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Pressure meaning

Pressure is defined as the force exerted by fluid on a determined surface area and it is expressed as a unit of force on a unit of surface. There is a number of ways to express this relationship but the most commonly used is bar, Pascal or PSI. The relationship between these 3 methods of expressing pressure is shown in the table below.

Pressure	kPA	bar	psi	kg/cm²
1 kPa	1	0,01	0,145	0,0102
1 bar	100	1	14,5	1,02
1 psi	6,9	0,069	1	0,07
1 kg/cm²	98	0,981	14,2	1

Pressure is defined by the following equation:

$$P\ (\text{Pressure}) = \frac{F\ (\text{force})}{A\ (\text{area})}$$

Where F = mass kg x acceleration (m/sec²) and thus:

$$F = \frac{kg \cdot m}{s^2} = \frac{1\ kgm}{s^2} = 1\ N\ (\text{Newton}) = 0{,}102\ kp \text{ and also } 1\ kg = 9{,}81\ N$$

In a system SI the force is expressed as N, the surface in square meters and the final result is:

$$P = \frac{F}{A} = \frac{N}{m^2} = 1\ Pa\ (\text{Pascal})$$

In practical applications the use of Pascal is inconvenient because the unit is too small; therefore bar is the most commonly used unit.

It will be useful to mention the 2 basic laws that express the relationship between pressure, volume and the temperature of the gas.

BOYLE's law

At a constant temperature, the volume of an enclosed gas is inversely proportional to the absolute pressure and therefore for a certain quantity of gas the product of volume and absolute pressure is a constant:

$$P_1 \cdot V_1 = P_2 \cdot V_2\ ;\ P_3 \cdot V_3 = \text{const.}$$

The law of Gay LUSSAC

The volume of a certain quantity of gas at a constant pressure is directly proportional to the temperature measured on Kelvin grade.

Therefore: $V_1 : V_2 = T_1 : T_2$ (at constant pressure)

as well as, at a constant volume, the pressure varies in direct proportion to the change in temperature:

$P_1 : P_2 = T_1 : T_2$ (at costant volume)

Based on this information it results that for example, to fill a cylinder chamber one requires the same volume of air as is the volume of the chamber multiplied by the pressure at constant temperature.

If the temperature should caryy during the filling phase, it would not substantially change the value (V·P) because if the difference between the temperature of the air is for example 20°C, by using the law GUY/ LUSSAC, one would have:

assuming a cylinder chamber capacity of 100 l.

the line air temperature of 30°C at a pressure of 6 bar and temperature and temperature of the air in the cylinder at 10°C.

$$V_1 : V_2 = T_1 : T_2$$

$$100 : V_2 = 273 + 30 : 273 + 10$$

$$V_2 = \frac{100 \ x \ 283}{303} = 93{,}4 \ l$$

In the same manner for the pressure:

$$P_1 : P_2 = T_1 : T_2$$

$$6 : P_2 = 273 + 30 : 273 + 10$$

$$P_2 = \frac{6 \ x \ 283}{303} = 5{,}6 \ bar$$

It is apparent that in both cases the variation is only about 6,6%.
To calculate the cylinder's air consumption in liters per minute it can be used the following equation:

$$Q = \frac{D^2\pi \bullet 2C \bullet N \bullet P}{4 \bullet 10^6}$$

where :

Q	=	Consumption (of air in liters per minute)
C	=	Cylinder stroke (in millimeters)
D	=	Diameter (in millimeters)
N	=	Number of cycles per minute
P	=	Absolute pressure (system pressure + 1)
10^6	=	Multiplier to covert cubic millimeters ti liter s

This equation does not consider the presence of the cylinder rod and variations in temperature.

1 . Flow characteristics

If a cylinder is expected to exert certain force and travel a certain distance in a required time, it is necessary to determine the flow rates of the control valve. Therefore it is necessary to understand the laws of flow and the relationship between pressures, drop in pressures and flow rates to determine whether a valve is capable of supplying at a fixed inlet pressure the flow that is necessary for the cylinder to do the job at an acceptable drop in pressure.

To accurately determine these values one must proceed in a systematic and precise manner. The results are presented in a number of different ways depending on the applicable standard and different experimental measurement methods. They consist principally of numerical coefficients that have to be applied to equations which approximate the flow rates of valves. To understand the significance of these equations it is necessary to be understand the flow within a pneumatic valve.

Let us assume that a valve has first an absolute feed pressure P_1 (manifold pressure plus ambient pressure), followed by absolute pressure P_2 and T_1 the absolute temperature of the inlet air.
Flow rate Q througt the valve depends on these values. In figure 1 qualitative curves are shown describing the flow Q through a valve having an exit pressure P_2.

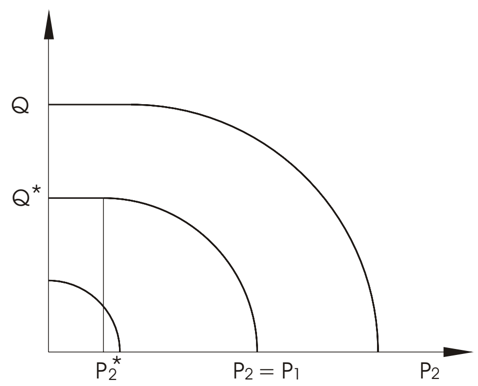


Fig. 1 - Flow curves

Each curve is characterized by a constant inlet pressure P_1.

Looking at the middle curve you will notice that if P_2 is equal to P_1 the flow rate is zero. As the exit pressure P_2 decreases, the flow rate increases until it reaches a maximun value Q^* for $P_2 = P^*_2$, corresponding to sonic flow rates. If the pressure P_2 is further reduced, the flow rate remains constant since the maximum flow rate has been reached. Increasing the inlet pressure P_1 the curves are equally applicable and show icrease in flow rate. If the inlet pressure P_1, is decreased, it will eventually reach the point where the valve is not operative.

The part that is of principal interest to a user of pneumatic valves is the subsonic portion which precedes the critical flow conditions. This portion is expressed in a numer of manners which attempt to define in a simple manner the flow using experimental coefficient.

2. Valve "C" and "b"

Recommendation CETOP RP 50P (derived from ISO standards DIS 6358.2) expresses flow rate on the basis of two experimental coefficients: the conductance C and critical pressure ratio b.

The conductance $C = Q^*/P_1$ is the ratio between the maximum flow rate Q^* and the absolute inlet pressure P_1 in sonic flow conditions and at an air temperature of 20°C.
The critical ratio $b = P^*_2/P_1$ is the ratio between the absolute outlet pressure P_2 and the absolute inlet pressure P_1 at which the flow became sonic.
The equation represents an elliptic approximation of the relationship between the pressure and flow:

$$Q_N = C \cdot P_1 \cdot K_t \cdot \sqrt{1-\left(\frac{r-b}{1-b}\right)^2} \quad [1]$$

Where:

Q_N	is a flow rate in dm^3/s referred to normal conditions corresponding to 1,013 bar at 20 degrees;	
C	is the conductance of the valve in $\frac{dm^3}{s \cdot bar}$	
P_1	is the absolute inlet pressure in bars;	
r	is the ratio between the peak and valley pressures P_2/P_1;	
b	is the critical pressure ratio;	
$k_t = \sqrt{293/T_1}$	is the correction factor which considers the absolute inlet temperature T_1	
$T_1 = 273+t_1$	is the absolute temperature in °K, while t_1 is the temperature in °C.	

The experimental determination of coefficients C and b of a valve is done by compressed air using a circuit diagramed in figure 2.

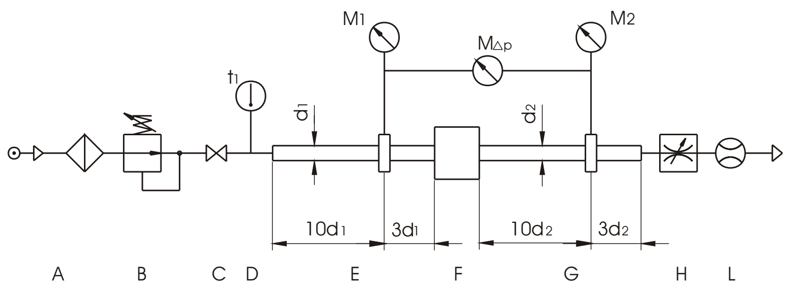


Fig. 2 - Test circuit according to CETOP standard

A	A source of filtered compressed air.
B	Pressure reducer and control of peak pressure P_1.
C	Intercept valve.
D	Temperature sensor for T_1 inlet, located in a low flow zone.
E	Tube measuring peak pressure.
F	Tested valve.
G	Tube measuring low pressure.
H	Flow regulator to control downstream pressure P_2.
L	Flow gauge.
M_1, M_2	Measuring instruments for inlet and outlet pressures.
$M_{\Delta P}$	Pressure drop measuring instruments assuming $P_1 - P_2 < 1$ bar.

Note that to measure the peak and low pressures of the valve the standards specify a range of tubes - to allow proper cupling with the valve unnder test - and that the point where the pressure readings are taken is specified based on the internal diameter of the tube.

Conductance C is expressed in equation:
Q^* is the critical flow rate at peak pressure P_1 constant and not less than 3 absolute bars and at an inlet temperatute T_1.

$$C = \frac{Q^*}{P_1 \cdot K_t} \quad [2]$$

The critical ration b id determined by the following equation:

$$b = 1 - \frac{\Delta P}{P_1\left[1-\sqrt{1-\left(\frac{Q'}{Q^*}\right)^2}\,\right]} \qquad [3]$$

For an assigned pressure P_1 and the pressure drop $\Delta p = P_1 - P_2 = 1$ bar the flow rate is measured.
Equation 3 is used to calculate critical ratio b because it is difficult to experimentally ascertain pressure P^*_2 at which point the flow becomes sonic.
Both the value C and the critical ratio b are subsonic system when $P_2 > b \cdot P_1$.
Under sonic conditions, $P_2 \leq b \cdot P_1$, equation 1 can be simplified. Maximum flow rate can be determined from equation:

$$Q^* = C \cdot P_1 \cdot k_t \qquad [4]$$

Hydraulic coefficient K_v

This coefficient allows the calculation of flow rates for liquids passing through a valve by using the following equation:

$$Q = Kv \sqrt{\frac{\Delta p}{\varrho}} \qquad [5]$$

Where:

- Q is the flow rate of liquid in l/min
- Δp is pressure drop across the valve in psi ($P_1 - P_2$)
- ϱ is the density of liquid in Kg/dm³
- Kv is the hydraulic coefficient in $\frac{l}{min}\left(\frac{kg}{dm^3 \cdot bar}\right)^{1/2}$

Using these units the flow rate coefficient Kv represents the flow rate of water in liters per minute across a valve that has a pressure drop of 1 bar.
To execute the measurement, the standards VDE/VDI specify an arrangement as shown in the diagram below. Again, the eplaces where the pressure measurements are taken are a function of the internal diameter of the tube.

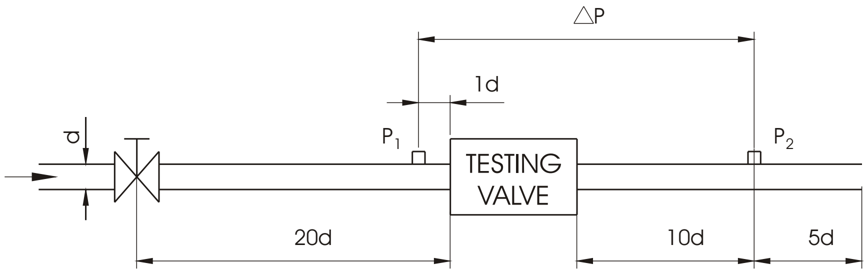


Fig. 3

In certain cases the flow rate is measured in m³/h which corresponds to a Kv in $\frac{m^3}{h}\left(\frac{kg}{dm^3 \cdot bar}\right)^{1/2}$

In thos case, to obtain value K_v in $\frac{l}{min}\left(\frac{kg}{dm^3 \cdot bar}\right)^{1/2}$ the value K_v should be miltiplied by expression $\frac{m^3}{h}\left(\frac{kg}{dm^3 \cdot bar}\right)^{1/2}$ for a numerical coefficient 16,66.

Use of the hydraulic coefficient K_v is perfectly suitable to express flow obtained, while only an approximation is given in the case of compressed air. It is possible to transfer experiences and value derived from liquids also for air if proper consideration is given to the differences in density and assuming that the flow of air has the same effects as the flow of water with similar pressure drop and flow reductions It is therefore possible to calculate reliable values for compressed air by using flow coefficients K_v derived from experiments with water.

From the various equations to calculate flow rate Q_N across a valve for an absolute inlet pressure P_1 and a variable low pressure P_2, we prefer the following:

$$Q_N = 28{,}6 \cdot K_v \cdot \sqrt{P_2 \cdot \Delta P} \cdot \sqrt{\frac{T_n}{T_1}} \qquad [6]$$

Where:
- Q_n is normal flow rate in l/min;
- K_v is hydraulic coefficient in $\frac{l}{min}\left(\frac{kg}{dm^3 \cdot bar}\right)^{1/2}$
- T_N is absolute reference temperature;
- T_1 is absolute inlet temperature in °K;
- P_2 is absolute low pressure in bar;
- Δp is pressure drop $P_1 - P_2$ in bar.

Equation [6] is valid up to a value of $\Delta p = \frac{P_1}{2}$ or for $P_2 = \frac{P_1}{2}$

For lower values of P_2 we assume a constant flow rate which corresponds to a sonic flow rate Q^*_N derived from equation:

$$Q^*_N = 14{,}3 \cdot K_V \cdot P_1 \sqrt{\frac{T_n}{T_1}} \qquad [7]$$

Standard flow rate Q_{Nn}

The nominal flow rate is volume flow, at normal conditions, which passes through a valve at a relative peak pressure of $P_1 = 6$ bar (7 bar absolute) and which has a pressure drop of one bar correponding to a relative minimum pressure of $P_2 = 5$ bar (6 bar absolute).
Normally the nominal flow rate is given in l/min and can be easily determined from an experimental flow curve for a peak pressure of 6 bar. Nominal flow rate is useful for a preliminary assessment of the capability of various valves; it should be applied directly only if the application conditions are similar to thosa listed above. To be able to compare valves whose coefficient is expressed in different manner, it is possible to use conversion expressions:

$$Q_{Nn} = 420 \cdot C \cdot \sqrt{1 - \left(\frac{0{,}857 - b}{1 - b}\right)^2} \qquad [8]$$

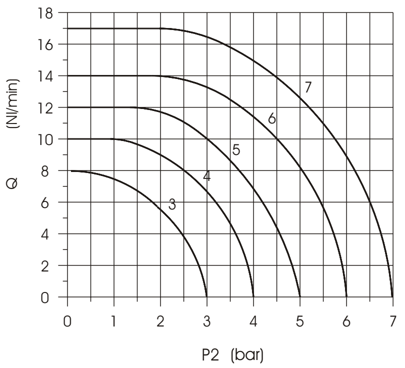
Where: Q_{Nn} = is in l/min and C in $\frac{dm^3}{s \cdot bar}$

The relationship between hydraulic coefficient KV and the corresponding nominal flow rate value is as follows:

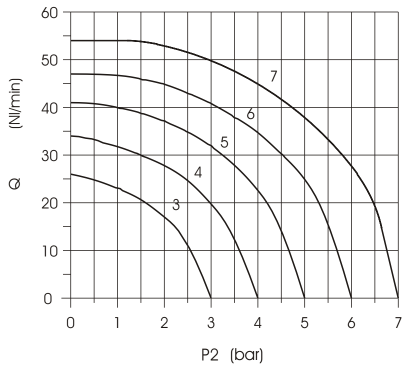
$$Q_{Nn} = 66\, K_V$$

Where: Q_{Nn} is l/min and K_V in $\frac{l}{min}\left(\frac{kg}{dm^3 \cdot bar}\right)^{1/2}$ [9]

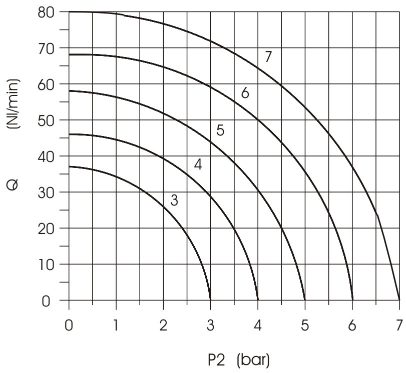
Flow rate curves



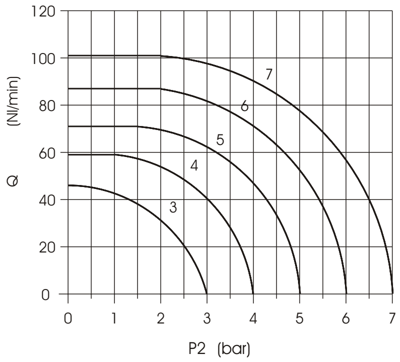
Miniature solenoid valve 10 mm



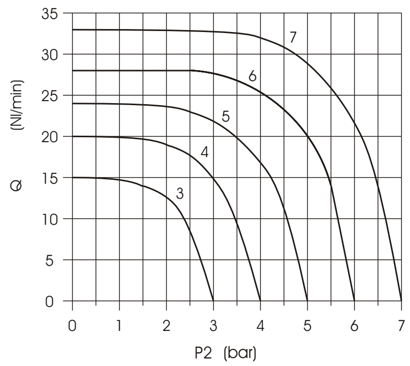
Micro solenoid valve 15 mm
Orifice Ø 1,1 mm



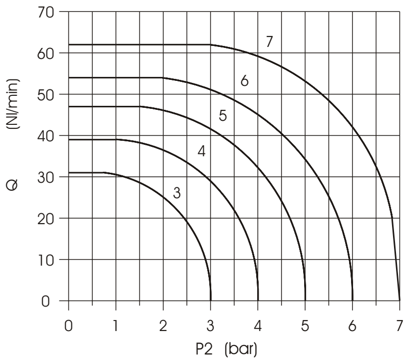
Micro solenoid 15 mm
Orifice Ø 1,5 mm



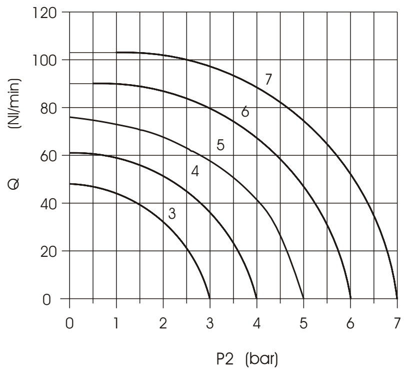
Solenoid valve 22 mm
M2, M2/1, 305M1, 305M5/B
M5/B - M3P



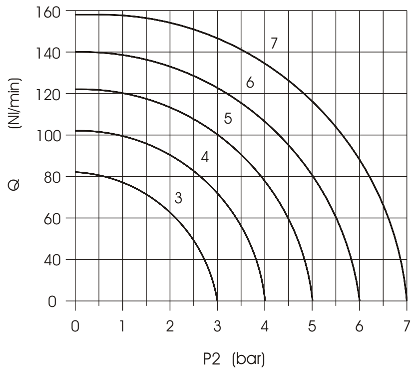
Solenoid valve 22 mm
M2/9 - M4P (2 Watt)



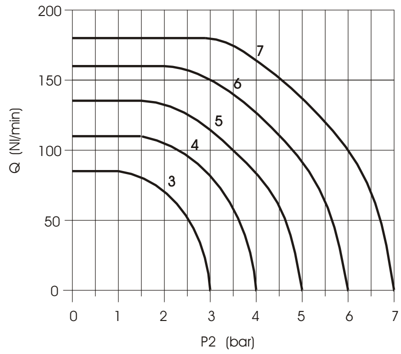
Solenoid valve 22 mm
305M1/9 (2 Watt)



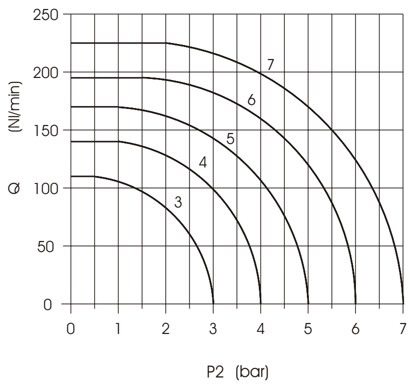
Solenoid valve 22 mm
305M1/1 - 3/2 (N.O.)



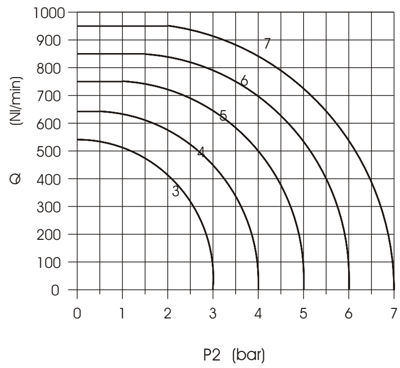
Solenoid 32 mm
S and S/1 - S/2



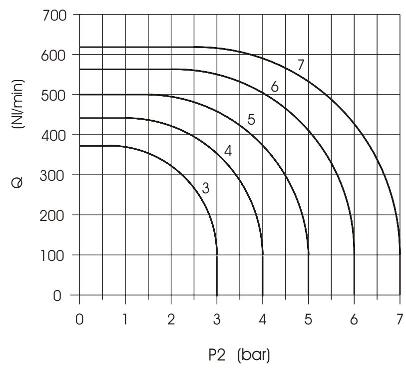
Valves and Solenoid valves
Series 104
Tube Ø4 - 2/2, 3/2, 5/2 e 5/3



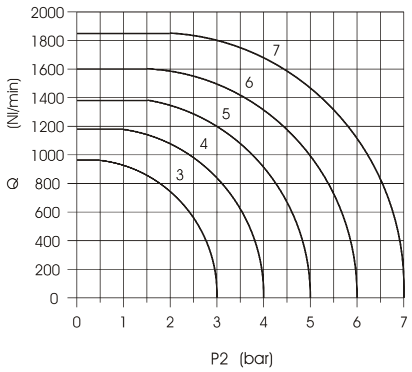
Valve Series 105
M5



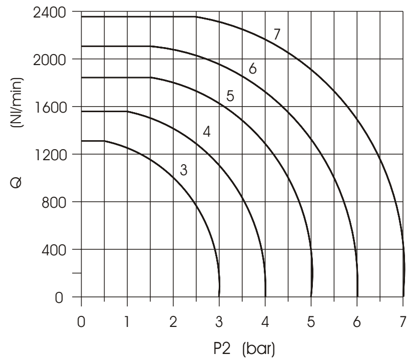
Valves and Solenoid valves
Series 228, 428, 468
G 1/8" - 3/2 and 5/2



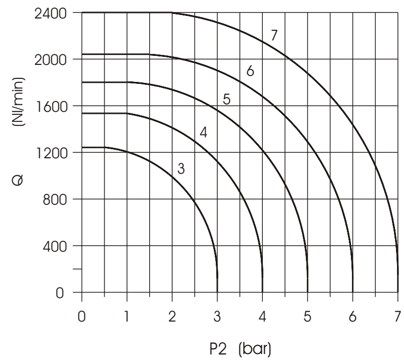
Valves and Solenoid valves
Series 228, 428, 468
G 1/8" - 5/3



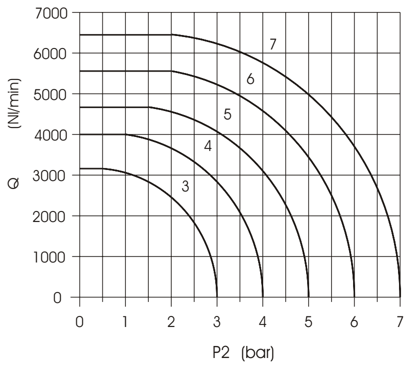
Valves and Solenoid valves
Series 214/2, 414/2, 514/N
G 1/4"



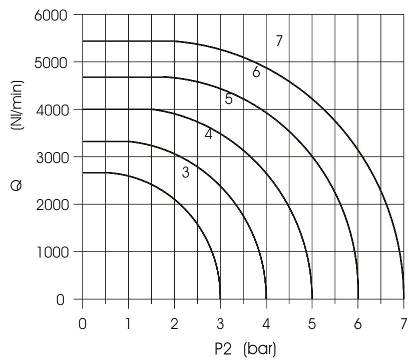
Valves and Solenoid valves
Series 224, 424, 464
G 1/4" - 3/2 and 5/2



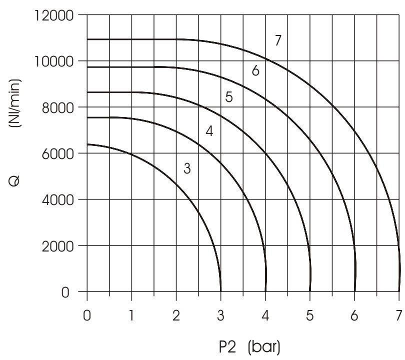
Valves and Solenoid valves
Series 224, 424, 464
G 1/4" - 5/3



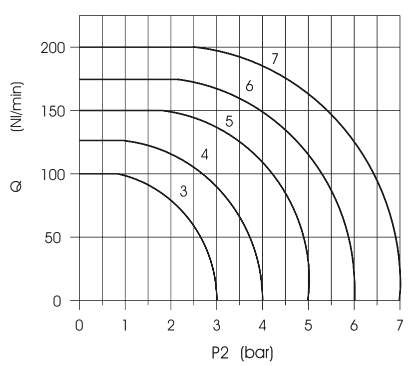
Valves and Solenoid valves
Series 212, 412
G 1/2" - 3/2 and 5/2



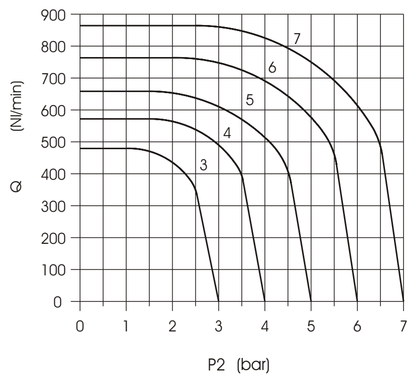
Valves and Solenoid valves
Series 212 and 412
G 1/2" - 5/3



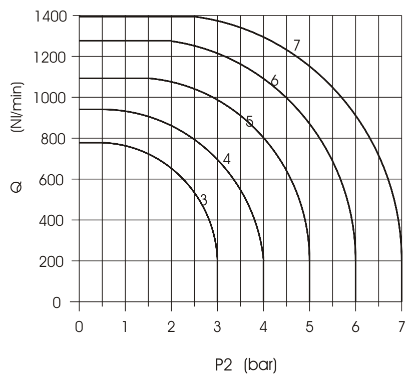
Valves and Solenoid valves
Series 211 and 411
G 1"



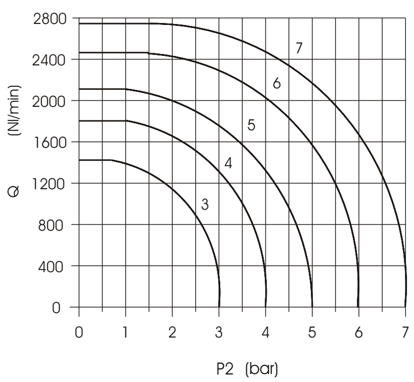
Valves-Poppet system
Series 705
M5



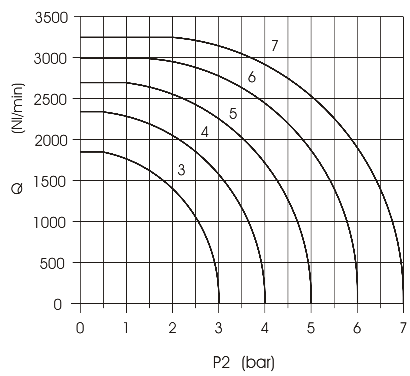
Valves-Poppet system
Series 718
G 1/8"



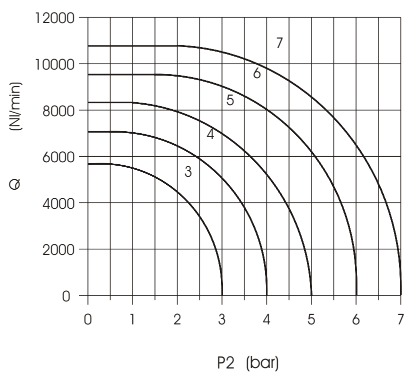
Valves and Solenoid valves-Poppet system
Series 778 and 788
G 1/8"



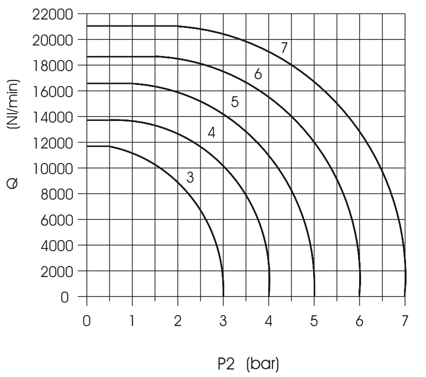
Valves and Solenoid valves-Poppet system
Series 774 and 784
G 1/4"



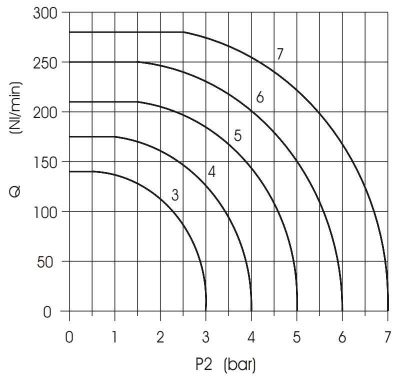
Valves and Solenoid valves-Poppet system
Series 779
G 3/8"



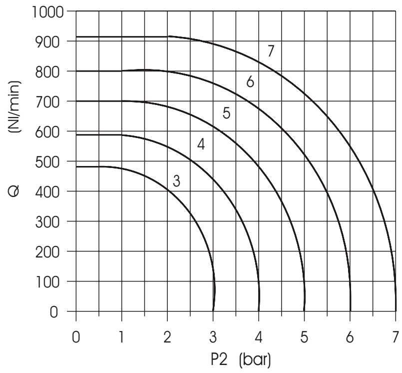
Valves and Solenoid valves-Poppet system
Series 773
G 3/4"



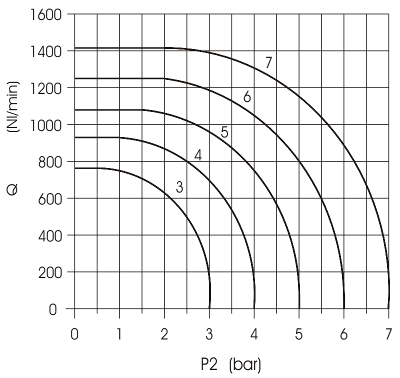
Valves and Solenoid valves-Poppet system
Series 771
G 1"



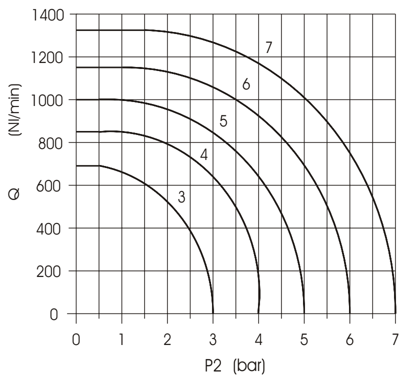
Distributors and Electrodistributors
Series 805 and 815
M5



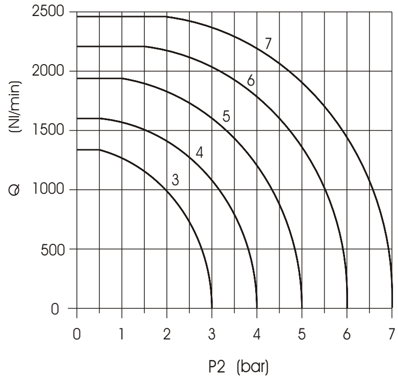
Distributors and Electrodistributors
Series 808 and 818
G 1/8"



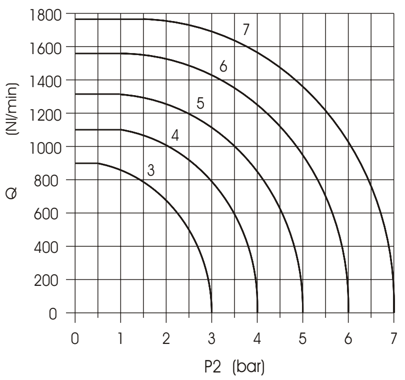
Distributors and Electrodistributors
Series 828
G 1/8" - 5/2



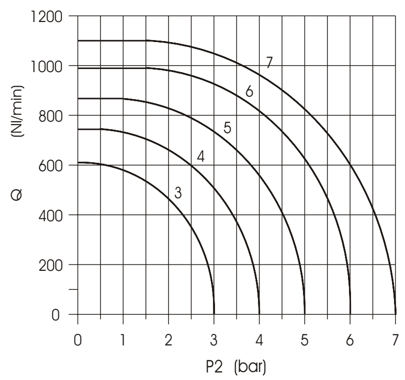
Distributors and Electrodistributors
Series 828
G 1/8" - 5/3



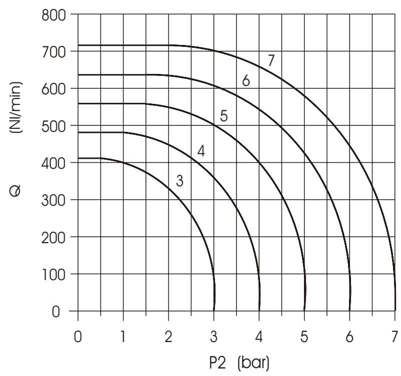
Distributors and Electrodistributors
Series 824
G 1/4" - 5/2



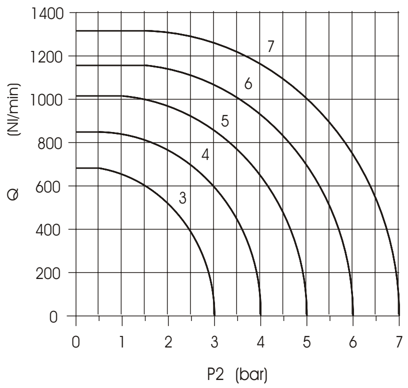
Distributors and Electrodistributors
Series 824
G 1/4" - 5/3



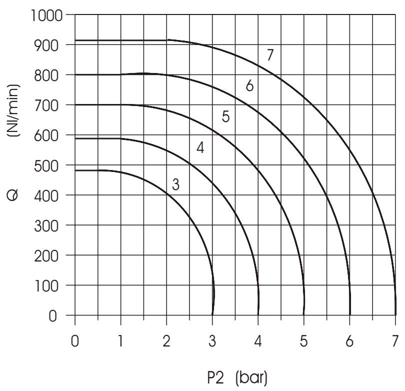
Distributors and Electrodistributors
Series 858/2 - 858/3
G 1/8" - 5/2



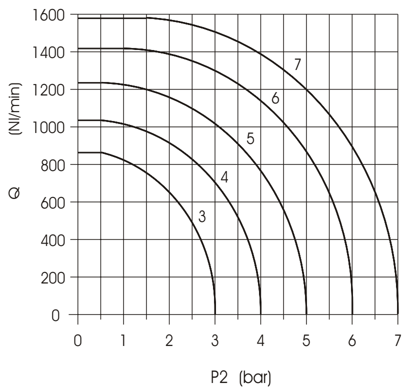
Distributors and Electrodistributors
Series 858/2 - 858/3
G 1/8" - 5/3



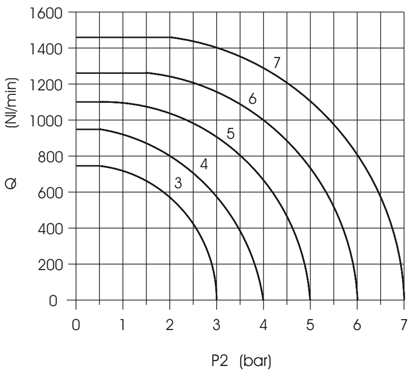
Distributors and Electrodistributors
Series 858/4
G 1/8" - 5/2



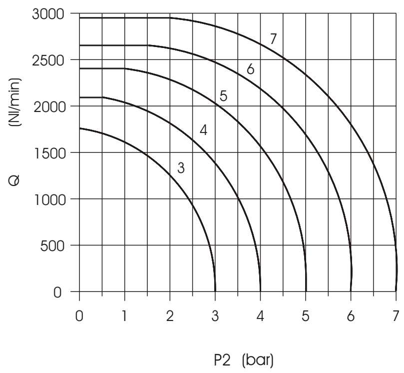
Distributors and Electrodistributors
Series 858/4
G 1/8" - 5/3



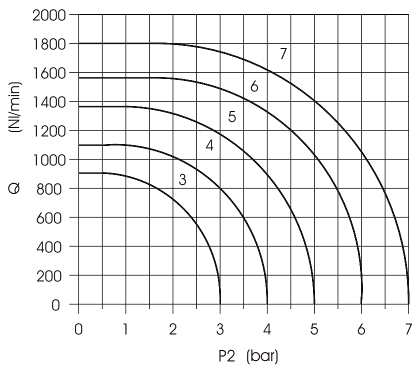
Distributors and Electrodistributors
Series 1001 -1051
"ISO 1" - 5/2



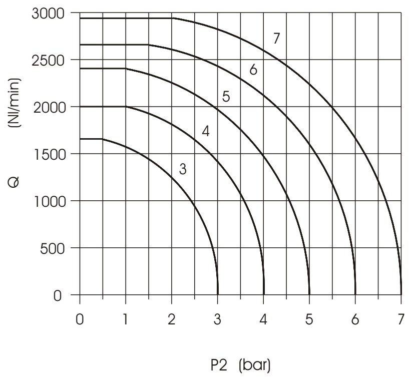
Distributors and Electrodistributors
Series 1001 - 1051 - "ISO 1" - 5/3



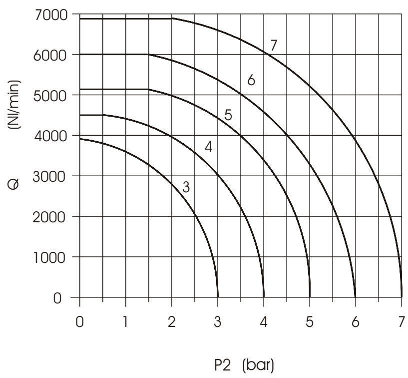
Distributors and Electrodistributors
Series 1002 - 1052 - "ISO 2"



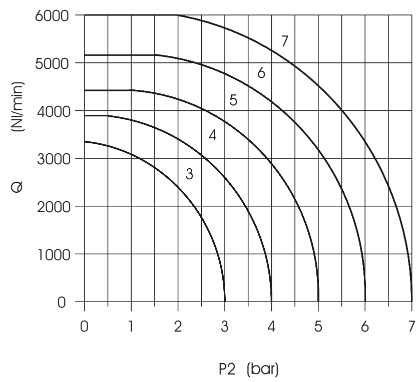
Distributors and Electrodistributors
Series 1011 - "ISO 1"



Distributors and Electrodistributors
Series 1012 - "ISO 2"



Distributors and Electrodistributors
Series 1013 - "ISO 3" - 5/2



Distributors and Electrodistributors
Series 1013 - "ISO 3" - 5/3

Grades of protection of the coil or solenoids with a connector

The grade of protection indicates the inherent capacity of an electrical apparatus when charged to resist accidental contacts or penetration by solid or liquid particles.
It is defined by code "I.P." followed by numbers; the first one, from 0 to 6 classifies resistance against accidental contact and penetration by dust. The second one, from 0 to 8, classifies resistance to penetration by liquide. The following are definitions of the various grades.

Grades of protection against contacts or penetration of solid foreign matters

Firs number	Protection Denomination	Explanation
0	No protection	People are not protected against accidental contacts with charged or moving parts. Machines are not protected against penetration by solid foreign matters.
1	Protection against penetration by large solid matters.	Protects large surfaces from accidental contact with charged or moving parts inside the machine, such us contact with hands, but does not protect against volotary contact with these parts. Protects machine against penetration by solid matters with a diameter of more than 50 mm.
2	Protection against penetration by medium-sized solid matters.	Protects finger from accidental contact with charged or moving partes inside the machine. Protects against penetration by solid matter with a diameter or more than 12 mm., such as fingers.
3	Protection against penetration by small solid matters.	Protects tools, conductors, and similar abjects with a thickness or more than 2,5 mm. from contact with charged of moving parts inside the machine. Protects against penetration by solid matters with a diameter of more than 2,5 mm., such as tools and wires.
4	Protection against penetration by very small solid matters.	Protects tools, conductors and similar objects with a thickness of more than 1 mm. from contact with charged or moving parts inside the machine. Prevents solid bodies with a diameter of more than 1 mm. such as small tools and wires, from entering the machine.
5	Protection against dust deposits.	Completely protects from contact with charged or moving parts inside the machine. Protects against dust deposits. The quality of dust allowed to enter the machine is reduced to ensure that it functions properly.
6	Protection against the penetration of dust particles.	Completely protects from contact with charged or moving parts inside the machine. Totally prevents dust from entering the machine.

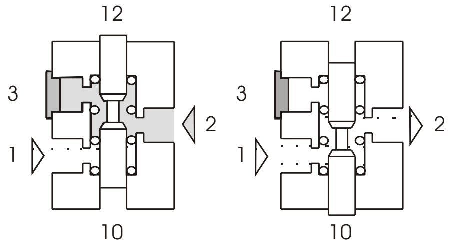
Grades of protection against water penetration

Second number	Protection Denomination	Explication
0	No protection	No particular protection.
1	Protection against water drops moving in a perpendicular direction.	Water drops which fall perpendicularly must not damage the machine.
2	Protection against water drops moving in an oblique direction.	Water drops which fall at any angle up to 15 to the vertical must not damage the machine.
3	Protection against dripping water.	Water which falls at any angle up to 60 to the vertical must not damage the machine.
4	Protection against spraying water.	Water sprayed from any direction against the machine must not cause damage.
5	Protection against jets of water.	Jets of water launched from any direction against the machine must not cause damage.
6	Protection against flooding.	Water which penetrates the machine because of temporany flooding, such as rough sea, must not damage the machine.
7	Protection against immersion.	When the machine is immersed for predetermined time and pressure values, water must not enter in such quantities that is causes damage.
8	Protection against submersion.	When the machine is submerged at a predetermined pressure for an undetermined period of time, water must not enter the machine in such quantities that it causes damage.

Function 2/2
Normally CLOSED

1 = INLET PORT
2 = OUTLET PORT
3 = PLUGGED

AT REST

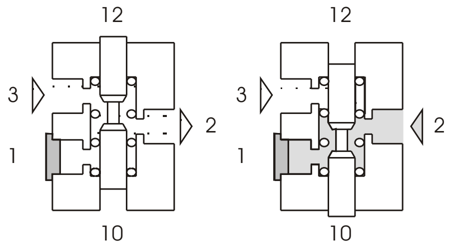


ACTUATED

Function 2/2
Normally OPEN

1 = PLUGGED
2 = OUTLET PORT
3 = INLET PORT

AT REST

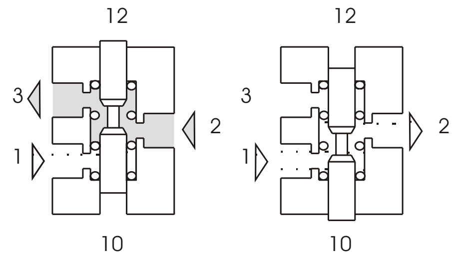


ACTUATED

Function 3/2
Normally CLOSED

1 = INLET PORT
2 = OUTLET PORT
3 = EXHAUST PORT

AT REST

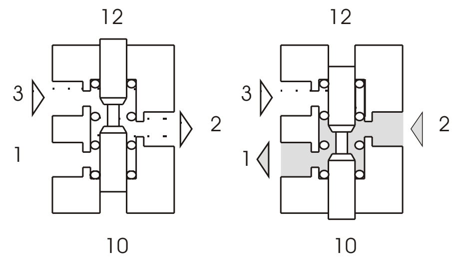


ACTUATED

Function 3/2
Normally OPEN

1 = EXHAUST PORT
2 = OUTLET PORT
3 = INLET PORT

AT REST

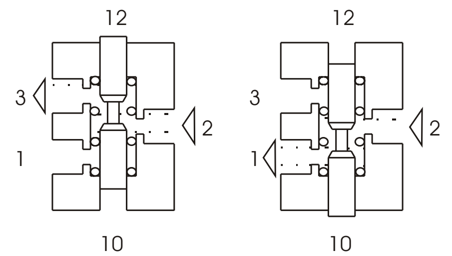


ACTUATED

Function 3/2
Selection of 1 pressure

1 = OUTLET PORT
2 = INLET PORT
3 = OUTLET PORT

AT REST

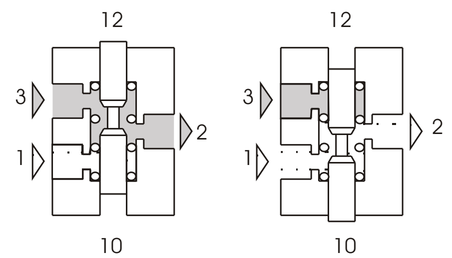


ACTUATED

Function 3/2
Selection of 2 pressures

1 = INLET PORT P_1
2 = OUTLET PORT P_1 - P_2
3 = INLET PORT P_2

AT REST

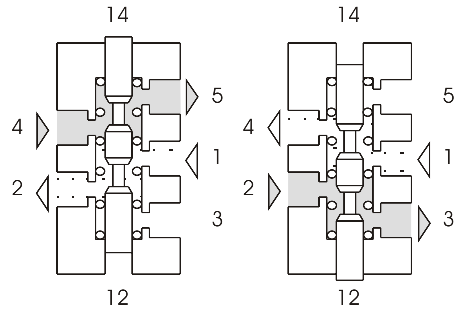


ACTUATED

Function 5/2

1 = INLET PORT
2 = OUTLET PORT
3 = EXHAUST PORT 2
4 = OUTLET PORT
5 = EXHAUST PORT 4

AT REST



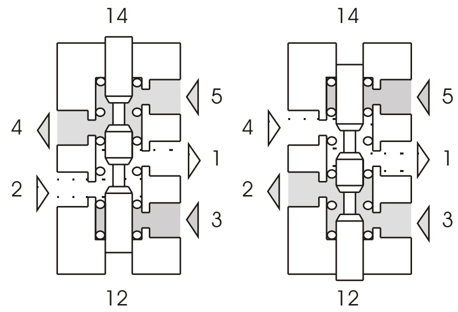
ACTUATED

Function 5/2

Selection of 2 pressures

1 = EXHAUST PORT P_1 - P_2
2 = OUTLET PORT P_1
3 = INLET PORT P_1
4 = OUTLET PORT P_2
5 = INLET PORT P_2

AT REST

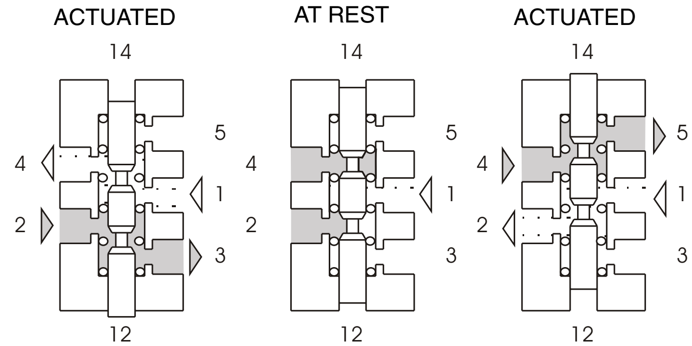


ACTUATED

Function 5/3

CLOSED CENRES

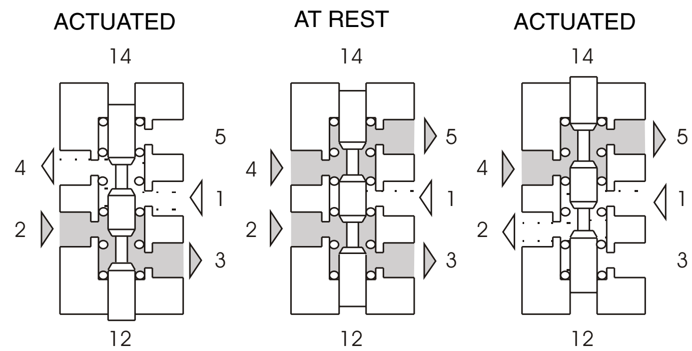
1 = INLET PORT
2 = OUTLET PORT
3 = EXHAUST PORT 2
4 = OUTLET PORT
5 = EXAUST PORT 4



Fonction 5/3

OPEN CENTRES

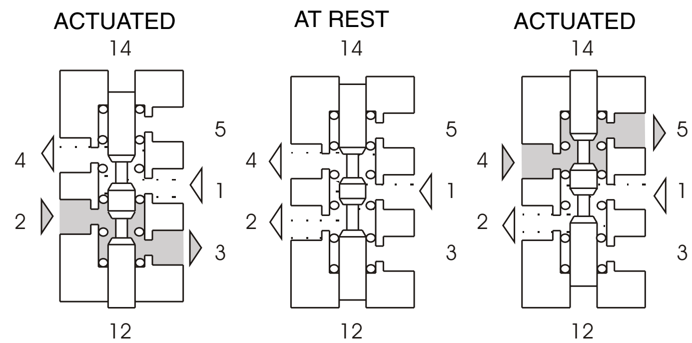
1 = INLET PORT
2 = OUTLET PORT
3 = EXHAUST PORT 2
4 = OUTLET PORT
5 = EXHAUST PORT 4



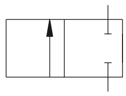
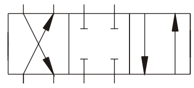
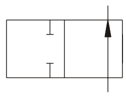
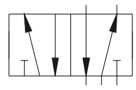
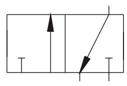
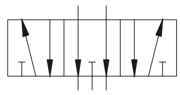
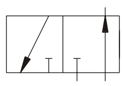
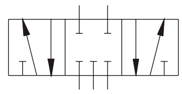
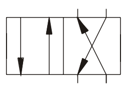
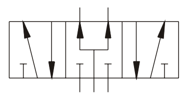
Function 5/3

PRESSURED CENTRES

1 = INLET PORT
2 = OUTLET PORT
3 = EXHAUST PORT 2
4 = OUTLET PORT
5 = EXHAUST PORT 4



Direction control valves

Normally closed 2 position 2-way valve		3 position 4-way valve - joint exhaust connection closed centre	
Normally open 2 position 2-way valve		2 position 5- way valve - separate exhaust connection	
Normally open 2 position 3-way valve		3 position 5-way valve - open centres	
Normally open 2 position 3-way valve		3 position 5-way valve closed centres	
2 position 4-way valve - joint exhaust connection		3 position 5-way valve pressured centres	

Description

Connections

The connections displayed in the symbol must correspond to the connections of the elements. The reading key consists of numbers of letters that when combined make it possible to definire all the connections.

Description by numbers 0, 1, 2, 3, ...9
One number = main connection
Two number = control connection

Description by letters
A, B, after the numbers for several main connections X,Y, before the numbers for supplementary pressure connections.

Main connections principales

1 = Feed connection
2 = Work connection, in the presence of one output connection
2 and 4 = Utilization connection, in the presence of two output connections
2, 4, 6 = Utilization connection, in the presence of three output connections
3 = Air exhaust connection
3 and 5 = Air exhaust connection, in the presence of two exhaust
3, 5, 7 = Air exhaust connections, in the presence of three exhaust connections.

When a pneumatic devices in in operating position, connection 3 is always joined with connection 2 (with the exception of 2/2 way valves) and connection 5 always with connection 4.

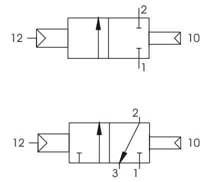
Comparison

Definition of the Connections									
Pneumatics						3-way		5-way	
CETOP	1	2	3	4	5	12	10	14	12
DIN	P	B	S	A	R	Z	Y	Z	Y

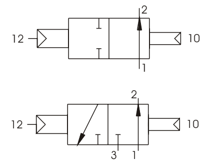
Control connections

Control connection 10, 12, 14

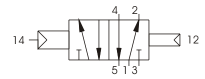
10 means:
Pressure connection 1 is closed if the control connection 12 is not operating.



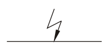
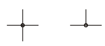
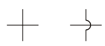
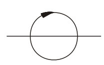
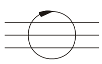
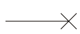
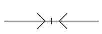
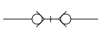
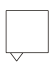
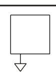
12 means:
Utilization connections 2 joined with connection 1 if the control connection 12 is operating.



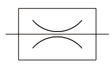
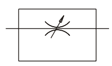
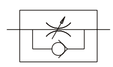
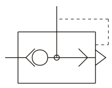
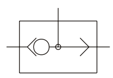
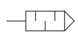
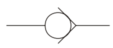
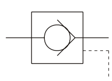
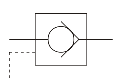
14 means:
Connection 1 is joined with connection 4 if the control connection 14 is operating.



Piping and connections

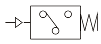
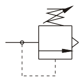
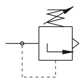
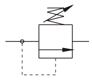
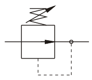
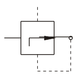
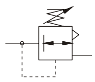
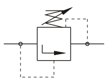
Pressure line	
Control line	
Exhaust line	
Flexible line	
Electric line	
Piping connections	
Piping intersection	
Main air connection	
Three- way rotating intake	
Closed air intake	
Air intake with connection	
Quick coupling connection without non-return valve	
Quick coupling connection with non-return valve	
Air exhaust unthreaded connection	
Air exhaust threaded connection	
	

Complementary valves

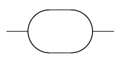
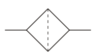
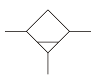
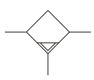
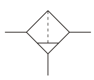
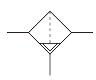
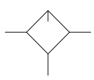
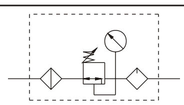
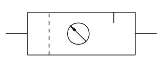
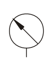
Throttle valve	
Bidirectional flow regulator	
Unidirectional flow regulator	
Quick exhaust valve	
Shuttle valve	
Silencer	
Non-return valve without spring	
Non-return valve with spring	
Non-return valve controlled during closing	
Non-return valve controlled during opening	

Pneumatic symbols

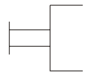
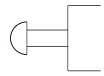
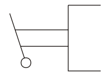
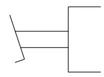
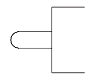
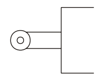
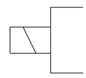
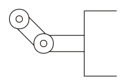
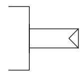
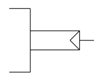
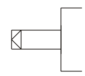
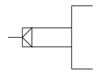
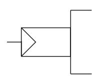
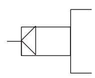
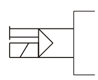
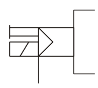
Pressure control valves

Pressure switch	
Free discharge pressure relief valve	
Free discharge pilot-operated pressure relief valve	
Sequence valve	
Pressure regulator without exhaust valve	
Pilot-operated pressure regulator without exhaust valve	
Pressure regulator without exhaust valve (free)	
Differential pressure regulator	

Air treatment mechanisms

Pneumatic accumulator (capacity)	
Air filter	
Manual drain air	
Automatic drain air	
Filter - with manual drain	
Filter - with automatic drain	
Lubricator	
Air service unit (detailed symbol)	
Air service unit (simplified symbol)	
Gauge	

Operating devices

Manual control (generic)	
Button	
Lever	
Pedal	
Mechanical button	
Spring	
Roller	
Single solenoid valve	
One way trip roller	
Pressure direct control	
Pressure direct control External pilot	
Pressure indirect control	
Pressure indirect control External pilot	
Pressure indirect control	
Released pressure indirect control	
Electropneumatic solenoid	
Electropneumatic solenoid external pilot	
Two-hand control