

# Model SDR11F

## Elliptical Tube Flowmeter

### OVERVIEW

- The Elliptical Tube Flowmeter is a differential pressure type flowmeter which has a tapered restriction of elliptic profile in the tube and measures flow rate by differential pressure.
- The elliptical tube flowmeter is combined with a remote-sealed differential pressure transmitter and no leading pipe is required. From its structure, the elliptical tube flowmeter is free from clogging by deposits or slurries.
- It has a wide range of application such as two phase fluid containing a liquid, slurry, gas, steam, powder.
- With its tapered restriction of elliptic profile, the pressure loss is extremely less than other types of differential pressure flowmeter.



### FEATURES

#### Principle

Differential pressure( $\Delta p$ ) develops between the front part and the tube of the restriction, and this varies as the square of flow rate( $Q$ ). Therefore, the flow rate is represented by the following equation.

$$Q = k \sqrt{\frac{\Delta p}{\rho}}$$

$k$ : Flow factor

$\rho$ : Flowing density

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

#### Streamlines allowing a smooth flow

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

- The passage and tube have a structure that makes them resistant to scaling or clogging.
- Output is with excellent reproducibility due to smooth and stable streamline by elliptic tube. The rangeability of flow rate is as wide as 1 to 10, so measurement is possible down to almost zero flow rate.

- Even with a short upstream length, it provides high accuracy
- Its pressure loss is less than that of orifices ( $\frac{1}{2}$  to  $\frac{1}{4}$  for the same construction ratio) and 8 to 50 percent of the differential pressure that developed. It can reduce energy loss.
- Because of its quick response, the flowmeter can measure pulsation flow.

#### Wide pressure tapholes employed

For the pressure tapholes, larger diameters tapholes (10 to 14 mm) than the standard orifices tapholes are employed. With those large diameters to avoid clogging, the flowmeter brings about stable measurement even for fluids containing scaling or solid material.

#### Combination with $\frac{1}{2}$ in. Remote Sealed Transmitter

- It is directly to connected to the connection flange ( $\frac{1}{2}$  in.) of the sensor end of the  $\frac{1}{2}$  in. remote sealed transmitter, so no pressure leading pipe is required.
- Range configuration can be easily done by the Smart Communicator SFC.

## SPECIFICATIONS

### Accuracy

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

Beta ratio by diameter	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 the installed differential pressure transmitter)

### Size

25 mm to 150 mm (consult with Yamatake representative for 200 mm or larger.)

### pipng connection

Flanged

### Wetted materials

SS316, SS316L

### Transmitter connection

Connect to a ½ in. Remote Sealed Transmitter-specific flange or ½ in. standard flange.

## Straight pipe lengths

Table 1. The minimum straight pipe length

D: Nominal diameter

β ratio by diameter	Upstream side L <sub>1</sub>						Downstream side L <sub>2</sub>
	Elliptic tube flowmeter One 90-degree bend	Elliptic tube flowmeter Two or more 90-degree bends on a single plane	Elliptic tube flowmeter Two or more 90-degree bends not lying on a single plane	Elliptic tube flowmeter Reducer	Elliptic tube flowmeter Expansion pipe	Elliptic tube flowmeter Sluice valve (fully open)	All the joints shown to the left
0.40	0.5D	1.5D	40D	2.5D	1.5D	2.5D	0.6D
0.50	1.5D	2.5D	40D	5.5D	2.5D	3.5D	1.0D
0.60	3.0D	3.5D	40D	8.5D	3.5D	4.5D	1.5D
0.70	4.0D	4.5D	40D	10.5D	5.5D	5.5D	2.0D

Note 1: The radius of curvature in the bend shall be equal to or greater than the inner diameter of the pipe

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

## Diagram for Bore Diameter and Tube Diameter Selection

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

### How to use the diagram

#### Calculating equivalent flow rate

##### Measured fluid

Water

##### Flow rate

80 m<sup>3</sup>/h (at 15 °C)

##### Pipe diameter

100mm

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

	β ratio by diameter	Differential pressure on the diagram
(1)	D=100, β=0.7	10.5kPa
(2)	D=100, β=0.6	23kPa
(3)	D=100, β=0.5	51kPa

- Recommended β ratio = 0.6

#### Conversion of flow rate into equivalent water flow rate

##### 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).

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

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

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

$Q_{BW}$  : Water flow rate (at 15°C) [m<sup>3</sup>/h]

$Q_B$  : Flow rate of measured liquid (at 15 °C) [m<sup>3</sup>/h]

$Q_O$  : Flow rate of measured liquid (at measuring temperature) [m<sup>3</sup>/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)

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

#### Calculation example

##### Measured fluid

Gas-liquid, two-phase flow

##### Flow rate

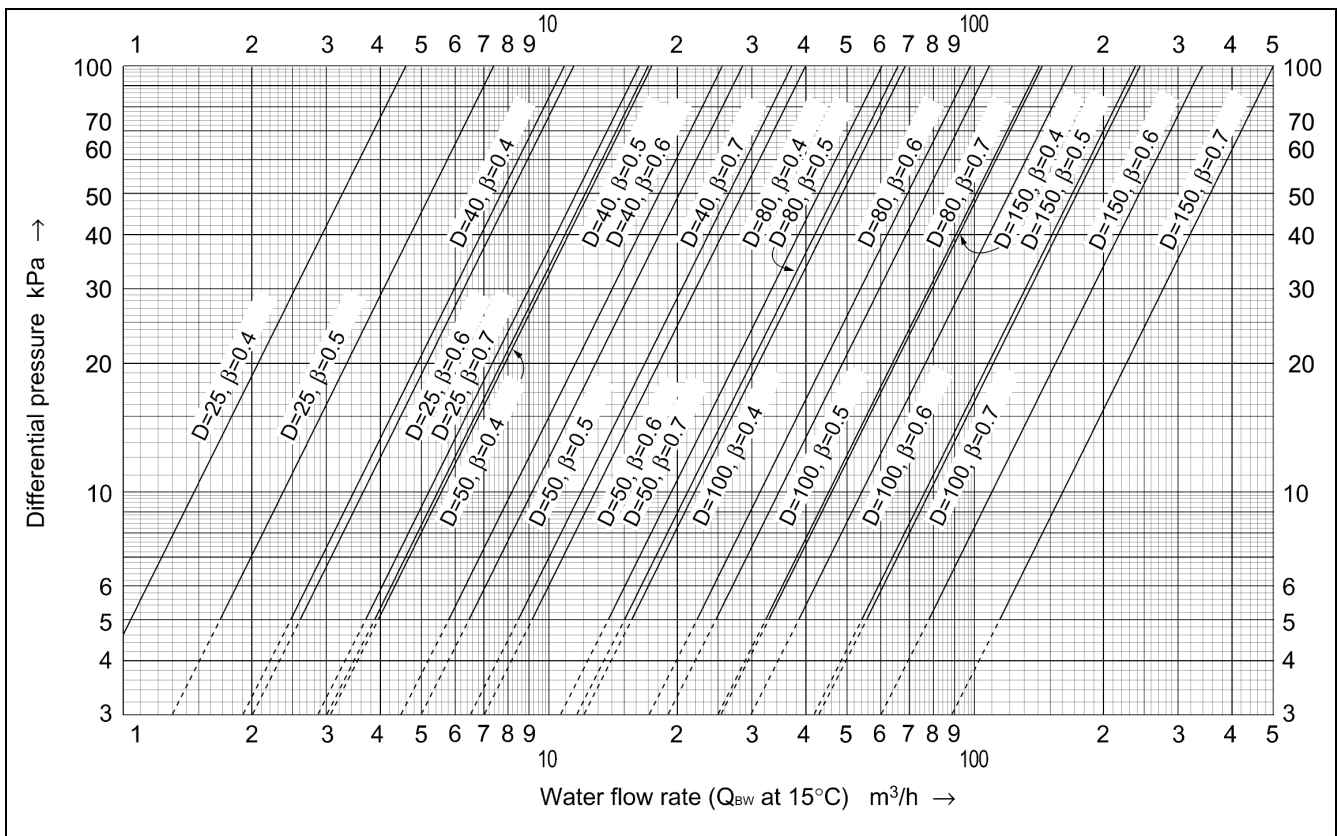
90m<sup>3</sup>/h (under measuring conditions)

##### 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]

**How to use the diagram**

**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 80mm curves with the flow rate 3000kg/h line. Select one of the three candidates (1), (2), and (3) from the table below.

	β ratio	Differential pressure on the diagram
(1)	D=80, β=0.7	10.2 kPa
(2)	D=80, β=0.6	22.5 kPa
(3)	D=80, β=0.5	50 kPa

- Recommended β ratio = 0.6.

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

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 0.7MPa saturated steam flow rate.

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

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

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

$\gamma$  : Density of steam (under measuring conditions) [kg/m<sup>3</sup>]

4.1 : Density of saturated steam at 0.7 MPa [kg/m<sup>3</sup>]

**Calculation example**

**Measured fluid**

Superheated steam

**Flow rate**

4000 kg/h (at 1.8 MPa, 300 °C)

**Fluid pressure**

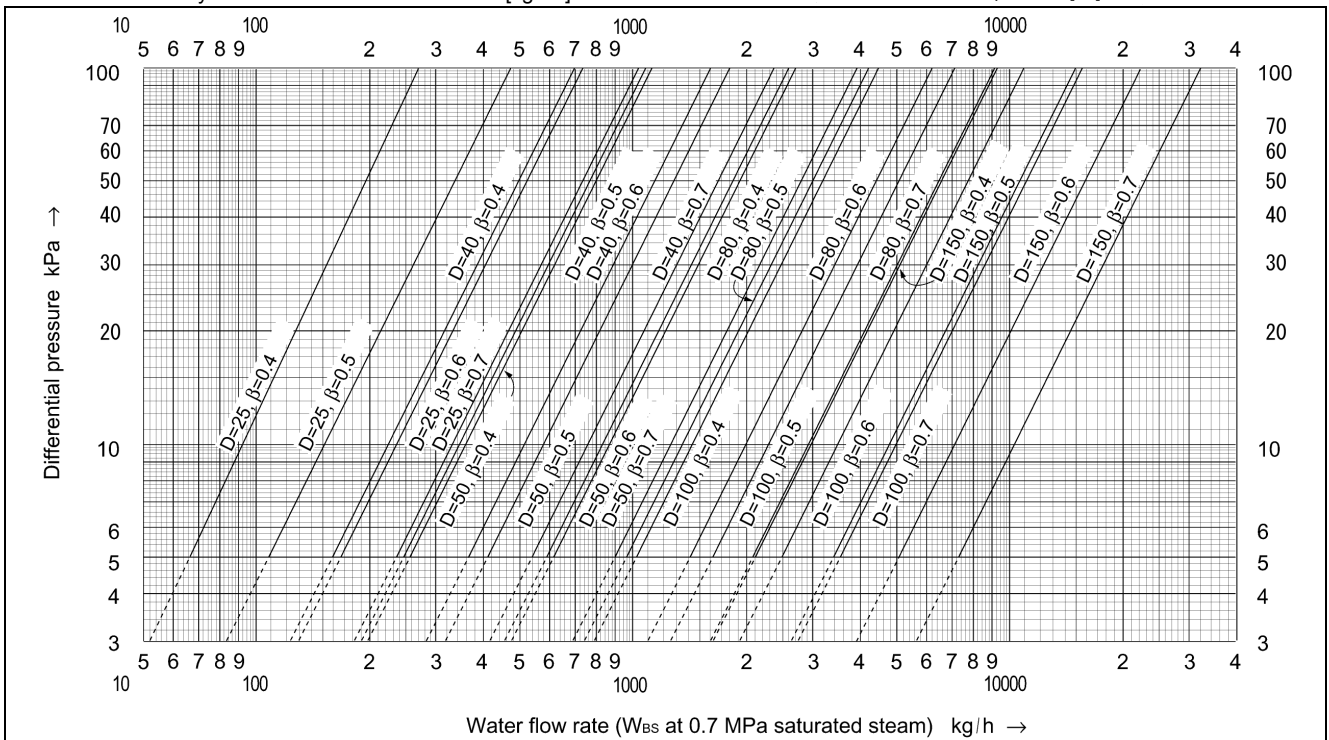
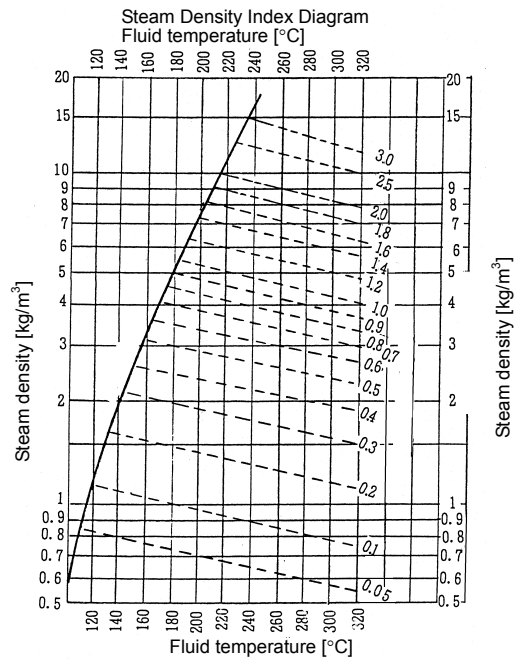
1.8 MPa

**Fluid density**

7.3 kg/m<sup>3</sup>

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.

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



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

**How to use the diagram**

**Calculation of equivalent flow rate**

**Measured fluid**

Air

**Flow rate**

8000 m<sup>3</sup>/h (at 0 °C and 101 kPa)

**Pipe diameter**

150 mm

- Look up the intersections of pipe diameter 150 mm curves with the flow rate 8000 m<sup>3</sup>/h line on the diagram. You will find two candidates (1) and (2) as shown in the table below.

	β ratio	Differential pressure on the diagram
(1)	D=150, β=0.7	32 kPa
(2)	D=150, β=0.6	67 kPa

- There are various approaches to select. Choose (if you want small pressure loss. Because the differential pressure gage has a minimum range of 0 to 2.5 kPa and maximum range of 0 to 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.

**Conversion of flow rate into equivalent air flow rate**

If the fluids 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).

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

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

$Q_{NA}$  : Air flow rate (at 0 °C and 101 kPa) [m<sup>3</sup>/h (normal)]

$Q_N$  : Flow rate of measured gas (at 0 °C and 101 kPa) [m<sup>3</sup>/h (normal)]

$Q$  : Flow rate of measured gas (under measuring conditions) [m<sup>3</sup>/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

**Calculation example**

**Measured fluid**

Gas

**Flow rate**

7000 m<sup>3</sup>/h (at measuring temperature)

**Specific gravity of fluid**

0.6

**Fluid temperature**

95 °C

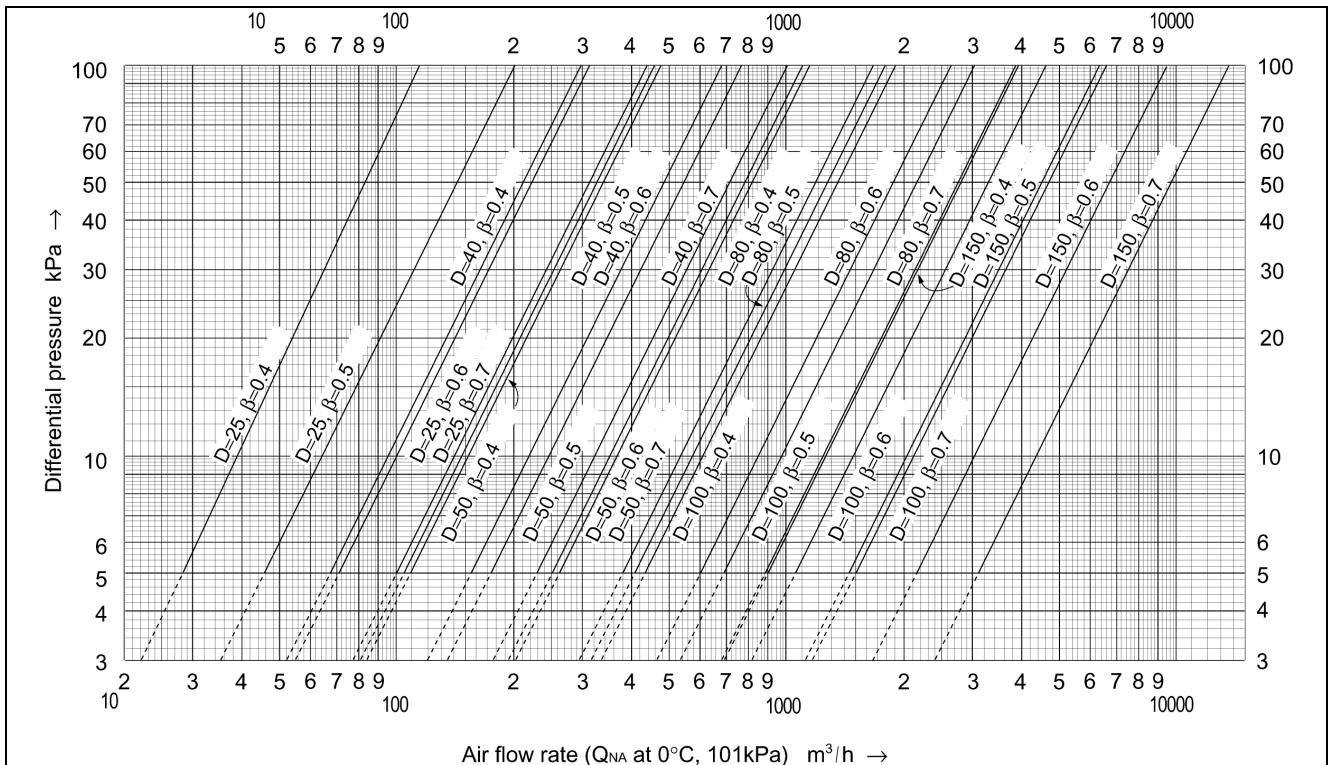
**Fluid pressure**

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).

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

$$\approx 8062 \text{ m}^3/\text{h} [N]$$



### Calculation of Pressure Loss by Elliptic Tube Flowmeter

[For liquid, gas, and steam]

#### Calculation of pressure loss

**Measured fluid**

XXXXX

**β ratio**

β=0.7

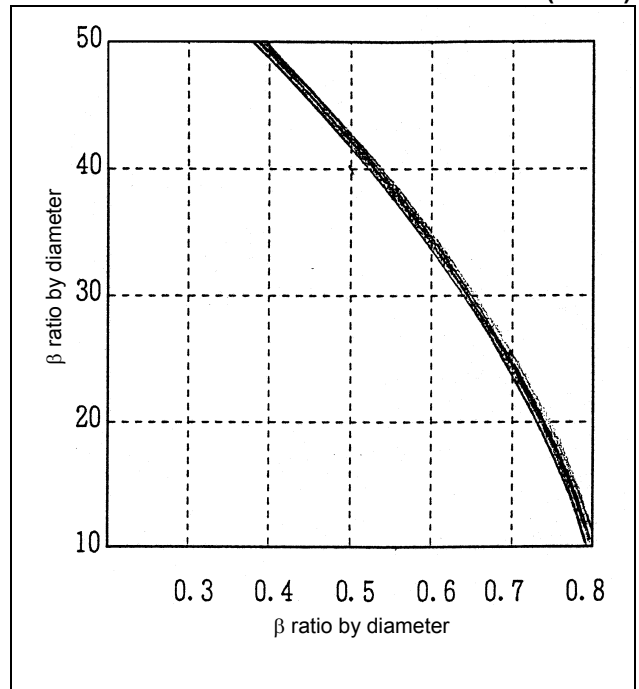
**Differential pressure**

10 kPa

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

$$10 \text{ kPa} \times 24\% / 100 = 2.4 \text{ kPa}$$

Thus, 2.4 kPa is the pressure loss



## MODEL SELECTION

Flange type (25 mm to 150 mm)

Basic model No.

SDR 11F

Selective specifications

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Optional specifications (multiple choice)

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Diameter	25mm	025	
	40mm	040	
	50mm	050	
	80mm	080	
	100mm	100	
	150mm	150	
	Piping schedule	Schedule 10	
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	SS316	B	
	SS316L	L	
Beta ratio by diameter	$\beta=0.4$	40	
	$\beta=0.5$	50	
	$\beta=0.6$	60	
	$\beta=0.7$	70	
Transmitter connection	1/2inch standard flange (the same flange rating as the selective specifications)	F	
	1/2inch Remote-specific flange with SUS630 bolts, nuts, and gaskets)	S	

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

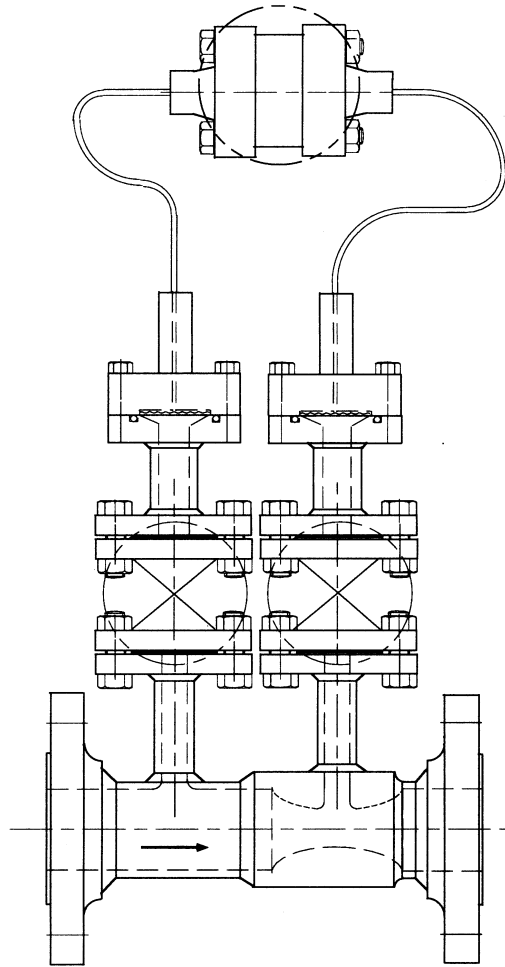
Note 1: Consult Yamatake representative for specifications other than those shown above.

Note 2: A 1/2inch Remote Sealed Transmitter is required. For the specifications, model number, and other details are in transmitter document SS2-STJ300-0100

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

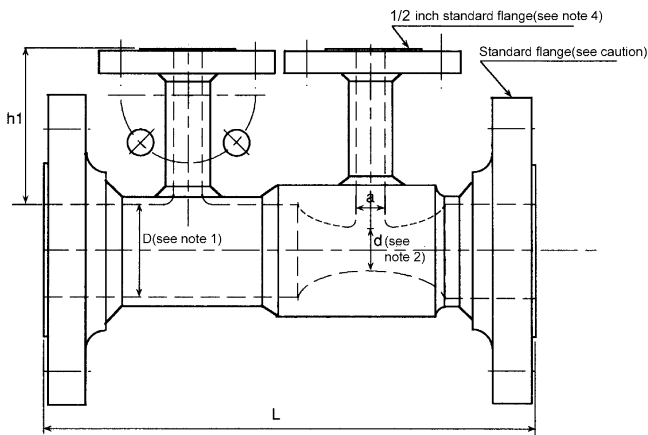
**DIMENSIONS**

**Configuration drawing**

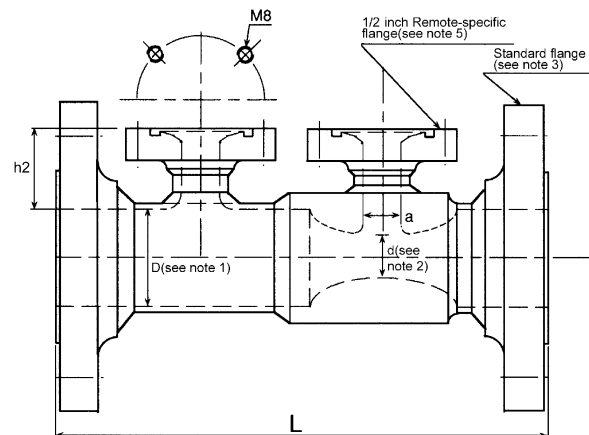


**Fig 1. Combination of SDR 11F and Remote Sealed Transmitter**

**Outline Drawing**



**Fig 2. Transmitter connection 1/2 inch standard**



**Fig 3. Transmitter connection 1/2 inch Remote-specific flange type**

**Table 1. Dimension table of SDR11F**

Nominal diameter		Dimensions (mm)						Weight (kg)			
D		L			h1	h2	a	JIS 10K	JIS 20K	ANSI 150 JPI 150	ANSI 300 JPI 300
mm	inch	JIS 10K ANSI 150 JPI 150	ANSI 300 JPI 300	JIS 20K							
25	1	230	230	230	65	50	10	4.0	6.0	4.5	6.0
40	1½	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	21.4	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 ( $\beta$ ) selected in the model number table.

Note 3: Flange you selected in the model number table

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

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

Note 6: Values of weight apply for  $\beta=0.6$ , pipe schedule 40, and 1/2inch standard flange. Incase of JPI. The sa,e weogit 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).

# Note



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