

Elliptic Throat Flowmeter

Model SDR11F

Outline

- The Elliptic Throat Flowmeter is a flow-restriction flowmeter which has a tapered restriction of elliptic profile in its passage and measures flow rate by measuring differential pressure between the front part and the throat of the restriction.
- The pressure tapholes to pick up differential pressure and the differential pressure sensor section have a structure that makes them hardly prone to clogging with deposit or slurry.
- It has a wide range of application such as a solid-gas, two-phase fluid containing a liquid, slurry fluid, gas, steam, powder, and the like.
- With its small pressure loss, the flowmeter saves energy. It contributes CO₂ reduction.

Principle

Differential pressure (Δp) develops between the front part and the throat of the restriction, and this varies as the square of flow rate (Q). Therefore, the flow rate is represented by the following equation.

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

This is the same principle as for orifices, flow nozzles, and venturi tubes.

Features

1. Streamlines allowing a smooth flow

The throat of the restriction is made semi-elliptic in cross-sectional form. Therefore, stagnation-free and smooth streamlines are obtainable before and after the throat.

- (1) The passage and throat have a structure that makes them hardly prone deposition or clogging.
- (2) Because the streamlines are stable, output can be obtained with good reproducibility. The rangeability of flow rate is as wide as 1 to 10, so measurement is possible down to almost zero flow rate.
- (3) Even with a short upstream length, measurement is possible with high accuracy.
- (4) Its pressure loss is smaller than that of orifices (1/2 to 1/4 for the same contraction ratio) and 8 to 50 percent of the differential pressure that developed. It can reduce energy loss and allow a smaller mechanical power source to be used.
- (5) Because of its quick response, the flowmeter is also resistant to fluid pulsation (about 1 Hz).



2. Wide pressure tapholes employed

For the pressure tapholes, larger diameters ($\phi 10$ to $\phi 14$ mm) than the prescription for ordinary orifices are employed. With those large diameters to avoid clogging, the flowmeter brings about stable measurement even for fluids containing deposit or solid matter.

3. Combination with 1/2-inch Remote Sealed Transmitter

- (1) It is possible to connect the 1/2-inch Remote Sealed Transmitter directly to the connection flange (1/2-inch) of the sensor end or sluice valve, so no pressure conduits are required.
- (2) The transmitter has no moving parts and is small and light. For installation of the transmitter, there is a choice offered between separate installation by a 1/2-inch station and line mounting for direct installation.
- (3) Flow rate span changes can be easily made by the Smart Commutator SFC.

Standard Specifications

Accuracy:

Nominal diameter	Reynolds number range	Accuracy
25 to 40A	(1)	±1.0 %F.S.
	(2)	±1.25%F.S.
50 to 150A	(1)	±0.75%F.S.
	(2)	±1.0 %F.S.

Contraction ratio	Reynolds number range (1)	Reynolds number range (2)
0.4	5,000 to 1,000,000	500 to 5,000
0.5		
0.6	15,000 to 1,000,000	500 to 15,000
0.7		1,000 to 15,000

Fluid pressure:

Up to the flange rating (maximum operating pressure varies with fluid temperature.)

Fluid temperature:

-40 to +280°C (depends on wetted temperature range of the installed differential pressure transmitter)

Connection bore diameter:

25A to 150A (consult with your representative for 200A or larger.)

Piping connection:

Flanged

Wetted surfaces:

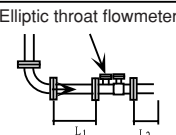
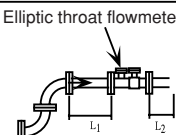
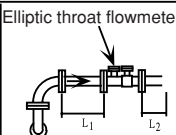
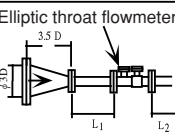
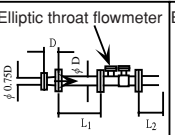
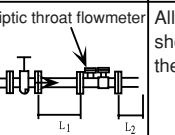
SUS316, SUS316L

Transmitter connection:

Connect to a 1/2-inch Remote Sealed Transmitter-specific flange or 1/2-inch standard flange.

Straight Pipe Section Lengths on the Inflow and Outflow Sides Required from the Measured Pipeline

Table: The minimum straight pipe sections installed between the flowmeter and upstream and downstream of joints. Measurements are multiples of the piping diameter.

Contraction ratio by diameter (β)	Upstream side L_1						Downstream side L_2
	Elliptic throat flowmeter  One 90-degree bend	Elliptic throat flowmeter  Two or more 90-degree bends on a single plane	Elliptic throat flowmeter  Two or more 90-degree bends not lying on a single plane	Elliptic throat flowmeter  Contraction pipe	Elliptic throat flowmeter  Expansion pipe	Elliptic throat flowmeter  Sluice valve (fully open)	
0.40	0.5	1.5	40	2.5	1.5	2.5	0.6
0.50	1.5	2.5	40	5.5	2.5	3.5	1.0
0.60	3.0	3.5	40	8.5	3.5	4.5	1.5
0.70	4.0	4.5	40	10.5	5.5	5.5	2.0

Note 1: The radius of curvature in the bend shall be equal to or greater than the inner diameter of the force tube line.

Note 2: The upstream and downstream straight pipe sections are the distances measured from the flanges flowmeter.

Model Number and Configuration Table

Flange type (25mm to 150mm)

Basic model number

SDR11F

Selective specifications

Optional specifications (multiple choices)

Diameter	25mm	025				
	40mm	040				
	50mm	050				
	80mm	080				
	100mm	100				
	150mm	150				
Piping schedule	Schedule 10	B				
	Schedule 20	C				
	Schedule 40	D				
	Schedule 80	E				
	SGP	G				
Flange rating	JIS10K	J1				
	JIS20K	J2				
	ANSI150	A1				
	ANSI300	A3				
	JPI150	P1				
	JPI300	P3				
Body material	SUS316	B				
	SUS316L	L				
Contraction ratio	$\beta = 0.4$				40	
	$\beta = 0.5$				50	
	$\beta = 0.6$				60	
	$\beta = 0.7$				70	
Differential pressure takeout method	1/2-inch standard flange (the same flange rating as the selective specifications)					F
	1/2-inch Remote-specific flange (with SUS 630 bolts, nuts, and gaskets)					S

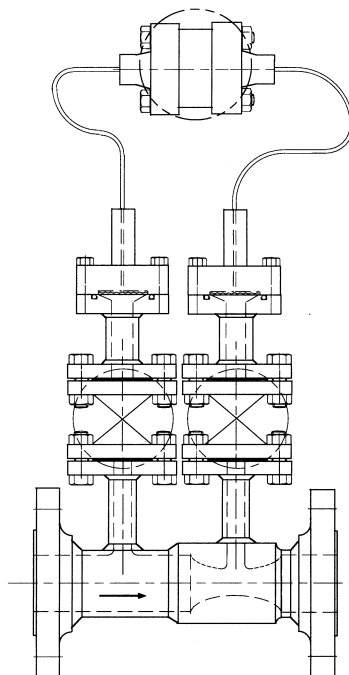
XX	No options
D1	Oil removal and moisture removal treatment
T1	Dimensional inspection sheet
T2	MIL sheet
T3	Documents in conformity with the High Pressure Gas Safety Ace (see note 3)

Note 1: Consult your representative for specifications other than those shown above.

Note 2: A 1/2-inch Remote Sealed Transmitter is required. For the specifications, model number, and other details are in transmitter document SS2-DST350-0100.

Note 3: Three documents "Strength Calculation," "Pressure Test Results," and "MIL Sheet" are supplied. If you select this model number, always specify design pressure and temperature.

Configuration Drawing



Combination of SDR 11F and Remote Sealed Transmitter

Diagram for Bore Diameter and Throat Diameter Selection

[For liquids: Conversion of differential pressure and flow rate with reference to water]

• How to use the diagram

Measured fluid : Water
 Flow rate : 80 m³/h (at 15°C)
 Pipe diameter : 100 mm

1. Look up on the diagram the intersections of pipe diameter 100 mm curves with the flow rate 80 m³/h line. Three candidates ①, ②, ③ are available for your selection, as shown in the table below.

	Contraction ratio by diameter β	Differential pressure on the diagram
①	D=100, $\beta=0.7$	10.5kPa
②	D=100, $\beta=0.6$	23 kPa
③	D=100, $\beta=0.5$	51 kPa

2. There are various approaches to take. We recommend D = 100, $\beta = 0.6$ of candidate ② in consideration of its adaptability if flow rate changes, in the future.

• How to use the diagram

1. Conversion of flow rate into equivalent water flow rate
 For fluids other than water, select one formula from among the following available (1), (2) and (3) and convert value into an interim water flow rate (at 15°C).

$$Q_{BW} = Q_B \times G_B \times \sqrt{1/G_0} \quad (1)$$

$$Q_{BW} = G_0 \times \sqrt{G_0} \quad (2)$$

$$Q_{BW} = W \times \sqrt{1/G_0} \quad (3)$$

Q_{BW} : Water flow rate (at 15°C) [m³/h]

Q_B : Flow rate of measured liquid (at 15°C) [m³/h]

Q_0 : Flow rate of measured liquid (at measuring temperature) [m³/h]

W : Flow rate of measured liquid (flow rate by weight) [kg/h]

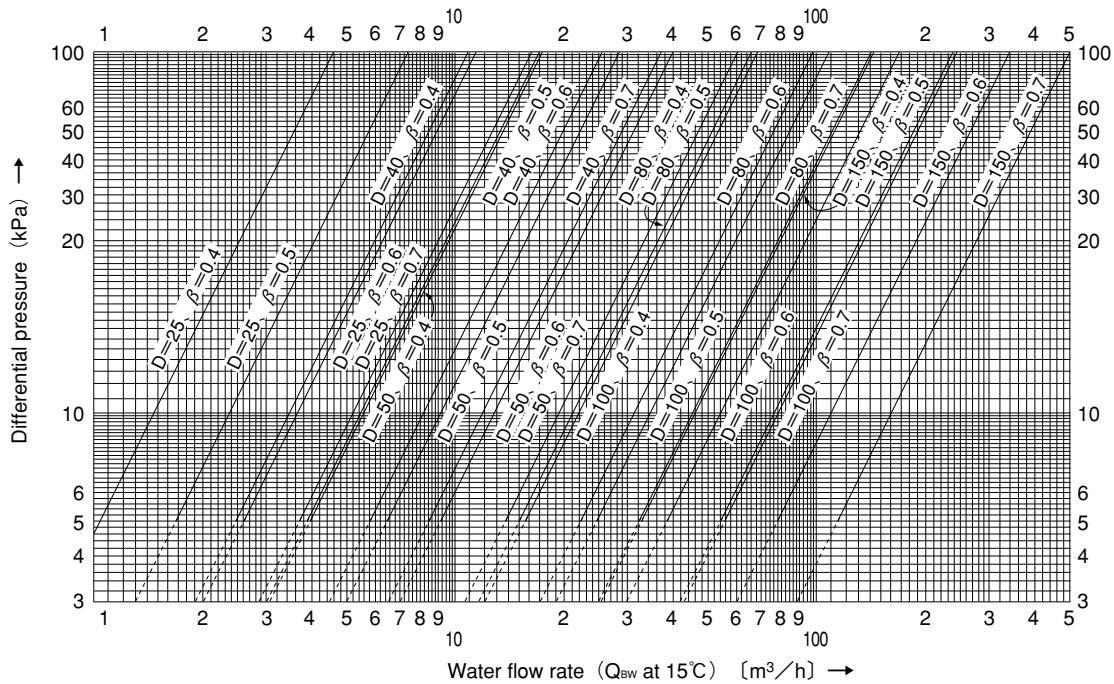
G_B : Ratio of density of measured liquid (at 4°C) to density of water (at 4°C)

G_0 : Ratio of density of measured liquid (at measuring temperature) to density of water (at 4°C)

2. Calculation example

Measured fluid : Gas-liquid, two-phase flow
 Flow rate : 90 m³/h (under measuring conditions)
 Specific gravity of fluid : 0.79 (at measuring temperature)
 Because the generated flow rate is the flow rate of a two-phase flow under specific measuring conditions, we first use Formula (2) for conversion into a water flow rate at 15°C.

$$Q_{BW} = 90 \times \sqrt{0.79} = 80 \text{ m}^3/\text{h}$$



[For steam: Conversion of flow rate and differential pressure of steam]

• Calculating equivalent flow rate

Measured fluid : Steam
 Flow rate : 3000 kg/h (saturated steam at 0.7 MPa)
 Pipe diameter : 80 mm

- Look up on the diagram the intersections of pipe diameter 80 mm curves with the flow rate 300 kg/h line. Select one of the three candidates ①, ②, and ③ from the table below.

	Contraction ratio by diameter β	Differential pressure on the diagram
①	D=80, $\beta = 0.7$	10.2kPa
②	D=80, $\beta = 0.6$	22.5kPa
③	D=80, $\beta = 0.5$	50 kPa

- There are various approaches to take. Choose ① or ② if you want a small pressure loss. Because the differential pressure gage has a minimum range of 0 - 2.5 kPa and maximum range of 0 - 100 kPa, we recommend D = 80, $\beta = 0.6$ of ② out of consideration for its easy adaptation to eventual flow changes in the future.

• How to use the diagram

- Conversion into equivalent saturated steam flow rate at a pressure of 0.7 MPa

If the steam to be measured is a fluid other than saturated steam at 0.7 MPa, and if you want to use the conversion diagram below, use the following conversion formula below to convert into an interim 0.7 MPa saturated steam flow rate.

$$W_{BS} = W \sqrt{\frac{4.1}{\gamma}} \quad (1)$$

W_{BS} : Converted steam flow rate (equivalent to 0.7 MPa saturated steam) [kg/h]

W : Steam flow rate (under measuring conditions) [kg/h]

γ : Density of steam (under measuring conditions) [kg/m³]

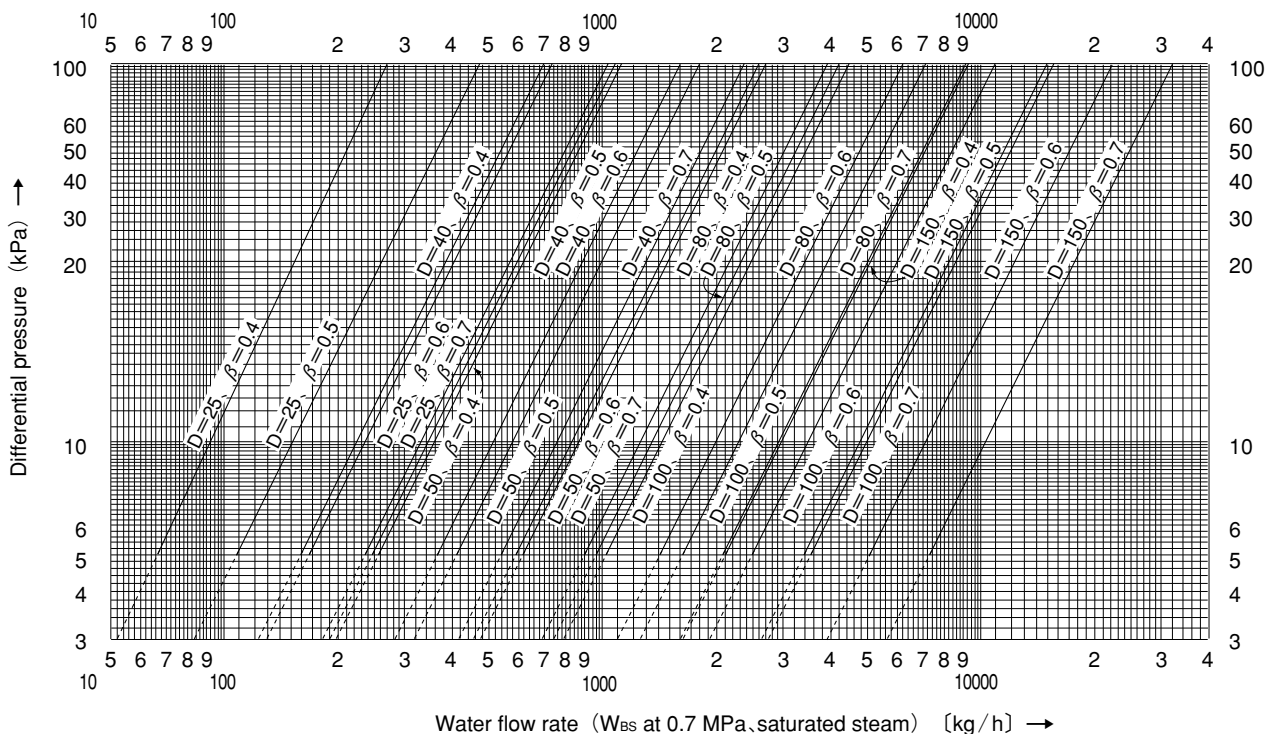
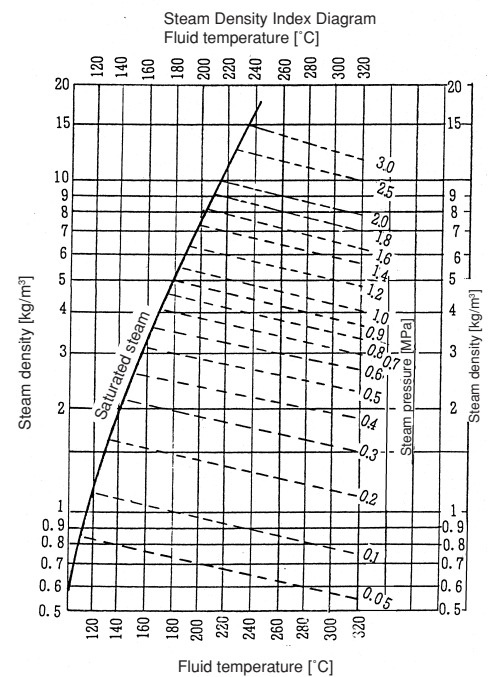
4.1 : Density of saturated steam at 0.7 MPa [kg/m³]

2. Calculation example

Measured fluid : Superheated steam
 Flow rate : 4000 kg/h (at 1.8 MPa, 300°C)
 Fluid temperature : 300°C
 Fluid pressure : 1.8 MPa
 Fluid density : 7.3 kg/m³

Because the generated flow rate is the flow rate of superheated steam under specific measuring conditions, we first use Formula (1) for conversion into a flow rate of saturated steam at 0.7 MPa.

$$W_{BS} = 4000 \sqrt{\frac{4.1}{7.3}} = 3000 \text{ kg/h}$$



[For gases: Conversion of differential pressure and flow rate with reference to air]

• Calculation of equivalent flow rate

Measured fluid : Air
 Flow rate : 8000 m³/h (at 0°C and 101 kPa)
 Pipe diameter : 150 mm

1. Look up the intersections of pipe diameter 150 mm curves with the flow rate 8000 m³/h line on the diagram. You will find two candidates ① and ② as shown in the table below.

	Contraction ratio by diameter β	Differential pressure on the diagram
①	D=150、β=0.7	32kPa
②	D=150、β=0.6	67kPa

2. There are various approaches to select. Choose (if you want a small pressure loss. Because the differential pressure gage has a minimum range of 0 - 2.5 kPa and maximum range of 0 - 100 kPa, we recommend D = 150, β = 0.7 of candidate ① in consideration of its easy adaptation if flow rate changes, in the future.

• How to use the diagram

1. Conversion of flow rate into equivalent air flow rate

If the fluid to be measured is a fluid other than air, and if you want to use the conversion diagram below, select either conversion formulae (1) or (2) and convert measured value into an interim air flow rate (at 0°C and 101 kPa).

$$Q_{NA} = Q_N \sqrt{\frac{T}{273} \times \frac{0.101}{P}} \times G \tag{1}$$

$$Q_{NA} = Q_N \sqrt{\frac{273}{T} \times \frac{P}{0.101}} \times G \tag{2}$$

- Q_{NA} : Air flow rate (at 0 °C and 101 kPa) [m³/h (normal)]
- Q_N : Flow rate of measured gas (at 0°C and 101 kPa) [m³/h (normal)]
- Q : Flow rate of measured gas (under measuring conditions) [m³/h]
- T : Absolute temperature of measured gas [°K]
- P : Absolute temperature of measured gas [MPa abs.]
- G : Specific gravity of measured gas with air taken as unity

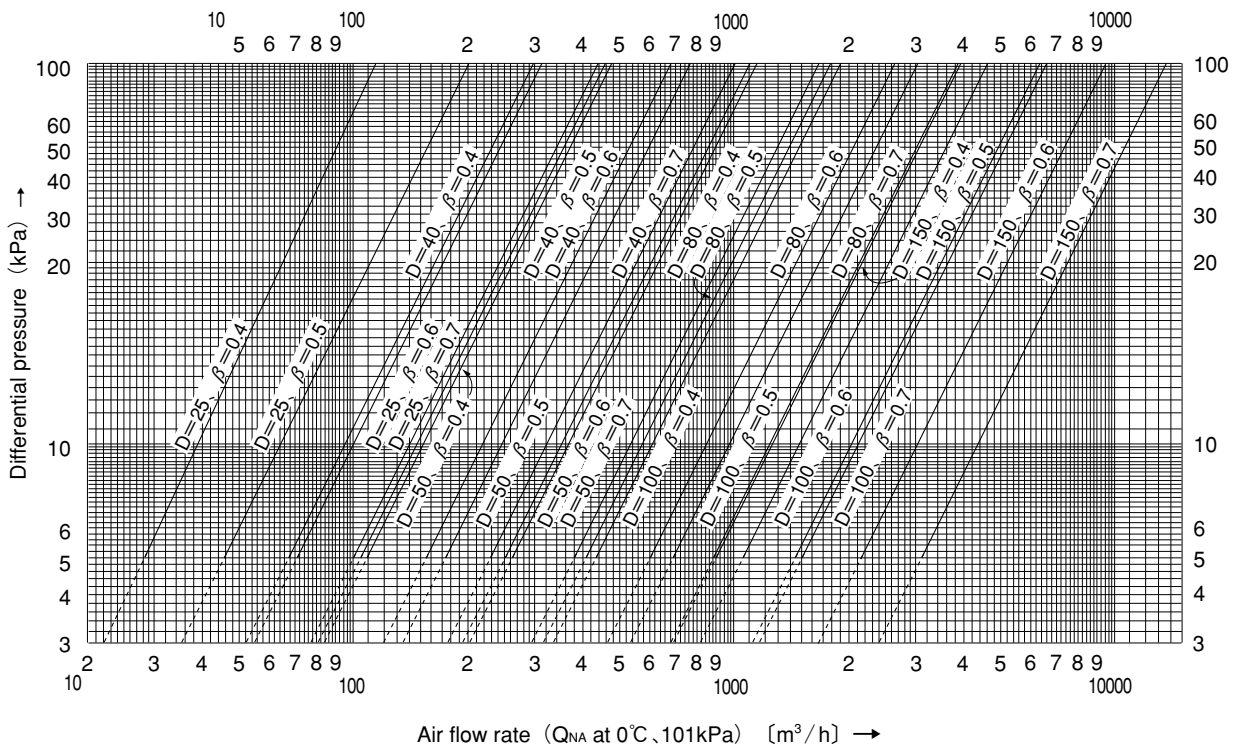
2. Calculation example

Measured fluid : Gas
 Flow rate : 7000 m³/h (at measuring temperature)
 Specific gravity of fluid : 0.6
 Fluid temperature : 95°C
 Fluid pressure : 0.2 MPa

Because the generated flow rate is the flow rate of a gas under specific measuring conditions, we first use Formula (2) for conversion into an air flow rate (at 0°C and 101 kPa).

$$Q_{NA} = 7000 \sqrt{\frac{273}{273+95} \times \frac{0.101+0.2}{0.101}} \times 0.6$$

$$\doteq 8062 \text{ m}^3/\text{h (normal)}$$



Calculation of Pressure Loss by Elliptic Throat Flowmeter

[For liquids, gas, and steam]

- Calculation of pressure loss

Measured fluid : XXXXX

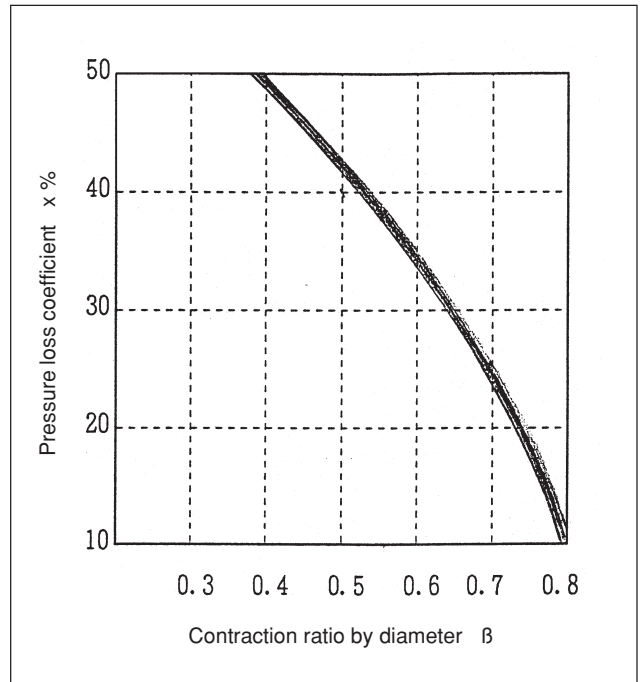
Contraction ratio by diameter : $\beta = 0.7$

Differential pressure : 10 kPa

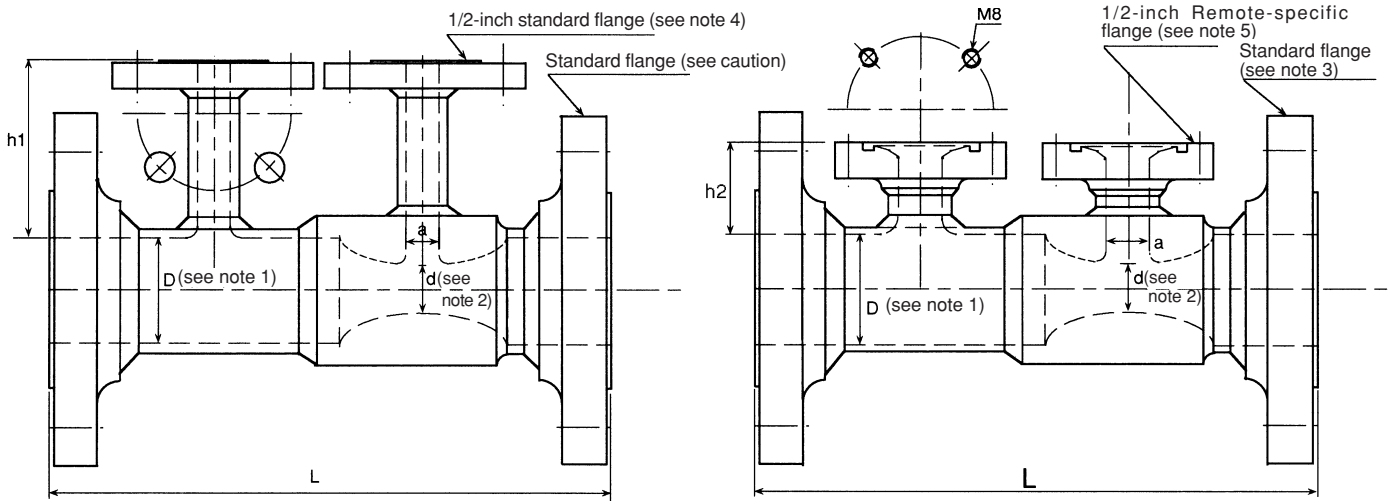
1. Look up the value of pressure loss coefficient for $\beta = 0.7$ on the diagram. You will find a value of $x = 24\%$.
2. The pressure difference is 10 kPa. With this and the pressure loss coefficient $x = 10\%$, the pressure loss becomes:

$$10\text{kPa} \times 24\%/10\% = 2.4\text{kPa}$$

Thus, 2.4 kPa is the pressure loss.



Outline Drawing



Nominal diameter		Dimensions (mm)						Weight (kg)			
D		L			h1	h2	a	JIS10K	JIS20K	ANSI150 JPI150	ANSI300 JPI300
A	B	JIS10K ANSI150 JPI150	ANSI300 JPI300	JIS20K							
25	1	230	230	230	65	50	10	4.0	6.0	4.5	6.0
40	1 1/2	240	240	240	65	50	10	7.5	8.0	6.5	9.5
50	2	250	280	280	65	50	14	9.0	9.5	9.0	11.5
80	3	314	364	376	65	50	14	12.0	15.0	14.0	18.5
100	4	362	406	416	65	50	14	17.0	22.0	21.5	30.5
150	6	477	525	535	65	50	14	40.0	48.0	49.0	59.5

Note 1: Pipe schedule selected in the model number table.

Note 2: Contraction ratio by diameter (β) selected in the model number table.

Note 3: Flange you selected in the model number table.

Note 4: The size is 1/2-inch, and pressure rating is the flange rating selected.

Note 5: Flange to use with our 1/2-inch remote-seal differential pressure transmitter.

Note 6: Values of weight apply for $\beta = 0.6$, pipe schedule 40, and 1/2-inch standard flange.
In case of JPI, the same weight as ANSI.

Caution: Treating "non-SI units" other than the "statutory units of measures" given in this document.

The term of validity for use of "non-SI units": Until the limitation of the respite for use under the new Units of Measures Act (invalid after the limitation of the respite for use).

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