Thermal Gas Mass Flow Meter

Catalogue

1.About This Manual

Thank you for choosing our company's products.

This manual is written for professionals in the Chinese market who are native speakers of Chinese. As of the publication date of this manual, we will no longer randomly provide English manuals for products supplied to the Chinese market. For customers with special needs, you can also contact us to obtain the English manual.

Through this manual, we strive to enable you to accurately understand the measurement principle, related concepts, professional terms, as well as the correct methods and conditions for installation and application of thermal gas mass flowmeters.

2.Safety Matters

2.1 Users

The thermal gas mass flowmeter is a precise instrument that applies the latest technologies and processes and complies with relevant standards. Improper installation and use may cause abnormal operation and damage to the instrument or even the process control equipment. Engineering technicians who install, set up and wire the product must carefully read this manual before using the instrument and truly understand the accurate meanings expressed therein, as well as the working conditions and process parameters of the application site.

2.2 Storage and Handling

- Storage temperature: -40℃ ~ 80℃
- Relative humidity: 20 ~ 90%
- During storage and transportation, the instrument should be placed inside the packaging box to avoid bumps or impacts.

2.3 Application Conditions

Before installation, it is necessary to ensure that the highest temperature and pressure of the measured medium do not exceed the nominal temperature and pressure. Also, determine whether the measured gas is pure and does not contain particulate matter, as particulate matter may cause damage to the sensor.

2.4 Safety Standards and Regulations

When installing, wiring and using this product, you should follow the requirements stated in this manual as well as general international safety standards, accident prevention measures and relevant local regulations.

2.5 Electromagnetic Compatibility

This product complies with the EMC (Electromagnetic Compatibility) standards.

- EMC (Electromagnetic Compatibility) Specifications: IEC 61326-1: 1997 / IEC 801-3 / EN 55011
- Radio Interference: EN 50081-1: 1992
- Immunity: EN 50082-1: 1992

When other instruments that do not comply with the IEC61326-1 electromagnetic compatibility standard are used in conjunction with this product, effective measures should be taken to ensure the normal and safe operation of the instruments.

2.6 Safety Integrity and Explosion Protection

In hazardous areas where there is or may be a mixture of flammable gas and air, explosion-proof flow meters should be selected; intrinsically safe explosion-proof flow meters must be used in conjunction with appropriate safety barriers that have obtained intrinsically safe explosion-proof certification;

The installation, wiring and associated equipment of the intrinsically safe instrument system should comply with the relevant standards and regulations of the country where it is located.

2.7 Environmental Protection

The packaging of this product complies with ISO:14001 standards and is made of paper materials that are biodegradable or recyclable and do not cause environmental pollution.

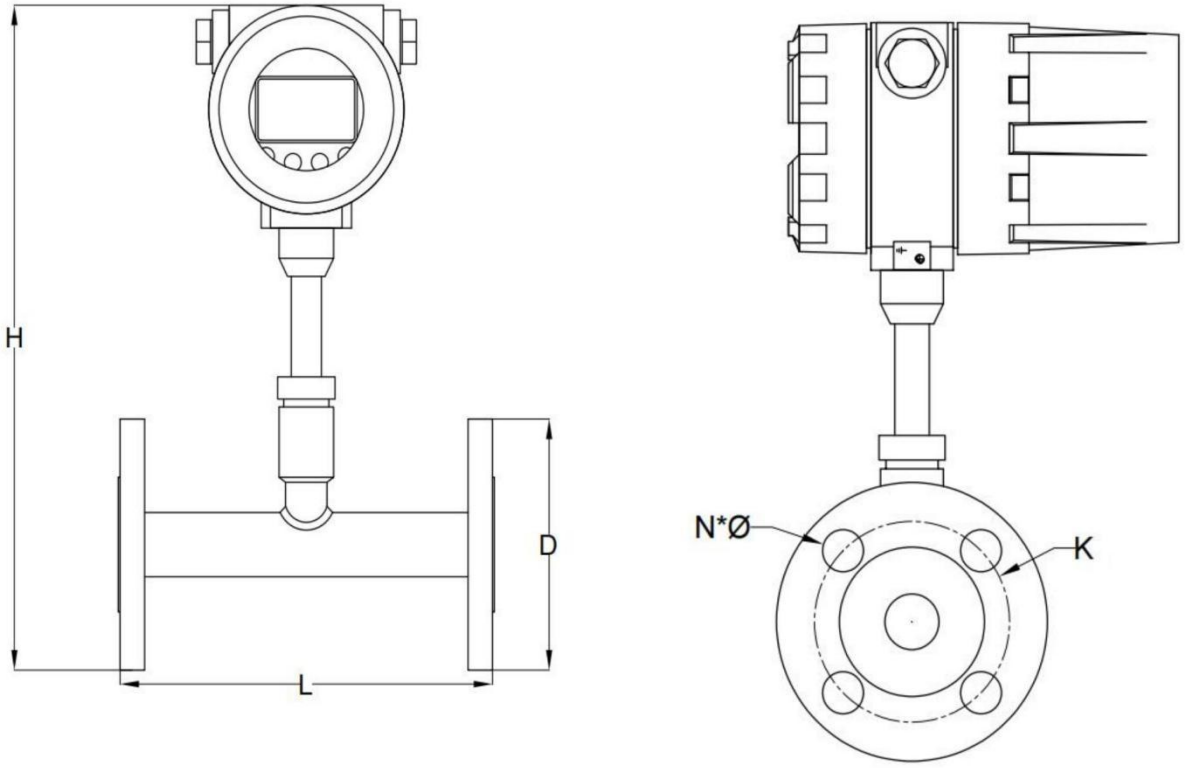
3.Overview

3.1 Measurement Principle

The thermal gas mass flowmeter consists of two parts: the sensor and the signal analysis, processing and control unit. The sensor part measures the temperature, while the other part is used for heating. The former monitors the actual process temperature value; the latter maintains a constant temperature value, ensuring that it is always higher than the actual process temperature and maintains a constant temperature difference with it. The greater the mass flow of the gas, the greater the cooling effect, and the more energy is required to maintain the differential temperature. Therefore, by measuring the energy of the heater, the mass flow of the measured gas can be obtained.

3.2 Product Shape and Dimensions

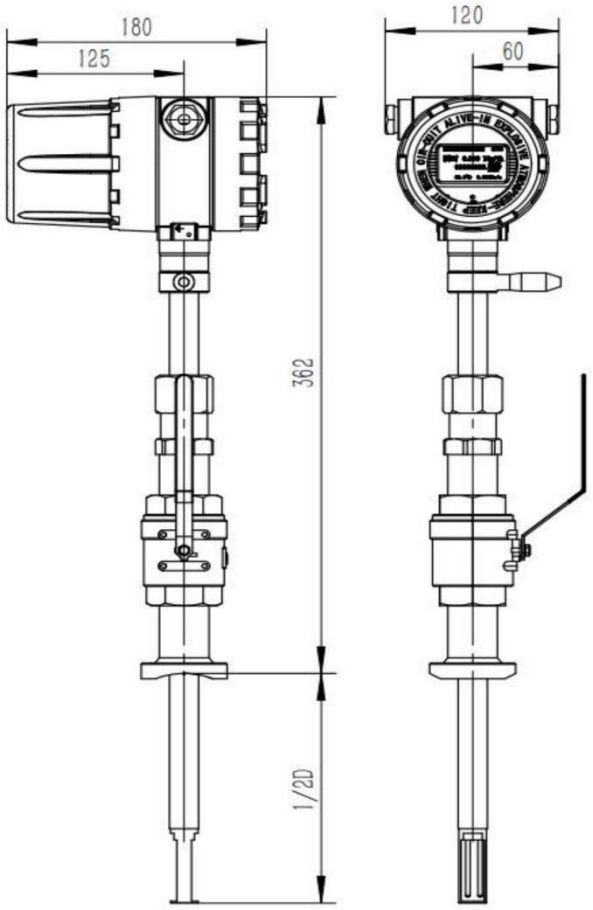
Pipe section type:



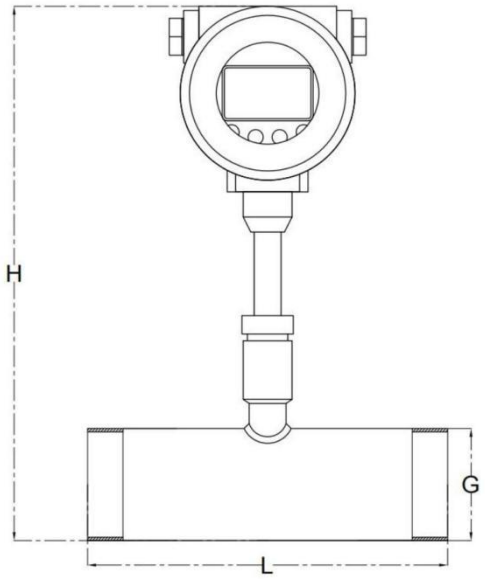
Flange connection size table

Caliber （mm）	L(mm)	H(mm)	D(mm)	K(mm)	N*φ
15	200	315	95	65	4*14
20	200	320	105	75	4*14
25	200	325	115	85	4*14
32	200	337	140	100	4*18
40	200	342	150	110	4*18
50	200	350	165	125	4*18
65	200	360	185	145	4*18
80	200	368	200	160	8*18
100	200	378	220	180	8*18
125	250	550	250	210	8*18
150	300	580	285	240	8*22
200	300	620	340	295	12*22
250	300	680	405	350	12*22
300	300	740	460	400	12*22

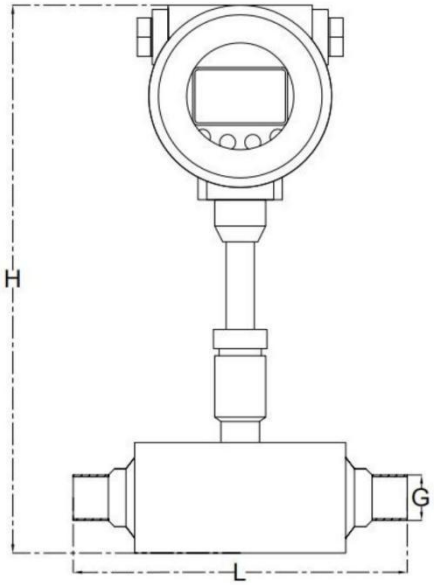
Insertion type: (Unit: mm)



Thread connection size table: (Unit: mm)



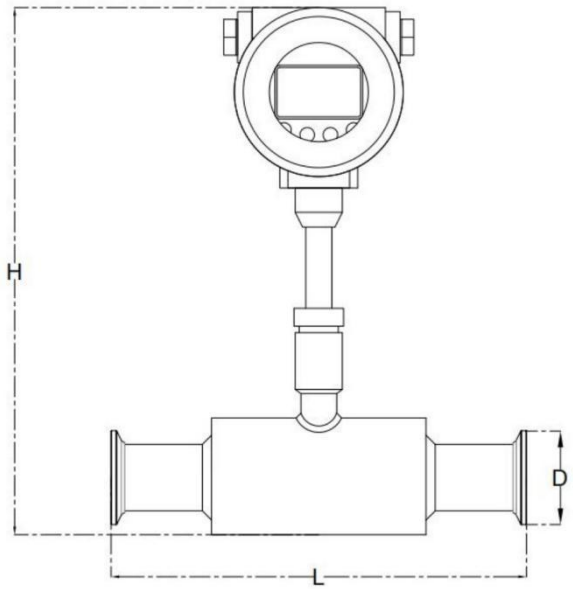
DN40-DN50



DN15-DN32

Caliber（mm）	L(mm)	H(mm)	G
15	200	293	1/2
20	200	293	3/4
25	200	293	1
32	200	293	5/4
40	200	308	3/2
50	200	308	2

Clamp connection size table: (Unit: mm)



Caliber（mm）	L(mm)	H(mm)	D(mm)
15	200	293	50.5
20	200	293	
25	200	293	
32	200	293	
40	200	308	64
50	200	308	78

3.3 Product Application

- Compressed air
- Natural gas in boiler rooms or dryers
- Carbon dioxide gas in breweries
- Biogas and aeration in wastewater treatment plants
- Generated gases (such as argon, nitrogen, carbon dioxide, helium, oxygen)
- Gas leakage detection

4.Wiring

4.1 Wiring Preparation

Before connecting, carefully read the wiring methods and requirements for other unit instruments or systems that are used in conjunction with the thermal gas mass flowmeter;

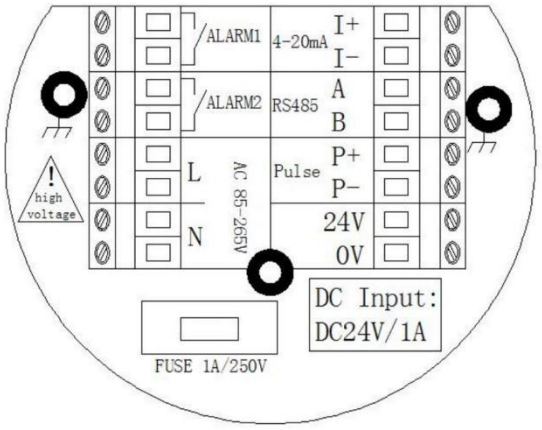
When connecting the external cables, it is recommended to use a two-core shielded cable and ensure a good seal at the cable connection point.

4.2 Terminal Connection Description

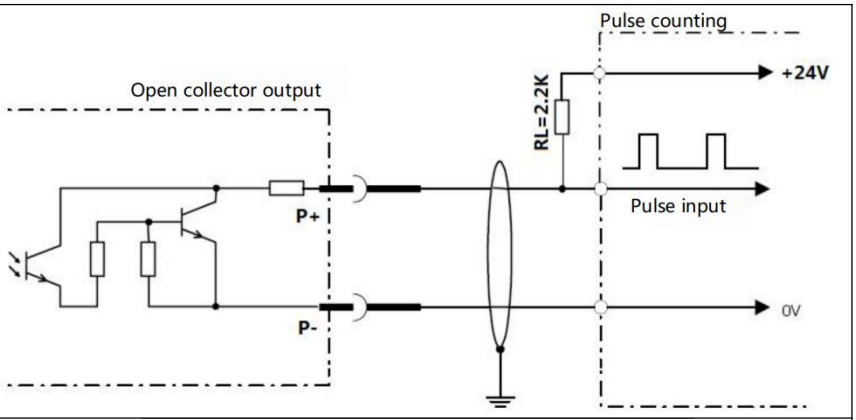
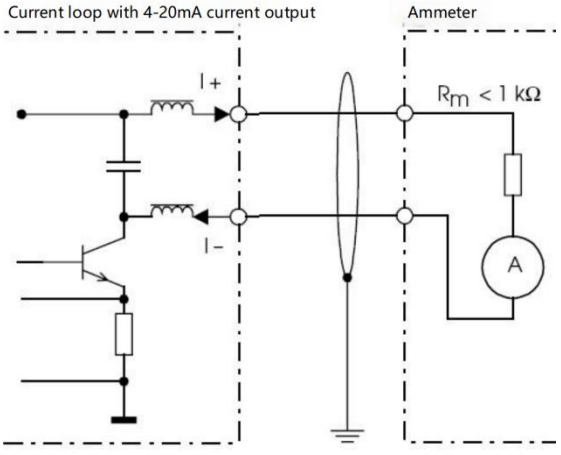
For intrinsically safe products, it is necessary to select intrinsically safe instrument cables that comply with relevant standards and ensure that the cable parameters meet the requirements of the intrinsically safe instrument system: the working voltage range is DC18 ~ 30V or AC85 - 220V. If the DC voltage is higher than DC30V, the instrument will be damaged. Measures should be taken to prevent the supply voltage from exceeding 30V;

The 24V DC power supply for the thermal gas mass flowmeter should meet IEC-1010-1 or equivalent standards of SELV safety sub-voltage;

Before connecting the DC power supply, measure the supply voltage with a voltmeter to confirm that the applied voltage is DC24V;

Connector terminal PCB diagram	Logo	Meaning	Usage
	24V	24V power input positive	Explanation: In actual use, only one of the options needs to be selected.
	0V	24V power input negative	
	L	AC input live wire	
	N	AC input neutral wire	
	P+	Pulse output positive	Measure cumulative pulses
	P-	Pulse output negative	
	I+	Current loop output positive	Analog output
	I-	Current loop output negative	
	485+/A	RS485 communication output A	Read the instrument data
	485-/B	RS485 communication output B	
	ALARM1	Alarm output 1	Alarm lower limit
	ALARM2	Alarm output 2	Alarm upper limit
		PCB installation hole	

4.3 Wiring of Terminal Connectors

Pulse output wiring	
Current output connection	

5. Technical Specifications

Performance	Technical Specifications
Accuracy	Flanged type: 1.5%; Insert type: 2.5%;
Repetition	±0.3%
Applicable pipe diameter range	Φ 15 - φ2000
Applicable flow rate range	0 - 550000 Nm3/h (φ2000 air)
Applicable pressure range	Less than 2 Mpa
Applicable medium temperature range	0 - 150℃ ; 0 - 250℃ ; 0 - 350℃
Applicable medium	All dry and clean gases (except acetylene)
Sensor diameter	Pipe section type: φ 18; Insert type: Φ20
Sensor material	1Cr18Ni9Ti, Hastelloy alloy, titanium, 316L, 304 stainless steel
Probe tube material (protective tube)	1Cr18Ni9Ti, 304 stainless steel, 316L
Transmitter housing material	Die-cast aluminum
Power supply voltage	DC24V/1.5A, AC110V or AC220V
Power consumption	≤25W
Output	Output: 4-20mA, RS485, HART
On-site display	16 characters x 4 rows
Supply type	Separate structure or integrated structure
Structural form	Insertion type and pipe type
Alarm	2 relays, 3A/250V AC, 3A/30V DC
Protection level	lP65
Cable outlet hole	M20x1.5

5.1 Flow Comparison Table for Various Sizes

Inner diameter (mm)	Minimum flow rate (Nm/s)	Maximum flow rate (Nm/s)	Minimum flow volume (Nm3/h)	Maximum flow volume (Nm3/h)	Normal flow volume (Nm3/h)
15	0.1	100	0.063	63	1-40
20	0.1	100	0.113	113	2-80
25	0.1	100	0.176	176	2.5-125
32	0.1	100	0.289	289	5-250
40	0.1	100	0.452	452	6-320
50	0.1	100	0.707	707	10-500
65	0.1	100	1.195	1195	15-850
80	0.1	100	1.81	1810	20-1300
100	0.1	100	2.827	2827	40-2000
125	0.1	100	4.418	4418	60-3000
150	0.1	100	6.362	6362	95-3000
200	0.1	100	11.30	11310	160-3000
250	0.1	100	17.671	17671	250-11000
300	0.1	100	25.447	25447	380-16000
350	0.1	100	34.636	34636	500-22000
400	0.1	100	45.239	45239	650-30000
450	0.1	100	57.255	57255	850-41000
500	0.1	100	70.685	70685	1000-50000
600	0.1	100	101.787	101787	1500-70000
700	0.1	100	138.544	138544	2000-100000
800	0.1	100	180.955	180955	2700-150000
900	0.1	100	229.022	229022	3400-140000
1000	0.1	100	282.743	282743	4000-200000
1500	0.1	100	636.172	636172	9000-430000
2000	0.1	100	1130.973	1130973	15000-770000

Note: Please refer to the normal flow range. For maximum and minimum flows that require expansion and customization, please confirm with the technical team.

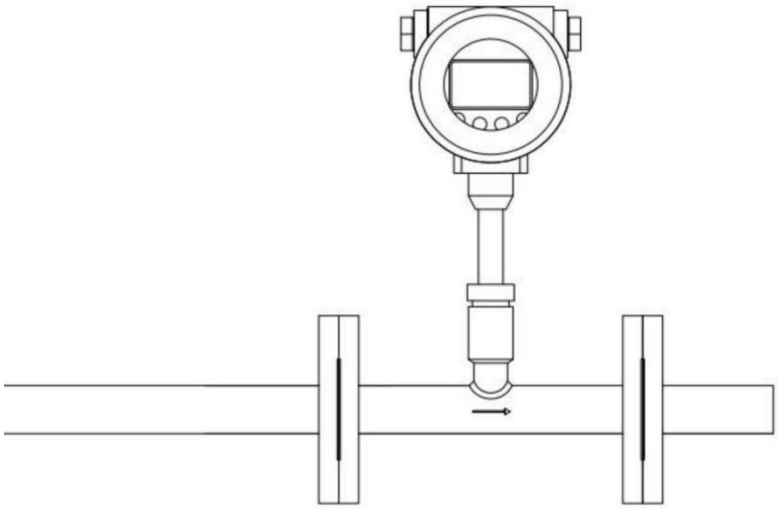
6.Installation

A stable flow field is the prerequisite for accurate measurement by thermal instruments. Therefore, please pay attention to the following points during the installation of the instruments.

6.1 Installation Method

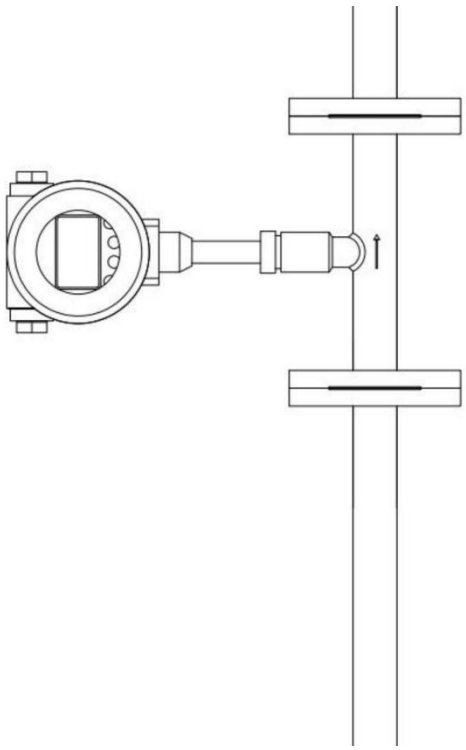
Horizontal installation

The maximum working pressure during horizontal installation is 2 MPa.



Vertical installation

The working pressure of vertical installation shall not exceed 2 MPa.

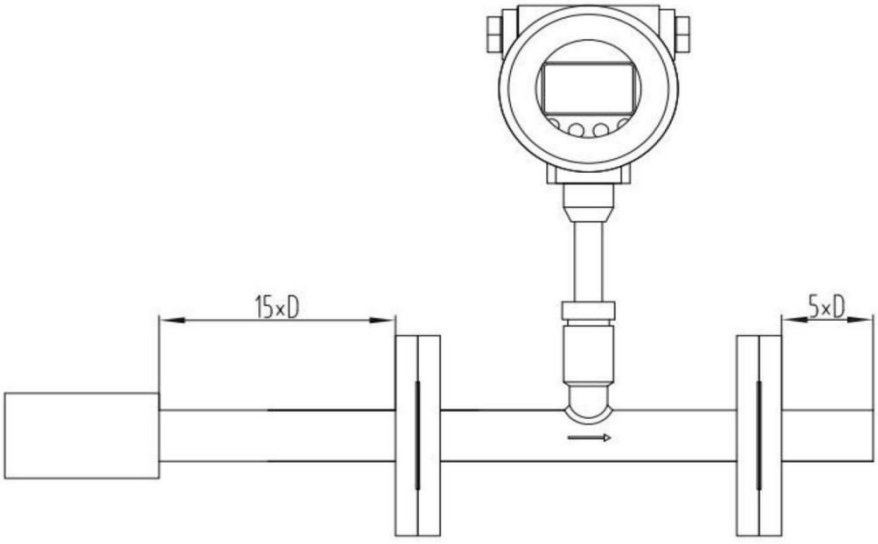


6.2 Installation Requirements for Pipes

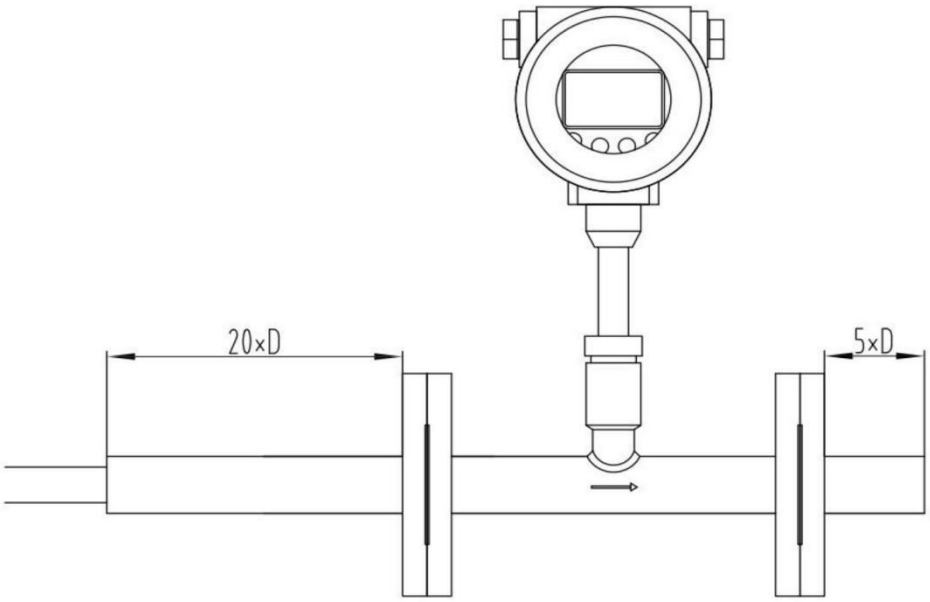
Several disturbance sources (such as pipe bends, gradually narrowing pipes, valves, T-shaped pipes, etc.) are located at the inlet pipeline of the thermal instrument. Please take measures to minimize their impact on the measurement performance as much as possible.

The following illustration shows the minimum recommended straight pipe length for different types of pipes. If the measurement space is large enough, the straight pipe length should be expanded as much as possible. Without considering other factors, the minimum recommended straight pipe length for the sensor is:

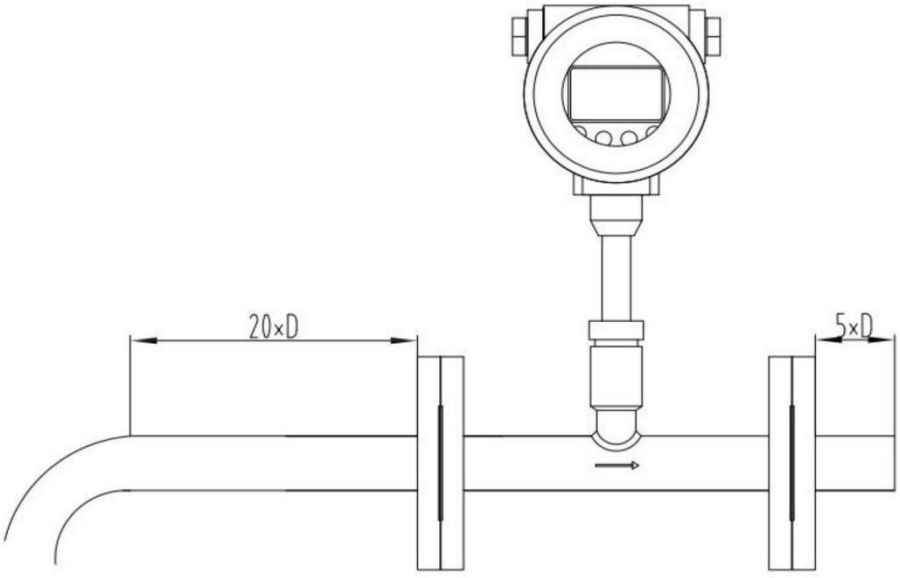
- Front straight pipe section: Minimum is 10 × DN
- Rear straight pipe section: Minimum is 5 × DN
- The recommended values are all the minimum values. Generally, increasing the length will improve the measurement performance of the flowmeter.
- If there are two or more interference sources in the front straight pipe section of the instrument, the recommended maximum length of the front straight pipe is the absolute minimum.
- It is recommended to install the control valve behind the flowmeter.
- For gases with lower specific gravity such as helium and hydrogen, the length of the front straight pipe should be doubled.



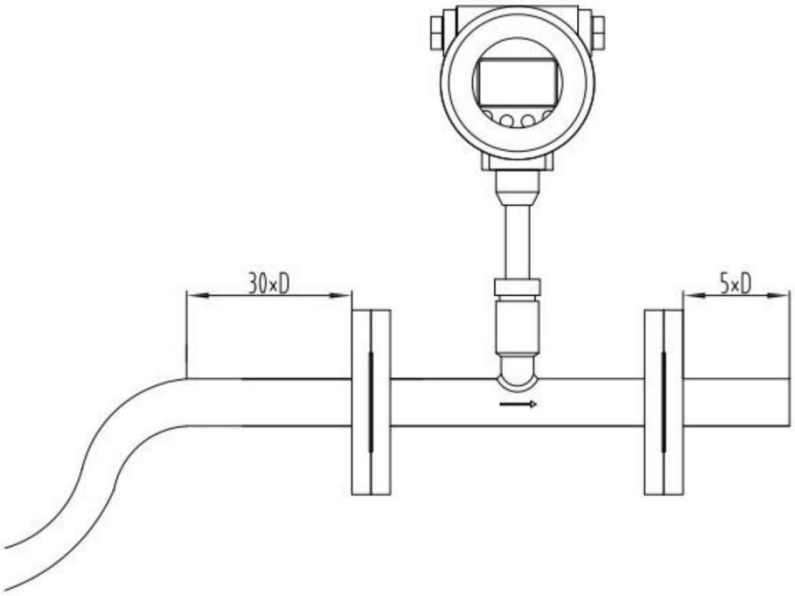
Reduced-diameter pipe



Expanded diameter pipeline



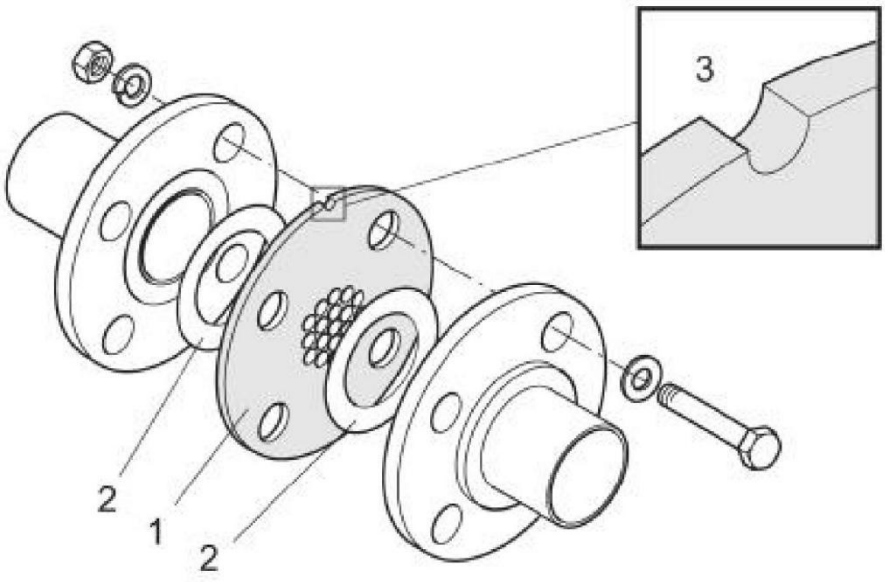
A 90-degree elbow



Two 90-degree elbows

6.3 Flow Regulator

If the length of the front straight pipe section cannot reach the recommended value, it is recommended to install a flow regulator.



The flow rectifier should be installed between the two flanges of the pipeline and should be installed coaxially with the installation bolts.

- 1 = Flow rectifier
- 2 = Sealing ring or gasket
- 3 = Positioning groove

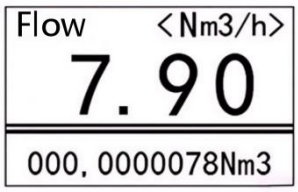
7.Operation

7.1 Header Keyboard and Display

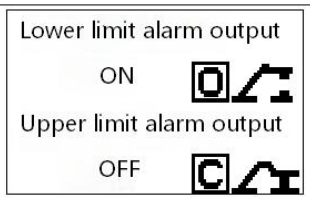
	ESC	ESC: Cancel/Exit Key
		Shift Key
		Modify/Scroll Key
	ENT	ENT: Confirm/Enter Key

7.2 Menu Instructions

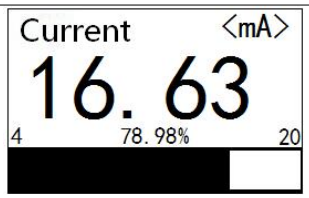
7.2.1 Display Menu



Display instantaneous flow, instantaneous flow unit, cumulative flow and unit

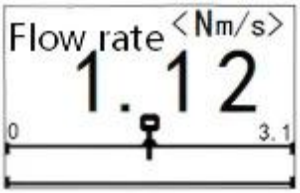


The upper and lower limit alarm flow values indicate the alarm status. When there is no alarm, the relay is in the normally open state.



The current value currently output and the percentage of current output

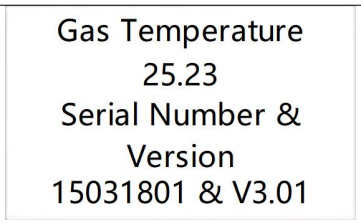
Strip-shaped dynamic display



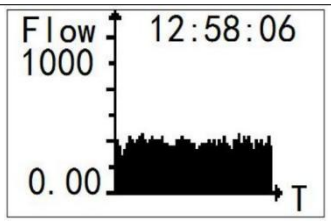
Display instantaneous flow rate, with the unit being fixed m/s

0 and 3.1 represent the measurement range of instantaneous flow rate, which changes with the variation of the range setting value

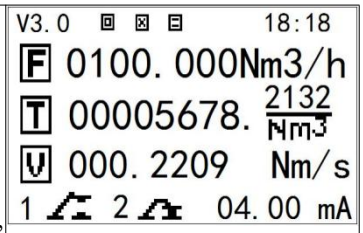
Dynamic display of the flow rate in the pipeline. The greater the flow rate, the faster the point velocity inside the pipeline.



Gas temperature value and serial number as well as version



Historical data. The last piece of data represents the data at the current time point. The time interval between data points can be set.



All information display windows

First line: V3.0 is the software version number, and the box indicates the status.

The first one from the left

Interface displays in a loop,

Interface does not display in a loop

The second

The backlight is constantly on,

for a moment

The third

Communication protocol is other

MODBUS RTU Protocol

18:18 System time

The second row represents instantaneous flow rate

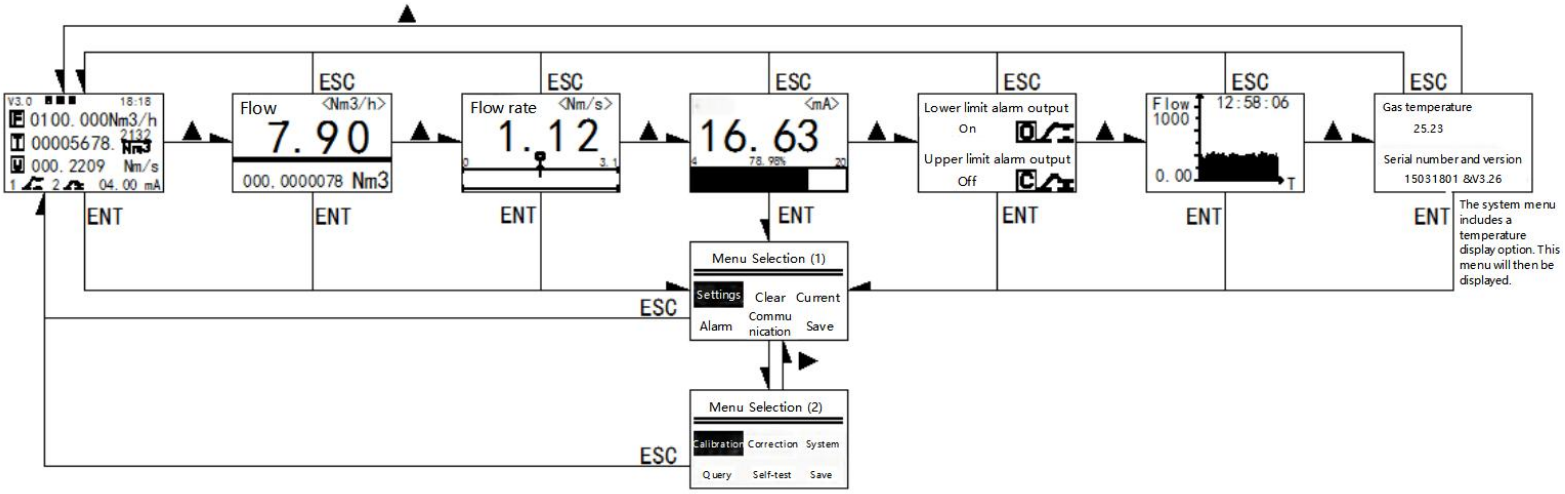
The third row represents cumulative flow rate

The fourth row represents flow velocity

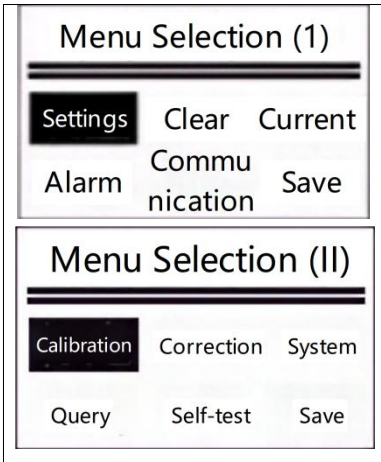
The fifth row represents relay and current

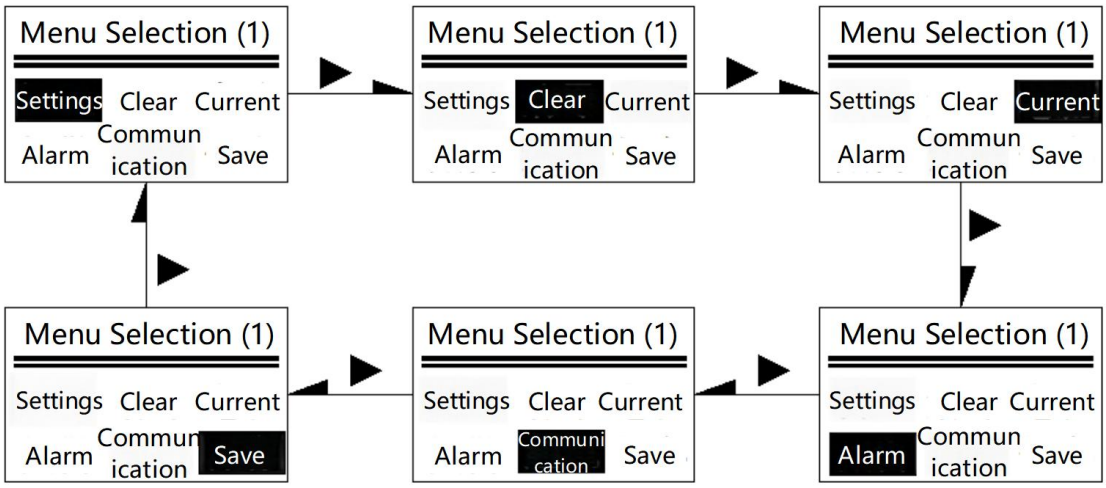
7.2.2 Menu Selection and Password Input Menu

Five display interfaces can be viewed by pressing the  'page turn key', and pressing the confirmation key will lead to the menu selection interface. For non-flow interface, pressing the cancel key will return to the flow interface.

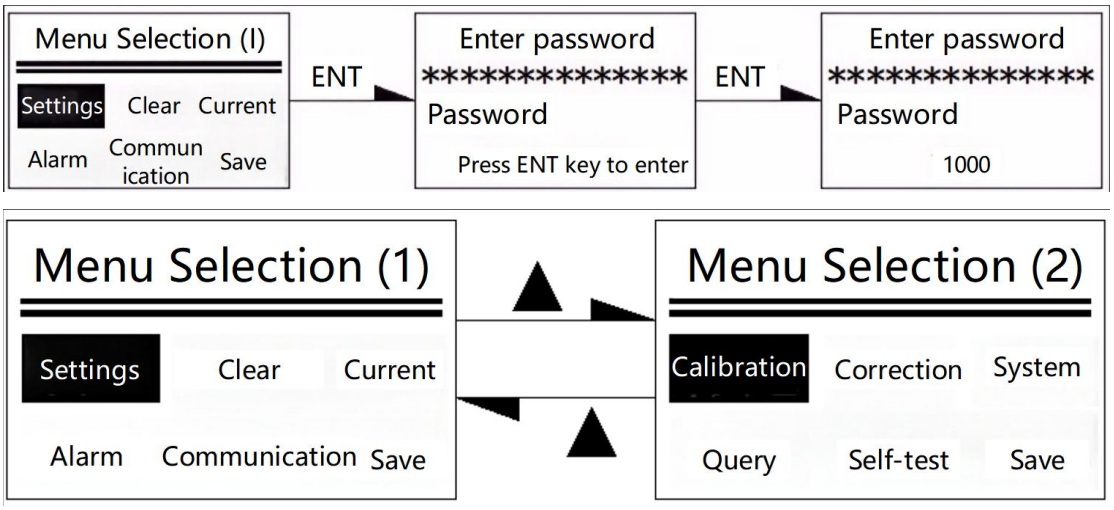


Select the desired function menu by using the shift key.

	Menu Selection Settings : Basic parameter settings Reset : Cumulative integer and decimal settings Current : Current parameter settings Alarm : Upper and lower alarm limits and alarm hysteresis settings Communication : RS485 communication parameter settings Save : Parameter saving and restoring parameters Calibration : Calibration settings Correction : Secondary correction of flow rate System : System parameter settings Query : Historical data query Self-check : Automatic detection of each function
	Settings, reset, current, alarm, communication, correction, system password: 1000 Calibration password: 0603 Query, self-check, save password: None



Set the basic parameter menu. Move the black rectangular box to the "Settings" section. Press the "ENT" key. A password input menu will appear. Press the "ENT" key again. A blinking cursor will show. Enter the password. After the password is entered, press the "ENT" key again to confirm. If the password is correct, you will directly enter the parameter setting menu. If the password is incorrect, the "Error" character will appear. Press the "ENT" key again to re-enter the password.



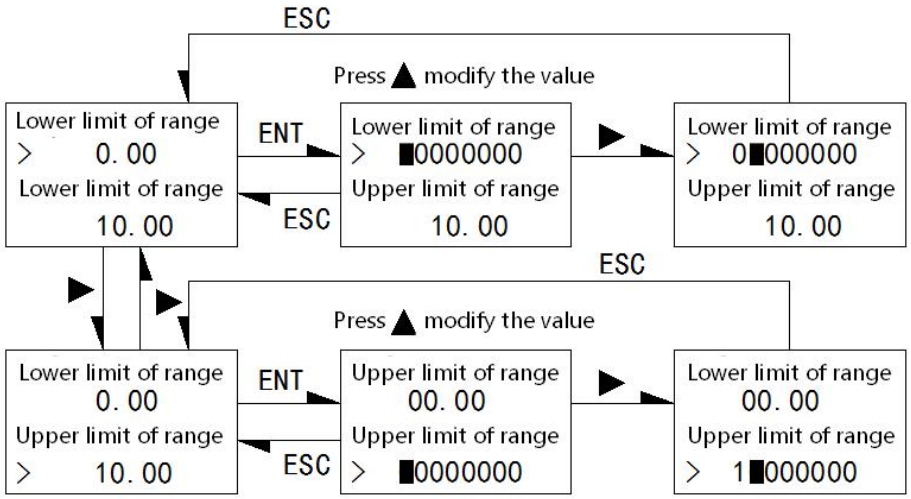
7.2.3 Parameter Menu

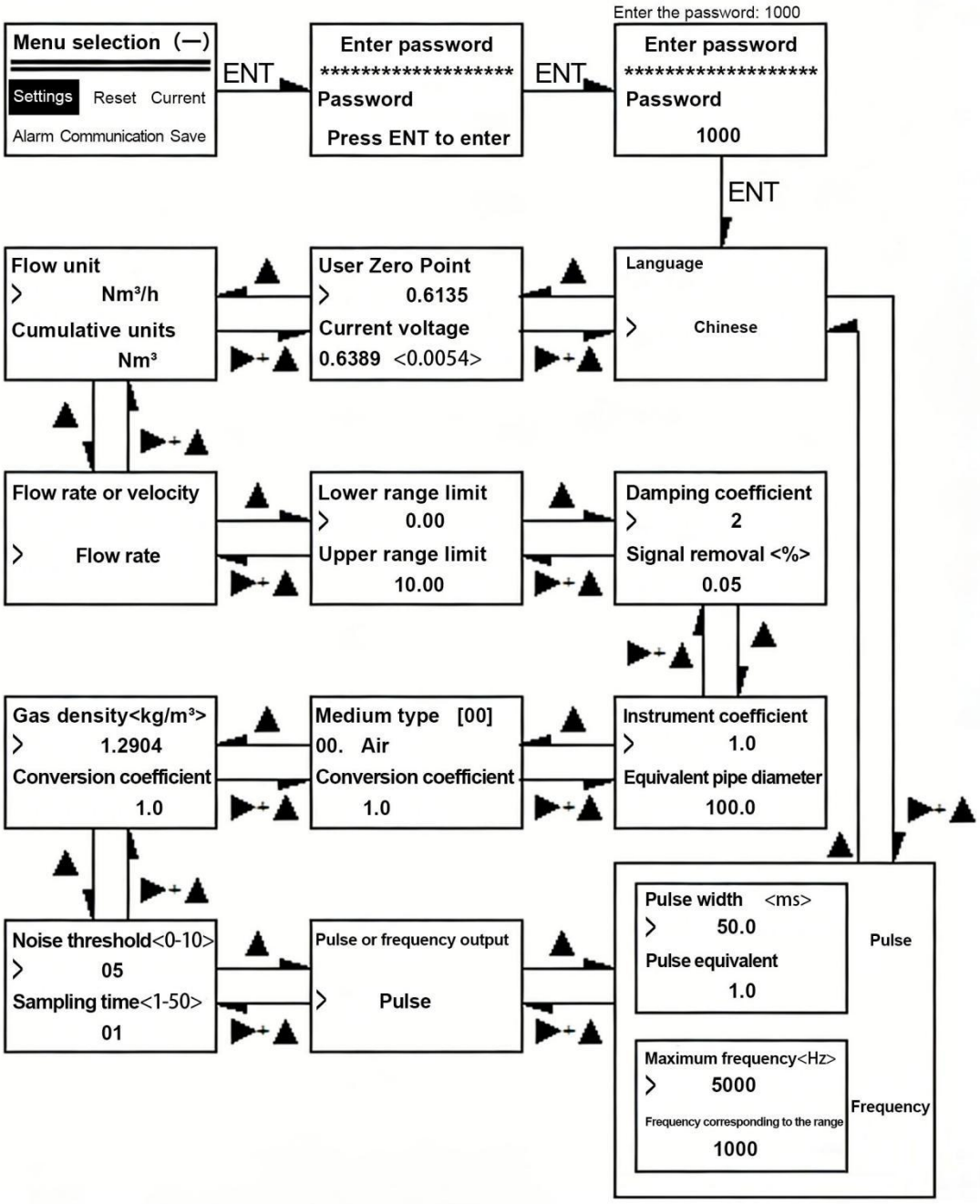
Language > Chinese	Language option: Chinese or English
User zero point > 0.6135 Current voltage 0.6389<0.0054>	User zero-point voltage setting: Depending on the on-site working conditions, the user's zero-point voltage will also vary. Users can set the user's zero-point according to the on-site situation. When the user's zero-point is set to zero, the instrument will automatically set the current actual voltage to the user's zero-point voltage. When there is no flow in the pipeline, the meter shows a non-zero flow rate. The flow rate can be adjusted by modifying the zero-point. The value in <> is equal to the calibrated zero-point minus the user's zero-point.
Flow unit > Nm3/h Cumulative units Nm3	> Indicates that it can be set up The flow units are as follows: g/min, g/s, Kg/min, Kg/h, Nm3/h, Nm3/min, NL/h, NL/min, SCFM. The cumulative units are: g, Kg, Nm3, NL, CFM. The cumulative units change along with the flow units and do not require separate settings.
Flow rate or velocity > Flow rate	Flow or flow rate: Selecting the output of 4-20mA indicates whether it is for flow or flow rate. If the selected option is flow rate, then the range limits will be for flow rate.
Lower limit of range > 0. 00 Upper limit of range 10. 00	> Indicates that it can be set up.Press the shift key to switch the ' > ' between the upper and lower limits of the range. Press the ENT key to enter the settings. After entering, the first character will flash.
Damping coefficient > 2 Small signal resection <%> 0.05	Damping coefficient: Default 2, range 0-50 Reducing the damping coefficient enables rapid detection of flow changes, while increasing the damping coefficient smooths the current flow display value. Signal attenuation: Eliminate zero-point fluctuations and express as a percentage of the range.
Instrument coefficient > 1.0 Equivalent pipe inner diameter mm 100.0	Instrument coefficient: This can be adjusted to change the calibration correction coefficient to compensate for the interference of the fluid cross-sectional velocity distribution and the influence of specific application environments. The instrument coefficient is a multiplicative factor for the linear flow signal. Display value = Instrument coefficient x Actual measurement value Pipe inner diameter: Input according to actual application, unit is mm

Media type [00] 00. Air Conversion factor 1.0	Medium type: 00-59, see Appendix II If you need to modify the values, then make the changes manually in the next menu.
Gas density <kg/m3> > 1.2904 Conversion factor 1.0	Density of medium: Unit Kg/m3 Measuring the density of the medium is different from the calibration of the medium. It can be used for density correction and also for the conversion between volume units and weight units. Conversion coefficient: The conversion coefficient between the calibrated gas and the measured gas.
Noise threshold <0-10> > 05 Sampling time <1-50> 01	Noise threshold: The value ranges from 0 to 10, used to eliminate noise signals. The larger the value, the greater the amount of noise signal eliminated. Sampling period: The default is 200ms, indicating that the sampling values within 200ms are averaged. The larger the time setting, the more samples are averaged, and the flow value calculated through this value will be more stable. The sampling period is set to 5, and the sampling period is 5 x 200ms = 1 second.
Pulse or frequency output > Pulse	Output selection: Frequency or pulse
Pulse width <ms> > 50.0 Pulse equivalent 1.0	Output pulse width time (50 - 1000 ms) Pulse single quantity: The number of single quantities corresponding to each pulse There are four options: 1.0, 10.0, 100.0, 1000.0. The pulse increment is set to 10.0, indicating that each output pulse corresponds to 10 units of volume quantity.
Maximum frequency <Hz> > 5000 Frequency corresponding range 1000	The maximum frequency is the maximum frequency of the output. Example: Flow rate 0 - 1000 Nm3/h, is represented by the output frequency ranging from 0 to 5000 Hz. Then the maximum frequency is set to 5000 Hz, and the corresponding range of the frequency is 1000 Nm3/h.

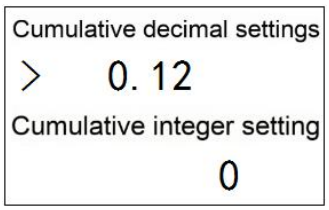
On the menu selection interface, select the corresponding function menu, enter the password to proceed.

After entering the settings menu, press the "ESC" key to return to the menu selection interface, and press the "ENT" key to enter the numerical settings.

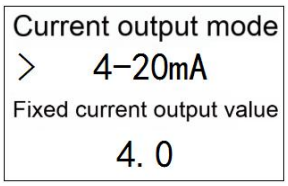
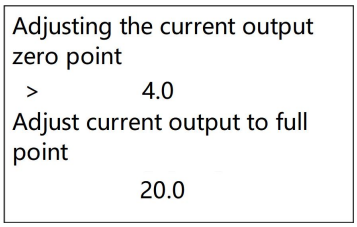



Menu selection (—)
Settings
Reset
Current
Alarm
Communication
Save
ENT
Enter password
****
Password
Press ENT to enter
ENT
Enter the password: 1000
Enter password
****
Password
1000
ENT
Flow unit
Nm³/h
Cumulative units
Nm³
User Zero Point
0.6135
Current voltage
0.6389 <0.0054>
Language
Chinese
Flow rate or velocity
Flow rate
Lower range limit
0.00
Upper range limit
10.00
Damping coefficient
2
Signal removal <%>
0.05
Gas density<kg/m³>
1.2904
Conversion coefficient
1.0
Medium type [00]
00. Air
Conversion coefficient
1.0
Instrument coefficient
1.0
Equivalent pipe diameter
100.0
Noise threshold<0-10>
05
Sampling time<1-50>
01
Pulse or frequency output
Pulse
Pulse width <ms>
50.0
Pulse equivalent
1.0
Pulse
Maximum frequency<Hz>
5000
Frequency corresponding to the range
1000
Frequency

7.2.4 Cumulative Menu

	Cumulative decimal and integer clearing or setting

7.2.5 Current Menu

	Current output mode: 4-20mA and fixed current output When choosing the fixed current output, you can set the fixed current output value. Fixed current output value: 4mA, 8mA, 12mA, 16mA, 20mA
	The current output mode is 4-20mA. When there is no flow, the output current value measured with a multimeter is 3.89 mA. Then, set the zero point of the current output to: 3.89 mA. When the maximum flow occurs, the output current value measured with a multimeter is 19.75 mA. Then, set the zero point of the current output to: 19.75 mA.

The method for calibrating the output current in the fixed current output mode:
Step 1: Connect the multimeter to the current loop circuit;
Step 2: Set the current output mode to fixed current output (Fixed);
Step 3: Press the shift key, move ‘ >’ to the next line, press the confirm key to enter the setting state, press the modify/scroll key to select the output current value, select 4mA output, press the confirm key to exit the setting state;
Step 4: Observe the display of the multimeter. If it is 4mA, no calibration is required. If it is 3.90mA, press the modify/scroll key to enter the calibration menu, move ‘ >’ to the zero-point current adjustment before (Adjust lout Zero), press the confirm key to enter the setting, input 3.90, press the confirm key to exit the setting;
Step 5: Press the shift key and the modify/scroll key simultaneously, the menu returns to the previous level. Move ‘ >’ to the next line, press the confirm key to enter the setting state, press the modify/scroll key to select the output current value, select 20mA output, press the confirm key to exit the setting state;
Step 6: Observe the display of the multimeter. If it is 20mA, no calibration is required. If it is 19.90mA, press the modify/scroll key to enter the calibration menu, move ‘ >’ to the zero-point current adjustment before (Adjust lout Span), press the confirm key to enter the setting, input 19.90, press the confirm key to exit the setting;
Step 7: Press the shift key and the modify/scroll key simultaneously, the menu returns to the previous level. Move ‘ >’ to the next line, press the confirm key to enter the setting state, press the modify/scroll key to select the output current value, while observing the display value on the multimeter. If it is consistent, it indicates successful calibration. If there is a difference, re-calibration is required. The re-calibration steps are the same as above.

7.2.6 Alarm Menu

Lower alarm limit <%> > 2 Upper alarm limit <%> 8	Setting of upper and lower limit flow alarm values: This value is expressed as a percentage of the range. For example, if "Low Alarm" is set to 10%, Alarm value = (Upper limit of range - Lower limit of range) * 10% Alarm hysteresis value is set to 5.0 If the current displayed value is less than the lower alarm value, an alarm output will occur. After the alarm, if the current displayed value returns to above the lower alarm value and is greater than (lower alarm value + hysteresis value), the alarm will be eliminated. If the current displayed value is greater than the upper alarm value, an alarm output will occur. After the alarm, if the current displayed value returns to below the upper alarm value and is less than (upper alarm value + hysteresis value), the alarm will be eliminated.
Lower limit alarm hysteresis <%> > 0.5 Upper limit alarm hysteresis <%> 0.5	

7.2.7 Communication Menu

Modbus device ID > 1	The device ID for MODBUS communication is 0 - 255.
Communication parameters > Baud rate 9600 Parity bit None Stop bits 1	The communication baud rate and parity setting for the RS485 communication interface. The stop bit cannot be set; it is fixed at 1 stop bit.
Communication Protocol > Modbus RTU	The communication protocols for RS485 and RS232 interfaces, the Modbus RTU protocol, the explanations of register addresses can be found in Appendix 1. The others are user-defined protocols.

7.2.8 Save Menu

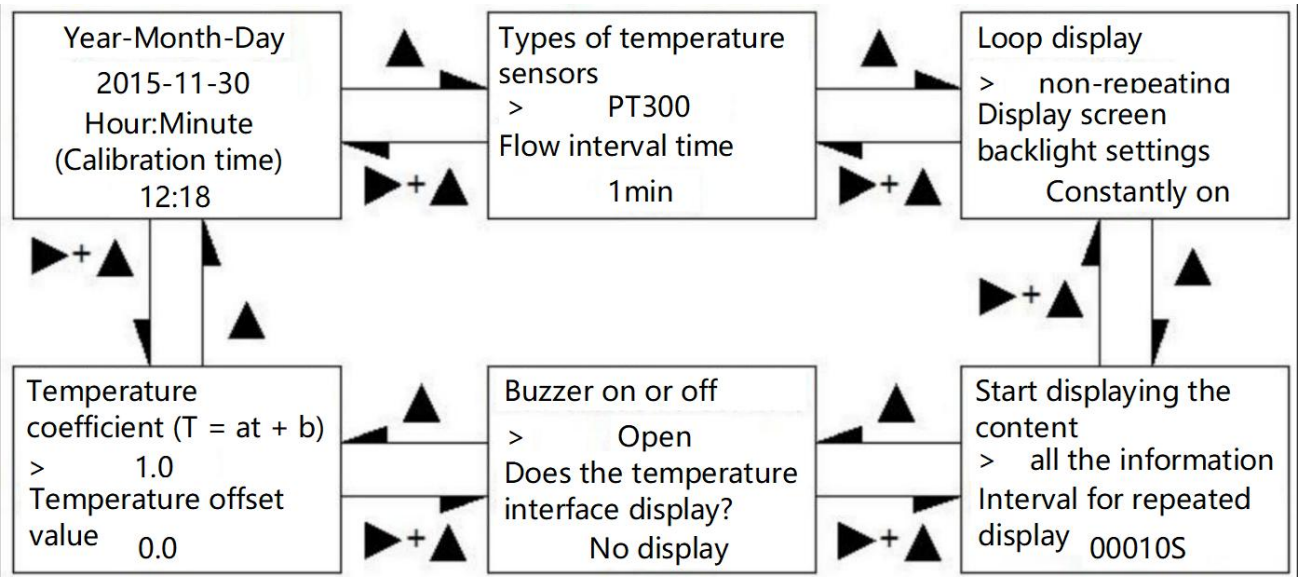
Save parameters > save Restore parameters Restore Save Parameters	Save parameters > save... Restore parameters Restore Saving Parameters...	Save parameters > save OK Restore parameters Restore Saved Successfully	Save parameters > save Err Restore parameters Restore Save Failed
Save parameters save Restore parameters > Restore Restore Parameters		Save parameters save Restore parameters Restore OK Recovery Success	Save parameters save Restore parameters Restore Err Failed Recovery

7.2.9 System Menu

Year-Month-Day 2015-11-30 Hour:Minute (Synchronization Time) 12:18	System time calibration
Types of temperature sensors > PT300 Flow interval time 1min	The types and models of temperature measurement sensors are determined based on the hardware configuration. Once the circuit is determined, the model of the sensor does not need to be modified. The flow interval time refers to the time interval for updating data on the historical data curve. The historical data curve displays 64 points of historical data. The time interval between two adjacent data points is the interval time in question.
Cyclic display > No cyclic display Display backlight settings Always on	Continuous display, select "Continuous", then all information, flow, flow rate, current, relay, historical data, and temperature (with display setting) will be displayed continuously. Backlight settings, constant brightness and short duration. The short duration means the display backlight will be on for 30 seconds and then turn off.
Startup display content > All information Cycle display interval time 00010 S	Start display content, used to set the content to be displayed when the device is powered on. Cycle display interval time, the time interval for the interface to cycle and display between each interface when the interface is set to cycle display.
Buzzer on or off > On Temperature interface: Display or not? No display	The buzzer is either turned on or off. When it is turned on, it indicates that the button has been pressed and the buzzer will sound; when it is turned off, it means the button has not been pressed and the buzzer will not sound. Whether the temperature interface displays or not, if it is set to display, the temperature value can be queried in the display interface.

Temperature coefficient (T=at+b) > 1.0 Temperature offset value 0.0	The temperature coefficient is the "a" coefficient in the formula, and the temperature offset value is the "b" coefficient in the formula. T = at+b

On the menu selection interface, select the corresponding function menu and enter by entering the password.



Appendix Ⅰ: Modbus Address Table

Register Address	Register Name	Number of Registers	Data Type	Data Format
4x0001-4x0002	Instantaneous flow rate	2	float	IEEE754
	Send	01 03 00 00 00 02 C4 0B		
	Receive	01 03 04 00 00 00 00 FA 33		
4x0003-4x0004	Instantaneous flow rate	2	float	IEEE754
	Send	01 03 00 02 00 02 65 CB		
	Receive	01 03 04 00 00 00 00 FA 33		
4x0005-4x0006	Current value at present	2	float	IEEE754
	Send	01 03 00 04 00 02 85 CA		
	Receive	01 03 04 00 00 00 00 FA 33		
4x0007-4x0008	Cumulative integers	2	Unsigned long	Unsigned long integer
	Send	01 03 00 06 00 02 24 0A		
	Receive	01 03 04 00 00 00 00 FA 33		
4x0009-4x0010	Cumulative decimal places	2	float	IEEE754
	Send	01 03 00 08 00 02 45 C9		
	Receive	01 03 04 00 00 00 00 FA 33		
4x0011-4x0012	Cumulative floating-point number	2	float	IEEE754
	Send	01 03 00 0A 00 02 E4 09		
	Receive	01 03 04 00 00 00 00 FA 33		
4x0013-4x0014	Medium temperature	2	float	IEEE754
	Send	01 03 00 0C 00 02 04 08		
	Receive	01 03 04 BA 4A 41 F8 CF 2F		
4x0015-4x0016	The current collected signal value	2	float	IEEE754
	Send	01 03 00 0E 00 02 A5 C8		
	Receive	01 03 04 82 1F 40 36 52 5B		
4x0017-4x0018	Minimum flow rate value	2	float	IEEE754
4x0019-4x0020	Maximum flow rate value	2	float	IEEE754
4x0021	Status of lower limit relay	1	Unsigned int	Unsigned integer
4x0022	Status of upper limit relay	1	Unsigned int	Unsigned integer
4x0051-4x0052	Product ID number	2	Unsigned long	Unsigned long integer
4x0053	Modbus device ID	1	Unsigned int	Unsigned integer

4x0054	Baud rate	1	Unsigned int	Unsigned integer
4x0055	Check digit	1	Unsigned int	Unsigned integer
4x0056	Stop bit	1	Unsigned int	Unsigned integer
4x0057	Language	1	Unsigned int	Unsigned integer
4x0058	Instantaneous flow unit	1	Unsigned int	Unsigned integer
4x0059	Cumulative flow unit	1	Unsigned int	Unsigned integer
4x0060	Current output mode	1	Unsigned int	Unsigned integer
4x0061	Fixed current output value guide	1	Unsigned int	Unsigned integer
4x0062	The PWM value corresponding to the fixed current output value	1	Unsigned int	Unsigned integer
4x0063	Zero point of current PWM value	1	Unsigned int	Unsigned integer
4x0064	Full point of current PWM value	1	Unsigned int	Unsigned integer
4x0065	Output pulse or frequency	1	Unsigned int	Unsigned integer
4x0066-4x0067	Pulse width	2	float	IEEE754
4x0068-4x0069	Single quantity corresponding to pulse output	2	float	IEEE754
4x0074-4x0075	Zero-point current calibration	2	float	IEEE754
4x0076-x40077	Full-point current calibration	2	float	IEEE754
4x0078-4x0079	Lower limit of range	2	float	IEEE754
4x0080-4x0081	Upper limit of range	2	float	IEEE754
4x0082-4x0083	Lower limit of alarm	2	float	IEEE754
4x0084-4x0085	Upper limit of alarm	2	float	IEEE754
4x0086-4x0087	Lower limit alarm hysteresis	2	float	IEEE754
4x0088-4x0089	Upper limit alarm hysteresis	2	float	IEEE754
4x0090-4x0091	Damping coefficient	2	float	IEEE754
4x0092-4x0093	Signal attenuation cut-off	2	float	IEEE754
4x0094-4x0095	Gas standard state density	2	float	IEEE754
4x0096-4x0097	Gas conversion coefficient	2	float	IEEE754
4x0098-4x0099	Standby			
4x0100-4x0101	Standby			
4x0102-4x0103	Instrument coefficient	2	float	IEEE754

4x0104-4x0105	Pipe inner diameter	2	float	IEEE754
4x0106-4x0107	Sampling time period	2	float	IEEE754
4x0108-4x0109	Noise coefficient	2	float	IEEE754

Appendix II: Table of Density of General Gases and Conversion to Air Density

Currently, the laboratory is unable to calibrate the mass flow rate based on the actual gas used by the user. Usually, the gas flow rate used by the user is converted into the air flow rate for calibration. When the user is using it, the directly output and displayed value is the actual mass flow rate or volume flow rate of the gas being used.

The conversion for different gases is carried out through conversion coefficients. The conversion coefficients for single-component gases can be found in a table. As shown in the following table:

	Gas	Specific Heat (cal/g°C)	Density (g/L at 0°C)	Conversion Factor
00	Air	0.24	1.2048	1.0000
01	Argon Ar	0.125	1.6605	1.4066
02	Arsine AsH3	0.1168	3.478	0.6690
03	Boron Tribromide BBr3	0.0647	11.18	0.3758
04	Boron Trichloride BCl3	0.1217	5.227	0.4274
05	Boron Trifluoride BF3	0.1779	3.025	0.4384
06	Borane B2H6	0.502	1.235	0.5050
07	Tetrachlorocarbon CCl4	0.1297	6.86	0.3052
08	Perfluorocarbon CF4	0.1659	3.9636	0.4255
09	Methane CH4	0.5318	0.715	0.7147
10	Acetylene C2H2	0.4049	1.162	0.5775
11	Ethylene C2H4	0.3658	1.251	0.5944
12	Ethane C2H6	0.4241	1.342	0.4781
13	Propyne C3H4	0.3633	1.787	0.4185
14	Propene C3H6	0.3659	1.877	0.3956
15	Propane C3H8	0.399	1.967	0.3459
16	Butynene C4H6	0.3515	2.413	0.3201
17	Butene C4H8	0.3723	2.503	0.2923
18	Butane C4H10	0.413	2.593	0.2535
19	Pentane C5H12	0.3916	3.219	0.2157
20	Methanol CH3OH	0.3277	1.43	0.5805
21	Ethanol C2H6O	0.3398	2.055	0.3897
22	Trichloroethane C3H3Cl3	0.1654	5.95	0.2763
23	Carbon Monoxide CO	0.2488	1.25	0.9940
24	Carbon Dioxide CO2	0.2017	1.964	0.7326
25	Hydrogen Cyanide C2N2	0.2608	2.322	0.4493
26	Chlorine Cl2	0.1145	3.163.	0.8529

27	Deuterium gas D2	1.7325	0.1798	0.9921
28	Fluorine gas F2	0.197	1.695	0.9255
29	Tetraclorogermanium GeCl4	0.1072	9.565	0.2654
30	Germanium hydride GeH4	0.1405	3.418	0.5656
31	Hydrogen gas H2	3.4224	0.0899	1.0040
32	Bromine hydride HBr	0.0861	3.61	0.9940
33	Hydrogen Chloride HCI	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 H2S	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 N2	0.2486	1.25	0.9940
40	Neon Ne	0.2464	0.9	1.4066
41	Ammonia NH3	0.5005	0.76	0.7147
42	Nitrogen Oxide NO	0.2378	1.339	0.9702
43	Dinitrogen Tetroxide NO2	0.1923	2.052	0.7366
44	Dinitrogen Monoxide N2O	0.2098	1.964	0.7048
45	Oxygen O2	0.2196	1.427	0.9861
46	Phosphorus trichloride PCI 3	0.1247	6.127	0.3559
47	Phosphine PH3	0.261	1.517	0.6869
48	Pentofluorophosphorus PF5	0.1611	5.62	0.3002
49	Trichlorophosphorus oxychloride POCI3	0.1324	6.845	0.3002
50	Tetrafluorosilicon SiCI4	0.127	7.5847	0.2823
51	Tetrafluorosilicon SiF4	0.1692	4.643	0.3817
52	Silane Si H4	0.3189	1.433	0.5954
53	Dichlorosilane Si H2CI2	0.1472	4.506	0.4095
54	Trichlorosilane Si HCI3	0.1332	6.043	0.3380
55	Sulfur Hexafluoride SF6	0.1588	6.516	0.2624
56	Sulfur Dioxide SO2	0.1489	2.858	0.6829
57	Tetrachlorotitanium TiCI4	0.1572	8.465	0.2048
58	Hexafluorotungsten WF6	0.0956	13.29	0.2137
59	Xenon Xe	0.0379	5.858	1.4066

Appendix III. Sensor Calibration

Step：

1. Locate the Ro temperature value (resistance value measured at °C) and the Alpha value on the instrument calibration sheet.

2. Turn off the instrument power supply and let it cool naturally for 6 minutes.

3. Open the instrument cover, remove the PT20 and PT300 leads as shown in the figure.

4. Set the multimeter to the ohm setting (2K), and connect PT200 A and PT200 B (temperature sensors). Measure the resistance between A and B. Record the result in Table 1.

5. Set the multimeter to the ohm setting (200 Ω), and connect PT20 A and PT20 B (speed sensors). Measure the resistance value between A and B and record it in Table 1.

6. Use the measured resistance values and Ro and Alpha Ro values to calculate the temperature of each sensor:

$$T = \frac{R_{final} - R_o}{A_{lpha} \times R_o}$$

Among them:

T = Celsius

Rfinal = Sensor resistance measurement value Ro = Resistance value at 0°C (calibration sheet)

Alpha = Specific value for each sensor (calibration sheet)

7. Compare Table 1. If the temperature difference is within 10 degrees Celsius, the sensor is normal.

8. Remove the multimeter and connect the 4 leads. Ensure the leads are properly connected before powering on, then cover the outer cover of the instrument. Table 1:

Temperature sensor resistance	T
Speed sensor resistance	T

Appendix Ⅳ: Fault Detection and Maintenance

Flow Meter Fault Handling

Before carrying out any hardware repair work, please confirm whether the following contents are correct. These contents will affect the performance of the system.

1. Check if the flow meter has an electrical power supply, and verify if the voltage level and polarity are correct.

2. Check if the wiring of the flow meter is correct.

3. Check if the lengths of the upstream and downstream straight pipe sections of the flow meter meet the requirements.

4. Check if the direction pointer of the flow meter points to the downstream.

5. Ensure that the measured pipeline has no leakage.

Before dismantling the instrument, please disconnect the power supply!

Before maintenance, make sure the pipeline is free of pressure!

Question	Possible Causes	Solution
Abnormal speed or wave move	Abnormal or irregular fluid flow	Check whether the required straight pipe sections for installation meet the requirements.
	The rectifier is not installed at the front end of the sensor	Correct the direction of the meter body.
	The probe element is damaged	Return to the manufacturer for replacement.
	Electronic component is abnormal	Return to the manufacturer.
	Grounding loop	Check the wiring.
The speed measurement is either too high or too low.	The sensor and the fluid flow direction are not aligned properly.	The flow direction indicator needs to indicate the downstream of the fluid
	The rectifier has not been installed at the front end of the sensor.	Correct the direction of the table body
No response to traffic flow	No power supply	Turn on the instrument power supply
	Water vapor present in the airflow	Install a dehydrator or install a filter at the upstream
	The low flow cut-off setting is too high	Set through the keyboard or the upper computer software
	The flow is lower than the minimum flow level of the instrument	Set the user range, reduce the flow to the maximum calibration value, or contact the manufacturer for re-calibration.
	Sensor failure	Return to the manufacturer
	Circuit board failure	Return to the manufacturer