Applications of Hydraulics & Pneumatics

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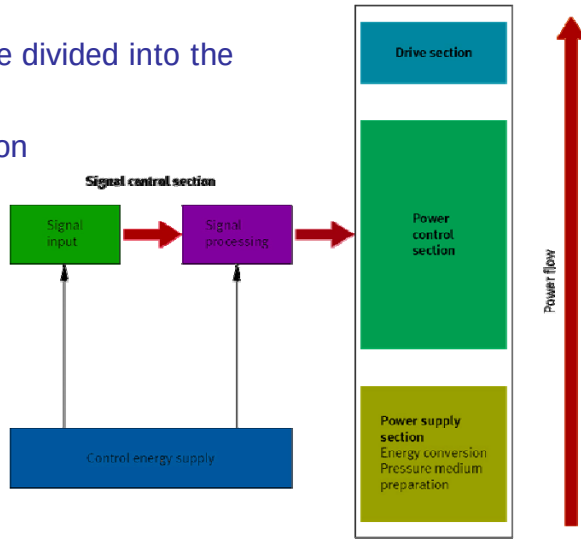
Hydraulics Systems

A hydraulic system can be divided into the following sections:

- The signal control section
- The power section



Signal Control

The signal control section is divided into signal input (sensing) and signal processing (processing).

Signal input may be carried out:

- manually
- mechanically
- contactlessly

Signals can be processed by the following means:

- by the operator
- by electronics
- by pneumatics
- by mechanics
- by hydraulics

Power Control

The power is supplied to the drive section by the power control section in accordance with the control problem. The following components perform this task:

- **directional control valves**
- **flow control valves**
- **pressure valves**
- **non-return valves.**

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Valves

Various aspects are taken into consideration when classifying valves:

- Function
- Design
- Method of actuation

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Valves: function

- A selection is made between the following types of valve based on the tasks they perform in the hydraulic system:
- **Non-Return Valves**
- **Directional Control Valves**
- **Pressure Valves**
- **Flow Control Valves**

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Valves: Design

Spool principle	Poppet principle
flow leakage	good sealing
sensitive to dirt	non-sensitive to dirt
simple construction even in the case of multi-position valves	complicated design as multi-position valves
pressure-compensated	pressure compensation must be achieved
long actuation stroke	short actuation stroke

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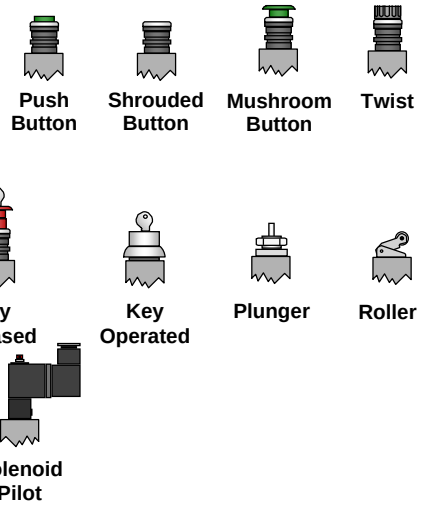
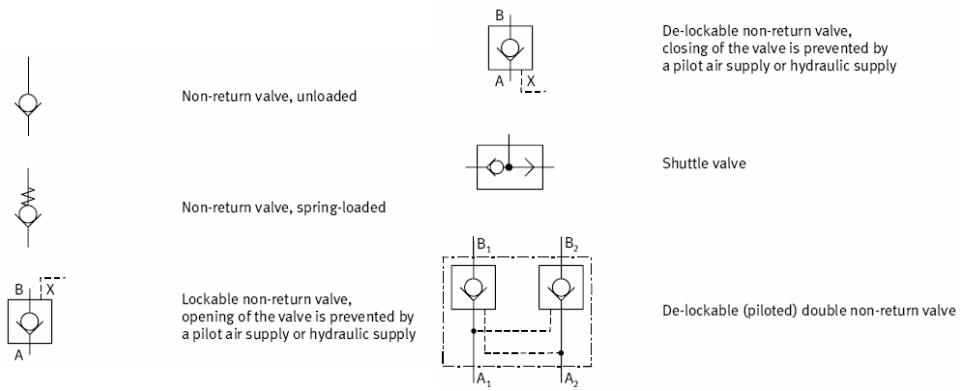
Valves: Actuation

- An operator is the mechanism that causes a valve to change state
- They are classified as manual, mechanical and electrical



Non-Return Valves

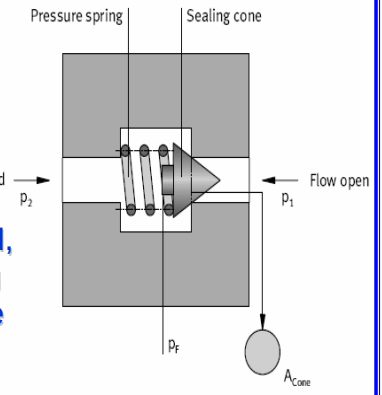
- Non-return valves are distinguished as follows:
  - Non-return valves (unloaded, spring-loaded)
  - Lockable and unlockable non-return valves



Check Valve

Symbol:

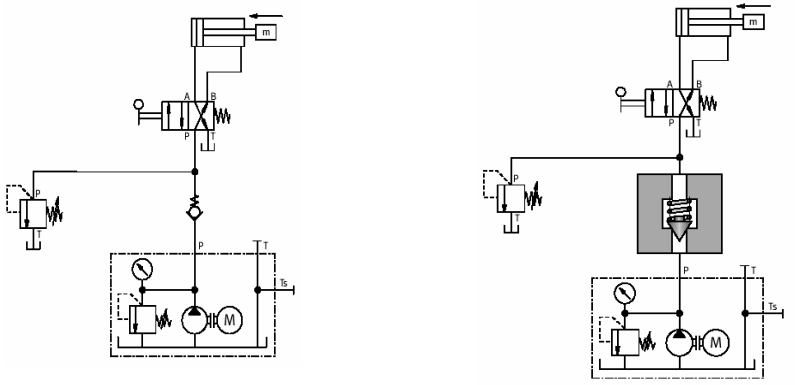
- It allows free flow in one direction only and no flow is possible in reverse direction.



- As the non-return valve is spring-loaded, the spring force operates on the sealing cone in addition to the counter pressure p2 and flow is produced when:

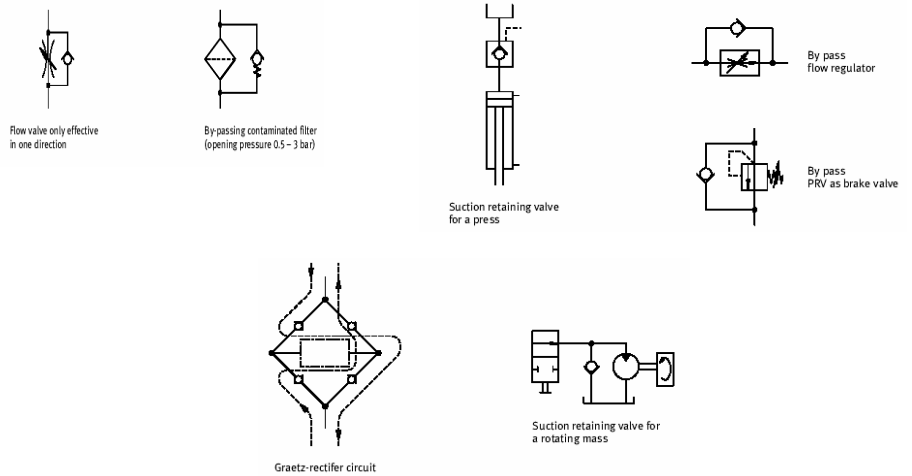
$$p_1 \rangle p_2 + p_f$$

Pump protection by check valve



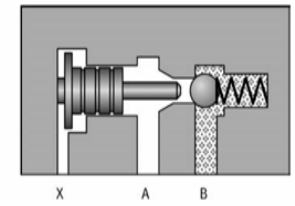
- When the electric motor is switched off, the load pressure cannot drive the pump backwards. Pressure peaks which occur in the system do not affect the pump but are diverted by the pressure relief valve.

Application Of Check Valves

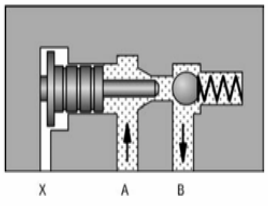


Pilot Operated Check Valve

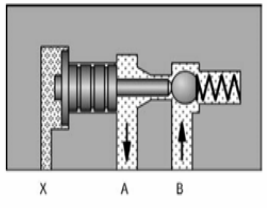
- Pilot operated check valve permits free flow in one direction and block return flow, until opened by a pilot line.



Flow blocked from B to A



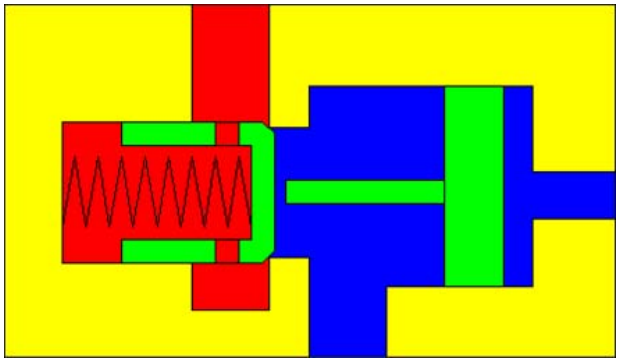
Flow from A to B



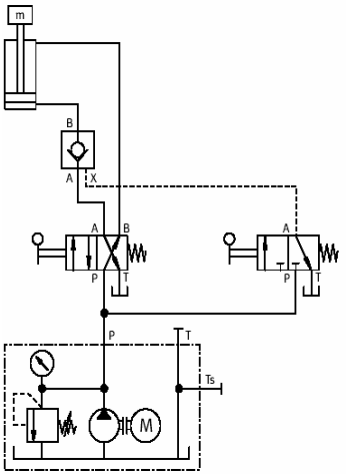
Flow from B to A

- If the hydraulic fluid is to flow from B to A, the valve poppet with the de-locking piston must be lifted away from its seat. The de-locking piston is pressurised via control port X.

Pilot Operated Check Valve

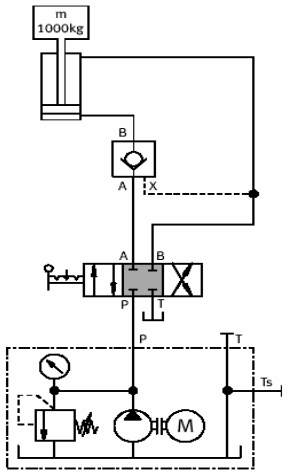


De-lockable non-return valve



- Once the 3/2-way valve is actuated, the pilot piston is pressurized and the sealing element of the non-return valve opens. This allows the hydraulic fluid to flow away from the piston side via the 4/2-way valve to the reservoir.

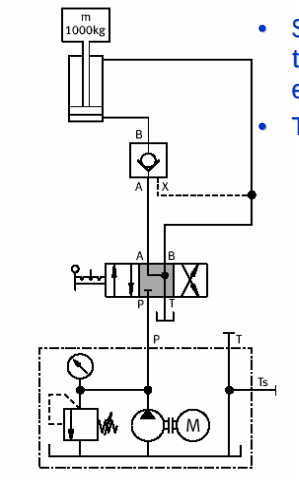
Piloted non-return valve



- A piloted non-return valve which is raised only closes when the control oil can be discharged from the pilot port to the reservoir. For this reason, using a piloted nonreturn valve calls for a special mid-position of the 4/3-way valve.

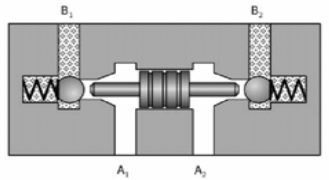
- The piloted non-return valve cannot close immediately as pressure can only escape from the closed control port X via the leakage from the directional control valve.

Piloted non-return valve

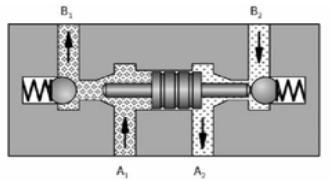


- Since in this mid-position ports A and B are connected to T, and P is closed, both control port X and port B are exhausted at the non-return valve.
- This causes the nonreturn valve to close immediately.

Piloted double non-return valve



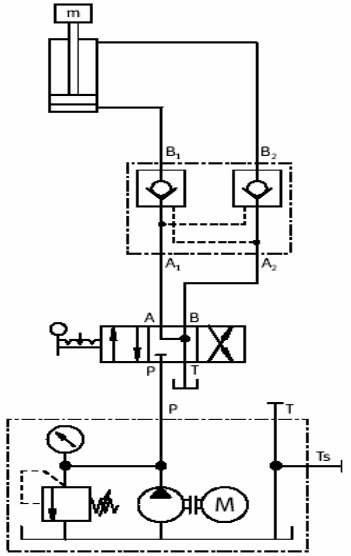
Piloted double non-return valve, closed

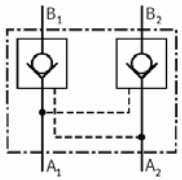


Piloted double non-return valve, open

- Free flow is possible either in the flow direction from A1 to B1 or from A2 to B2, flow is blocked either from B1 to A1 or from B2 to A2.
- If flow passes through the valve from A1 to B1, the control piston is shifted to the right and the valve poppet is lifted from its seat. By these means, flow is opened from B2 to A2 (the valve operates in a corresponding manner where there is flow from A2 to B2).

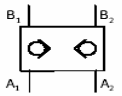
Piloted double non-return valve





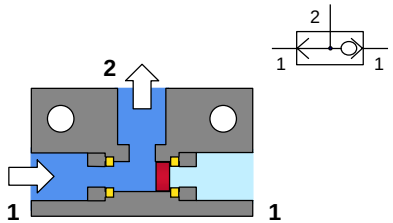
De-lockable (piloted) double non-return valve

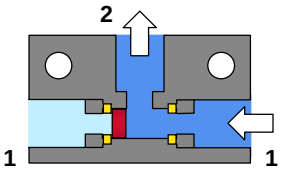
simplified
(not standardised)

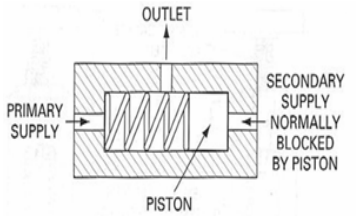


Shuttle Valve (OR Valve)

- An signal given to either the left hand port 1 or the right hand port 1 will result in an output at port 2
- The sealing disc moves across to seal the exhaust signal line to prevent loss of signal pressure



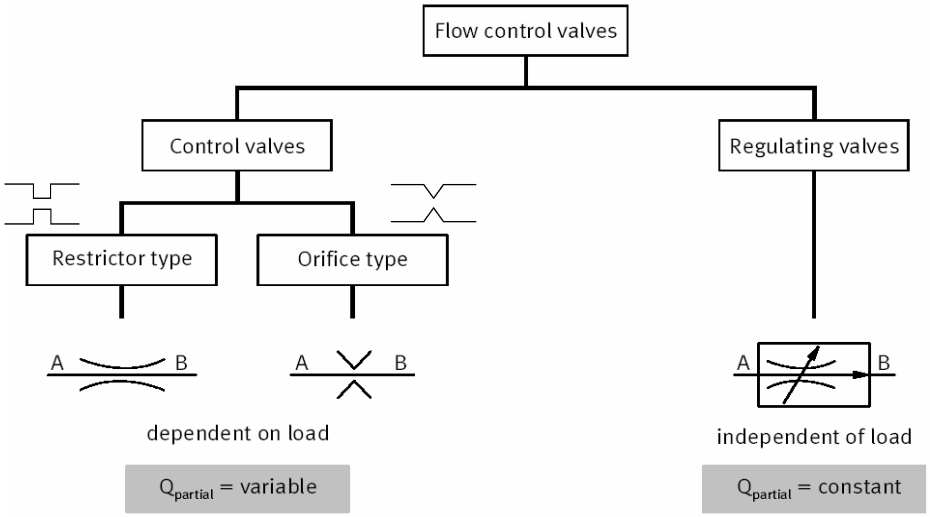




Flow Control Valves

- Flow-control valves are used to control an actuator's speed by metering flow.
- Metering is measuring or regulating the flow rate to or from an actuator.
- A reduction in the flow cross-section in the flow control valve causes an increase in pressure ahead of this. This pressure causes the pressure relief valve to open and, consequently, results in a division of the flow rate. This division of the flow rate causes the flow volume required for the r.p.m. or speed to flow to the power component and the excess delivery to be discharged via the pressure relief valve.
- This results in a considerable energy loss.
- In order to save energy, adjustable pumps can be used. In this case, the increase in pressure acts on the adjustable pump device.

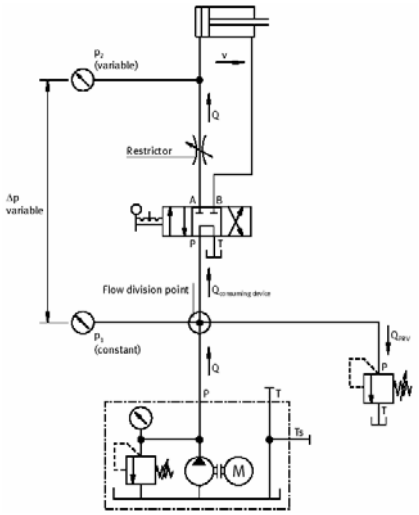
Flow Control Valves



Restrictors and orifice valves

- Restrictors and orifice valves represent a flow resistance.
- This resistance is dependent on the flow cross-section and its geometric form and on the viscosity of the liquid. When hydraulic fluid is passed through the flow resistor, there is a fall in pressure as a result of friction and of an increase in the flow velocity.
- the resistance of the orifice is determined by the turbulence and becomes independent of viscosity. For this reason, orifice valves are used in cases where independence from temperature and, therefore, from viscosity is required, e.g. in flow gauges.
- In many control systems, a specified high fall in pressure is a requirement. In such cases, restrictors are used.

Restrictors and orifice valves



- The operation of restrictors is flow-dependent. Consequently, they are not suitable for adjusting a constant flow rate in the case of a changeable load.

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The requirements for adjustable restrictors

- build-up of a resistance;
- constant resistance in the face of changing hydraulic fluid temperatures, i. e. independent of viscosity;
- sensitive adjustment – the sensitivity of adjustment of a restrictor is dependent amongst other things, on the ratio of the orifice cross-sectional area to the control surface area;
- economical design.

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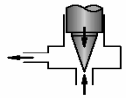
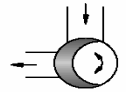
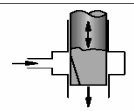
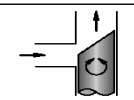
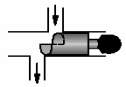
The various designs of adjustable restrictor

Type		Resistance	Dependence on viscosity	Ease of adjustment	Design
	Needle restrictor	Increase in velocity, high friction owing to long throttling path	Considerable owing to high friction	Excessive cross-sectional enlargement with a short adjustment travel, unfavourable ratio area to control surface	Economical, simple design
	Circum-ferential restrictor	As above	As above, but lower than for the needle restrictor	Steadier cross-sectional enlargement, even ratio area to control surface, total adjustment travel only 90°.	Economical, simple design, more complicated than the needle restrictor
	Longitudinal restrictor	As above	As above	As above, however sensitive adjustment owing to long adjustment travel	As for circumferential restrictor
	Gap restrictor	Main part: increase in velocity, low friction, short throttling path	Low	Unfavourable, even cross-sectional enlargement, adjustment travel of 180°	Economical
	Gap restrictor with helix	Increase in velocity, maximum friction	Independent	Sensitive, even cross-sectional enlarge-ment, adjustment travel of 360°	Expensive to produce helix

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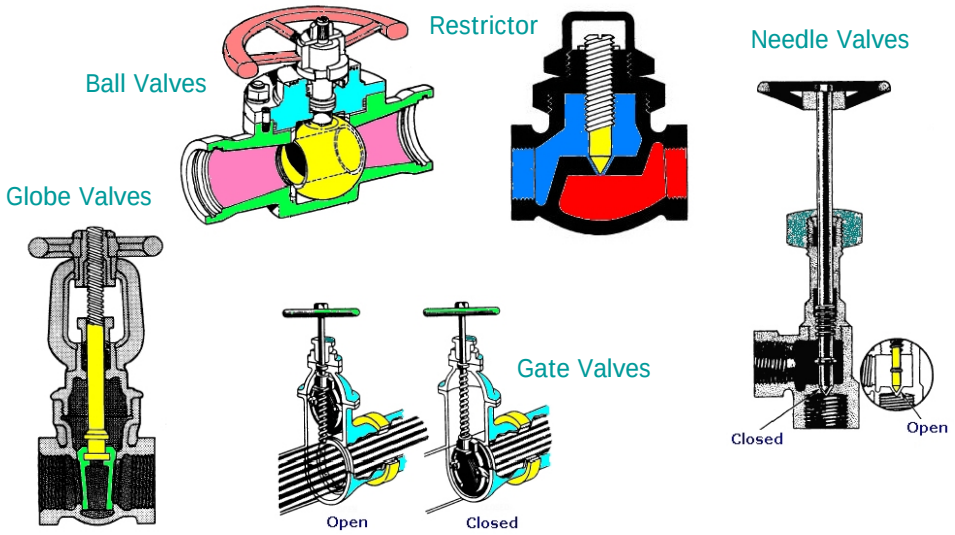
The various designs of adjustable restrictor



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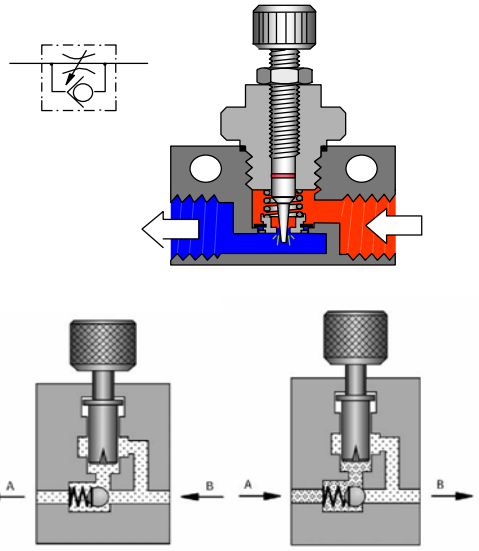
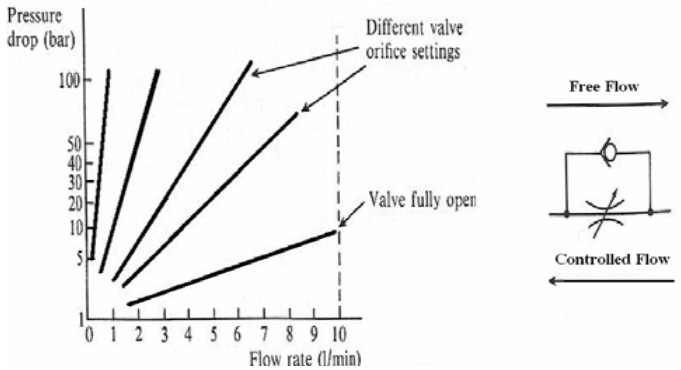
One-way flow control valve

- The one-way flow control valve where the restrictor is only effective in one direction is a combination of a restrictor and a non-return valve.
- Unidirectional, line mounted adjustable flow regulator
  - Free flow in one direction
  - Adjustable restricted flow in the other direction

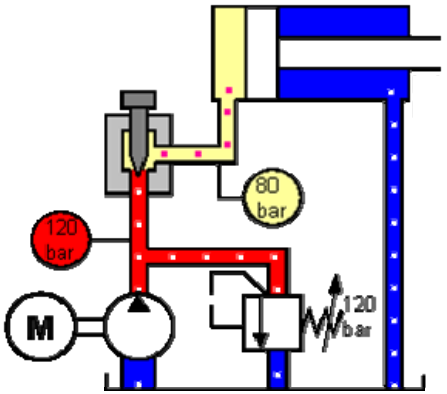


Characteristic Curve of one-way flow control



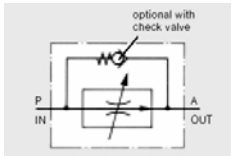
- The one-way flow-control valves do not compensate for changes in fluid temperature or pressure and are considered noncompensating valves.

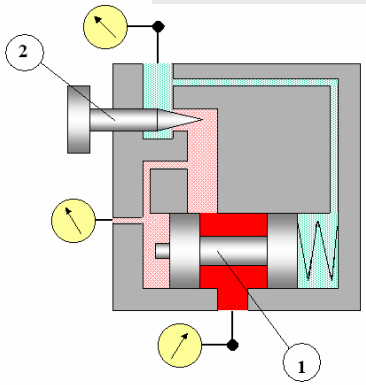
Example



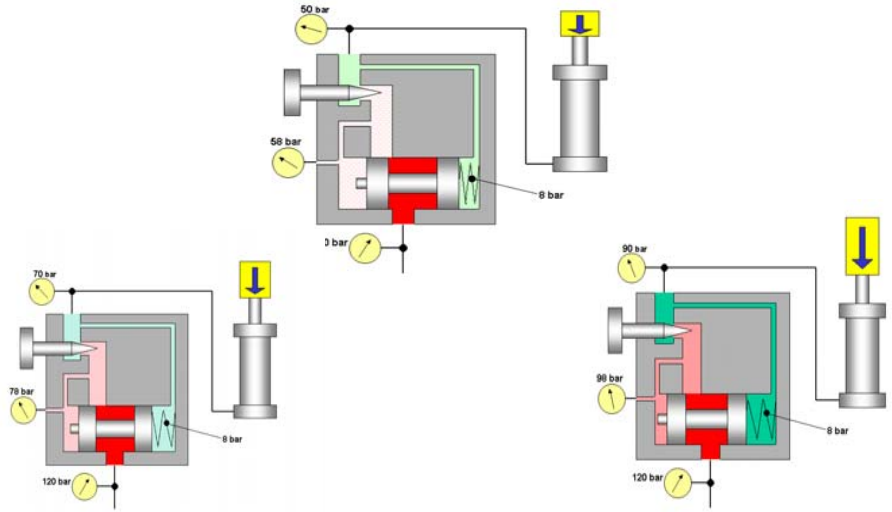
Two-way flow control valve

- in load changing, for constant velocity of load, the pressure drop via the throttle point must be kept constant.
- A restrictor (2) (adjustable restrictor) and a second restrictor (1) (regulating restrictor or pressure balance) are built-in for the desired flow rate.
- These restrictors change their resistance according to the pressures present at the input and output of the valve. The total resistance of the two restrictors combined with the pressure relief valve causes the flow division.
- Other Name: Pressure compensated flow control Valve

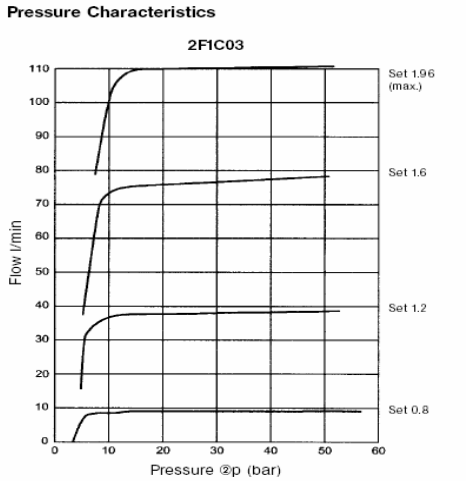




Two-way flow control valve



Industrial example



Applications

- 2-way flow control valves provide a constant flow rate in the face of changing loads. so they are suitable for the following application examples:
  - Workpiece slides which operate at a constant feed speed with varying working loads;
  - Lifting gear where the lowering speeds need to be carefully restricted.