CHAPTER 8
NORMALLY-CLOSED SOLENOID VALVES
FOR INDUSTRIAL APPLICATIONS

APPLICATION

The solenoid valves illustrated in this chapter are designed for the applications specified in TABLE 26, where the different fluids are indicated with the following symbols, according to an already established code:

- W = Water
- L = Air
- B = Secondary coolants (solutions of glycol and water)
- O = Light oils (diesel fuel)

In conclusion, these valves can be used:

- with fluids in the gaseous state belonging to Group 2, as defined in Article 13, Chapter 1, Point (b) of Directive 2014/68/EU, with reference to EC Regulation No. 1272/2008.
- with fluids in the liquid state belonging to Group 1, as defined in Article 13, Chapter 1, Point (a) of Directive 2014/68/EU, with reference to EC Regulation No. 1272/2008.

OPERATION

The valves listed in this chapter are normally closed valves (NC). This means that when the coil is not energised, the plunger closes the fluid flow. When the coil is energised, the plunger opens the valve seat connecting the inlet to the outlet.

All the above indicated valves are sold in the version without coil (with the S suffix), and in the version with series 9300, type HF2 - “FAST LOCK” coils (A6 suffix with coil 9300/RA6-220/230 VAC).

The valves in series 1512 and 1522 are direct acting valves. Their operation depends only on the magnetic field produced by the current flow into the coil. Opening/closing of main valve seat, the only seat, is directly controlled by the mobile plunger.

These valves can work with zero pressure differential.

The valves in series 1132 e 1142 are pilot operated diaphragm solenoid valves. Their operation depends not only on the magnetic field produced by the current flow into the coil, but also on a minimum inlet pressure, which is necessary to:

- open the diaphragm and keep it lifted off the main opening
- close the diaphragm and ensure the tightness on the main opening

Opening/closing of main valve seat is controlled by the diaphragm while opening/closing of pilot seat is controlled by the mobile plunger of the coil.

These valves cannot work with zero differential pressure.

CONSTRUCTION

The main parts of the solenoid valves described in this chapter are constructed with the following materials:

- Hot forged brass EN 12420 – CW 617N for body and cover
- Austenitic stainless steel EN 10088-2 – 1.4303 for enclosure where the plunger moves
- Ferritic stainless steel EN 10088-3 – 1.4105 for the plunger
- Austenitic stainless steel EN ISO 3506 – A2-70 for tightening screws between body and cover.
- Fluorocarbon rubber (FPM) for outlet seal gaskets, seat gasket and diaphragm

VALVE SELECTION AND FLOW RATE CALCULATION

TABLE 26 shows the following functional characteristics for the selection of a solenoid valve for industrial applications:

- Connection dimensions
- PS: maximum allowable pressure of the fluid
- TS: maximum / minimum allowable temperature of the fluid
- TA: maximum / minimum allowable ambient temperature
- Kv: discharge factor
- minOPD: minimum Opening Pressure Differential. This is the minimum pressure differential between inlet and outlet at which a pilot-operated solenoid valve can open and stay opened or close and maintain the seal.
- MOPD: maximum Opening Pressure Differential according to ARI STANDARD 760 : 2001. This is the maximum pressure differential between inlet and outlet at which a solenoid valve can open.

With the Kv factor listed in TABLE 26 it is possible to calculate the flow rate through the valve, if you know the acceptable pressure drop, the type of fluid and the operating pressure; in addition, it is also possible to check the pressure drop through the valve, if you know the flow rate.

With the following formula it's possible to calculate the volumetric flow rate of a liquid:

$$Q = Kv \times \sqrt{\frac{\Delta p}{\rho}}$$

For water with a temperature between 5 and 30 °C and density (ρ) equal to 1 kg/dm³ the formula is:

$$Q = Kv \times \sqrt{\Delta p}$$

With the following formula, it is possible to calculate the volumetric flow rate of a gas:

$$\text{if } \Delta p < \frac{p_1}{2} \quad Q_n = 514 \times Kv \times \sqrt{\frac{\Delta p \times p_2}{\rho_n \times (273 + t_1)}}$$

$$\text{if } \Delta p > \frac{p_1}{2} \quad Q_n = 257 \times Kv \times \frac{p_1}{\sqrt{\rho_n \times (273 + t_1)}}$$

For air at 20 °C and density (ρ) equal to 1.29 kg/dm³ the formulas are:

$$\text{if } \Delta p < \frac{p_1}{2} \quad Q_n = 26{,}4 \times Kv \times \sqrt{\Delta p \times p_2}$$

$$\text{if } \Delta p > \frac{p_1}{2} \quad Q_n = 13{,}2 \times Kv \times p_1$$

where:

Kv = Kv factor of the valve [m³/h]
Q = volumetric flow rate for a liquid [m³/h]
Q_n = volumetric flow rate for a gas at "normal" reference conditions, 0 °C and 760 mm Hg [m_n^3/h]
p_1 = absolute pressure upstream from the valve [bar abs]
p_2 = absolute pressure downstream from the valve [bar abs]
t_1 = temperature upstream from the valve [°C]
Δ_p = pressure drop through the valve [bar]
ρ = density of a liquid [kg/dm³]
ρ_n = volumetric mass for a gas at "normal" reference conditions, 0 °C and 760 mm Hg [kg/m_n^3]

Entering the following data in TABLE 27:
- p_1 = absolute pressure upstream from the valve [bar abs]
- Δp = pressure drop through the valve [bar]

It is possible to identify the corresponding airflow rate value under the following reference conditions:
- Temperature at the valve inlet = 20 °C
- Pressure at the outlet (absolute) = 1 bar
- Kv factor of the valve considered = 1 m³/h

Example of the use of TABLE 27: Select the valve suitable for use with a flow rate of 200 m³/h of air, assuming an absolute pressure of 8 bars at the valve inlet (= 7 bars of relative pressure + 1 bar) and an acceptable pressure drop across the valve of 1.5 bar.
Intersecting the column p1 = 8 bar abs with the line Δp = 1.5 bar, the flow rate value is equal to 87 m³/h. This is the flow rate value of a hypothetical valve with Kv = 1 m³/h working under the above-mentioned conditions. Dividing 200 by 87 equals 2.29 m³/h. This is the Kv value required in the case under consideration. In TABLE 26, select the valve with the Kv value nearest to 2,29, rounding up, and subsequently checking that all the characteristics of the selected valve (max. opening pressure differential, connections, etc.) are suitable.

VISCOSITY

The values of MOPD (maximum opening pressure differential) specified in TABLE 26, are suitable for fluids with maximum kinematic viscosity of 12 cSt, where:

1 cSt = 10^{-6} m²/sec

For kinematic viscosity values greater than 12 cSt, it is necessary to multiply the maximum differential pressure by the following reducing factors:

Kinematic viscosity, cSt	Reducing factors
12	1
12 / 30	0.8
30 / 45	0.7

When the viscosity of the fluid is expressed as dynamic viscosity, i.e. in cP, where:

1 cP = 10^{-3} N sec/m².

The corresponding value of kinematic viscosity in cSt is obtained by the following relation:

$$\nu = \frac{\mu}{\rho}$$

where:
ν = Kinematic viscosity [cSt]
μ = dynamic viscosity [cP]
ρ = volumetric mass of the fluid at the temperature considered [kg/dm³]

TABLE 28 shows the approximate equivalences among the most common units of measure of viscosity at the same temperature.
Moreover, remember that the viscosity of a fluid may change, even significantly, as the temperature varies. Therefore, if the temperature of the fluid does not ensure viscosity values compatible with the correct operation of the valve, the valve might not open.

INSTALLATION

Before installation, check that the valve model meets the application requirements and check that the flow direction in the pipe corresponds to the arrow stamped on the body of the valve.

Make sure that the pipes are clean. If possible, fit an inspectable filter before the valve, avoid that foreign matter enter the valve. Make sure that the sealing materials (tape, jointing paste, etc.) do not obstruct the valve supply holes or exiting pilot holes (pilot-operated versions).

Connect the valve to the pipes or fittings, using the wrench only on the dedicated body surfaces. Do not use the coil or the plunger enclosure as a lever arm.

The valves can be mounted in any position as long as the coil does not point downwards. An assembly that keeps the coil upwards is recommended to avoid any accumulation of impurities inside the guide pipe. When using hoses, fix the valve using the dedicated fixing holes in the body.

Before connecting a valve to the electrical system, make sure that the line voltage and frequency correspond to the values marked on the coil. Direct current valves do not require a fixed polarity. To promote heat dissipation from the coil, position the valve in a ventilated environment, far from any other heat sources. The increase in the coil temperature, added to the environment and fluid temperatures, may lead to a temperature that can cause burns. It is recommended to suitably protect the coil from water and humidity.

TRACEABILITY

Direct action valves in series 1512 are identified by laser marking on the valve enclosure of the mobile plunger. This marking includes the following data: valve code, fluids, PS, TS, and production lot.

The direct action valves in series 1522 and the pilot-operated diaphragm solenoid valves in series 1132 and 1142 are identified by a plastic label fit on the valve enclosure of the mobile plunger (below the coil when present). This label includes the following data: valve code, fluids, PS, TS, and production lot.

TABLE 26: General characteristics of general purpose valves

Catalogue Number	Seal	Media	FPT Connections	Seat size nominal Ø [mm]	Kv Factor [m³/h]	Operating Principles	Opening Pressure Differential [bar]					PS [bar]	TS [°C]		TA [°C]		Risk Category according to PED Recast
							min OPD	MOPD coil series					min.	max.	min.	max.	
								9100 9110 9300 (AC)	9160 (AC)	9120 9320 (AC)	9120 9320 (DC)						
1512/01#	FPM	W.L.O.	G 1/8"	1,5	0,07	Direct Acting	0	30	30	30	30	30	-15	+130	-15	+50	Art. 4.3
1522/02#		W.O.	G 1/4"	4,5	0,40			10	10	12	8						
1522/03#			G 3/8"														
1522/04#			G 1/2"														
1132/03#		W.L.O..B.	G 3/8"	12,5	2,1	Diaphragm Pilot Operated	0,1	25	25	30	15						
1132/04#			G 1/2"		2,2												
1132/06#			G 3/4"	20	5,5		0,15	12	12	15	12	15					
1132/08#			G 1"		6,0												
1142/010#			G 1.1/4"	38	22		0,3	12	12	15	12						
1142/012#			G 1.1/2"		24												

= S , A6

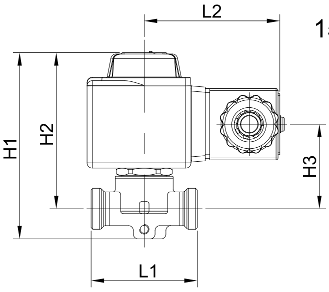
TABLE 27 - Air Capacity [m_n^3/h] (1)

Pressure Drop [bar]	Inlet pressure [bar abs]																							
	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1,500	1,300	1,200	1,100	1,050	1,030	1,015
0,0025																					1,38	1,35	1,33	1,33
0,005																				2,00	1,95	1,91	1,89	1,88
0,010																			2,94	2,82	2,76	2,69	2,66	2,65
0,015																		3,94	3,59	3,44	3,37	3,29	3,25	3,23
0,025																	5,9	5,07	4,62	4,43	4,33	4,23	4,17	
0,05																10,1	8,2	7,11	6,47	6,19	6,05	5,90		
0,1	35,3	34,3	33,3	32,2	31,1	30,0	28,8	27,6	26,3	24,9	23,5	21,9	20,3	18,5	16,5	14,2	11,5	9,88	8,95	8,55	8,35			
0,15	43,2	42,0	40,7	39,4	38,1	36,7	35,2	33,7	32,1	30,4	28,6	26,8	24,7	22,5	20,1	17,3	13,9	11,88	10,72	10,22				
0,25	55,6	54,0	52,4	50,7	48,9	47,1	45,2	43,3	41,2	39,0	36,7	34,3	31,7	28,8	25,6	21,9	17,5	14,76	13,20					
0,5	78,1	75,8	73,5	71,1	68,6	66,0	63,3	60,5	57,5	54,4	51,1	47,6	43,8	39,6	34,9	29,5	22,9	18,67						
1	108,8	105,6	102,2	98,8	95,2	91,5	87,6	83,5	79,2	74,7	69,8	64,7	59,0	52,8	45,7	37,3	26,4							
1,5	131,3	127,3	123,1	118,8	114,3	109,6	104,8	99,7	94,3	88,5	82,4	75,8	68,6	60,5	51,1	39,6								
2	149,3	144,6	139,7	134,6	129,3	123,8	118,1	112,0	105,6	98,8	91,5	83,5	74,7	64,7	52,8									
2,5	164,3	158,9	153,4	147,6	141,6	135,3	128,7	121,7	114,3	106,4	97,9	88,5	78,1	66,0										
3	177,1	171,1	164,9	158,4	151,7	144,6	137,2	129,3	121,0	112,0	102,2	91,5	79,2											
3,5	188,1	181,5	174,6	167,5	160,0	152,2	144,0	135,3	125,9	115,8	104,8	92,4												
4	197,6	190,4	182,9	175,1	167,0	158,4	149,3	139,7	129,3	118,1	105,6													
4,5	205,8	198,0	189,9	181,5	172,6	163,3	153,4	142,8	131,3	118,8														
5	212,8	204,5	195,8	186,7	177,1	167,0	156,2	144,6	132,0															
5,5	218,9	210,0	200,6	190,8	180,5	169,6	157,8	145,2																
6	224,0	214,5	204,5	194,0	182,9	171,1	158,4																	
6,5	228,2	218,1	207,5	196,2	184,3	171,6																		
7	231,7	220,9	209,5	197,6	184,8																			
7,5	234,3	222,8	210,8	198,0																				
8	236,1	224,0	211,2																					
8,5	237,2	224,4																						
9	237,6																							

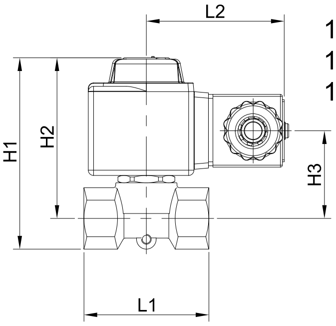
(1) The table provides air capacity values in m^3/h under the following conditions:
- temperature at valve inlet: + 20°C
- pressure at outlet (absolute): 1 bar
- Kv of the solenoid valve: 1 m^3/h

TABLE 28: Viscosity equivalence

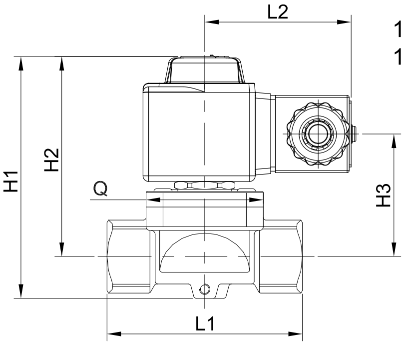
Cinematic Viscosity [cSt] o [mm^2/s]	Engler Degree [°E]	Saybolt Universal Seconds [Ssu]	Seconds Redwood N.1 [SRW N.1]
1	1	---	---
2	1,1	32,7	31
3	1,2	36	33,5
4	1,3	39	36
5	1,4	42,5	38,5
7	1,5	49	44
10	1,8	59	52
15	2,3	77,5	68
20	2,9	98	86
25	3,4	119	105
30	4	140	120
35	4,7	164	145
40	5,3	186	165
50	6,6	232	205
60	8	278	245
70	9,2	324	286
80	10,5	370	327
90	12	415	370
100	13	465	410



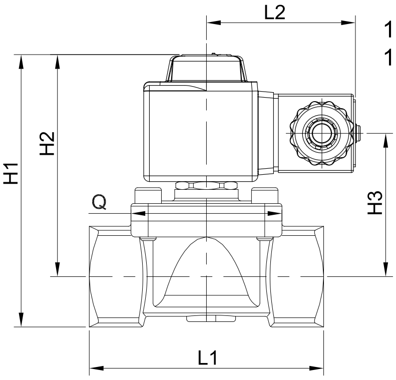
1512/01



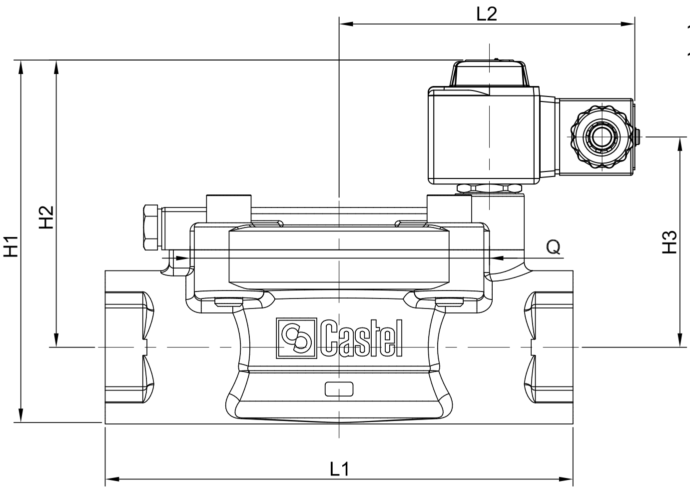
1522/02
1522/03
1522/04



1132/03
1132/04



1132/06
1132/08



1142/010
1142/012

<table>
<tr><th colspan="8">TABLE 29: Dimensions and weights of GP valves (valves with 9300 coils)</th></tr>
<tr><th rowspan="2">Catalogue Number</th><th colspan="6">Dimensions [mm]</th><th rowspan="2">Weight [g]</th></tr>
<tr><th>H_1</th><th>H_2</th><th>H_3</th><th>L_1</th><th>L_2</th><th>Q</th></tr>
<tr><td>1512/01#</td><td>69</td><td>57</td><td>34</td><td>44</td><td rowspan="4">52</td><td>–</td><td>310</td></tr>
<tr><td>1522/02#</td><td rowspan="3">71</td><td rowspan="3">59</td><td rowspan="3">36</td><td rowspan="3">51</td><td rowspan="3">–</td><td>385</td></tr>
<tr><td>1522/03#</td><td>370</td></tr>
<tr><td>1522/04#</td><td>355</td></tr>
<tr><td>1132/03#</td><td rowspan="2">91</td><td rowspan="2">75</td><td rowspan="2">47</td><td rowspan="2">75</td><td rowspan="4">52</td><td rowspan="2">45</td><td>670</td></tr>
<tr><td>1132/04#</td><td>635</td></tr>
<tr><td>1132/06#</td><td rowspan="2">101</td><td rowspan="2">81</td><td rowspan="2">52</td><td rowspan="2">88</td><td rowspan="2">57</td><td>960</td></tr>
<tr><td>1132/08#</td><td>670</td></tr>
<tr><td>1142/010#</td><td rowspan="2">131</td><td rowspan="2">104</td><td rowspan="2">76</td><td rowspan="2">168</td><td rowspan="2">104</td><td rowspan="2">104</td><td>3850</td></tr>
<tr><td>1142/012#</td><td>4000</td></tr>
</table>

With coil 9320 the dimension L_2 is equal to 65 mm and the weights must be increased of 500 g.

Connectors are not included in the boxes and have to be ordered separately