

## Miniature and Subminiature Solenoid Valves

Gems specializes in made-to-order fluidic systems, and a major segment of that activity includes the integration of miniature solenoid valves and manifold assemblies. Our miniature and subminiature solenoid valves are utilized in solutions that serve industries ranging from medical and biotech to automotive and industrial equipment.

Gems solenoid valves are designed to your specifications for each unique application. Each series offers a broad range of construction/performance options to build an endless array of configurations—too many to list in this catalog. From custom coils and manifolds to exotic materials and flow characteristics, there is very little that we cannot accomplish. Whether pneumatic or liquid, cryogenic or high temperature, vacuum or high-pressure, we partner with you to identify, create, and produce the best possible fluidic solution.

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### General Purpose Valves

A broad range of 2- and 3-way solenoid valves in both miniature and subminiature sizes. A wide selection of configuration options allows easy customization to match specific application requirements.



### Isolation Valves

Isolation diaphragms protect media and moving parts alike. Ideal for high-purity and aggressive media applications.



### Cryogenic Valves

These valves provide reliable service to media temperatures as low as -196°C (-320°F). Ideal for liquid Nitrogen and Carbon Dioxide use.



# 4 Steps to Valve Selection

The steps described in this section will help you identify the performance criteria needed to meet your application requirements and select the right valve.

## Step 1 – Calculating $K_v$

Begin by calculating the valve flow factor ( $K_v$ ) using: operating pressure differential; flow rate for your application; Density of Liquids; and in some circumstances, temperature. If you already know your  $K_v$  please go directly to Step 2.

Flow factor  $K_v$  combines the effects of all flow restrictions in the valve into a single number.  $K_v$  represents the flow of water with temperature ranging between 5°C and 30°C through a valve in cubic meters per hour with a pressure drop of 1 bar.  $K_v$  can also be calculated for gases.

## Temperature and $K_v$

Because gases are compressible, temperature (T) has a greater effect on volume and therefore is included as a separate variable in gas  $K_v$  calculations through your valve.

## Relationship between $K_v$ and $C_v$

$K_v$  is commonly referred to as the valve flow factor. It is the metric equivalent of  $C_v$ .

$$K_v = 0.853 C_v$$

## Liquid Flow

Because liquids are incompressible, their flow rate depends only on the difference between the inlet and outlet pressures ( $P_1 - P_2$  or  $\Delta P$ , pressure differential. Figure 1).

The  $K_v$  of any valve flowing liquid media can be determined with the equation shown below.

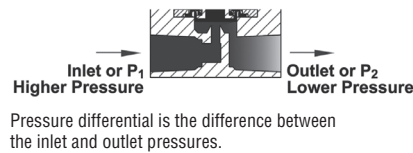
### Liquid Flow Formula

$$K_v = V \sqrt{\frac{\rho}{\Delta P}}$$

#### Where:

- $K_v$  = Valve flow factor
- $V$  = Volume flow rate in  $m^3/h$
- $\rho$  = Density of liquids in  $kg/m^3$  (water = 1)
- $P_1$  = Upstream pressure in bar
- $P_2$  = Downstream pressure in bar
- $\Delta P$  = Pressure differential (PSID)

Fig. 1: Pressure Differential



### Example: Using Water at 25°C:

- $V = 0.45 m^3/h$
- $\rho = 1$
- $P_1 = 8.01 \text{ ABS bar}$
- $P_2 = 3.2 \text{ ABS bar}$
- $\Delta P = 8.01 - 3.20 = 4.81 \text{ bar}$

$$K_v = 0.45 \sqrt{\frac{1}{4.81}} = .20$$

## Gas Flow

Since gases are compressible fluids, there are two separate equations for high and low-pressure differential flow.

### Gas Flow $K_v$ Formula

- Formula 1 – Low-pressure differential flow is when  $P_2 > \frac{P_1}{2}$  and the following equation is used:

$$K_v = \frac{V_g}{519} \sqrt{\frac{\rho_g T_1}{\Delta P P_2}}$$

- Formula 2 – High-pressure differential flow is when  $P_2 \leq \frac{P_1}{2}$  and the following equation is used:

$$K_v = \frac{V_g}{259.5 P_1} \sqrt{\rho_g T_1}$$

#### Where: $K_v$ = Valve Flow Factor

- $K_v$  = Valve flow factor
- $V_g$  = Flow rate of gases in  $m^3/h$
- $P_1$  = Upstream pressure in ABS bar
- $P_2$  = Downstream pressure in ABS bar
- $\rho_g$  = Density of gases at 0°C and 1013 mbar in  $Kg/m^3$
- $T_1$  = Temperature of gas in Degree Kelvin ( $^{\circ}C + 273$ )

### Example: Using Air:

- $V_g = 16.99 m^3/h$
- $P_1 = 2.39 \text{ ABS bar}$
- $P_2 = 1.01 \text{ ABS bar}$
- $\rho_g = 1.284 \text{ Kg/m}^3$
- $T_1 = 25^{\circ}C = 298^{\circ}K (25 + 273)$
- Because  $P_2 > \frac{P_1}{2}$  we will use Formula 1.

$$K_v = \frac{16.99}{519} \sqrt{\frac{1.284 (298)}{1.38 (1.01)}} = .54$$

# 4 Steps to Valve Selection

The steps described in this section will help you identify the performance criteria needed to meet your application requirements and select the right valve.

## Step 1 – Calculating C<sub>v</sub>

Begin by calculating the valve flow coefficient (C<sub>v</sub>) using: operating pressure differential; flow rate for your application; Specific Gravity; and in some circumstances, temperature. If you already know your C<sub>v</sub> please go directly to Step 2.

C<sub>v</sub> combines the effects of all flow restrictions in the valve into a single number. C<sub>v</sub> represents the quantity of water, at 68°F and in gallons per minute (GPM) that will flow through your valve with a 1psi pressure differential. C<sub>v</sub> can also be calculated for gases.

Specific Gravity (SG) for liquid is the ratio of the density, or specific weight of the liquid, relative to that of water. Similarly, the SG for gas is the ratio of the density, or specific weight of the gas, relative to that of air. The SG of your media is important in calculating C<sub>v</sub> because it directly correlates to the flow rate through your valve.

## Temperature and C<sub>v</sub>

Temperature is not included in the C<sub>v</sub> calculation for non-compressible fluids (liquids) and is only used in determining SG. Conversely, because gases are compressible, temperature (T) has a greater effect on volume and therefore is included as a separate variable in gas C<sub>v</sub> calculations through your valve.

## Relationship Between C<sub>v</sub> and K<sub>v</sub>

C<sub>v</sub> is commonly referred to as the flow coefficient and is the imperial equivalent of K<sub>v</sub>. C<sub>v</sub> is used primarily in the US.

$$C_v = 1.16 K_v$$

## Liquid Flow

Because liquids are incompressible, their flow rate depends only on the difference between the inlet and outlet pressures (P1 - P2 or ΔP, pressure differential. Figure 1).

The C<sub>v</sub> of any valve flowing liquid media can be determined with the equation shown to the right.

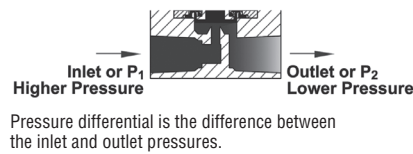
### Liquid Flow Formula

$$C_v = \frac{V}{\sqrt{\frac{\Delta P}{SG}}}$$

#### Where:

- C<sub>v</sub> = Valve flow coefficient
- V = Flow rate in GPM
- ΔP = Pressure differential (PSID)
- SG = Specific Gravity

Fig. 1: Press Differential



### Example: Using Water at 68°F:

- V = 3.08 GPM
- P1 = 100 PSI
- P2 = 40 PSI
- SG = 1

$$C_v = \frac{3.08}{\sqrt{\frac{100-40}{1}}} = .398$$

## Gas Flow

Since gases are compressible fluids there are two separate equations for high and low-pressure differential flow.

### Gas Flow C<sub>v</sub> Formula

- Low-pressure differential flow is when  $P_2 > \frac{P_1}{2}$  and the following equation is used:

$$C_v = \frac{V}{16.05 \sqrt{\frac{(P_1^2 - P_2^2)}{(SG) T}}}$$

- High-pressure differential flow is when  $P_2 \leq \frac{P_1}{2}$  and the following equation is used:

$$C_v = \frac{V}{13.61 P_1 \sqrt{\frac{1}{(SG) T}}}$$

#### Where:

- C<sub>v</sub> = Valve flow coefficient
- V = Flow rate in SCFM
- P1 = Inlet pressure in PSIA
- P2 = Outlet pressure in PSIA
- SG = Specific Gravity
- T = Temperature of gas in Degree Rankine (°F + 460)

16.05 and 13.61 are constants used in gas flow equations

### Example: Using Air:

- V = 10 SCFM
- P1 = 20 PSIG = 34.7 PSIA (20 + 14.7)
- P2 = 0 PSIG = 14.7 PSIA (0 + 14.7)
- SG = 1
- T = 72° F = 532° Rankine (72 + 460)

Since this is high-pressure differential flow (14.7 ≤ 34.7 / 2), we use the following equation:

$$C_v = \frac{10}{13.61 \cdot 34.7 \sqrt{\frac{1}{(1) 532}}} = .49$$

## Step 2 – Valve Function

Identify how your valve will function in your application. Pick from the choices below.

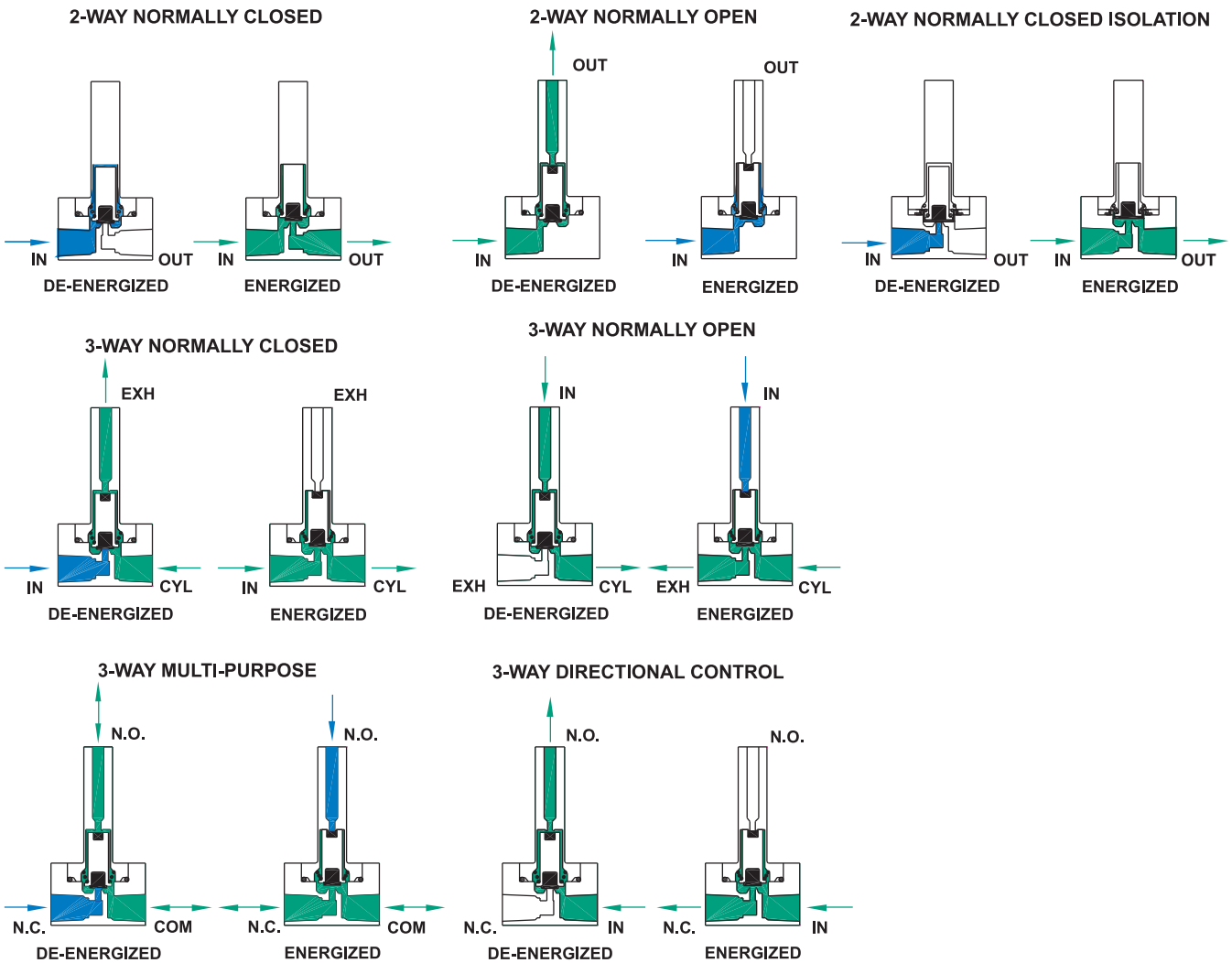
### An important note regarding $K_v$ and valve function:

The  $K_v$  calculated will apply to either the Body Orifice or the Stop Orifice depending on the valve's function.

For example, the Stop Orifice for a 3-way normally closed valve, when de-energized, is the exhaust port. In other words,  $K_v$  is calculated using the specific Inlet Pressure (P1) and Outlet Pressure (P2) for the flow paths described below.

#### Flow Key

- Blocked Flow
- Free Flow



### Step 3 – Identify Your Valve Series

Select possible valve series candidate using the overview charts below. Begin by choosing the category for your application:

- General Purpose
- Isolation
- Cryogenic

Using the charts, select maximum operating pressure differential (MOPD), the  $K_v$  function, and additional specifications needed for your application to select possible valve series. The detailed performance specs for each series are located on the corresponding pages listed on the chart.

General Purpose							
Function	2- & 3-Way						
Media	Gas Only	Gas & Liquid					
Size	Sub-Miniature			Miniature			
$K_v$ Range	0.015 - 0.060			0.016 - 0.367		0.038 - 0.751	
$C_v$ Range	0.018 - 0.070			0.019 - 0.430		0.045 - 0.880	
Port Configuration	#10-32 Manifold Mount	I.D. Tube Barb, Manifold or Face-Mount		#10-32, 1/8, 1/4 NPT, Manifold Mount		1/8, 1/4, 3/8 NPT, Manifold Mount	
Orifice Dia (mm)	0.762 - 1.981		0.781 - 1.321	0.813 - 3.962	1.575 - 5.334	1.194 - 9.525	
Orifice Dia (in)	0.030 - 0.078		0.031 - 0.052	0.032 - 0.156	0.062 - 0.210	0.047 - 0.375	
Power (watt)	0.65, 2		0.5, 1, 2	6	7	10	
MOPD (bar)	12	17	6.9	69	28	62	
MOPD (psi)	175	250	100	1000	400	900	
Valve Series	<b>E, EH</b>	<b>G, GH</b>	<b>M</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Pages	<b>J-9, J-10</b>	<b>J-12 – J-14</b>	<b>J-7, J-8</b>	<b>J-16 – J-18</b>	<b>J-20 – J-22</b>	<b>J-24 – J-26</b>	<b>J-28, J-30</b>

Isolation				Cryogenic				
Function	2-Way, Normally Closed Only							
Media	Gas & Liquid			Liquid				
Size	Sub-Miniature		Miniature		Miniature			
$K_v$ Range	0.014 - 0.034		0.017 - 0.256		0.038 - 0.375		0.034 - 0.657	
$C_v$ Range	0.016 - 0.040		0.020 - 0.300		0.045 - 0.440		0.040 - 0.770	
Port Configuration	1/8 Barb, Face-Mount, #10-32 Threaded Flat Bottom		#10-32, 1/8 NPT, 1/4 NPT, Manifold Mount		1/8, 1/4 NPT		1/8, 1/4, 3/8 NPT	
Orifice Dia (mm)	0.787 & 1.321		0.813 - 3.962		1.168 - 4.775		1.168 - 6.350	
Orifice Dia (in)	0.031 & 0.052		0.032 - 0.156		0.046 - 0.188		0.046 - 0.250	
Power (watt)	2		7		9		15	
MOPD (bar)	5.2		10		62		69	
MOPD (psi)	75		150		900		1000*	
Valve Series	<b>Chem-S™</b>		<b>AS</b>	<b>BS</b>		<b>B-Cryo</b>	<b>D-Cryo</b>	
Pages	<b>J-31, J-32</b>		<b>J-33, J-34</b>	<b>J-35, J-36</b>		<b>J-37, J-38</b>	<b>J-39, J-40</b>	

\*Consult factory for higher MOPD.

### Step 4 – Make Your Selection and Configure Your Valve

Complete your valve design by selecting the additional design parameters to build the best possible valve. For example:

- Materials needed for your media (stainless steel, brass, fluoroelastomer, EPDM, etc.)
- Coil construction (lead wire, quick connect spade, grommet, conduit, yoke, etc.)
- Port configuration
- Manifold assembly
- Voltage

We specialize in application specific valves. Our modular valve designs, coupled with our cutting edge 3D modeling and innovative CNC manufacturing capabilities, result in fluidic systems that are truly adaptable to any originally manufactured equipment.