Common Specifications/Selection Steps

Standard Specifications

Valve specifications	Valve construction		Zero differential pressure type pilot operated piston type
	Withstand pressure (with water pressure)		2.0 MPa
	Body material		C37 (Brass), Stainless steel
	Seal material		FKM
	Enclosure		Dust-tight, Water-jet-proof type (IP65) Note 2)
	Environment		Location without corrosive or explosive gases
Coil specifications	Rated voltage	AC	100 VAC, 200 VAC, 110 VAC, 230 VAC, (220 VAC, 240 VAC, 48 VAC, 24 VAC) Note 1)
		DC	24 VDC
	Allowable voltage fluctuation		±10% of rated voltage
	Allowable leakage voltage	AC (Built-in full-wave rectifier type)	5% or less of rated voltage
		DC	2% or less of rated voltage
	Coil insulation type		Class H

Note 1) Voltage in ( ) indicates special voltage. (Refer to page 221.)
Note 2) For enclosure, refer to “Glossary of Terms” on page 226. When using the product in a place which requires water resistance, please contact SMC.

⚠ **Be sure to read “Specific Product Precautions” before handling.**

⚠ **When pressure differential is less than 0.01 MPa, operation may become unstable. Please contact SMC in case of low flow operation. (Refer to page 223.)**

Solenoid Coil Specifications

Normally Closed (N.C.)

DC Specification

Model	Power consumption (W) Note 1)	Temperature rise (°C) Note 2)
VXS23/24	12	100
VXS25/26	15	100

Note 1) The value at ambient temperature of 20°C and when the rated voltage is applied. (Variation: ±10%)
Note 2) The value at ambient temperature of 20°C and when the rated voltage is applied. The value depends on the ambient environment. This is for reference.

AC Specification (Built-in Full-wave Rectifier Type)

Model	Apparent power (VA) Note 1) 2)	Temperature rise (°C) Note 3)
VXS23/24	12	100
VXS25/26	15	100

Note 1) The value at ambient temperature of 20°C and when the rated voltage is applied. (Variation: ±10%)
Note 2) There is no difference in the frequency and the inrush and energized apparent power, since a rectifying circuit is used in the AC (Built-in full-wave rectifier type).
Note 3) The value at ambient temperature of 20°C and when the rated voltage is applied. The value depends on the ambient environment. This is for reference.

Selection Steps

Step 1 Select the fluid.

Item	Selection item	Page	Symbol
Select the fluid.	Steam (* Can be used with heated water.)	219	5 ❶

VXS2 3 **5** A B (❶)

Step 2 Select “Body material”, “Port size” and “Orifice diameter” from “Flow rate — Pressure” of each fluid.

Item	Selection item		Symbol
Select from “Flow rate — Pressure.” • Body material • Port size • Orifice diameter	Size, Valve	Size 3	3 ❷
	Body material	C37	A ❸
	Port size	1/4	
	Orifice diameter	10	

VXS2 **3** 5 **A** B (❷ ❸)

Step 3 Select electrical specification.

Item	Selection item		Symbol
Select electrical specification.	Voltage	100 VAC	A ❹
	Electrical entry	Grommet	

VXS2 3 5 A **B** (❹)

Step 4 For other special options, refer to page 221.

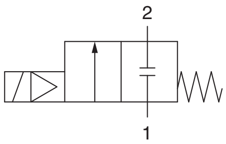
For Steam

∗ Can be used with heated water.

Model/Valve Specifications

N.C.

Symbol



When the valve is closed, flow is blocked from port 1 to port 2. However, if the pressure in port 2 is higher than port 1, the valve will not be able to block the fluid and it will flow from port 2 to port 1.

Normally Closed (N.C.)

Body material	Size	Port size (Nominal diameter)	Orifice diameter (mmø)	Model	Min. operating pressure differential Note 1) (MPa)	Max. operating pressure differential Note 3) (MPa)		Flow rate characteristics		Max. system pressure Note 3) (MPa)	Weight Note 2) (g)
						AC	DC	Kv	Cv		
C37, Stainless steel	**3**	1/4 (8A)	10	**VXS235**	0	1.0		2.1	2.4	1.0	600
		3/8 (10A)						2.4	2.8		
	4	1/2 (15A)	15	**VXS245**				4.6	5.3		720
	5	3/4 (20A)	20	**VXS255**				7.9	9.2		1100
	6	1 (25A)	25	**VXS265**				10.4	12.0		1300

Note 1) The operation of the valve may be unstable due to the capacity of the pressure supply source such as pumps and boilers or the pressure loss by the orifice of piping. Please contact SMC to check if the required valve size can be used in the application. Please contact SMC for the compatibility of the circuit flow and valve size. (Refer to page 223.)
Note 2) Weight of grommet type. Add 10 g for conduit, 30 g for DIN terminal, and 60 g for conduit terminal type respectively.
Note 3) Refer to "Glossary of Terms" on page 226 for details on the maximum operating pressure differential and the maximum system pressure.

Fluid and Ambient Temperature

Fluid	Temperature (°C)	Ambient temperature (°C)
Steam	183 or less	–20 to 60
Heated water	99 or less	

Note) With no freezing

Valve Leakage Rate

Internal Leakage

Fluid	Seal material	Leakage rate Note 1) 2)
Steam	FKM	1 cm^3/min or less Note 3)
Heated water		0.1 cm^3/min or less

Note 1) Leakage is the value at ambient temperature 20°C.
Note 2) Leakage is the value when the pressure differential ranges from 0.02 MPa to the maximum operating pressure differential.
Note 3) With air

External Leakage

Fluid	Seal material	Leakage rate Note 1)
Steam	FKM	1 cm^3/min or less
Heated water		0.1 cm^3/min or less

Note 1) Leakage is the value at ambient temperature 20°C.

CE RoHS

How to Order

VXS2 [3] 5 [A] [B]

Fluid

5	For Steam

Common Specifications

Seal material	FKM
Coil insulation type	Class H
Thread type	Rc

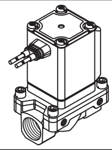
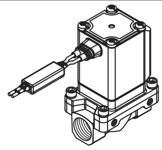
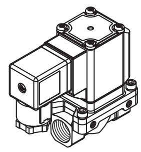
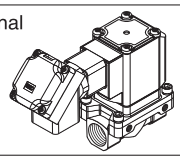
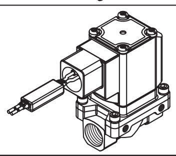
Size/Valve type

Symbol	Size	Valve type
3	10A	N.C.
4	15A	N.C.
5	20A	N.C.
6	25A	N.C.

Body material/Port size/Orifice diameter

Symbol	Body material	Port size	Orifice diameter
A	C37	1/4	10
B		3/8	
C	Stainless steel	1/4	
D		3/8	
F	C37	1/2	15
G	Stainless steel		
H	C37	3/4	20
J	Stainless steel		
K	C37	1	25
L	Stainless steel		

Voltage/Electrical entry

Symbol	Voltage	Electrical entry
A	24 VDC	Grommet 
B	100 VAC	Grommet (With surge voltage suppressor) 
C	110 VAC	
D	200 VAC	
E	230 VAC	
G	24 VDC	DIN terminal (With surge voltage suppressor Note)) 
H	100 VAC	
J	110 VAC	
K	200 VAC	
L	230 VAC	
N	100 VAC	Conduit terminal (With surge voltage suppressor) 
P	110 VAC	
Q	200 VAC	
R	230 VAC	
T	100 VAC	Conduit (With surge voltage suppressor) 
U	110 VAC	
V	200 VAC	
W	230 VAC	
Z	Other voltages	

Note) For the class H type DIN terminal, use it in combination with the connector provided.

For other special options, refer to page 221.

Special voltage	24 VAC
	48 VAC
	220 VAC
	240 VAC
DIN terminal with light	
Conduit terminal with light	
Oil-free	
G thread	
NPT thread	
With bracket	
Special electrical entry direction	

Other Special Options

VX2
VXK
VXD
VXZ
VXS
VXB
VXE
VXP
VXR
VXH
VXF
VX3
VXA

Electrical options (Special voltage, With light)

VXS2 [3][5][A] Z [1A]

- Enter standard product number. (3, 5, A)
- Electrical option (Z)
- Special voltage/Electrical entry/Electrical option (1A)

Special voltage/Electrical entry/Electrical option

Specification	Symbol	Voltage	Electrical entry
Special voltage	**1A**	48 VAC	Grommet (With surge voltage suppressor)
	1B	220 VAC	
	1C	240 VAC	
	1U	24 VAC	
	1F	48 VAC	DIN terminal (With surge voltage suppressor)
	1G	220 VAC	
	1H	240 VAC	
	1V	24 VAC	
	1K	48 VAC	Conduit terminal (With surge voltage suppressor)
	1L	220 VAC	
	1M	240 VAC	
	1W	24 VAC	
	1P	48 VAC	Conduit (With surge voltage suppressor)
	1Q	220 VAC	
	1R	240 VAC	
	1Y	24 VAC	
With light	**2A**	24 VDC	DIN terminal (With surge voltage suppressor)
	2B	100 VAC	
	2C	110 VAC	
	2D	200 VAC	
	2E	230 VAC	
	2F	48 VAC	
	2G	220 VAC	
	2H	240 VAC	
	2V	24 VAC	
	2L	100 VAC	Conduit terminal (With surge voltage suppressor)
	2M	110 VAC	
	2N	200 VAC	
	2P	230 VAC	
	2Q	48 VAC	
	2R	220 VAC	
	2S	240 VAC	
	2W	24 VAC	

Other options (Oil-free, Port thread)

VXS2 [3][5][A][A][Z]

- Enter standard product number. (3, 5, A, A)
- Other option (Z)

Other option
Oil-free/Port thread

Symbol	Oil-free	Port thread
Nil	—	Rc
A	—	G
B		NPT
D	○	G
E		NPT
Z	○	Rc

∗ Enter symbols in the order below when ordering a combination of electrical option, other option, etc.

Example) **VXS2 [3][5][A] Z [1A][Z][XB][A]**

- Electrical option (Z 1A)
- Other option (Z)
- Special electrical entry direction (A)
- With bracket (XB)

Installation options
(Mounting option/Special electrical entry direction)

The following shows combinations that can be selected using installation options.

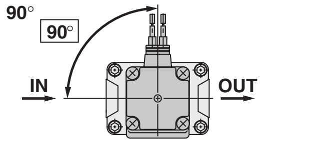
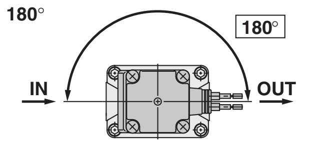
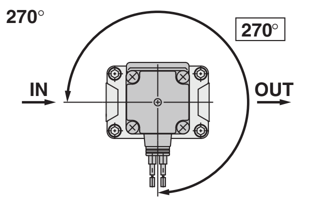
Combinations

Symbol	Special electrical entry direction	With bracket
XC□	●	
XB□	●	●

Special Electrical Entry Direction

VXS2 □□□□ XC A

Enter standard product number.

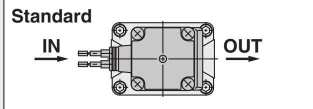
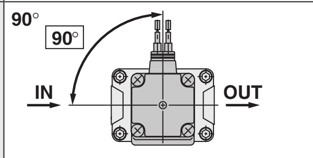
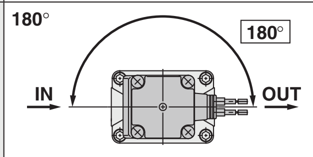
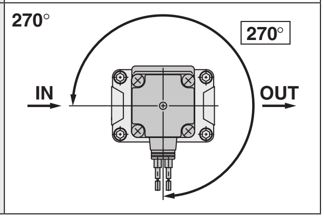
Symbol	Rotation angle
A	90° 
B	180° 
C	270° 

*1 Available for the VXS23 to 26.
*2 Bracket is packed in the same container as the main body.

With Bracket/ Special Electrical Entry Direction

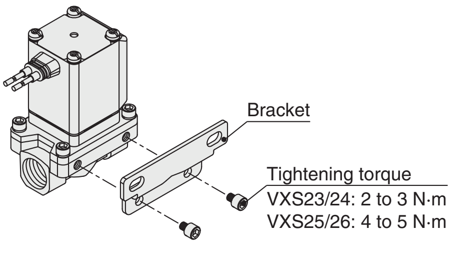
VXS2 □□□□ XB A

Enter standard product number.

Symbol	Rotation angle
Nil	Standard 
A	90° 
B	180° 
C	270° 

*1 Available for the VXS23 to 26.
*2 Bracket is packed in the same container as the main body.

How to mount a bracket



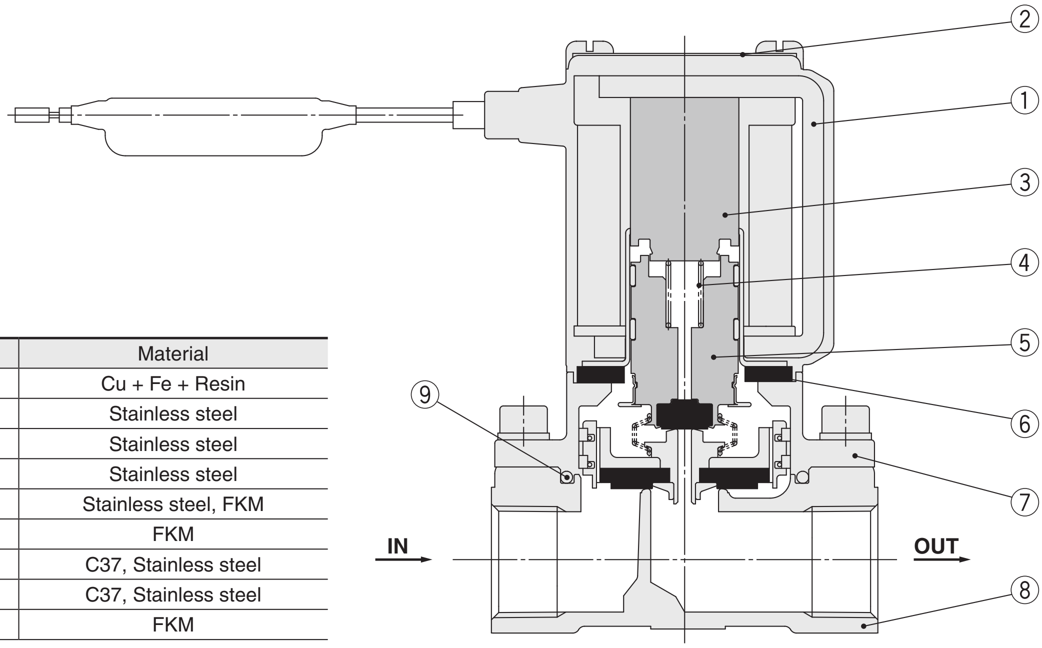
* Enter symbols in the order below when ordering a combination of electrical option, other option, etc.

Example) **VXS2 3 5 A Z 1A Z XB A**

- Electrical option (1A)
- Other option (Z)
- Special electrical entry direction (A)
- With bracket (XB)

Construction/Normally Closed (N.C.)

Body material: C37, Stainless steel



Component Parts

No.	Description	Material
1	**Solenoid coil**	Cu + Fe + Resin
2	**Coil cover**	Stainless steel
3	**Tube assembly**	Stainless steel
4	**Return spring**	Stainless steel
5	**Armature/Piston assembly**	Stainless steel, FKM
6	**Stopper**	FKM
7	**Bonnet**	C37, Stainless steel
8	**Body**	C37, Stainless steel
9	**O-ring**	FKM

Working Principle

De-energized

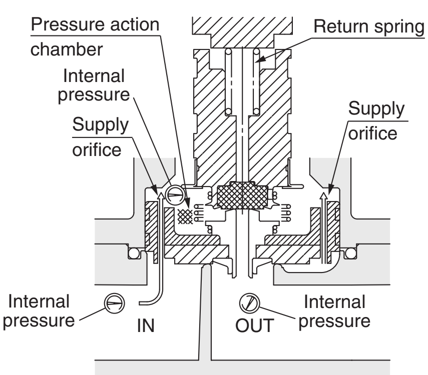
The fluid enters from the IN goes through the supply orifice to fill the pressure action chamber. Main valve is closed by the pressure in the pressure action chamber and the reaction force of the return spring.

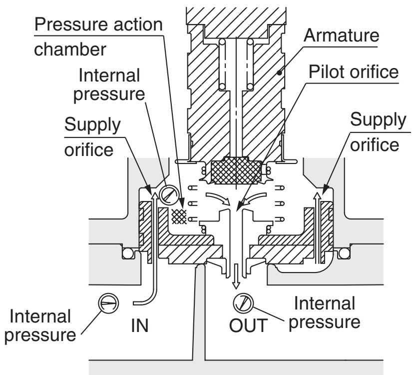
Energized (Pilot valve open)

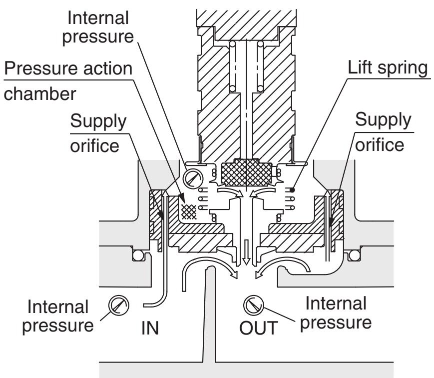
When the coil is energized, the armature is attracted causing the pilot orifice to opening. The fluid filling the pressure action chamber flows to the OUT side through the pilot orifice.

Energized (Main valve open)

The pressure in the pressure action chamber decreases by discharging fluid through the pilot orifice. Because the force which pushes down the valve is reduced by the discharge of the fluid, the force that pushes up the main valve overcomes the push down force and opens the main valve. The main valve opens by the lift spring reaction force even if pressure on the IN side is 0 MPa or very low pressure.





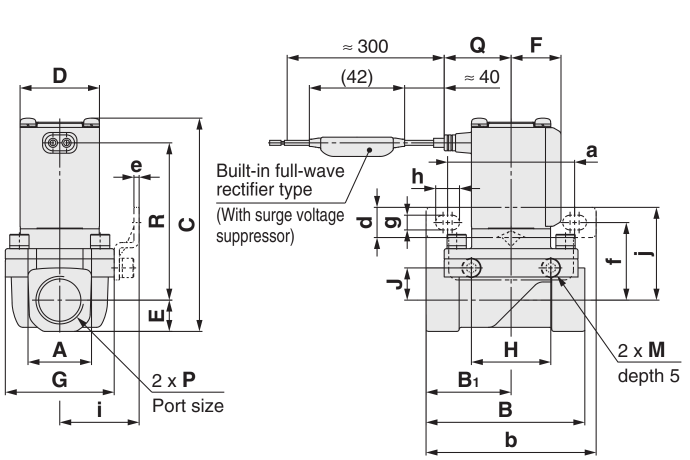


⚠Warning

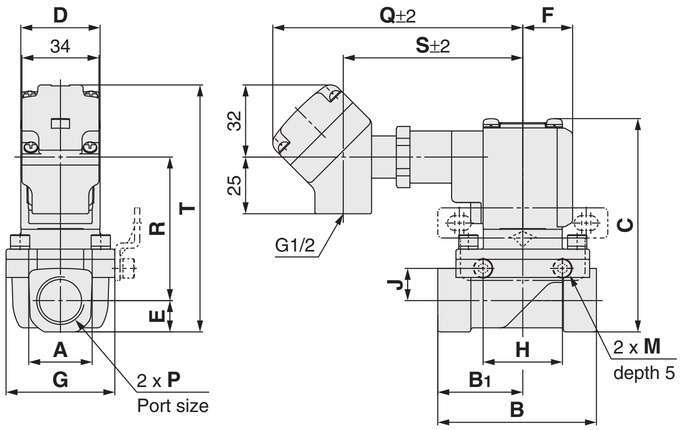
Unstable flow may occur with the product under the following conditions: • low flow from the pump or boiler, etc. • use of several elbows or tees in the circuit, or • thin nozzles installed at the end of the piping etc. This can cause valve opening/closing failure, or oscillation, and cause a valve malfunction. If products are used with vacuum, then the vacuum level can be unstable due to these conditions. Please contact SMC to check if the valve can be used in the application by providing the relevant fluid circuit.

Dimensions/Body Material: C37, Stainless Steel

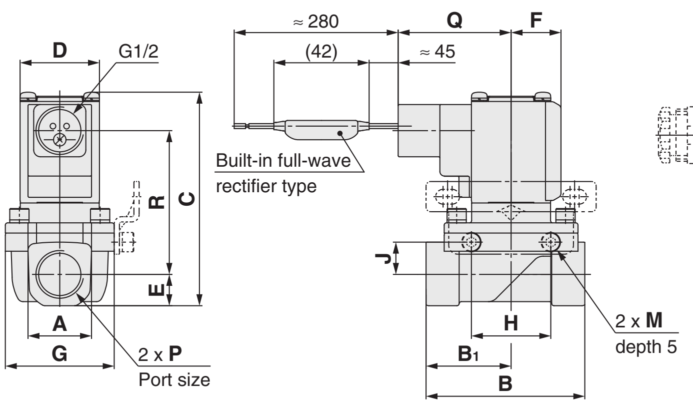
Grommet



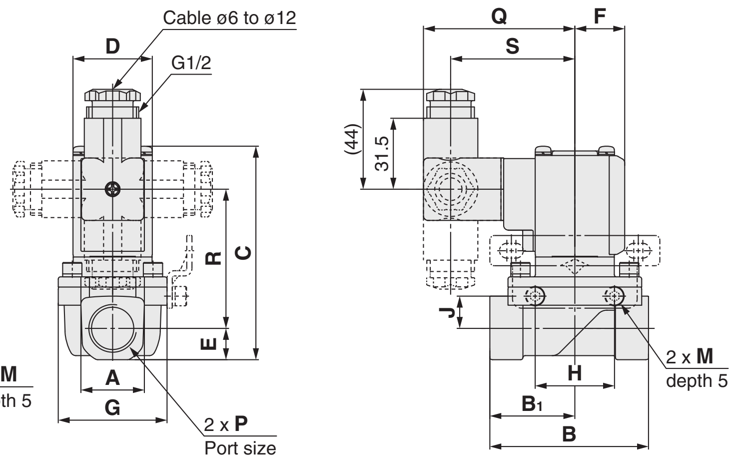
Conduit terminal

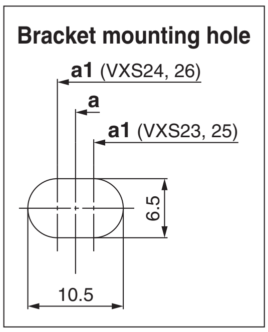


Conduit



DIN terminal





Dimensions

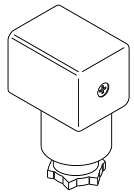
(mm)

Model	Port size P	A	B	B1	C	D	E	F	G	H	J	M	Bracket mounting a	b	d	e	f	g	h	i	j
VXS23	1/4, 3/8	21	57	28.5	87.5	35	10.5	22	40	35	10	M5	56	75	13.5	2.3	30	6.5	10.5	31	37
VXS24	1/2	28	70	37.5	94	35	14	22	48	35	14	M5	56	75		2.3	34	6.5	10.5	35	41
VXS25	3/4	33.5	71	38.5	105.5	40	17	24.5	62	33	15.2	M6	70.5	92		2.3	39	6.5	10.5	43	46
VXS26	1	42	95	49.5	111.5	40	20	24.5	66	37	17.2	M6	70.5	92		2.3	41	6.5	10.5	45	48

Model	Port size P	Electrical entry: Grommet Q	Grommet R	DIN terminal Q	DIN terminal R	DIN terminal S	Conduit terminal Q	Conduit terminal R	Conduit terminal S	Conduit terminal T	Conduit Q	Conduit R
VXS23	1/4, 3/8	29.5	66	67	58	55	110.5	60	79.5	102.5	50	60
VXS24	1/2	29.5	69.5	67	61.5	55	110.5	63.5	79.5	109	50	63.5
VXS25	3/4	32	78	69.5	70	57.5	113	72	82	120.5	52.5	72
VXS26	1	32	81	69.5	72.5	57.5	113	74.5	82	126.5	52.5	74.5

Replacement Parts

● DIN Connector Part No.



<Coil Insulation Type/Class H>

Electrical option	Rated voltage	Connector part no.
None	24 VDC	**GDM2A-G-S5**
	100 VAC	**GDM2A-R**
	110 VAC	
	200 VAC	
	220 VAC	
	230 VAC	
	240 VAC	
	24 VAC	
	48 VAC	
With light	24 VDC	**GDM2A-G-Z5**
	100 VAC	**GDM2A-R-L1**
	110 VAC	**GDM2A-R-L1**
	200 VAC	**GDM2A-R-L2**
	220 VAC	**GDM2A-R-L2**
	230 VAC	**GDM2A-R-L2**
	240 VAC	**GDM2A-R-L2**
	24 VAC	**GDM2A-R-L5**
	48 VAC	**GDM2A-R-L5**

● Gasket Part No. for DIN Connector

VCW20-1-29-1-F

● Bracket Assembly Part No.

VXZ [3] 0S−14A−1

3	VXS2$^{3}_{4}$5□
5	VXS2$^{5}_{6}$5□

∗ 2 mounting screws are shipped together with the bracket assembly.

Glossary of Terms

Pressure Terminology

1. Maximum operating pressure differential

The maximum pressure differential (the difference between the inlet and outlet pressure) which is allowed for operation. When the outlet pressure is 0 MPa, this becomes the maximum operating pressure.

2. Minimum operating pressure differential

The minimum pressure differential (the difference between the inlet pressure and outlet pressure) required to keep the main valve fully open.

3. Maximum system pressure

The maximum pressure that can be applied inside the pipelines (line pressure).
[The pressure differential of the solenoid valve portion must be less than the maximum operating pressure differential.]

4. Withstand pressure

The pressure in which the valve must be withstood without a drop in performance after holding for one minute under prescribed pressure (static pressure) and returning to the operating pressure range. [value under the prescribed conditions]

Electrical Terminology

1. Apparent power (VA)

Volt-ampere is the product of voltage (V) and current (A).
Power consumption (W): For AC, W = V·A·cosθ. For DC, W = V·A.
Note) cosθ shows power factor. cosθ ≈ 0.9

2. Surge voltage

A high voltage which is momentarily generated by shutting off the power in the shut-off area.

3. Degree of protection

A degree defined in the "JIS C 0920: Waterproof test of electric machinery/appliance and the degree of protection against the intrusion of solid foreign objects."

Verify the degree of protection for each product.

IP – □ □

First characteristic numeral — Second characteristic numeral

● **First Characteristics: Degrees of protection against solid foreign objects**

0	Non-protected
1	Protected against solid foreign objects of 50 mmø and greater
2	Protected against solid foreign objects of 12 mmø and greater
3	Protected against solid foreign objects of 2.5 mmø and greater
4	Protected against solid foreign objects of 1.0 mmø and greater
5	Dust-protected
6	Dust-tight

● **Second Characteristics: Degrees of protection against water**

0	Non-protected	—
1	Protected against vertically falling water drops	Dripproof type 1
2	Protected against vertically falling water drops when enclosure tilted up to 15°	Dripproof type 2
3	Protected against rainfall when enclosure tilted up to 60°	Rainproof type
4	Protected against splashing water	Splashproof type
5	Protected against water jets	Water-jet-proof type
6	Protected against powerful water jets	Powerful water-jet-proof type
7	Protected against the effects of temporary immersion in water	Immersible type
8	Protected against the effects of continuous immersion in water	Submersible type

Example) IP65: Dust-tight, Water-jet-proof type

"Water-jet-proof type" means that no water intrudes inside an equipment that could hinder from operating normally by means of applying water for 3 minutes in the prescribed manner. Take appropriate protection measures, since a device is not usable in an environment where a droplet of water is splashed constantly.

Others

1. Material

FKM: Fluororubber

2. Oil-free treatment

The degreasing and washing of wetted parts

3. Symbol

When the valve is closed, flow is blocked from port 1 to port 2. However, if the pressure in port 2 is higher than port 1, the valve will not be able to block the fluid and it will flow from port 2 to port 1.

VXS Series
Solenoid Valve Flow Rate Characteristics
(How to indicate flow rate characteristics)

1. Indication of flow rate characteristics

The flow rate characteristics in equipment such as a solenoid valve, etc. are indicated in their specifications as shown in Table (1).

Table (1) Indication of Flow Rate Characteristics

Corresponding equipment	Indication by international standard	Other indications	Conformed standard
Pneumatic equipment	*C*, *b*	—	ISO 6358: 1989 JIS B 8390: 2000
	—	*S*	JIS B 8390: 2000 Equipment: JIS B 8379, 8381-1, 8381-2
		Cv	ANSI/(NFPA)T3.21.3 R1-2008
Process fluid control equipment	*Kv*	—	IEC60534-1: 2005 IEC60534-2-3: 1997 JIS B 2005-1: 2012 JIS B 2005-2-3: 2004 Equipment: JIS B 8471, 8472, 8473
	—	*Cv*	

2. Pneumatic equipment

2.1 Indication according to the international standards

(1) Conformed standard

ISO 6358: 1989 : Pneumatic fluid power—Components using compressible fluids— Determination of flow rate characteristics

JIS B 8390: 2000 : Pneumatic fluid power—Components using compressible fluids— How to test flow rate characteristics

(2) Definition of flow rate characteristics

The flow rate characteristics are indicated as a result of a comparison between sonic conductance ***C*** and critical pressure ratio ***b***.

Sonic conductance ***C*** : Value which divides the passing mass flow rate of an equipment in a choked flow condition by the product of the upstream absolute pressure and the density in a standard condition.

Critical pressure ratio ***b*** : Pressure ratio (downstream pressure/upstream pressure) which will turn to a choked flow when the value is smaller than this ratio.

Choked flow : The flow in which the upstream pressure is higher than the downstream pressure and where sonic speed in a certain part of an equipment is reached.
Gaseous mass flow rate is in proportion to the upstream pressure and not dependent on the downstream pressure.

Subsonic flow : Flow greater than the critical pressure ratio

Standard condition : Air in a temperature state of 20°C, absolute pressure 0.1 MPa (= 100 kPa = 1 bar), relative humidity 65%.
It is stipulated by adding the "(ANR)" after the unit depicting air volume.
(standard reference atmosphere)
Conformed standard: ISO 8778: 1990 Pneumatic fluid power—Standard reference atmosphere, JIS B 8393: 2000: Pneumatic fluid power—Standard reference atmosphere

(3) Formula for flow rate

It is described by the practical units as following.

When

$$\frac{P_2 + 0.1}{P_1 + 0.1} \leq b, \text{ choked flow}$$

$$Q = 600 \times C\,(P_1 + 0.1)\sqrt{\frac{293}{273 + T}} \quad \cdots\cdots (1)$$

When

$$\frac{P_2 + 0.1}{P_1 + 0.1} > b, \text{ subsonic flow}$$

$$Q = 600 \times C\,(P_1 + 0.1)\sqrt{1 - \left[\frac{\frac{P_2 + 0.1}{P_1 + 0.1} - b}{1 - b}\right]^2}\sqrt{\frac{293}{273 + T}} \quad \cdots\cdots (2)$$

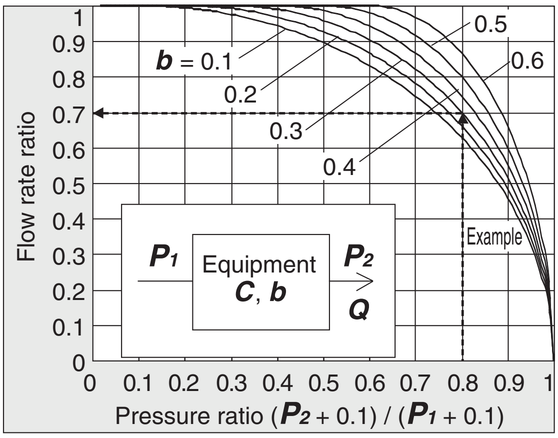
Q : Air flow rate [L/min (ANR)]
C : Sonic conductance [$dm^3/(s \cdot bar)$], dm^3 (Cubic decimeter) of SI = L (liter).
b : Critical pressure ratio [—]
P_1 : Upstream pressure [MPa]
P_2 : Downstream pressure [MPa]
T : Temperature [°C]
Note) Formula of subsonic flow is the elliptic analogous curve.
Flow rate characteristics are shown in Graph (1) For details, please use the calculation software available from SMC website.

Example)
Obtain the air flow rate for $P_1 = 0.4$ [MPa], $P_2 = 0.3$ [MPa], $T = 20$ [°C] when a solenoid valve is performed in $C = 2$ [$dm^3/(s \cdot bar)$] and $b = 0.3$.

According to formula 1, the maximum flow rate $= 600 \times 2 \times (0.4 + 0.1) \times \sqrt{\frac{293}{273 + 20}} = 600$ [L/min (ANR)]

Pressure ratio $= \frac{0.3 + 0.1}{0.4 + 0.1} = 0.8$

Based on Graph (1), it is going to be 0.7 if it is read by the pressure ratio as 0.8 and the flow ratio to be $b = 0.3$.
Hence, flow rate = Max. flow x flow ratio = 600 x 0.7 = 420 [L/min (ANR)]



Graph (1) Flow rate characteristics

(4) Test method

Attach a test equipment with the test circuit shown in Fig. (1) while maintaining the upstream pressure to a certain level which does not go below 0.3 MPa. Next, measure the maximum flow to be saturated in the first place, then measure this flow rate at 80%, 60%, 40%, 20% and the upstream and downstream pressure. And then, obtain the sonic conductance ***C*** from this maximum flow rate. In addition, calculate ***b*** using each data of others and the subsonic flow formula, and then obtain the critical pressure ratio ***b*** from that average.

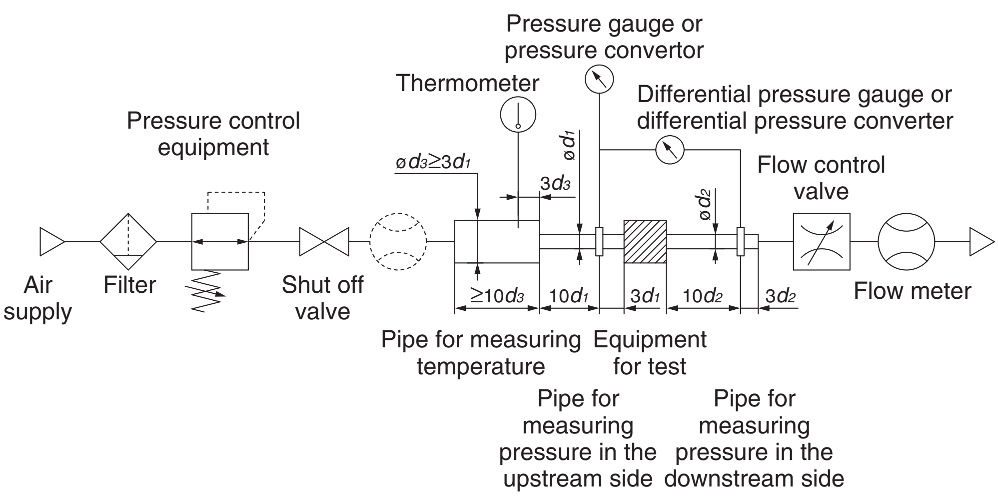


Fig. (1) Test circuit based on ISO 6358: 1989, JIS B 8390: 2000

2.2 Effective area *S*

(1) Conformed standard

JIS B 8390: 2000: Pneumatic fluid power—Components using compressible fluids—Determination of flow rate characteristics

Equipment standards: JIS B 8373: Solenoid valve for pneumatics
JIS B 8379: Silencer for pneumatics
JIS B 8381-1: Fittings for pneumatics—Part 1: Push-in fittings for thermoplastic resin tubing
JIS B 8381-2: Fittings for pneumatics—Part 2: Compression fittings for thermoplastic resin tubing

(2) Definition of flow rate characteristics

Effective area ***S***: The cross-sectional area having an ideal throttle without friction deduced from the calculation of the pressure changes inside an air tank or without reduced flow when discharging the compressed air in a choked flow, from an equipment attached to the air tank. This is the same concept representing the “easy to run through” as sonic conductance ***C***.

(3) Formula for flow rate

When

$\frac{P_2 + 0.1}{P_1 + 0.1}$ 0.5, **choked flow**

$$Q = 120 \times S\,(P_1 + 0.1)\sqrt{\frac{293}{273 + T}} \quad \cdots\cdots(3)$$

When

$\frac{P_2 + 0.1}{P_1 + 0.1} > 0.5$, **subsonic flow**

$$Q = 240 \times S\,\sqrt{(P_2 + 0.1)\,(P_1 - P_2)}\sqrt{\frac{293}{273 + T}} \quad \cdots\cdots(4)$$

Conversion with sonic conductance ***C***:

$$S = 5.0 \times C \quad \cdots\cdots(5)$$

Q : Air flow rate[L/min(ANR)]
S : Effective area [mm^2]
P_1 : Upstream pressure [MPa]
P_2 : Downstream pressure [MPa]
T : Temperature [°C]

Note) Formula for subsonic flow (4) is only applicable when the critical pressure ratio ***b*** is the unknown equipment. In the formula (2) by the sonic conductance ***C***, it is the same formula as when ***b*** = 0.5.

(4) Test method

Attach a test equipment with the test circuit shown in Fig. (2) in order to discharge air into the atmosphere until the pressure inside the air tank goes down to 0.25 MPa (0.2 MPa) from an air tank filled with the compressed air at a certain pressure level (0.5 MPa) which does not go below 0.6 MPa. At this time, measure the discharging time and the residual pressure inside the air tank which had been left until it turned to be the normal values to determine the effective area ***S***, using the following formula. The volume of an air tank should be selected within the specified range by corresponding to the effective area of an equipment for test. In the case of JIS B 8379, the pressure values are in parentheses and the coefficient of the formula is 12.9.

$$S = 12.1\,\frac{V}{t}\,\log_{10}\left(\frac{P_s + 0.1}{P + 0.1}\right)\sqrt{\frac{293}{T}} \quad \cdots\cdots(6)$$

S : Effective area [mm^2]
V : Air tank capacity [L]
t : Discharging time [s]
P_s : Pressure inside air tank before discharging [MPa]
P : Residual pressure inside air tank after discharging [MPa]
T : Temperature inside air tank before discharging [K]

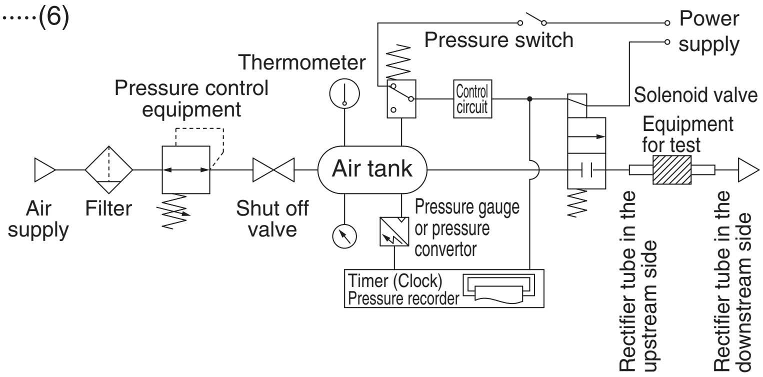


Fig. (2) Test circuit based on JIS B 8390: 2000

2.3 Flow coefficient *Cv* factor

The United States Standard ANSI/(NFPA)T3.21.3: R1-2008R: Pneumatic fluid power—Flow rating test procedure and reporting method for fixed orifice components

This standard defines the ***Cv*** factor of the flow coefficient by the following formula that is based on the test conducted by the test circuit analogous to ISO 6358.

$$Cv = \frac{Q}{114.5\sqrt{\dfrac{\Delta P\,(P_2 + P_a)}{T_1}}} \quad \cdots\cdots (7)$$

ΔP : Pressure drop between the static pressure tapping ports [bar]
P_1 : Pressure of the upstream tapping port [bar gauge]
P_2 : Pressure of the downstream tapping port [bar gauge]: $P_2 = P_1 - \Delta P$
Q : Flow rate [L/s standard condition]
P_a : Atmospheric pressure [bar absolute]
T_1 : Upstream absolute temperature [K]

Test conditions are < $P_1 + P_a = 6.5 \pm 0.2$ bar absolute, $T_1 = 297 \pm 5$K, 0.07 bar $\leq \Delta P$ 0.14 bar.

This is the same concept as effective area ***A*** which ISO 6358 stipulates as being applicable only when the pressure drop is smaller than the upstream pressure and the compression of air does not become a problem.

3. Process fluid control equipment

(1) Conformed standard

IEC60534-1: 2005: Industrial-process control valves. Part 1: control valve terminology and general considerations
IEC60534-2-3: 1997: Industrial-process control valves. Part 2: Flow capacity, Section Three-Test procedures
JIS B 2005-1: 2012: Industrial-process control valves – Part 1: Control valve terminology and general considerations
JIS B 2005-2-3: 2004: Industrial-process control valves – Part 2: Flow capacity – Section 3: Test procedures
Equipment standards: JIS B 8471: Solenoid valve for water
JIS B 8472: Solenoid valve for steam
JIS B 8473: Solenoid valve for fuel oil

(2) Definition of flow rate characteristics

Kv factor: Value of the clean water flow rate represented by m^3/h that runs through the valve (equipment for test) at 5 to 40°C, when the pressure difference is 1 x 105 Pa (1 bar). It is calculated using the following formula:

$$Kv = Q\sqrt{\frac{1 \times 10^5}{\Delta P} \cdot \frac{\rho}{1000}} \quad \cdots\cdots (8)$$

Kv : Flow coefficient [m^3/h]
Q : Flow rate [m^3/h]
ΔP : Pressure difference [Pa]
ρ : Density of fluid [kg/m^3]

(3) Formula of flow rate

It is described by the practical units. Also, the flow rate characteristics are shown in Graph (2).

In the case of liquid:

$$Q = 53Kv\sqrt{\frac{\Delta P}{G}} \quad \cdots\cdots (9)$$

Q : Flow rate [L/min]
Kv : Flow coefficient [m^3/h]
ΔP : Pressure difference [MPa]
G : Relative density [water = 1]

In the case of saturated aqueous vapor:

$$Q = 232Kv\sqrt{\Delta P(P_2 + 0.1)} \quad \cdots\cdots (10)$$

Q : Flow rate [kg/h]
Kv : Flow coefficient [m^3/h]
ΔP : Pressure difference [MPa]
P_1 : Upstream pressure [MPa]: $\Delta P = P_1 - P_2$
P_2 : Downstream pressure [MPa]

VX2
VXK
VXD
VXZ
VXS
VXB
VXE
VXP
VXR
VXH
VXF
VX3
VXA

Conversion of flow coefficient:

$Kv = 0.865\,Cv$ ··(11)

Here,

Cv factor: Value of the clean water flow rate represented by US gal/min that runs through the valve at 40 to 100°F, when the pressure difference is 1 lbf/in² (psi)

Value is different from ***Kv*** and ***Cv*** factors for pneumatic purpose due to different test method.

(4) Test method

Connect the equipment for the test to the test circuit shown in Fig. (3), and run water at 5 to 40°C. Then, measure the flow rate with a pressure difference where vaporization does not occur in a turbulent flow (pressure difference of 0.035 MPa to 0.075 MPa when the inlet pressure is within 0.15 MPa to 0.6 MPa). However, as the turbulent flow is definitely caused, the pressure difference needs to be set with a large enough difference so that the Reynolds number does not fall below 1 x 105, and the inlet pressure needs to be set slightly higher to prevent vaporization of the liquid. Substitute the measurement results in formula (8) to calculate ***Kv***.

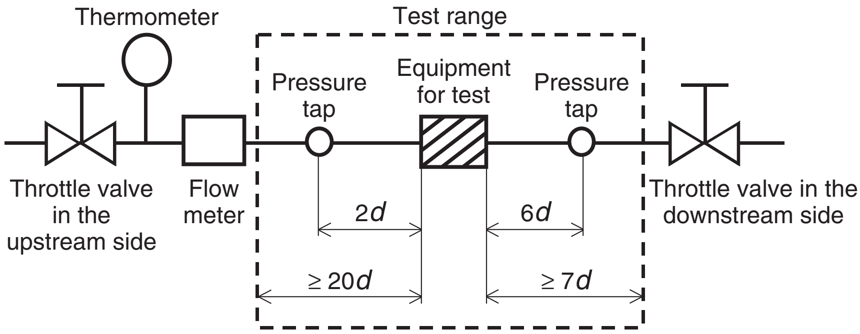
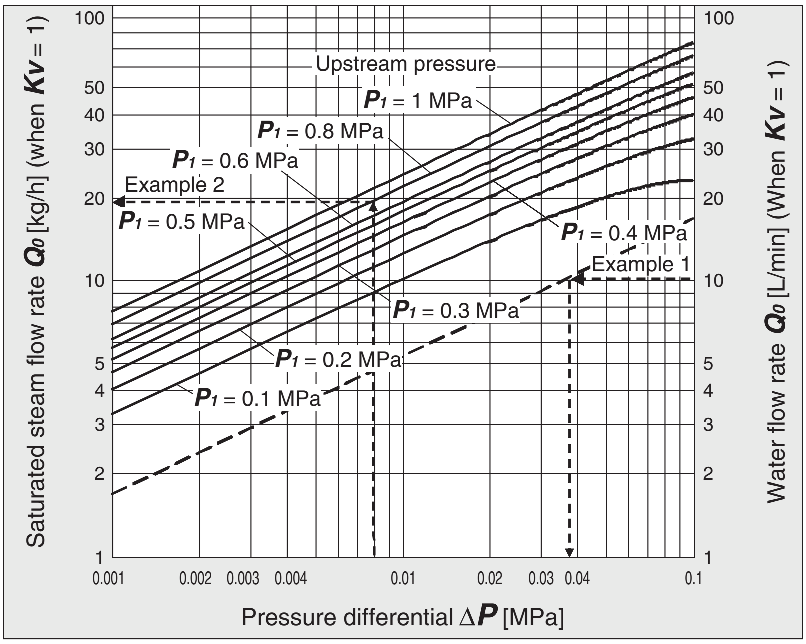


Fig. (3) Test circuit based on IEC60534-2-3, JIS B 2005-2-3



Graph (2) Flow rate characteristics

Example 1)

Obtain the pressure difference when water [15 L/min] runs through the solenoid valve with a Kv = 1.5 m³/h.

As the flow rate when Kv = 1 is calculated as the formula: $Q_0 = 15 \times 1/1.5 = 10$ [L/min], read off ΔP when Q_0 is 10 [L/min] in Graph (2). The reading is 0.036 [MPa].

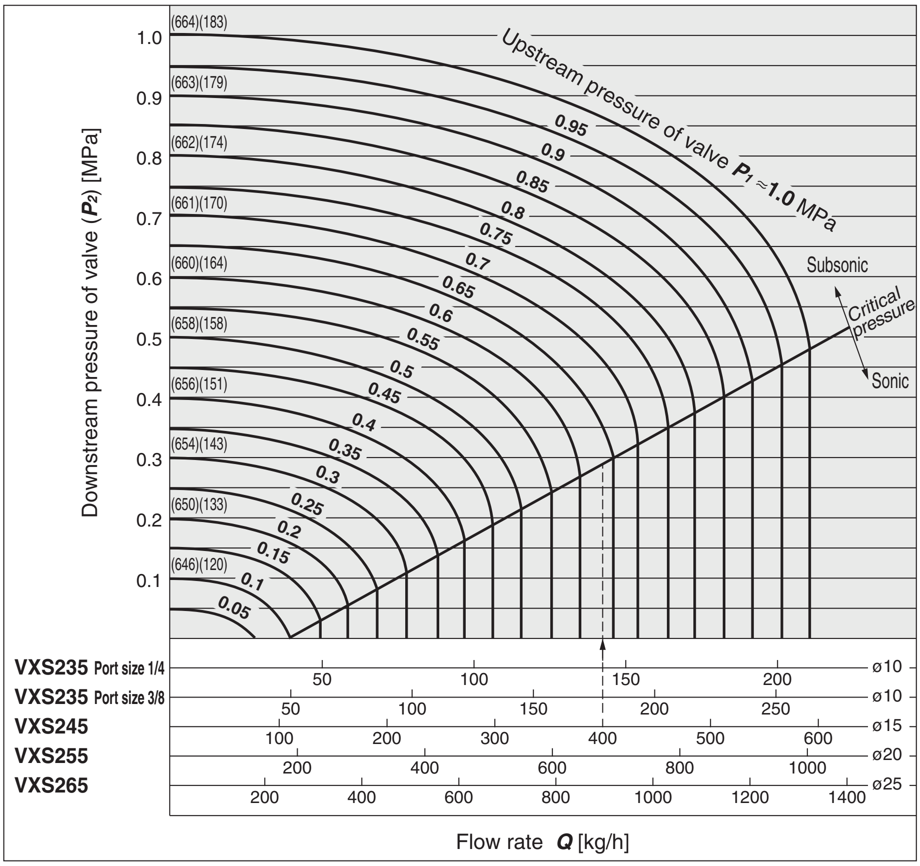
Example 2)

Obtain the saturated steam flow rate when P_1 = 0.8 [MPa] and ΔP = 0.008 [MPa] with a solenoid valve with a Kv = 0.05 [m³/h]. Read off Q_0 when P_1 is 0.8 and ΔP is 0.008 in Graph (2), the reading is 20 kg/h. Therefore, the flow rate is calculated as the formula: $Q = 0.05/1 \times 20 = 1$ [kg/h].

Flow Rate Characteristics

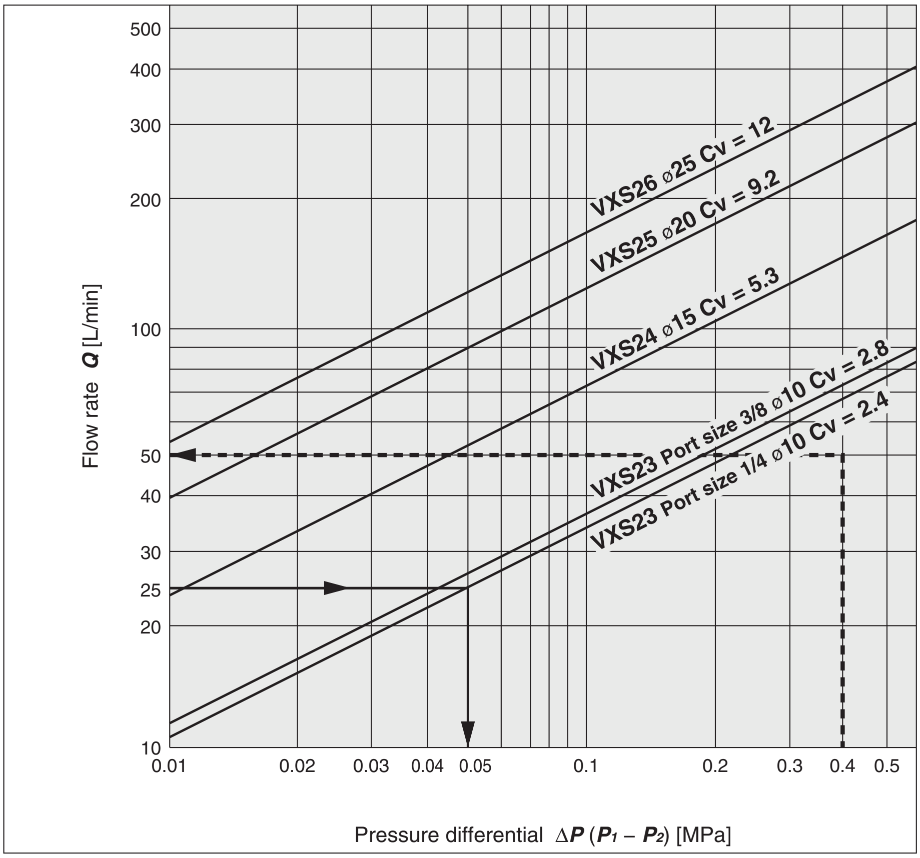
Note) Use this graph as a guide. In the case of obtaining an accurate flow rate, refer to pages 227 and 228.

For Saturated Steam



( ): Saturated steam holding heat (kcal/kg) ( ): Saturation temperature (°C)

For Water



How to read the graph

The pressure differential to generate a flow rate of 25 L/min water is as follows.
For a ø10 orifice (VXS23/Port size 1/4),
ΔP ≈ 0.05 MPa
The optimum size for a pressure differential of **ΔP** ≈ 0.2 MPa and a flow of 50 L/min will be the VXS23 (ø10 orifice, port size 3/8).