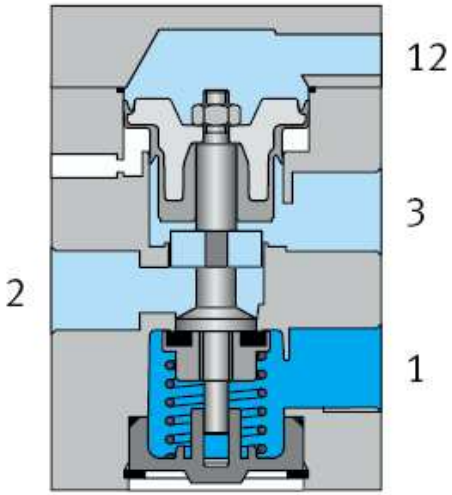


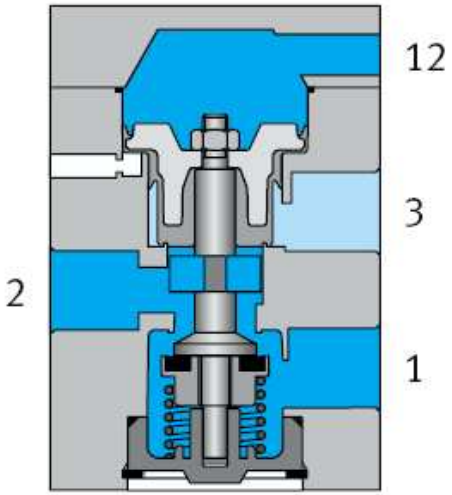
Example of 3/2-Way Valve

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





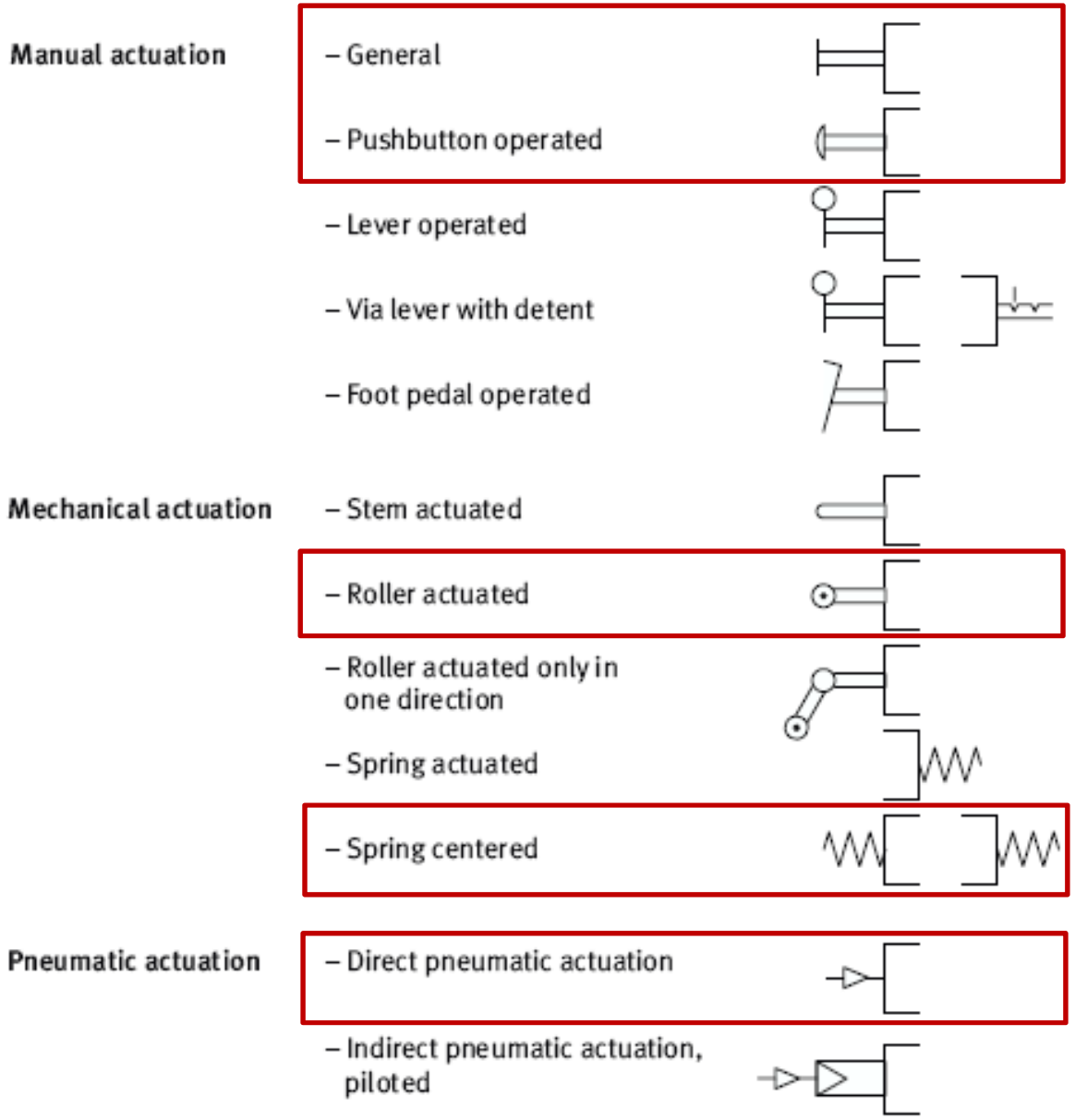




Types of actuation

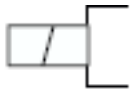
- The symbols for the types of actuation are drawn directly on the valve symbols.
- Selection - Depending upon system requirements
  - Manually actuated
  - Mechanically actuated
  - Pneumatically actuated
  - Electrically actuated
  - Combined types of actuation
- Purpose
  - Actuate
  - Reset
  - Center

Types of actuation



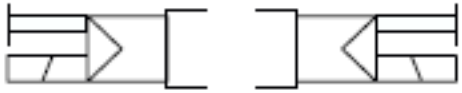
Types of actuation

Solenoid actuation – Single-solenoid operation



– Double-solenoid operation

Combined actuation – Double solenoid valve, piloted, with manual override



Non-return, Flow Control and Pressure Control Valves

Non-return valves

– Non-return valve (check valve)

– Non-return valve, spring-loaded

– Shuttle valve (OR function)

– Dual pressure valve (AND function)

– Quick exhaust valve

– One-way flow control valve

Flow control valve

– Flow control valve (throttle valve), adjustable

Pressure control valves

– Adjustable pressure regulating valve without relief port

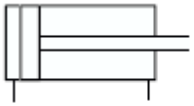
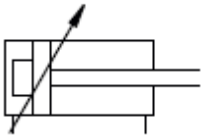
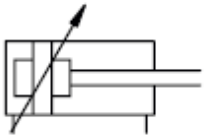
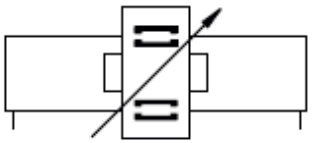
Symbols for the Principle Working Elements

- The symbol is represented with the advance motion to the right in the system circuit diagram
- Sloping arrow over piston: denotes adjustable end position cushioning

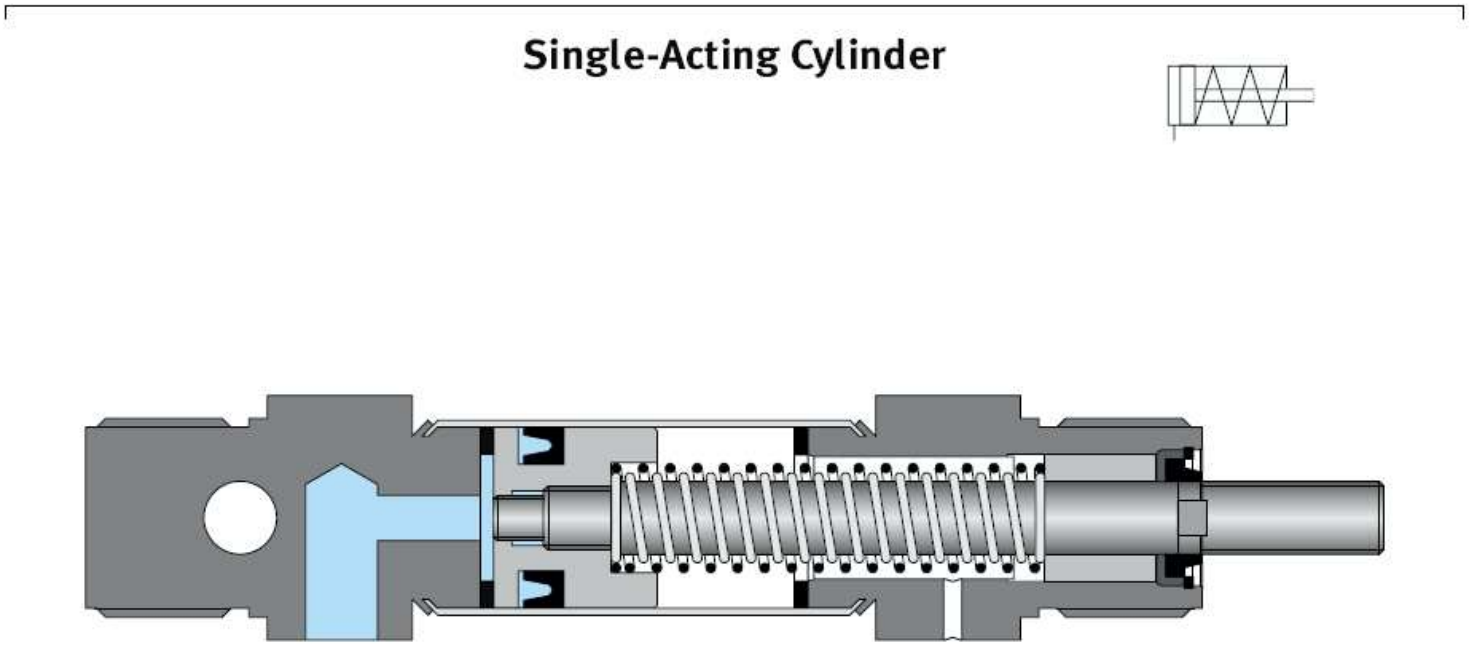
Single-acting:
Performs work in one direction

Double-acting:
Performs work in both directions

Linear Actuators

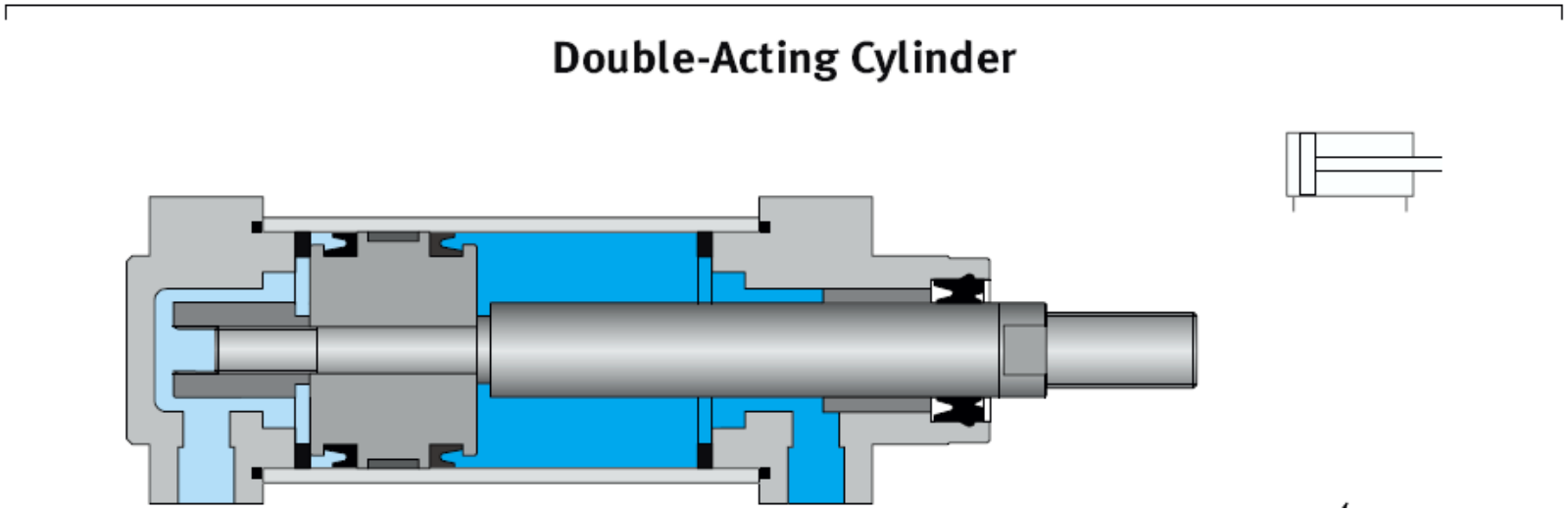
– Single-acting cylinder	
– Double-acting cylinder	
– Double-acting cylinder with through piston rod	
– Double-acting cylinder with single, non-adjustable cushioning	
– Double-acting cylinder with single, adjustable cushioning	
– Double-acting cylinder with adjustable cushioning at both ends	
– Rodless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

Single-Acting Cylinder



Source: FESTO

Double-Acting Cylinder

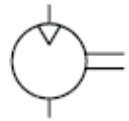


Source: FESTO

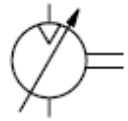
Symbols for the Principle Working Elements

Rotary Drives

– Air motor, constant displacement, rotation in one direction

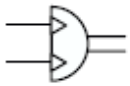


– Air motor, variable displacement, rotation in one direction

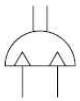


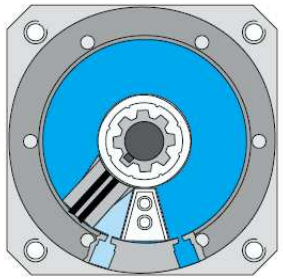
– Air motor, variable displacement, rotation in both directions

– Pneumatic rotary motor

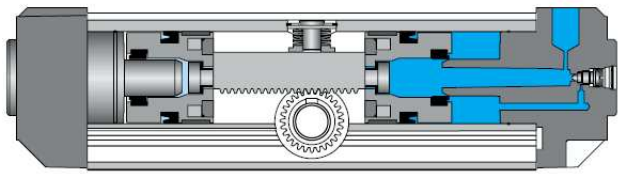


Swivel Drive





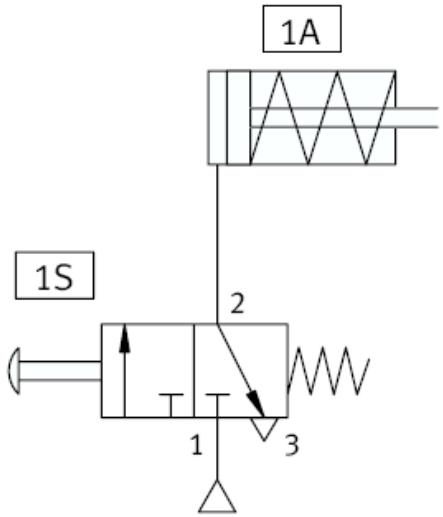
Rotary Cylinder



Source: FESTO

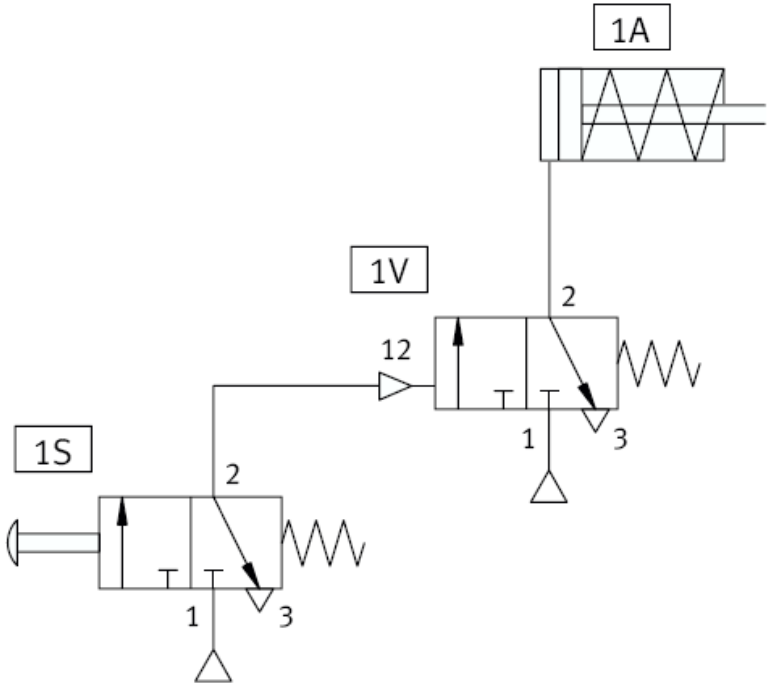
Direct and indirect Actuation

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