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## 1. Working Principle and property

The throttling device associated with the differential-pressure instrument is used to measure the single-phase fluid in the closed ring pipe, the principle of it is based on Bernoulli's equation and the fluid continuity equation.

### 1.1 Principle:

The throttling device shall be assembled into the ring pipe, when the fluid flows through the throttling element, the differential-pressure will appear between the upstream and downstream sides, See figure 1.

In accordance with Bernoulli's equation, the flow basic equation can be obtained by derivation.

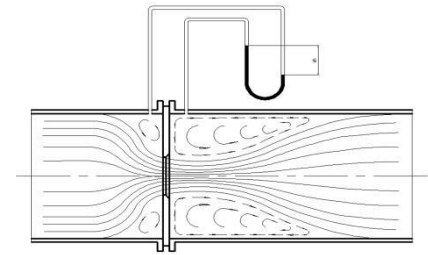


Figure 1

$$q_m = 1.2643 * \epsilon * \frac{C\beta^2}{\sqrt{1-\beta^4}} D^2 * \sqrt{\Delta P * \rho_1}$$

In the formula:  $q_m$ :-----The mass flow of the fluid (kg/h)

C:-----Output coefficient

$\epsilon$  :-----The expandable coefficient of the beam of flow after the fluid flows through the throttling element. (to liquid  $\epsilon = 1$ )

$\beta$  : -----Radial ratio ( $\beta = d/D$ , OF them d: bore diameter of the orifice, D: the inside diameter of the pipe)

$\Delta P$ :----The dp value obtained from the pressure tap side at the downstream and upstream of the throttling element. (kPa)

$\rho$  :-----The density of the fluid. (kg/m<sup>3</sup>)

The dp value shall be turned into standard current signal with dp transmitter, further, by indicating meter or data processing device, the flow and total flow of the fluid shall be displayed.

## 1.2 product Property:

1) The measurable fluid varieties with the throttling device are comprehensive, from the high-temperature and high-pressure fluid to the low-temperature and minus-pressure fluid, the throttling device is applicable comprehensively.

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- 2) The structure is simple and rigid.
- 3) The property is constant, the operation is reliable.
- 4) It is convenient to assemble, operate and maintain.
- 5) It is not in need of actual-flow calibration, this is especially important to measure the gas flow and the fluid flow in big volume.

## 2. Installation

Normally, the mode to connect the throttling device and the pipe line is welding, attention must be paid for this structure: First of all, two sections of nipples that are same as the processing pipe line shall be selected, the length shall be between 100-500mm, the end face of the nipples should be plane, they shall be firmly welded in butt welding to the two flanges associated with the throttling device respectively, then, the throttling device with a section of nipple shall be welded in butt welding to the processing pipe line.

### 2.1 Basic Requirements

- 1) For the new pipe, the line-cleaning must be done before the assembly of the throttling device, to prevent the damage or block of the orifice plate by the dregs inside the pipe.

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- 2) Before assembly, the verification must proceed for whether the type, specification of the throttling device are in conformity with the date of the condition of the pipe, flow range etc .or not the end marked with “+” near pressure tap should be connected with the upstream pipeline of the fluid the end marked with “-” should be connected with the downstream pipeline of the fluid .
- 3) The central line of the throttling device should be coaxial with the central line of the pipe, the uncoaxality should not be over  $0.015D(\frac{1}{\beta}-1)$ , of them , D is inside diameter,  $\beta$  is bore ratio.

The position of the pressure tap principally be able to ensure (when to measure the flow of gas medium) automatic drainage or (when to measure the flow of liquid medium) automatic ventilation, i.e. When to measure the liquid , the pressure tap should be selected in 45° at the down part , When to measure the gas, the pressure tap should be selected in 45° at the up part , when to measure the gas flow with impurity , it should

be near the vertical orientation . See figure 2

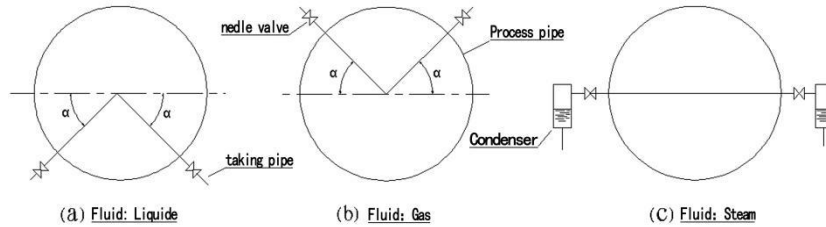


Figure 2

## 2.2 The requirements to the piping

- 1) The throttling device should be assembled between the two sections of straight pipes with equivalent cross-section , the deviation of the diameters of the nipples at upstream and downstream and the average inside diameter in the length range of 2 DN at least from the upstream end face of the orifice should be  $\leq 0.3\%$ .
- 2) The medium must be full of the pipe near the throttling device (including the front and rear nipples); If it is necessary to install an isolating valve, the gate valve should be selected and it must keep full open during the operation; If it is necessary to install

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a regulating valve, it should be installed after the nipple of 5DN at the downstream.

3) In the range of the nipples of the restricting elements at up and down streams, there should be no prominent washer in the pipe; Any situation that interferes the flow should be prevented. (e. g. the input and output of the fluid)

4) At the upstream and downstream of the throttling device, it must be ensured that the minimum nipple and the mode of the resistant parts at the upstream is relevant to the diameter ratio of the restricting parts.

The length of the minimum nipple at upstream and downstream sides of the throttling device

(to indicate in multiples of D)

$\beta$	The Mode of the Part Resistant Element and the Minimum Nipple Length at the Upstream Side of the Orifice Plate						The length of the minimum nipple at the downstream of the restricting element
	One 90° bend or a tee flowing only in one branch	There are multiple 90° bends in one plane	Void bends (there are multiple 9° bends in various plane)	Reducing tube (turning into D from 2D, length $\geq 3D$ ; turning into D from 0.5D, length $\geq 1.5D$ )	Full-open stop valve	Full-open gate valve	
$\leq 0.20$	10 (6)	14 (7)	34 (17)	16 (8)	18 (9)	12 (6)	4 (2)
0.25	10 (6)	14 (7)	34 (17)	16 (8)	18 (9)	12 (6)	4 (2)
0.30	10 (6)	16 (8)	34 (17)	16 (8)	18 (9)	12 (6)	5 (2.5)
0.35	12 (6)	16 (8)	36 (18)	16 (8)	18 (9)	12 (6)	5 (2.5)
0.40	14 (7)	18 (9)	36 (18)	16 (8)	20 (10)	12 (6)	6 (3)



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0.45	14 (7)	18 (9)	38 (19)	18 (9)	20 (10)	12 (6)	6 (3)
0.50	14 (7)	20 (10)	40 (20)	20 (10)	22 (11)	12 (6)	6 (3)
0.55	16 (8)	22 (11)	44 (22)	20 (10)	24 (12)	14 (7)	6 (3)
0.60	18 (9)	26 (13)	48 (24)	22 (11)	26 (13)	14 (7)	7 (3.5)
0.65	22 (11)	32 (16)	54 (27)	24 (12)	28 (14)	16 (8)	7 (3.5)
0.70	28 (14)	36 (18)	62 (31)	26 (13)	32 (16)	20 (10)	7 (3.5)
0.75	36 (18)	42 (21)	70 (35)	28 (14)	36 (18)	24 (12)	8 (4)

Remarks: the digits outs of the brackets are the minimum nipple length without adding the error, the digits in the brackets shall add ceiling error of  $\pm 0.5\%$ .

### 2.3 the requirement to the tapping lead-out pipeline

1) The inside diameter of the pressure-leading pipe is relevant to the length pipeline, normally, the pipe with the bore of 12-16mm shall be used in the length of 45m (see the following table)

Measured Fluid	Inside Diameter (mm) Length (m)	<16	16-45	45-90
	Water, steam, dry gas		7-10	10
Wet gas		13	13	13
Oil with Low-Medium Viscosity		13	19	25
Dirty Liquid or Gas		25	25	38

2) The nipples led out from the pressure tap should be in an identical level, if the throttling device should be installed to the vertical pipe, a certain distance should be kept between the pressure-lead nipples (vertical direction), it has an impact on the zero point of the differential pressure transmitter, it should be rectified by zero point

transport.

3) The dp pipeline should be supported by a firm racket, preventing over loading and vibration, at the same time, to avoid the tapping error resulted by differential temperature, the two Pieces of tapping pipelines should be as possible and wrapped with insulating material, in the cold season, associated hear should be provided to avoid freeze.

4) On the pipeline of the dp signal, there should be no baggy space that may retain liquid or gas, if it can' t be avoided, the gas collector (or exhaust valve) and settling vessel (or hydrophobic device) should be established. When the dp pipeline is very long (over 30m), it should be declined in section and the gas collector (or exhaust valve) and settling vessel (or hydrophobic device ) should be established in various section.

### **3. Operation and Maintenance**

#### **3.1 Operation**

1) The throttling device must be applied with the dp transmitter, only in this way, the flow can be obtained. With the view of adjusting the zero point at the local site, ”

three-valve group” must be added at the pressure-lead pipe of the dp transmitter, the method to apply can be found in the instruction manual of the transmitter.

2) With the view of knowing the dp value of the actual flow by measurement, beside correctly laying tapping pipeline, furthermore, keeping the conducting medium in the tapping pipeline in single phase state (liquid phase or gas phase) should be made, i. e. When the flow of liquid medium is measured, the tapping pipeline must be full of liquid, there should be no gas in it; when the flow of gas medium is measured, the tapping pipeline must be full of gas, there should be no condensed liquid in it. for this, the gas collector or setting device can be added to collect the gas in the liquid (exhaust in period) or liquid in the gas (drain in period).

3) Whether the design data to the throttling device is in conformity with the actual condition or not is directly relevant to the measuring accuracy. When the throttling device is put into use, if the measured data is in the range of design parameters, normally, the measuring accuracy can not be over the designed calculated accuracy; but, if the measured data are far away from the range of the design parameters (assuming the selection, fabrication, assembly of the throttling device and the dp transmitter are all in

conformity with the requirements) maybe, there is something wrong with the provided design data, then, the design data should be revised, the calculated result shall be redesigned.

4) During the ope change of the processing conditions results the change of the fluid data, the auto-trace compensation of temperature and pressure should be adopted, or, the measuring error shall be brought about. At present, many types of intelligent flow displays have appeared on the market, the medium temperature, pressure, the medium density, compressing coefficients, flow factors under standard conditions (output factors) etc. can be input to ensure the precise measurement of the throttling device.

### **3.2 Maintenance**

The working property of the orifice plate is pretty reliable, the normal faults are pressure tap block, pressure-lead pipe block or leak, the pressure tap, pressure-lead pipe should always be rinsed or blown down, various sealing joints should always be fastened. When the ambient temperature is below 0°C, the tapping nipple should be wrapped with insulating material or the heat-associating pipeline should be laid. When the high temperature medium is measured, the condenser or insulator should be added, to prevent

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the high temperature medium enters into the pressure-testing vessel of the dp transmitter.

#### 4. Local Preservation and Storage

The place to preserve the instrument should be possessed of the following conditions:

- a) Rain and moisture proof;
- b) Without mechanic vibration, and preventing the shock;
- c) Temperature range:  $-10^{\circ}\text{C} \sim +400^{\circ}\text{C}$ ;
- d) The humidity is  $\leq 80\%$ ;
- e) Avoiding open preservation.