

OUTLINE

The **Mass V-Cone flowmeter** with a differential pressure type flow element V-Cone, is equipped with a differential pressure transmitter with density compensator. The **Mass V-Cone flowmeter** can measure the mass flow of saturated steam and gases without a separate pressure transmitter. The optional multi-functional converter transmits the pressure and temperature signals for further application for gas services.

The V-Cone flowmeter has a V-Cone shaped throttling device developed based on actual fluid experiments. It features self-reslapping the flow profile, stable differential pressure and self-draining.

FEATURES

- Convenient mass flow rate measurement
Measuring pressure at the same time, the direct mounted differential pressure transmitter can measure the mass flow rate with a loaded compensating function of saturated steam and gas density. The separate input from a RTD (Resistance type temperature detector) allows the temperature and pressure compensation of gas flow.
- Short straight runs
The Required straight runs are less than 1/5 of those required for orifices and vortex flowmeters. The narrow installation space allows simple and flexible piping arrangement to save space and cost.
- Stable differential pressure signal
The secondary pressure is measured at the center of the cone, which makes the differential pressure signal stable at as low as 0.025kPa.
- Wide Rangeability
Since the differential pressure created by the meter is stable at low flow rate it can measure the flow rate in the range of the turn down ratio 10:1 to cover the wide flow range with the standard differential pressure.
- Low pressure loss
The stable measurement at low differential pressure allows low pressure loss which improves energy efficiency of the plant.
- High reliability
V-Cone shape has durable structure against wear or adhesion without moving parts. It assures you a long reliable operation without maintenance.



MEASUREMENT PRINCIPLE

The principle of V-Cone flowmeter is the same as that of a common differential pressure type flowmeter, and it is based on the Bernoulli's theorem of the conservation of a fluid energy.

As shown in Fig.1, the pressure P_1 at the approaching point to V-Cone decreases to P_2 at the edge point with increasing fluid velocity by throttling the flow path along the contoured shape of V-Cone. P_1 and P_2 are measured from the pressure taps and the difference of the two pressures is given as:

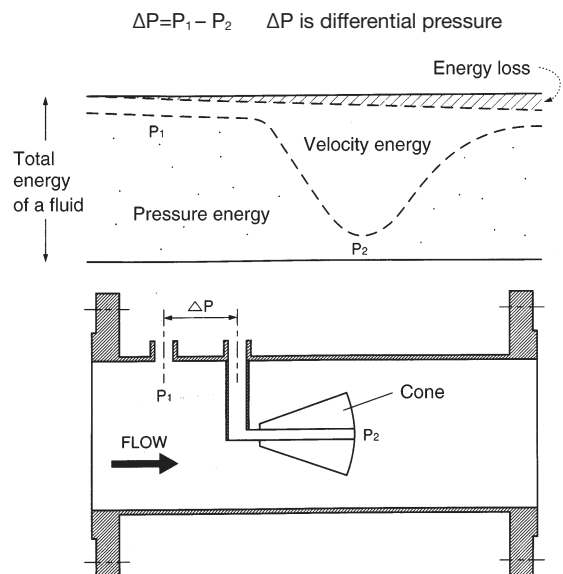


Fig. 1

The following formula explains the relation of flow rate and differential pressure.

$$Q = \frac{3600 \times \pi \times \sqrt{2} \times \beta^2 \times D^2 \times Cd \times \sqrt{\Delta P \times 1000} \times Y}{4 \times \sqrt{\rho} \times \sqrt{(1-\beta^4)}}$$

- Q : Flow rate [m³/h]
- β : Beta ratio
- D : Inside diameter [m]
- Cd : Discharge coefficient
- ΔP : Differential pressure [kPa]
- ρ : Density [kg/m³]

- Y : Gas expansion factor
Y=1-(0.649+0.696×β⁴) × ΔP / (k × P)
- k : Specific heat ratio
- P : Line pressure [kPa]

STANDARD SPECIFICATIONS

- Size : 15mm (1/2inch) to 300mm (12inch)
- Measuring fluids : Gases, Saturated steam
- Material
 - Body, flange, lead pipe :Stainless steel 304
 - Differential pressure transmitter
 - Diaphragm : SUS316L
 - Other wet parts : Equivalent to SUS316L
 - Case and cover : Aluminum alloy
 - 3 valve manifold : Body ; Equivalent to SUS316 Seal ; PTFE
 - Seal of lead pipe parts : PTFE
 - Sealing liquid of transmitter: Silicone oil
- Process connection : Flanges
JIS 10K RF or ASME Class 150 RF
- Beta ratio : 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80

Fluid temperature and Maximum allowable pressure

Fluids		Saturated steam	Gas
Temperature °C	General type	Max.190	-40 to 120
	Flameproof enclosure	Max.190	-20 to 100
Maximum allowable pressure MPa		Max.1.0	-0.05 to 0.99

- Ambient temperature
 - General type : -40 to 85°C
 - Flameproof enclosure: -20 to 55°C
- Storage temperature and humidity : -40 to 85°C
0 to 100%RH
- Accuracy : ±2% of Max. flow rate
 - Guaranteed Rangeability : 10:1 as standard
 - Reynolds No. : ≧ 8000
 - Differential pressure : ≧ 0.025 kPa for gas
: ≧ 0.05 kPa for saturated steam
- Power supply : 11.4 to 42.0VDC
- Output signal : 4 to 20mADC 2-wire
- Maximum load : 600Ω at supply voltage 24VDC

- Required straight runs
- A [Measuring fluid : Gases and saturated steam with Reynolds No. ≧ 200,000]

Joints or other obstacles	Upstream	Downstream
1 piece of 90° bend	0D	0D
2 pieces of 90° bend	0D	0D
T joint	0D	0D
Butterfly valve (Flow control valve)	*1	1D
Butterfly valve (Full open)	2D	0D
Gate valve (Full open) or full port ballvalve (Full open)	0D	0D
Expander (Diameter 0.67D expands to 1D, length 2.5D)	2D	1D
Reducer (Diameter 3D reduces to 1D, length 3.5D)	0D	0D

*1: not recommended

- B [Measuring fluid : Both Gases and saturated steam with Reynolds No. >200,000]

Joints or other obstacles	Upstream	Downstream
1 piece of 90° bend	1D	1D
2 pieces of 90° bend	1D	1D
T joint	1D	1D
Butterfly valve (Flow control valve)	*1	1D
Butterfly valve (Full open)	2D	1D
Gate valve (Full open) or full port ballvalve (Full open)	1D	1D
Expander (Diameter 0.67D expands to 1D, length 2.5D)	2D	1D
Reducer (Diameter 3D reduces to 1D, length 3.5D)	0D	0D

*1: not recommended

[Notes]

- D shows the nominal size of V-Cone flowmeter.
- The required straight runs are the distance from the flange faces of V-Cone flowmeter.
- Add 1D to the above mentioned figures for the service β ratio is 0.70 or more.

Differential pressure transmitter

- Flow indication : Digital indication with unit scale on 5 digits LCD
- Enclosure : IP67/ JIS C 0920
- Explosionproof : TIIS : Exd IIC T4 Gb (Explosion proof)
- Cable connection : G1/2 2 pieces
Use an explosion proof packing type cable gland X-SFRCA for the cable connection of the TIIS flameproof construction.
- Painting : Acid proof painting and light gray
- Temperature input : Pt100Ω or JPt100Ω 3-wire system required for temperature compensation of gas measurement.

COMPENSATION EQUATION

(1) Gas
$$Q [m^3/h(nor)] = Q_{MAX} \times \sqrt{\frac{273.15+T_B}{273.15+T_I} \times \frac{P_I}{P_B} \times \frac{\Delta P}{\Delta P_{MAX}}}$$

(2) Saturated steam
$$Q [kg/h] = Q_{MAX} \times \sqrt{\frac{\rho_I}{\rho_B} \times \frac{\Delta P}{\Delta P_{MAX}}}$$

- Q : Compensated flow rate
- Q_{MAX} : Maximum flow rate
- T_I : Actual gas temperature [°C]
- T_B : Temperature at design condition [°C]
- P_I : Actual gas pressure [MPa(abs)]
- P_B : Pressure at design condition [MPa(abs)]
- ρ_I : Density of saturated steam at actual measurement [kg/m³]
- ρ_B : Density of saturated steam at design condition [kg/m³]
- ΔP : Measured differential pressure [kPa]
- ΔP_{MAX} : Differential pressure at maximum flow rate [kPa]

MODEL CODE

			VM	-					-						
Construction			VM										General type		
	EP	-	VM										Flameproof enclosure		
Combination *1													5	V-Cone + Differential pressure transmitter	
													6	V-Cone + Differential pressure transmitter with degreasing treatment	
													7	V-Cone + 3 Valve manifold + Differential pressure transmitter	
													8	V-Cone + 3 Valve manifold + Differential pressure transmitter with degreasing treatment	
Fluid													3	Gas	
													4	Saturated steam	
Connection													1	JIS 10K RF SO flange	
													2	ANSI CLASS 150 RF SO flange	
													9	Others	
Flow direction													6	Left to right, horizontal	
													7	Right to left, horizontal	
Size													01	15mm	1/2 inch
													02	20mm	3/4 inch
													03	25mm	1 inch
													04	40mm	1 1/2 inch
													05	50mm	2 inch
													06	65mm	2 1/2 inch
													08	80mm	3 inch
													10	100mm	4 inch
													13	125mm	5 inch
													15	150mm	6 inch
													20	200mm	8 inch
													25	250mm	10 inch
												30	300mm	12 inch	
Beta ratio													45	0.45	
													50	0.50	
													55	0.55	
													60	0.60	
													65	0.65	
													70	0.70	
													75	0.75	
													80	0.80	

*1 The flowmeter without 3-valve manifold does not allow to dismantle the transmitter from the flowmeter or to make its zero adjustment during operation.

MAXIMUM FLOW RATE RANGE

- Flow rates shown in the each table indicate the maximum flow rate range in which the accuracy is guaranteed at each size and at prescribed pressure or density. The minimum flow rate within the range of which the accuracy is guaranteed is 1/10 of the maximum flow rate.
- Maximum flow rate range at measuring air at 20°C and following pressure

Size		Maximum flow rate (m³/h(nor))										
		Pressure (Gage)	0.1MPa	0.2MPa	0.3MPa	0.4MPa	0.5MPa	0.6MPa	0.7MPa	0.8MPa	0.9MPa	0.99MPa
		Density (kg/m³)	2.393	3.582	4.771	5.960	7.149	8.337	9.526	10.715	11.904	12.974
15	1/2"	Min.	71	71	71	71	71	71	71	71	71	71
		Max.	91	137	177	199	220	238	256	272	287	301
20	3/4"	Min.	93	93	93	93	93	93	93	93	93	93
		Max.	159	238	306	346	381	414	444	472	498	521
25	1"	Min.	119	119	119	119	119	119	119	119	119	119
		Max.	254	381	491	554	610	662	710	755	798	834
40	1 1/2"	Min.	184	182	182	182	182	186	199	211	222	232
		Max.	599	898	1156	1304	1438	1560	1673	1779	1879	1964
50	2"	Min.	161	233	233	255	280	302	323	343	362	377
		Max.	987	1481	1905	2150	2370	2571	2758	2933	3097	3239
65	2 1/2"	Min.	229	282	325	364	399	431	461	489	516	538
		Max.	1427	2140	2754	3108	3426	3716	3986	4239	4477	4681
80	3"	Min.	354	434	502	562	616	666	712	755	796	831
		Max.	2204	3306	4253	4800	5291	5740	6156	6546	6914	7230
100	4"	Min.	609	748	865	968	1061	1147	1226	1301	1371	1432
		Max.	3798	5697	7330	8272	9117	9891	10609	11281	11915	12458
125	5"	Min.	957	1175	1359	1520	1666	1800	1925	2042	2153	2248
		Max.	5965	8946	11512	12991	14319	15534	16661	17716	18712	19566
150	6"	Min.	1382	1697	1963	2196	2407	2601	2781	2951	3111	3248
		Max.	8620	12927	16633	18770	20689	22444	24073	25598	27037	28270
200	8"	Min.	2419	2971	3436	3844	4214	4553	4869	5165	5446	5686
		Max.	14723	22080	28410	32060	35337	38336	41118	43723	46181	48287
250	10"	Min.	3813	4684	5416	6060	6642	7177	7675	8142	8584	8964
		Max.	23210	34807	44786	50541	55706	60434	64818	68925	72800	76120
300	12"	Min.	5470	6718	7768	8692	9527	10294	11008	11679	12313	12857
		Max.	32859	49277	63405	71552	78865	85558	91765	97578	103065	107765

- Maximum flow rate range at measuring saturated steam

Size		Maximum flow rate (kg/h)										
		Pressure (Gage)	0.1MPa	0.2MPa	0.3MPa	0.4MPa	0.5MPa	0.6MPa	0.7MPa	0.8MPa	0.9MPa	1.0MPa
		Density (kg/m ³)	1.131	1.658	2.169	2.676	3.176	3.673	4.169	4.662	5.153	5.644
15	1/2"	Min.	65	67	69	70	71	72	73	74	75	76
		Max.	79	117	153	172	189	204	218	232	244	256
20	3/4"	Min.	86	89	91	93	94	95	97	98	99	100
		Max.	137	202	266	299	328	354	379	402	423	444
25	1"	Min.	109	113	115	118	119	121	123	125	125	127
		Max.	219	324	426	478	525	567	606	643	678	711
40	1 1/2"	Min.	168	173	177	191	209	224	239	253	266	279
		Max.	516	763	1004	1127	1236	1336	1428	1515	1596	1673
50	2"	Min.	215	243	279	311	339	365	390	412	434	454
		Max.	851	1259	1656	1858	2038	2202	2355	2497	2631	2759
65	2 1/2"	Min.	284	347	398	444	484	521	556	588	618	648
		Max.	1230	1819	2393	2685	2946	3183	3404	3609	3803	3988
80	3"	Min.	439	535	615	685	747	805	858	908	955	1000
		Max.	1899	2810	3696	4147	4549	4916	5256	5574	5874	6158
100	4"	Min.	756	922	1060	1180	1287	1386	1478	1564	1645	1722
		Max.	3273	4842	6369	7147	7840	8472	9058	9606	10122	10613
125	5"	Min.	1186	1448	1664	1852	2021	2176	2321	2456	2583	2705
		Max.	5141	7605	10003	11224	12312	13306	14226	15086	15897	16667
150	6"	Min.	1714	2092	2403	2676	2920	3144	3353	3548	3732	3908
		Max.	7428	10989	14453	16218	17790	19225	20555	21798	22969	24082
200	8"	Min.	3000	3662	4207	4684	5112	5504	5869	6211	6533	6840
		Max.	12687	18770	24687	27701	30386	32838	35109	37232	39233	41133
250	10"	Min.	4729	5773	6632	7384	8058	8677	9251	9790	10299	10783
		Max.	20001	29589	38916	43668	47901	51766	55346	58693	61847	64842
300	12"	Min.	6782	8280	9512	10591	11558	12445	13269	14042	14772	15466
		Max.	28315	41889	55095	61821	67815	73287	78354	83093	87558	91798

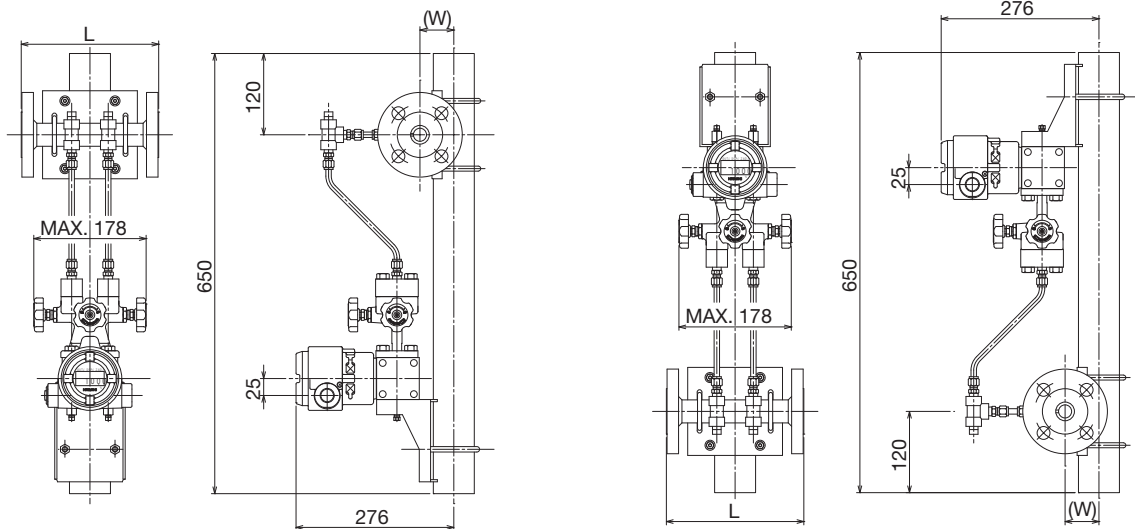
DIMENSIONS

- Fig. "a" Saturated steam

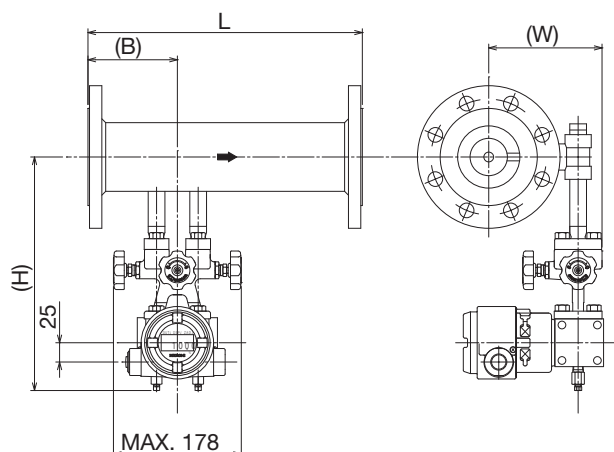
15mm to 40mm or 1/2 inch to 1 1/2 inch
Flow direction : Left to right or Right to left

- Fig. "b" Gases

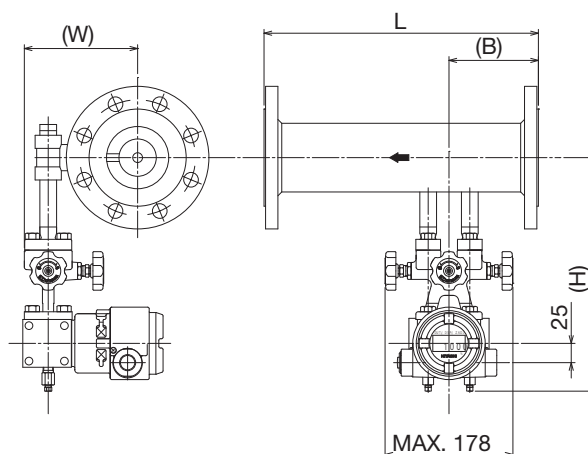
15mm to 40mm or 1/2 inch to 1 1/2 inch
Flow direction : Left to right or Right to left



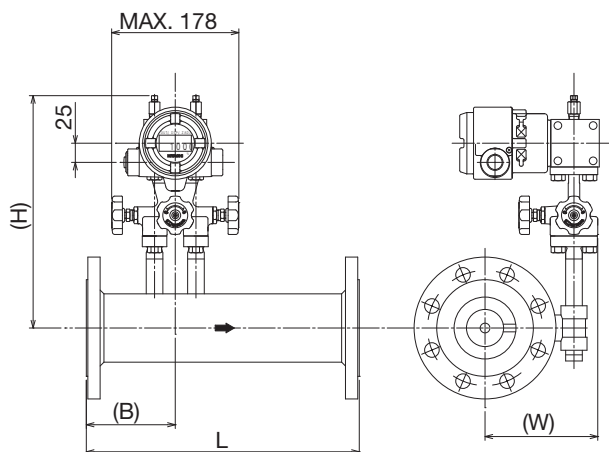
- Fig. "c" Saturated steam
50mm to 300mm or 2 inch to 12 inch
Flow direction : Left to right



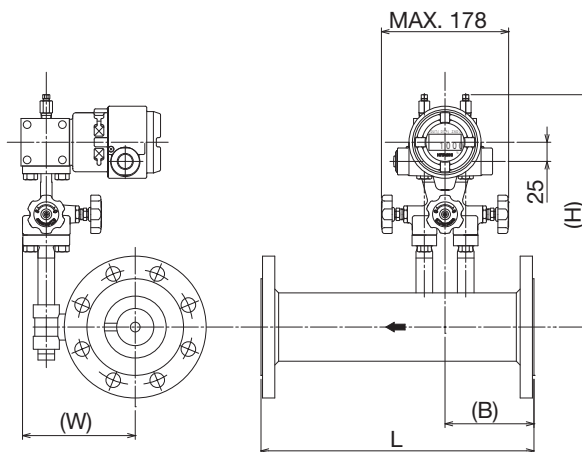
Flow direction : Right to left



- Fig. "d" Gases
50mm to 300mm or 2 inch to 12 inch
Flow direction : Left to right



Flow direction : Right to left



Size	L (mm)	(B) (mm)	(W) (mm)	(H) (mm)				Figures	Mass (kg) *1
				With 3 Valve manifold		Without 3 Valve manifold			
				Saturated Steam	Gases	Saturated Steam	Gases		
15mm 1/2"	203	-	44	-	-	-	-	a, b	18
20mm 3/4"	203	-	47	-	-	-	-	a, b	19
25mm 1"	203	-	50	-	-	-	-	a, b	20
40mm 1 1/2"	254	-	57	-	-	-	-	a, b	22
50mm 2"	305	116	132	287	323	197	233	c, d	19
65mm 2 1/2"	305	116	138	295	331	205	241	c, d	22
80mm 3"	356	116	146	302	338	212	248	c, d	23
100mm 4"	406	129	174	327	363	237	273	c, d	28
125mm 5"	559	135	187	342	378	252	288	c, d	42
150mm 6"	559	135	201	352	388	262	298	c, d	46
200mm 8"	660	154	241	387	423	297	333	c, d	75
250mm 10"	711	154	268	412	448	322	358	c, d	89
300mm 12"	762	160	294	437	473	347	383	c, d	108

*1 The figures show the mass of flowmeter with JIS 10K RF SO flanges.

OPTIONAL UNIT

- Multi Functional Converter
Type EDB500MA

Power supply : Either 100V / 110V AC±10%, 5VA 50 / 60Hz
or 24V DC±10%, 0.12A

Input : 4-20mA DC from output of Mass V-Cone flowmeter

Outputs

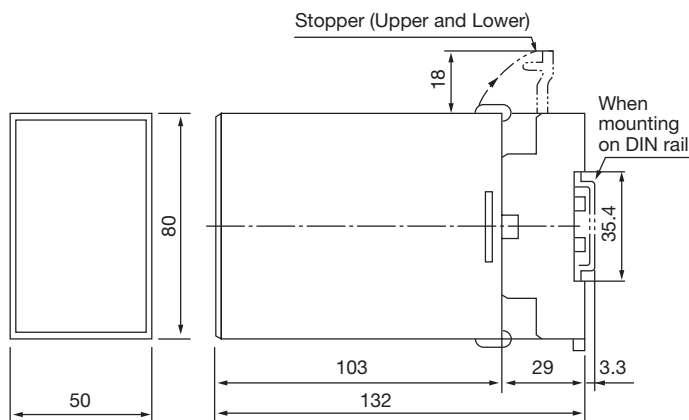
- Output 1 : Flow rate signal 1 to 5 VDC
- Output 2 : Pressure signal 1 to 5 VDC
- Output 3 : Temperature signal 1 to 5 VDC when a resistance temperature detector is used for gas service.

Conversion accuracy : ±0.1%F.S. for each output 1, 2 and 3.

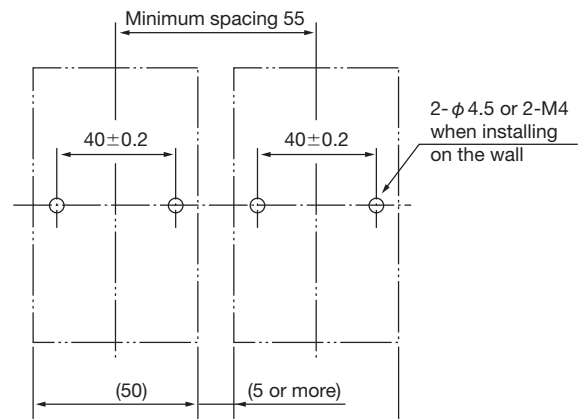


[DIMENSIONS]

BODY

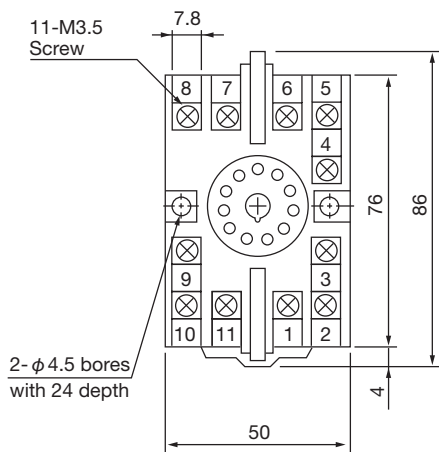


INSTALLATION METHOD

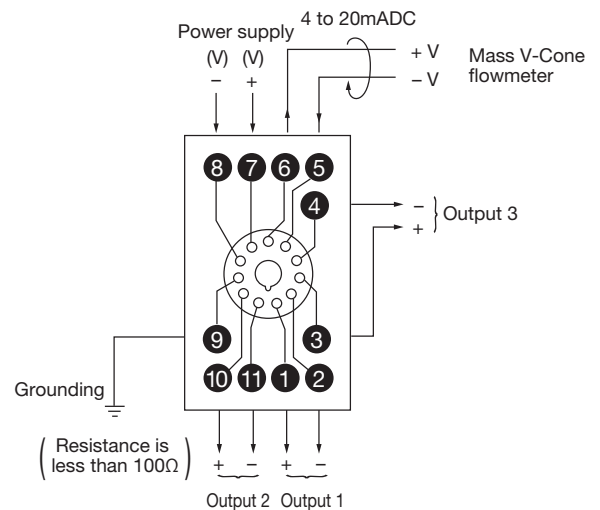


- Space the instruments as shown above.
- Use a DIN rail with nominal 35mm width if required. Keep minimum 5mm space between the instruments with an attached spacer between them.
- Install ducts, if required, apart at least 20mm from the top and bottom surfaces of the instrument.

SOCKET



[Wiring diagram]



• Resistance temperature detector

Class : Pt100 Class B

Applicable standard : JIS C1604-1997

Materials : Sheath SUS316, Nipple and flange SUS304

Terminal box : Aluminum die casting with silver painting

Wiring connection : G1/2

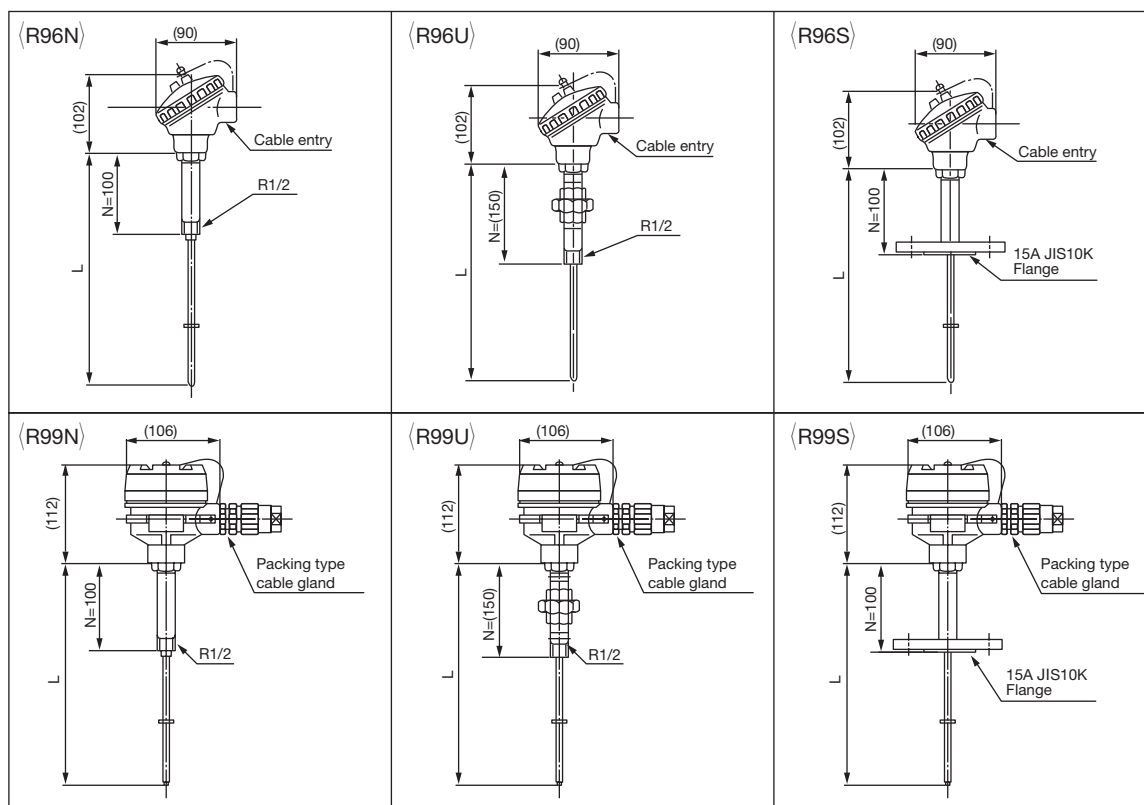
MODEL CODE

	*		-				3	100-B	
Construction	R96								General type
	R99								Flameproof enclosure (Exd IIC T6)
Basic model	N-3								Nipple type R1/2 with N=100mm
	U-4								Nipple type R1/2 with an union and N=150 mm
	S-1								15A JIS10K RF flange type with 22 dia. support pipe N=100 mm
Terminal box		EL							General type, made of aluminum die casting (ADC) *1
		GE							Flameproof enclosure, made of aluminum die casting (ADC) *2
Total length "L"		Numerals							"L" dimension in mm
Diameter of sheath		D							3.2 mm diameter
		E							4.8 mm diameter
		F							6.4 mm diameter
		G							8.0 mm diameter
Fixed code							3		3
Measuring range		L							-200 to 100 °C
		M							0 to 350 °C
		H							0 to 500 °C
Fixed code							100-B		100-B
Additional specifications								/J10RF15/A-(L-100)	With 15A JIS10K RF flange *3

*1 Selectable only when "Construction" code is "R96"

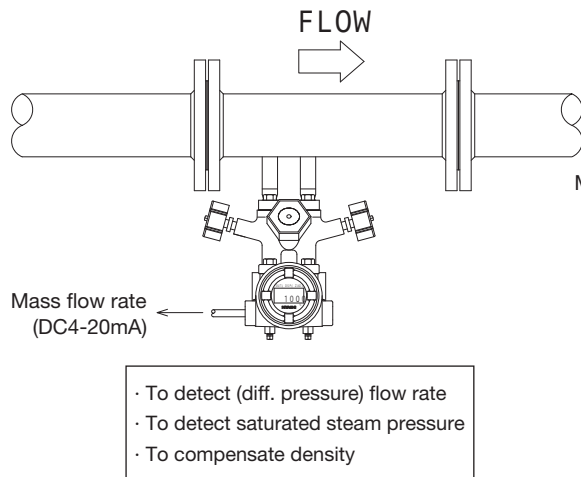
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*2 Selectable only when "Construction" code is "R99"

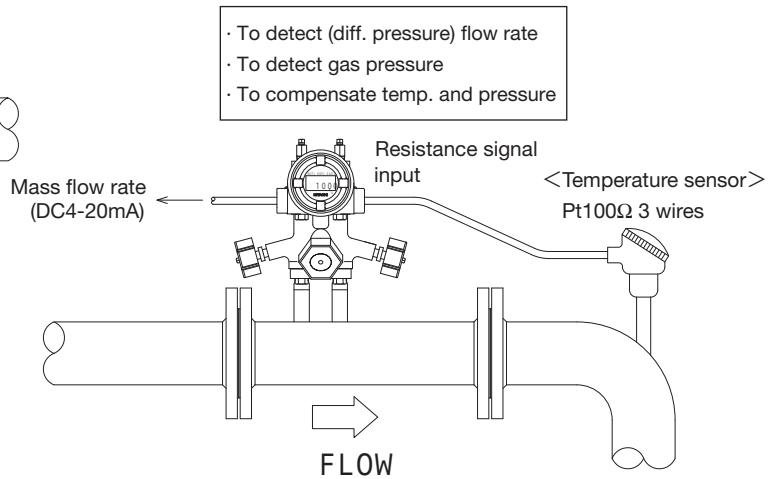


EXAMPLES OF APPLICATION

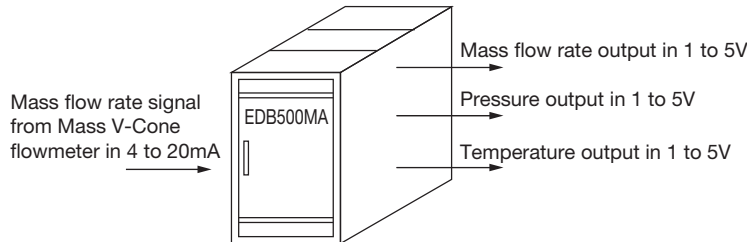
- For saturated steam flow measurement



- For gas flow measurement



- Optional Multi Functional Converter
It outputs flow rate, pressure and temperature independently.



Note: The temperature output is available when the resistance temperature detector is connected to the Mass V-Cone flowmeter for gas services.

* Specification is subject to change without notice.

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