# Symbols and Tables

| | | | |
|---|---|---|---|
| $q$ | = | Displacement | : $cm^3$ |
| $n$ | = | Revolutions | : $min^{-1}$ |
| $p$ | = | Pressure | : bar |
| $\Delta p$ | = | Pressure drop | : bar |
| $Q$ | = | Oil capacity | : l/min = $dm^3$/min |
| $v$ | = | Speed | : m/s |
| $L$ | = | Length | : m |
| $D$ | = | Piston diameter | : mm |
| $d$ | = | Piston rod diameter | : mm |
| $D_i$ | = | Bore of pipe | : mm |
| $D_h$ | = | Hydraulic diameter | : mm |
| $A$ | = | Area | : $cm^2$ |
| $a$ | = | Ring area | : $cm^2$ |
| $t$ | = | Time | : s. |
| $m$ | = | Volume | : kg |
| $F$ | = | Force | : daN |
| $M$ | = | Torque | : Nm |
| $P$ | = | Power | : kW |
| $A_s$ | = | Break load | : daN |
| $E$ | = | Elasticity module | : kp/$cm^2$ |
| $l$ | = | Free column length | : m |
| $S$ | = | Safety factor | |
| $v$ | = | Kinematic viscosity | : $mm^2$/s |
| $\eta v$ | = | Volumetric efficiency | |
| $\eta m$ | = | Mechanical efficiency | |
| $\eta t$ | = | Total efficiency | |
| $\lambda$ | = | Resistance figure | |
| $V_{ac}$ | = | Accumulator size | |
| $V_x$ | = | Required oil capacity available in accumulator | |
| $P_1$ | = | Lowest oil pressure | |
| $P_2$ | = | Highest oil pressure | |
| $P_o$ | = | Pre-charge | |

**Ratio factors:**

| | | |
|---|---|---|
| Power | 1 kw | = 1,36Hp |
| | 1Hp | = 75 kpm/s |
| | | = 0,736 kw |
| Torque | 1 kpm | = 9,81 Nm |
| | | = 7,233 lbf ft |
| | 1 Nm | = 0,102 kpm |
| Pressure | 1 kp/$cm^2$ | = 98.000 Pa |
| | | = 0,981 bar |
| | | = 9,81 N/$cm^2$ |
| | | = 14,22 psi |
| | 1 psi | = 0,06895 bar |
| | | = 0,0703 kp/$cm^2$ |
| | 1 bar | = 1,0194 kp/$cm^2$ |
| Volume | 1 US, gallon | = 3,785 liter |
| | 1 Eng. gallon | = 4,546 liter |
| | 1 $in^3$ | = 16,38 $cm^3$ |
| | 1 liter | = 1,0 dm3 |
| Area | 1 $in^2$ | = 645,2 $mm^2$ |
| | 1 $foot^2$ | = 92900 $mm^2$ |
| Speed | 1 km/h | = 0,2778 m/s |
| | 1 foot/s | = 0,3048 m/s |
| | 1 mile/h | = 0,447 m/s |
| Acceleration | 1 foot/$s^2$ | = 0,3048 m/$s^2$ |
| Length | 1 in | = 25,4 mm |
| | 1 foot | = 0,3048 m |
| | 1 yd | = 0,9144 m |

**Pump:**

Power consumption $N_{an} = \dfrac{Q \times p}{600 \times \eta t}$ [kW]

Supplied oil capacity $Q = \dfrac{q \times n \times \eta v}{1000}$ [l/min]

Input torque $M = \dfrac{q \times p}{62{,}8 \times \eta m}$ [Nm]

**Motor:**

Oil consumption [l/min] $Q = \dfrac{q \times n}{1000 \times \eta v}$

Output torque $M = \dfrac{q \times \Delta p \times \eta m}{62{,}8}$ [Nm]

Output power $N = \dfrac{Q \times \Delta p \times \eta t}{600}$ [kW]

Speed $n = \dfrac{Q \times \eta v \times 1000}{q}$ [$min^{-1}$]

**Cylinder:**

Compressive force $F = p \times A \times \eta m$ [daN]

Tensile force $F = p \times a \times \eta m$ [daN]

Speed out $v = \dfrac{Q \times \eta v}{6 \times A}$ [m/s]

Speed in $v = \dfrac{Q \times \eta v}{6 \times a}$ [kW]

Oil consumption out $Q = \dfrac{A \times v \times 6}{2^v}$ [l/min]

Oil consumption in $Q = \dfrac{a \times v \times 6}{2^v}$ [l/min]

Compressive force with differential cut-in $F = P \times (A - a) \times \eta m$ [daN]

**Tube:**

Flow speed $v = \dfrac{Q \times 100}{6 \times D^2 \times 0{,}785}$ [m/s]

Pressure loads in straight pipe leads $\Delta p = \dfrac{\lambda \times L \times 0{,}89 \times v^2 \times 5}{D_i}$ [bar]

Resistance number: $\lambda = \dfrac{64}{R_e}$ $\lambda$ turb. $= \dfrac{0{,}316}{4\sqrt{R_e}}$

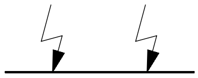
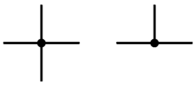
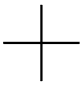
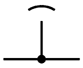
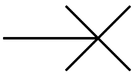
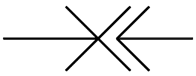
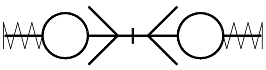
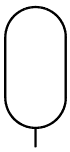
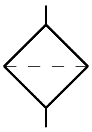
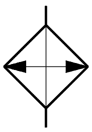
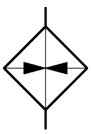
Reynolds number $R_e = \dfrac{v \times D_h \times 1000}{v}$

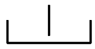
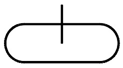
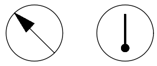
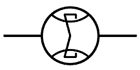
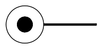
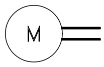
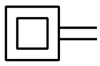
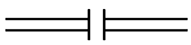
**Accumulator size:**

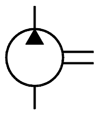
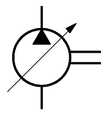
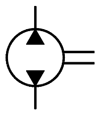
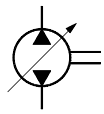
With slow charging and slow discharging $V_{ac} = \dfrac{V_x \times \dfrac{P_1}{P_o}}{1 - \dfrac{P_1}{P_2}}$

With quick charging and quick discharging $V_{ac} = \dfrac{V_x \times \dfrac{P_1}{P_o}}{1 - \left(\dfrac{P_1}{P_2}\right)^{\frac{1}{1,5}}}$

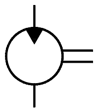
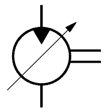
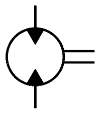
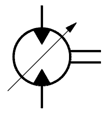
With slow charging and quick discharging $V_{ac} = \dfrac{V_x \times \dfrac{P_2}{P_o}}{\left(\dfrac{P_2}{P1}\right)^{\frac{1}{1,5}} - 1}$

| | |
|---|---|
| Work line |  |
| Pilot line |  |
| Drain line |  |
| Electric line |  |
| Flexible line |  |
| Line connections |  |
| Corssing lines |  |
| Venting |  |
| Pressure connection w. plug |  |
| With line connection |  |
| Quick koupling w. check valve |  |
| Accumulator |  |
| Filter |  |
| Cooler |  |
| Heater |  |

| | |
|---|---|
| Reservoir, open |  |
| Reservoir, pressurized |  |
| Enclosure for several components in one unit |  |
| Manometer, Thermometer |  |
| Flow meter |  |
| Pressure source |  |
| Electromotor |  |
| Combustion engine |  |
| Coupling |  |

| | Constant | Variable |
|---|---|---|
| 1 Flow direction |  |  |
| 2 Flow directions |  |  |

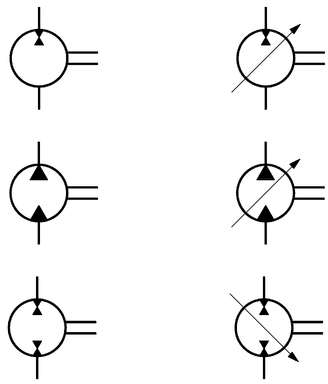
Displacement pump

| | Constant | Variable |
|---|---|---|
| 1 Flow direction |  |  |
| 2 Flow directions |  |  |

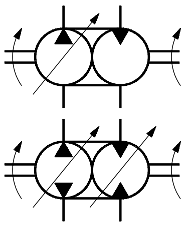
Displacement motor

Constant    Variable

Combined pump-motors



Hydrostatic transmission

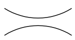


Shaft, lever, rod, piston



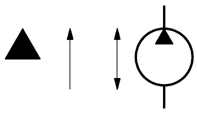
Spring

Throttling, depending on viscosity

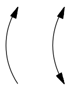


Restriction, not viscosity influenced

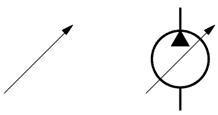
Flow direction



Direction of rotation

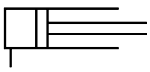


Variable setting

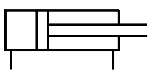


Cylinders

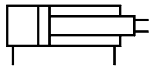
Single acting



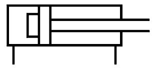
Double acting



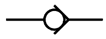
Differential cylinder



Cylinder with cushion

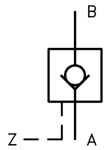


Check valve, not spring loaded



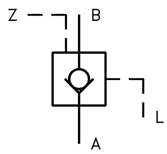
Spring loaded

Pilot controlled check valve

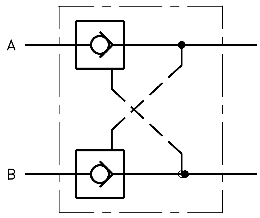



Pilot controlled opening

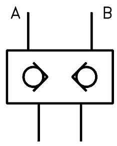
Pilot controlled closing



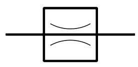

Example



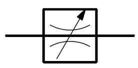

Simplified



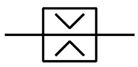

Restrictor, fixed



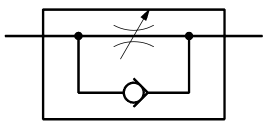
Restrictor, variable



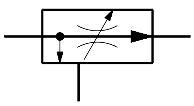
Restrictor, not viscosity influenced



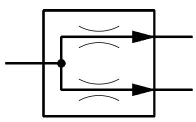
Throttle-check valve



3-way by-pass flow regulator

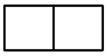


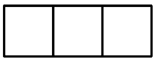
Flow divider

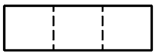


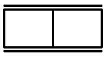
## Directional valves

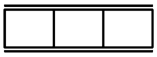
*Basic symbol:*

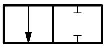
Two - way 

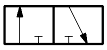
Three - way 

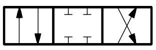
Two - way 

Without fixed position
2 - extreme position 

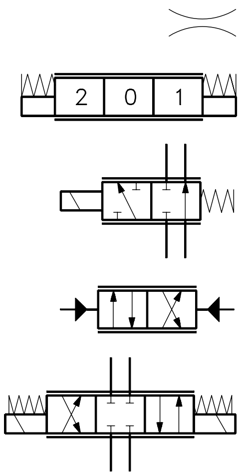
2 - extreme position
and between (OSP) 

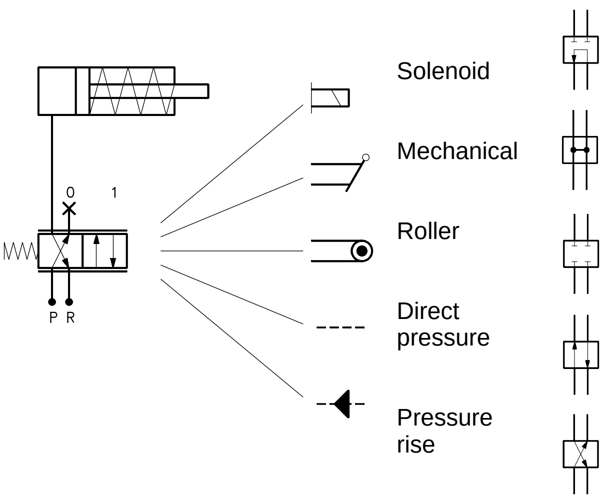
2/2 - valve 

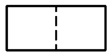
3/2 - valve 

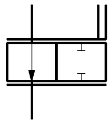
4/3 - valve 

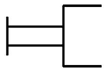
*Examples*

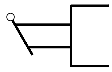


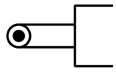



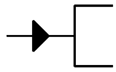

with transient intermittend pos. 

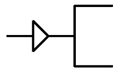
mechanical feed back 

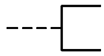
Hand operated 

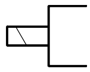
Lever 

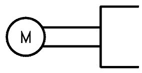
Roller 

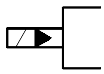
Hydraulic operated 

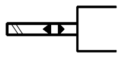
Pneumatic operated 

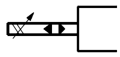
Direkt pressure 

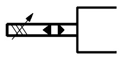
Solenoid 

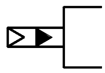
Motor operated 

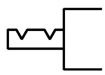

Solenoid, hydraulik-operated 

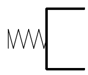
PVEO 

PVEM 

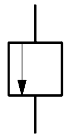
PVEH 

Pneumatic,
hydraulic-operated 

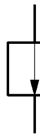
Mekanical lock 

Spring return 

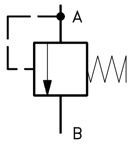
Normally closed



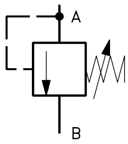
Normally open



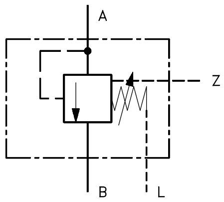
Pressure limiting valve, fixed setting



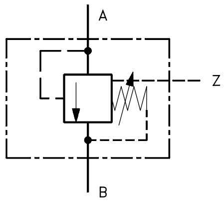

Pressure limiting valve, variable



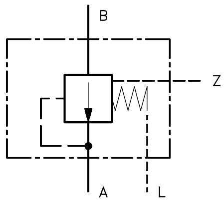

Pilot operated, external drain line



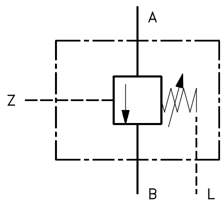

Internal drain



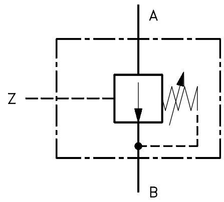

Pressure reduction line



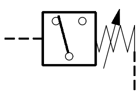

Pilot controlled opening valve




Pilot controlled closing valve




Pressure switch



A.B. Work lines

P. Pump connection (pressure)

R.S.T. Return /Tank

X.Y .Z. Pilot line

L, Drain line