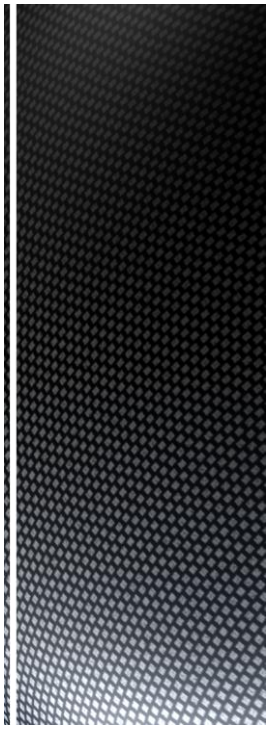
Manufacturing Laboratory (21-410)

Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session # 2

Pneumatics & Hydraulics



References

- *Dr. György Paál, "Hydraulic and Pneumatic Systems"*
- *John R. Groot, et al."Introduction to Pneumatics and Pneumatic Circuit Problems for FPEF Trainer"*

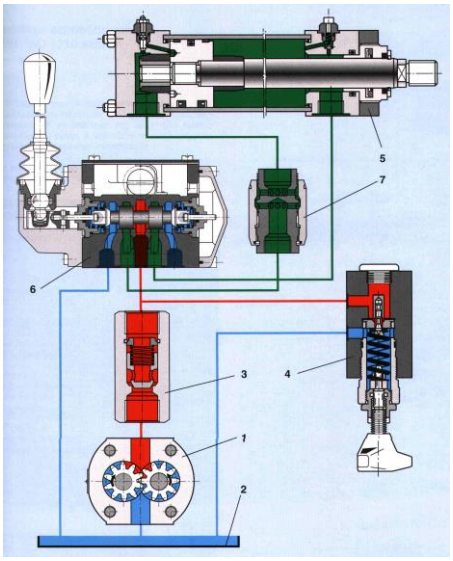
Description

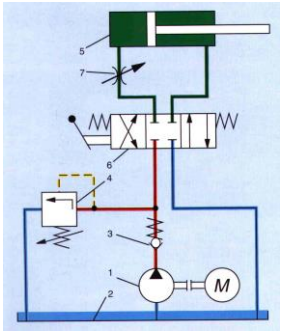
Power transmission:

Hydro = water, aulos = pipe

The means of power transmission is a liquid (pneumatic → gas)

A typical hydraulic system





1 – pump
2 – oil tank
3 – flow control valve
4 – pressure relief valve
5 – hydraulic cylinder
6 – directional control valve
7 – throttle valve

A typical hydraulic system

- *Simple method to create linear movements*
- *Creation of large forces and torques, high energy density*
- *Continuously variable movement of the actuator*
- *Simple turnaround of the direction of the movement, starting possible under full load from rest*
- *Low delay, small time constant because of low inertia*
- *Simple overload protection (no damage in case of overload)*
- *Simple monitoring of load by measuring pressure*
- *Arbitrary positioning of prime mover and actuator*
- *Large power density (relatively small mass for a given power compared to electrical and mechanical drives)*
- *Robust (insensitive against environmental influences)*

Disadvantages of hydrostatic drives

- *Working fluid is necessary (leakage problems, filtering, etc.)*
- *It is not economic for large distances*

Hydraulic fluids - tasks

- *They have the following primary tasks:*
- *Power transmission (pressure and motion transmission)*
- *Signal transmission for control*

- *Secondary tasks:*
- *Lubrication of rotating and translating components to avoid friction and wear*
- *Heat transport, away from the location of heat generation, usually into the reservoir*
- *Transport of particles to the filter*
- *Protection of surfaces from chemical attack, especially corrosion*

Hydraulic fluids - requirements

- *Functional*
  - *Good lubrication characteristics*
  - *Viscosity should not depend strongly on temperature and pressure*
  - *Good heat conductivity*
  - *Low heat expansion coefficient*
  - *Large elasticity modulus*

- *Economic*
  - *Low price*
  - *Slow aging and thermal and chemical stability long life cycle*

Hydraulic fluids - requirements (contd.)

- *Safety*
  - *High flash point or in certain cases not inflammable at all*
  - *Chemically neutral (not aggressive at all against all materials it touches)*
  - *Low air dissolving capability, not inclined to foam formation*

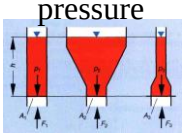
- *Environmental friendliness*
  - *No environmental harm*
  - *No toxic effect*

Hydraulic fluid types

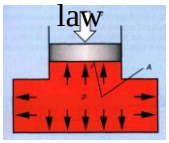
- *Water (3%)*
- *Mineral oils (75%)*
- *Not inflammable fluids (9%)*
- *Biologically degradable fluids (13%)*
- *Electrorheological fluids (in development)*

Hydraulic Calculation basics

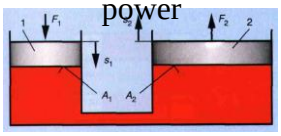
a) Hydrostatic pressure



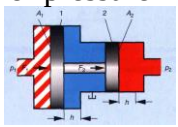
b) Pascals's law



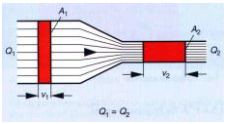
c) Transmission of power



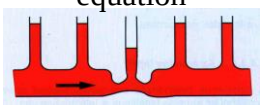
d) Transmission of pressure



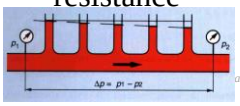
e) Continuity



g) Bernoulli equation



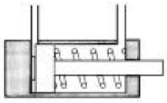
f) Flow resistance

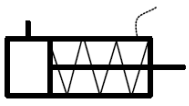


Pneumatic

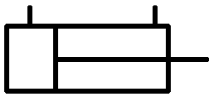
- *Single acting cylinder - a cylinder in which air pressure is applied to the movable element (piston) in only one direction.*

- *Spring return cylinder - a cylinder in which a spring returns the piston assembly*



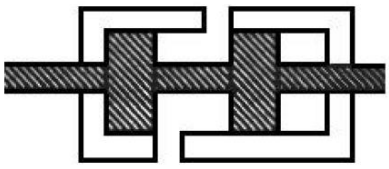


- *Double acting cylinder - a cylinder in which air pressure may be alternately applied to the piston to drive it in either direction.*

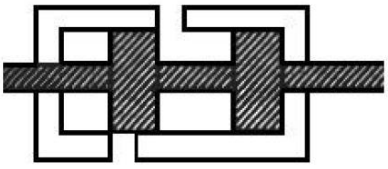


Pneumatic

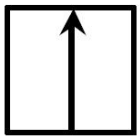
- ***Two-Way Directional Valve***
- *A two-way directional valve consists of two ports connected to each other with passages, which are connected and disconnected.*

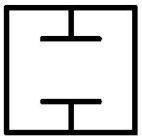


Flow Path Open



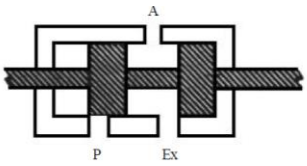
Flow Path Closed

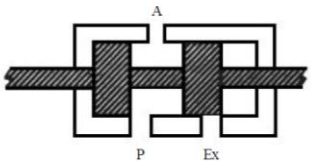


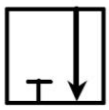


Pneumatic

- ***Three-Way Directional Valve***
- *A three-way directional valve consists of three ports connected through passages within a valve body that are shown here as port A, port P and port Ex.*
- *If port A is connected to an actuator, port P to a source of pressure and port Ex is open to exhaust, the valve will control the flow of air to (and exhaust from) Port A.*

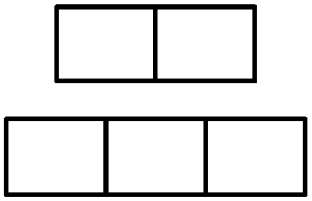






Pneumatic

- ***Position Boxes***
- *Every valve provides two or more usable positions, each position providing one or more flow paths.*

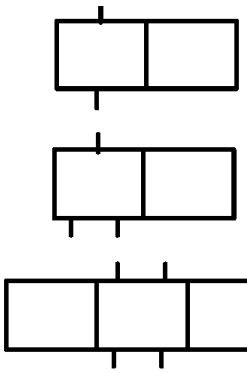


A 2-Position valve is shown by two boxes.

A 3-Position valve is shown by three boxes.

Pneumatic

- ***Valve ports***
- *Every valve port, which appears on the outside of the valve, is supposed to be shown on the symbol. But the ports are shown on only one of the boxes, the box that represents the flow paths that exist at the start of the machine cycle.*

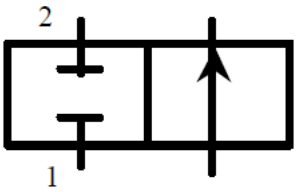


A 2-position 2-port valve

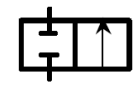
A 2-position 3-port valve

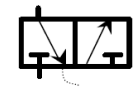
A 3-position 4-port valve

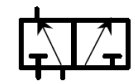
Pneumatic

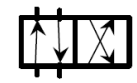


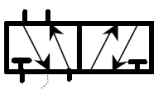
Two- Position Valves

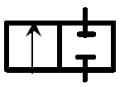

2-Way, Blocked at start of cycle

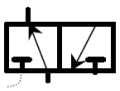

3-Way, Blocked at start of cycle

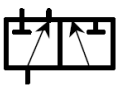

2-Inlet Selector

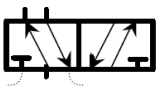

4-Way, 4-port Single Inlet


4-Way, 5-port Dual Pressure Common Exhaust

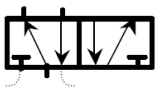

2-Way, Open at start of cycle


3-Way, Open at start of cycle

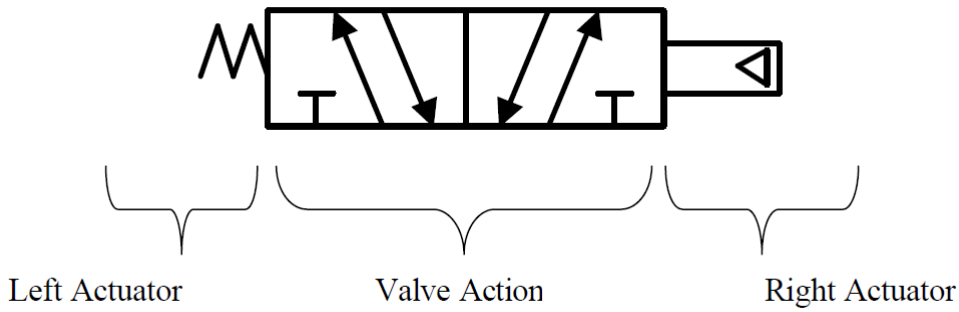

Distributor (Diverter)


4-Way, 5-Port Single Inlet Dual Exhausts

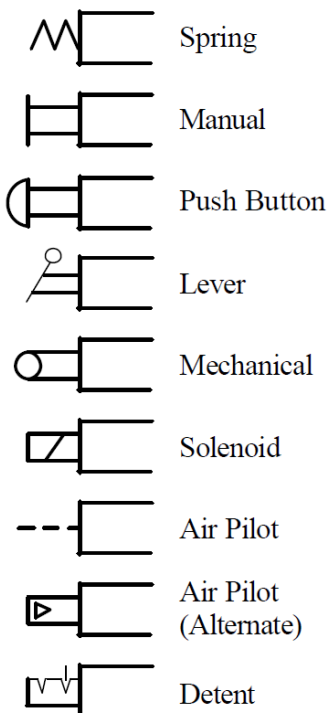
or

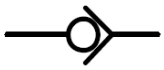


Pneumatic



Pneumatic

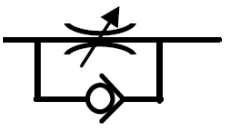




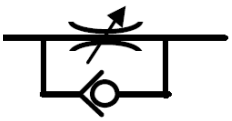
Check Valve - Allows flow in one direction, but blocks flow in the other direction. In this example flow can go from right to left, but now flow left to right is blocked.

Fixed Restriction or orifice - Restricts flow in both directions.

Adjustable Restriction - Restricts flow in both directions.



Flow Control Valve - (also called speed control valve) allows free flow in one direction but restricts flow in the other direction. In this example free flow is from right to left, restricted flow from left to right.

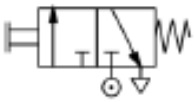


In this example, free flow is from left to right. Restricted flow is from right to left.

Pneumatic

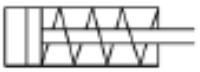
The basic rules of circuit diagram setting are as follows:

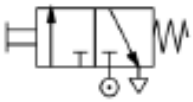
1.



In a pneumatic circuit, the flow of energy is from the bottom to the top. Therefore, the air supply unit should be put at the bottom left corner.

2.

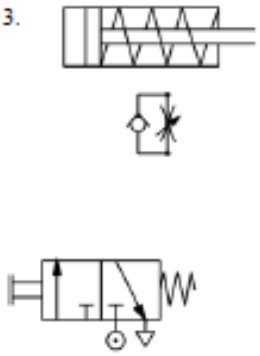




The work cycle should be drawn from left to right. The first operating cylinder should be placed at the upper left corner.

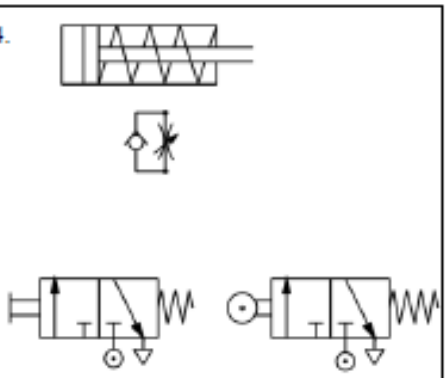
Pneumatic

3.



Power control valves should be drawn directly under the cylinder controlled by them, forming a power unit.

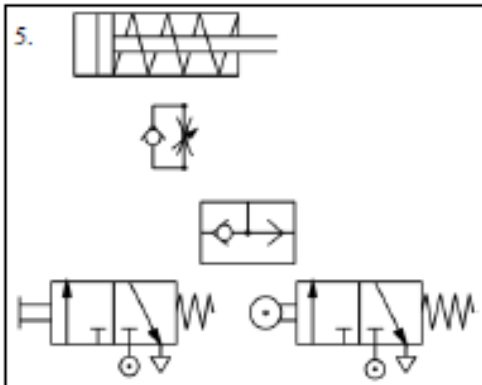
4.



Control cylinders and operational valves (signal components) driven by power control valves should be placed at the lower levels of the diagram.

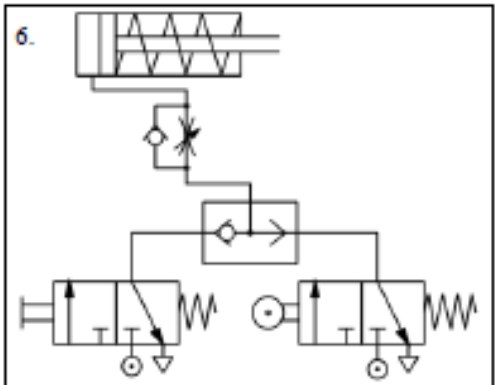
Pneumatic

5.



Assistance valves, such as those with logic functions (for example, memory, 'AND', 'OR', 'NOT", delay, etc), can be put between the pneumatic components and the power control valves.

6.



Use the line which represents the connecting pipe to connect all the air supply unit and the pneumatic components to complete the pneumatic circuit. Check carefully the circuit and the logic of the operation before use to avoid any accident.