catalogue

# LGW inner venturi tube flow meter

operating instruction

1 Overview

LGW inner turi pipe flow meter is a new differential pressure flow measuring instrument with inner turi pipe as throttle parts. Neventuri tube is based on the traditional Venturi tube measurement principle and the traditional Venturi tube structure made a qualitative change and set the classic Venturi tube, ring hole plate, wear-resistant hole plate, tapered entry hole plate as one of the advantages of a new generation of venturi tube, Its measurement characteristics and use performance is better than the standard hole plate, nozzle and classical Venturi tube, Can be used to measure a variety of liquids, gases and steam, Especially suitable for measuring other types of measuring instruments difficult to measure all kinds of gas, unclean natural gas, high wet gas and other dirty fluids, In most industrial measurement occasions, Can be the replacement of the traditional hole plate, nozzle, classic venturi tube ideal replacement products.

2. Product structure and measurement principle

2.1 Product Structure

The inner turi tube is composed of a circular measuring tube 1 and a special core 2 placed in the measuring tube and coaxially with the circle in the measuring tube (see the schematic diagram of the inner turi tube structure in Figure 1 and the special core structure diagram in Figure 2). The special core is a geometric rotating body, which is connected by the front cone 6 (or cone 6), the middle column 7 and the rear cone 8. The proportion of the three sections and the angle of the conical and conical platform vary according to the measurement conditions. An annular cross flow channel is formed between the special core and the inner circle of the measuring tube, and the change law of the axial cross section area is the same as that of the axial cross section area of the traditional venturi tube. The placement of the special core in the measuring pipe is positioned with the bearing shaft 9 and 10 of the core (only the rear supporting shaft 9 for small and medium products) and the bearing ring 3.4 coaxial with the circle in the measuring pipe, and fixed with the stop parts. The supporting ring is composed of three or four supporting ribs with a coaxial inner ring, outer ring and one connecting the inner and outer ring. On the wall of the measuring pipe, provide a pressure joint 5 for measuring the front and rear static pressure of the fluid joint. Both ends of the measuring pipe are flanges for connection to the field process pipe.
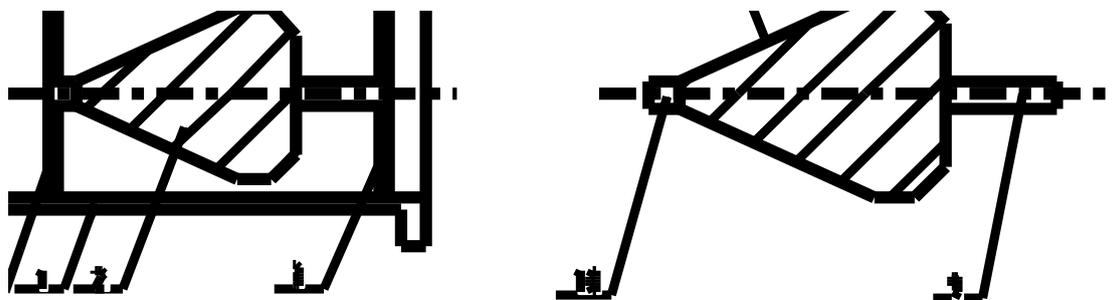
2.2 Measurement principle

In terms of the basic measurement principle, the measurement principle of the classical Venturi tube is the same, which is based on the law of conservation of energy- -the Bernoulli equation and the flow continuity equation. According to the basic measurement principle of differential pressure type flowmeter, the fluid flow through the pipe, the fluid in throttle cause local shrinkage, so that the flow rate increases, the static pressure drop, before and after the static pressure difference (differential pressure), the greater the flow rate of the fluid, the formation of differential pressure, the greater the fluid flow, the fluid flow through the flow and throttle process, by measuring the differential pressure, can know that fluid flow through the flow of the pipe.

3. Product technical performance

Uncertainty of outflow coefficient: $\pm$ 0.5% (measurement range 101)

Uncertainty of expansion coefficient: meet GB / T2624-93

Measurement range: 101, and it can be wider

Outflow coefficient stability: in the existing all kinds of differential pressure flow meters, the best stability

Pressure loss: measure about 1 / 5 of the differential pressure (about 1 / 3 of the hole plate pressure loss).

The length requirements of the installed straight pipe section: equivalent to or shorter than the classic venturi tube, generally upstream 3D, downstream 1D.

Suitable medium range: all kinds of liquids, gases and steam, including all kinds of gas, non-clean natural gas, high wet gas and dirty fluid containing more bubbles or a certain amount of solid particles. It can also measure the strong and corrosive fluid.

Reynolds number range as applicable: ReD 410^{3}The lower limit of the Reynolds number can be lower, when the uncertainty of the outflow coefficient is relatively large.

Applicable pipe diameter range: 25mm~1500mm (products with diameter less than 25mm and greater than 1500mm can also be provided according to user needs).

4. Product type and specifications

4.1 Product specifications

DN25mm~DN1500mm series products according to the diameter of measuring pipe:

25、（40）、50、80、100、150、200、（250）、300、（350）、400、500、600、（700）、800、（900）、1000、（1100）、1200、1400、1500

The connection between the two ends of the measuring pipe and the process pipe of the user adopts the national standard flange, and the chemical standard flange can also be used at the request of the user, and the products of welding or other connection forms can be provided.

Core structure, using Figure 2-1 or Figure 2-2, determined by design according to measurement conditions and requirements.

4.2 Pressure type

According to the differential pressure pressure method, LGW venturi flowmeter is divided into two types: ordinary pressure and remote flange pressure. Remote flange pressure is used for measuring pressure guide pipe, such as measuring high viscosity of heavy oil or other dirty fluid that is particularly easy to block the pressure channel.

4.3 Material of the product

The material of core and supporting ring is 1Cr18Ni9Ti or carbon steel, or other materials specified by the user; the material of pressure outlet joint is 1Cr18Ni9Ti or 1 Cr 13. The above materials are selected and ordered by the user.

For all the products used in strong corrosion media, the materials used shall be determined through consultation with the user.

5 The configuration of the flow measurement system

5.1 Composition of the flow measurement system

A typical flow measurement system consisting of LGW flowmeter shall include the following parts (see Figure 3 schematic of measurement system):

graph 3

① LGW inner venturi

② Differential pressure transmitter, differential pressure signal line and accessories

③ Pressure and temperature sensor

④ Intelligent flow (or flow, energy) display, calculus or flow computer

As above, the serial number ②, ③ and ④ can be configured by our company or by the user.

5.2 Allocation of the flow measurement system

① LGW inner turi tube, the structure parameters of each product are designed according to the use conditions and measurement range provided by the user, and the products of the same specification may not be universal for different measurement conditions.

② The type of differential pressure transmitter (ordinary pressure or far pressure) is determined according to the pressure mode, the upper range corresponds to the random file given field using the maximum differential pressure △ Pmax selection, the selected measurement range should be slightly higher than △ Pmax and close to △ P max quite grade products. The accuracy of the differential pressure transmitter should be reasonably selected according to the use conditions and the flow uncertainty requirements of the measurement system. The guide pressure pipe and the configured accessories of the differential pressure signal pipeline should be rationally configured according to the measurement conditions according to the differential pressure flow meter verification regulation JJG640-94 Annex 1 "laying method and installation principle of the differential pressure signal pipeline".

③ The specifications of the pressure and temperature sensors are reasonably configured according to the measurement conditions. When the pressure and temperature compensation correction requirements for the flow measurement of the measurement system, the pressure and temperature

sensors can not be matched.

④ The function of the flow display microcomputer shall meet the measurement conditions and the requirements of the measurement system for flow measurement, display and signal remote transmission, with reasonable selection and configuration.

6. Standard (check) of the flowmeter

6.1 Factory calibration of the flowmeter

If the user has no special calibration requirements for the flowmeter, each flowmeter calibrates the real flow coefficient C on the water calibration device before leaving the factory, and the calibration certificate is issued.

When the product is used to measure gas or vapor, the expandability coefficient ε is the calculated value (the expandable coefficient cannot be calibrated separately). At the request of the order, the gas can also be used to determine the product ε C of the product's outflow coefficient and the expandability coefficient, and the calibration certificate can be issued.

The calibration of newenturi pipe flowmeter is not necessary before the factory. When the calibration means of the user's measurement site or the empirical data provided by the manufacturer can meet the measurement requirements without separate calibration, the calibration before the factory can also be exempted.

6.2 Calibration method

The coefficient calibration method in JJG640-94 differential pressure flowmeter is used for the factory calibration and use verification of the flowmeter. The calibration flow range of the outflow coefficient shall generally cover the actual flow measurement range. When the capacity of the calibration equipment cannot meet the above coverage requirements, the upper limit of the calibration shall not be less than 210^5. When the motion viscosity of the calibration medium is different from that of the calibration medium under the actual working conditions, the calibration flow range should be converted according to the Reynolds number principle. The conversion is calculated by using the following formula:

$$q_{vb} = q_{vg} \times \frac{v_b}{v_g}$$

In formula: q_{vb}、 q_{vg}—— Is the volume flow m of the calibration medium and the measured medium respectively^3/h

v_b、 v_g—— Is the motion viscosity m of the calibration medium and the measured medium, respectively^2/s

6.3 Uncertainty requirements of the calibration equipment

Standard flow device: Es 0.1%

differential pressure transmitter：∣E△Full range of p 0.1%

Thermometer: 0- -50℃ standard mercury thermometer, a separation value of 0.1℃

Ambrometer: ± 0.2%

Time izer: score value 0.1 seconds

The range configuration of the differential pressure transmitter should ensure that the uncertainty of the actual differential pressure value of each flow verification point is not greater than 0.2%, and that the uncertainty of the calibration curve (value) given by the verification certificate of the differential pressure transmitter is allowed.

The calibration of the outflow coefficient allows the use of the standard table method, and the uncertainty of the standard table should be better than 0.2%.

6.4 Calculation method of the real standard outflow coefficient and its uncertainty

6.4.1 Outflow coefficient of the test point

For water calibration, the outflow coefficient Ci of each flow test point is calculated by formula (1), and for gas calibration, the (ε C) i of each test point is calculated by formula (2).

$$C_i = \frac{4q_v\sqrt{1-\beta^4}}{\pi D^2 \beta^2 \sqrt{2\Delta P/\rho_1}} \quad\text{...}\quad (1)$$

$$(\varepsilon C)_i = \frac{4q_v\sqrt{1-\beta^4}}{\pi D^2 \beta^2 \sqrt{2\Delta P/\rho_1}} \quad\text{...}\quad (2)$$

In q. (1) and (2), q_vIt is the standard volume flow value of each flow verification point during calibration.

6.4.2 Actual outflow coefficient of the flowmeter, take the maximum outflow coefficient C of all the verification points within the actual verification range$_{imax}$And the minimum outflow coefficient, C$_{imin}$The average value, calculated according to formula (3).

$$C = \frac{1}{2}\left(C_{i\max} + C_{i\min}\right) \quad\text{..}\quad (3)$$

6.4.3 Uncertainty of the outflow coefficient of the real standards

The uncertainty of the real standard outflow coefficient is calculated according to formula (4). $\frac{\delta C}{C}$

$$\frac{\delta C}{C} = \pm\left(E_r^2 + E_l^2 + E_s^2 + \frac{1}{4}E_{\Delta P}^2 + \frac{1}{4}E_{\rho_1}^2\right)^{1/2} \quad\text{......................}\quad (4)$$

In formula (4):

E$_r$-Measure repeatability, take E from all verification points within the calibration range$_r$The maximum value of

E$_l$- -The linearity of the outflow coefficient within the verification range is calculated according to formula (5)

E$_S$- -Standard flow device uncertainty

E$_{\Delta p}$— Differential pressure measurement uncertainty

E$_{\rho_1}$-Fluid density uncertainty used for verification in the laboratory, E$_{\rho_1}$It's negligible

$$E_1 = \frac{C_{i\max} - C_{i\min}}{C_{i\max} + C_{i\min}} \quad\text{..}\quad (5)$$

In a calibration certificate, only the Reynolds number R can be given for each calibration point$_{eD}$And its corresponding outflow coefficient without the calculation of linearity and calibration outflow coefficient.

When calibration with gas, the calibration certificate only gives the Reynolds number R for each calibration point$_{eD}$、 $\triangle P/P_1$Values and their corresponding ε C values, and no ε C uncertainty is calculated.

7 Use and installation requirements of products

7.1 General requirements for the use of the inner church pipe flowmeters

7.1.1 This flowmeter is only applicable to the fluids in the measuring circular cross-section pipe, and the fluid must be filled with the measuring pipe.

7.1.2 This flowmeter is only for measuring fluid in subsonic flow.

7.1.3 This flowmeter is not suitable for the measurement of the pulsatile flow.

7.1.4 If the actual installation conditions cannot meet the relevant requirements of this specification 8.2, the user shall reasonably introduce additional measurement uncertainty with reference to GB / T2624-93.

7.1.5 For the responsibility to the user, if the user intends to use the original order flow meter for the use conditions and measurement range beyond the original order requirements, please consult our company in advance.

7.1.6 The personnel installing and using the meter shall be familiar with the contents of this manual and receive professional technical training in the use of differential pressure meter.

7.2 Installation requirements of the interior turi pipe

7.2.1 The characteristics of the inner venturi pipe determine the requirements of the straight pipe section, which can be lower than the length of the straight pipe section required by the classic venturi pipe. Usually, the upstream should be not less than 3D and the downstream is not less than 1D, depending on the condition of the pipeline.

7.2.2 The sealing washer at the flange connection should not burst into the tube.

7.2.3 Valves used in the system shall be installed downstream of the inner turi tube.

7.2.4 When used for measuring coke oven gas or other fluids with special insulation requirements, thermal insulation facilities shall be installed at the venturi pipe (including pressure joint) and pipe connection flange for insulation.

7.2.5 The pipe connected to the inner turi pipe shall be inspected visually and within the 2D length range upstream of the inlet flange. The inner diameter of the pipe shall be cylindrical, and the difference between any diameter measurement and the average diameter shall not exceed 2% of the average diameter. The inner diameter of the pipe connected downstream of the pipe shall be the same as the nominal diameter of the pipe, but it does not need to be measured accurately.

7.2.6 The offset distance between the upstream pipe axis of the pipe and the pipe shall be less than 0.005D, and the angle between the pipe shall be less than 1°.

7.3 Laying and installation requirements of differential pressure signal pipeline

The laying and installation of differential pressure signal pipeline and accessories are crucial to ensure the measurement accuracy and reliability of the measuring system. In this respect, the differential pressure flow measurement technology has accumulated a very rich experience after years of practice. This specification describes JJG640- -94 "Verification regulations for differential pressure flowmeter" appendix 1 "Installation method of differential pressure signal pipeline" as the laying and installation requirements of the inner Churi pipe flowmeter for the differential pressure signal pipeline. See the Appendix of this specification for more details.

7.4 Requirements for use, maintenance, verification and calibration

7.4.1 The outflow coefficient C of the internal venturi tube shall be verified regularly during use. Because the outflow coefficient of the tube can be kept constant for a long time, the verification period can be greatly extended than the verification period of the standard differential pressure device stipulated in the verification regulation JJG640 of the differential pressure flowmeter, depending on the conditions of the measured medium. Suggestion: The clean fluid verification period is generally 8 years: the non-clean fluid verification cycle is generally 6 years. When the reliability of the internal management work is questioned for some reason, the verification work should be carried out in advance.

7.4.2 The differential pressure transmitter used in the inner venturi tube shall be verified regularly. The verification period refers to the use requirements of the differential pressure transmitter products or

implements the relevant technical standards of the national industry.

7.4.3 The supporting flow display calculus shall be calibrated regularly, and the calibration period is no longer than one year.

7.4.4 The differential pressure signal pipeline and accessories should be checked regularly and maintained regularly. There are heat tracing and insulation layer, including the inspection of heat tracing system and insulation layer. Special attention should be paid to check the reliability of the balance valve and the bypass pipe valve of the three valve sets. Regular maintenance cycle is set at the user's discretion.

7.4.5 When the inner turi tube is used for non-clean fluid measurement, the second pressure outlet should be regularly checked for any foreign body blockage (the inspection period shall be determined by the user). If there is foreign body blockage, it should be removed. When removing the blockage, the pressure outlet should not be damaged. During use, allow to blow out the pressure port in front of the three valve sets.

7.4.6 Judgment and handling of measurement faults

During the operation of the system, if abnormal flow data, follow the following procedures to check and eliminate the fault;

① Check whether the signal transmission line is normal;

② Check whether the flow display computer or computer is working normally;

③ Check whether the differential pressure signal pipeline system is normal, there is no leakage, special attention should be paid to check whether the balance valve and bypass valve of the three valve group is reliable;

④ Check whether the differential pressure transmitter works normally;

⑤ Check for foreign body blockage.

8 Flow debugging and online real-time correction method of the user measurement system

8.1 Basic formula of flow calculation

As a differential pressure flow meter, the flow calculation method is the same as the hole plate and the classical venturi tube. The flow calculation formula given by the national standard GB / T2624 is fully applicable to the inner turi tube. Only one thing to be noted is that the throat of the inner turi tube is a ring gap between the outer circle of the inner core and the inner circle of the measuring tube. The throttle diameter of the inner turi tube is defined as the equivalent β value. The so-called equivalent β value refers to the aperture d of the annular cross-section area of the throat being converted into a circular orifice with the same (equivalent) circulation area[1]The ratio to the measured tube inner diameter D, i. e., while (here d $\beta = \dfrac{d^1}{D}$ $d^1 = \sqrt{D^2 - d_1^2}$ [1]The diameter of the core), so the mathematical expression of the equivalent β value of the tube is:

$$\beta = \frac{\sqrt{D2 - d_1^2}}{D} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{（6）}$$

When using the standard formula to calculate the flow of the pipe, the aperture d in the original standard formula should be changed or replaced by D • β. Mass flow q of the nwenturi tube $\sqrt{D^2 - d_1^2}$ [m]Calculculation formula as formula (7) and volume flow calculation formula as

formula (8).

$$q_m = \frac{C}{\sqrt{1-\beta^4}} \varepsilon_1 \frac{\pi}{4} D^2 \beta^2 \sqrt{2\Delta p \times \rho_1} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{（7）}$$

$$q_v = \frac{C}{\sqrt{1-\beta^4}} \varepsilon_1 \frac{\pi}{4} D^2 \beta^2 \sqrt{2\Delta p / \rho_1} \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{（8）}$$

The name significance of each symbol in formulas (7) and (8) is the same as that of gb GB / T2624, where the outflow coefficient C is the real flow calibration value, and the expandability coefficient is ε_1 Calculated values were used.

8.2 Flow debugging and calculation method

For users, the flow debugging of the measurement system generally does not need to use formula (7), (8) for calculation. In the factory random file "flow calculation sheet" of LGW, the special calculation formulas (9) and (10) are much more simplified than formula (7) and (8). In the calculation sheet, the calculation results of common working condition flow, maximum flow and minimum flow are also given for user reference.

$$q_m = K * \sqrt{\Delta P} * \sqrt{\rho_1} * \varepsilon \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{（9）}$$

$$q_V = K * \sqrt{\Delta P} / \sqrt{\rho_1} * \varepsilon \quad \cdots\cdots\cdots\cdots\cdots \text{（10）}$$

In formula (9) and (10):

q_m-Working condition mass flow rate kg / h

q_v-Working volume flow m³/h

K- -The coefficient of the tube device is calculated according to the structural parameters of each tube and the real standard outflow coefficient C according to formula (7) and (8), and the specific values are given in the calculation sheet

Δ P-Measurement of differential pressure kPa

ρ_1-The density of the fluid before the throttle is kg / m³

ε — Gas expandability coefficient is calculated in this specification 8.5

The differential pressure Δ P in formula (9) and (10) shall be calculated by formula (11) according to the output current value I of the differential pressure transmitter.

$$\Delta P = (I - 4) \times \frac{\Delta P_{max}}{16} \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{（11）}$$

In the above formula:

Δ P $_{max}$—— The differential pressure value kPa corresponding to the full range of the differential pressure transmitter (output current 20 mA)

The output current value of the I —— differential voltage transmitter is mA

Using formula (9), (10), there is no need for supporting secondary instruments, as long as the output current value of the differential voltage transmitter is measured, and then according to the known working condition density ρ_1 And the expandability coefficient ε , you can easily calculate the working condition flow. In the process of system debugging and operation, if the abnormal flow display is found, the secondary instrument is disconnected, and using the above manual calculation method, we can determine the problem whether the problem is in the differential pressure device, the differential pressure transmitter or the flow calculator (improper configuration setting or other

operation errors, etc.).

8.3 Online real-time correction method of traffic

During the operation of the system, when the working condition variation is large and the user requires the measurement accuracy is high, it is necessary to make online real-time correction of the flow measurement deviation due to the change of fluid density and expandability coefficient (only occurring in the gas and vapor measurement). This kind of correction, because of the use of traditional differential pressure flow instrument, must be achieved with the use of the flow calculator or computer and other secondary instruments of the correction operation function. Using the secondary instrument with the perfect flow compensation operation and processing function, in the system debugging, according to the measurement conditions and compensation and correction needs, select the corresponding operation and processing function, to correctly complete the configuration operation, the flow can be automatically completed after real-time correction.

About the content of flow measurement online real-time correction and specific calculation method, has not yet formed a unified standard, many instrument manufacturers market sell flow calculus, calculus, the compensation correction function, calculation accuracy also has certain difference, therefore, the user should according to their own measurement requirements, reasonable matching secondary instrument. In order to facilitate the effective implementation of the online traffic correction as above, the general compensation correction method is discussed in principle here.

① Full scale percentage calculation correction method

Based on formula (9) and (10), the full scale differential pressure of the transmitter ΔP is calculated according to the instrument coefficient and measurement conditions$_{max}$(Corresponding output current is 20 mA) corresponding full scale flow q_{mmax}perhaps q_{vmax}, Then according to the measured flow point q_{mi}perhaps q_{vi}And its corresponding differential pressure of ΔP_i(Corresponding to the output current I_i), fluid density ρ_{1i}, Expandability coefficient, ε_{1i}, Calculate according to formula (12) or (13) configuration programming.

$$q_{mi} = q_{m\max} * \sqrt{\frac{I_i - 4}{16}} * \sqrt{\frac{\rho_{1i}}{\rho_{1max}}} * \frac{\varepsilon_{1i}}{\varepsilon_{1\max}} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad （12）$$

$$q_{vi} = q_{v\max} * \sqrt{\frac{I_i - 4}{16}} * \sqrt{\frac{\rho_{1\max}}{\rho_{1i}}} * \frac{\varepsilon_{1i}}{\varepsilon_{1\max}} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad （13）$$

If the measurement is a liquid, the $\varepsilon_{1i} / \varepsilon_{1max}=1$; If the measurement is gas, but the density and expandability coefficient are not necessary due to the small change, the latter two terms of formula (12) and (13) are equal to 1.

In particular, the ρ in Equations (12), (13)$_{1max}$、 ε_{1max}They respectively refer to the working condition density ρ used when calculating the full-scale flow rate$_1$And the expandability coefficient, ε_1， ρ_{1max}、 ε_{1max}Does not represent the maximum density and the maximum expandability coefficient that may occur during the measurement. Full-scale flow rate corresponding to the ε_{1max}Should be based to full scale differential pressure ΔP_{max}And working condition pressure P_1Calculate according to the ε calculation formula.

② Real-time calculation method

Based on formulas (9), (10) and (11), direct configuration programming to calculate the flow q of each detection point$_{mi}$perhaps q_{vi}According to the measured ΔP_i(The corresponding measured I_i）、 ρ_{1i}(Corresponding measured working condition pressure P_1, temperature T), ε_{1i}(Corresponding to the measured $\triangle P$ and P_1) Calculate. If the measurement is liquid, $\varepsilon =1$; if it is gas but requires density and expandability coefficient compensation correction, ρ_1, ε

as a constant and combined with the device coefficient K into a new constant term, which is the simplest flow measurement operation.

Perhaps due to the influence of traditional practice, a variety of traffic calculators and display calculus sold on the market, almost all use the full scale percentage calculation correction method. When the gas is measured and the working condition variation range is large, the correction error of the expandability coefficient using the full scale percentage method is larger than the real-time calculation method.

The key of the online real-time flow correction is to deal with the fluid density change correction. For the measurement of gas and steam, the compensation correction of the expandability coefficient must also be done well. The next section will discuss the fluid density and expandability coefficient in detail.

8.4 Fluid density

8.4.1 Fluid density

It can be seen from the flow calculation formula that the fluid density is the main physical parameter that affects the use of the differential pressure flow meter. Whether the density value used is accurate has a direct impact on the accuracy of the flow measurement.

Liquid, gas, steam density is a function of temperature, pressure, multi-component mixed fluid, its density is related to the proportion of the component, when measuring temperature, pressure or fluid components changes its density will change, the fluid, the density can according to the fluid component, pressure, temperature from the reference book directly check or according to the calculation formula given. In the actual measurement, the sampling test value of the measurement site is often used. For the measurement occasions where fluid components, temperature and pressure change frequently and require high measurement accuracy, an online densitometer can be installed in the measurement system for real-time measurement of density.

8.4.1.1 Liquid density

The density of water can be obtained by checking; the density of crude oil varies with its origin (components), and the field test value is used; for typical oil products and other liquids with corresponding standard, for liquid without standard density. During the operation of the system, the density correction of the liquid temperature change, such as the hot water density correction of the heating system, should better use the calculation correction method of quadratic polynomial.

8.4.1.2 Density of water vapor

The density of water vapor is generally checked from the water vapor table specified in the standard. Because the physical property of water vapor is far away from the ideal gas, in the operation process of the system to correct the temperature and pressure change cannot use the simple method of "proportional to the pressure and inversely proportional to the temperature".

8.4.1.3 Density of the general dry gas

The dry air and the gas density of various single components are generally based on the density ρ of the gas in the standard state$_n$On the basis, the pressure and temperature are converted according to formula (14).

$$\rho = \rho_n \frac{PT_nZ_n}{P_nTZ} \cdots\cdots\cdots\cdots\cdots\cdots （14）$$

In the upper equation, ρ_n、P_n、T_n, Zn and ρ, P, T, Z, respectively, are the gas density, pressure, temperature, and compression coefficient in the standard state and in the measured working condition, where the temperature shall be absolute temperature and the pressure shall be absolute pressure. The gas density and compression coefficient of dry air and other single

components in the standard state can generally be found in reference books.

8.4.1.4, the density of the mixed gas

In the standard state, the mixed gas density is calculated according to the gas density of each component and the standard state according to formula (15).

$$\rho_n = \rho_{n1}x_1 + \rho_{n2}x_2 + \cdots\cdots \rho_{nm}x_m \quad (15)$$

In the formula (15):

ρ_n- -Gas density of the mixed gas in the standard state

ρ_{ni}- -The density of component i in the mixed gas in the standard state, i=1~m

x_i- -Volume percentage content of component i in the mixed gas in the standard state, i=1~m

The mixed gas density under measured working condition is calculated based on the mixed gas density under standard state and according to the measured working condition temperature and pressure according to formula (14).

The calculation method of compression coefficient is complicated, but it can be simplified. Among them: for all kinds of gas, because the measurement condition is generally relatively low, mostly below 0.5MPa, the temperature is also close to the room temperature, the compression coefficient is Z=1.

The main component of natural gas is methane (CH_4), Where the dry well natural gas is generally CH_4The content is about 98%. If reliable gas component analysis data is missing, the density of natural gas can be approximated according to CH_4count.

For the measurement of trade settlement, the density of natural gas needs to be calculated accurately, please refer to the oil and natural gas operating standards and the corresponding national standards.

8.4.1.5 Density of the wet gas

In general, the field-measured air, all kinds of gas, flue gas, etc., are all wet gas containing a certain amount of water vapor. The density of wet gas is calculated by formula (15), (16), (17) according to its relative humidity.

$$\rho_s = \rho_{sg} + \rho_{ss} \cdots\cdots\cdots\cdots\cdots\cdots (16)$$

$$\rho_{sg} = \rho_{gn} \frac{P - \varphi P_{smax}}{P_n} \frac{T_n Z_n}{TZ} \cdots\cdots\cdots\cdots\cdots (17)$$

$$\rho_{ss} = \varphi\rho_{smax} \cdots\cdots\cdots\cdots\cdots (18)$$

In formulas (15), (16), (17):

ρ_s-Wet gas density kg / m^3

ρ_{sg}-Dry gas density in wet gas kg / m^3

ρ_{ss}-Water vapor density in wet gas kg / m^3

ρ_{gn}-Dry gas density at standard state kg / m^3

P、T、Z、P_n, Tn, Zn-are the absolute pressure, absolute temperature and compression coefficient of the measured working condition and standard state respectively

ψ — Relative humidity of the wet gas

P_{smax}-Maximum water vapor pressure (full steam pressure) kPa at temperature T

ρ_{smax}-Maximum density of water vapor (full steam density) kg/m at temperature T^3

8.5 Calculation method of expandability coefficient

Because the gas (including steam, the same below) has expansibility, the density of the gas

caused by the decrease of the static pressure is basically consistent with the isentropic change process of thermodynamics; also, due to the expansiability of the gas, the contraction degree of the fluid flows through the same adjoint. The gas and liquid are different, and the minimum beam shrinkage cross section of the gas is larger than that of the liquid. The expandability coefficient in the flow calculation formula is a scientific correction of the difference between the gas density change and the flow beam contraction when measuring the gas by using the throttle parts with known outflow coefficient.

A results of previous studies show that the expandability coefficient ε is $\triangle$ P / P₁The function is related to the isoentropy index κ of the gas and the β value of the measuring part and the expandability coefficient is different. When the structure form and the β value of a measuring part is determined, for the measured gas, the expandability coefficient ε can be considered only with $\triangle$ P / P₁And change. Therefore, in the process of system operation, generally speaking, the change of the expandability coefficient can be only based on the variable $\triangle$ P / P₁Changes for online real-time correction.

Theoretical analysis and experimental results show that the ε value of the LGW inner venturi tube is close to that of the classical one.equal $\triangle$P/P₁At 0.04, the ε value of the two tubes is basically the same, which can be calculated by the calculation formula of the classical formula (19).equal $\triangle$P/P₁At large values, the ε will be slightly larger than the ε of the classical one.to this end, $\triangle$P/P₁When it is large and the accuracy of flow measurement is high, the ε value can be calculated using the empirical formula (20) corrected by experiment.

$$\varepsilon_1 = \left[\left(\frac{\kappa\tau^{(2/\kappa)}}{\kappa-1}\right)\left(\frac{1-\beta^4}{1-\beta^4\tau^{(2/\kappa)}}\right)\left(\frac{1-\tau^{(\kappa-1)/\kappa}}{1-\tau}\right)\right]^{1/2} \quad\cdots\cdots\cdots\cdots\cdots\cdots （19）$$

$$\varepsilon_1 = 1 - \left(A + B\beta^4\right)\times\frac{\Delta P}{\kappa P_1} \quad\cdots\cdots\cdots\cdots\cdots\cdots （20）$$

In formula (19), (20):

ε_1= Expandability coefficient

τ — Pressure ratio before and after throttle, τ =P₂/P₁

κ — Gas isoentropy index

β — The throttle diameter ratio of inner turi tube

P_1、 P_2- -The absolute pressure of before and after throttling, kPa, respectively

$\triangle$ P- -Measurement of differential pressure, kPa

A, B-coefficient, specific values will be given in the "traffic calculation sheet" of the random file of Venturi products

8.6 Conversion method of the standard state volume flow rate

Air, gas, natural gas and other gas measurement units, often use the standard state volume flow, used to record as Nm³/h。From the measured operating condition volume flow rate qᵥThe volume flow rate q is converted to the standard state$_{vn}$Using the formula for (21)

$$q_{vn} = q_v\frac{PT_nZ_n}{P_nTZ} \quad\cdots\cdots\cdots\cdots\cdots\cdots （21）$$

P. in formula. (21)ₙ, Tn, Zn, P, T, and Z, represent the absolute pressure, absolute temperature, and compression coefficient of the standard state and measured working states, respectively.

9 Evaluation method of the uncertainty of user traffic measurement

According to GB / T2624-93, the uncertainty of volume flow measurement when the user uses

the inner church pipe flow meter is evaluated according to formula (22), and the uncertainty of mass flow measurement is evaluated according to formula (23).

$$\frac{\delta q_v}{q_v} = \left[\left(\frac{\delta C}{C}\right)^2 + \left(\frac{\delta \varepsilon}{\varepsilon}\right)^2 + \frac{1}{4}\left(\frac{\delta \Delta P}{\Delta P}\right)^2 + \frac{1}{4}\left(\frac{\delta \rho_1}{\rho_1}\right)^2\right]^{1/2} \quad\dotsb\quad (22)$$

$$\frac{\delta q_m}{q_m} = \left[\left(\frac{\delta C}{C}\right)^2 + \left(\frac{\delta \varepsilon}{\varepsilon}\right)^2 + \frac{1}{4}\left(\frac{\delta \Delta P}{\Delta P}\right)^2 + \frac{1}{4}\left(\frac{\delta \rho_1}{\rho_1}\right)^2\right]^{1/2} \quad\dotsb\quad (23)$$

In formula (22) and (23), the calculation error of secondary instruments such as flow calculation display instrument is not included.

In formulas (22) and (23), $\delta C / C$ is the uncertainty of outflow coefficient given by the real flow calibration, and $\delta \varepsilon / \varepsilon$ is the uncertainty of expansionability coefficient, which is calculated according to the calculation formula of $\delta \varepsilon / \varepsilon$ in GB / T2624-93. In formula (22), (23), $\delta \Delta P / \Delta P$, $\delta \rho_1 / \rho_1$ It should be reasonably determined by the user according to the measurement uncertainty of the differential pressure transmitter and density value. When converting the density, the gas density ρ of the standard state for general gases $_n$ The uncertainty can be regarded as the second order small amount, is not considered, the uncertainty of the gas compression coefficient, is generally not considered when the pressure is not very high. The uncertainty of natural gas density used for trade settlement measurement shall be treated according to the corresponding industry standards.

For the estimation method of fluid density uncertainty, if there is no special provision, the user can also refer to the estimation of fluid density error in Annex 6 of JJG640-94 differential pressure flowmeter verification procedure ".

10 Selection and ordering instructions

10.1 Users should fill in the order consultation form of LGW, and our company can assist users to make reasonable selection according to the consultation order. The consultation sheet is also the basis for our company to design the product for user orders.

10.2 When doing engineering design, the design institute can design and select according to the LGW product selection samples published by our company, and the owner or the complete engineering set unit shall still provide a complete LGW product order consultation form.

LGW inner pipe flowmeter product order consultation sheet is attached.

Appendix 1: Laying method and installation principles of differential pressure signal pipeline

1、explain

In order to ensure the reliability of the output differential pressure of the throttle device and accurately transmit it to the differential pressure meter or the differential pressure transmitter, the differential pressure signal pipeline shall be laid in accordance with the appendix.

2、connecting pipe

2.1 The guide pressure pipe shall be made of pressure resistance and corrosion resistance according to the nature and parameters of the measured fluid. Its inner diameter shall not be less than 6mm and the length shall be within 16m, depending on the nature of the measured fluid. The minimum inner diameter values at different lengths are shown in Table 1.

Table 1 Internal diameter and length of the guide pressure tube (mm)

lea pr Tu str fo / lea pr Tu lo lin / Be su str b	<16000	16000~45000	45000~90000
Water, water vapor, and dry gas	7~9	10	13
Wet gas	13	13	13
Low-and medium-viscosity products	13	19	25
Dirty liquid or gas	25	25	38

2.2 The guide pressure pipe shall be laid vertically or inclined, with its inclination less than 1:12, and the inclination of fluids with high viscosity shall be increased. When the differential pressure signal transmission distance is greater than 30m, the guide pressure pipe shall be inclined in sections, and the air collector (or exhaust valve) and settler (or discharge valve) shall be installed at each high and low points respectively.

2.3 In order to avoid the distortion of the differential pressure signal transmission, the positive and negative pressure catheter should be laid as close as possible. The guide pipe in cold areas should be equipped with frost protection, and the same measures should be taken as the main pipeline. Use electricity or steam to heat up the insulation, to prevent overheating. The fluid with low boiling point and easy to vaporize should also take the same measures as the main pipeline to prevent the fluid in the guide pressure tube.

3、Take pressure mouth

The pressure extraction port is generally set on the flange, ring chamber or clamping ring. The installation of flange, ring chamber and pressing ring shall prevent gas conduction pipe when the measured fluid is liquid, and when the measured fluid is liquid, prevent water and dirt from entering the conduction pipe.

3.1 When the main pipe of the throttle device is horizontal or inclined, the pressure installation position is shown in Figure 4.

graph 4

Figure 4 Schematic diagram of the position of the pressure outlet on the horizontal line or the inclined pipe

3.2 When the main pipe of the throttle device is vertical, the position of the pressure port is on the plane of the pressure device and can be selected arbitrarily.

4、 cut-off valve

The stop valve shall be installed on the signal pipe near the throttle parts. When the condenser is installed on the signal pipeline, the stop valve shall be installed in the position close to the condenser.

The pressure and corrosion resistance of the stop valve shall be the same as the main pipe. The circulation area of the stop valve should not be less than the circulation area of the guide pressure tube. The stop valve shall be structured to prevent the accumulation of gas or liquid in its body. To avoid affecting the transmission of differential pressure signal, it is recommended to use the direct hole stop valve.

5、 condensator

5.1 The function of the condenser is to condense the measured vapor in the pressure guide tube, and to make the condensate level in the positive and negative pressure guide pressure tube have an equal height and keep it constant. For this reason, the volume of the condenser should be greater than 3 times the maximum volume change of the working space of the differential pressure meter or the differential pressure transmitter in the full range. The horizontal cross-sectional area shall not be less than the working area of the differential pressure meter or differential pressure transmitter to ignore additional errors due to the condensate level fluctuations in the condenser.

5.2 The measured fluid is high pressure ($> 200 \cdot 10^5$Pa, 400℃) vapor, a condensate trap should be installed between the throttle part and the condenser to prevent the condensate back to the main pipeline and deform the throttle parts.

6、 Gas collector and settler

6.1 When the measured fluid is liquid, a gas collector or exhaust valve shall be installed at the highest point of the pressure guide pipe to collect and regularly discharge the gas in the signal line. When the installation position of the differential pressure meter or differential pressure transmitter is higher than the main pipeline, the gas collector or exhaust valve should be set up.

6.2 For all kinds of tested fluids, a settler or sewage discharge valve shall be installed at the lowest point of the pressure guide pipe to collect and regularly discharge the dirt in the signal pipeline and the water in the gas signal pipeline.

In order to facilitate blowing, it is recommended to use direct hole exhaust valve and discharge valve.

7. According to the properties of the measured medium and the relative position of the throttle device and the differential pressure transmitter (or differential pressure meter), the differential pressure signal pipeline has the following installation methods.
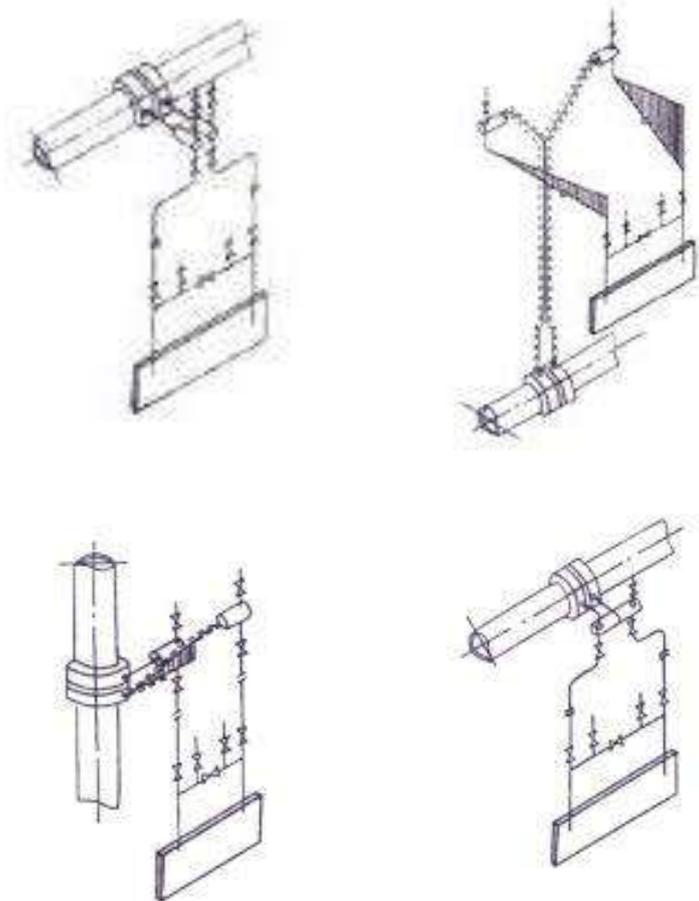
① When the measured fluid is a cleaning liquid, the installation mode of the signal line is shown in Figure 1. 4.28.
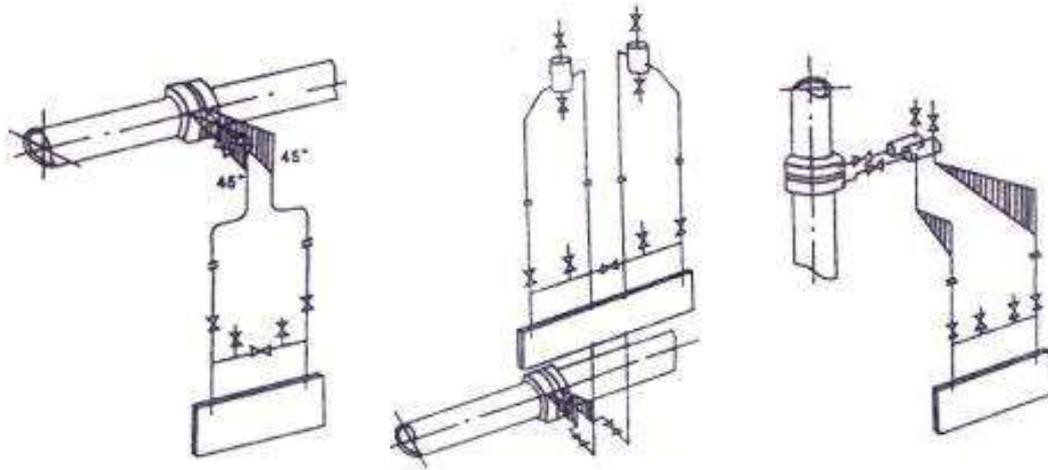
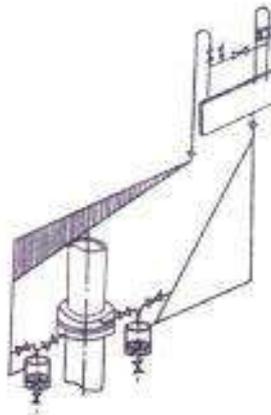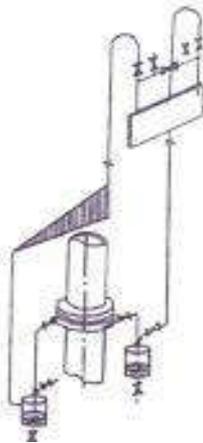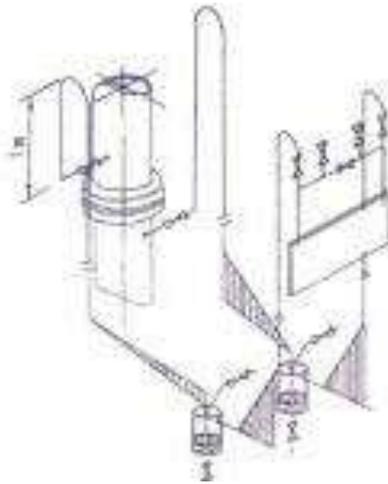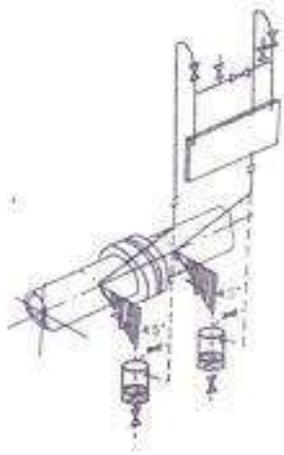② When the measured fluid is dry gas, the installation mode of the signal line is shown in Figure 1.4.29.
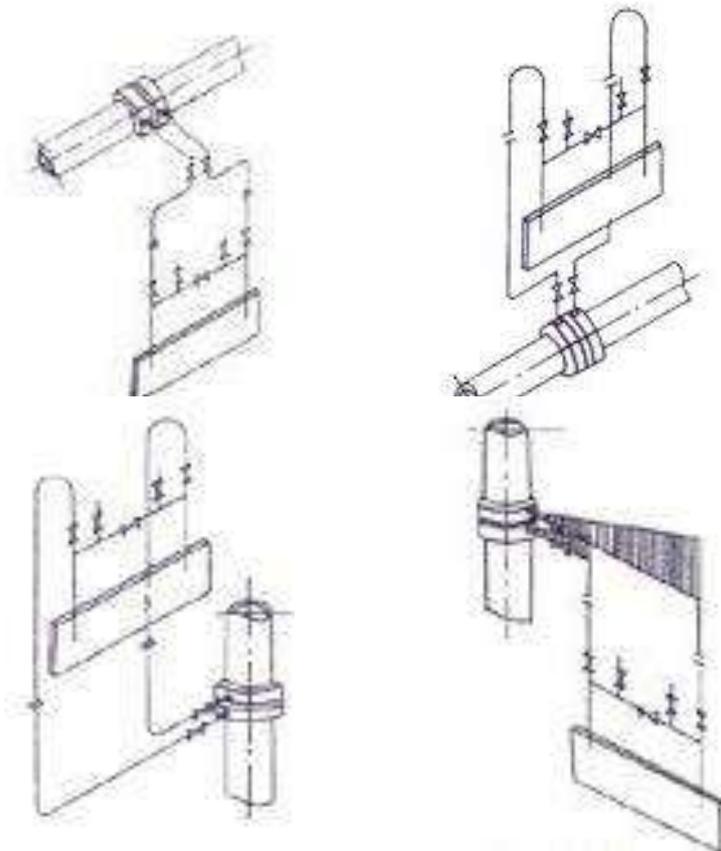
③ When the measured fluid is water vapor, the installation mode of the signal line is shown in Figure 1.4.30.

④ When the measured fluid is a clean gas, the installation mode of the signal line is shown in Figure 1.4.31.
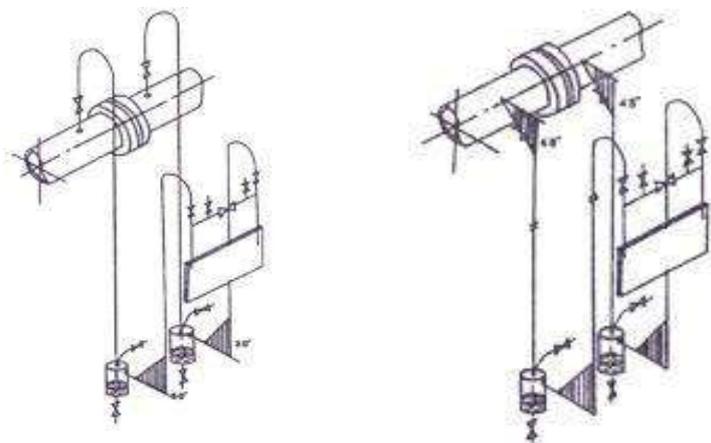
<u>User working condition consultation sheet</u>

conclude Goods unit	name		contacts	
	postal address		zip code	
	telephone		portraiture	
	E-mail			
Measuring fluid	Name-name			
	Industrial and mining density			
	Working condition viscosity			

Use cond	Fluid pressure (gauge pressure)	in common use	highest	lowest
	fluid temperature ℃	in common use	highest	lowest

iti on	rate of flow m³/h perhaps kg/h	in common use	maximum	minimum
Pipe inner diameter mm				
Effective range ratio requirements				
Calibration method requirements				
Flow meter installation of straight pipe section conditions	Upstream D and downstream D			
Flow-meter usage environment	Annual temperature range: local annual average atmospheric pressure:			
Flow meter use address	Provinces, cities and counties			
amount on order				
Requirements for delivery time				
User Supplemental Instructions				

Instructions for filling in the consultation form:

1、 When measuring the fluid as a mixture, if the user can not give the working condition density and viscosity, the percentage of the main fluid components must be given.

When measuring the fluid as dirty fluid, specify the type of foreign matter and the degree of dirty body in the fluid as far as possible.

2、 When the measurement fluid is coal gas, natural gas and other gas, the flow unit can also use the standard state cubic meter Nm per hour³/h。

3、 If users have no special requirements for the flow meter calibration method, this item can not be filled in.

4、 Only when the contents of the consultation sheet are exactly the same, can we share a consultation sheet.

5、 If our company needs a complete measurement system, please explain.