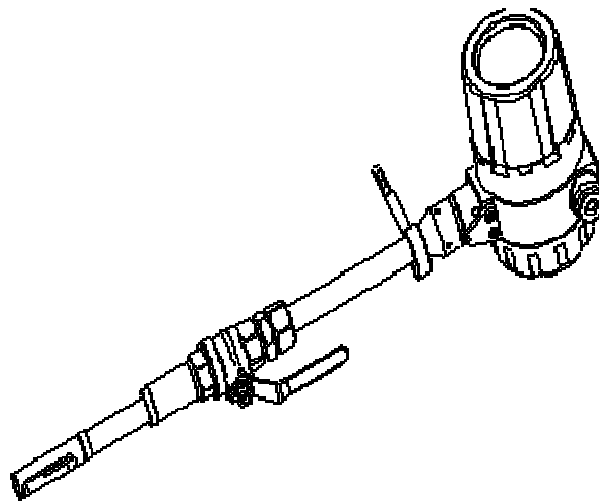


Thermal Gas Mass Flowmeter

Installation and Operation Guide



CONTENTS

Safety Information.....	1
Part 1 Introduction	4
Part 2 Specifications.....	6
Part 3 Mechanical Construction	8
3.1 Appearance	8
3.2 Dimensions.....	9
Part 4 Wirings	11
4.1 Instruction of Sensor Wirings	11
4.2 Instruction of Transmitter Wirings	11
4.3 The Wirings of Power Supply.....	12
Part 5 Installation	14
5.1 Installation Position	14
5.2 Pipework requirements	16
5.3 Installation Steps	17
Part 6 Operation and Programming	19
6.1 Display.....	19
6.2 Parameters Setup	20
6.2.1 Main Menu	20
6.2.2 Setup Menu.....	20
6.2.3 Unit Display.....	21
6.2.4 Self-Checking.....	21
6.2.5 Total Reset	21
6.2.6 Parameter Setup.....	22
6.2.7Calibration	24
6.2.8Password.....	26
6.2.9Query.....	27
Appendix 1 Troubleshooting and Repair	28
Appendix 2 The Density and Conversion Coefficient of Common Gas	30
Appendix 3 Upper Range Value of Common Gas.....	33

Safety Information

Thank you for purchasing our quality Thermal Gas Mass Flowmeter with independent research and development.

We have written this guide to provide the persons responsible for the installation, operation and maintenance of your flow meter with the product specific information they will need.

In order to prevent damage to instrument and make the instrument in the best performance and stable operation, please read this manual thoroughly before installation.

Please have a safekeeping of this manual and together with the instrument after reading.

Please pass this manual to technical department of end user to keep.

This manual classifies important grade of safety attentions by Caution and Warning.

Caution



Error operation in case of ignoring the tips might cause the personal injury, or damage to the instrument and property.

Warning



Error operation in case of ignoring the tips might cause the personal injury or major accident.

This manual contents the following icons:



Indicates safety attentions which are dangerous.



Indicates safety attentions which are needed to pay attention to.



Indicates safety attentions which are forbidden.



Select explosion-proof instrument for explosive environment application

Confirm whether the nameplate of instrument has the identifiers of explosion-proof certification and temperature class, the instrument can't be used in explosive environment without those identifiers.



The explosion-proof temperature class of instrument must meet the explosion-proof and temperature of environmental requirements on site

When the instrument is in used explosion-proof environment, make sure that the explosion-proof certification and temperature class of instrument meet to the requirements

on site.

 No opening while working in explosive environment

Before wirings, please power instrument off.

 The protection class of instrument must meet the working condition requirements on site

The requirement of protection class on site should be under, or the same as the protection class of instrument to ensure that the instrument is working fine.

 Confirm the power type

Customers can select the power type: 220VAC or 24VDC (Please state it when ordering).

Please confirm the power type before installation.

 Confirm the working environment of instrument and medium temperature

The environment on site and the maximum medium temperature should be under the nominal value of instrument. (The details of nominal value are shown in Part 2 Specifications.)

 No hot-tapped installation and maintenance while the medium temperature is too high

When temperature of measuring medium is higher than the temperature that human can bear, or higher than the temperature of possible danger, should shut down or do cooling process to reach a safety temperature, and then do hot-tapped operation. If there are no conditions to do hot-tapped operation, should shut down to avoid dangers.

 Confirm the ambient pressure of instrument and medium pressure

The ambient pressure on site and the maximum medium pressure should be under the nominal value of instrument. (The details of nominal value are shown in Part 2 Specifications.)

 No hot-tapped installation and maintenance while the medium pressure is too high

When absolute pressure of measuring medium is higher than 5 times standard atmospheric pressure, or higher than the pressure of possible danger, should shut down

or do reducing pressure to reach a safety pressure, and then do hot-tapped operation. If there are no conditions to do hot-tapped operation, should shut down to avoid dangers.



Extra requirements of special medium

The properties of some gas are special, it is needed to order special product, please check the manual of special product thoroughly to make sure whether it meets the requirements on site before installation.



No hot-tapped installation and maintenance while the medium is dangerous gas

When the medium may cause injury to humans, no hot-tapped installation and maintenance, should shut down or do security processing to reach a safety condition, and then do hot-tapped operation. If there are no conditions to do hot-tapped operation, should shut down to avoid dangers. The dangerous gases are such gas and chlorine, etc.



If doubting that the instrument in the event of failure, please do not operate it

If there are something wrong with the instrument or it had been damaged, please contact us.

Part 1 Introduction

Thermal gas mass flow meter is designed on the basis of thermal dispersion, and adopts method of constant differential temperature to measuring gas flow. It has advantages of small size, easy installation, high reliability and high accuracy, etc.

The meter contains two platinum resistance temperature sensors. The thermal principle operates by monitoring the cooling effect of a gas stream as it passes over a heated sensor. Gas flowing through the sensing section passes over two sensors one of which is used conventionally as a temperature sensor, whilst the other is used as a heater. The temperature sensor monitors the actual process values whilst the heater is maintained at a constant differential temperature above this by varying the power consumed by the sensor. The greater the gas velocity, the greater the cooling effect and power required to maintain the differential temperature. The measured heater power is therefore a measure of the gas mass flow rate.

The format of gas velocity and power is shown as below:

$$V = \frac{K[Q/\Delta T]^{1.87}}{\rho_g} \dots\dots(1)$$

Where: ρ_g is specific gravity of medium

V is velocity

K is balance coefficient

Q is heater power

ΔT is differential temperature

The medium temperature range of meter is $-40^{\circ}\text{C} \sim 220^{\circ}\text{C}$.

In the format (1), the specific gravity of medium is related to the density:

$$\rho = \rho_n \times \frac{101.325 + P}{101.325} \times \frac{273.15 + 20}{273.15 + T} \dots\dots(2)$$

Where: ρ_g is the medium density in working condition (kg/m^3)

ρ_n is the medium density in standard condition, 101.325kPa and 20°C (kg/m^3)

P is the pressure in working condition (kPa)

T is the temperature in working condition ($^{\circ}\text{C}$)

In the formats (1) and (2), there is a certain functional relationship between the velocity and pressure in working condition, medium density, the temperature in working condition.

Due to the sensor temperature is always 30°C higher than the medium temperature (environment temperature), and the meter adopts method of constant differential temperature, therefore the meter do not need to do temperature and pressure compensation in principle.

Part 2 Specifications

Features

- Measuring the mass flow or volume flow of gas
- Do not need to do temperature and pressure compensation in principle with accurate measurement and easy operation.
- Wide range: 0.5Nm/s~100Nm/s for gas. The meter also can be used for gas leak detection
- Good vibration resistance and long service life. No moving parts and pressure sensor in transducer, no vibration influence on the measurement accuracy.
- Easy installation and maintenance. If the conditions on site are permissible, the meter can achieve a hot-tapped installation and maintenance. (Special order of custom-made)
- Digital design, high accuracy and stability
- Configuring with RS485 or HART interface to realize factory automation and integration

Description	Specifications
Measuring Medium	Various gases (Except the acetylene)
Pipe Size	DN10~DN4000mm
Velocity	0.1~100 Nm/s
Accuracy	±1~2.5%
Working Temperature	Sensor: -40℃~+220℃ Transmitter: -20℃~+45℃
Working Pressure	Insertion Sensor: medium pressure≤ 1.6MPa Flanged Sensor: medium pressure≤ 1.6MPa Special pressure please contact us
Power Supply	Compact type: 24VDC or 220VAC, Power consumption ≤18W Remote type: 220VAC, Power consumption ≤19W
Response Time	1s
Output	4-20mA (optoelectronic isolation, maximum load 500Ω), Pulse, RS485 (optoelectronic isolation) and HART
Alarm Output	1-2 line Relay, Normally Open state, 10A/220V/AC or 5A/30V/DC
Sensor Type	Standard Insertion, Hot-tapped Insertion and Flanged
Construction	Compact and Remote

Pipe Material	Carbon steel, stainless steel, plastic, etc
Display	4 lines LCD Mass flow, Volume flow in standard condition, Flow totalizer, Date and Time, Working time, and Velocity, etc.
Protection Class	IP65
Sensor Housing Material	Stainless steel (316)

Part 3 Mechanical Construction

3.1 Appearance



Fig. 1 Standard Insertion Flow Meter
(Pipe size DN100-DN500)



Fig. 2 Flanged Flow Meter
(Pipe size DN10-DN80)

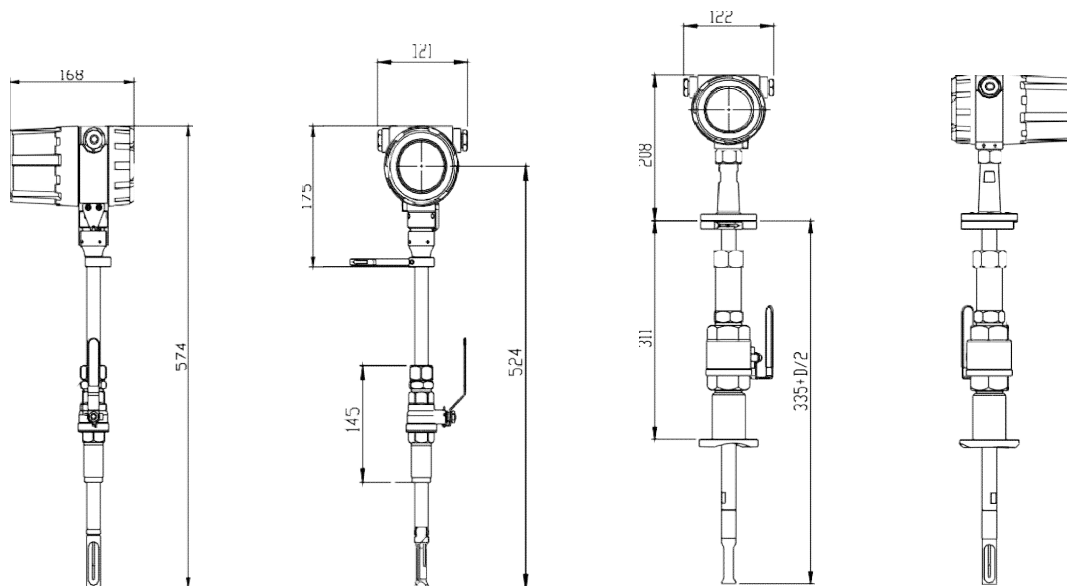


Fig. 3 Hot-tapped Insertion Flow Meter
(Pipe size DN100-DN4000. Special requirements please contact us)

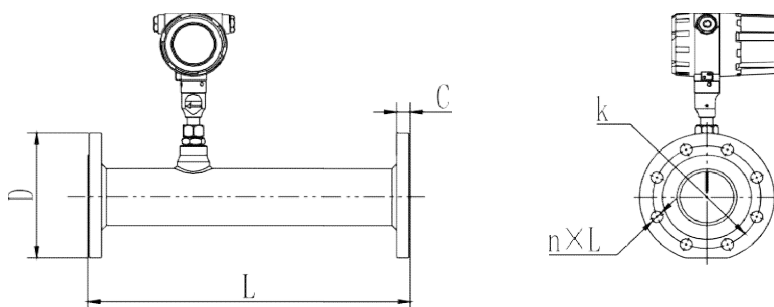
The insertion sensor of compact insertion flow meter should be inserted to axis of pipe, and the length of the insertion sensor is decided by pipe size, please confirm the pipe size when ordering. If the insertion sensor can't be inserted to axis of pipe, the manufacturer will provide a calibration factor to achieve an accurate measurement.

3.2 Dimensions

Dimensions of standard insertion sensor Dimensions of hot-tapped insertion sensor



The dimensions of flanged sensor



PN1.6Mpa Plane and surface plate flat welding steel pipe flanges (Unit: mm)

Nominal Diameter	Flange Outer diameter	Center Hole	Screw Hole	Screw Thread	Sealing Face		Flange Thickness	Pipeline Length
DN	D	k	n×L		d	f	C	L
15	95	65	4×14	M12	46	2	14	280
20	105	75	4×14	M12	56	2	16	280
25	115	85	4×14	M12	65	2	16	280
32	140	100	4×18	M16	76	2	18	350
40	150	110	4×18	M16	84	2	18	350
50	165	125	4×18	M16	99	2	20	350
65	185	145	4×18	M16	118	2	20	400
80	200	160	8×18	M16	132	2	20	400
100	220	180	8×18	M16	156	2	22	500

For DN15-DN80, the meter can be made with threading to connect.

The above table is used for rated pressure of 1.6MPa. If the rated pressure is more than 1.6MPa, please contact us for special order.

Part 4 Wirings

 No operation when the meter is working

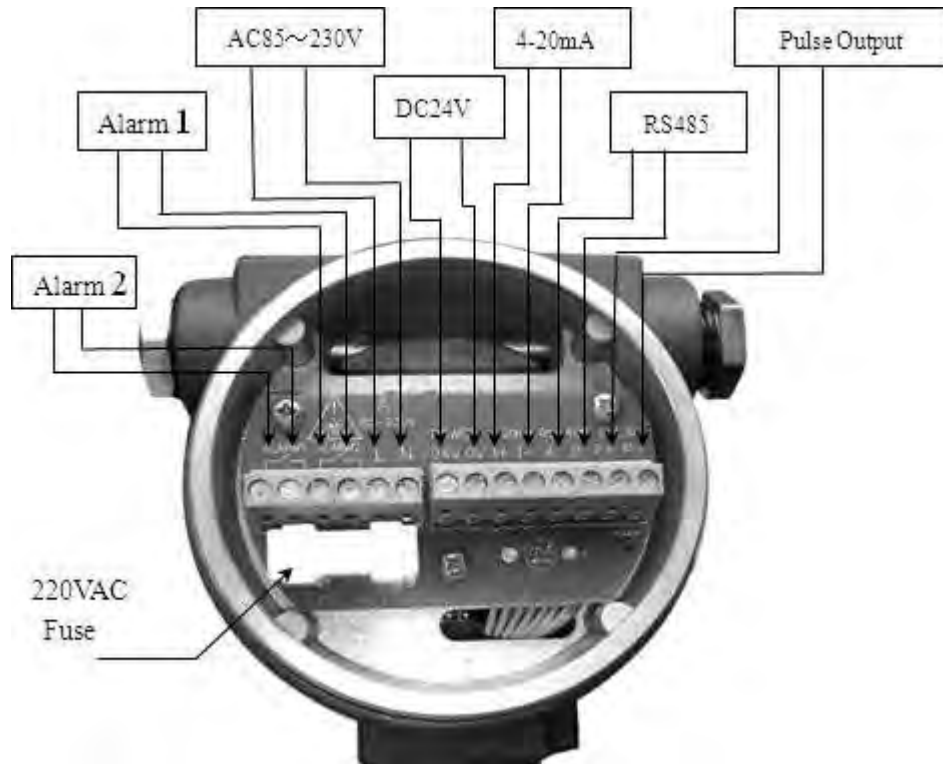
 Confirm the power supply type

4.1 Instruction of Sensor Wirings

1	2	3	4
RT1	RT2	RH1	RH2

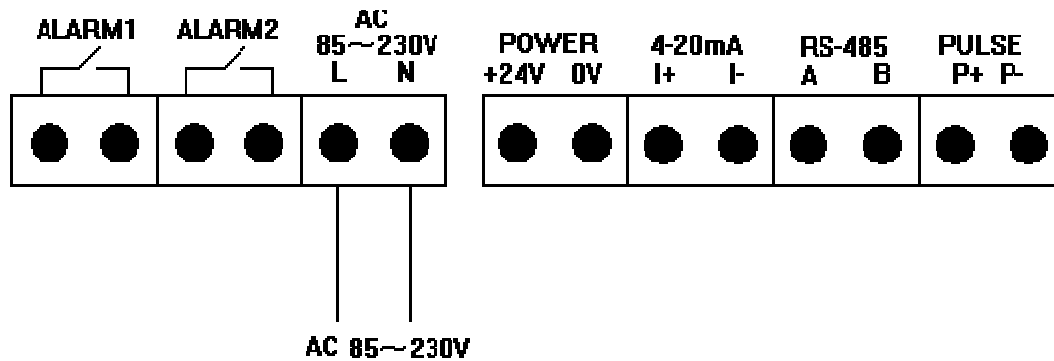
Temperature sensor (Pt1000) Heater (Pt20)

4.2 Instruction of Transmitter Wirings

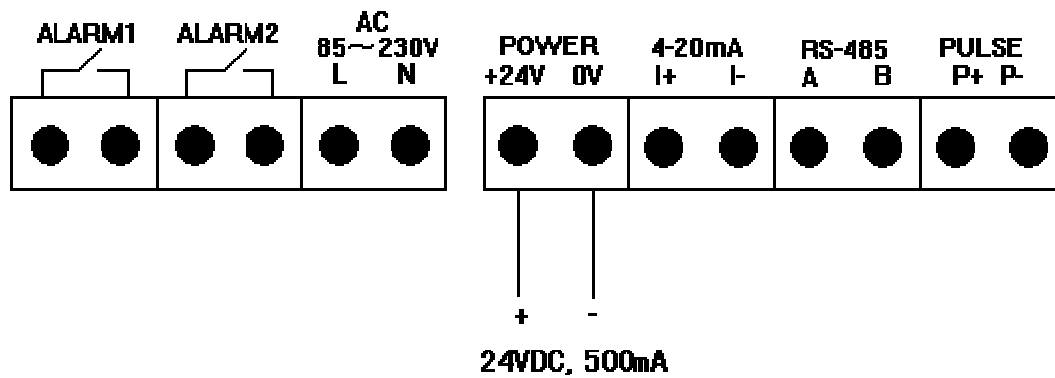


4.3 The Wirings of Power Supply

1. AC power supply

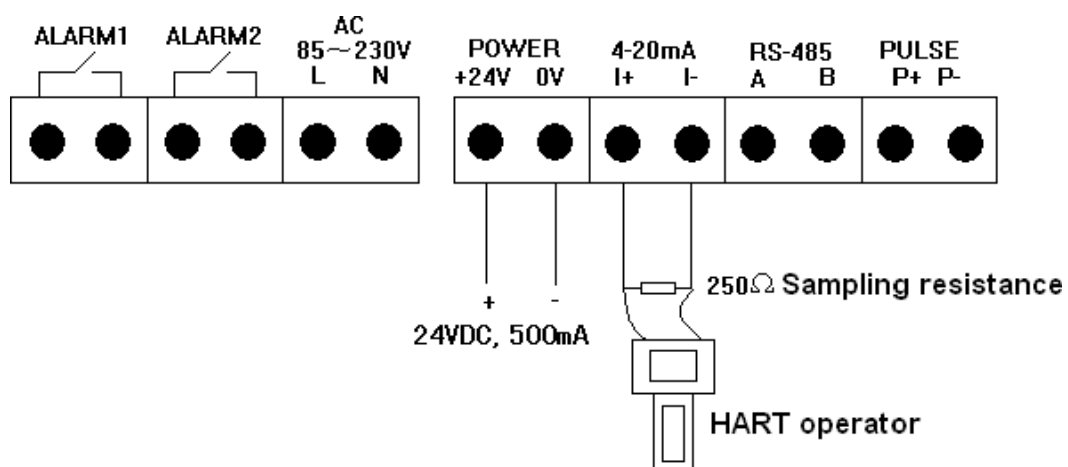


2. DC power supply

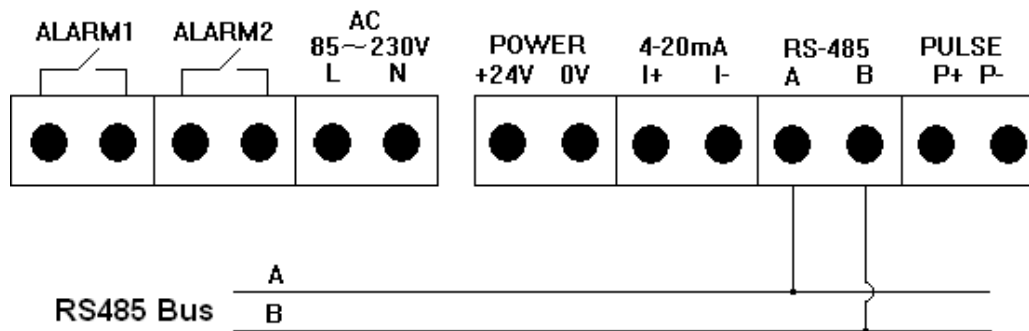


4.4 The Wirings of Outputs

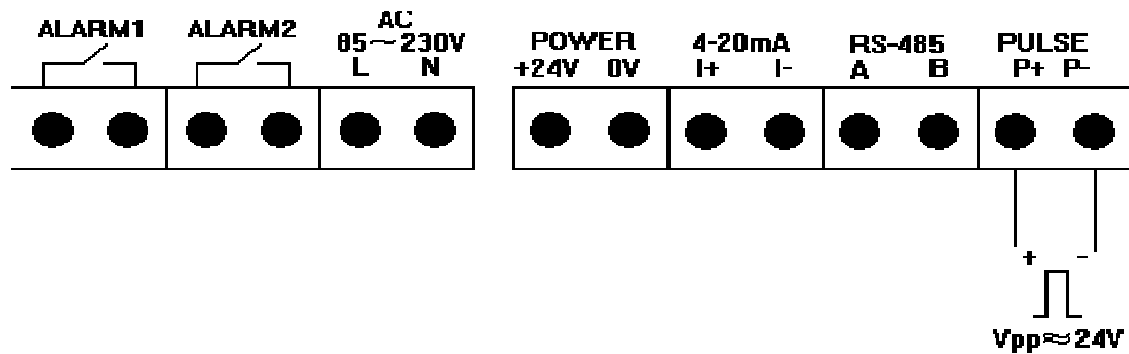
1. The wirings of Four-Wire 4-20mA output and HART operator



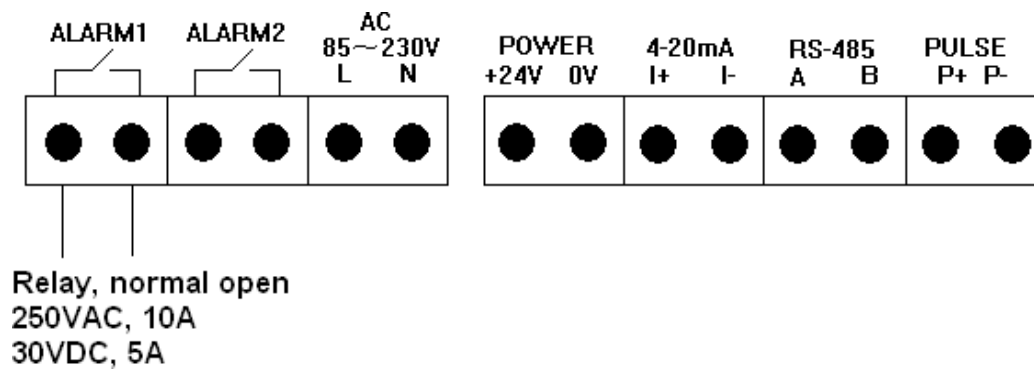
2. The wirings of RS485 output



3. The wirings of pulse output



4. The wirings of alarm output



Part 5 Installation

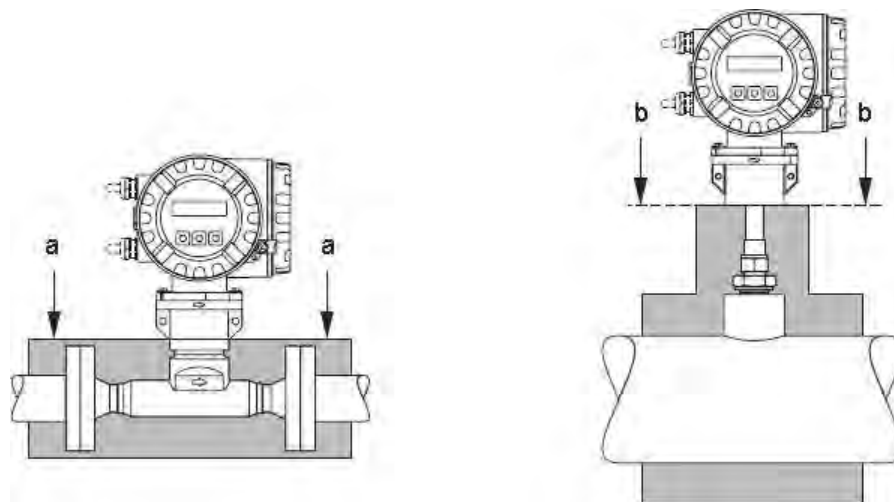
5.1 Installation Position

Thermal meters require a fully developed flow profile as a prerequisite for correct flow measurement. For this reason, please note the following points when installing the device.

- Observe the recommended inlet and outlet requirements.
- Good engineering practice is necessary for the associated pipe work and installation.
- Ensure correct alignment and orientation of the sensor.
- Take measures to reduce or avoid condensation (e.g. install a condensation trap, thermal insulation, etc.).
- The maximum permitted ambient temperatures and the medium temperature range must be observed.
- Install the transmitter in a shaded location or use a protective sun shield.
- For mechanical reasons, and in order to protect the pipe, it is advisable to support heavy sensors.
- No installation in where large vibration exists
- No exposure in the environment containing a lot of corrosive gas
- No sharing power supply with frequency converter, electric welding machine and other machines which can make power-line interference. If necessary, please add power conditioner for transmitter power supply.

Thermal insulation

When the gas is very humid or saturated with water (e. g. Bio Gas), the piping and flowmeter body should be insulated to prevent water droplets condensing on the measuring sensor.



a Maximum insulation height for the flanged sensor

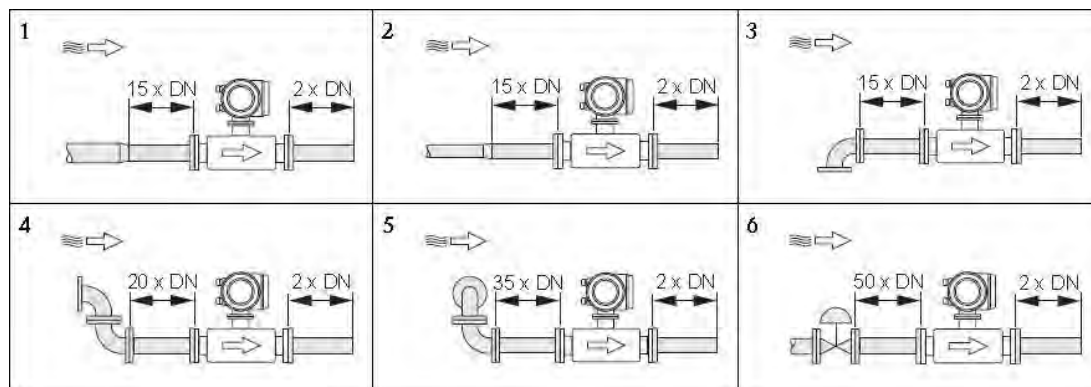
b Maximum insulation height for the insertion sensor

The thermal dispersion principle is sensitive to disturbed flow conditions.

- As a general rule, the thermal flowmeter should always be installed as far away as possible from any flow disturbances. For further information please refer to ISO 14511.
- Where two or more flow disturbances are located upstream of the meter, the recommended inlet length for the flow disturbance causing strongest disturbance must be used. E.g. where a valve is mounted before a bend, upstream of the flowmeter, $50 \times \text{DN}$ of pipe work is required from the valve to the flowmeter.
- For very light gases such as Helium and Hydrogen all upstream distances should be doubled.

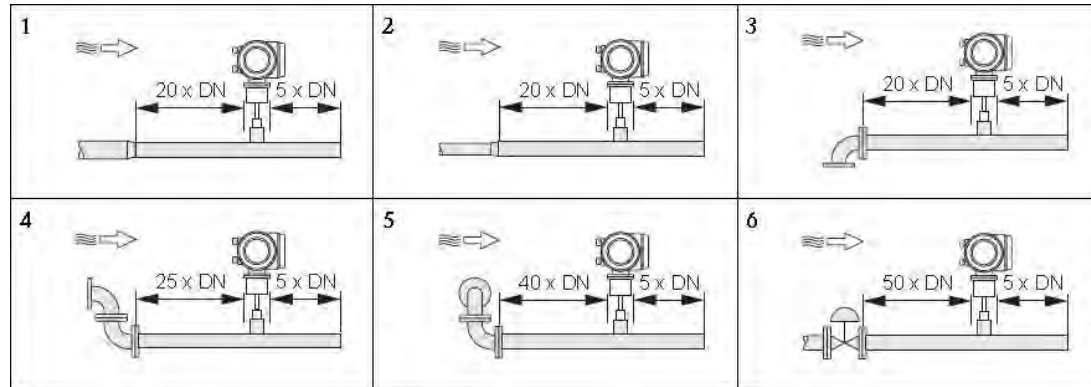
The minimum recommendations for inlet and outlet runs (without flow conditioner) are:

Flanged sensor



1 = Reduction, 2 = Expansion, 3 = 90° elbow or T-piece, 4 = 2 × 90° elbow, 5 = 2 × 90° elbow (3-dimensional), 6 = Control valve.

Insertion sensor



1 = Reduction, 2 = Expansion, 3 = 90° elbow or T-piece, 4 = 2 × 90° elbow, 5 = 2 × 90° elbow (3-dimensional), 6 = Control valve or pressure regulator.

A specially designed perforated plate flow conditioner can be installed if it is not possible to observe the inlet runs required.

5.2 Pipework requirements

- Good engineering practice should be followed at all times:
- Correct preparation, welding and finishing techniques
- Correctly sized gaskets
- Correctly aligned flanges and gaskets
- Connecting pipe work should match the internal diameter of the flowmeter.
- Maximum pipe diameter mismatch should not exceed:
 - 1 mm (0.04 inch) for diameters < DN 200 (8")
 - 3 mm (0.12 inch) for diameters ≥ DN 200 (8")
- New installations should be free of metallic and abrasive particles to prevent damage to the sensing elements on start-up

For further information please refer to ISO 14511.

5.3 Installation Steps

The base of thermal flowmeter



The base of Hot-tapped insertion type

The base of standard insertion type

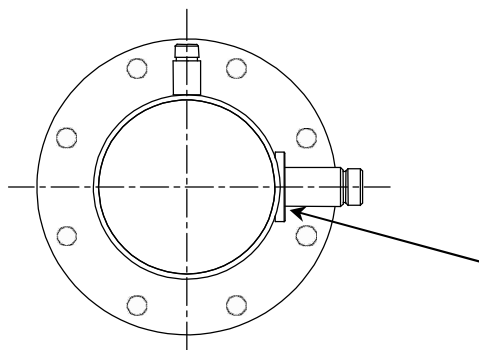


No welding in explosive environment



Carry out the welding operation in accordance with the requirements of special environment.

When installing, place the base on the top of pipe, and make the through-hole of base be perpendicular to axis of pipe. The good welding location of base and welding process is as below.



Before Welding, the base should be processed as the same as the circular arc of pipe to ensure sealing

Good welding location of base

The installation of standard insertion type

Identify an appropriate location for the flow meter.

Confirm the inner diameter and wall thickness of pipe

- Place the other part of meter into ball valve, and calculate the insertion depth according to the inner diameter and wall thickness of pipe. This step doesn't need to screw the nut by hand.
- Turn the connecting rod of sensor to make the mark direction of sensor as the same flow direction.
- According the calculated data on site, ensure the insertion depth by corresponding

calibration on the connecting rod, and then screw the nut tightly.

- If the meter is horizontal installation, the display of the meter can be installed in the direction of 90°, 180° or 270° to meet various requirements.

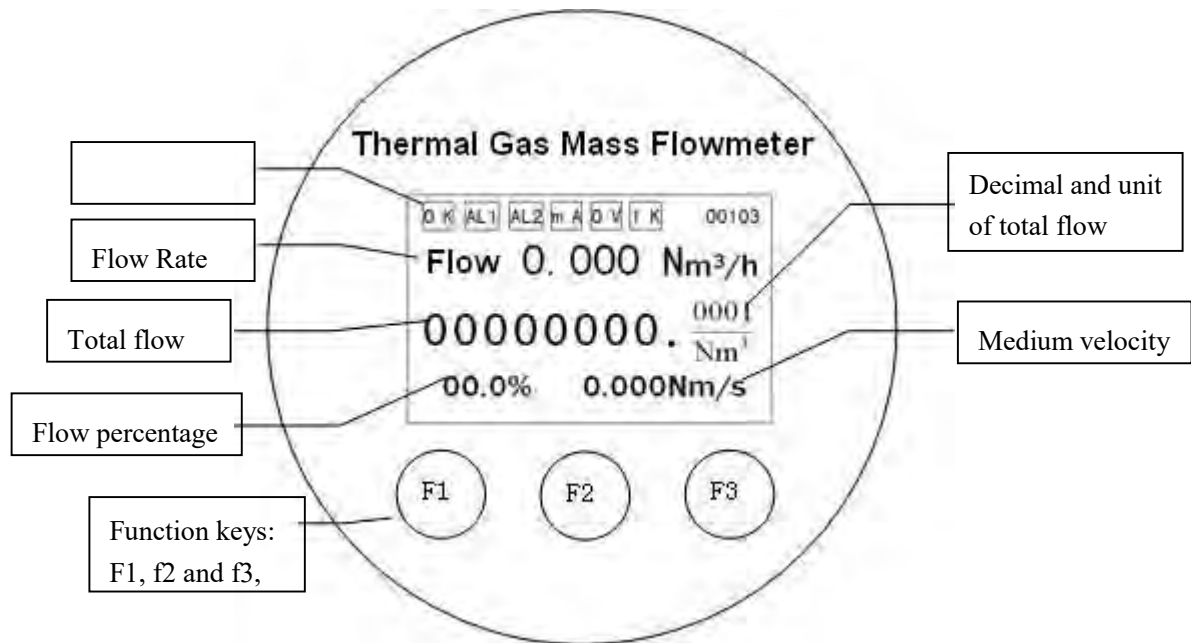
The installation of hot-tapped insertion type

- Before installation, please conform the connection type and install fittings.
- Before installation, the site must be shut down, and strictly follow the rules of factory.
- Identify an appropriate location for the flow meter.
- According to length requirement of meter, cut the pipe, and install the flanges and bolts on the pipe.
- Ensure the mark direction of meter is as the same flow direction, the display is perpendicular to horizontal plane, the axis of pipeline is paralleled to horizontal plane, the error can't be more than ± 2.5 , and then fix the meter by bolts.

Part 6 Operation and Programming

6.1 Display

The display of meter in working status is shown as below.



The prompt line:

OV: If the operation parameters overflow, it display OV, else it will be blank.

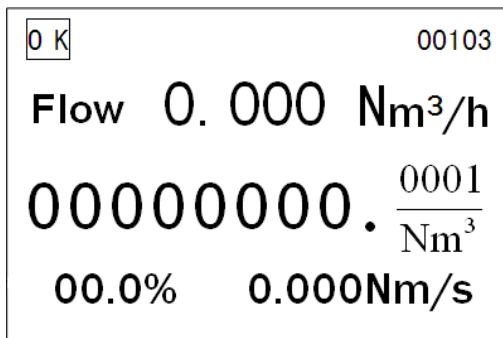
1K: For convenience of display and read, when the total flow is more than 10 000 000, it display 1K, and the is the display total flow multiplied by 1000.

00103: Information of communication status. The first three digits indicate meter address; the forth digit indicates parity check (0: none; 1: odd; 2: even); and the fifty digit indicate baud rate (0: 1200; 1: 2400; 2: 4800; 3: 9600). If the meter address is 1, no parity check, and the baud rate is 9600, it will display "00103".

The meter has three function keys: F1, F2 and F3. F1 is Shift Key, F2 is Enter/Next Key, and F3 is Modify Key. (If there are some special functions of keys, please follow the instruction below the LCD)

6.2 Parameters Setup

6.2.1 Main Menu



In main menu, press F2 to enter setup menu.

In setup menu, press F1 and F2 at the same time to enter main menu.

6.2.2 Setup Menu

- Setup menu--**
1. Display Unit
 2. Total Reset
 3. Setup
 4. Calibration
 5. Password
 6. Record **query**

In main menu, press F2 to enter setup menu. In setup menu, press F1 to select submenu, and press F2 to enter submenu.

6.2.3 Unit Display

Flow: Nm³/h
Total: Nm³

Shift Enter Mod

In setup menu, press F1 to select "Unit Display", and press F2 to enter.
Press F1 to select the unit of flow or total, and press F3 to modify the unit.

Flow: The unit of flow rate. The unit can be selected Nm³/h, Nm³/min, NI/h, NI/min, t/h, t/min, kg/h and kg/min.

Total: The unit of total flow. The unit can be selected Nm³, NI, t and kg.

Select the needed unit, and then press F2 Enter key, the main menu will display with the selected unit.

6.2.4 Total Reset

Total reset Pwd

000000

Shift Enter Mod

In setup menu, press F1 to select "Total Reset", and press F2 to enter.

Press F1 to password, input reset password (default password is 000000), press F1 to shift digit, and press F3 to change the digit's number.

After inputting password, press F2 to enter total reset submenu.

Total flow reset

0000000.0000

Reset Enter Reset

In order to prevent error operation, press F1 and F3 keys at the same time to do total reset. After finishing total reset, the display shows 0000000.0000.

In this submenu, press F2 key to enter running time reset.

Run Time Reset

00000000 min

Reset Enter Reset

The unit of running time is minute.

The largest time is with 8 digits, and the reset operation is as the same as total reset.

After resetting, press F2 key to return main menu.

6.2.5 Parameter Setup

Settings Pwd

000000

Shift Enter Mod

In setup menu, press F1 to select "Parameter Setup", and press F2 to enter.

Input reset password (default password is 000000), press F1 to shift digit, and press F3 to change the digit's number.

After inputting password, press F2 to finish password setup and enter language setup.

Pipe diameter

0100.000 mm

Shift Enter Mod

Pipe diameter is used to input the inner diameter of pipe. For rectangular tube, it needs to input a equivalent inner diameter. The unit is mm.

The range is 0000.000~9999.999.

Press F2 to enter filter coefficient.

Damping time: 00

Shift Enter Mod

Damping time. If the flow has a big fluctuation, increase this value to get a stable reading.

The range is 0~32, 0 means no filter.

Press F2 to enter low flow cutoff.

Flow Cut-off

000000.000

Shift Enter Mod

Flow cut-off. Cut off the low flow according to the actual situation, and the unit is the same as flow rate.

The range is 0000.0000~9999.9999.

Press F2 to enter Density in Standard Condition.

Std density

1.0000 Kg/m3

Shift Enter Mod

Std density. (20℃, 101.325KPa).

That is used for flow rate display.

Medium: 00

Air

F factor: 1.0000

Shift Enter Mod

The F factor in meter is reference value, if necessary, modify this value.

The meter contain the conversion coefficient of 59 gases, if the medium is mixed gas, it needs to calculate the coefficient.

The density and conversion coefficient of common gas are shown in appendix 3.

Press F2 to enter Full scale flow.

Output Sel: Flow

Set scale:

0000000.000

Shift Enter Mod

Output Sel. Corresponding to 4-20mA output, and the unit is the same as flow rate. The range is 0000.0000~9999.9999.

Press F2 to enter RS485 communication.

Dev ID: 001

Baud: 9600

Parity: None

Shift Enter Mod

RS485 communication setup.

The meter's Dev ID range: 0~255. Baud rate can be selected 1200, 2400, 4800 and 9600. Parity check can be selected none, odd and even.

Press F2 to enter HART setup.

HART Addr:00

W Protect:OFF

Shift Enter Mod

HART communication setup.

The HART address range: 00~15. Protect is "OFF", the HART operator can write data; Protect is "On", the HART operator can't write data.

Press F2 to enter frequency output.

Pulse Out: Pulse
Freq: 0000-5000Hz
F.S: 0005000.000

Shift Next Mod

Frequency output: Pulse and Equivalent.

If Pulse (Flow rate) is selected, the first value of Freq is the frequency of pulse which is corresponding to flow 0, and the second value of Freq is the frequency of pulse which is corresponding to maximum flow.

Press F3 to enter equivalent output.

Date and Time:
2012-05-16
09:13:29

Shift Enter Mod

The date and time affect the data query and saving. Therefore, set the date and time before recording data.

Time Setting?

Yes Back No

Choose No

Initialization:

Yes Back No

Choose No

6.2.6 Calibration

The parameters in this submenu are very important. In order to prevent unauthorized operation or wrong operation, it needs to input password before entering this submenu.

Calibrated Pwd

000000

Shift Enter Mod

In setup menu, press F1 to select “Calibration”, and press F2 to enter.

Input the right password to enter calibration submenu.

Press F2 to enter zero voltage value.

AD Zero: Measure

0.0162V

Confirm zeroflow

Rec Next Mod

AD Zero value is used to set the voltage value while the flow rate is 0.

Before calibration, confirm the flow in pipe is zero, and waiting for more than 30s to steady the flow. Press F1 and F3 keys at the same time until the meter displays success.

This value is can be input manually. Press F3 to select “Input”, input this value manually, and then press F2 to enter R value.

Note: Don't input zero voltage value when the meter is running.

Flow rate: Seq 01

Vol: 00.6574

F.R: 000.000 Nm/s

Shift Next Mod

Flow rate. Set the voltage and velocity in more than 40 sections.

After calibration, Input the voltage and velocity from small section to large section. (The velocity is zero in section 00).

Press F2 to enter flow correction.

Note: The meter calculates the flow by velocity table. Please don't modify the data in the table.

Flow coe: Seq 1

Flow: 0000000.000

Coe: 000000.0000

Shift Next Mod

Flow correction. It can correct the flow in 5 sections.

I Cal: 4mA
Measure:00.0000

Shift Next Mod

Current calibration. If there is deviation in current output, use this submenu to calibrate current output.

Press F2 to enter zero and coefficient of current.

Zero: +0.0000
Coe: 1.0000

Shift Enter Mod

Current zero and coefficient calibration.

Note: Please don't modify these values when the meter is running.

Appendix 1 Troubleshooting and Repair

Fault	Cause	Solution
No display	1. No power supply	Get power supply
	2. SMPS is damaged	Get power supply, if the power indicator light is out, it means that the SMPS is damaged, Please contact supplier.
	3. The wirings of DC24V are reversed	Check the wirings, make the wirings right
	4. The position of LCD is wrong	Reinstall the LCD
	5. The LCD is damaged	Check the power indicator light. If the light is on, it means that the LCD is damaged. Please contact supplier
Low velocity	1. The wirings of sensor are reversed	Rewiring or reinstall the sensor
	2. The sensor is dirty	Clean sensor
	3. The sensor is damaged	Return to supplier
	4. Some parameters of flow setting are wrong	Check the parameters setting
Abnormal velocity and large fluctuation	1. Some parameters of velocity setting are wrong	Check the parameters setting
	2. Fluid properties is pulsating in turn	Adjust the system filter
	3. The sensor is dirty	Clean sensor
	4. The sensor is damaged	Return to supplier
Abnormal 4-20mA output	1. The setting of 20mA range is wrong	Right settings
	2. The Transmitter has fault	Return to supplier
	3. The connection is not a loop circuit	Check the connection
Abnormal frequency output	1. Some parameters of frequency setting are wrong	Right settings
	2. The Transmitter has fault	Return to supplier

	3.The connection cable is damaged	Check the connection
Abnormal alarm	1. Some parameters of setting are wrong	Right settings
	2.The meter has no alarm function	Contact supplier
	3.The relay is damaged	Return to supplier
Abnormal RS485 output	1. The settings of baud rate and address are wrong	Right settings
	2. The wirings are reversed	rewiring
	3. The connection cable is damaged	Check the connection

Appendix 2 The Density and Conversion Coefficient of Common Gas

According to different gas on site, the calibration in lab translates the flow rate of actual gas on site into flow rate of air, and then begins to calibrate the flow rate at present. Therefore, when using the meter on site, the meter displays mass flow or volume flow of actual gas.

When translating the flow rate of gas into flow rate of air, there is a conversion coefficient table of different gas.

Table 1 The Density and Conversion Coefficient of Common Gas

	Gas	Specific heat (KJ/g*°C)	Density (g/l, 0°C)	Conversion Coefficient
0	Air	0.24	1.2048	1.0000
1	Argon (Ar)	0.125	1.6605	1.4066
2	Arsine (AsH ³)	0.1168	3.478	0.6690
3	Boron Tribromide (BBr ³)	0.0647	11.18	0.3758
4	Boron Trichloride (BCl ³)	0.1217	5.227	0.4274
5	Boron Trifluoride (BF ³)	0.1779	3.025	0.5050
6	Borane (B ² H ⁶)	0.502	1.235	0.4384
7	Carbon Tetrachloride (CCl ⁴)	0.1297	6.86	0.3052
8	Carbon Tetrafluoride (CF ⁴)	0.1659	3.9636	0.4255
9	Methane (CH ⁴)	0.5318	0.715	0.7147
10	Acetylene (C ² H ²)	0.4049	1.162	0.5775
11	Ethylene (C ² H ⁴)	0.3658	1.251	0.5944
12	Ethane (C ² H ⁶)	0.4241	1.342	0.4781
13	Allylene (C ³ H ⁴)	0.3633	1.787	0.4185
14	Propylene (C ³ H ⁶)	0.3659	1.877	0.3956
15	Propane (C ³ H ⁸)	0.399	1.967	0.3459
16	Butyne (C ⁴ H ⁶)	0.3515	2.413	0.3201
17	Butene (C ⁴ H ⁸)	0.3723	2.503	0.2923
18	Butane (C ⁴ H ¹⁰)	0.413	2.593	0.2535
19	Pentane (C ⁵ H ¹²)	0.3916	3.219	0.2157
20	Carbinol (CH ³ OH)	0.3277	1.43	0.5805

21	Ethanol (C ² H ⁶ O)	0.3398	2.055	0.3897
22	Trichloroethane (C ³ H ³ Cl ³)	0.1654	5.95	0.2763
23	Carbon Monoxide (CO)	0.2488	1.25	0.9940
24	Carbon Dioxide (CO ²)	0.2017	1.964	0.7326
25	Cyanide (C ² N ²)	0.2608	2.322	0.4493
26	Chlorine (Cl ²)	0.1145	3.163.	0.8529
27	Deuterium (D ²)	1.7325	0.1798	0.9921
28	Fluoride (F ²)	0.197	1.695	0.9255
29	Germanium Tetrachloride (GeCl ⁴)	0.1072	9.565	0.2654
30	Germane (GeH ₄)	0.1405	3.418	0.5656
31	Hydrogen (H ₂)	3.4224	0.0899	1.0040
32	Hydrogen Bromide (HBr)	0.0861	3.61	0.9940
33	Hydrogen Chloride (HCl)	0.1911	1.627	0.9940
34	Hydrogen Fluoride (HF)	0.3482	0.893	0.9940
35	Hydrogen Iodide (HI)	0.0545	5.707	0.9930
36	Hydrogen Sulfide (H ₂ S)	0.2278	1.52	0.8390
37	Helium (He)	1.2418	0.1786	1.4066
38	Krypton (Kr)	0.0593	3.739	1.4066
39	nitrogen (N ₂)	0.2486	1.25	0.9940
40	Neon (Ne)	0.2464	0.9	1.4066
41	Ammonia (NH ₃)	0.5005	0.76	0.7147
42	Nitric Oxide (NO)	0.2378	1.339	0.9702
43	Nitrogen Dioxide (NO ₂)	0.1923	2.052	0.7366
44	Nitrous Oxide (N ₂ O)	0.2098	1.964	0.7048
45	Oxygen (O ₂)	0.2196	1.427	0.9861
46	Phosphorus Trichloride (PCl ₃)	0.1247	6.127	0.3559
47	Phosphorane (PH ₃)	0.261	1.517	0.6869
48	Phosphorus Pentafluoride (PF ₅)	0.1611	5.62	0.3002
49	Phosphorus Oxychloride (POCl ₃)	0.1324	6.845	0.3002
50	Silicon Tetrachloride (SiCl ₄)	0.127	7.5847	0.2823

51	Silicon Fluoride (SiF ₄)	0.1692	4.643	0.3817
52	Silane (SiH ₄)	0.3189	1.433	0.5954
53	Dichlorosilane (SiH ₂ Cl ₂)	0.1472	4.506	0.4095
54	Trichlorosilane (SiHCl ₃)	0.1332	6.043	0.3380
55	Sulfur Hexafluoride (SF ₆)	0.1588	6.516	0.2624
56	Sulfur Dioxide (SO ₂)	0.1489	2.858	0.6829
57	Titanium Tetrachloride (TiCl ₄)	0.1572	8.465	0.2048
58	Tungsten Hexafluoride (WF ₆)	0.0956	13.29	0.2137
59	Xenon (Xe)	0.0379	5.858	1.4066

Appendix 3 Upper Range Value of Common Gas

(Unit: Nm³/h. The follow table can be extended)

Nominal Diameter (mm)	Air	Nitrogen (N ₂)	Oxygen (O ₂)	Hydrogen(H ₂)
15	65	65	32	10
25	175	175	89	28
32	290	290	144	45
40	450	450	226	70
50	700	700	352	110
65	1200	1200	600	185
80	1800	1800	900	280
100	2800	2800	1420	470
125	4400	4400	2210	700
150	6300	6300	3200	940
200	10000	10000	5650	1880
250	17000	17000	8830	2820
300	25000	25000	12720	4060
400	45000	45000	22608	7200
500	70000	70000	35325	11280
600	100000	100000	50638	16300
700	135000	135000	69240	22100
800	180000	180000	90432	29000
900	220000	220000	114500	77807
1000	280000	280000	141300	81120
1200	400000	400000	203480	91972
1500	600000	600000	318000	101520
2000	700000	700000	565200	180480

The flow rate in standard condition: The flow rate is in the condition of 20℃ temperature and 101.325kPa pressure.

The unit of flow rate is optional: Nm³/h, Nm³/min, L/h, L/min, t/h, t/min, kg/h or kg/min.

The reduction formula of flow rate in working condition and flow rate in standard condition:

$$Q_s = \frac{0.101325+p}{0.10325} \cdot \frac{273.15+20}{273.15+t} \cdot Q_n$$

Qs: The flow rate in standard condition (Nm³/h).

Qn: The flow rate in working condition (m³/h).

t: The medium temperature in working condition (°C).

p: The medium pressure in working condition (Gauge pressure, kPa).