1 2 way solenoid valves

1.1 2 way normally closed direct acting solenoid valves

1.2 2 way normally open direct acting solenoid valves

1.3 2 way normally closed solenoid valves with pilot control

1.4 2 way normally open solenoid valves with pilot control

1.5 2 way normally closed combined operation solenoid valves

1.6 2 way normally open combined operation solenoid valves

1.7 Proportional direct acting solenoid valves

2 3 way solenoid valves

2.1 3 way normally closed direct acting solenoid valves

3 Solenoid valves for automatic drink-dispensers

3.1 Single solenoid valves for automatic drink-dispensers

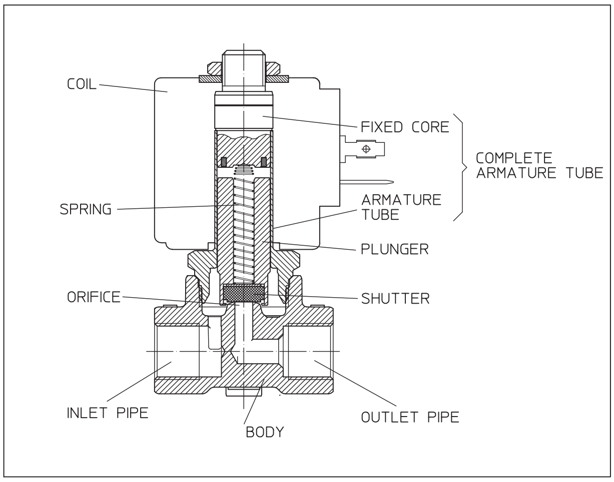
3.2 Banks of solenoid valves for automatic drink-dispensers

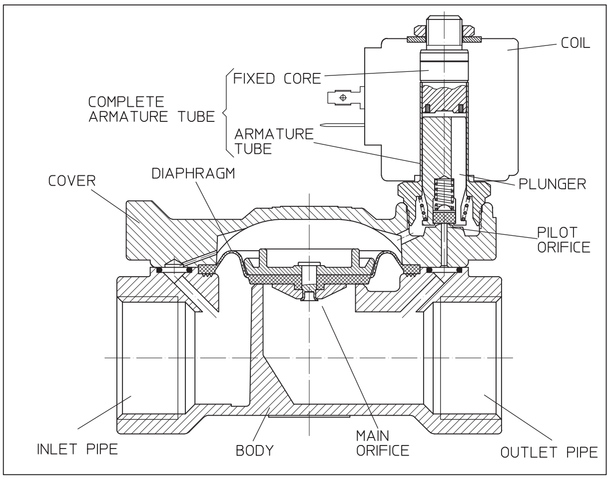
4 5 way solenoid valves

5 Special solenoid valves and banks

Glossary

This chapter illustrates some of the technical terms used in the ODE catalogue.





Fixed core: component in ferrous-magnetic material which, due to the effect of a magnetic field generated from the coil, attracts the plunger.

Plunger: component in ferrous-magnetic material which, under the effect of a magnetic field, moves towards the fixed core causing directly or indirectly the switching of the solenoid valve. Often the plunger houses one or more shutters which open or close one or more orifices for the functioning of the solenoid valve.

Complete plunger: this is the grouping of the plunger, the shutters and any springs.

Armature tube: a guide tube in which the plunger runs.

Complete armature tube: the assembly of fixed core and armature tube, generally welded or assembled with rolling, threading or other means.

Coil: consists of a copper winding, a support bobbin and a holder in ferrous-magnetic material. The whole is covered over with insulating material from which the electrical connections emerge, which may be different depending on the type of coil. (see COIL INDEX). The winding generates the magnetic field while the ferrous-magnetic holder closes the magnetic circuit constituted by the holder itself, the plunger and the fixed core.

Shutter (or sealing gasket): this component may be housed directly in the plunger, in a gasket housing, in the piston, or be part of the complete diaphragm. With a movement the shutter opens or closes an orifice thus permitting or preventing the flow of fluid.

Certain valves have more than one shutter, for example the three way direct action solenoid valves: the two shutters, housed at the ends of the fixed core, alternately open and close the inlet and outlet orifices. There are also two shutters in the combined operation and in the pilot control solenoid valves, one acting on the pilot orifice and the other on the main orifice.

Sometimes shutter function is carried out directly by the diaphragm or piston.

Note: In the same solenoid valve there may be shutters made of different materials.

Orifice: This is a holed component which is opened or closed by the shutter, permitting or preventing the passage of fluid. It may be either machine-tooled or inserted. The main orifice of a solenoid valve is the one permitting maximum flow of the valve itself while the pilot orifice, when opened or closed due to an unbalance of pressure, leads to opening or closure of the main one by means of a diaphragm or a piston.

Diaphragm: an element of mixed action or solenoid valves with pilot control which opens or closes the main orifice due to the effect of different pressures on its surfaces.

Complete diaphragm: this is the grouping of components united to the diaphragm such as diaphragm bearings, rivet etc.

Piston: an element of mixed action or solenoid valves with pilot control which opens or closes the main orifice due to the effect of different pressures on its surfaces.

Complete piston this is the grouping of components united to the piston such as rivet, shutter etc.

Body: central part of the solenoid valve. The pipes are on the body and the main orifice, generally, is inside. In some cases the body is divided in two parts: for example in solenoid valves for drink dispensensing there is the upper body with the inlet pipe and the lower body with the main orifice and the outlet pipe.

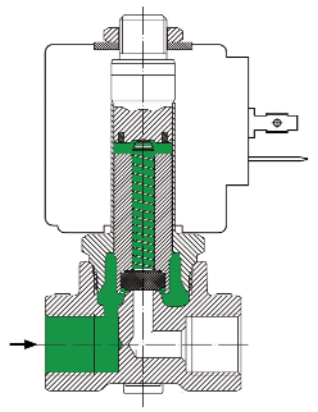
Cover: this is found in certain solenoid valves, generally in all with pilot control ones, the cover of which normally houses the pilot orifice.

Pipe: a mechanical component for connecting the solenoid valve to inlet, outlet and exhaust pipes.

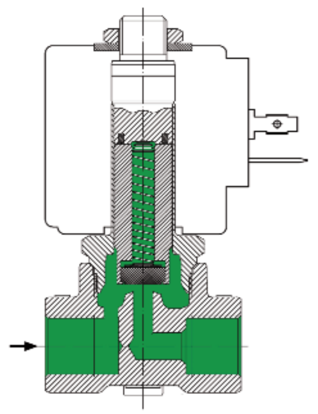
1.1 2 way normally closed direct acting solenoid valves

Main components: body with main orifice, complete armature tube + complete plunger (normally closed kit), coil.

Functioning:



COIL DE-ENERGIZED:
SOLENOID VALVE CLOSED



COIL ENERGIZED:
SOLENOID VALVE OPEN

2 way normally closed direct acting solenoid valves have an inlet pipe and a outlet pipe. The plunger, on which a sealing gasket is mounted, provides directly for opening and closing the main orifice. When the coil is not energized the plunger is in such a position as to close the orifice thus preventing the flow of fluid.

When the coil is energized the plunger moves to such a position as to open the orifice, permitting fluid flow.

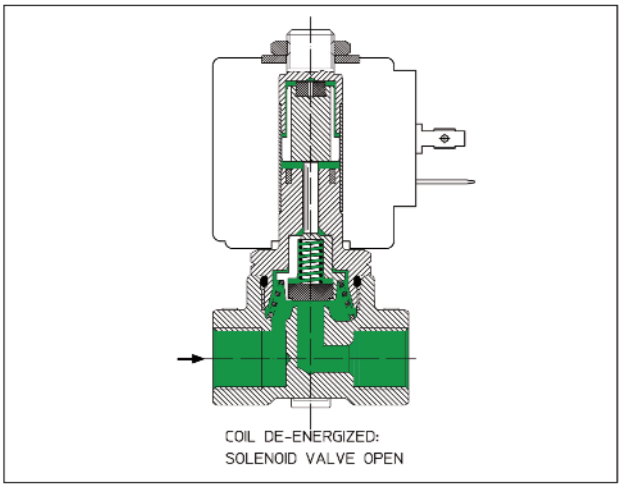
Notes:

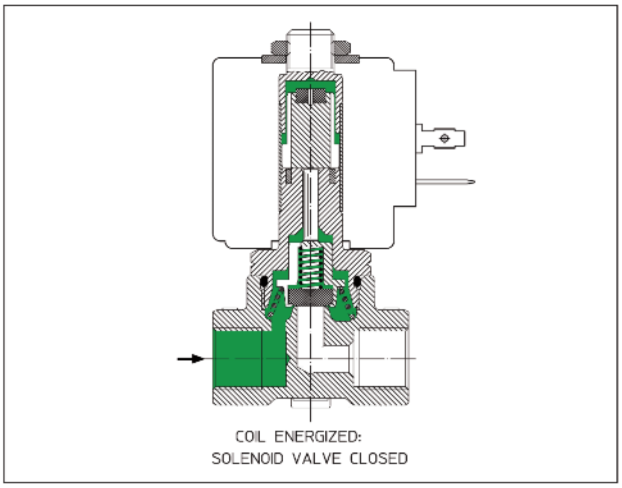
In this solenoid valve family an increase in pressure causes an increase in the force required to open the valve: if the pressure difference between inlet and outlet is greater than the maximum value for which the solenoid valve has been designed, the latter may not open even with the coil energized.

1.2 2 way normally open direct acting solenoid valves

Main components: body with main orifice, complete armature tube + plunger + rod + gasket holder assembly (normally open kit), coil.

Functioning:





2 way normally open direct acting solenoid valves have an inlet pipe and a outlet pipe. The plunger, acting on the gasket holder by means of a rod, provides for opening and closing the solenoid valve. When the coil is not energized the gasket holder, under the action of a spring, is kept in such a position that the orifice is open, permitting fluid flow.

When the coil is energized the plunger moves downwards and, by means of the rod, pushes the gasket holder into a position that closes the orifice, preventing fluid flow.

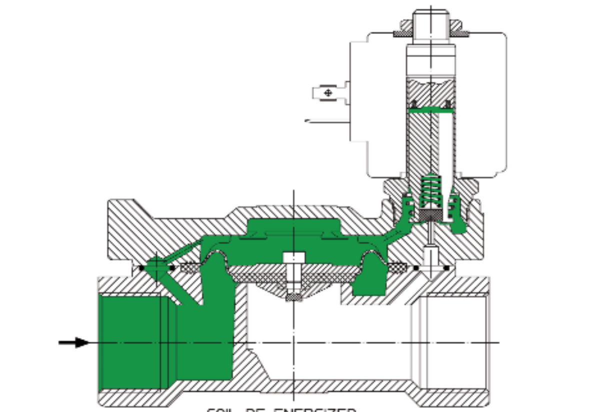
Notes:

In this solenoid valve family an increase in pressure causes an increase in the force required to open the valve: if the pressure difference between inlet and outlet is greater than the maximum value for which the valve has been designed, the latter may not reopen even with the coil deactivated.

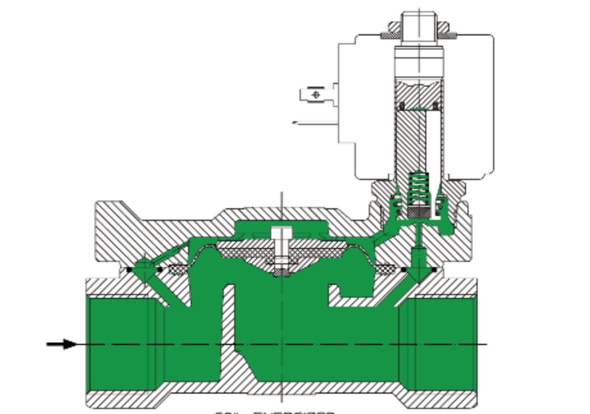
1.3 2 way normally closed solenoid valves with pilot control

Main components: body with main orifice, cover, diaphragm (or piston) assembly, complete armature tube, + complete plunger (normally closed kit), coil.

Functioning:



COIL DE-ENERGIZED:
SOLENOID VALVE CLOSED



COIL ENERGIZED:
SOLENOID VALVE OPEN

2 way normally closed solenoid valves with pilot control have an inlet pipe and a outlet pipe. The main orifice, in the body, is opened by the effect of an unbalance in pressure between the upper and lower surfaces of a diaphragm (or piston): when the coil is not energized there is fluid under pressure in the chamber above the diaphragm while beneath the diaphragm there is pressure only in the area external to the main orifice: thus the resultant of the forces on the diaphragm is such as to push it and close the main orifice. When the coil is energized, movement of the plunger, on which a gasket is mounted, causes opening of the pilot orifice and discharging of the chamber above the diaphragm: the pressure unbalance moves the diaphragm which opens the main orifice.

Notes:

In this family of solenoid valves there must be a minimum pressure difference between the inlet pipe and the outlet one to ensure correct functioning of the solenoid valve. However, an excessive pressure difference between inlet and outlet, as with 2 way normally closed direct acting solenoid valves, causes an increase in the force required to open the pilot orifice, so if this pressure difference is greater than the maximum value for which the solenoid valve has been designed, the latter may not open even when the coil is energized.

For a correct operation of the solenoid valve, and to avoid a quick wear of the diaphragm, it is advisable that, once starting the valve closing, the actual flow isn't higher than the Kv (i.e.: flow rate through the valve with a pressure loss of 1 bar).

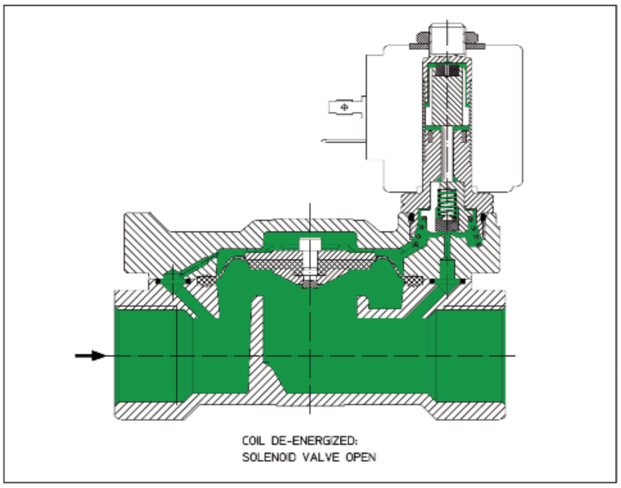
For this reason, should the inlet pressure when the valve is open, be higher than 1 bar, it is not advisable the use of the valve itself with free outlet, i.e. without an outlet restriction bringing the pressure drop to the value of 1 bar.

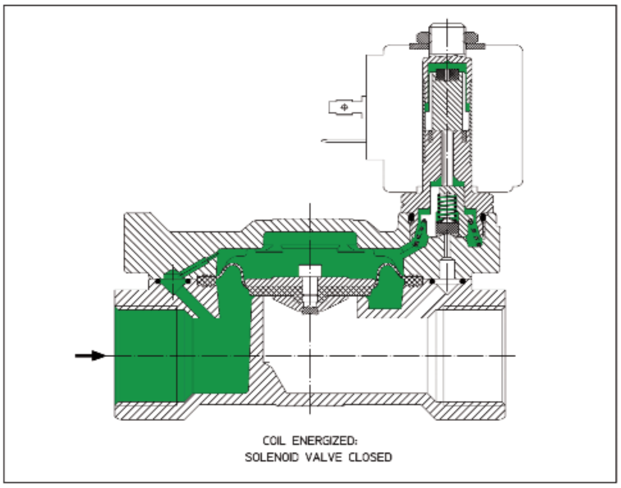
Moreover, particular attention must be paid in designing the hydraulic circuit to the problem of water hammering which could cause overpressures such as to lacerate the diaphragm or damage other parts of the solenoid valve.

1.4 2 way normally open solenoid valves with pilot control

Main components: body with main orifice, cover, diaphragm (or piston) assembly, complete armature tube + plunger + gasket holder + gasket (normally open kit), coil

Functioning:





2 way normally open solenoid valves with pilot control have an inlet pipe and a outlet pipe. Functioning of these solenoid valves is, as regards movement of the diaphragm, identical to that of 2 way normally closed solenoid valves with pilot control except that in place of the normally closed kit a normally open kit is mounted to open and close the pilot orifice. So in this case with the coil energized the pilot orifice is closed and the diaphragm therefore in such a position as to close the main orifice, whereas with the coil not energized the pilot orifice is open, thus cau-sing the main orifice to open.

Notes:

In this family of solenoid valves there must be a minimum pressure difference between the inlet and outlet pipes to ensure correct functioning of the solenoid valve.

However, an excessive pressure difference between inlet and outlet, as with 2 way normally open direct acting solenoid valves, causes an increase in the force required to open the pilot orifice, so if this pressure difference is greater than the maximum value for which the solenoid valve has been designed, the latter may not reopen even when the coil is not energized.

For a correct operation of the solenoid valve, and to avoid a quick wear of the diaphragm, it is advisable that, once starting the valve closing, the actual flow isn't higher than the Kv (i.e.: flow rate through the valve with a pressure loss of 1 bar).

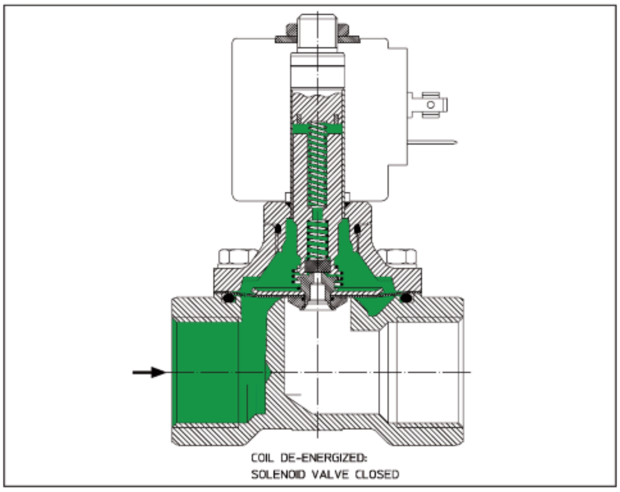
For this reason, should the inlet pressure when the valve is open, be higher than 1 bar, it is not advisable the use of the valve itself with free outlet, i.e. without an outlet restriction bringing the pressure drop to the value of 1 bar.

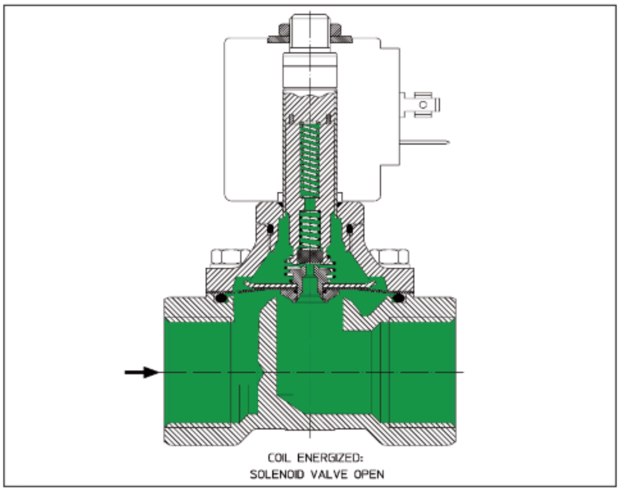
Moreover, particular attention must be paid in designing the hydraulic circuit to the problem of water hammering which could cause overpressures such as to lacerate the diaphragm or damage other parts of the solenoid valve.

1.5 2 way normally closed combined operation solenoid valves

Main components: body with main orifice, cover, diaphragm (or piston) assembly, complete armature tube + complete plunger, coil.

Functioning:





2 way normally closed combined operation solenoid valves have an inlet pipe and a outlet pipe. Opening of the main orifice, which is in the body, comes about by an unbalance is pressure between the upper and lower surfaces of a diaphragm (or piston) together with direct action of the plunger which is fixed to the diaphragm. Functioning is substantially similar to that of solenoid valves with pilot control as regards diaphragm movement except that even with small pressure differences between inlet and outlet, functioning is ensured by the direct action of the plunger on the diaphragm. So, also in this case, when the coil is not energized there is fluid under pressure in the chamber above the diaphragm while beneath the diaphragm there is pressure only in the area external to the main orifice: therefore the resultant of the forces on the diaphragm is such as to push it to close the main orifice. When the coil is energized, movement of the plunger, on which a gasket is mounted, opens an orifice on the complete diaphragm (pilot orifice) and discharges the chamber above the diaphragm. At the same time the plunger exercises direct force on the diaphragm, aiding its opening. The sum of this force and the unbalance of pressures on the two sides of the diaphragm causes the diaphragm to move and open the main orifice.

Notes: In this family of solenoid valves there must not be a minimum pressure difference between the inlet and outlet pipes to ensure correct functioning of the solenoid valve.

However, an excessive pressure difference between inlet and outlet, as with 2 way normally closed direct acting solenoid valves, causes an increase in the force required to open the pilot orifice, so if this pressure difference is greater than the maximum value for which the solenoid valve has been designed, the latter may not open even when the coil is energized.

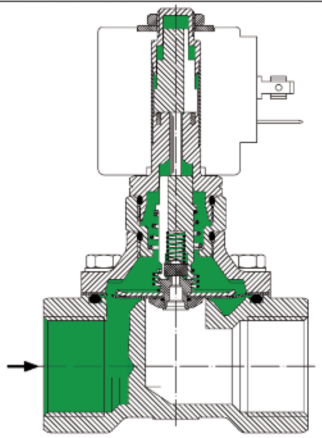
For a correct operation of the solenoid valve, and to avoid a quick wear of the diaphragm, it is advisable that, once starting the valve closing, the actual flow isn't higher than the Kv (i.e.: flow rate through the valve with a pressure loss of 1 bar).

For this reason, should the inlet pressure when the valve is open, be higher than 1 bar, it is not advisable the use of the valve itself with free outlet, i.e. without an outlet restriction bringing the pressure drop to the value of 1 bar.Moreover, particular attention must be paid in designing the hydraulic circuit to the problem of water hammering which could cause overpressures such as to lacerate the diaphragm or damage other parts of the solenoid valve.

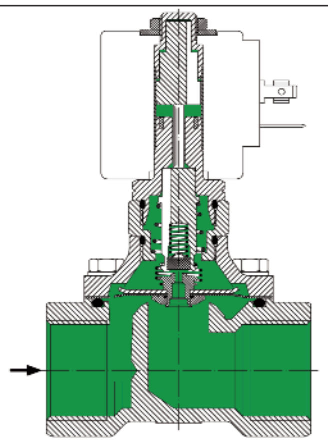
1.6 2 way normally open combined operation solenoid valves

Main components: body with main orifice, cover, diaphragm (or piston) assembly, complete armature tube + complete plunger, coil.

Functioning:



COIL ENERGIZED:
SOLENOID VALVE CLOSED



COIL DE-ENERGIZED:
SOLENOID VALVE OPEN

2 way normally open combined operation solenoid valves have an inlet pipe and a outlet pipe.

2 way normally open functioning is substantially similar to that of solenoid valves mixed actuated normally closed. The difference is basically in the piloting kit. Instead of a normally closed solenoid operator, it is mounted a normally open kit. In this case when the coil is powered the piloting orifice will be closed and the main seat will keep close the valve. The opposite happen when the coil is not powered and the main seat remains open allowing the fluid flow.

Notes: In this family of solenoid valves there must not be a minimum pressure difference between the inlet and outlet pipes to ensure correct functioning of the solenoid valve.

However, an excessive pressure difference between inlet and outlet, as with 2 way normally closed direct acting solenoid valves, causes an increase in the force required to open the pilot orifice, so if this pressure difference is greater than the maximum value for which the solenoid valve has been designed, the latter may not open even when the coil is energized.

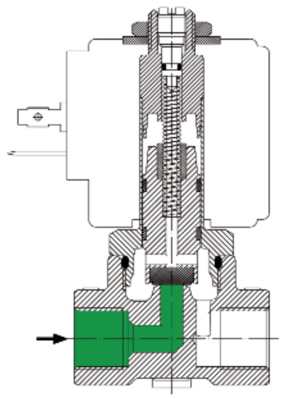
For a correct operation of the solenoid valve, and to avoid a quick wear of the diaphragm, it is advisable that, once starting the valve closing, the actual flow isn't higher than the Kv (i.e.: flow rate through the valve with a pressure loss of 1 bar).

For this reason, should the inlet pressure when the valve is open, be higher than 1 bar, it is not advisable the use of the valve itself with free outlet, i.e. without an outlet restriction bringing the pressure drop to the value of 1 bar.Moreover, particular attention must be paid in designing the hydraulic circuit to the problem of water hammering which could cause overpressures such as to lacerate the diaphragm or damage other parts of the solenoid valve.

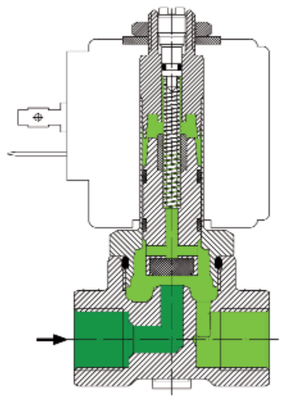
1.7 Proportional direct acting solenoid valves

Main components: body with main orifice, complete armature tube + adjustment screws + plunger + gasket, coil.

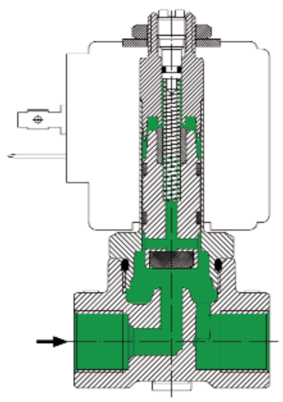
Functioning:



COIL DE-ENERGIZED:
SOLENOID VALVE CLOSED



COIL ENERGIZED WITH CURRENT LESS THAN THE MAXIMUM PERMISSIBLE:
SOLENOID VALVE PARTIALLY OPEN



COIL ENERGIZED TO MAXIMUM:
SOLENOID VALVE COMPLETELY OPEN

Proportional direct acting solenoid valves have an inlet pipe and a outlet pipe. The plunger, on which a sealing gasket is mounted, provides directly for opening and closing the main orifice of the solenoid valve.

Unlike 2 way normally closed solenoid valves which have only two states, open and closed, a proportional solenoid valve, in function of the current run in the coil, can open partially. The solenoid valve can be set with the adjustment screws in such a way that, with the coil not energized, a perfect seal at maximum project pressure is guaranteed.

For clarification regarding methods used for energising and controlling this type of solenoid valve, see the functioning scheme for these valves in this section.

It is important to note that proportional solenoid valves are always operated by Direct Current (DC).

Notes:

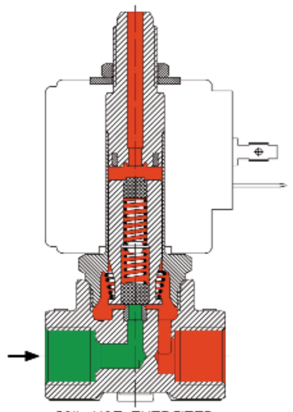
On these valves, unlike the other models, the fluid shall enter into the valve so to pass through the main orifice from the lower side towards the higher one.

In this family of solenoid valves an increase in pressure, as with three way solenoid valves, causes a reduction in the pressure required to open the valve: if the pressure difference between inlet and outlet is greater than the maximum value for which thesolenoid valve has been tared, the latter may open even when the coil is not energized. Proportional solenoid valves are tared individually, at the moment of installation and inspection testing, with the adjustment screws in the fixed core: any modification of this taring may make the valve work in a different way with regard to the data shown on the label.

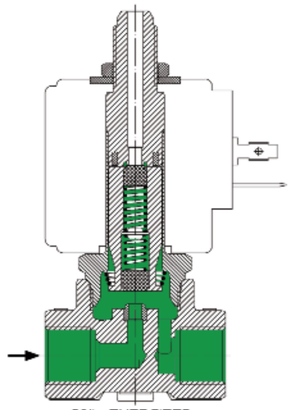
2.1 3 way normally closed direct acting solenoid valves

Main components: body with orifice, complete armature tube + fixed core + plunger + 2 gaskets (3 way kit), coil.

Functioning:



COIL NOT ENERGIZED:
SOLENOID VALVE CLOSED;
OUTLET CONNECTED WITH THE EXHAUST PORT



COIL ENERGIZED:
SOLENOID VALVE OPEN;
EXHAUST PORT CLOSED

3 way normally closed solenoid valves have an inlet pipe, a outlet pipe and an exhaust pipe. The plunger, on which two gaskets are mounted, provides directly for opening and closing the solenoid valve's main orifice with one of the two gaskets and, simultaneously, opening or closing the outlet orifice with the other gasket. When the coil is not energized the plunger is in such a position as to close the main orifice,preventing the flow of fluid from the inlet pipe to the outlet pipe, whereas the outlet pipe is in communication with the exhaust pipe.

When the coil is energized the plunger moves to a position in which it opens the main orifice and closes the exhaust orifice, permitting fluid to flow from the inlet pipe to the outlet one and preventing flow to the exhaust.

Notes:

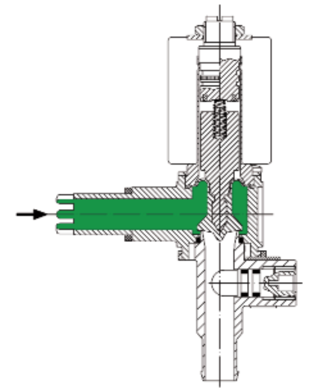
On these valves, unlike the other models, the fluid shall enter into the valve so to pass through the main orifice from the lower side towards the higher one.

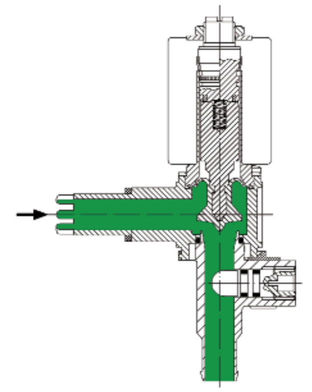
In this family of solenoid valves an increase in pressure causes a reduction in the force required to open the valve: if the pressure difference between inlet and outlet is greater than the maximum value for which the solenoid valve has been designed, the latter may open even when the coil is not energized.

3.1 Single solenoid valves for automatic drink-dispensers

Main components: body, lower body with orifice, complete armature tube + fixed core + plunger + cap gasket (2 way kit), coil.

Functioning:





Single solenoid valves for drink-dispenser have an inlet pipe and a outlet pipe on which there is generally a small pipe for attaching a vent. The plunger, on which the sealing cap gasket is fitted, provides directly for opening and closing the orifice, as with two way normally closed solenoid valves.

When the coil is not energized the plunger is in a position that closes the orifice, preventing fluid flow from the inlet to the outlet pipe.

When the coil is energized the plunger moves to a position that opens the orifice, permitting fluid flow from the inlet to the outlet pipe.

As well as opening and closing the orifice, the cap gasket provides for keeping the fluid separate from the armature tube-complete plunger and to avoid any deposit of limestone into the armature tube.

On the outlet pipe there is usually an adjustment screw for setting the solenoid valve's flow, dividing the conduit.

Notes:

In this family of solenoid valves an increase in inlet pressure causes a reduction in the force required to open the valve: if the inlet pressure is greater than the maximum value for which the solenoid valve has been designed, the latter may open even when the coil is not energized.

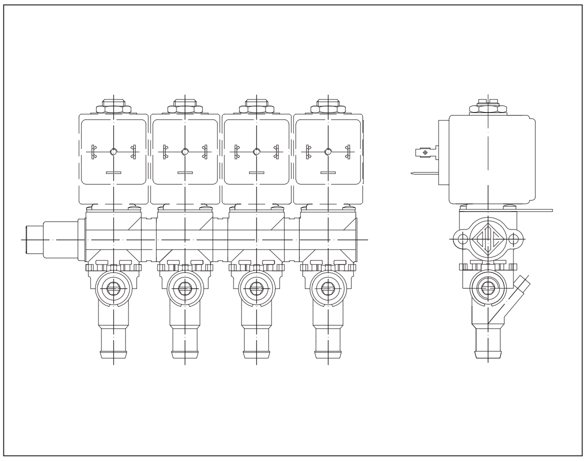
On the lower body of the solenoid valves for automatic drink-dispensers there is also a little venting fitting, on which usually a plastic pipe is connected.

This device assures a better fluid efflux, and therefore a steady flow.

3.2 Banks of solenoid valves for automatic drink-dispensers

Main components: headers, lower bodies with orifices, complete armature tube + fixed cores + plungers + cap gaskets (2 way kit), coils.

Functioning:



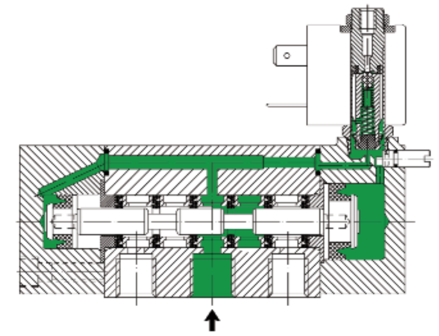
From a functional viewpoint groups of solenoid valves are identical to the singles. The only difference is that they can be put together to form a group of solenoid valves with an inlet pipe and various outlet pipes, each one of which can be opened by energizing the corresponding coil.

The number of components of the group is in theory unlimited, but normally there are not more than 4 ÷ 5 elements in a group.

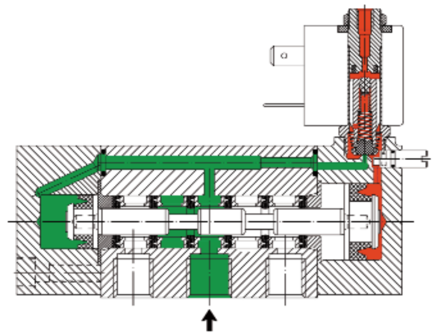
4 5 way solenoid valves

Main components: solenoid valve body, profiled shaft, pistons, spring where required, 3 way kit, coil.

Functioning:



COIL ENERGIZED: THE FORCE ON THE LARGE PISTON (RIGHT) IS GREATER THAN THAT ON THE SMALL PISTON (LEFT), MOVING THE PROFILED SHAFT ON THE LEFT



COIL DE-ENERGIZED: THERE IS NO FORCE ACTING ON THE LARGE PISTON (RIGHT) WHILE PRESSURE ON THE SMALL PISTON PUSHES THE PROFILED SHAFT TO THE RIGHT

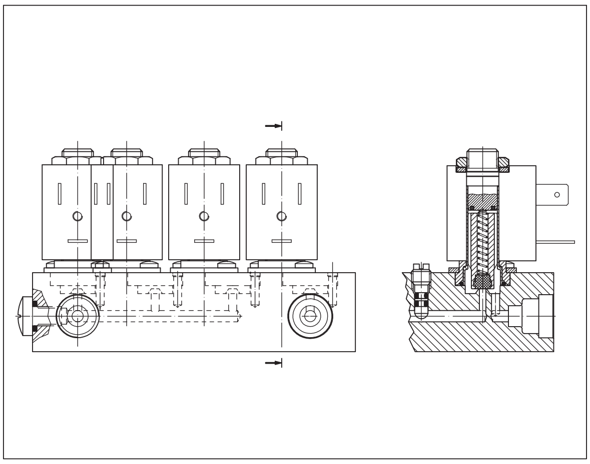
5 way solenoid valves are divided into two distinct groups: pneumatic return and spring return. In pneumatic return 5 way solenoid valves, on energizing or not energizing the coil and on the consequent opening or closing of a pilot orifice an unbalance of forces is created on two pistons of different section, fixed to a suitably profiled shaft which moves, putting the inlet pipe (pipe 1) in communication with one of the other 4 pipes and putting others into outlet, closing or opening them in accordance with specific schemes for each individual valve. Closure of the pilot orifice causes the return of the profiled shaft to its original position due to a play of pressures.

In 5 way spring return solenoid valves there is, instead of the small piston, a spring which carries out the function of returning the piston to its initial position when the coil is de-energized the pilot orifice is closed.

Notes:

For correct functioning of the solenoid valve there must be a specified minimum pressure for each type of solenoid valve at the inlet pipe (pipe 1).

5 Special solenoid valves and banks



Typical of ODE are the design and the manufacture of solenoid valves or special banks carried out according to customer's requirements. Should no standard valve completely meet customer's requirements, it is possible to carry out the design of special new valves or banks, for quantities to be determinated from time to time. At present ODE manufacture many different "special" valves or banks, that, in most cases, are made by one or more standard "kits" (armature tube, core, coil) on valve bodies made by different materials, designed according to customer's needs.

It is possible, therefore, to have banks by solenoid valves of different features such as 2-way and 3-way, Normally Open and Closed, direct operated.

General Description

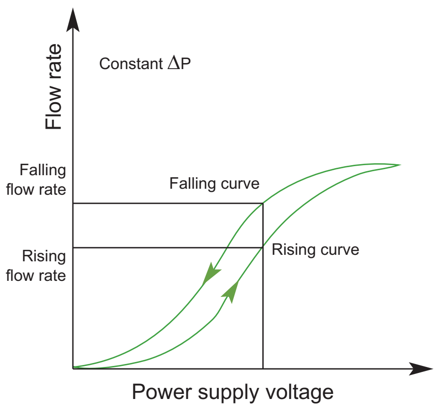
ODE PROPORTIONAL SOLENOID VALVES allow the fluid flow rate passing through them to be controlled by varying the current into the coil.
This is the main difference between this type of solenoid valve and the traditional type with which the flow rate of the fluid is determined exclusively by the difference between the pressure upstream and downstream of the same solenoid valve (ΔP).
If, with the same ΔP, it is necessary to have different flow rates, proportional solenoid valves are suitable to solve the problem.
From the pratical point of view, although a DIRECT CURRENT COIL is scheduled for running, a proportional valve needs a particular power supply that allows to control the current into the coil by varying a parameter known as Duty-Cycle, which is directly connected to it. (see paragraph "Notes about the control electronics")

Technical Description

As mentioned above, with this type of solenoid valve, the flow rate is determied by the current into the coil and by ΔP.
Therefore, it is possible to draw rate-of-flow curves where one of these parameters is kept constant while the other is the independent variable.
For example, it is possible to trace different graphs with ΔP taken as the parameter (e.g. 1 bar, 2 bar, 3 bar, etc.) in which the flow rate is a function of the current that flows into the coil (which is directly connected to the duty cycle: see paragraph "Notes about the control electronics")
It is important to note that by varying the ΔP with the same current through the coil, there will be different flow rates.
Therefore, it will be better if ΔP has a constant value if a flow rate linked directly to the current that flows into the coil only is required. Ohterwise, the flow rate will be affected.
It is also important to note that more ΔP increases, the less the current through the coil will have to be for since the pressure allows the opening of the valve itself.

Hysteresis

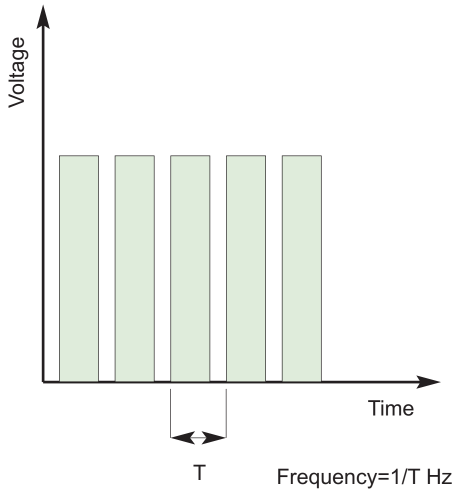
To explain this phenomenon it is worth describing how the laboratory test which lets us draw the flow rate-Duty Cycle graphs with constant pressure is carried out.
ΔP is taken to a value which must remain constant, then the valve is powered with a Duty Cycle which increases step by step and the flow rate relating to certain Duty Cycle values is noted (e.g. 50%, 60%, 70%, etc.).
Once reached the 100%, the Duty Cycle is reduced and the flow rate for the same Duty Cycle values is me asured: in general the latter rate-of-flow values will be slightly greater than thos noted previously for the same Duty Cycle value.
This phenomenon takes the name of flow rate hysteresis and it will be necessary to take it into account when using the solenoid valve.



Other parameters:

Other parametes in the catalogue are:
- repeatability which indicates the maximum error committed by repeating the test with identical procedures (ΔP, rising or falling stage, etc.).
- sensitivity which indicates the minimum increase to be given to the voltage to obtain a variation in flow rate (with constant ΔP).

Notes about the control electronics



We mentioned before that DIRECT CURRENT COILS are used on this kind of valves.
As a matter of facts, it is a RECTANGULAR PULSE tension which should arrive to coil poles as shown in the diagram. Our electronic circuit energise te coil by this kind of power supply, allowing the control of Duty Cycle by means of a control signal from 0 to 10 volt. Duty Cycle is directly related to the current flowing through the coil, so that a change of Duty Cycle causes a change of current through the coil: the higher the Duty Cycle is, the higher will be the power absorption by the coil, and the higher valve opening.
If the solenoid valve is to be powered with electronics other than ODE, it is advisable to supply the coil with rectangular pulses with a frequency between 600 Hz and 800 Hz .
With slightly different frequecies, lower performance in terms of hysteresis, repeatability and sensitivity can be obtained. To obtain the proportional effect it is possible to vary the voltage supply at the coil poles: this method is not recommended as it will bring to an increase of the flow rate hysteresis.

Typical applications

Electromedical field.
Industrial automation.
Integral-derivative process control.

PROTECTION METHODS

An explosion is caused by the simultaneous presence of the following 3 FACTORS:
1) Combustion supporter: oxygen in the air (always present).
2) Combustible material: this can be in gas, vapour or dust form.
3) Ignition energy: this can derive from electrical or thermal phenomena.

The presence of a spark or a flame may not be necessary to cause the explosion: the simple increase in surface temperature of some equipment component to a temperature greater than the ignition temperature of the gas in the atmosphere can cause an explosion.
In order to eliminate one of the three factors which can cause the explosion, certain protection measures defined by the **PROTECTION METHOD** are applied to the equipment.

Method symbol		**Definition**	
“d”		EXPLOSION-PROOF HOUSING	The parts which could provoke a dangerous atmosphere are placed in a housing capable of resisting the pressure developed by an internal explosion of an explosive mixture and to prevent the explosion from being transmitted to the surrounding atmosphere.
“e”		INCREASED SAFETY	The possibility of excessive temperature or the presence of electric arcs or sparks inside and on the external parts of the electrical material are eliminated thanks to high-coefficient safety measures in such a way as to prevent them from appearing during normal operation.
“i”	“ia”	INTRINSIC SAFETY	A circuit inside which no spark or thermal effect produced in the test conditions provided for by the regulations (normal operation and in case of breakdown) is able to cause a given explosive atmosphere to ignite.
	“ib”		
“m”		ENCAPSULATION	Resin encapsulation contains the parts that, through sparks or heating could cause an explosive atmosphere to ignite.
“o”		IMMERSION IN OIL	The electrical material is immersed in oil.
“p”		INTERNAL OVERPRESSURE	Internal overpressure, maintained with respect to the atmosphere, with a neutral protection gas.
“q”		IMMERSION UNDER SAND	The housing is filled with a powdery material.
“de”		MIXED	"d" and "e" methods adopted simultaneously.

By the legislative provisions, in dangerous atmospheres, in Italy only equipment conforming to the "EEx" European standards can be used which have been certified by an authorized laboratory and which bear the distinctive community mark.
As in some countries there are local protection methods which are not recognized by CENELEC, some of these are listed as follows:
- (CEI 79-15) "N" non-incendiary protection method for zone 2 (Netherlands and United Kingdom)
- "H" hermetic protection method (Netherlands)
- "S" protection method (Netherlands and Germany)
- ICS-6 A NSI/NEMA 7.9 Standard (U.S.A.)

PARAMETERS FOR THE CHOICE OF THE PROTECTION METHOD

The choice of protection method depends on the place where the equipment is to be installed (class and zone) and subsequently on the type of atmosphere present.
The danger areas are the places in the system where a dangerous atmosphere could be created during normal operation or because of breakdowns. In Italy the classification of danger areas is regulated by the CEI 64-2 standard, some notes on which are given as follows:

DANGEROUS ATMOSPHERE

A dangerous atmosphere is an atmosphere formed, or reasonably liable to be formed, by the mixing with air, at atmospheric conditions, of inflammable substances in the form of gas, vapours, smoke or powders in such proportions that a thermal phenomenon (excessive temperature, electric arc or spark) may cause them to explode.

DANGEROUS PLACE

Dangerous places are subdivided into the following four classes (in function of the substances present):
- C0 (CLASS 0 places): places containing explosive substances.
- C1 (CLASS 1 places): places containing inflammable substances in the form of gas or vapours in minimum quantities indicated by the standard.
- C2 (CLASS 2 places): places containing inflammable powders (E-electric conductors; NE-non-electric conductors).
- C3 (CLASS 3 places): places containing inflammable substances in quantities which are lower than the minimum indicated for class 1.

DANGEROUS ZONES

A zone where the presence of a dangerous atmosphere is possible. There are four types of dangerous zone depending on the fact that the dangerous atmosphere is:
- permanent or for long periods of time (ZONE 0)
- intermittent in normal service (ZONE 1)
- episodic or for short periods of time (ZONE 2)
- present for periods of less than 0,01 hour a year. (ZONE R)

The safety required depends on the CLASS combined with the ZONE rating.

DANGEROUS PLACE CLASS		ZONE RATING	SAFETY ELECTRIC SYSTEM TYPES				
			"d"	"ia"	"ib"	"e"	"m"
C0		C0Z0	**V**	I	**V**	**V**	**V**
		C0Z1	R	I	**V**	**V**	**V**
		C0Z2	R	R	I	**V**	**V**
		C0ZR	R	R	R	R	R
C1		C1Z0	**V**	I	**V**	**V**	**V**
		C1Z1	I	R	I	I	**V**
		C1Z2	R	R	R	R	I
		C1ZR	R	R	R	R	R
C2	E		R	R	I	R	I
	NE		R	R	R	R	R
C3		C3Z1	I	R	I	I	**V**
		C3Z2	R	R	R	R	R

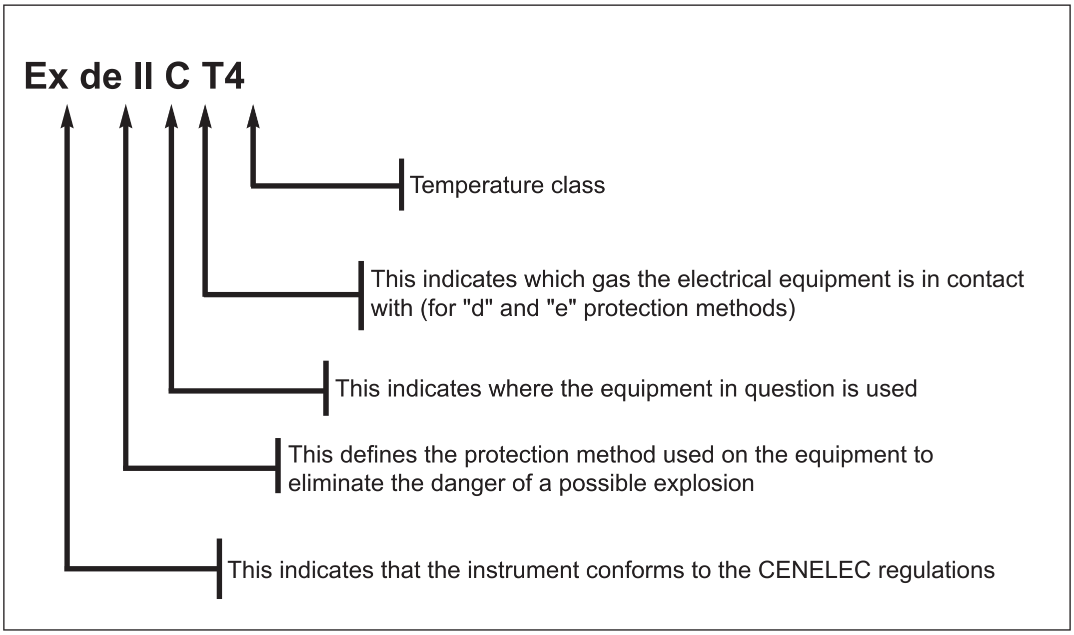
R Redundant
I Suitable
V Forbidden

For CLASS 1 (C1) equipment, the standards provide for a further classification based on the installation place and the gas type that may be present. Therefore, there are 2 subgroups:
GROUP I - Equipment to be used in mines
GROUP II - Equipment for surface installation.

GROUP II is further subdivided based on the atmosphere to which the equipment is destined. For protection modes "d" and "i", the standards define three subgroups (A-B-C) which identify the gases with which the equipment comes into contact.

TEMPERATURE CLASSES
For all GROUP II equipment, the standards also provide a classification based on the maximum surface temperature that the same equipment can reach both during normal operation and because of any breakdowns which may occur. The temperatures are referred to a room temperature of 40°C.

GAS TYPE			**TEMPERATURE CLASSES Max surface temperature (°C)**						
GROUP		DENOMINATION	Ignition temperature	T1 450°	T2 300°	T3 200°	T4 135°	T5 100°	T6 85°
II	A	acetone	540°C	●					
		acetic acid	485°C	●					
		ammonia	630°C	●					
		ethane	515°C	●					
		methylene chloride	556°C	●					
		methane (CH_4)	595°C	●					
		carbon monoxide	605°C	●					
		propane	470°C	●					
		n-butane	365°C		●				
		n-butyl	370°C		●				
		hydrogen sulphide	270°C			●			
		n-hexane	240°C			●			
		acetaldehyde	140°C				●		
		ether	170°C				●		
		ethyl nitrite	90°C						●
	B	ethylene	425°C		●				
		ethyl oxide	429°C-440°C		●				
	C	acetylene (C_2H_2)	305°C		●				
		carbon disulphide (CS_2)	102°C					●	
		hydrogen (H_2)	560°C	●					



The equipment which is to be installed in a dangerous atmosphere must be identified with a code which specifies all its characteristics.

The presently available certifications are:

Ex	d	II	C	T4	(Ø 13)
Ex	m	II		T4	(Ø 10

MEASUREMENT UNITS

Fundamental measurement units in the S.I. International System

Dimension	Name	Symbol
Lenght	metre	m
Mass	kilogram	kg
Time	second	s
Intensity of electric current	ampere	A
Thermodynamic temperature	Kelvin	K
Quantity of substance	mole	mol
Candle power	candles	cd
Plane angle	radians	Rad
Solid angle	steradians	sr

Meaning of prefixes commonly used for different measurement units:

Prefix	Symbol	Factor	
exa	............E	............10^{18}	
peta	............P	............10^{15}	
tera	............T	............10^{12}	(see Note below)
giga	............G	............10^{9}	(see Note below)
mega	............M	............10^{6}	
kilo	............k	............10^{3}	
etto	............h	............10^{2}	
deca	............da	............10^{1}	
deci	............d	............10^{-1}	
centi	c	............10^{-2}	
milli	............m	............10^{-3}	
micro	............µ	............10^{-6}	
nano	............n	............10^{-9}	
pico	............p	............10^{-12}	
femto	............f	............10^{-15}	
atto	............a	............10^{-18}	

N.B.: the term "billion" in Italy, Germany and Britain has the meaning of 10^{12} whereas in U.S.A. and France it has the meaning of 10^{9}. Therefore, if this term should be used, it is advisable to request an clear explanation of its meaning so as to avoid mistakes.

The S.I measurement unit for pressure is the **PASCAL**. Symbol: **Pa**. 1 Pa = 1 N/m2.

Other units used:

- **Bar**. .... 1 Bar = 10^5 Pa
- **At=Kg/cm²** (technical atmosphere)........... 1 At = 9.8066 x 10^4 Pa
- **Psi** (Pound/square inch)........................... 1 Psi = 6.894757 x 10^3 Pa
- **Atm** (physical atmosphere)...................... 1 Atm = 101.325 x 10^3 Pa
- **mm Hg** (millimetres of mercury).............. 1 mm Hg = 133.322 Pa
- **m H_2O** (metres of water)........................... 1m H_20 = 9.80665 x 10^3 Pa

Pa	Bar	Psi	Atm	At(Kg/cm²)	mm Hg	m H_2O
2.000	0,02	0,29	0,02	0,02	15,001	0,204
4.000	0,04	0,58	0,039	0,041	30,003	0,408
6.000	0,060	0,87	0,059	0,061	45,004	0,612
8.000	0,08	1,16	0,079	0,082	60,005	0,816
10.000	0,1	1,45	0,099	0,102	75,006	1,02
20.000	0,2	2,901	0,197	0,204	150,013	2,039
30.000	0,3	4,351	0,296	0,306	225,019	3,059
40.000	0,4	5,802	0,395	0,408	300,026	4,079
50.000	0,5	7,252	0,493	0,51	375,032	5,099
100.000	1	14,504	0,987	1,02	750,064	10,197
150.000	1,5	21,756	1,48	1,53	1.125,096	15,296
200.000	2	29,008	1,974	2,039	1.500,128	20,394
250.000	2,5	36,26	2,467	2,549	1.875,159	25,493
300.000	3	43,512	2,961	3,059	2.250,191	30,591
350.000	3,5	50,764	3,454	3,569	2.625,223	35,69
400.000	4	58,016	3,948	4,079	3.000.255	40,789
450.000	4,5	65,268	4,441	4,589	3.375,287	45,887
500.000	5	72,519	4,935	5,099	3.750,319	50,986
600.000	6	87,023	5,922	6,118	4.500,383	61,183
700.000	7	101,527	6,908	7,138	5.250,446	71,38
800.000	8	116,031	7,895	8,158	6.000,51	81,577
900.000	9	130,535	8,882	9,178	6.750,574	91,774
1.000.000	10	145,039	9,869	10,197	7.500,638	101,972
2.000.000	20	290,078	19,738	20,395	15.001,275	203,943
3.000.000	30	435,117	29,608	30,592	22.501,913	305,915
4.000.000	40	580,156	39,477	40,789	30.002,55	407,886
5.000.000	50	725,195	49,346	50,986	37.503,188	509,858

The S.I measurement unit for temperature is the **Kelvin**. Symbol: **K**.
Other units used are shown in the table:

K	°C	°F
0	-273,16	-459,688
243,16	-30	-22
248,16	-25	-13
253,16	-20	-4
258,16	-15	5
263,16	-10	14
268,16	-5	23
273,16	0	32
278,16	5	41
283,16	10	50
288,16	15	59
293,16	20	68
298,16	25	77
303,16	30	86
313,16	40	104
323,16	50	122
333,16	60	140
343,16	70	158
353,16	80	176
363,16	90	194
373,16	100	212
383,16	110	230
393,16	120	248
403,16	130	266
413,16	140	284
423,16	150	302
433,16	160	320
443,16	170	338
453,16	180	356
463,16	190	374
473,16	200	392

Formulae to convert from one unit to another: $T(°C) = T(K) - 273,16$
$T(°F) = (T(K) - 273,16) \times 9/5 + 32$

The S.I measurement unit for force is the **Newton**. Symbol: **N**.

Other units of force:

- **Kgf** (Kilogram force)............... 1 kg_f = 9.8665 N
- **lb** (Pound).............................. 1 lb = 4.4482 N
- **Kip** (kilopound)...................... 1 kip = 4,448.2 N
- **p** (pond)................................ 1 p = 9.80665 x 10^{-3} N
- **kp** (Kilopond).......................... 1 kp = 9.80665 N
- **oz** (ounce).............................. 1 oz = 0.2780 N
- **pdl** (poundal).......................... 1 pdl = 0.1382 N

N	Kg_f	lb	kip	p	kp	oz	pdl
0	0	0	0	0	0	0	0
1	0,101	0,225	0,00022	102	0,102	3,6	7,24
2	0,203	0,45	0,00045	204	0,204	7,19	14,47
3	0,304	0,674	0,00067	306	0,306	10,79	21,71
4	0,405	0,899	0,0009	408	0,408	14,39	28,94
5	0,507	1,124	0,00112	510	0,51	17,99	36,18
6	0,608	1,349	0,00135	612	0,612	21,58	43,42
7	0,709	1,574	0,00157	714	0,714	25,18	50,65
8	0,811	1,798	0,0018	816	0,816	28,78	57,89
9	0,912	2,023	0,00202	918	0,918	32,37	65,12
10	1,014	2,248	0,00225	1.020	1,02	35,97	72,36
20	2,027	4,496	0,0045	2.039	2,039	71,94	144,72
30	3,041	6,744	0,00674	3.059	3,059	107,91	217,08
40	4,054	8,992	0,00899	4.079	4,079	143,88	289,44
50	5,068	11,241	0,01124	5.099	5,099	179,91	361,79
60	6,081	13,489	0,01349	6.118	6,118	215.83	434,15
70	7,095	15,737	0,01574	7.138	7,138	251,8	506,51
80	8,108	17,985	0,1798	8.158	8,158	287,77	578,87
90	9,122	20,233	0,02023	9.177	9,177	323,74	651,23
100	10,135	22,481	0,02248	10.197	10,197	359,71	723,59
500	50,677	112,405	0,11241	50.986	50,986	1.798,56	3.617,95
1.000	101,353	224,81	0,22481	101.972	101,972	3.597,12	7.235,89

MEASUREMENT UNITS | power

The S.I measurement unit for power is the **Watt**. Symbol: **W**. 1W = 1 Joule/sec.
Other units of power:

- **CV = HP** (Horsepower) 1CV= 1HP = 735W
- **Kcal/h** ((kilocalorie per hour) 1Kcal/h = 1.162 W
- **erg/sec** 1 erg/sec = 10^{-7}W
- **Kgf x m/sec** 1 Kgf x m/sec = 9.81W
- **kW** 1 kW = 1000W

W	CV = HP	Kcal/h	erg/sec	Kgf x m/sec	kW
1	0,001	0,861	10.000.000	0,102	0,001
2	0,003	1,721	20.000.000	0,204	0,002
4	0,005	3,442	40.000.000	0,408	0,004
6	0,008	5,164	60.000.000	0,612	0,006
8	0,011	6,885	80.000.000	0,815	0,008
10	0,014	8,606	100.000.000	1,019	0,01
20	0,027	17,212	200.000.000	2,039	0,02
40	0,054	34,423	400.000.000	4,077	0,04
60	0,082	51,635	600.000.000	6,116	0,06
80	0,109	68,847	800.000.000	8,155	0,08
100	0,136	86,059	1.000.000.000	10,194	0,1
140	0,19	120,482	1.400.000.000	14,271	0,14
180	0,245	154,905	1.800.000.000	18,349	0,18
200	0,272	172,117	2.000.000.000	20,387	0,2
400	0,544	344,234	4.000.000.000	40,775	0,4
600	0,816	516,351	6.000.000.000	61,162	0,6
800	1,088	688,468	8.000.000.000	81.549	0,8
1.000	1,361	860,585	10.000.000.000	101,937	1
2.000	2,721	1.721,17	20.000.000.000	203,874	2
3.000	4,082	2.581,756	30.000.000.000	305,81	3
4.000	5,442	3.442,341	40.000.000.000	407,747	4
5.000	6,803	4.302,926	50.000.000.000	509,684	5
6.000	8,163	5.163,511	60.000.000.000	611,621	6
7.000	9,524	6.024,096	70.000.000.000	713,558	7
8.000	10,884	6.884,682	80.000.000.000	815,494	8
9.000	12,245	7.745,267	90.000.000.000	917,431	9
10.000	13,605	8.605,852	100.000.000.000	1.019,368	10
11.000	14,966	9.466,437	110.000.000.000	1.121,305	11
12.000	16,327	10.327,022	120.000.000.000	1.223,242	12
13.000	17,687	11.187,608	130.000.000.000	1.325,178	13
14.000	19,048	12.048,193	140.000.000.000	1.427,115	14
15.000	20,408	12.908,778	150.000.000.000	1.529,052	15
16.000	21,769	13.769,363	160.000.000.000	1.630,989	16
17.000	23,129	14.629,948	170.000.000.000	1.732,926	17

NB.: sometimes the power absorbed by coils is expressed in volt-amperes (VA). This measurement unit does not have a fixed correspondence with the S. I. measurement unit (Watt). This non-correspondence is because of the voltage-current phase displacement which, when the coil is energized with alternating current, varies as the coil and the valve on which it is mounted vary.
An APPROXIMATE value for VA-Watt correspondence is 0.6: 1 VA = 0.6 Watts

The S.I. measurement for leangth is the **meter**. Symbol: **m**.

Other units of leangth:
- **in** (inch)....................1 inch = 0.0254 m
- **ft** (feet).....................1 ft = 0.3048 m
- **yd** (yard)..................1 yd = 0.9144 m

Metric measurement units which are often used:

- decimeter	(dm)	1 dm	= 10^{-1}m	= 0.1 m
- centimeter	(cm)	1 cm	= 10^{-2} m	= 0.01 m
- millimeter	(mm)	1 mm	= 10^{-3} m	= 0.001 m
- micron	(µm)	1 µm	= 10^{-6} m	= 0.000001m
- nanometer	(nm)	1 nm	= 10^{-9} m	= 0.000000001 m
- Kilometer	(km)	1 km	= 1000 m	

The S.I measurement unit for kinematic viscosity is the **m²/sec**.

Other units of kinematic viscosity:

- **St** (stoke) = 1 cm²/sec.......... 1 St = 10^{-4} m²/sec
- **cSt** (centiStoke).................... 1 cSt = 10^{-6} m²/sec
- **°E** (degrees Engler)............ For the °E ↔ cSt relationship, see the table
- **R"** (Redwood 1).................... For the Redwood 1 ↔ cSt relationship, see the table
- **Redwood 2**........................... For the Redwood 2 ↔ cSt relationship, see the figure
- **SUS** (Saybold Universal)..... For the Saybold universal ↔ cSt relationship, see the table
- **Saybold Furol**....................... For the Saybold Furol ↔ cSt relationship, see the figure

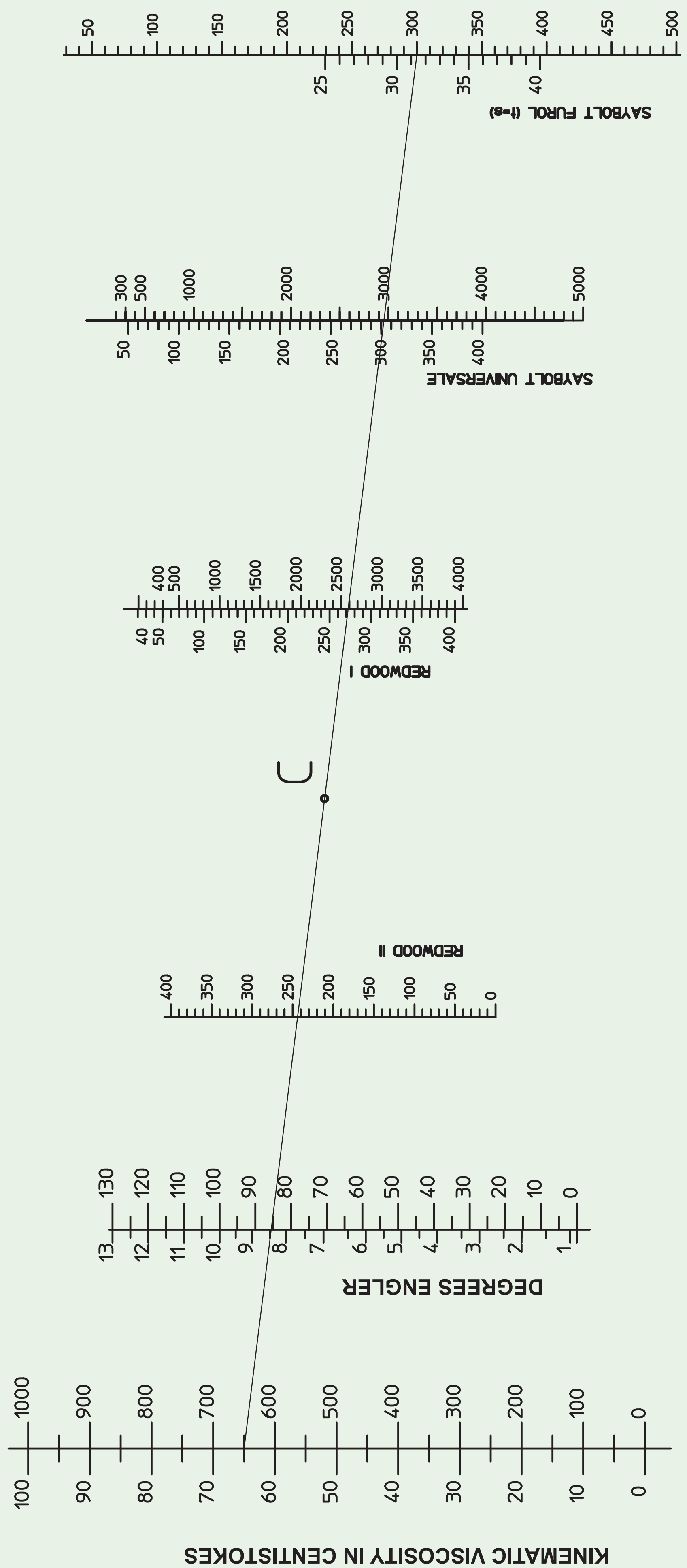
m²/sec	St	cSt	°E	Redwood 1 (70°F)	Saybold Un. (100 °F)
0,000002	0,02	2	1,1195	30	32,62
0,000004	0,04	4	1,3075	35	39,14
0,000006	0,06	6	1,4805	41	45,56
0,000008	0,08	8	1,6535	46	52,09
0,00001	0,10	10	1,834	52	58,91
0,000012	0,12	12	2,023	58	66,04
0,000014	0,14	14	2,2222	65	73,57
0,000016	0,16	16	2,435	71	81,3
0,000018	0,18	18	2,646	78	89,44
0,00002	0,20	20	2,876	85	97,77
0,000025	0,25	25	3,47	104	119,3
0,00003	0,30	30	4,08	123	141,3
0,000035	0,35	35	4,71	143	163,7
0,00004	0,40	40	5,35	164	186,3
0,000045	0,45	45	5,995	184	209,1
0,00005	0,50	50	6,64	204	232,1
0,000055	0,55	55	7,30	224	255,1

NB: the table gives kinematic viscosity values in the range in which ODE solenoid valves are normally used.

The various kinematic viscosity measurement units can be transformed in a simple way by using the figure below.

Example: We want to know the centiStoke viscosity corresponding to 8,5°E. We draw a line passing through point C, intersecting the Engler degrees chart at value 8,5. This line intersects the centiStokes chart at value 65, corresponding to 8,5°E.

Note: It is important to note that when the value we start from is on the left of a chart, (as 8,5°E), also the corresponding value should be read on the left of the corresponding chart


KINEMATIC VISCOSITY IN CENTISTOKES
DEGREES ENGLER
REDWOOD II
REDWOOD I
SAYBOLT UNIVERSALE
SAYBOLT FUROL (t=s)

MEASUREMENT UNITS

Measurement unit for energy

The S.I measurement unit for energy or work is the **Joule**. Symbol: **J**.
1 J = 1N x m = 1 W x sec = 1 kg x m^2/sec^2

Other units of energy or work:

- **Wh** (Watt-hour).................... 1 Wh = 3,600 J
- **kWh** (Kilowatt-hour)............. 1 kWh = 3.6 x 10^6 J
- **cal** (international calorie)..... 1 cal = 4.1868 J
- **Cal, Kcal** (great calorie)...... 1 Cal = 1 Kcal = 4,186.8 J
- **BTU** (British Termal Unit).... 1 BTU = 1,055.056 J
- **CVh** (horsepower-hour)....... 1 CVh = 2.64779 x 10^6 J
- **eV** (elettron volt)................... 1 eV = 1.6021892 x 10^{-19} J

J	Wh	kWh	cal	Cal=Kcal	BTU	CVh	eV
0	0	0	0	0	0	0	0
2.000	0,56	0,0006	477,69	0,478	1,9	0,0008	1,248 X 10^{22}
4.000	1,11	0,0011	955,38	0,955	3,79	0,0015	2,497 X 10^{22}
6.000	1,67	0,0017	1.433,08	1,433	5,69	0,0023	3,745 x 10^{22}
8.000	2,22	0,0022	1.910,77	1,911	7,58	0,003	4,993 X10^{22}
10.000	2,78	0,0028	2.388,46	2,388	9,48	0,0038	6,241 X 10^{22}
20.000	5,56	0,0056	4.776,92	4,777	18,96	0,0076	1,248 X10^{23}
30.000	8,33	0,0083	7.165,38	7,165	28,43	0,0113	1,872 X 10^{23}
40.000	11,11	0,0111	9.553,84	9,554	37,91	0,0151	2,497 X 10^{23}
50.000	13,89	0,0139	11.942,29	11,942	47,39	0,0189	3,121 X 10^{23}
100.000	27,78	0,0278	23.884,59	23,885	94,78	0,0378	6,241 X 10^{23}
150.000	41,67	0,0417	35.826,88	35,827	142,17	0,0567	9,362 X 10^{23}
200.000	55,56	0,0556	47.769,18	47,769	189,56	0,0755	1,248 X 10^{24}
250.000	69,44	0,0694	59.711,47	59,711	236,95	0,0944	1,560 X 10^{24}
500.000	138,89	0,1389	119.422,95	119,423	473,91	0,1888	3,121 X 10^{24}
750.000	208,33	0,2083	179.134,42	179,134	710,86	0,2833	4,681 X 10^{24}
1.000.000	277,78	0,2778	238.845,9	238,846	947,82	0,3777	6,241 X 10^{24}
2.000.000	555,56	0,5556	477.691,79	477,692	1.895,63	0,7553	1,248 X 10^{25}
3.000.000	833,33	0,8333	716.537,69	716,538	2.843,45	1,133	1,872 X 10^{25}
4.000.000	1.111,11	1,1111	955.383,59	955,384	3.791,27	1,5107	2,497 X 10^{25}
5.000.000	1.388,89	1,3889	1.194.229,48	1194,229	4.739,08	1,8884	3,121 X 10^{25}
6.000.000	1.666,67	1,6667	1.433.075,38	1.433,075	5.686,9	2,266	3,745 X 10^{25}
7.000.000	1.944,44	1,9444	1.671.921,28	1.671,921	6.634,72	2,6437	4,369 X 10^{25}
8.000.000	2.222,22	2,2222	1.910.767,17	1.910,767	7.582,54	3,0214	4,993 X 10^{25}
9.000.000	2.500	2,5	2.149.613,07	2.149,613	8.530,35	3,3991	5,617 X 10^{25}
10.000.000	2.777,78	2.777,78	2.388.458,97	2.388,459	9.478,17	3,7767	6,241 X10^{25}

MEASUREMENT UNITS

Measurement unit of the flow factor

UDM 09

Kv is the volume of water in l/min which flows through the valve at a pressure drop of 1 bar across the valve at 20°C.
The capacity coefficient used in the U.S.A. is called Cv and is the water capacity flow in USA Gallons per minute [gpm] with a Δp charge loss of 1 psi. The following dimensional equations are applicable:

[l/min] = 0,06 [m^3/h] = 0,26417 [gpm]
1 [gpm] = 3,785412 [l/min] = 0,22712 [m^3/h]
[psi] = 6,89475*10^{-2} [bar]

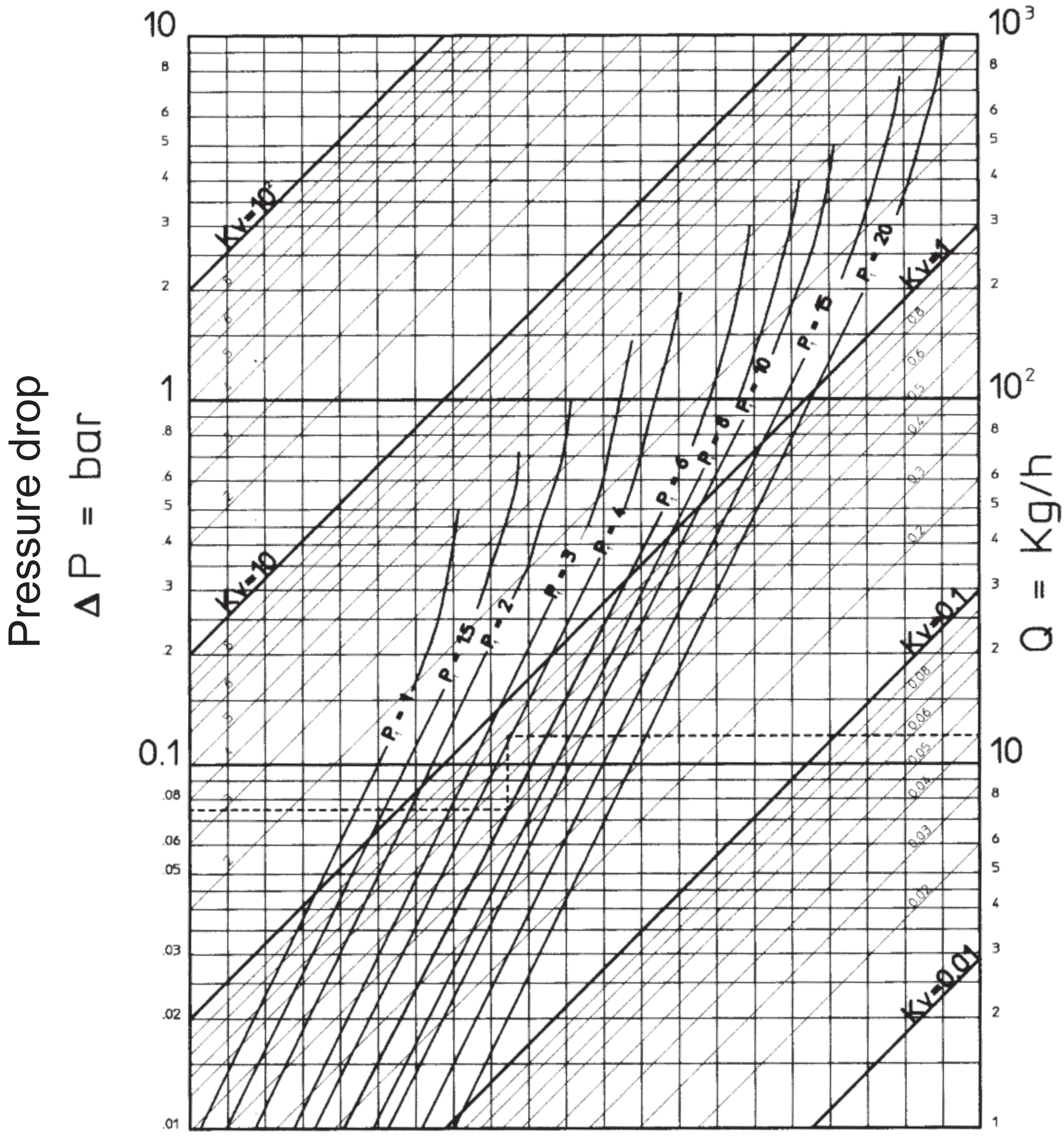
This means:

To obtain	Multiply	Factor
Kv in [l/min]	Kv in [m^3/h]	16,67
	Cv in [gpm]	3,79
Kv in [m^3/h]	Kv in [l/min]	0,06
	Cv in [gpm]	0,23
Cv in [gpm]	Kv in [l/min]	0,26
	Kv in [m^3/h]	4,4

Flow rate conversion table

Kv(l/min)	Kv(m^3/h)	Cv(gpm)	Kv(l/min)	Kv(m^3/h)	Cv(gpm)	Kv(l/min)	Kv(m^3/h)	Cv(gpm)	Kv(l/min)	Kv(m^3/h)	Cv(gpm)
0,1	0,006	0,0264	26	1,56	6,8685	120	7,20	31,7007	320	19,20	84,5351
0,2	0,012	0,0528	27	1,62	7,1326	125	7,50	33,0215	330	19,80	87,1768
0,3	0,018	0,0793	28	1,68	7,3968	130	7,80	34,3424	340	20,40	89,8185
0,4	0,024	0,1057	29	1,74	7,6610	135	8,10	35,6632	350	21,00	92,4602
0,5	0,030	0,1321	30	1,8	7,9252	140	8,40	36,9841	360	21,60	95,1020
0,6	0,036	0,1585	31	1,86	8,1893	145	8,70	38,3050	370	22,20	97,7437
0,7	0,042	0,1849	32	1,92	8,4535	150	9,00	39,6258	380	22,80	100,3854
0,8	0,048	0,2113	33	1,98	8,7177	155	9,30	40,9467	390	23,40	103,0271
0,9	0,054	0,2378	34	2,04	8,9819	160	9,60	42,2675	400	24,00	105,6688
1,0	0,06	0,2642	35	2,1	9,2460	165	9,90	43,5884	410	24,60	108,3106
1,5	0,09	0,3963	36	2,16	9,5102	170	10,20	44,9093	420	25,20	110,9523
2,0	0,12	0,5283	37	2,22	9,7744	175	10,50	46,2301	430	25,80	113,5940
2,5	0,15	0,6604	38	2,28	10,0385	180	10,80	47,5510	440	26,40	116,2357
3,0	0,18	0,7925	39	2,34	10,3027	185	11,10	48,8718	450	27,00	118,8774
3,5	0,21	0,9246	40	2,4	10,5669	190	11,40	50,1927	460	27,60	121,5192
4,0	0,24	1,0567	41	2,46	10,8311	195	11,70	51,5136	470	28,20	124,1609
4,5	0,27	1,1888	42	2,52	11,0952	200	12,00	52,8344	480	28,80	126,8026
5,0	0,3	1,3209	43	2,58	11,3594	205	12,30	54,1553	490	29,40	129,4443
6,0	0,36	1,5850	44	2,64	11,6236	210	12,60	55,4761	500	30,00	132,0861
7,0	0,42	1,8492	45	2,70	11,8877	215	12,90	56,7970	510	30,60	134,7278
8,0	0,48	2,1134	46	2,76	12,1519	220	13,20	58,1179	520	31,20	137,3695
9,0	0,54	2,3775	47	2,82	12,4161	225	13,50	59,4387	530	31,80	140,0112
10	0,6	2,6417	48	2,88	12,6803	230	13,80	60,7596	540	32,40	142,6529
11	0,66	2,9059	49	2,94	12,9444	235	14,10	62,0804	550	33,00	145,2947
12	0,72	3,1701	50	3,00	13,2086	240	14,40	63,4013	560	33,60	147,9364
13	0,78	3,4342	55	3,30	14,5295	245	14,70	64,7222	570	34,20	150,5781
14	0,84	3,6984	60	3,60	15,8503	250	15,00	66,0430	580	34,80	153,2198
15	0,90	3,9626	65	3,90	17,1712	255	15,30	67,3639	590	35,40	155,8615
16	0,96	4,2268	70	4,20	18,4920	260	15,60	68,6847	600	36,00	158,5033
17	1,02	4,4909	75	4,50	19,8129	265	15,90	70,0056	650	39,00	171,7119
18	1,08	4,7551	80	4,80	21,1338	270	16,20	71,3265	700	40,00	184,9205
19	1,14	5,0193	85	5,10	22,4546	275	16,50	72,6473	750	45,00	198,1291
20	1,2	5,2834	90	5,40	23,7755	280	16,80	73,9682	800	48,00	211,3377
21	1,26	5,5476	95	5,70	25,0963	285	17,10	75,2890	850	51,00	224,5463
22	1,32	5,8118	100	6,00	26,4172	290	17,40	76,6099	900	54,00	237,7549
23	1,38	6,0760	105	6,30	27,7381	295	17,70	77,9308	1000	60,00	264,1721
24	1,44	6,3401	110	6,60	29,0589	300	18,00	79,2516			
25	1,5	6,6043	115	6,90	30,3798	310	18,60	81,8934			

Steam diagram



Example: Determine the capacity with a loss of loaf of 750 mm H_2O and a relative pressure above the solenoid vallve of 5 bar with Kv=0,8 m^3.
Starting from the pressure drop value draw an horizontal line until it crosses the absolute pressure P_1=5+1=6 bar, and from this point of intersection, a vertical line to meet the Kv value 0,8; on the right-hand ordinate you can read the flow rate Q=12,8.