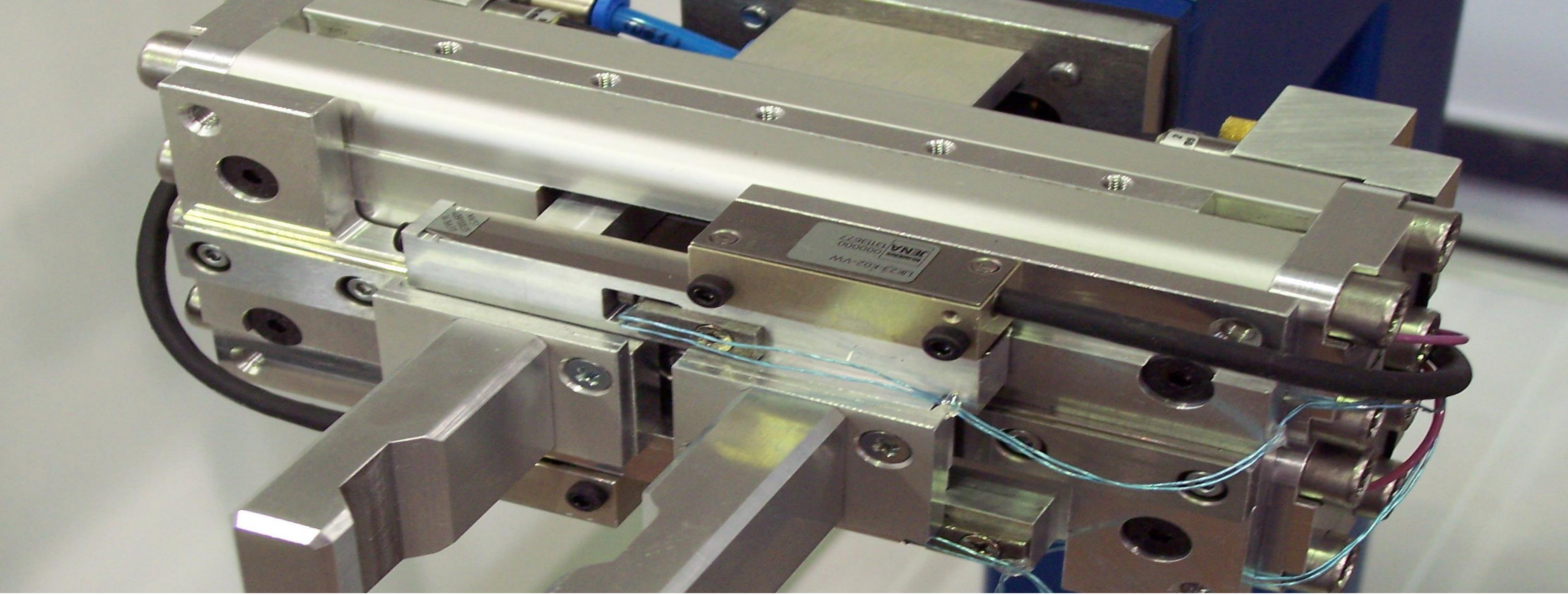


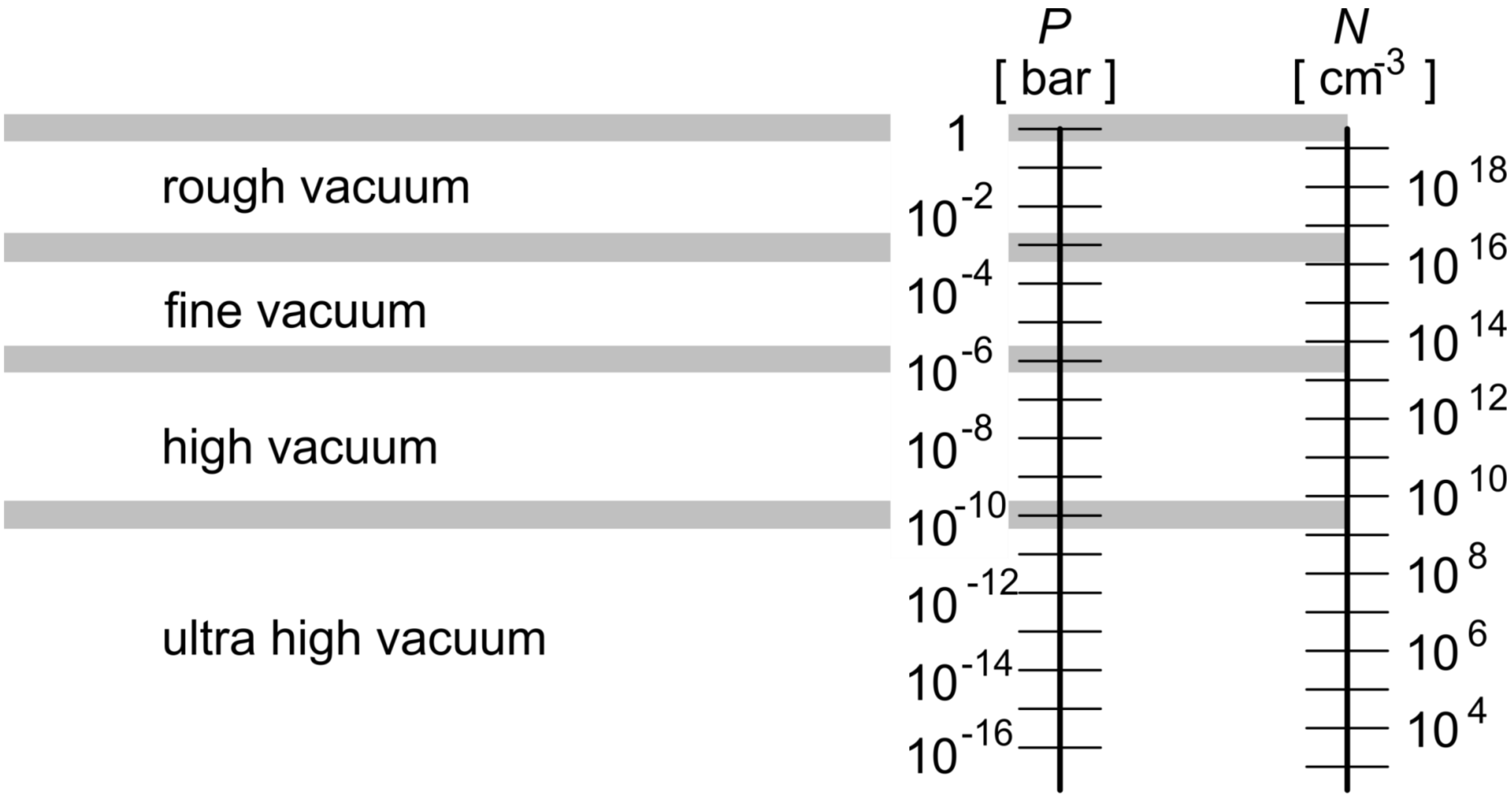
Fundamentals of Fluid Power – Pneumatics

Fourth Lecture - Applications

FoFP Pneumatics - Lecture 4
Olivier Reinertz
2019

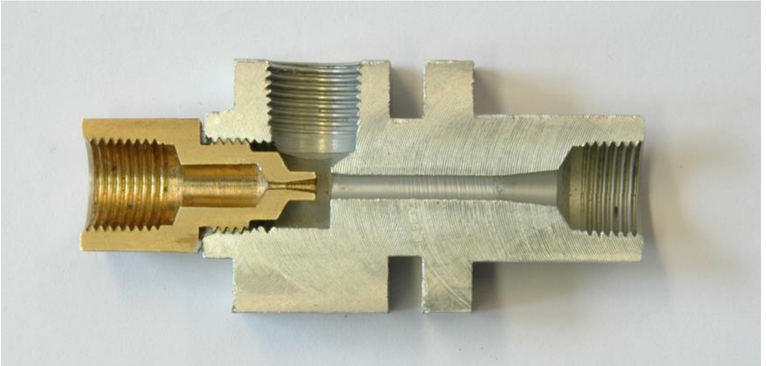
Outline

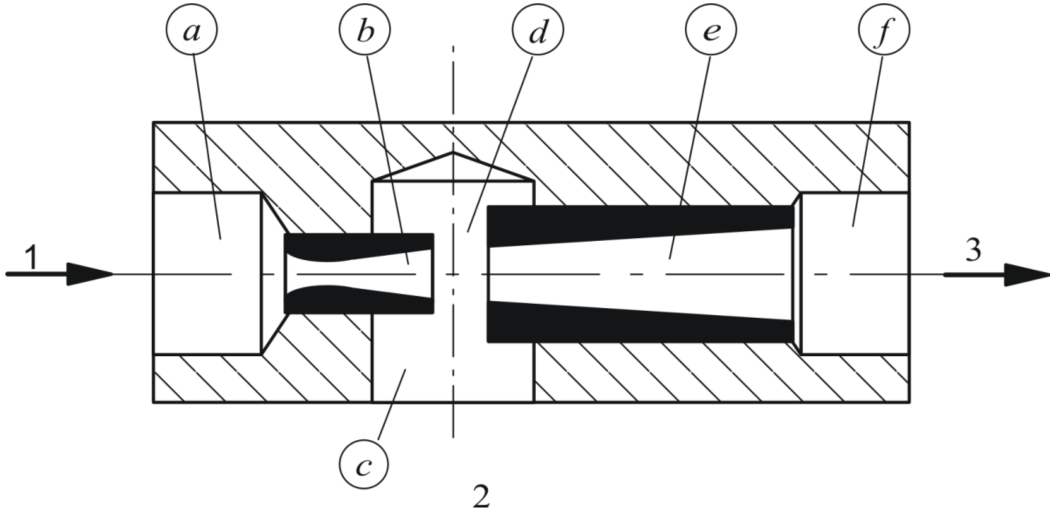
Vacuum Classification According to DIN 28400



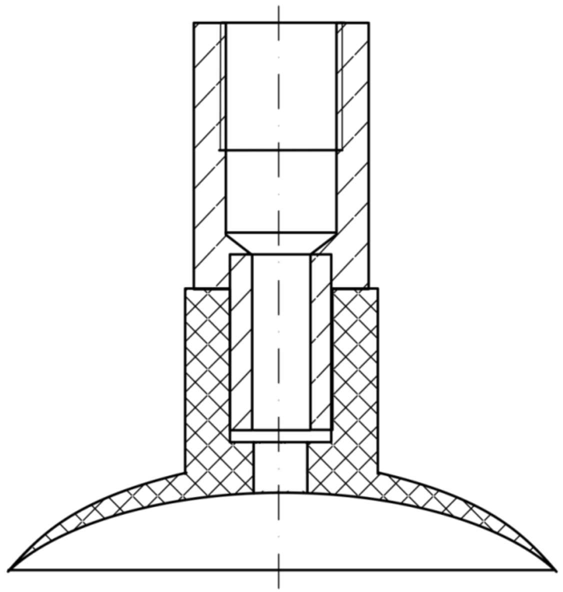
P : absolute pressure
N : number of particles per space unit for air at 20° C

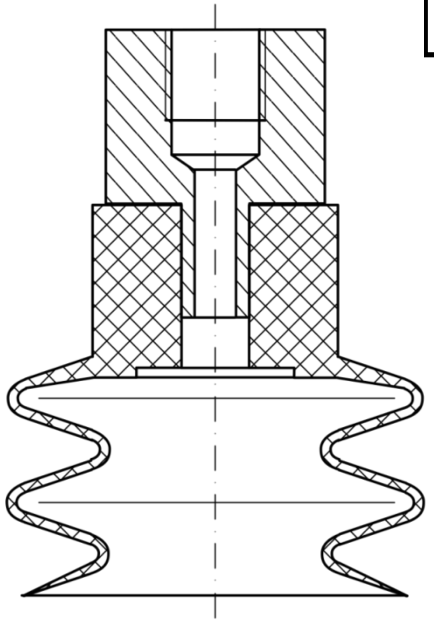
Ejector

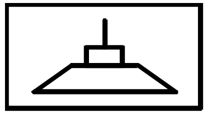




Different Types of Suction Grippers



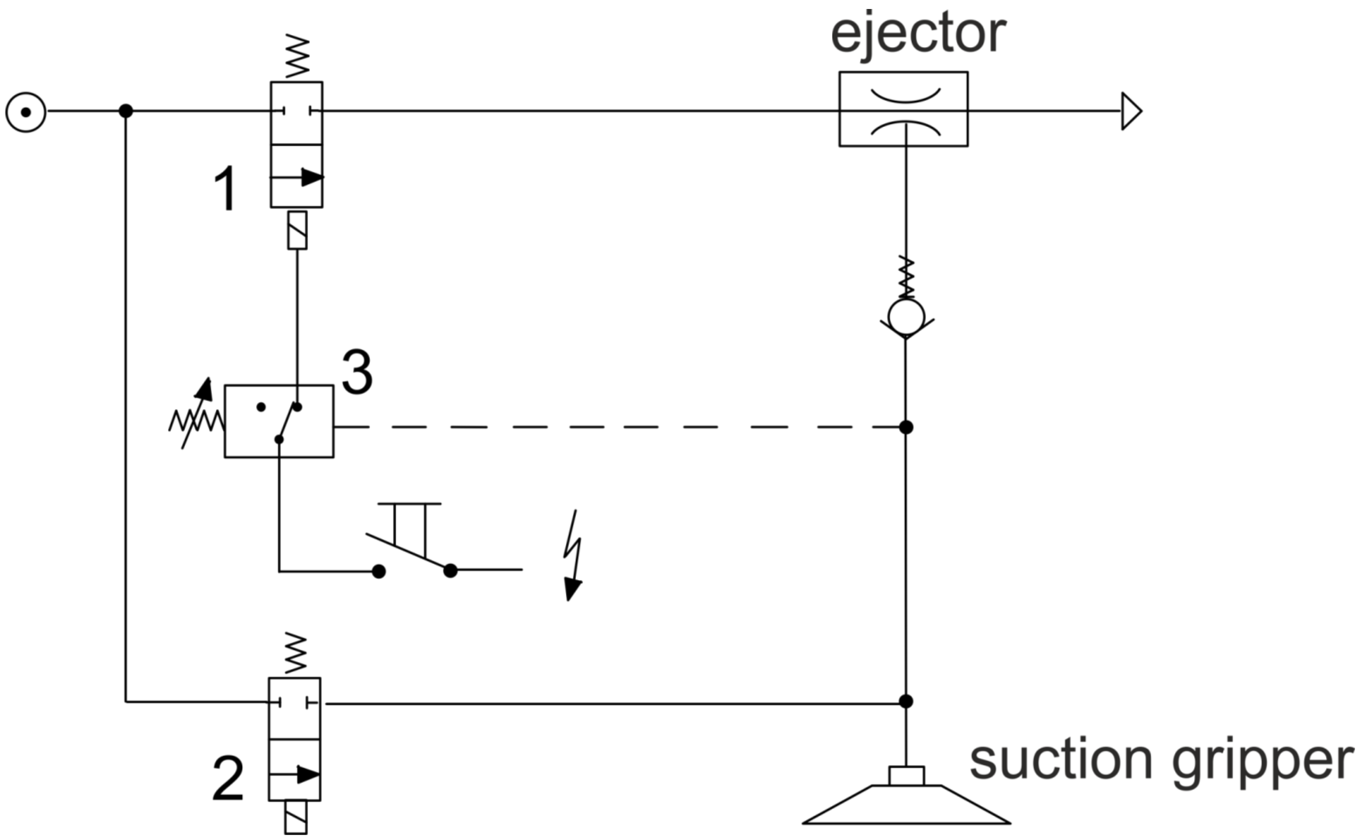




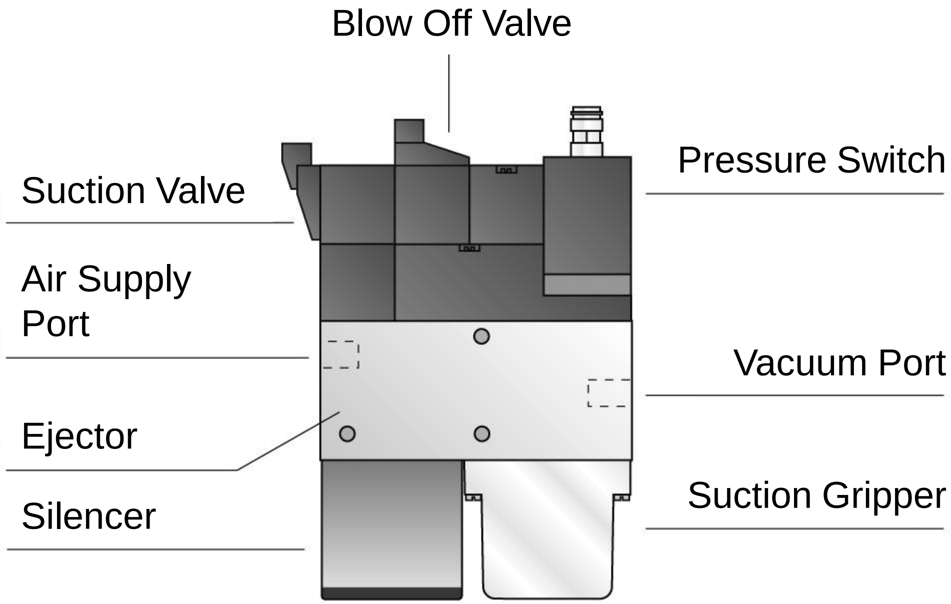
flat suction gripper

telescopic suction gripper

Suction Gripper with Ejector



Integrated Ejector



Source: Schmalz

Outline

Open and Closed Loop Control

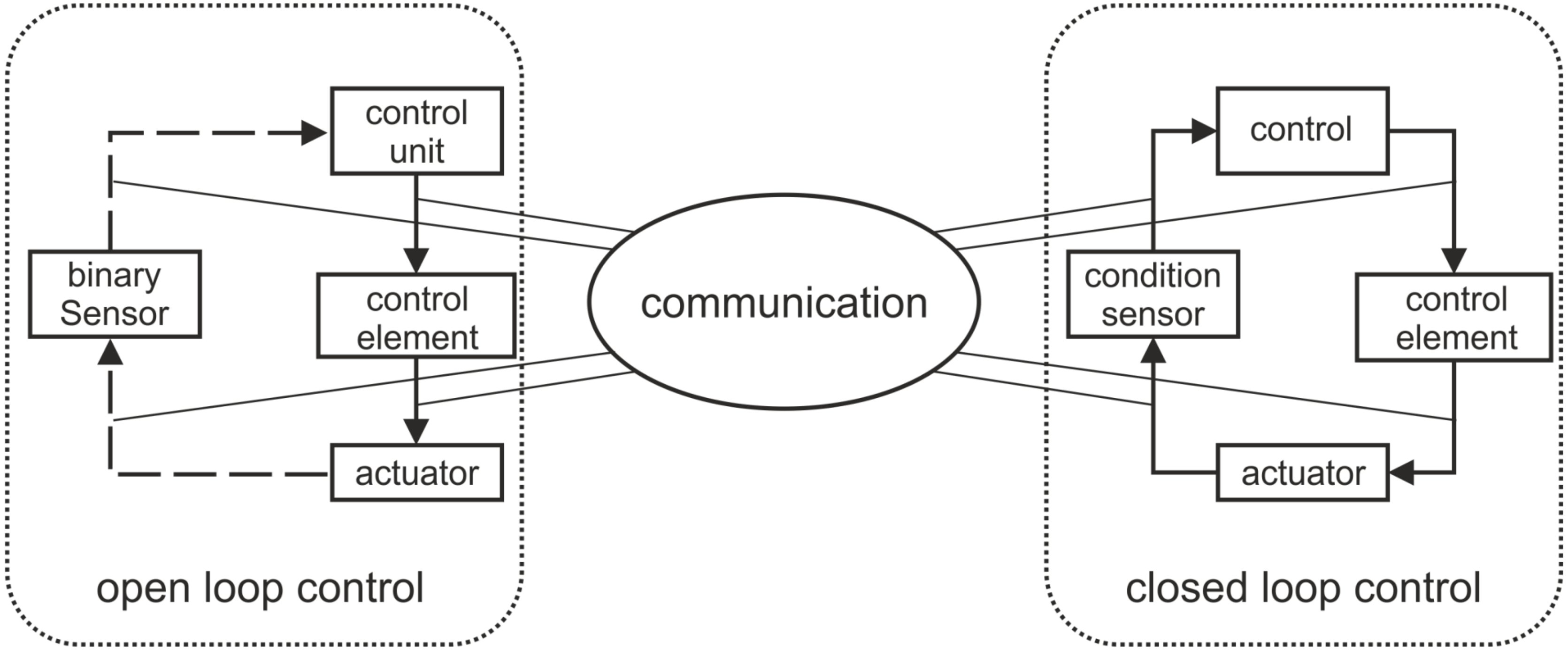
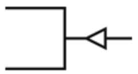
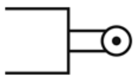
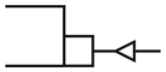
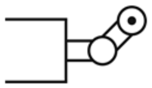
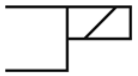
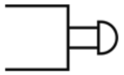
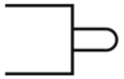


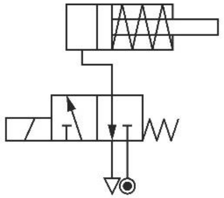
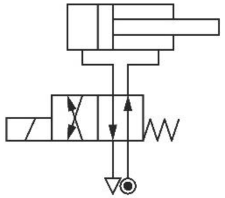
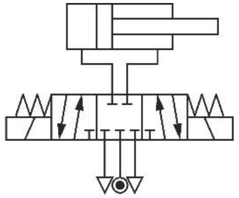
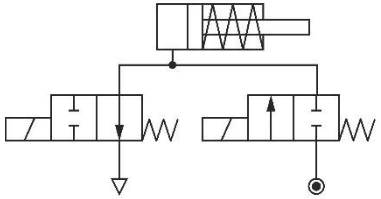
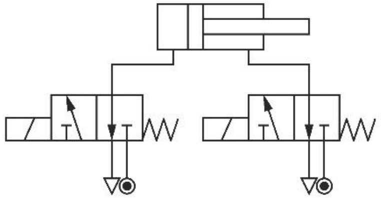
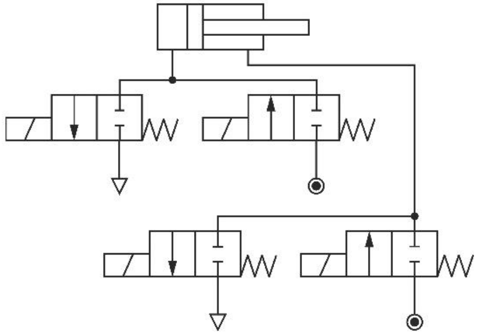
Fig. 4-1

Selected Actuations of Pneumatic Valves According to DIN-ISO 1219-1

symbol	description	symbol	description
	pressurised, directly operated		roller plunger
	pressurised, small acting area		roller lever for actuation in one moving direction
	magnet coil with single winding		manual actuation
	spring force		plunger actuation
			manual actuation with detent

Tab. 4.1-2

Example Circuits for Controlling a Cylinder

Single Acting Cylinder	Double Acting Cylinder	
 Controlled by an electromagnetically actuated spring returned 3/2-way valve	 Controlled by an electromagnetically actuated spring returned 4/2-way valve	 Controlled by an electromagnetically actuated spring centered 5/3-way valve
 Controlled by two electromagnetically actuated spring returned 2/2-way valves	 Controlled by two electromagnetically actuated spring returned 3/2-way valves	 Controlled by four electro-magnetically actuated spring returned 2/2-way valves

Tab. 4.1-3

Intentional Sequence Control

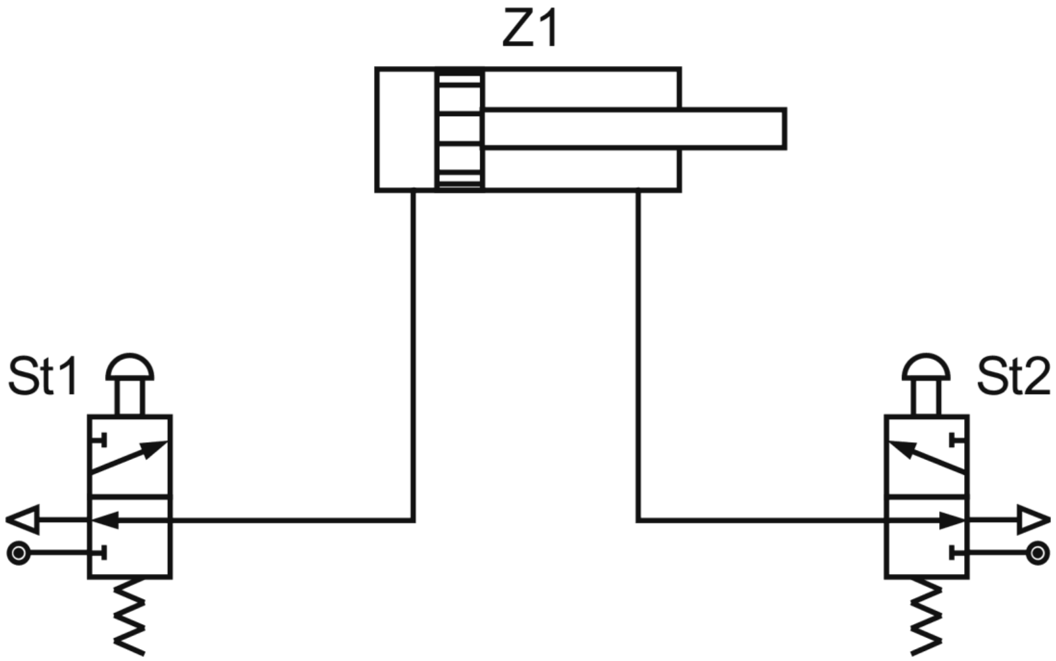


Fig. 4.1-4

Stroke-Depending Sequence Control

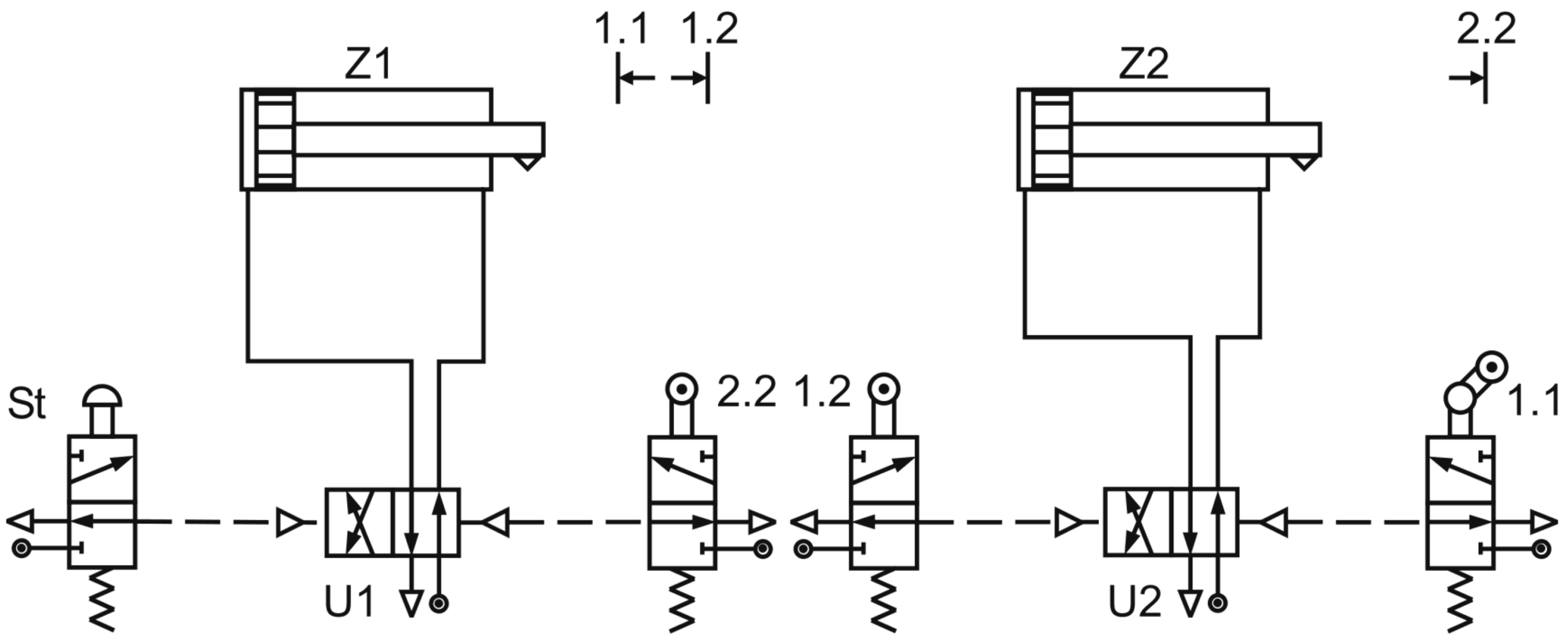


Fig. 4.1-5

Time-Depending Sequence Control

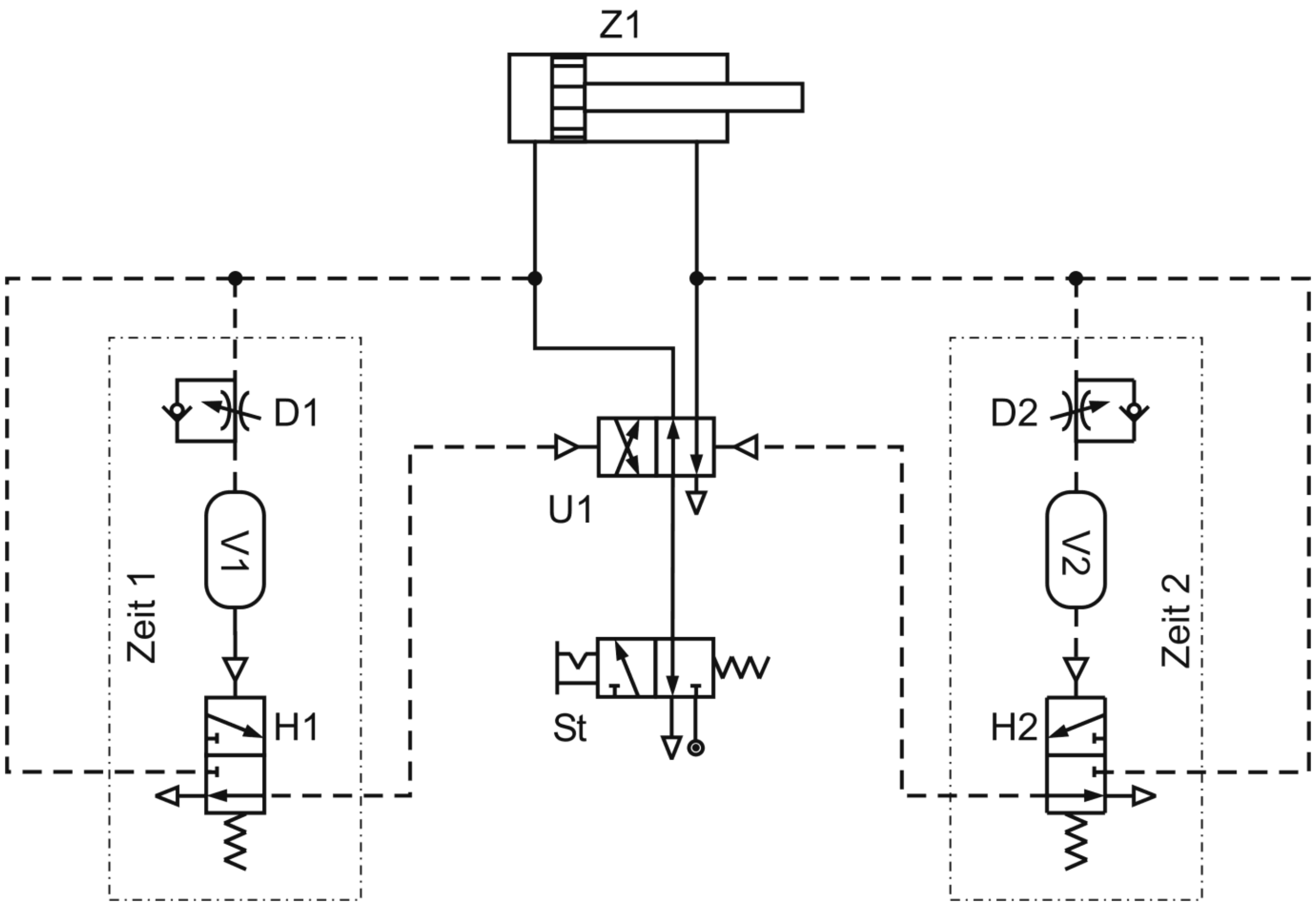


Fig. 4.1-6

Pressure-Depending Sequence Control

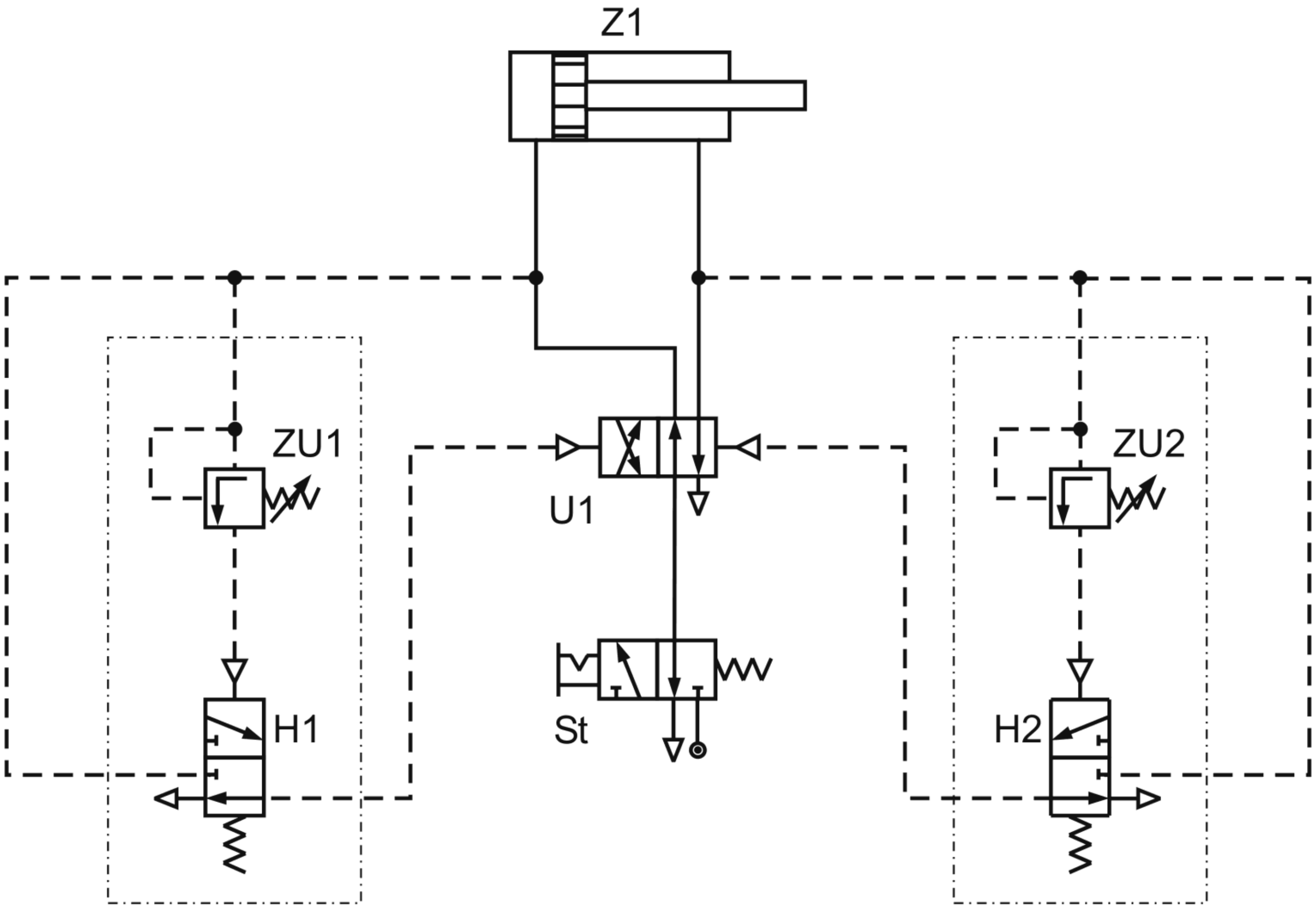


Fig. 4.1-7

Example for Location Chart (top) and Function Chart (bottom)

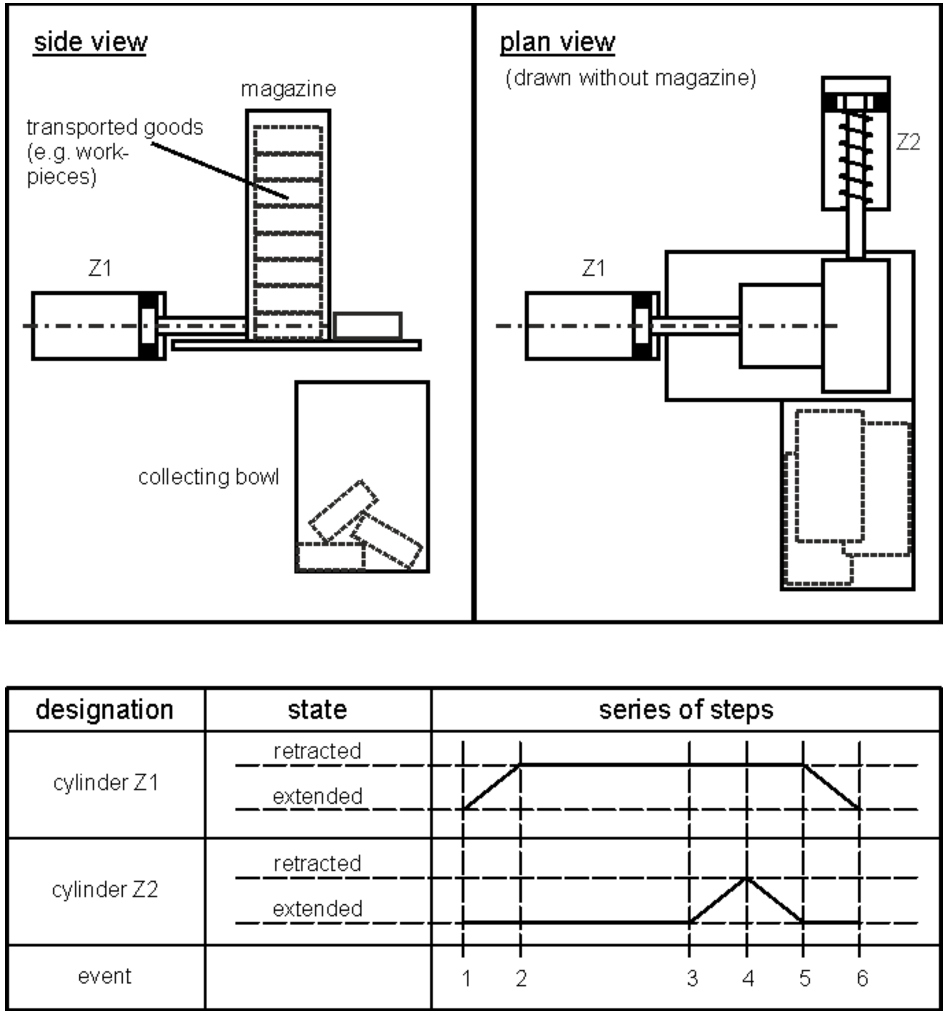


Fig. 4.1-1

GRAFCET Function Chart

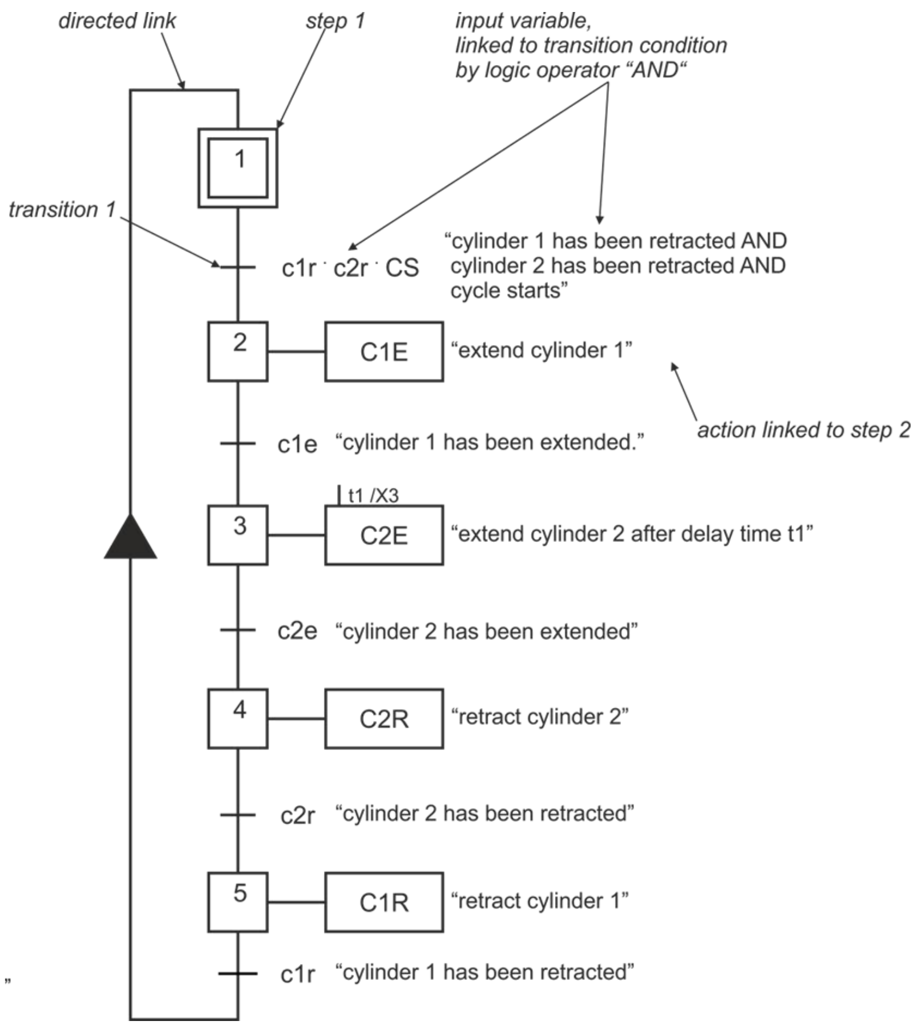


Fig. 4.1-2

input	
CS	cylinder start
c1e	cylinder 1 is extended
c1r	cylinder 1 is retracted
c2e	cylinder 2 is extended
c2r	cylinder 2 is retracted
output	
C1E	extending cylinder 1
C1R	retracting cylinder 1
C2E	extending cylinder 2
C2R	retracting cylinder 2

Circuit Diagram of a Sequence Control

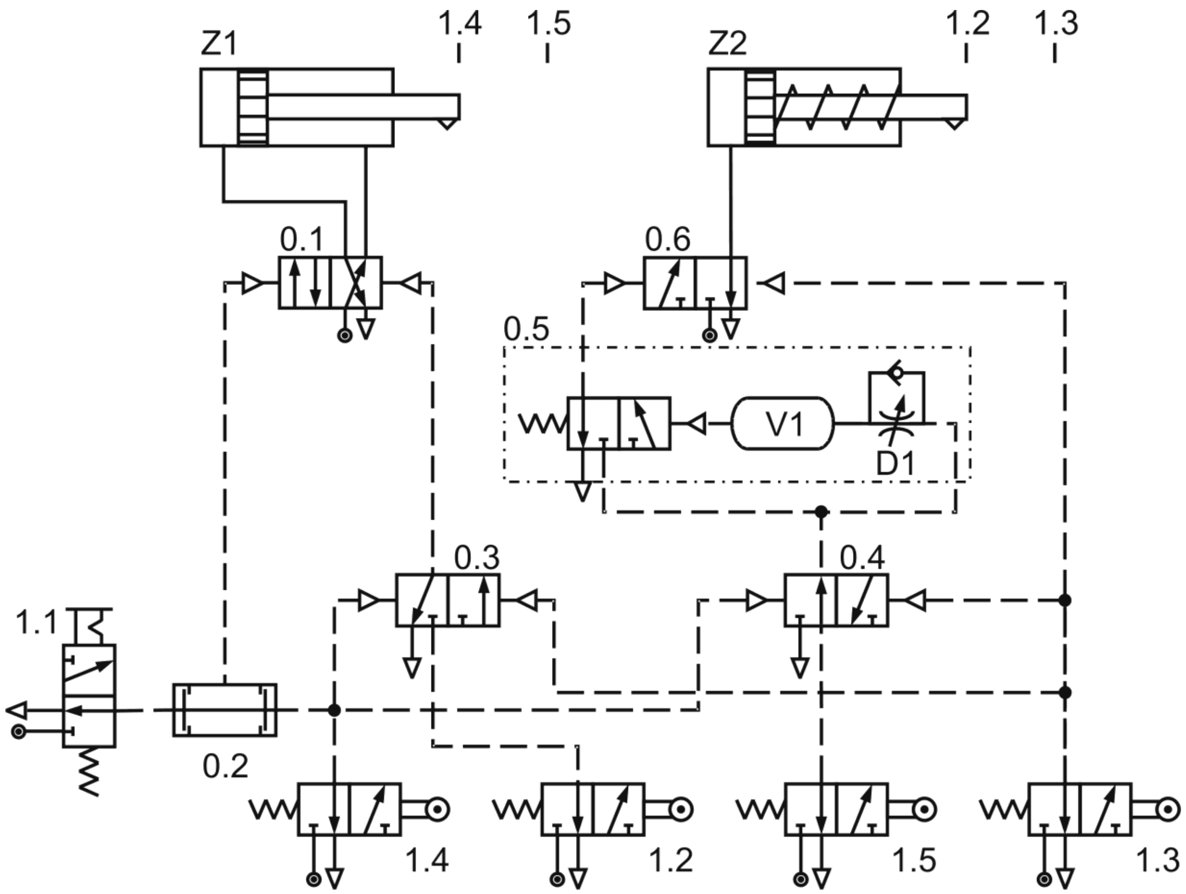
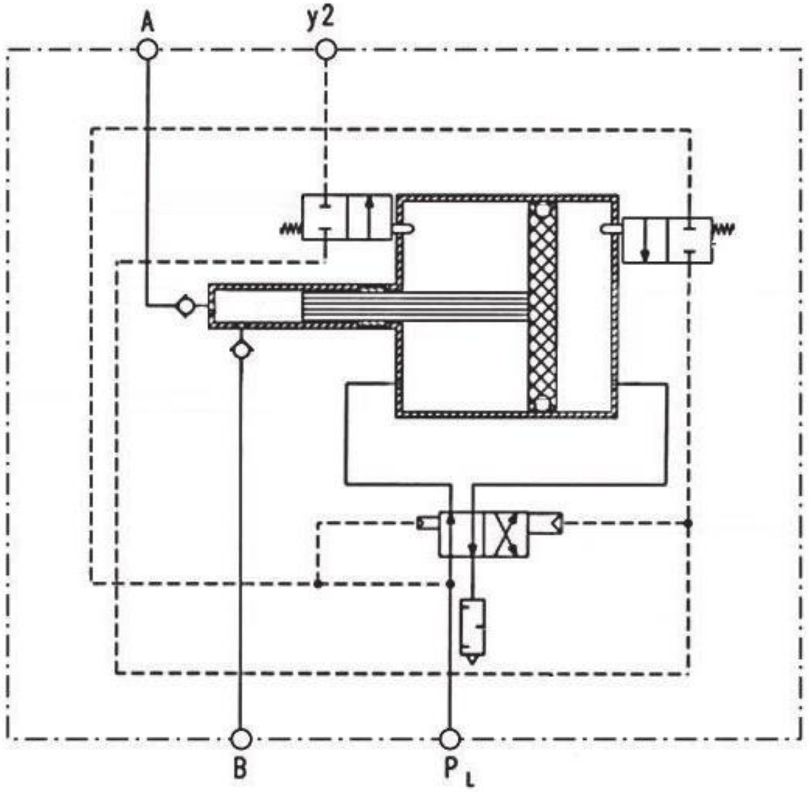
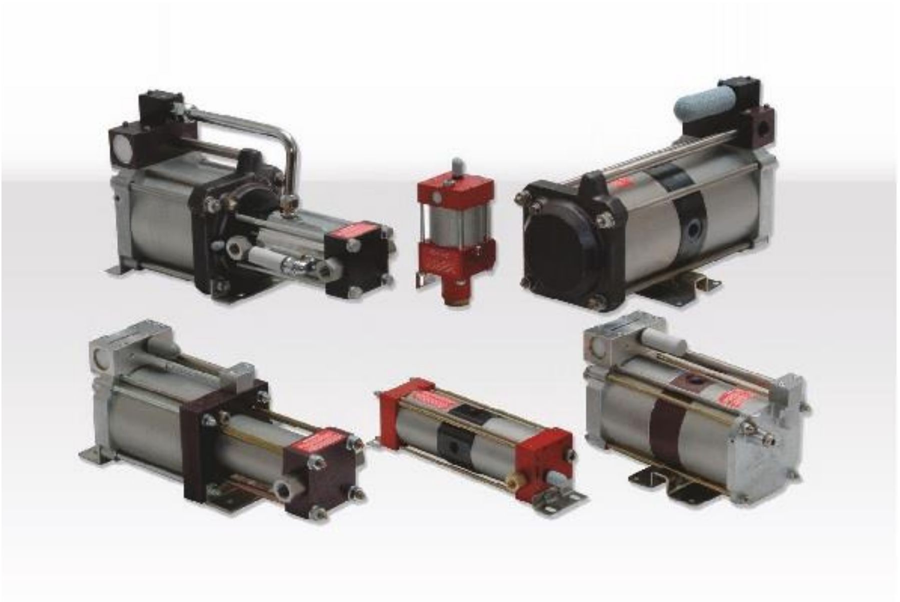


Fig. 4.1-3

Sequence Control – Example Pressure Booster

- Component for local pressure increase
  - Double acting self controlled pressure transformer (position controlled)
  - Multiplication of inlet pressure

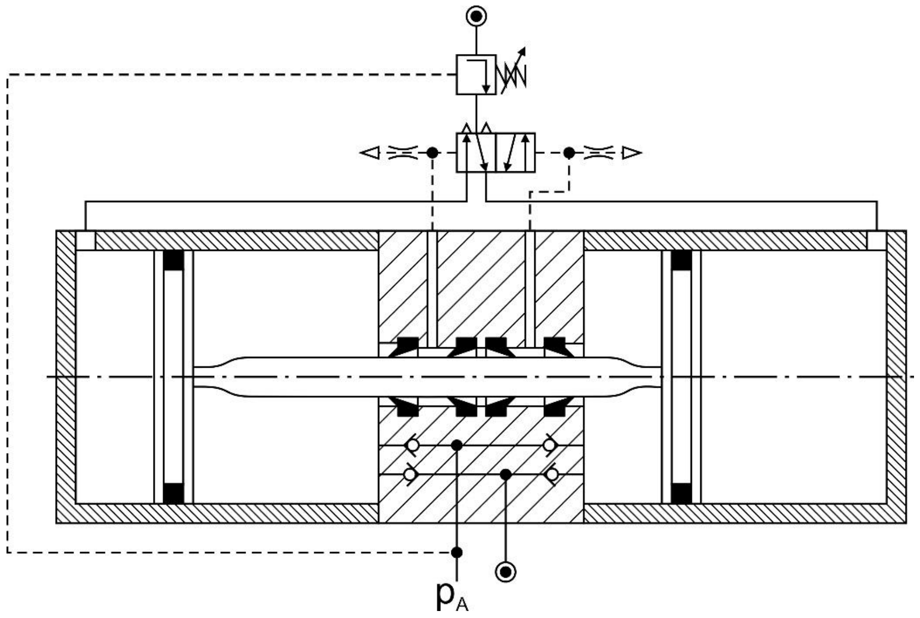


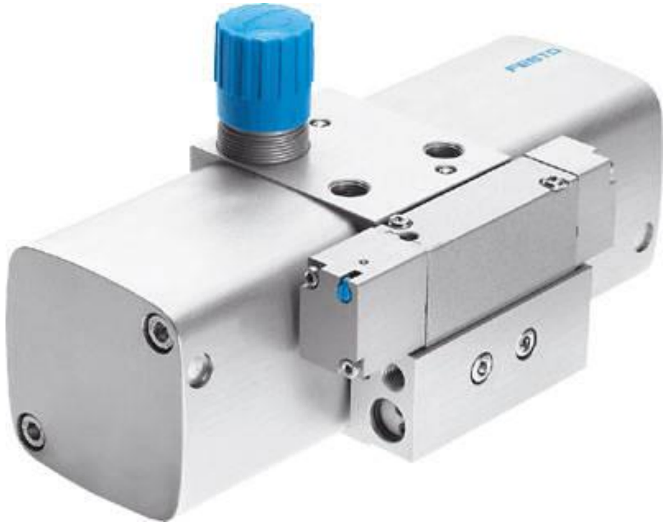


Source: Maximator

Sequence Control – Example Pressure Booster

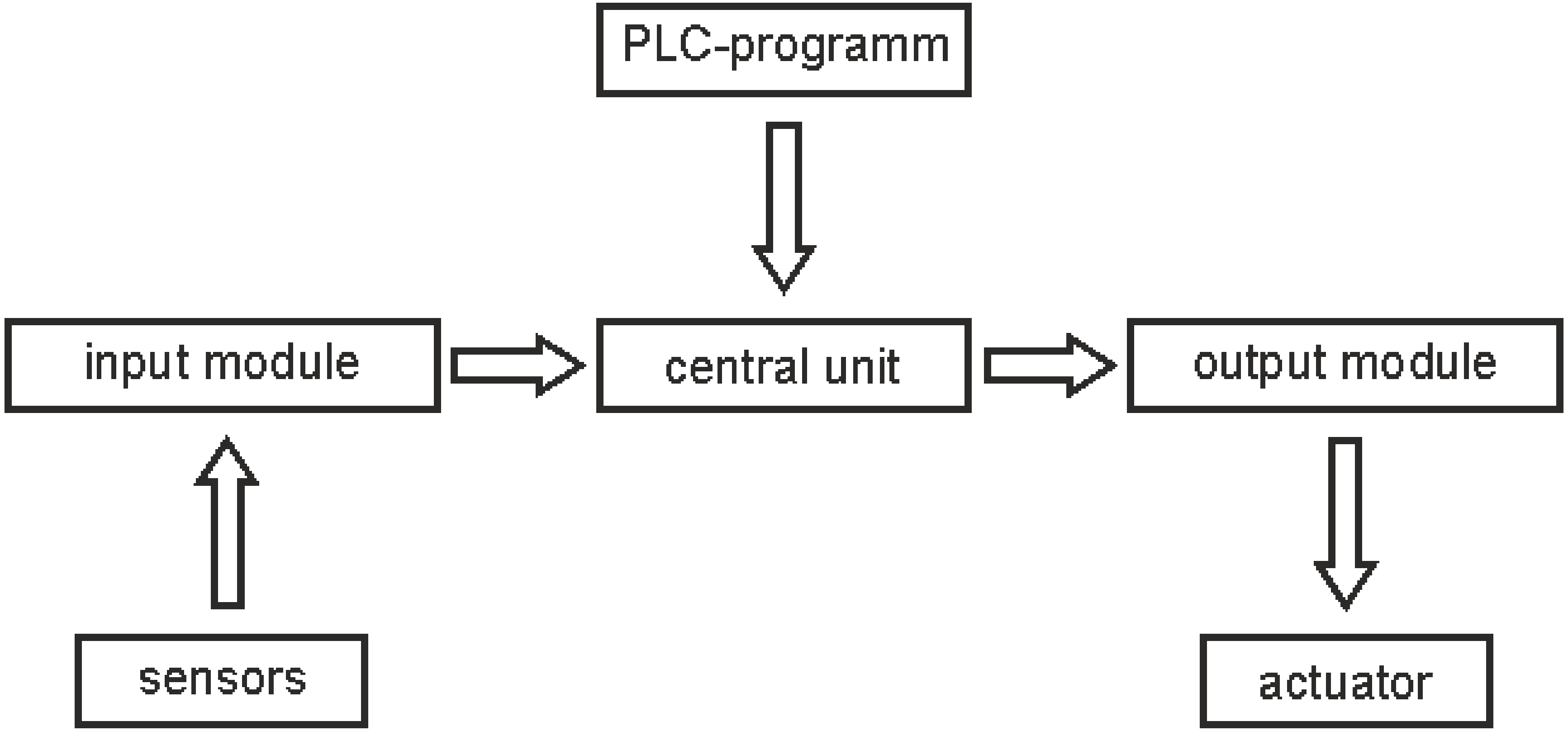
- Component for local pressure increase
  - Double acting self controlled pressure transformer (position controlled)
  - Doubling of inlet Pressure
  - Integrated Control for outlet pressure (automatic start/stop)
  - Pilot „valves“ on piston rod



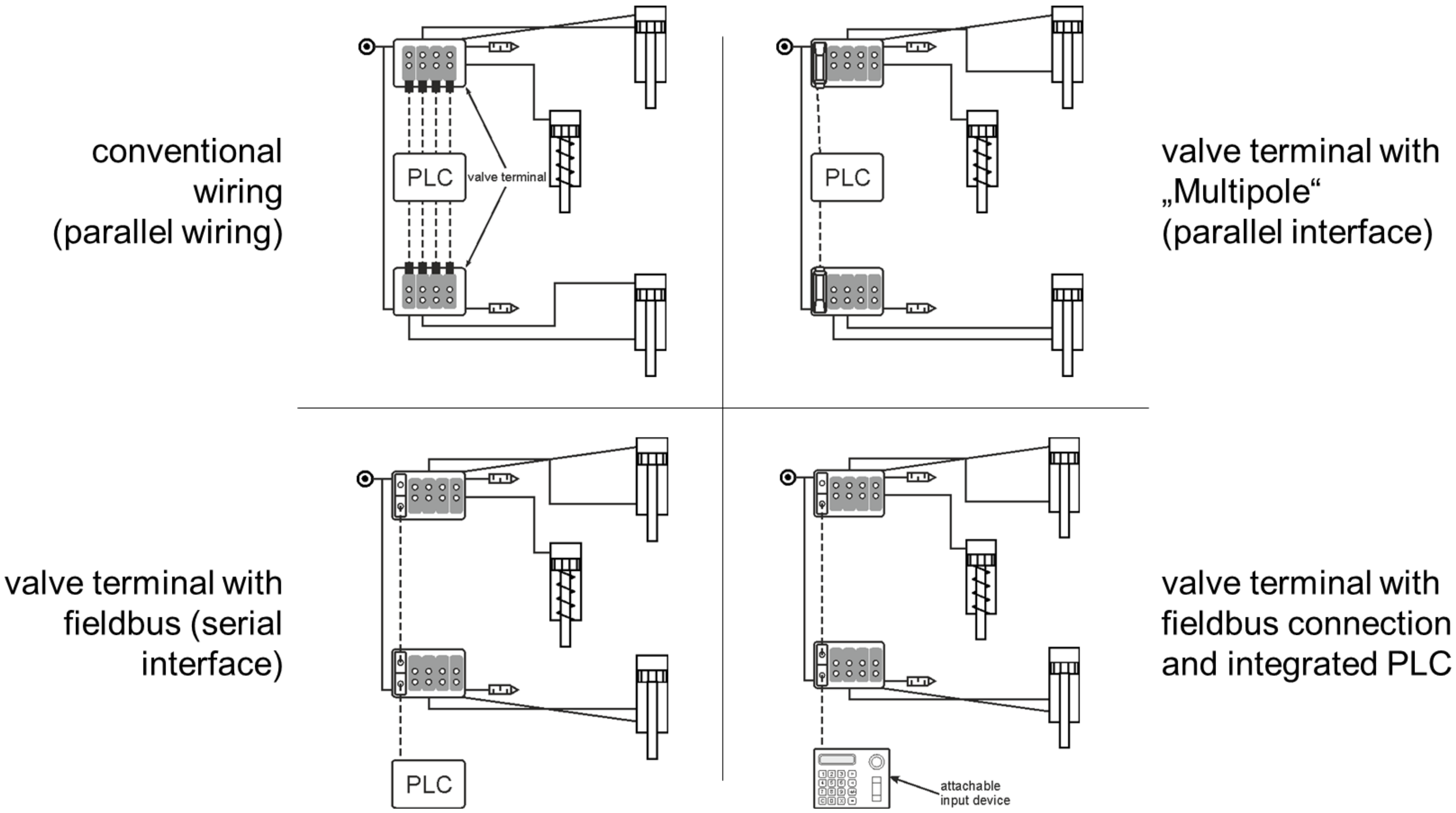


Source: Festo

Programmable Logical Control (PLC) and System Components



PLC - Comparison of Different Types of Wirings and Connections



Position Sensor – Reed-Switch

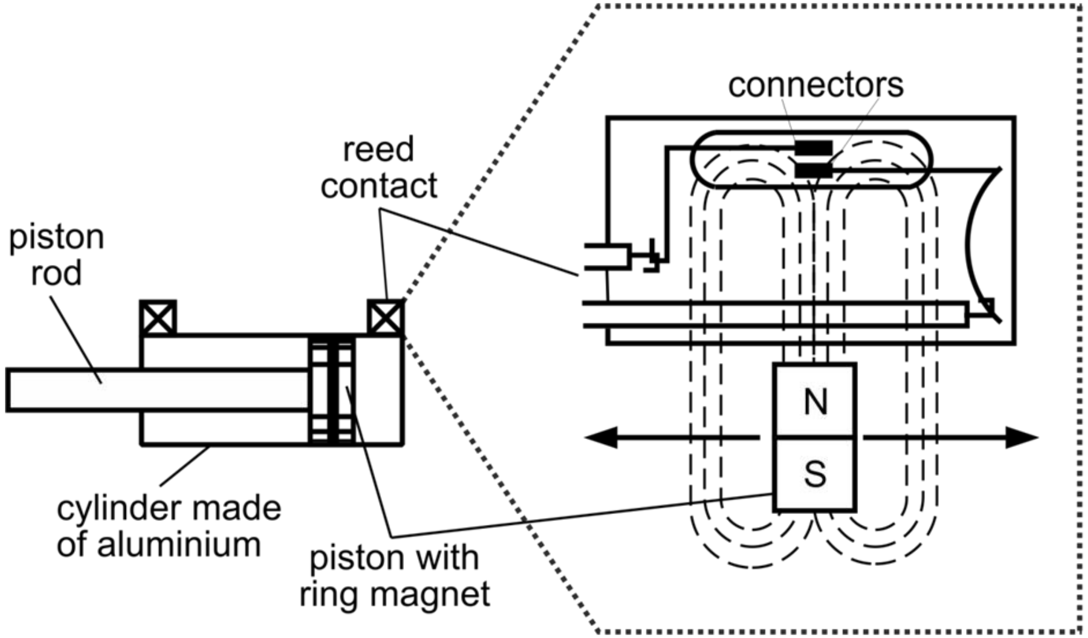


Fig. 4.1-12

Source: Norgren Herion

Position Sensor - Hall-Switch

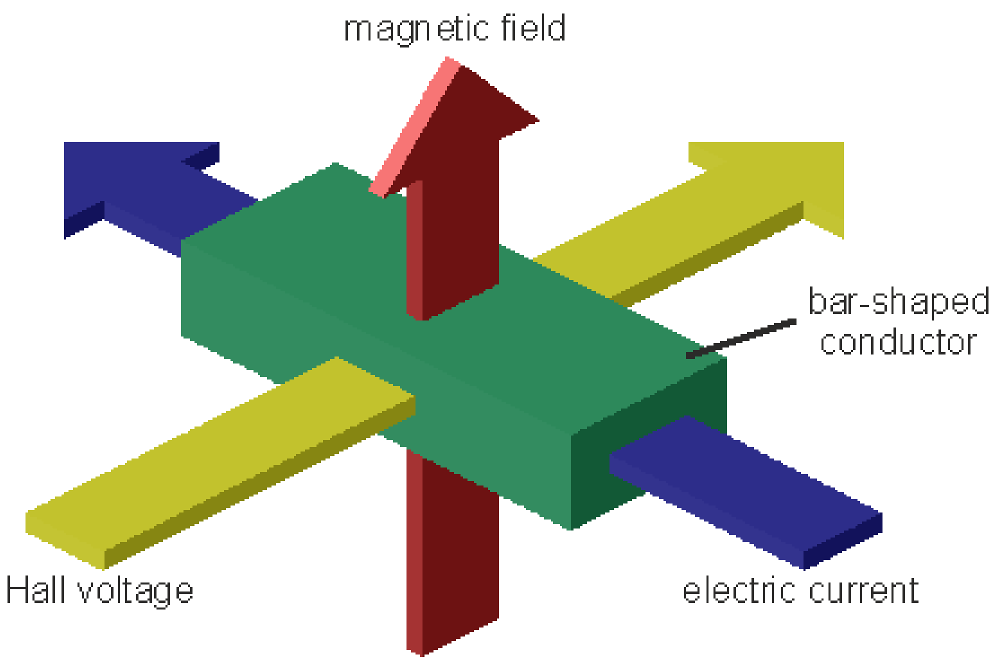


Fig. 4.1-13

Source: FESTO

Position Sensor – Magneto-Resistive Switch

- Anisotropic Magneto-Resistive Effect (AMR)
  - Anisotropic electrical Resistance of thin magnetically conducting layers (Direction of anisotropy controlled by magnetic flux direction)

- Evaluation of a magneto resistive wheatstone bridge

- Benefits:
  - No moving parts (Endurance)
  - Higher Sensitivity compared to Hall-Switches

  → Standard solution for position switches on pneumatic cylinders

Source: FESTO

Soft-Stop Positioning Drive

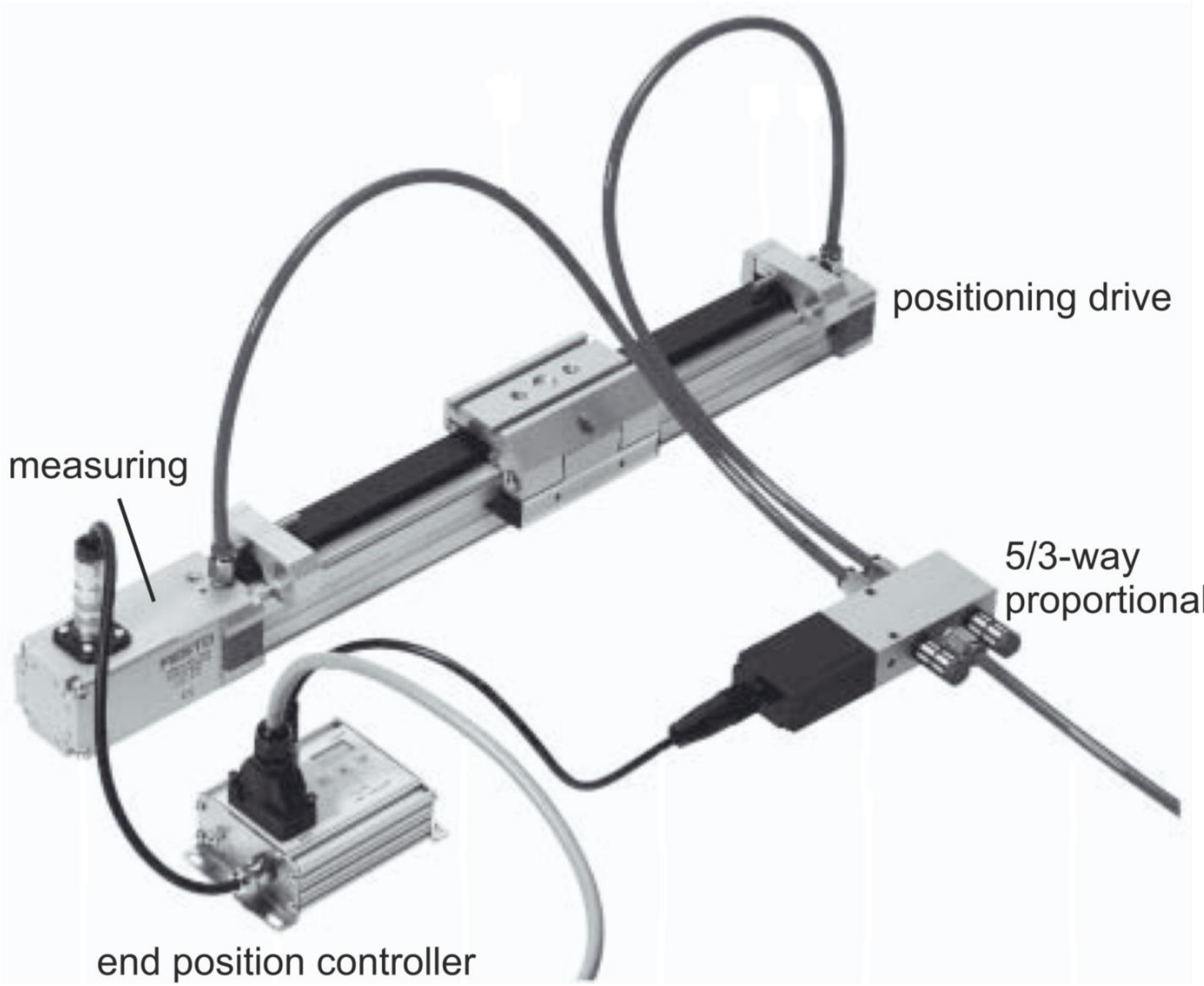


Fig. 4.2-7

Source: FESTO

Outline

Limitations of First Law of Thermodynamics

Complex Modelling of Heat Flows

- Mostly no reliable data available
- Consideration of simplified changes of state
  - Specification of pressure/volume-Correlation

Small Significance of Inner Energy

- Energy is only temperature dependent
  - Neglecting the potential of compressed air to provide mechanical energy while cooling down during decompression.

Definition of Exergy

Definition – Exergy

The exergy e_x describes the quality of an energy in form of its maximum working capacity.

$$e_{ex} = e_a + (h_1 - h_U) - T_U \cdot (s_1 - s_U)$$

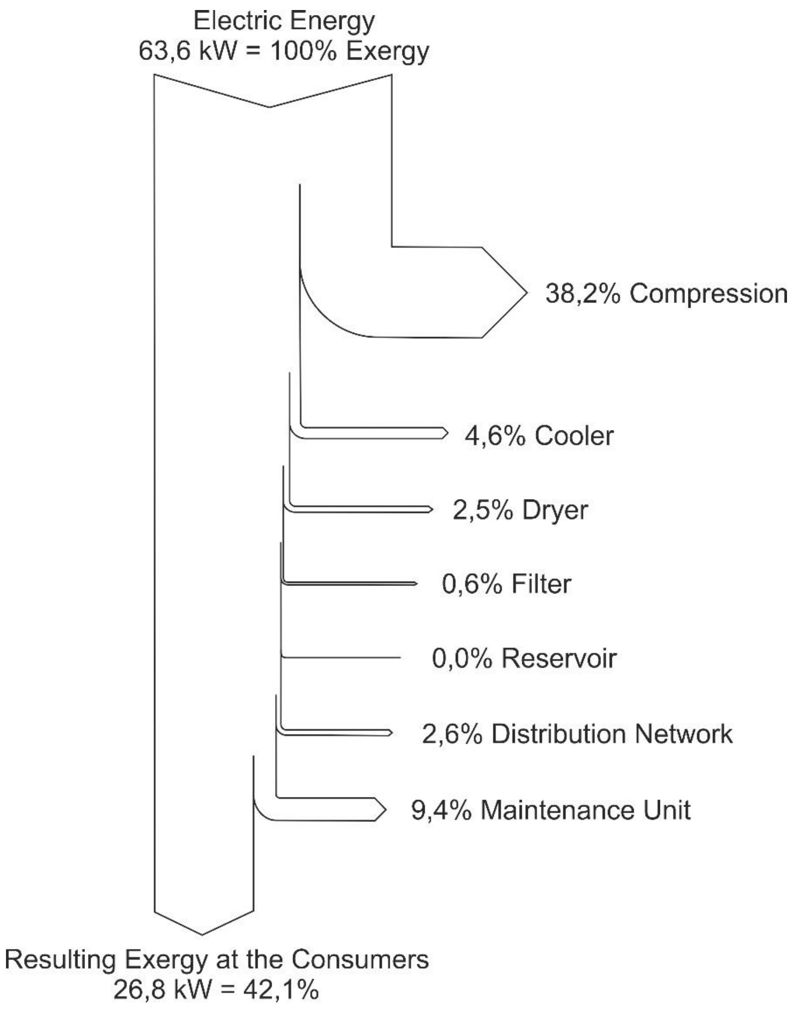
It can exclusively be defined in relation to an (ambient) condition. In contrast to the energy, exergy can be destroyed in real energy conversions.

Exergy of Ideal Gases

$$e = e_a + c_p(T_1 - T_U) - T_U \cdot \left(R \cdot ln\left(\frac{p_1}{p_U}\right) - c_p \cdot ln\left(\frac{T_1}{T_U}\right)\right)$$

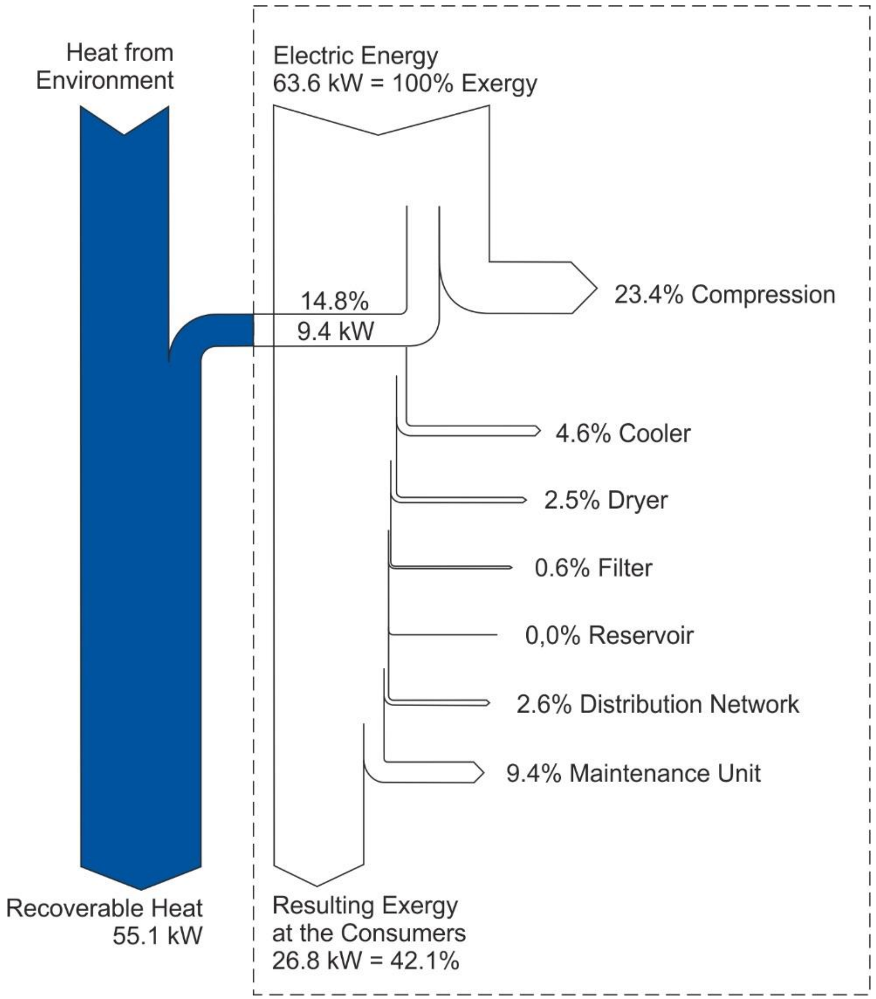
ATTENTION: In case that a heat flow occurs at a temperature unequal to ambient temperature, the heat flow contains exergy.

Exergy Flow Diagramm



Data Source: Krichel, 2012

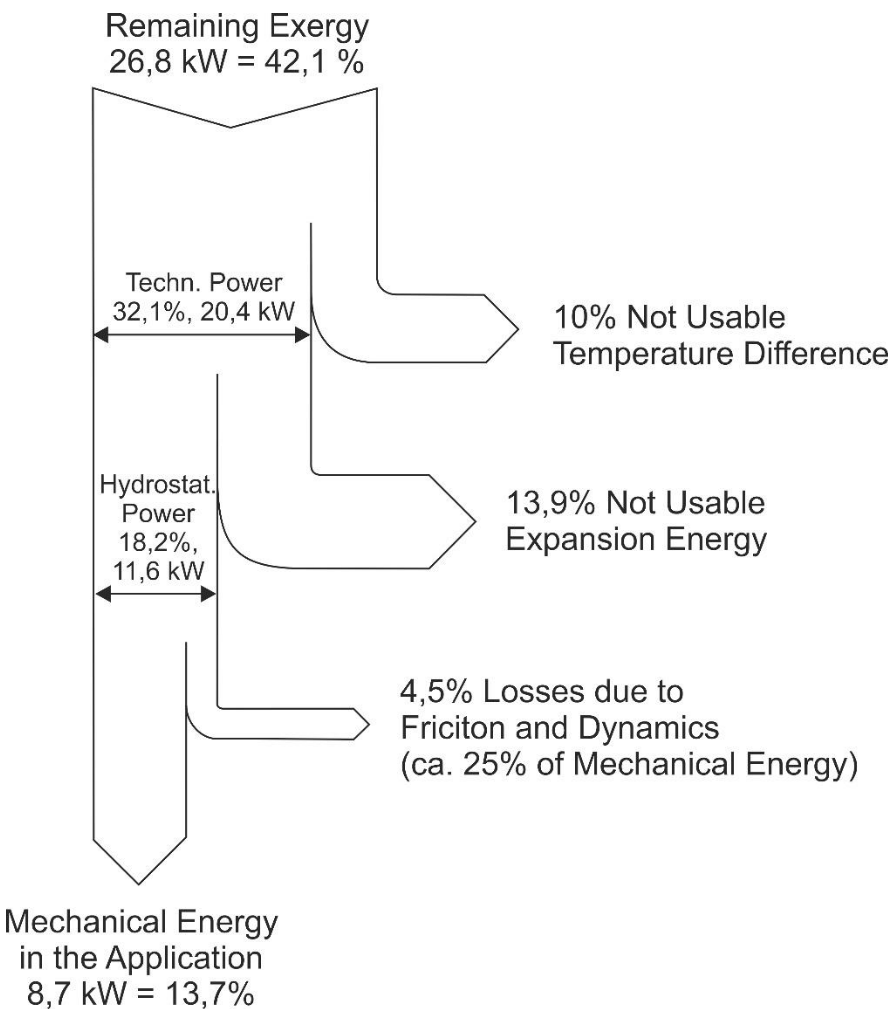
Heat Recovery



- Large amount of recoverable heat due to heat pump effect
- High benefit of recoverable heat
  - For domestic warm water, heating, etc.
- Exergy of heat is comparatively low
  - Heat recovery at ca. 60 °C
  - Small difference to ambient temperature

Data Source: Krichel, 2012

Exergy Usage of Cylinder Drives



Data Source: Krichel, 2012

Outline

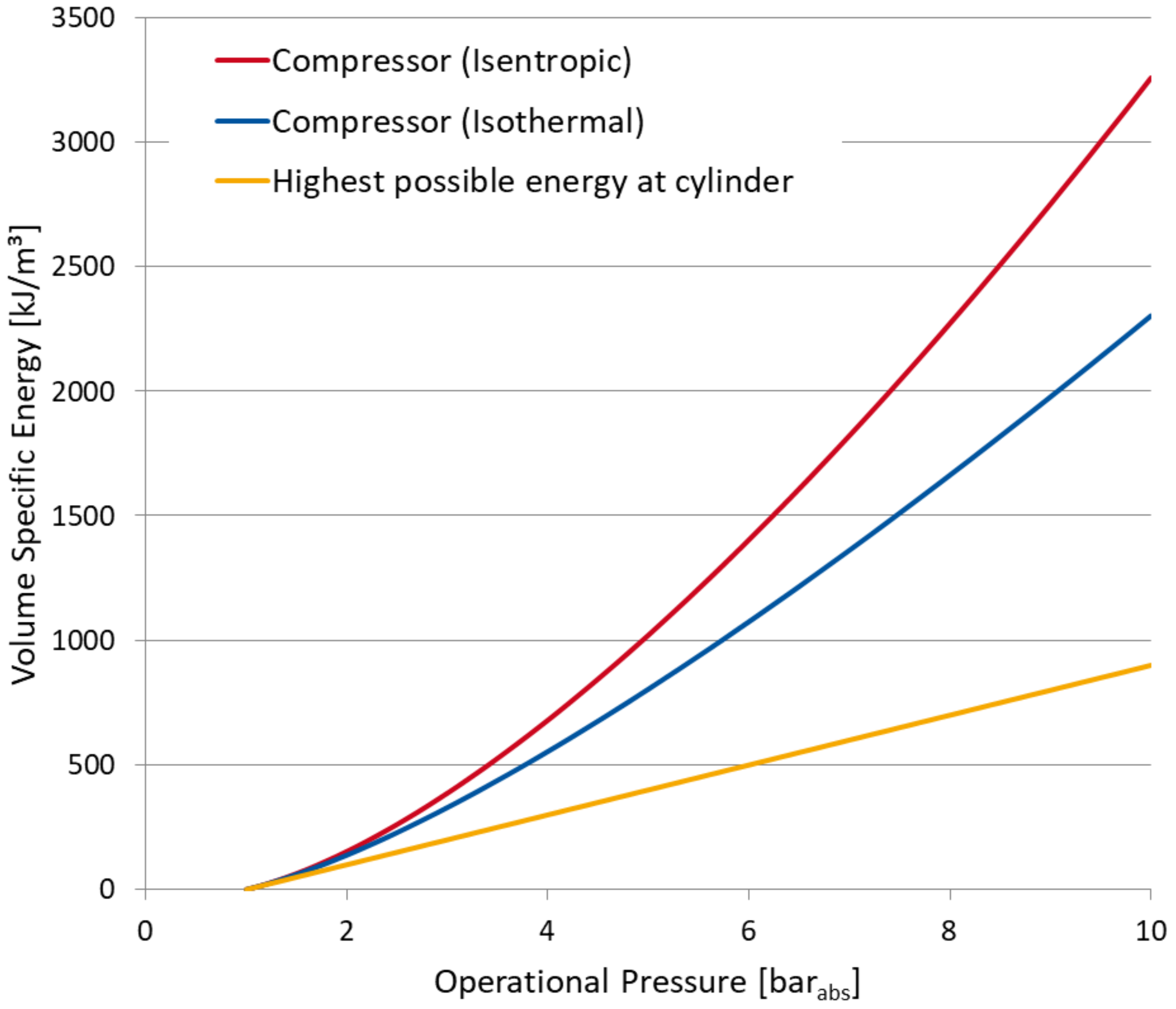
Measures for Efficiency Improvements

- Heat recovery at compressors
  - Up to 95% of the input power can be recovered
  - Usually at ca. 60-70 °C → Heating, domestic warm water, process heat?

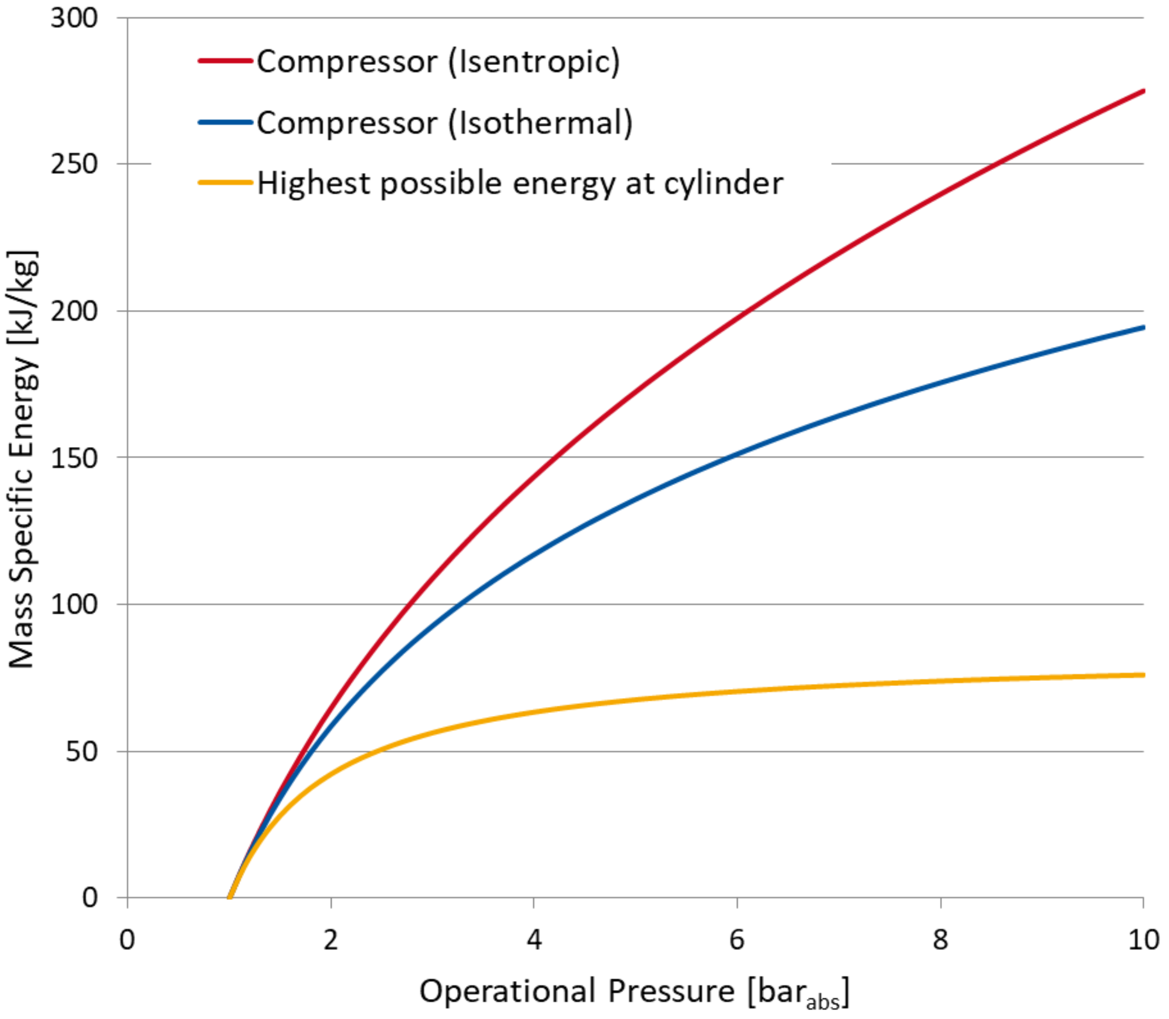
- Dimensioning
  - Air consumption of cylinders is proportional to cylinder volume (and dead volume!)
  - Reduction of dead volumes in hoses etc.

- Pressure Adjustment
  - Reduction of the pressure of the entire compressed air network

Specific Energy for Compression and at Hydrostatic Usage (Cylinders)



Specific Energy for Compression and at Hydrostatic Usage (Cylinders)



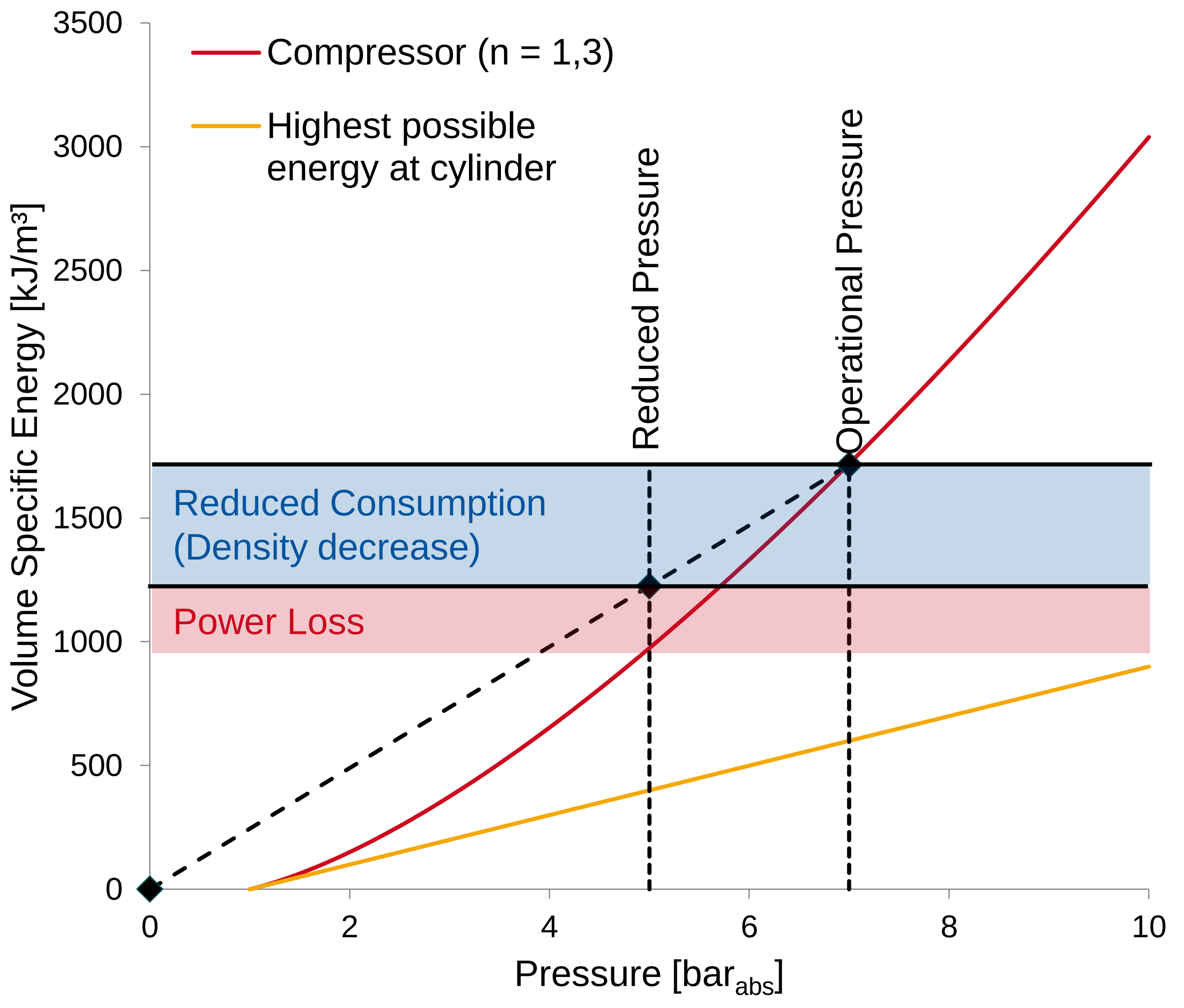
Measures for Efficiency Improvements

- Heat recovery at compressors
  - Up to 95% of the input power can be recovered
  - Usually at ca. 60-70 °C → Heating, domestic warm water, process heat?

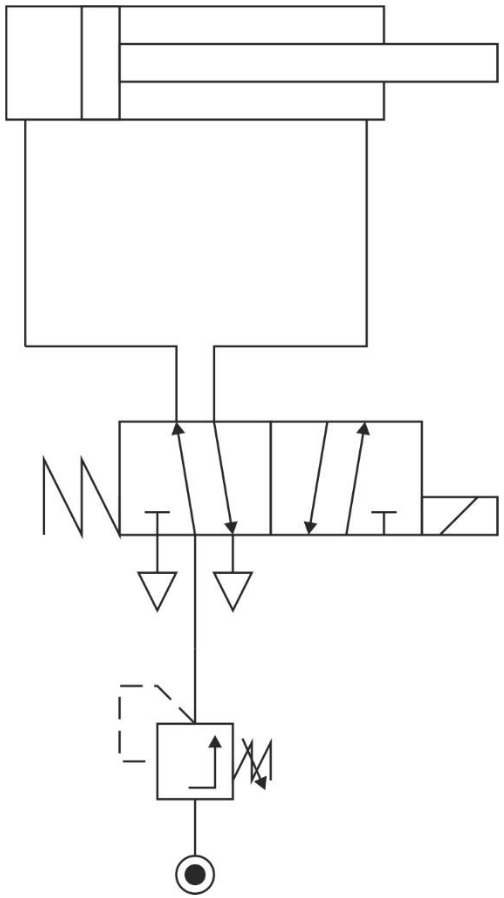
- Dimensioning
  - Air consumption of cylinders is proportional to cylinder volume (and dead volume!)
  - Reduction of dead volumes in hoses etc.

- Pressure Adjustment
  - Reduction of the pressure of the entire compressed air network
    → partially local pressure amplification required?
  - Pressure reducing valves for local pressure reduction of oversized drives
    (usually economically viable at differential pressures of only 0.5 bar)

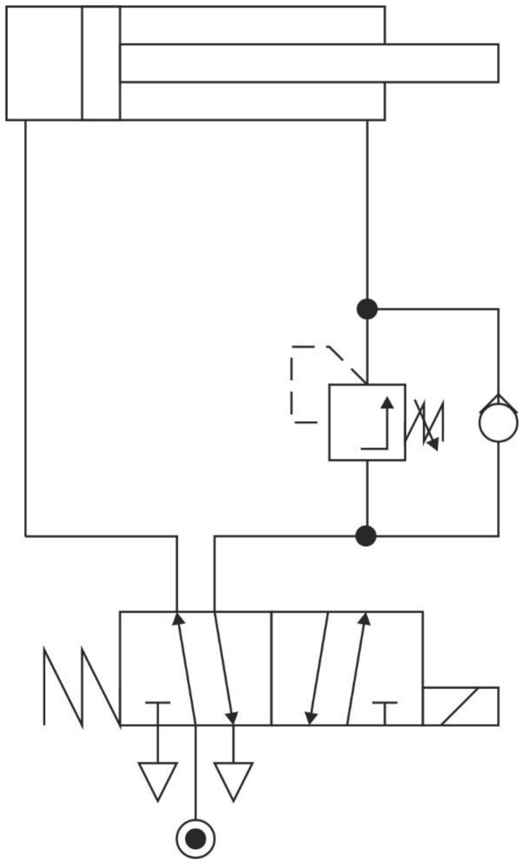
Effect of Local Pressure Reduction at Hydrostatic Usage (Cylinders)



Circuits for Local Pressure Reduction – Both Directions



Circuits for Local Pressure Reduction – Back Stroke



Measures for Efficiency Improvements

- Maintenance
  - Leakage Reduction
    - Ultra sound sensors for leakage localization and mass flow sensors at main lines for leakage detection and trend observation
    - Shut-off valves for unused (parts of) machines
  - Regular filter replacements (especially suction filters of the compressors)

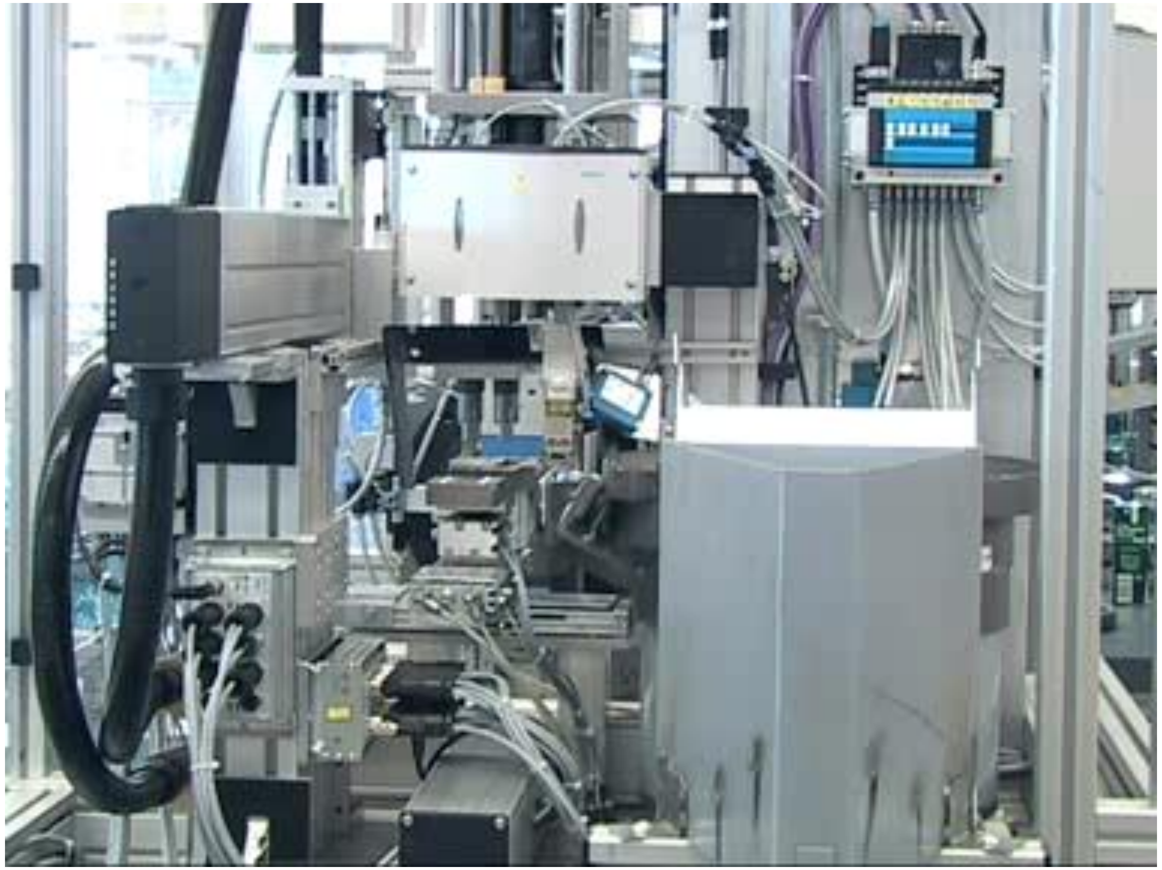
Energy efficiency-Module

Smart Pneumatics Analyser

Sources: Festo, Aventics

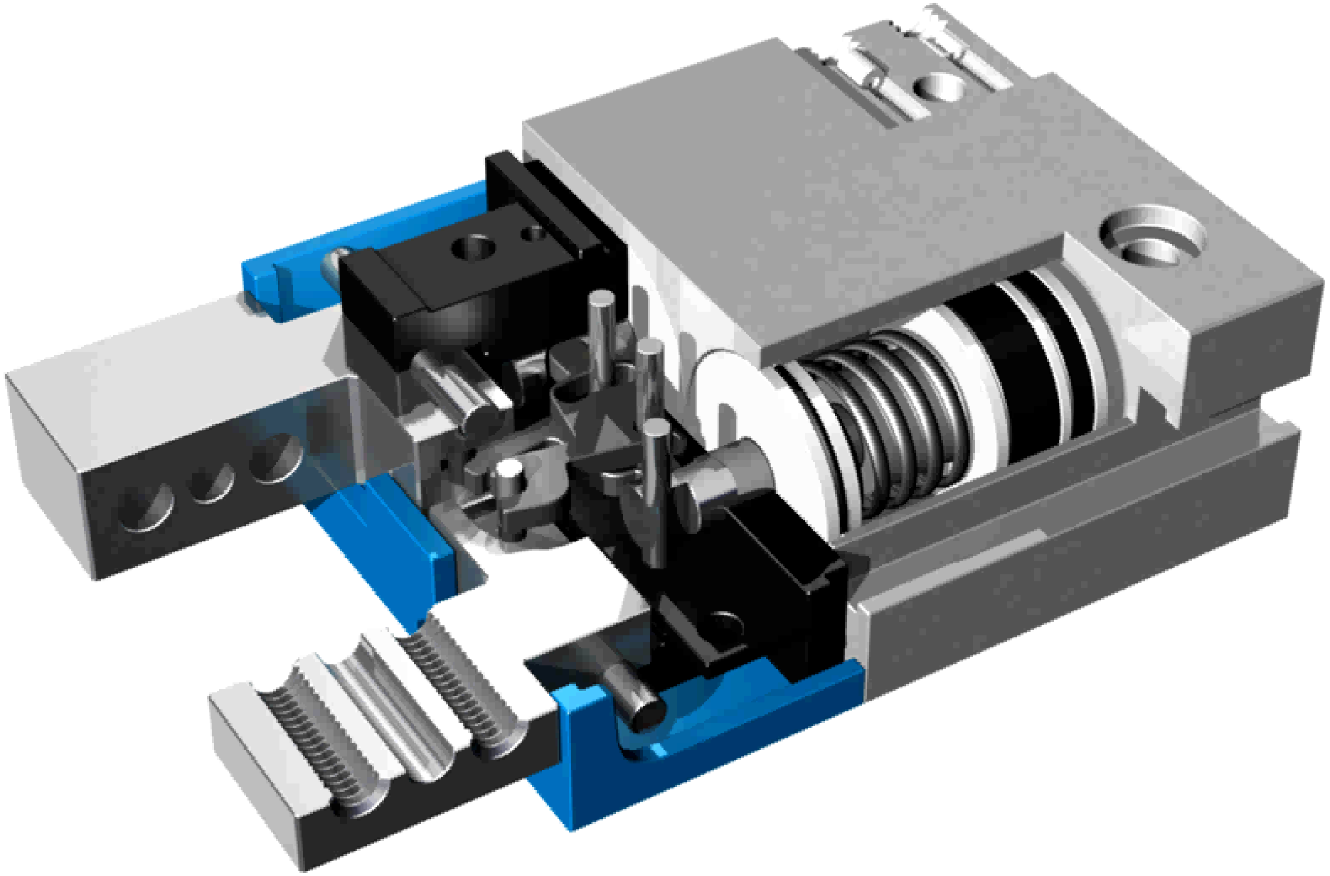
Outline

Parallel Gripper



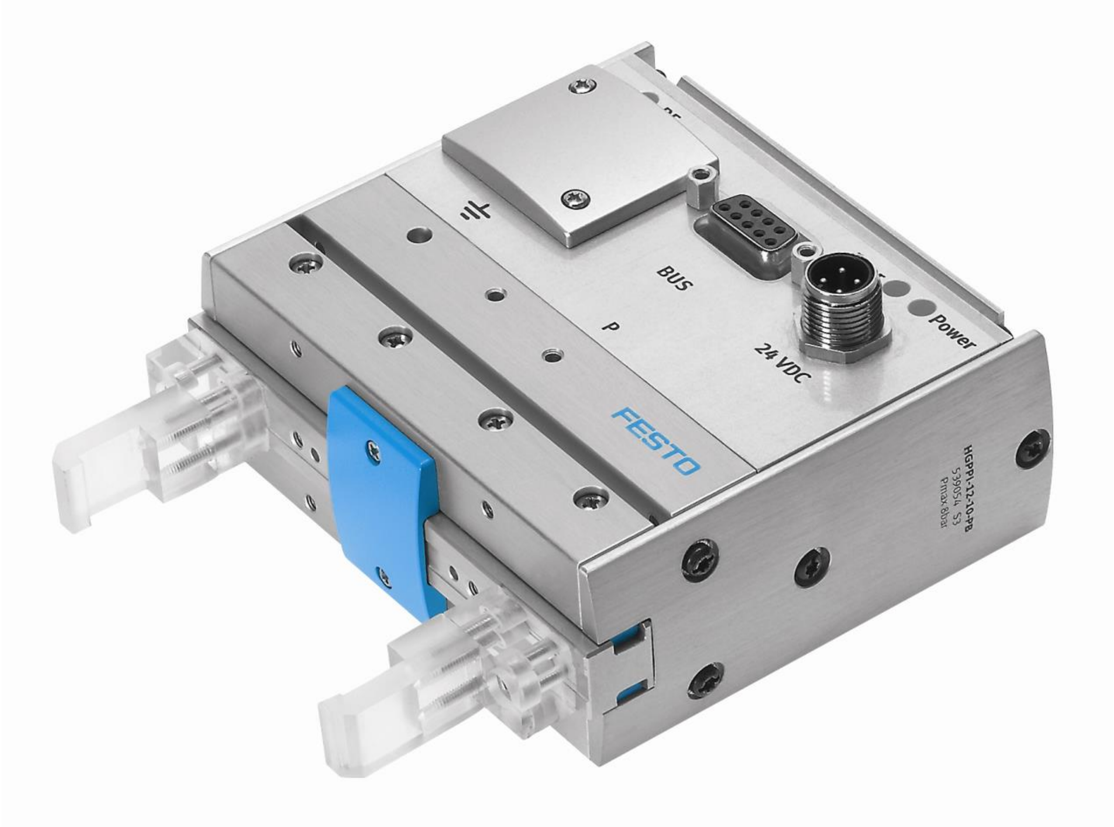
Source: Festo

Parallel Gripper



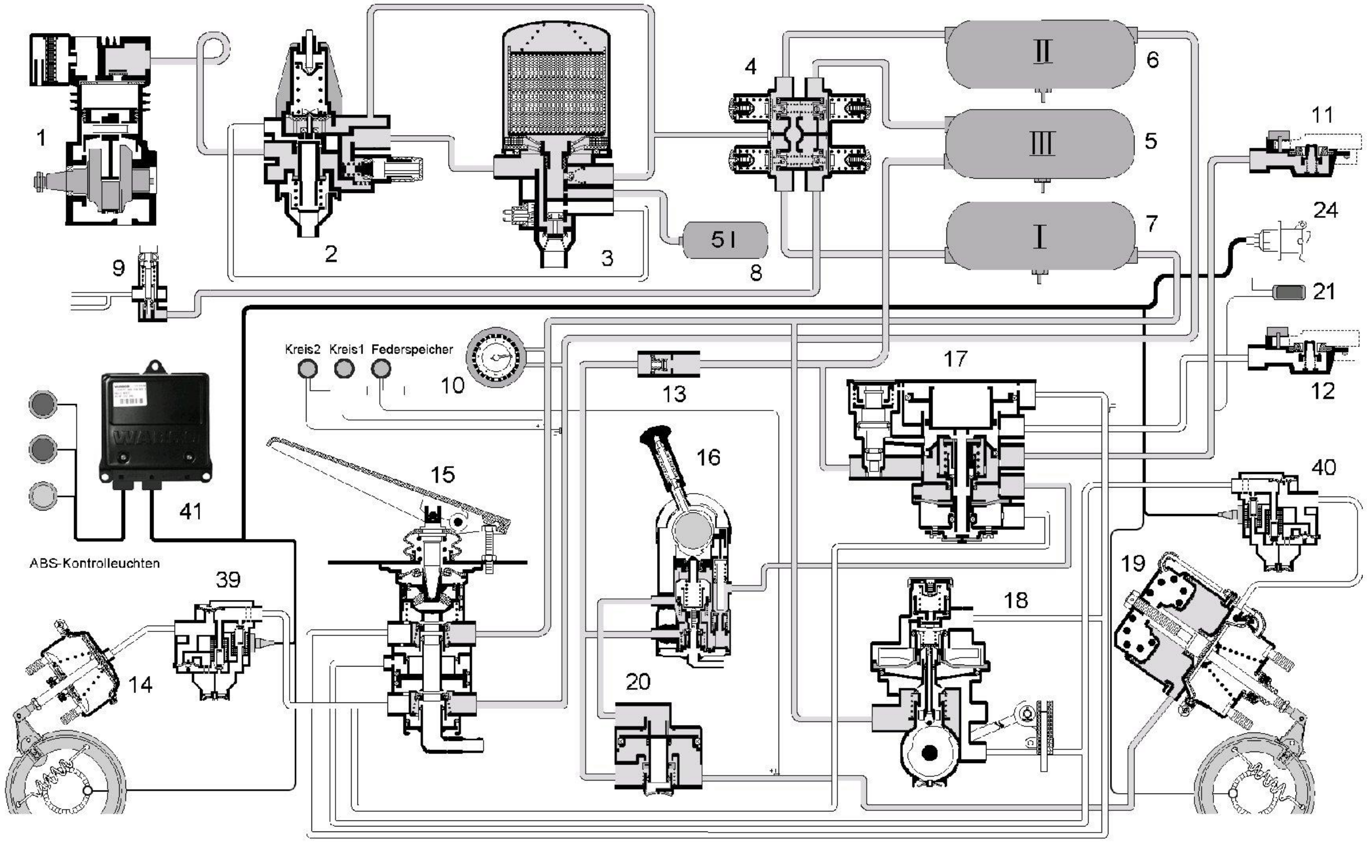
Source: Festo

Servo-Pneumatic Parallel Gripper



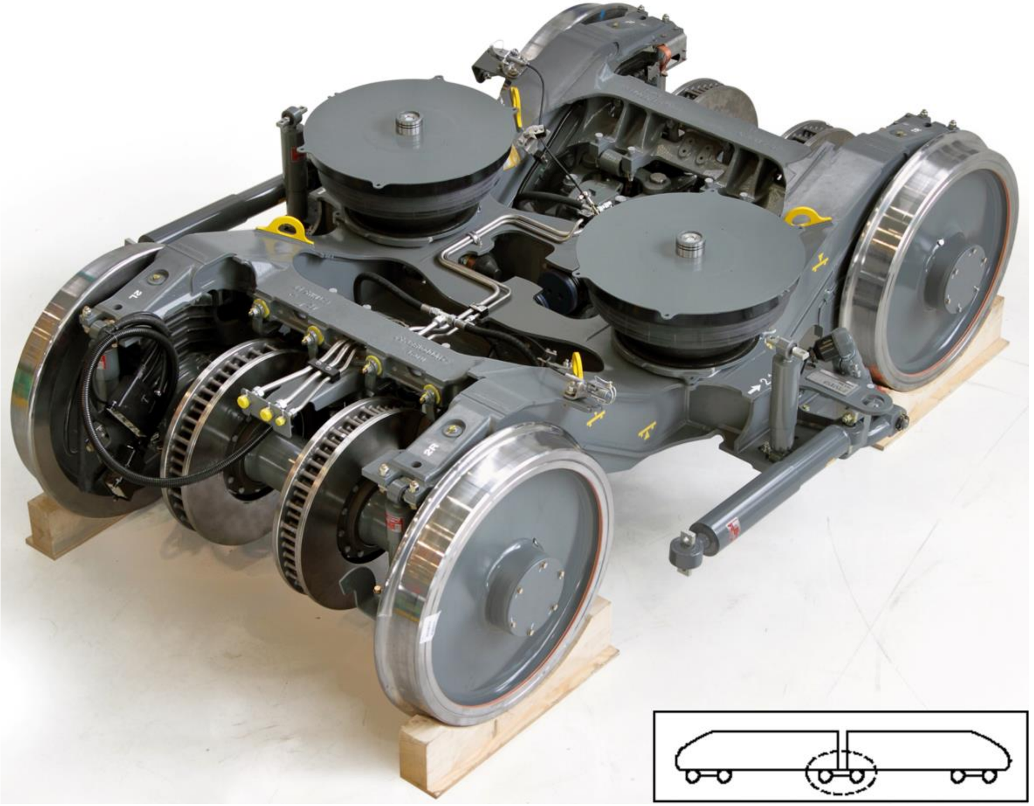
Source: Festo

Pneumatic Braking System with ABS in a Motor Vehicle



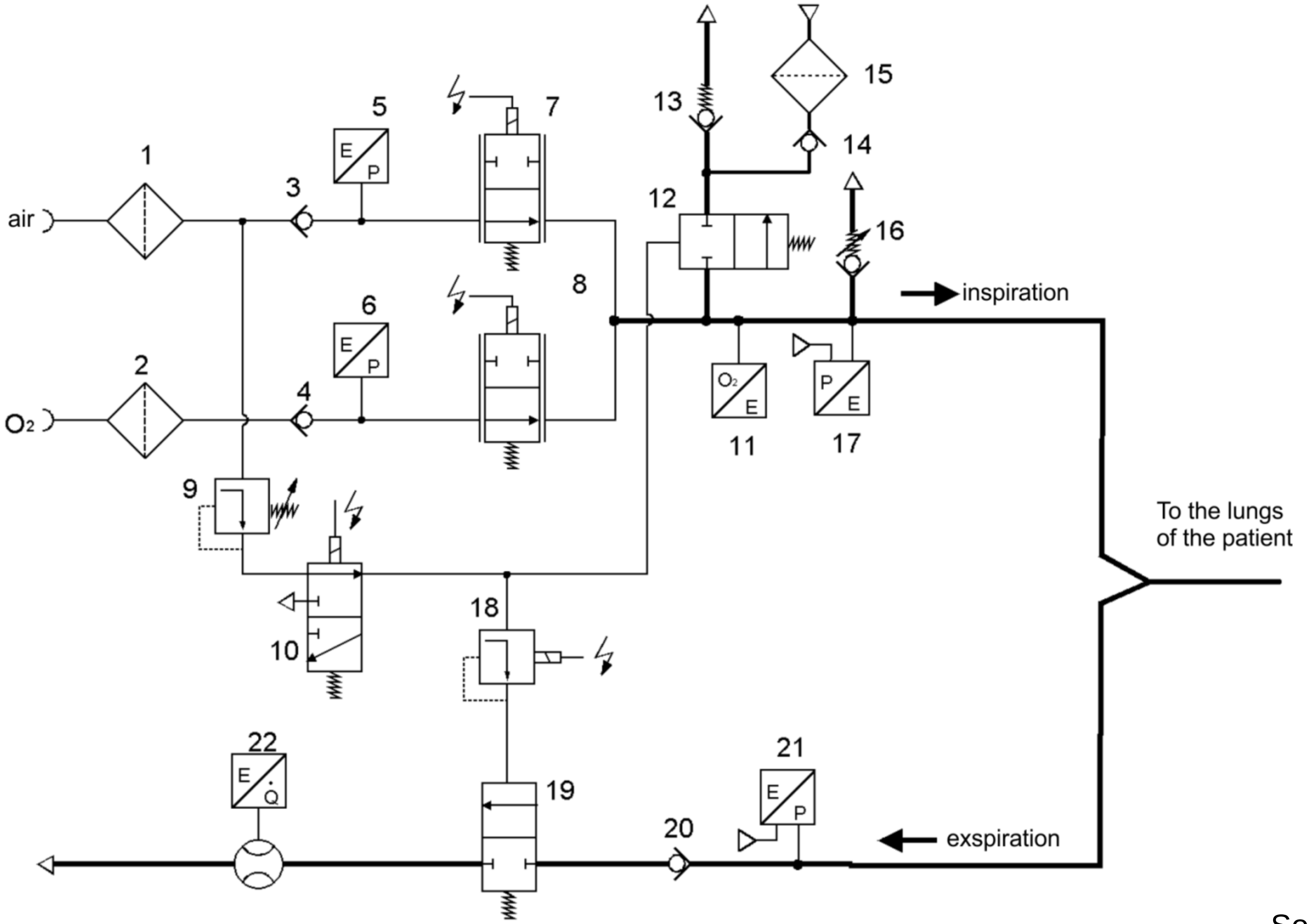
Source: Wabco

Jacobs-Bogie of the Local Passenger Train „Desiro City“ with Pneumatic Brakes and Spring Bellows



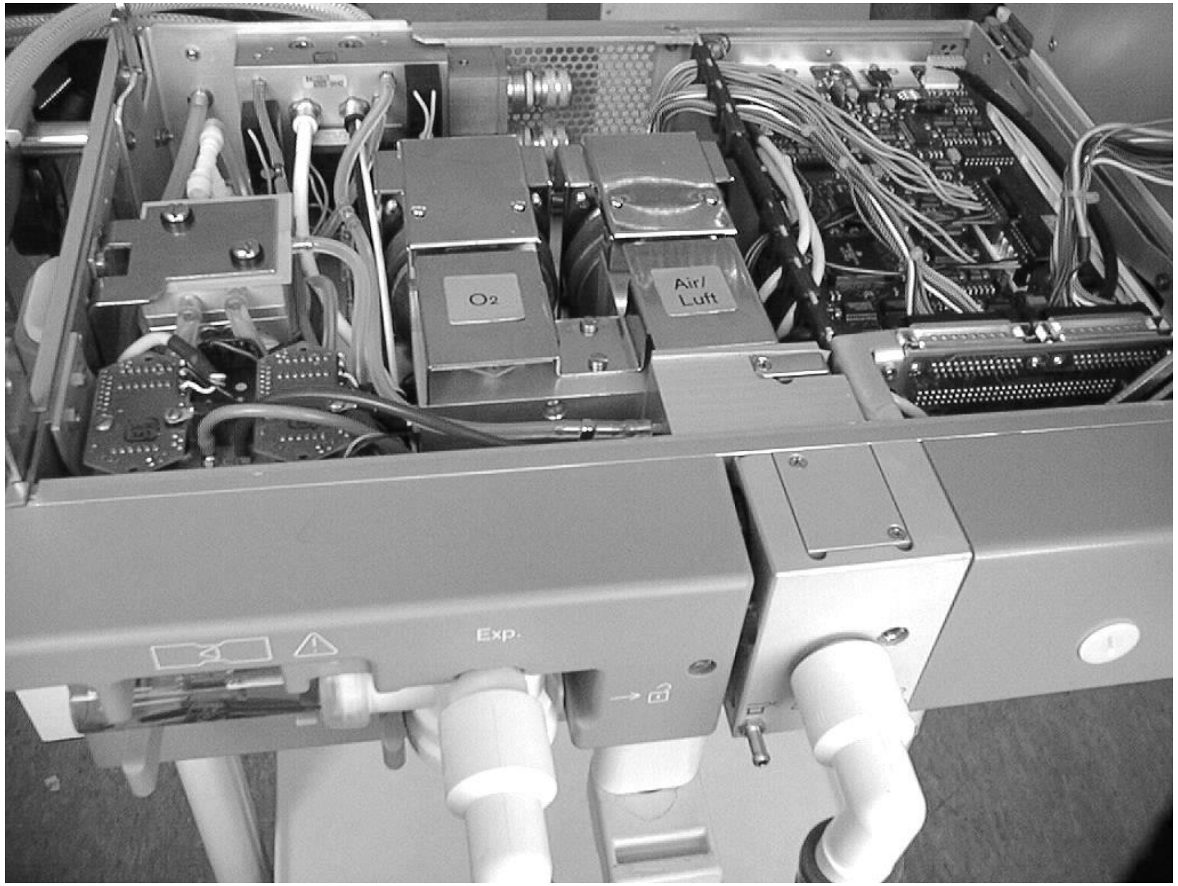
Source: Siemens Rail Systems
©JB2011

Simplified Pneumatic Diagram of an Artificial Respiration Device



Source: Dräger
Medizintechnik

View into the Intensive Ventilation Device „Evita“



Source: Dräger
Medizintechnik

Thank you for your attention.

Dr.-Ing. Olivier Reinertz
Olivier.reinertz@ifas.rwth-aachen.de