YSJL
Throttling device
User manual

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1. Product Purpose and Scope of Application

1.1 Features

In industries such as petroleum, chemical, metallurgy, power, light industry, textiles, scientific research, and military sectors, throttling devices remain extensively used for fluid flow measurement, control, and regulation throughout production processes. Although new instruments like electromagnetic flowmeters and vortex flowmeters have emerged in recent years, throttling devices still dominate the market due to their advantages of simple structure, robustness, reliable operation, stable performance, moderate accuracy, and cost-effectiveness. The differential pressure transmitter, a critical component of throttling devices, converts the pressure difference generated by these devices into standard 4~20mAD.C current signals. With a wide variety of specifications and models available, differential pressure transmitters can meet diverse user requirements. Notably, the newly developed intelligent differential pressure transmitters integrated with throttling devices not only simplify installation by eliminating the need for pipeline laying but also offer significant benefits. These advanced transmitters enable automatic temperature and pressure compensation, fault diagnosis, wide measurement ranges, on-site range adjustment, and communication with upper-level computers, thereby expanding the application scope of throttling devices.

Throttling devices include standard orifice plates, standard nozzles, long-diameter nozzles, classic Venturi tubes, Venturi nozzles, annular orifice plates, quarter-circular nozzles (quarter-circular orifice plates), conical inlet orifice plates, semicircular orifice plates, eccentric orifice plates, double orifice plates, low-pressure loss flow tubes, rectangular Venturi tubes, V-cone flow meters, wedge flow meters, built-in orifice plates, and flow-limiting orifice plates. For fluids with low Reynolds numbers or containing impurities, non-standard throttling devices may be selected.

1.2 The throttle device shall meet the following fluid conditions

1.2.1 The fluid must fill the pipeline and the flow is continuous.

1.2.2 The fluid must be a Newtonian fluid (e.g., ordinary water, acids, alkalis, superheated steam, various gases, or dry saturated steam). The fluid should not undergo phase changes (from liquid to gas or vice versa) near the throttling device. The fluid must be single-phase (gas or liquid) or can be considered single-phase, such as gas flows containing no more than 2% (by mass) uniformly dispersed solid particles, or liquid flows containing no more than 5% (by volume) uniformly dispersed bubbles.

1.2.3 Before the fluid flows through the throttle device, its flow must be parallel to the axis of the pipeline, and there must be no rotating flow or eccentric flow, and no pulsating flow or critical flow.

2. Working Principle, Structure, and Parameters

2.1 Principles

The throttling device is installed in the round pipe. When the fluid flows through the throttling device, the pressure difference between the upstream and downstream sides will be generated. According to the Bernoulli equation, the basic flow equation can be derived:

$$q_m = 0.12643 * \varepsilon * \frac{c\beta^2}{\sqrt{1-\beta^4}} * D^2 * \sqrt{\Delta P * \rho_1} \quad \cdots\cdots\cdots\cdots (1)$$

where: qm:..... mass flow rate of the fluid (Kg/h)

C:..... outflow coefficient

ε :.....the flow expansion coefficient of the fluid after passing through the throttling device (for liquids, ε =1)

β :..... the diameter ratio (β = d/D, where d is the orifice plate diameter (mm) and D is the pipeline inner diameter (mm))

D:..... Inner diameter of the measuring pipeline (operational state) (mm)

△P: Differential pressure (in kPa) measured at the upstream and downstream pressure taps of the throttling device

ρ 1: Density of the fluid (in upstream conditions of the throttle device) [Kg/m³]

The differential pressure transmitter converts the differential pressure value △P into a standard current signal, and then displays the flow rate or total amount of the fluid through the display instrument or data processing device.

2.2 Structure and Parameters

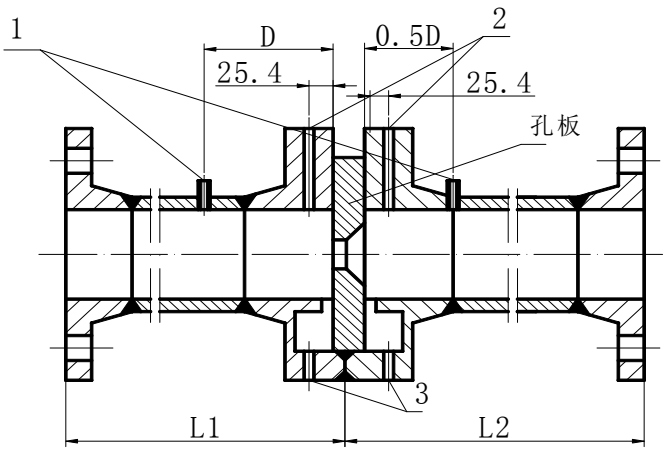
Their principles are basically the same, but the structure is different. The following are the structure and parameters of several commonly used throttle devices.

2.2.1 Standard orifice plate:

This is the most widely used standard orifice device with the broadest range of specifications. It is extensively applied in fluid flow measurement, particularly for gas flow measurement. The structure of the orifice plate varies depending on nominal pressure, nominal diameter, and pressure tapping method. Standard orifice plates are classified into three types based on common pressure tapping methods: angle tapping (including ring chamber tapping and separate drilling tapping), flange tapping, and radial tapping (D and D/2 tapping).

Its design and manufacturing comply with ISO5167 or GB/T2624 standards, and are verified according to the national standard JJG640-94.

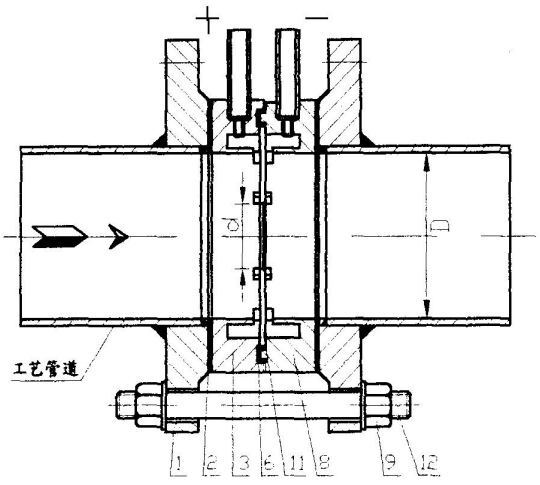
The above three pressure taking methods and pressure taking positions are shown in Figure（1):



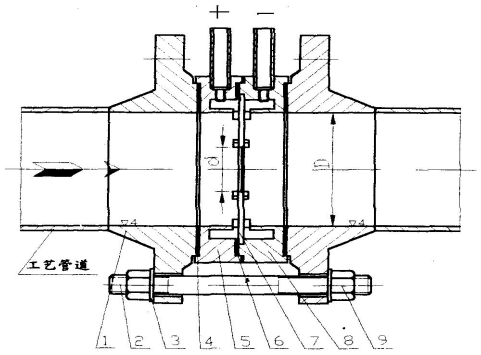
Figure（1） Schematic diagram of pressure measurement method and location
1. Span gauge (D/D/2 type) 2. Flange gauge 3. Corner joint (annular chamber) gauge

(1) Conditions for pressure tapping: d≥12.5mm, DN: 50 mm to 1600 mm, β =0.20 to 0.75

a. For chamber-type pressure tapping (DN≤400), refer to Figure（2） for structures with nominal pressure PN≤2.5MPa, Figure（3） for those with nominal pressure PN≤6.3MPa, Figure（4） for structures with nominal pressure PN≤10MPa, and Figure（5） for those with nominal pressure PN≤20MPa.

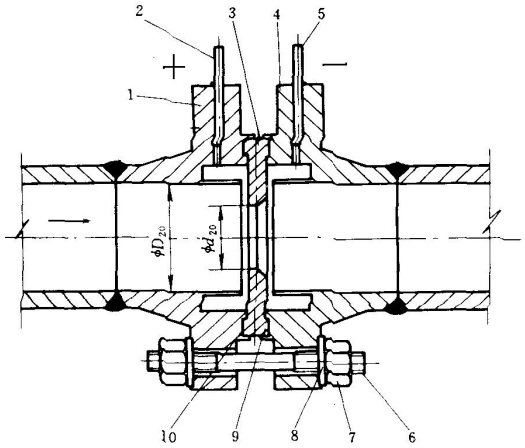


1. Flat welded flange 2. Gasket 3. Positive chamber 6. Gasket 8. Negative chamber 9. Nut 11. Standard hole plate 12. Double-ended bolt
Figure（2） Schematic diagram of the standard orifice plate structure and installation for chamber pressure measurement
（DN≤400，PN≤2.5MPa）



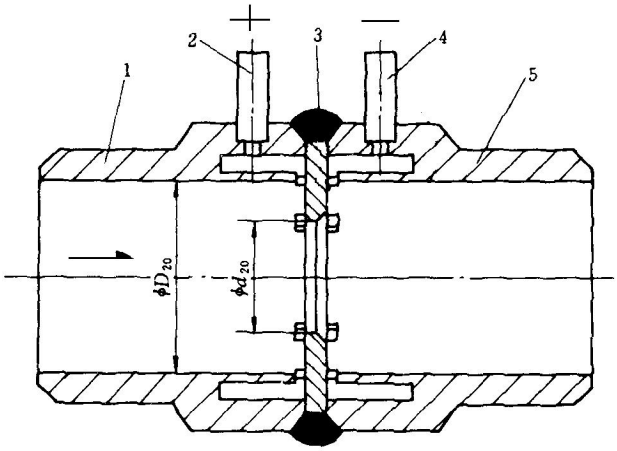
1. Butt-welded flange 2. Double-ended bolt 3. Washer 4. Spacer 5. Positive chamber 6. Spacer 7. Standard hole plate 8. Negative chamber 9. Nut

Figure（3）Schematic diagram of the standard orifice plate structure and installation for chamber pressure measurement （DN≤400，PN≤6.3MPa）



1. Ring chamber flange 2. Pressure tap tube 3. Standard orifice plate 4. Ring chamber flange 5. Pressure tap tube 6. Double-ended bolt 7. Nut 8. Washer 9. Gasket 10. Gasket

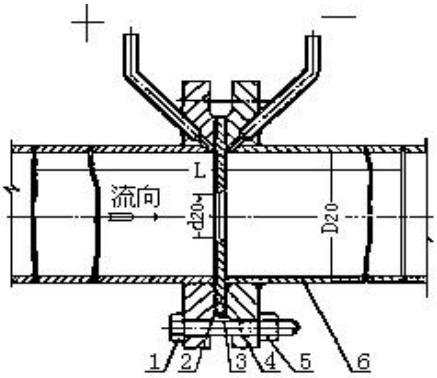
Figure（4）Schematic diagram of the standard orifice plate structure and installation for chamber pressure measurement （DN≤400，PN≤10MPa）



1. Front chamber 2. Pressure tap 3. Standard orifice plate 4. Pressure tap 5. Rear chamber

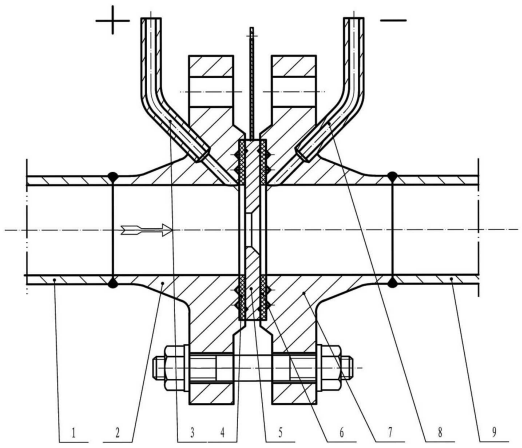
Figure（5）Schematic diagram of the standard orifice plate structure and installation for chamber pressure measurement （DN≤250，PN≤32MPa）

b. For individual borehole pressure testing (DN unrestricted), refer to Figure（6） for structures with DN≤1600 and nominal pressure PN≤2.5MPa; Figure（7） for DN≤400 with nominal pressure PN≤6.3MPa; and Figure（8） for DN≤200 with nominal pressure PN≤32MPa.



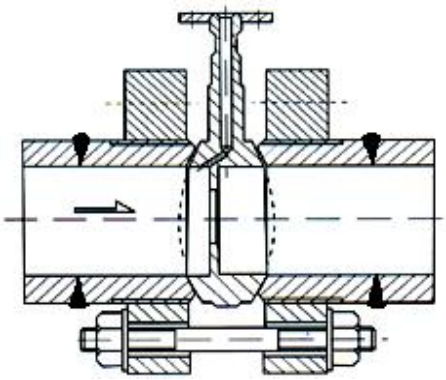
1. Bolt or stud 2. Washer 3. Standard hole plate 4. Flange 5. Nut, washer 6. Pipe

Figure（6）Schematic diagram of the standard orifice plate structure and installation for isolated borehole pressure measurement（DN≤1600，PN≤2.5MPa）



1. Front straight pipe section 2. Positive pressure flange 3. Positive pressure pipe 4. Gasket 5. Standard orifice plate 6. Gasket 7. Negative pressure flange 8. Negative pressure pipe 9. Rear straight pipe section

Figure（7）Schematic diagram of the standard orifice plate structure and installation for isolated borehole pressure measurement（DN≤400，PN≤6.3MPa）



Figure（8）Schematic diagram of the standard orifice plate structure and installation for isolated borehole pressure measurement High-pressure lens plate (DN≤200, PN≤32MPa)

(2) Flange pressure

Flange pressure tapping offers distinct advantages over socket tapping, including simplified assembly, easier installation, and effective dirt removal at the tapping port. It is widely adopted in industries such as oil refining and chemical processing for flow measurement, control, and regulation of various media. The industry generally recommends using flange pressure tapping.

Conditions for using flange pressure:

d≥12.5mm，DN：50 mm～1000 mm，β=0.20～0.75

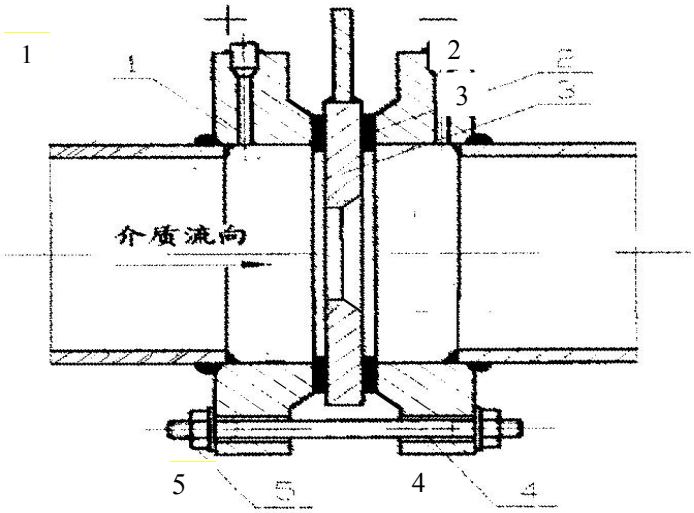
The following structures are adopted according to the different nominal pressure:

The structure of DN≤1000,PN≤2.5MPa is shown in Figure (9);

The structural design for DN≤500 and PN≤4MPa is shown in Figure (10).

The structural design for DN≤400 and PN≤10MPa is shown in Figure (11).

The structural design for DN≤250 and PN≤32MPa is shown in Figure (12).



1. Flat welded flange 2. Gasket 3. Standard hole plate 4. Double-ended stud 5. Nut

Figure (9) Schematic diagram of standard flange pressure tap and its installation
（DN≤1000，PN≤2.5MPa）

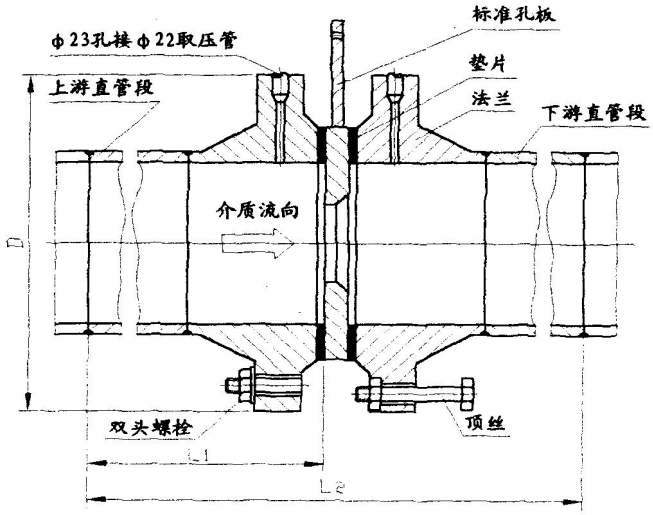


Figure (10) Schematic diagram of standard flange pressure tap and its installation
（DN≤500，PN≤4MPa）

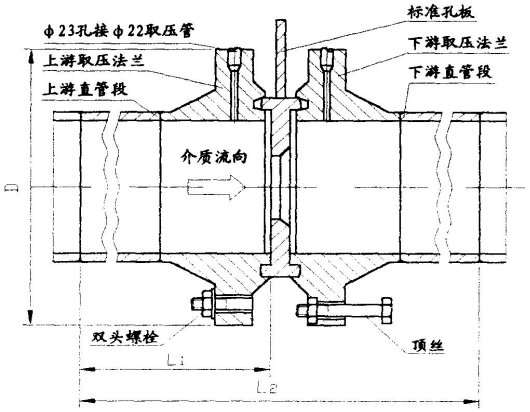


Figure (11) Schematic diagram of standard flange pressure tap and its installation
（DN≤400，PN≤10MPa）

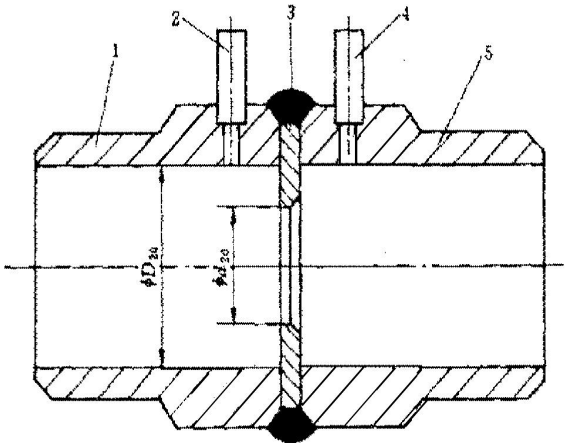


Figure ⑿ Schematic diagram of standard flange pressure tap and its installation
（DN≤250，PN≤32MPa）

⑶ Track gauge pressure

The gauge pressure method is less commonly used than the two above methods. It is best for users to order a complete set of perforated plates with front and rear straight pipe sections and pressure gauges, which will be very convenient for installation.

Conditions for using the radial distance pressure method:

d≥12.5mm，DN：50 mm～1600 mm， β =0.20～0.75

Please see Figure ⑬ and Figure ⑭ for the structure and installation diagram:

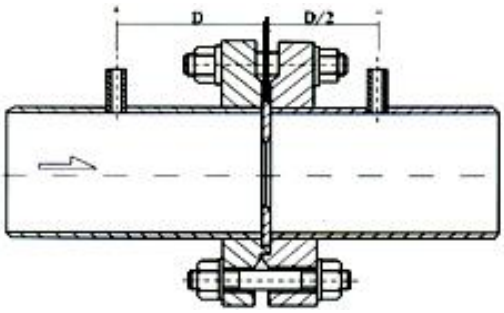


Figure ⑬ Schematic diagram of standard orifice plate structure and installation with spacing
（DN≤1600，PN≤2.5MPa）

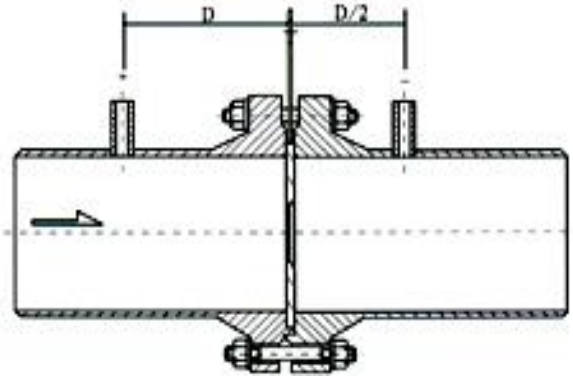


Figure ⑭ Schematic diagram of standard orifice plate structure and installation with spacing
（DN≤500，PN≤4MPa）

2.2.2 Ring Plate

I. Product use and scope of application

This patented annular orifice plate is designed for diverse fluid media including saturated steam, superheated steam, compressed air, various gaseous fuels, furnace exhaust gases, cooling water, heavy oil, residual oil, fuel oil, condensate, and corrosive chemical solutions. Beyond the standard orifice plate's inherent advantages of simple structure, robustness, and ease of installation, it offers the following distinctive benefits:

(1) More suitable for measuring saturated steam, superheated steam, gas, cooling water and other dirty fluids

Piping systems for steam transportation often contain impurities like rust, while gas and cooling water pipelines

harbor even more contaminants. Since impurities flow at slower velocities than the main stream and tend to accumulate near pipe walls, standard orifice plates used for flow measurement create flow patterns where impurities settle upstream and downstream. This not only disrupts the velocity distribution of fluid passing through the orifice plate, compromising measurement accuracy, but also causes blockages in the stagnation zone pressure taps, affecting normal operations. In contrast, our product's innovative design features central obstruction with peripheral flow. This configuration allows impurities to pass freely without hindering flow, while preventing blockages in the unobstructed pressure tap zone. Consequently, it enhances measurement precision and operational reliability while significantly reducing maintenance workload for instrumentation technicians.

On the other hand, steam pipeline systems inevitably experience steam interruptions, causing condensation. The standard orifice plate's "intermediate flow, peripheral obstruction" structure leads to condensate accumulation on both sides (the small-sized "drain holes" on the plate are prone to clogging and ineffective). During steam operation, the system must carry away accumulated water from both sides of the plate to establish proper static pressure differentials. This process can take tens of minutes, resulting in significant measurement errors—particularly during frequent steam interruptions, where inaccuracies may exceed 50%.

The unique design of this ring-shaped orifice plate, featuring "peripheral flow with central obstruction", ensures efficient condensate drainage during steam shutdown. When steam resumes flow, it rapidly establishes precise static pressure differentials before and after the orifice plate, eliminating residual errors caused by steam interruption. This configuration makes it a superior choice for measuring saturated and superheated steam compared to standard orifice plates, particularly in applications requiring frequent steam shutdowns.

(2) It is easier to adapt to the flow measurement of high temperature and high pressure fluid

When high-temperature fluids such as steam, gas, hot air, or fuel oil flow through standard orifice plates, the plate's perimeter is fixed within grooves on the ring chamber or flange. The stainless steel plate's thermal expansion coefficient typically exceeds that of the carbon steel groove. During high-temperature operation, the plate expands more than the groove. With the outer edge rigidly constrained, the excess expansion is accommodated by deformation of the plate's internal orifice (forming a bell-shaped structure). This deformation alters the orifice's internal geometry, significantly affecting the discharge coefficient and consequently compromising measurement accuracy.

The two sides of the ordinary orifice plate serve as the sealing function at the same time. When measuring high-pressure fluid, the sealing surface of the orifice plate has high requirements, and sometimes the lens pad orifice plate is used, so that the price of this throttle device is multiplied, and the replacement of the sealing parts in each maintenance greatly increases the maintenance cost, which increases the burden of users.

This patented product employs a ring-shaped orifice plate for high-temperature fluid measurement. The peripheral configuration of the flow measurement plate maintains a free state, where thermal expansion only alters external dimensions (which can be precisely calculated) without affecting edge sharpness or shape. Consequently, the discharge coefficient remains unchanged, ensuring measurement accuracy. When measuring high-pressure fluids, the orifice plate's installation within pipelines eliminates dependence on static pressure levels, keeping manufacturing costs relatively low. The primary considerations are pipe dimensions, flange specifications, material selection, and welding techniques, which prevents significant price increases. As a result, the ring-shaped orifice plate for high-pressure applications is priced lower than standard high-pressure orifice plates of equivalent specifications.

(3) More reliable and accurate than circular and eccentric perforated plates

Traditional methods using circular/oval perforated plates and eccentric perforated plates for measuring dirty fluids have two major limitations: they cannot effectively prevent pressure tap blockages, and their measurement accuracy is compromised due to manufacturing precision issues and geometric similarity challenges. In contrast, annular perforated plates not only reduce pressure tap clogging risks but also offer superior measurement accuracy through their simplified geometry, enabling precise machining and assembly. These advantages make this product a complete replacement for conventional circular/oval and eccentric perforated plates.

(4) Corrosion-resistant fluid flow measurement at lower cost

Due to the special structure of this product, it can be made of materials with strong corrosion resistance (such as

plastic), low cost, and wide range of temperature and pressure. In some cases where the flow rate does not change more than 4 times, the price of electromagnetic flowmeter is too high. The corrosion-resistant ring hole plate of this product can be selected.

(5) Due to the simple external shape of this product, it is easy to make a jacket insulation type

By introducing steam into the jacket, condensation or adhesion of measured fluids (such as heavy oil or residual oil) in the measuring section can be prevented. The application of coolant prevents vaporization-prone liquids (e.g., liquid ammonia) from forming two-phase flow when passing through the flow plates. Structurally, this design is simpler, more cost-effective, and offers a wider range of specifications compared to metal tube rotameters.

(6) The use of uniform pressure ring structure reduces the source of measurement error

The differential pressure transmitter is led to the average value of the static pressure of the cross section of the pressure pipe at the upstream and downstream of the flow measurement plate, which weakens the influence of the velocity distribution distortion formed by the local resistance of the upstream on the accuracy, and the actual accuracy is closer to the basic accuracy.

(7) Low front and rear straight pipe section requirements

The orifice plate (annular orifice plate) features a measuring tube section, which is preferable to standard orifice plates welded directly to process pipelines as welding slag can easily enter the tube or create vortex disturbances at joints. Typically, a 3DN upstream and 2DN downstream section suffices for measurement requirements. When upstream components include 90° elbows or partially open valves, maintaining at least 5DN upstream and 3DN downstream straight pipe sections is recommended to enhance measurement accuracy. In the 1930s, American scholar Howell first proposed this design. Subsequent experiments conducted by the National Engineering Laboratory (NEL) in the UK during the 1960s demonstrated that under severe rotational flow conditions, the discharge coefficient variation for standard orifice plates reaches 25%, while that for annular orifice plates remains below 1%. This indicates the annular orifice plate requires no extended straight pipe sections and can operate effectively under harsh pipeline conditions—a significant advantage beyond its capability to function in contaminated gas media.

(8) Adopt the integrated structure to reduce the laying of pipelines

The integrated annular orifice plate flowmeter combines a throttling device with a differential pressure transmitter into a single unit. This design not only simplifies installation by eliminating the need for pipeline laying, but also ensures high reliability with minimal maintenance. Its compact structure and straightforward setup make it easy to install. When paired with an intelligent differential pressure transmitter, the system allows convenient range adjustment via a handheld controller. The digital communication feature further expands the measurement range to 1:13.

Note that when installing, if the measured medium is gas, the head is installed upward, and if the measured medium is liquid and steam, the head is installed downward.

(9) The differential pressure transmitter with remote transmission diaphragm box can measure the flow of dirty fluids such as pulverized coal and residual oil

2. Usage conditions and technical parameters:

(1) Nominal diameter (mm): 50-2600 (larger diameter can be negotiated)

(2) Nominal pressure (MPa): ≤42

(3) Measurable Reynolds number (ReD) range for the fluid:

Standard type: 4×10^3 to 1×10^7 ; High viscosity type: 1×10^3 to 1×10^5 (calibrated)

(4) Accuracy (uncertainty of discharge coefficient):

Real flow calibration: ±1%, ±1.5%; sampling calibration: ±2.5%

(5) Connection mode:

Flange connection; welded connection

III. Working Principle and Structure

(1) Principle

This product – the annular orifice plate throttling device – operates on the same fundamental principles as standard orifice plates, based on the continuity equation of fluid and Bernoulli's equation. When installed in a circular pipe, the device creates a pressure difference between upstream and downstream sections as fluid flows through (see Figure 15). Through Bernoulli's equation derivation, the basic flow rate formula can be obtained:

$$\cdots \quad q_m = 0.12643 * \varepsilon * \frac{c\beta^2}{\sqrt{1-\beta^4}} * D^2 * \sqrt{\Delta P * \rho_1} \quad \cdots\cdots\cdots\cdots.\quad\cdots.\quad (2)$$

$$q_m = 0.12643 * \varepsilon * \frac{c\beta^2}{\sqrt{1-\beta^4}} * D^2 * \sqrt{\Delta P * \rho_1}$$

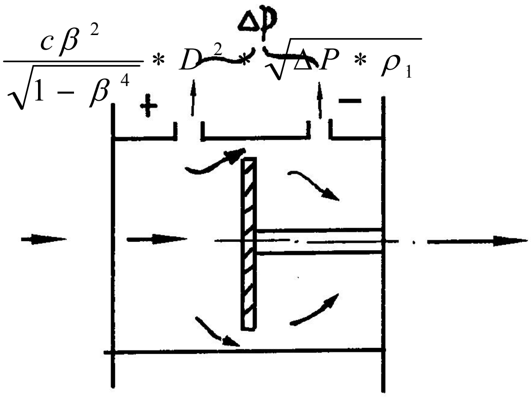


Figure (15) Working principle diagram of annular orifice plate

where: qm:......mass flow rate of the fluid (kg/h)

C:......outflow coefficient

ε :......the flow expansion coefficient of the fluid after passing through the throttling device (for liquids, ε =1)

β :...... the diameter ratio (β = d/D, where d is the equivalent aperture of the orifice plate (mm) and D is the pipe's inner diameter (mm))

D:... Inner diameter of the measuring tube (operational state) (mm)

△P: Differential pressure (KPa) measured at upstream and downstream ports of the throttling device

ρ 1: Density of the fluid (Kg/m^3) under upstream conditions of the throttling device

The flow measurement plate, correctly designed, calculated and manufactured, forms a barrier in the fluid. When the flow rate is qm, the differential pressure is generated as △P. The differential pressure transmitter converts the differential pressure value △P into a standard current signal, which is then displayed by the display instrument or data processing system to show the flow rate or total amount of the fluid.

(2) Structure

The patented annular orifice plate throttling device shares fundamental principles with standard orifice plates but demonstrates a radically different structural design. The annular orifice plate incorporates a built-in measuring tube, with a coaxial flow measurement plate fixed at its center. The upstream support ribs are staggered relative to the pressure taps, ensuring negligible obstruction to downstream fluid flow while maintaining complete unimpeded upstream flow. This configuration enables fully axially symmetric velocity distribution, facilitating geometric and dynamic similarity to enhance measurement accuracy. Figure (17) illustrates a gas-specific model with a pressure equalizing ring, suitable for applications with irregular upstream velocity profiles (e.g., near local resistance components like elbows or valves). Four evenly distributed pressure taps across the cross-section measure hydrostatic pressure. Asymmetric velocity distribution generates differential static pressure that is first concentrated within the equalizing ring, then homogenized before being transmitted to the differential pressure transmitter. This process effectively mitigates velocity distribution distortions caused by upstream resistance. Figure (18) shows the jacketed insulation variant, where steam (for thermal insulation) or coolant (for cooling) circulates through the outer casing. This design prevents viscous fluids from adhering to the measuring tube or flow plate, while protecting volatile liquids from vaporization due to sudden static pressure drops downstream.

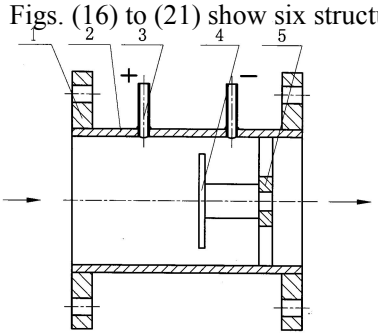
When measuring contaminated fluids like gas or circulating water, the specialized model with the

pressure-balancing ring shown in Figure (17) demonstrates significant advantages. The impurities in the fluid not only avoid accumulating on both sides of the flow measurement plate, but also reduce the risk of simultaneous blockage and differential pressure measurement failure when contaminants already adhere around the pressure ports. The four pressure ports design significantly lowers the probability of simultaneous clogging. Regular drainage through the discharge port effectively prevents blockage.

When measuring high-turbidity fluids such as residual oil, wastewater, and coal powder, the primary solution—without considering the challenges of two-phase flow—is to use differential pressure transmitters with remote diaphragm boxes for static pressure measurement. This method achieves higher accuracy than wedge flow meters and outperforms standard orifice plates and circular/oval plates. (See Figure (20) for contaminated fluid flow types)

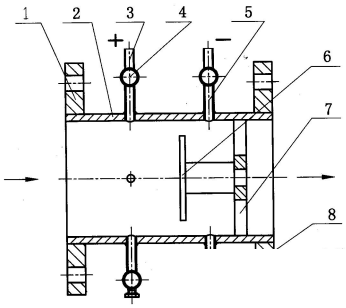
When spatial constraints or on-site installation of pressure pipelines are impractical, an integrated annular orifice flowmeter is recommended. This device offers: simple installation, compact structure, and minimal maintenance. When paired with a smart differential pressure transmitter, it enables convenient range adjustment via a handheld controller, reducing on-site operations. The digital communication feature further expands the measurement range.

Figs. (16) to (21) show six structural forms respectively



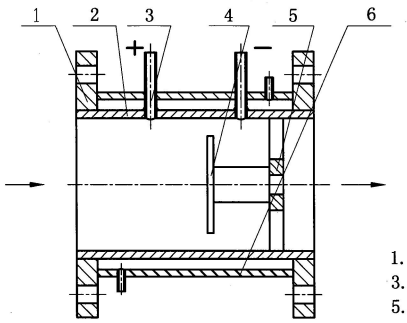
1. Main body flange 2. Measuring tube
3. Pressure tap 4. Flow measurement plate
5. Support

Figure (16) Standard Type



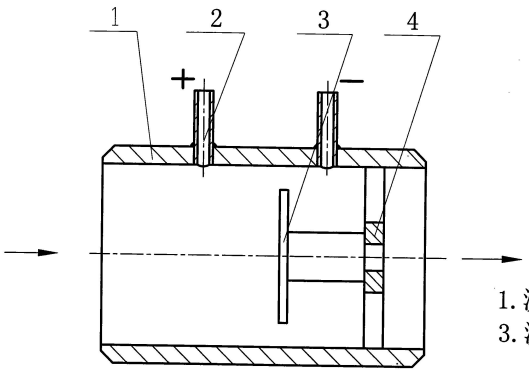
1. Main body flange 2. [illegible]
3. Pressure tap 4. Pressure equalizing ring
5. Pressure pipe 6. Flow measurement plate
7. Support 8. Drain plug

Figure (17) Gas-specific Type with Equalizing Ring



1. 本体法兰 2. 测量管
3. 取压管 4. 测流板
5. 支撑件 6. 夹套

Figure (18) Jacket insulation type



1. 测量管 2. 取压管
3. 测流板 4. 支撑件

Figure (19) High voltage type

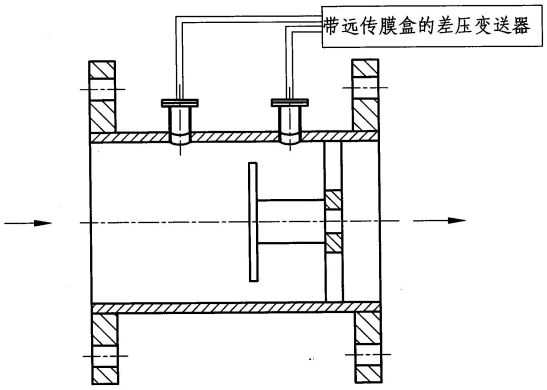


Figure (20) Dirty fluid type

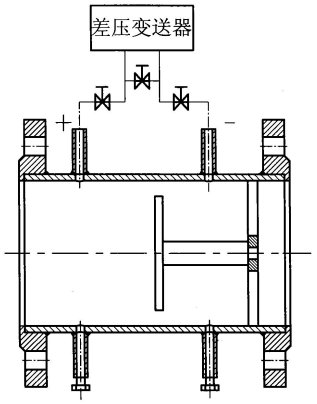


Figure (21) Solid type

(3) Connection method and size

There are two common connection methods for annular orifice plate throttle device: flange connection and welding connection.

When performing flange connections, the paired flanges must be welded to the pipeline. In addition to complying with the standards of the Ministry of Machinery, National Standards, Ministry of Electric Power, and Ministry of Petroleum, our company can also design and manufacture flanges according to international standards from the United States, Japan, Germany, and other countries, meeting the needs of various users. The connection dimensions for specific specifications are listed in Table (1).

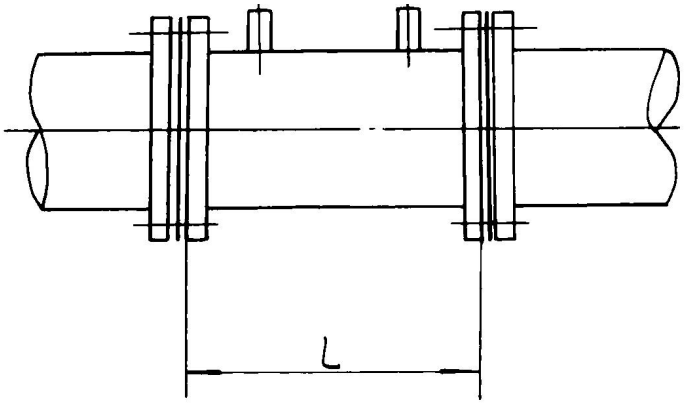


Table (1) Connection dimensions (the gap length between the two sides of the connection flange)

inside nominal diameter DN	50	80	100	150	200	250	300	350	400	450
L（mm）	220	270	300	380	460	520	600	700	800	850
inside nominal diameter DN	500	600	700	800	900	1000	1100	1200	1300	1400
L（mm）	900	1100	1200	1400	1500	1600	1800	1900	2100	2200
inside nominal diameter DN	1500	1600	1700	1800	1900	2000	2100	2200	2400	2600
L（mm）	2400	2600	2700	2800	3000	3200	3300	3400	3600	4000

2.2.3 Nozzle:

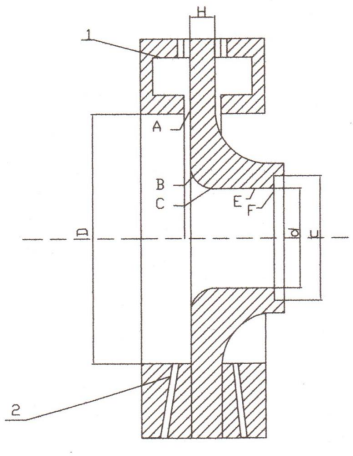
Compared to orifice plates, nozzles exhibit lower pressure loss, resulting in energy efficiency and enhanced durability, making them ideal for high-temperature and high-pressure fluid applications. Widely used in steam flow measurement across power generation and chemical industries, our company specializes in producing ISA1932 nozzles (commonly known as standard nozzles) and long-diameter nozzles. All designs and manufacturing processes strictly

comply with international standard ISO5167 and national standard GB/T2624.

⑴ ISA1932 nozzle (standard nozzle)

The standard nozzle employs two types of angle connection pressure measurement: either ring chamber or separate borehole.

The standard nozzle shape and pressure taking method are shown in Figure (22):



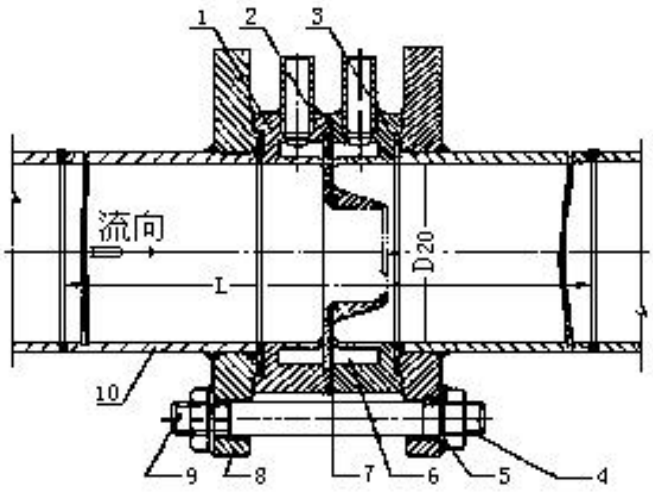
1.环室角接取压　2单独钻孔角接取压
图(22):标准喷嘴外形及取压

Compared with standard orifice plates, standard nozzles exhibit lower pressure loss, superior high-temperature and high-pressure resistance, stable performance, and extended service life. The nozzle comprises: a vertical-axis inlet plane section A, arc-shaped contraction sections B and C, a cylindrical throat E, and protective grooves F to prevent edge damage.

Application conditions: DN: 50~500; β: 0.3~0.8; ReD: 2×104~107

Uncertainty of discharge coefficient: ±0.8% to ±1.2%

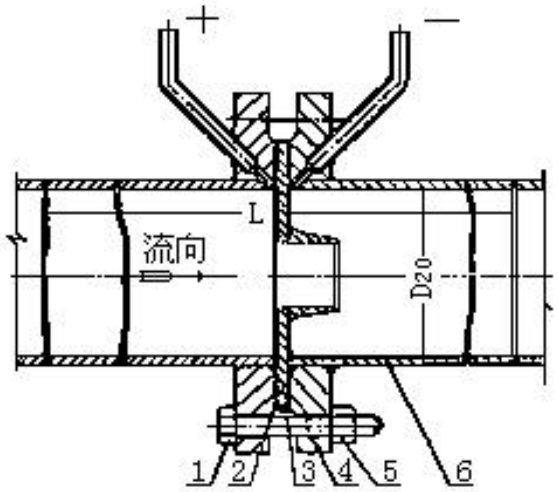
Due to the different use of pressure and temperature, the common structures are shown in FIG. (23) to FIG. (27):



1. Front chamber 2. Standard nozzle 3. Gasket 4. Nut 5. Washer 6. Rear chamber 7. Gasket 8. Flange 9. Double-ended bolt 10. Pipe

Figure (23) Schematic diagram of corner joint (annular chamber) pressure tap standard nozzle structure and installation

（DN≤400，PN≤2.5MPa）



1. Bolt 2. Gasket 3. Standard nozzle 4. Flange 5. Nut 6. Pipe

Figure (24) Schematic diagram of the standard nozzle structure and installation for corner joint (separately drilled) pressure tapping （DN≤500，PN≤2.5MPa）

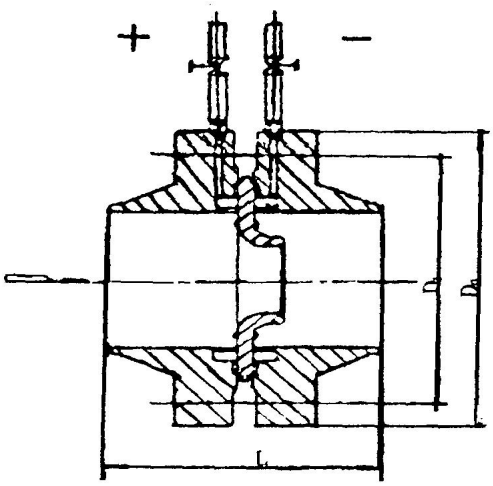
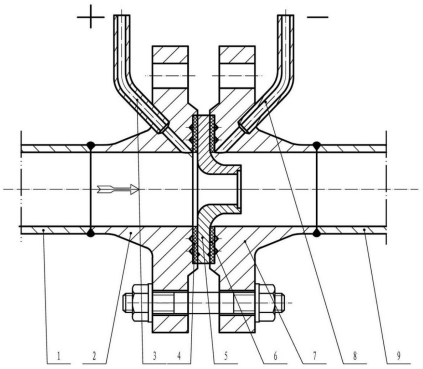
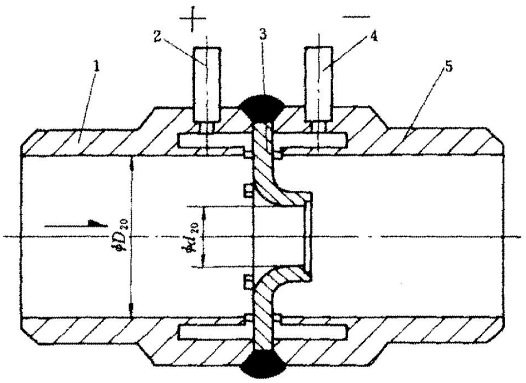


Figure (25) Schematic diagram of corner joint (annular chamber) pressure tap standard nozzle structure and installation （DN≤400，PN≤10MPa）



1. Front straight pipe section 2. Positive pressure flange 3. Positive pressure pipe 4. Gasket 5. Standard nozzle 6. Gasket 7. Negative pressure flange 8. Negative pressure pipe 9. Rear straight pipe section

Figure (26) Schematic diagram of the standard nozzle structure and installation with corner joint (separately drilled hole) pressure tap （DN≤500，PN≤10MPa）



1. Front pressure tap chamber 2. Pressure tap tube 3. Nozzle 4. Pressure tap tube 5. Rear pressure tap chamber

Figure (27) Schematic diagram of corner joint (annular chamber) pressure tapping welded structure, standard nozzle design, and installation （DN≤250，PN≤32MPa）

(2) Long nozzle

The long-jet nozzle complies with the international standard ISO5167 or the national standard GB/T2624. As a type of standard throttling device, it features an elliptical inner contour curve.

Application conditions: DN: 50~600; β: 0.2~0.8; ReD: 104~107

Uncertainty of discharge coefficient ±2%

The long-diameter nozzle employs a diameter-to-spacing pressure measurement configuration (D and D/2), featuring a tubular structure as shown in Figure (28). This design ensures leak-proof performance and high-temperature resistance, along with enhanced wear and corrosion resistance. It is widely used for flow measurement in high-temperature/high-pressure fluids such as superheated steam, boiler feedwater, and chemical solutions. The technology is extensively applied in power generation systems for main steam measurement and nuclear power plants for feedwater flow monitoring.

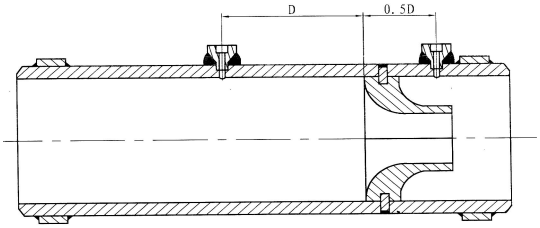


Figure (28) Schematic diagram of long diameter nozzle structure

DN50~600， PN≤42MPa

2.2.4 Classical (Classical) Venturi tube

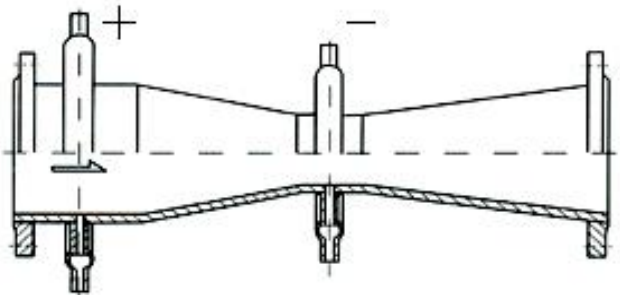


Figure (29) Schematic diagram of classical Venturi tube structure

The standard Venturi tube is designed to measure the volumetric flow rate of single-phase stable fluids (liquids, gases, or vapors) in closed pipelines. It is manufactured in accordance with ISO5167 and GB/T2624 standards.

Among all standard throttle devices, it requires the shortest upstream and downstream straight pipe section, the minimum pressure loss, stable performance and convenient maintenance.

The main technical parameters are shown in Table (2):

Venturi tube type	Nominal diameter DN (mm)	aperture ratio （β=d/D）	Reynolds number ReD	material quality
Has a rough casting shrinkage section The classic Venturi tube	100～800	0.3～0.75	$2^{\times}105^{\sim}2^{\times}106$	Cast iron or copper
A classical Venturi tube with a mechanical machining contraction section	50～250	0.4～0.75	$2^{\times}105^{\sim}2^{\times}106$	Carbon steel or stainless steel
A classic Venturi tube with a coiled brass plate contraction section	200～2600	0.4～0.7	$2^{\times}105^{\sim}2^{\times}106$	Carbon steel or stainless steel

For measuring flow in contaminated media, a pressure equalization ring configuration is recommended. This system features 4-8 evenly distributed pressure taps at the same cross-section, with collected pressure transmitted via a pressure conduit to a differential pressure transmitter. This design minimizes clogging risks while enabling regular impurity discharge through the vent port to clear accumulated debris from the pressure taps.

2.2.5 Venturi nozzle

Venturi nozzle is manufactured according to GB/T2624, and has two different structural forms and profiles. The outflow coefficient is stable, the accuracy is high and the reproducibility is good.

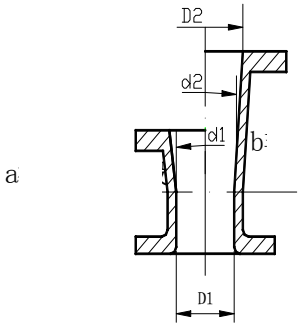


Figure (30) Venturi nozzle shape

Application conditions: DN: 65~500; β: 0.316~0.775; ReD: $1.5^{\times}105$~$2^{\times}106$

Uncertainty of discharge coefficient: ±(1.2~1.6)%

The structure and installation diagram are shown in Figure (31)

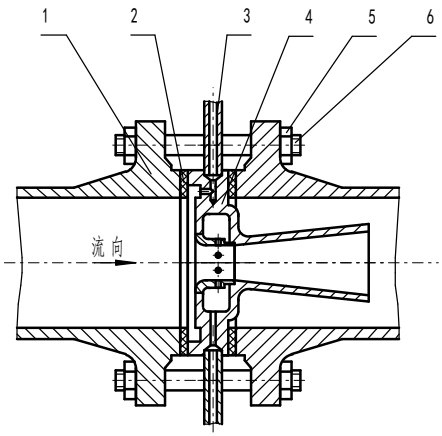


Figure (31) Venturi nozzle structure and installation diagram

2.2.6 Quarter-Circular Orifice Plate, also known as a quarter-circular nozzle, does not qualify as a standard throttling device but complies with the British Standard BS1042. As shown in Figure (32), its distinctive feature is the circular quarter-shaped inlet edge. Both angular and flange tapping methods are applicable. The overall structure mirrors that of standard orifice plates (see Figure 33). Primarily used for flow measurement in low Reynolds number fluids.

Application conditions: DN: 25-500; β: 0.245-0.6; ReD: ReDmin ≤ ReD ≤ 105β

ReDmin: 250 - 3250 (dependent on β, where β = d/D); accuracy (uncertainty): ±2% - ±2.5%

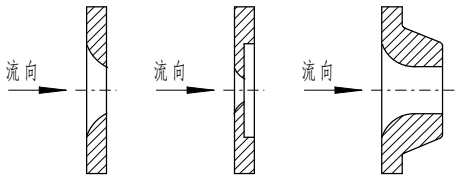


Figure (32) Quarter circle perforated plate

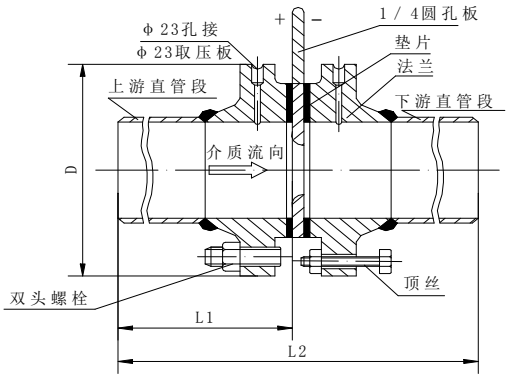


Figure (33) Schematic diagram of installation of quarter circle hole plate structure

2.2.7 Conical Inlet Orifice Plate: Essentially a standard orifice plate with inverted configuration. It employs angular joint pressure measurement, maintaining identical structural integrity to conventional orifice plates. Designed and manufactured in compliance with British Standard BS1042, this configuration is particularly suitable for flow measurement in low Reynolds number fluids.

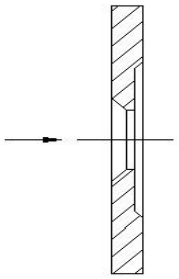


Figure (34) Cone-shaped inlet plate

Specifications: DN 25-500; d ≥ 6; β 0.1-0.316; ReD 250β to 2×10^5 β (β = d/D);

Accuracy (uncertainty): ±2%

2.2.8 Round hole plate, structure as shown in Figure (35):

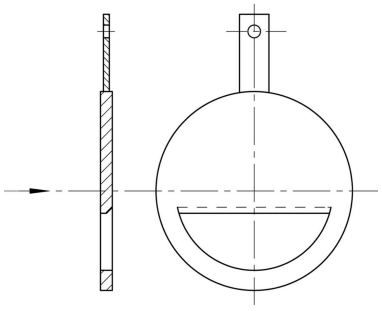


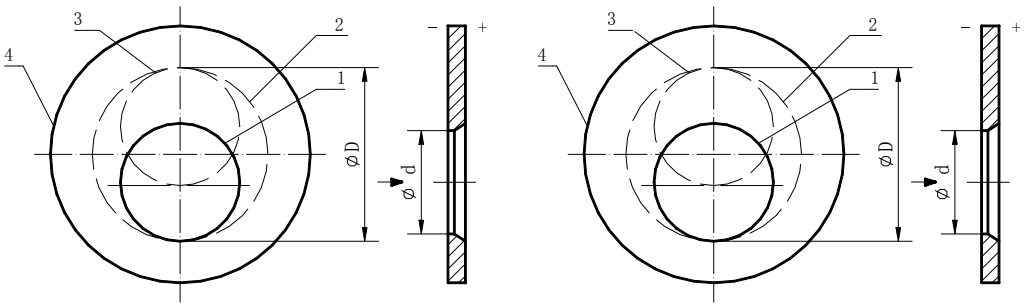
Figure (35) Circular perforated plate

Pressure measurement method: flange pressure measurement

Application conditions: DN 100-350; β 0.3-0.8; ReD> 80DN

Accuracy (uncertainty): ±2% to ±2.5%

2.2.9 Eccentric orifice plate, structure as shown in Figure (36):



1. Orifice plate opening 2. Inner diameter of the pipe 3. Another position of the orifice plate opening 4. Outer diameter of the orifice plate

Figure (36) Eccentric orifice plate

Pressure measurement method: corner connection.

Application conditions: DN: 100~1000; β: 0.46~0.84; ReD: 2×10^5 β $2\sim10^6$ β (β = d/D)

Accuracy (uncertainty): ±1% (β≤0.75); ±2% (β>0.75)

Excentric orifice plates and circular/segmented orifice plates are suitable for measuring wet steam, producer gas, coke oven gas, blast furnace gas, mixed gas, flue gas, water-containing oil, liquids with solid particles, and air-laden liquids. While excentric orifice plates offer higher accuracy than circular/segmented plates, they still fall short of standard sharp-angle orifice plates. Therefore, it is recommended to use configurations with a straight pipe section or upstream/downstream straight pipe sections connected via flanges.

Excentric orifice plates and circular/biased orifice plates are exclusively designed for horizontal or inclined pipelines, not vertical installations. When the measured fluid contains solid particles, the orifice should be positioned below the pipeline. If gas is present in the liquid, the orifice must be placed above. The pressure tap should be located opposite the tangential point between the circular/biased orifice plate's opening or notch and the pipeline. General measurement specifications and installation requirements for these plates shall follow standard orifice plate specifications.

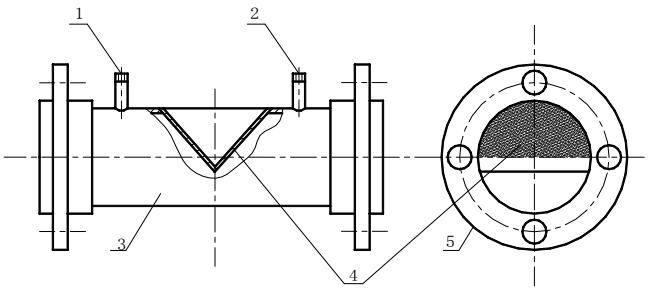
2.2.10 Wedge flowmeter

The detection piece of the wedge flowmeter is the wedge orifice plate (see Figure 37), which is a V-shaped throttle piece with a smooth top corner facing down. Due to its special structure, it has the following characteristics:

1. Suitable for flow measurement of viscous fluids with viscosity up to 500mPa・s.
2. Suitable for liquid-solid mixture containing suspended particles.
3. The Reynolds number has a wide range of applications, ranging from extremely low Reynolds numbers (ReD=300) to above 106.

Conditions: 25mm≤DN≤400mm,PN≤6.4MPa, t≤200℃;

Accuracy (uncertainty): Class 1.0 (real flow calibration), Class 1.5, Class 2.0, Class 2.5.



1. High pressure tap 2. Low pressure tap 3. Measured pipe 4. Wedge hole plate 5. Flange

Figure (37) Wedge flowmeter

2.2.11 Integrated throttling flowmeter

The integrated throttling flowmeter, designed in accordance with the international standard ISO5167 and Chinese national standard GB/T2624, is a wide-range ratio flowmeter that combines a throttling device (including standard orifice plates, nozzles, annular orifice plates, etc.) with a differential pressure transmitter into a single unit. This design not only simplifies installation by eliminating the need for pipeline laying, but also ensures easy maintenance with a

compact structure and minimal upkeep. When paired with an intelligent differential pressure transmitter, the system allows convenient range adjustment via a handheld controller. Through digital communication technology, the measurement range can be expanded to 1:13.

It is widely used in chemical, metallurgical, electric power, thermal and other measurement and testing projects. It adopts high reliability integrated orifice plate for flow measurement, which is used to detect steam (saturated and superheated steam), gas (compressed air, gas and other gases), cold and hot water, industrial wastewater and other liquid flow measurement.

Note: When installing the instrument, mount the head above for gas media and below for liquid or steam media. See Figure (38) for the structural diagram.

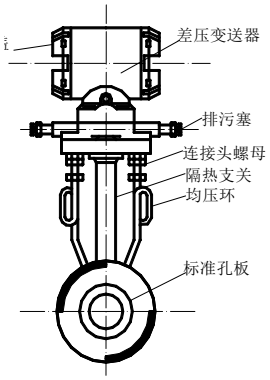


Figure (38) Schematic diagram of structure and installation of integrated throttling flowmeter

Application conditions: 50mm ≤ DN ≤ 1000mm, PN ≤ 10MPa, t ≤ 300℃

2.2.12 Low-pressure loss flow pipe

The structural diagram is shown in Figure (39), also known as the short-form Venturi tube. This design combines the advantages of orifice plates and Venturi tubes, offering both the high differential pressure measurement capability of orifice plates (which enhances flow measurement accuracy) and the low pressure loss characteristic of Venturi tubes (which saves energy). Compared to conventional Venturi tubes, it features a smaller axial length-to-diameter ratio (L/D), resulting in a compact installation size that facilitates transportation and assembly. Under the same flow conditions, it delivers higher differential pressure values while maintaining lower pressure loss at equivalent differential pressure, thus conserving energy. Its working principle aligns with standard throttling devices.

Conditions: 150mm≤D≤3000mm,PN:0.25~2.5MPa

Accuracy (uncertainty): ±1.5% (actual flow calibration)

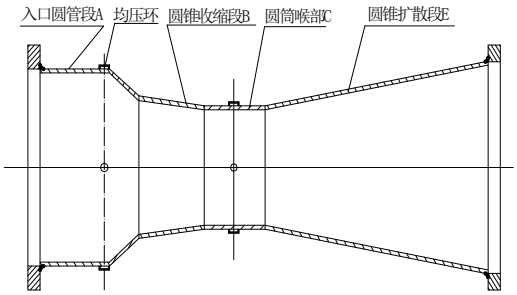


Figure (39) Low-pressure loss flow pipe outline

2.2.13 V-cone flowmeter

The V-cone flowmeter is an innovative differential pressure flow measurement device featuring a sharp conical body coaxially installed in the measuring tube as its throttling element. This advanced throttling mechanism combines the measurement principles of Venturi tubes with the advantages of classic Venturi tubes, annular orifice plates, and wear-resistant orifice plates. The structural diagram is shown in Figure (40).

Application conditions: β: 0.45～0.85; DN: 15～1200mm; PN: 0.25～20MPa; ReD: 5×103～1×107

Because the V-cone flowmeter adopts a special structure, it has the following characteristics:

1. The upstream and downstream straight pipe sections should be relatively short: the upstream straight pipe section should be 0D to 3D (3D is required downstream of the valve), and the downstream straight pipe section should be 0D to 1D.

2. Accuracy: ±0.5%; repeatability: 0.1%; range ratio: 15:1.

3. Resistant to dirt and low pressure loss.
4. It has the effect of flow adjustment and mixing of fluid.
5. Easy installation —— is an ideal flowmeter for technical transformation;
6. Maintenance free or minimal maintenance.

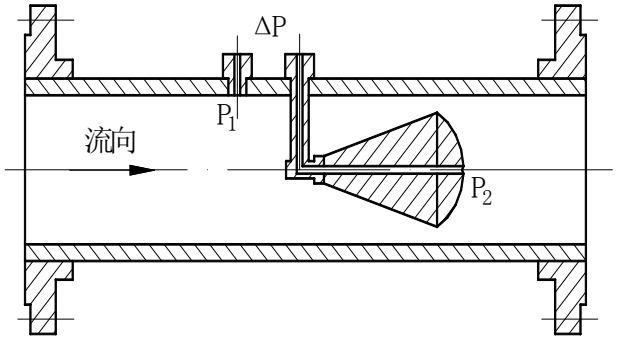


Figure (40) Schematic diagram of V-cone flowmeter structure

2.2.14 Rectangular Venturi tube

Rectangular ducts (riveted and welded from thin iron plates) are commonly used for air supply. For measuring airflow (such as suction in power plants, air supply, or heating furnace air supply), rectangular Venturi tubes can be employed. These are categorized into single-constricted and double-constricted types based on their structural design. The schematic diagram is shown in Figure (41).

Features: 1. Light structure, easy to transport, can also be assembled on site.
2. Easy to make and low cost (compared with the classical Venturi tube).
3. Small pressure loss, save energy.

Usage conditions: Inlet equivalent diameter (equivalent to nominal $\sqrt{W \times H}$ $\sqrt{W \times H}$ diameter) (mm): D=1.13≤1200

W: width (mm); H: height (mm)

Accuracy (uncertainty): ±5%

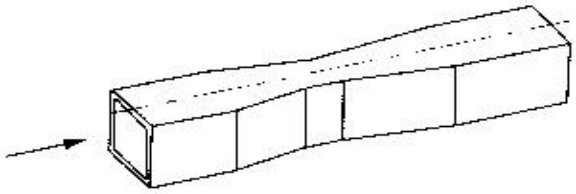


Figure (41) A schematic diagram of the rectangular Venturi tube structure

2.2.15 Flow restriction orifice plate

The flow restriction orifice plate is used for pressure reduction and flow limitation in fluid transportation processes. Unlike standard orifice plates, it does not require differential pressure signal detection. Instead, it utilizes the high pressure loss characteristic of sharp orifice plates to achieve the purpose of pressure reduction and flow limitation.

Flow restriction orifice plates are available in two configurations: single plates and multi-plate assemblies. Single plates are further classified as single-hole or multi-hole types, while multi-plate assemblies, also known as flow restriction plate groups, are categorized into single-hole and multi-hole configurations. Their structural design and installation procedures are based on standard orifice plate specifications.

It has the following characteristics:

1. Simple structure, durable, reliable work.
2. Under the condition of constant inner diameter of the pipeline, the smaller the throat opening is, the higher the flow rate is, and the more obvious the effect of pressure reduction and flow limitation is.

service condition ：

1. Nominal diameter (mm): 10-500

2. Nominal pressure (MPa): ≤40

3. Pressure reduction capacity: Each perforated plate can reduce about 2MPa, and multiple plates can be combined into a perforated plate group, and the overall pressure reduction capacity is not limited.



Figure (42) Flow restriction orifice plate

2.2.16 Inlet perforated plate

This type of orifice plate is integrated with the measuring tube, typically used for small-diameter pipes (DN≤ 50mm), hence also known as small-diameter orifice plates. For DN=50mm, it is a standard orifice plate that can be manufactured according to the ISO5167 international standard. For DN<50mm, it is a non-standard orifice plate, and its discharge coefficient can be calculated using the Stolz formula. When the required accuracy exceeds 2.5%, it is recommended to conduct actual calibration.

characteristic ：

1. Compact structure, strong and durable, reliable work.

2. It can measure small flow and is convenient for on-site installation.

3. A straight pipe section must be prepared (with 5D precision machining at the front and 2D at the rear).

Usage conditions: 1. Nominal diameter (mm): 15 ~ 50

2. Nominal pressure (MPa): ≤6.3

3. Accuracy (uncertainty): 2.5%

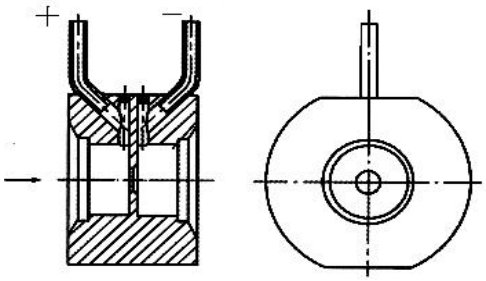


Figure (43) Concealed perforated plate

2.2.17 Sonic nozzle (critical flow Venturi nozzle)

The sonic nozzle, a colloquial term for the critical flow Venturi nozzle, has emerged as a vital tool in gas flow measurement in recent years. Renowned for its simplicity, reliability, and high precision, this device boasts a robust structure, minimal flow loss, stable performance, and dependable operation. Its rapid development in recent years has solidified its position as the industry standard for high-pressure, high-flow-rate gas measurement. Widely recognized both domestically and internationally, it demonstrates absolute advantages over other measurement methods in delivering standardized gas flow measurement solutions. Consequently, it has been extensively adopted for gas flow measurement, flow restriction applications, and calibration systems for gas flow meters.

1. Working Principle

When the airflow is subsonic, the gas velocity at the throat of a Venturi nozzle increases as the throttling pressure ratio (the ratio of outlet pressure P1 to upstream stagnation pressure P0) decreases. When the throttling pressure ratio drops below a critical threshold (0.528 for air), the throat velocity reaches its maximum value—the local sonic velocity —marking the onset of "critical flow." At this point, further reduction of the throttling pressure ratio no longer affects the

flow velocity (or flow rate), as the velocity stabilizes at a constant value unaffected by downstream pressure.

Flow formula:

$$q_m = \frac{A_* \cdot C \cdot C_* \cdot P_0}{\sqrt{(R/M) \cdot T_0}} \quad q_m = \frac{A_* \cdot C \cdot C_* \cdot P_0}{\sqrt{(R/M) \cdot T_0}} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(3)$$

where: qm: mass flow rate[Kg/s];

A*: Venturi nozzle throat area m^2

C： efflux coefficient ；

C*: Critical flow function (for actual fluids, one-dimensional isentropic flow);

P0: Absolute stagnation pressure at the inlet of the Venturi nozzle..... [Pa];

T0: Stagnation temperature at the inlet of the Venturi nozzle..... [K];

R: Universal gas constant, R=8314.4J/ (k mol • K);

M: The molar mass (molecular weight) of the gas..... [kg/mol].

II. Structure, characteristics and parameters

(1) Structure and features

According to ISO9300 standard, critical flow Venturi nozzle has two structural forms: circular throat Venturi nozzle and cylindrical throat Venturi nozzle.

a. The annular throat Venturi nozzle (see Figure 44) features a trumpet-shaped contraction at its inlet, which extends to the throat's minimum cross-section and is tangent to the downstream conical diffuser. As a result, the throat is essentially a ring-shaped structure with no length dimension.

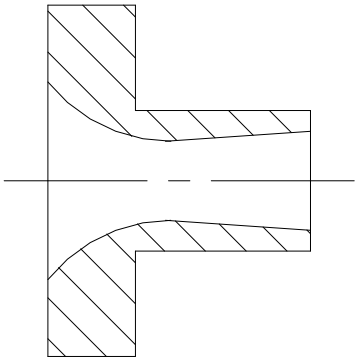


Figure (44) Circular throat Venturi nozzle

b. cylindrical throat Venturi nozzle (see Figure 45), whose inlet contraction section is a quarter circle with a radius equal to the throat diameter and tangent to the throat. The throat is a cylinder and smoothly connected to the conical diffuser downstream.

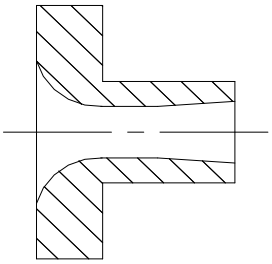


Figure (45) Cylindrical throat Venturi nozzle

(2) Technical parameters

DN：6～500mm; PN：0.25～16Mpa；

Accuracy (uncertainty of the discharge coefficient): ±(0.1－0.2)%.

3. Installation Requirements

The schematic diagram of the installation system of a device is shown in Figure (46).

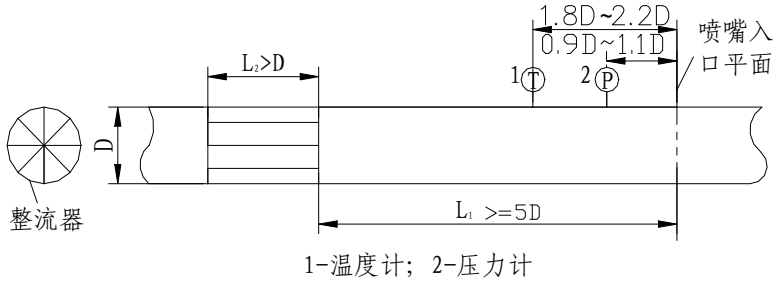


Figure (46) Schematic diagram of the installation system of a primary device

Important Note: Critical Flow Venturi nozzles are typically connected to process pipelines using either welding or flange connections. For flange connections, follow these steps: First, select two 100-500mm short pipes matching the process pipeline specifications. Smoothly trim the pipe ends and securely weld them to the flanges (see Figure 47). Next, weld the entire assembly of the critical flow Venturi nozzle with the pipeline. Ensure the sealing gasket remains intact to prevent damage.

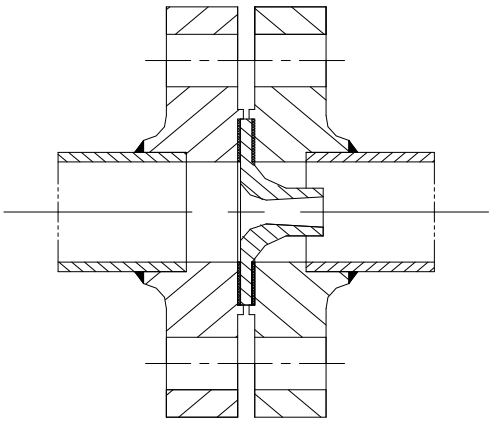


Figure (47) Schematic diagram of supersonic nozzle installation

(1) There are two installation configurations for Venturi nozzles upstream: either a large upstream space or a circular cross-section pipeline. For new pipeline systems with circular cross-section upstream sections, a purge line must be established before installing the critical flow Venturi nozzle to prevent blockages caused by debris or nozzle damage.

(2) The upstream pipeline's axis must align with the Venturi nozzle's axis, with an allowable deviation of ±0.02D. Within the upstream 3D length, the pipeline's roundness should be less than 0.01D, and the inner wall roughness must be below 10^-4D. The upstream pipeline diameter should exceed 4d, while downstream pipelines have no strict requirements.

(3) As shown in Figure (46), pressure and temperature measurement points are installed upstream of the Venturi nozzle, serving as primary signals for flow measurement. The technical requirements for pressure tap installation should follow the pressure tapping specifications for standard throttling devices. The diameter of the temperature sensor must be carefully selected to avoid interfering with pressure and flow measurements. Notably, the measured temperature should accurately represent the stagnation temperature at the nozzle inlet. A pressure measurement point should be installed downstream at a distance less than 0.5D from the outlet to verify whether the flow remains in the critical state.

(4) Drainage holes may be installed outside the upstream 1D of the upstream side pressure measurement point for the discharge of dirt in the pipeline. The positions of the drainage hole and the pressure hole should be in different planes. The diameter of the drainage hole should be less than 0.06D, and the drainage hole should not be opened when the flowmeter is working.

(5) If the upstream side is a large space, there should be no obstacles within 5d distance from the axial or entrance

plane of the detection piece.

4. Applications

(1) Direct measurement of gas flow: Research indicates that for medium pressure and temperature ranges, the throat Reynolds number should be at least 1×10^5 , with calculated flow deviations typically not exceeding $\pm1.5\%$. When the precision of temperature and pressure measurement instruments is sufficiently high, the measured gas flow deviation can generally be controlled within $\pm0.7\%$.

(2) As a standard measurement instrument in high-pressure, high-flow calibration systems: In recent years, advanced countries have established numerous high-pressure, high-flow gas flowmeter calibration systems to support the development of natural gas and other gas industries. These systems typically employ Venturi nozzles as standard measurement instruments for calibrating various industrial gas flowmeters. The system features a simple structure, low cost, user-friendly operation, and high efficiency.

(3) Using Venturi nozzle to improve bell-type flow verification system: Bell-type flow verification system is a widely used air flow verification system, with simple structure and low cost.

(4) For flow limitation: because the flow velocity reaches the speed of sound in the throat, the rear pressure does not change with the change of the front pressure, and the system is stable.

3. Install

Important Note: The throttling device is typically connected to the process pipeline using welding or flange connections. Regardless of the connection method, follow these steps: First, select two short pipes identical in length to the process pipeline (100-500mm). Trim the pipe ends to a flat surface and insert them into the flange holes before and after the throttling device. Securely weld the flanges together or use the device's built-in flanges. Finally, weld the entire throttling assembly with the process pipeline. Be especially cautious to prevent the sealing gasket from being damaged during welding.

3.1 Basic Requirements

1) For the newly established pipeline system, the pipeline must be swept before the installation of the throttle device, so as to prevent the blockage or damage of the throttle device by debris in the pipeline.

2) Before installation, verify that the throttling device's model and specifications match the pipeline conditions, flow range, and other parameters. Connect the end marked "+" to the upstream pipeline and the end marked "-" to the downstream pipeline near the pressure tap.

3) The centerline of the throttle device must be coaxial with the pipeline's centerline, with an allowable eccentricity of no more than 0.015D (), and its

Where D is the inner diameter of the pipe and β is $\overline{\beta}^{-1}$ the $\overline{\beta}^{-1}$ hole diameter ratio.

4) The pressure tap position should ideally enable automatic drainage (for gas flow measurement) or automatic venting (for liquid flow measurement). Specifically: for liquid measurement, position the tap within 45° below the horizontal plane; for gas measurement, within 45° above the plane. For impure gas flow measurement, the tap should be positioned near the vertical direction. Refer to Figure (48) for specific tap placement guidelines.

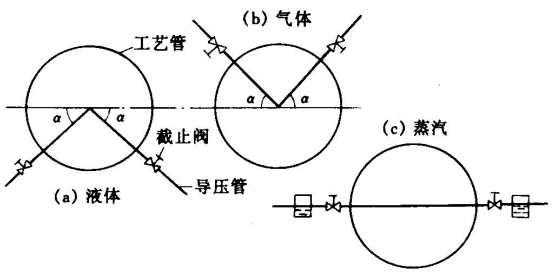


Figure (48) Schematic diagram of pressure tapping port installation

3.2 Requirements for pipelines

1) The throttle device shall be installed between two straight pipe sections with equal cross-sections. It is recommended that the upstream straight pipe section be 10DN and the downstream straight pipe section be 5DN. Furthermore, within a length range of at least 2DN from the upstream end face of the throttle device, the difference between the diameters of the upstream and downstream straight pipe sections and the average inner diameter D shall not exceed 0.3%.

2) The pipeline must be completely filled with the medium near the throttle device (including the straight pipe sections before and after). If an isolation valve is required, a gate valve should be installed and kept fully open during operation. If a control valve is required, it should be installed downstream of the 5DN pipe section.

Table (3) Upper limit of surface roughness of straight pipe section upstream of orifice plate

aperture ratio β	0.3	0.32	0.34	0.36	0.38	0.40	0.45	0.50	0.60	0.75
104K/D	25.0	18.1	12.9	10.0	8.3	7.1	5.6	4.9	4.2	4.0
The K value is the equivalent absolute roughness.										

The minimum length of straight pipe upstream and downstream of the orifice plate and nozzle in Table (4) is as follows:

diameter ratio β ⩽	Upstream side flow resistance form and minimum straight pipe section length							Minimum straight pipe length downstream of the throttle
	A single 90-degree elbow or tee (with only one branch outlet)	Two or more 90-degree elbows on the same plane	Two or more 90-degree elbows on different planes	Tapered tube (in 1.5~3D length from 2D to D)	Dilator (from 0.5D to D within 1-2 lengths)	The ball valve or gate valve is fully open	Full open on globe valve,	
0.20	10(6)	14(7)	34(17)	5	16(8)	12(6)	18(9)	4(2)
0.25	10(6)	14(7)	34(17)	5	16(8)	12(6)	18(9)	4(2)
0.30	10(6)	16(8)	34(17)	5	16(8)	12(6)	18(9)	5(2.5)
0.35	12(6)	16(8)	36(18)	5	16(8)	12(6)	18(9)	5(2.5)
0.40	14(7)	18(9)	36(18)	5	16(8)	12(6)	20(10)	6(3)
0.45	14(7)	18(9)	38(19)	5	17(9)	12(6)	20(10)	6(3)
0.50	14(7)	20(10)	40(20)	6(5)	18(9)	12(6)	22(11)	6(3)
0.55	16(8)	22(11)	44(22)	8(5)	20(10)	14(7)	24(12)	6(3)
0.60	18(9)	26(13)	48(24)	9(5)	22(11)	14(7)	26(13)	7(3.5)
0.65	22(11)	32(16)	54(27)	11(6)	25(13)	16(8)	28(14)	7(3.5)
0.70	28(14)	36(18)	62(31)	14(7)	30(15)	20(10)	32(16)	7(3.5)
0.75	36(18)	42(21)	70(35)	22(11)	38(19)	24(12)	36(18)	8(4)
0.80	46(23)	50(25)	80(40)	23(15)	54(27)	30(15)	44(22)	8(4)

Table (5) The minimum length of the straight pipe section of the Venturi tube is as follows:

diameter ratio β	Single 90° elbow	Two 90° bends on the same plane (*).	Two 90° elbows (*), (**), on different planes	Shrink 3D become different D, 3.5D length	Expand 0.75D become different D, length D	The ball valve or gate valve is fully open
0.30	0.5（***）	1.5(0.5)	(0.5)	0.5（***）	1.5(0.5)	1.5(0.5)
0.35	0.5（***）	1.5(0.5)	(0.5)	1.5(0.5)	1.5(0.5)	2.5(0.5)
0.40	0.5（***）	1.5(0.5)	(0.5)	2.5(0.5)	1.5(0.5)	2.5(1.5)
0.45	1.0(0.5)	1.5(0.5)	(0.5)	4.5(0.5)	2.5(1.0)	3.5(1.5)
0.50	1.5(0.5)	2.5(1.5)	(8.5)	5.5(0.5)	2.5(1.5)	3.5(1.5)
0.55	2.5(0.5)	2.5(1.5)	(12.5)	6.5(0.5)	3.5(1.5)	4.5(2.5)

0.60	3.0(1.0)	3.5(2.5)	(17.5)	8.5(0.5)	3.5(1.5)	4.5(2.5)
0.65	4.0(1.5)	4.5(2.5)	(23.5)	9.5(1.5)	4.5(3.5)	4.5(2.5)
0.70	4.0(2.0)	4.5(2.5)	(27.5)	10.5(2.5)	5.5(3.5)	5.5(3.5)
0.75	4.5(3.5)	4.5(3.5)	(29.5)	11.5(3.5)	6.5(4.5)	5.5(3.5)

3) Within the straight pipe sections upstream and downstream of the throttle component, no gaskets shall protrude into the pipeline; avoid any disturbance to the flow field (e.g., fluid inflow or outflow).

4) The minimum straight pipe section to be guaranteed on the upstream and downstream of the throttle device is related to the form of the upstream resistance piece and the ratio of the throttle piece diameter to β.

Note: 1. When the diameter of the thermometer sleeve or socket is less than 0.03D, the minimum length of the upstream straight pipe section is 5(3)D.

2. When the diameter of the thermometer sleeve or socket is 0.3D~0.13D, the minimum length of the upstream straight pipe section is 20 (10)D.

3. The installation of the thermometer sleeve or socket will not change the upstream straight pipe section required for other pipe fittings.

4. If a value in parentheses is used, an additional error of 0.5% of the arithmetic sum of the outflow coefficient errors shall be applied.

The values in the table are multiples of D.

Note: 1. (*) The bending radius of the elbow is ≥D.

2. (***) Since the effects of these fittings persist beyond 40 D, this table does not provide values without parentheses.

3. (***) Typically, no pipe fitting can be positioned within 0.5D of the upstream pressure tap of a standard Venturi tube.

3.3 Requirements for pressure tapping pipeline

1) The inner diameter of the suction pipe depends on the pipeline length. For pipelines under 45 meters, pipes with an inner diameter of 12-16mm are typically used (see Table 6 below).

Inner DN(mm) Length (m) / Fluid	＜16	16～45	45～90
Water, water vapor, dry	7～10	10	13
Moist air	13	13	13
Low-viscosity grease	13	19	25
Dirty liquid or gas	25	25	38

2) The short pipe drawn from the pressure port should be in the same horizontal plane. If the throttling device is installed on the vertical pipe, the short pipe drawn from the pressure port is separated from each other by a certain distance (vertical direction), which will affect the zero point of the differential pressure transmitter, and the zero point migration should be used to correct.

3) The differential pressure pipeline should have a firm support to avoid excessive load and vibration. In order to avoid the pressure error caused by temperature difference, the two pressure taking pipelines should be as close as possible and wrapped with insulation material. In cold season, heating should be added to prevent freezing.

4) Pressure differential pipeline systems must be free of any potential pockets where liquids or gases could accumulate. If unavoidable, install a trap (or vent valve) and a trap (or steam trap). For pipelines exceeding 30 meters in length, implement sectional inclines with traps (or vent valves) and traps (or steam traps) installed at each segment.

pour ：

① Condenser: When measuring steam and water flow temperature greater than 70℃, condenser should be installed.

② Isolator: When measuring fluids that are corrosive, prone to freezing, and prone to solid precipitation, an isolator should be installed.

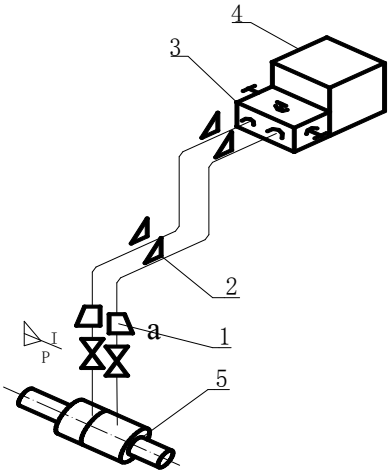
③ Collector: to measure the flow of liquid or water vapor. When the pressure transmitter is installed higher than the throttle device, the collector should be installed at the highest point of the pressure guide pipe.

④ Settler: When measuring the flow of dirty liquid or gas that may precipitate condensate or contain dirty matter, and the pressure transmitter is installed below the throttle device, a settler should be installed.

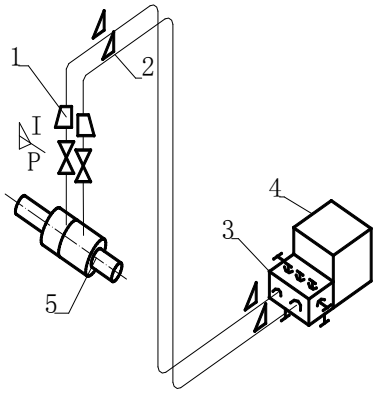
⑤ When measuring gas flow, the differential pressure transmitter is best installed above the throttle device; when measuring liquid and steam flow, the differential pressure transmitter is best installed below the throttle device.

3.4 Pipeline connection mode of throttle device and differential pressure transmitter:

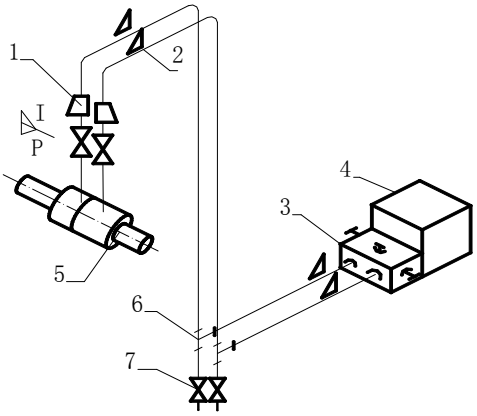
3.4.1 Schematic diagram of gas flow measurement pipeline connection mode, as shown in Figure (49).



b

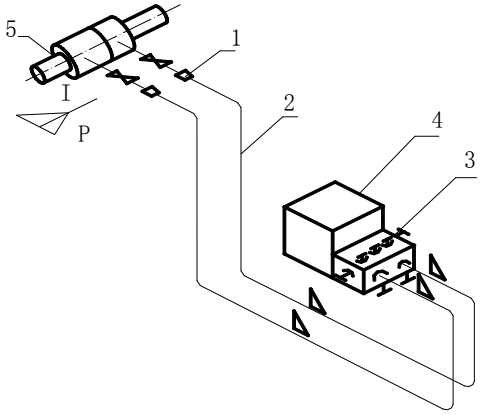


a

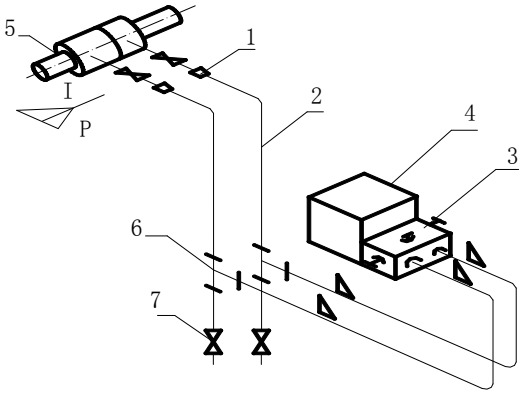


c

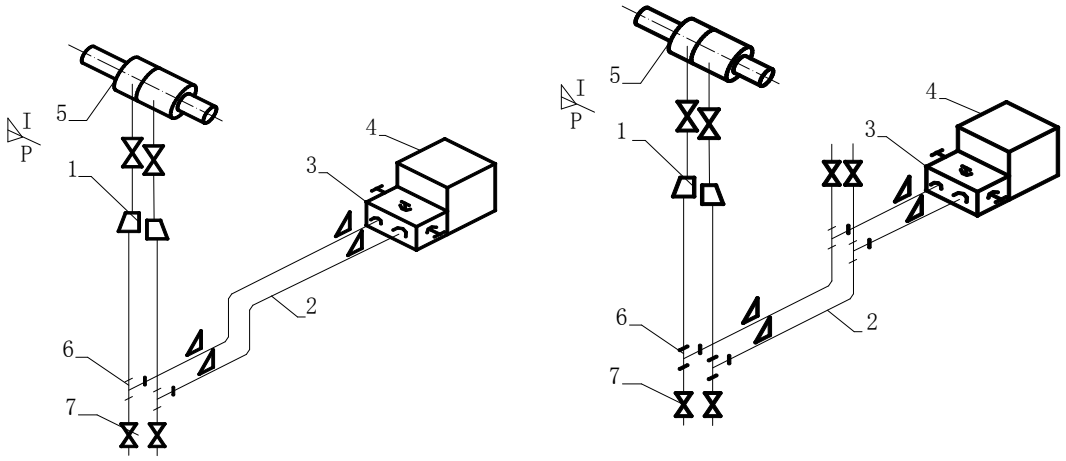
3.4.2 Schematic diagram of liquid flow measurement pipeline connection mode, as shown in Figure (50).



a

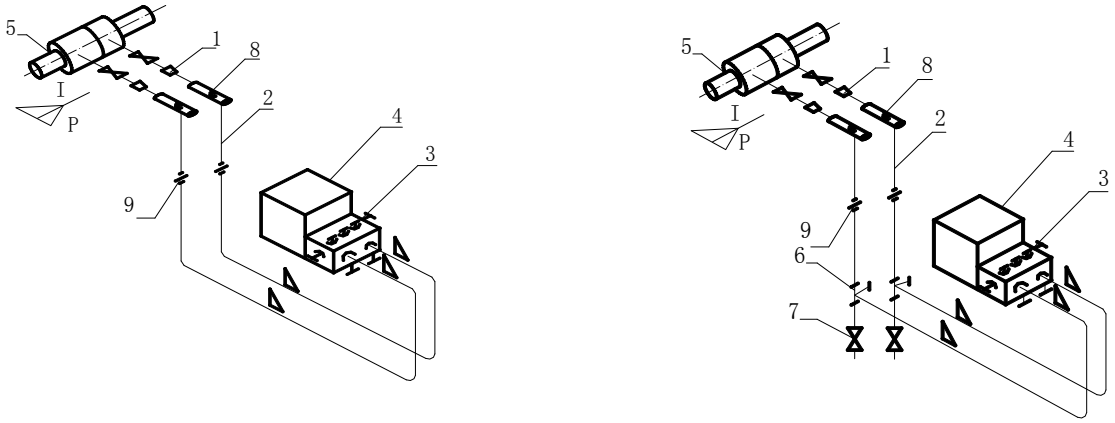


b

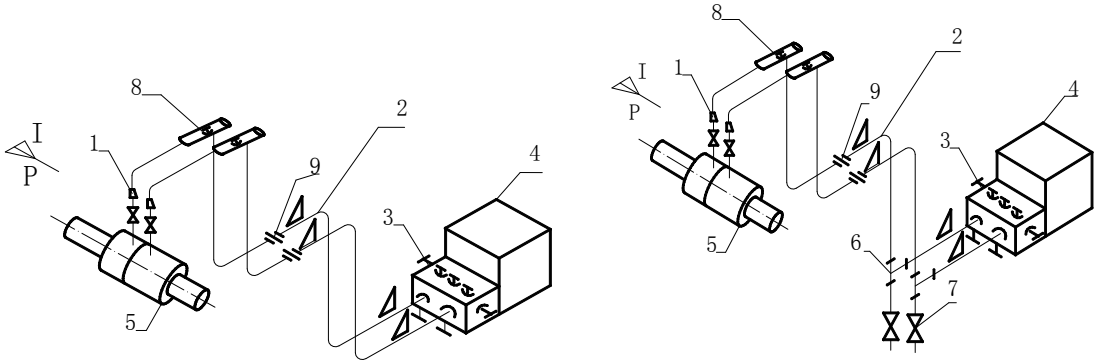


c d

3.4.3 Schematic diagram of steam flow measurement pipeline connection mode, as shown in Figure (51).



a b



c d

Part number description:

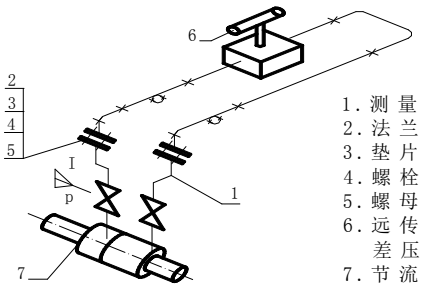
1. Butt-welded (socket welding) reducer joints Φ22/Φ14;
2. Seamless steel pipe Φ14×2
3. Three-valve assembly (or five-valve assembly) PN16, DN5, with a DN10 coupling;
4. Differential pressure transmitter
5. Throttling device;
6. PN6.3, DN10 welded (or ferrule-type) three-way intermediate joint
7. External thread ball valve (or globe valve), DN10;

8. Condenser, PN6.3, DN100, Φ14, with plug screw

9. Butt-welded (or ferrule-type) straight-through intermediate joint, PN6.3, DN10

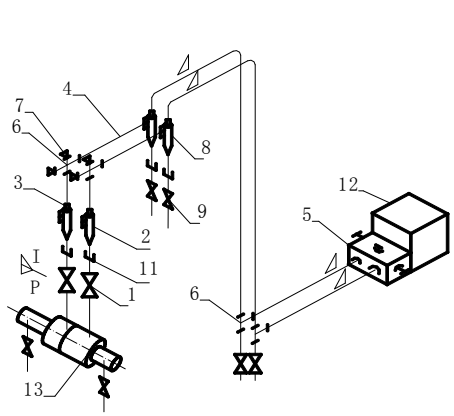
Note: When selecting pipe valve parts, the size should be selected according to the working pressure and temperature parameters, and must meet the process requirements and the matching of pipe size.

3.4.4 Schematic diagram of the connection mode of the flow pipe of the corrosive medium, as shown in Figure (52).

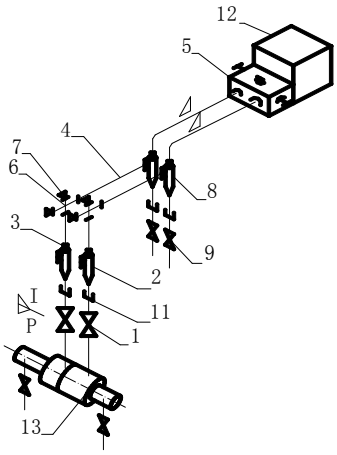


graph （52）

3.4.5 Schematic diagram of dust-containing gas pipeline connection mode measurement, as shown in Figure (53)



a



b

a b

Part number description:

1. Seamless steel pipe Φ22×2;
2. Separation vessel Φ55×3.53;
2. 3. Straight-through terminal connector;
4. Seamless steel pipe;
5. Three-valve group;
6. Four-way;
7. Plug;
8. Separation vessel Φ57×3.5;
9. Valve;
10. T-joint;
11. Direct terminal connector;
12. Differential pressure transmitter;
13. Throttling device;

4. Operation and Maintenance

4.1 Operation

1) The throttle device must be used with the differential pressure transmitter to determine the flow rate. To facilitate on-site zero-point adjustment, a "three-valve assembly" must be installed at the pressure lead pipe of the differential pressure transmitter. Refer to the transmitter's manual for usage instructions.

2) To accurately measure differential pressure values for actual flow measurement, proper installation of pressure tap piping is essential. Additionally, the pressure-conducting medium (which transmits fluid static pressure) within the pressure tap must remain in a single-phase state (liquid or gas). Specifically: When measuring liquid flow, the pressure tap must be completely filled with liquid without any gas admixture; when measuring gas flow, the pressure tap must be fully filled with gas without any condensed liquid. To achieve this, a gas collector or sedimentation chamber can be

installed to collect gases from liquids (with periodic discharge) or liquids from gases (with regular removal).

3) The alignment between the design parameters of the throttle device and actual operating parameters directly determines measurement accuracy. When the throttle device is operational, if measured parameters stay within the design specifications, measurement accuracy typically meets the calculated design standards. However, if measured parameters deviate significantly from the design parameters (assuming the throttle device and differential pressure transmitter meet all required specifications in terms of selection, manufacturing, and installation), this may indicate an error in the original design parameters. In such cases, the design parameters should be revised and the throttle device recalculated accordingly.

4) Variations in process conditions during operation may alter fluid parameters. Implementing automatic tracking and compensation for temperature and pressure is essential to prevent measurement errors. The market now offers various intelligent flow meters that can input parameters such as medium temperature, pressure, standard density, compression coefficient, and flow coefficient (outflow coefficient), ensuring accurate measurement of throttling devices.

4.2 Maintenance

The throttling device operates reliably, with common failures including blocked pressure taps, clogged or leaking pressure lead pipes. Regular cleaning or blowing of pressure taps, lead pipes, and all sealed connections is essential. When ambient temperatures drop below 0° C, insulation layers should be wrapped around pressure lead pipes or heating pipelines installed. When measuring high-temperature media, install condensers or isolators to prevent high-temperature media from entering the differential pressure transmitter's pressure measurement chamber.

4.3 On-site Storage and Storage

The storage location of the instrument shall meet the following conditions:

a） Rainproof and moisture-proof

b） No mechanical vibration and avoid impact.

c） Temperature range: -10℃~+55℃

d） The humidity is not greater than 80%

e） Avoid open storage

5. Unboxing and inspection:

Before unpacking and inspecting the purchased instrument, carefully check the packaging for any damage, tampering, or impact marks. If suspicious items are found that may have damaged internal components, immediately notify our company and the carrier. Exercise caution when opening the box to avoid scratching the throttle components or other parts. After unpacking, first locate the "Packaging List" in the accompanying documents and compare it with your order contract to verify each item. If you find any misshipped, missing, or damaged items, promptly inform our company. Confirm your instrument system configuration using the "Throttle Device Design Calculation Book" in the documentation, and proceed with installation, wiring, and operation accordingly. After inspection, properly store all accompanying materials!

Section Flow Device Code Summary Table

model —————□□□□ □□ □ □ □ □

YSJLB- standard orifice plate
(Pressure measurement method is not limited)
YSJLBJ-Standard Orifice Plate
(Edge pressure)
YSJLBF-Standard Orifice Plate
(Flange pressure)
YSJLBZ-Flat Plate
（DN＞1000）
YSJLBY integrated orifice plate flowmeter
YSJLBX-Internal Perforated Plate
YSJLBR-conical inlet orifice plate
YSJLBS quarter-round hole plate
YSJLBQ-Circular and Slit Plate
YSJLBP-eccentric plate
YSJLBT-end hole plate
YSJLBG High-Pressure Lens Plate
YSJLAT-Limiting flow orifice plate
YSJLH-Annular Plate(Standard)
YSJLHM(With equalizing ring)
YSJLHZ-Annular orifice plate
With diaphragm
YSJLHY integrated annular orifice plate flowmeter
YSJLHJ-Annular orifice plate (With jacket insulation)

YSJLP-ISA1932 nozzle
YSJLPY-Integrated Nozzle Flow Meter
YSJLC-Long Axis Nozzle
YSJLW-Classic Venturi tube
YSJLWJ-Rectangular Venturi Tube
YSJLWC-Insert Venturi
YSJLL-Venturi nozzle
YSJLD-low-pressure loss flow pipe
YSJLX-Cone Flow Meter
YSJLV-V type cone flowmeter
YSJLY-Sonic Nozzle

Accessories

code	0	1	2
appendix	ot hav	ompanion flang	Yes, see the contract

Flange material

code	0	1	2	3
material quality	not have	carbon steel	stainless steel SUS304	arbitral clause make a footnote

Chamber (or measuring tube) material

code	0	1	2	3	4
material quality	not have	carbon steel	Stainless steel SUS304	alloy steel	arbitral clause make a footnote

throttle component (at the minimum flow cross-section) material

encoding	1	2	3	4
terial qua	tainless stee SUS304	stainless steel SUS321	stainless steel SUS316L	ew contra

Tube Nominal Pressure (MPa)

code	01	02	03	04	06	07	08	09	10	11	00
pressure	0.25、0.6	1、1.6	2.5	4	6.3	10	16	25	32	40	ew contra

Critical flow Venturi nozzle. Nominal diameter (mm): Enter the value directly. If the number is less than four digits, add leading zeros.

For example, the nominal diameter is 150, and the code is 0150.

Flow Equipment Order Inquiry Form

Ordering Consultative Form for the Throttling Device

Ordering Unit				postal address Corraddress			
representative Rep		date Date		telephone Tel		portraiture Fax	
Instrument name Name of Instrument				model Model			
quantity Quantity				Select the upper limit of the differential pressure gauge Up limit value for chosen pres diff meter			
1. Measurement medium Measured medium				11. Average atmospheric pressure (use area) Average atmospheric pres （using region）			
2. Flow scale Scale				12. Relative humidity Φ =% Relative humidity			
3. Maximum flow rate (kg/h, t/h, m^3 /h) Max flow m3/h (0℃,101.325kPa; 20℃,101.325kPa, working status)				13. Pipe specifications (outer diameter × wall thickness) mm pipe bore（Outside diameter×Wall thickn.）			
4. Common flow rates: kg/h, t/h, m^3 /h Norm flow m3/h (0℃, 101.325kPa; 20℃,101.325kPa, working status)				14. Media composition Medium component percent volume to volume Volumetric percentage			
5. Minimum flow rate (kg/h, t/h, m^3 /h) Min flow m3/h (0℃, 101.325kPa; 20℃,101.325kPa; working status)				15. Select the type of throttle device Varieties of the throttling device selected			
6. Sheet pressure kPa Pres indicated by work meter				16. Throttling component material Material of the throttle element			
7. Working temperature ℃ Working temp ℃				17. Pipe material and condition Material and the condition of the pipe			
8. Measuring medium density (operational state) kg/m3 Measured medium density (work state)				18. Pipe installation location Mounting position of the pipe			
9. Measuring medium viscosity (operational state) mPa •s Measured medium viscosity (work state)				19. Pressure loss Pres loss			
10. Isentropic index in working state Isentropic exponent under workg state				20. Required attachment name Name of the attachment required			

Note:Points for attention in filling in the form:

1. This consignment note and the contract together constitute the basis for the order. It must be filled in clearly and cannot be altered.

1.This consultative form and the contract together shall be regarded as the basis of order, which must be written clearly, furthermore they’ ll be invalid if altered.

2. When measuring gas flow, the flow rate must be specified in m^3 /h (0 ℃ ,101.325kPa 20℃,101.325kPa, working condition)

2.The flow state must be filled in while the gas flow is measured: m3/h (0℃, 101.325kPa , 20℃,101.325kPa,working state)