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The Company promises to constantly improve product quality and therefore reserves the right to modify the contents of the Manual without notice.

使用说明书 Operation Instruction



VORTEX SHEDDING FLOW METER

涡街流量计



- 电压式
- 电容式
- 夹装式
- 法兰式
- 插入式
- 电池供电型
-

- Piezoelectric type
- Capacitive type
- Clamp type
- Flange type
- Plug-in type
- Battery-powered type
-



安徽省天长市仁和南路20号
邮编：239300
电话：(+86) 0550-7032831
传真：(+86) 0550-7090831
网址：www.tiankangybd.com
邮箱：tkybd@126.com

NO.20 South Renhe Road, Tianchang City, Anhui Province
Zip Code: 239300
Telephone: (+86) 0550-7032831
Fax: (+86) 0550-7090831
Website: www.tiankangybd.com
Mailbox: tkybd@126.com



安徽天康(集团)股份有限公司
ANHUI TIANKANG(GROUP) SHARES CO.,LTD

关于本公司

About The Company

安徽天康(集团)股份有限公司是一家国内知名的仪器仪表设计与制造公司,产品用于工业过程控制中的温度、压力、流量、液位测量以及数据分析。

作为工业现场参数测量仪表的主要生产商之一,我们为国内外的客户提供应用方面的专业知识、服务及技术支持。

公司产品的质量、性能来自于近四十年在工业仪表研发及制造的经验,以及对于技术的不断创新设计与持久开发。

Anhui Tiankang (Group) Co., Ltd. is a domestic and foreign well-known instrumentation design and manufacturing company, and the product is used in the temperature, pressure, flow, level measurement and data analysis in the industrial process.

As one of the main producers of industrial field parameter measuring instruments, we provide professional knowledge, service and support in the application for domestic and overseas clients.

The quality and performance of company's products are from the industrial instrument R&D and manufacturing experience for nearly 40 years, as well as the continuous innovation of technology design and sustainable development.

健康与安全

Health And Safety

为了确保我们的产品安全,不影响健康,务必注意以下各点:

1、使用前必须仔细阅读说明书的有关章节。

2、必须遵守容器或包装上的警示标签。

3、必须由经过培训的人员按照所列信息进行安装、操作、维护及保养。一切由于违反本说明书而造成的后果均由用户承担。

4、务必遵守一般的注意事项,以避免在高压或高温下运行时发生事故。

In order to ensure our product safety and do not affect the health, make sure to pay attention to the following points:

1. Make sure to read relevant chapters of the Instructions carefully before use.

2. Make sure to follow caution Label on the container or packaging.

3. Make sure that installation, operation, maintenance and preservation are performed by trained staff according to information listed. All consequences caused by violation of the Instructions shall be assumed by users.

4. Make sure to follow general notes to avoid accident in operation under high pressure and temperature.

有关手册所述设备使用的安全事项或任何相关的危害数据表(适用时)可以从公司取得,地址如封底所示,同时提供保养及备件信息。

Safety precautions relevant to equipment use described in the Manual and any relevant hazard data table (where applicable) can be obtained from the Company. Address is shown as the back cover and information on maintenance and spare parts is provided at the same time.

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一、安全指南 Safety Guide

1.1 用途

- 本测量设备用于测量密闭管道中的流体流量。包含液体、气体和蒸汽。
- 除本文指定用途外，其它任何用途均会对人员和整个测量系统的安全造成威胁，禁止使用。
- 制造商对由于不恰当使用或用于非指定用途而引起的损坏不承担责任。

1.1 Use

The measuring device is used to measure the fluid flow in a closed pipe, including liquids, gases and vapors.

Except the intended use in this manual, any other application may pose a threat to the safety of personnel and the entire measurement system.

The manufacturer is not liable for damage caused by improper use or unspecified use.

1.2 安装、调试和操作

- 本测量设备必须由获得授权的合格专业人员(例如电工)进行安装、连接、调试和维护，并要完全遵守《使用说明书》、适用规范、法律法规以及证书(与应用条件相关)中的规定。
- 专业人员必须事先阅读《使用说明书》，理解并遵守其中的规定。
- 安装本测量设备时，应在断电状态下且没有外部负荷或应力时进行。
- 只有在《使用说明书》明确允许的情况下，才能对本测量设备进行改动。
- 只能采用原装备件且在明确允许进行修理的情况下，才能进行维修。
- 如果对管路执行焊接操作，不可通过本测量设备实现焊接设备接地。

1.2 Installation, commissioning and operation

The measuring equipment must be installed, connected, commissioned and maintained by an authorized qualified professional (e.g., electrician) and must comply with the instructions in the User's Guide, applicable specifications, laws and regulations, and certificates (relevant to the application conditions).

Professionals must read the User's Guide in advance and understand and comply with the requirements.

When installing this measuring device, it shall be carried out in the event of a power failure and without external load or stress.

The measurement equipment can only be changed if it is expressly permitted in the "User's Guide".

The original spare parts can only be used and repairs can only be made if it is expressly permitted to be repaired.

If the welding operation is performed on the pipeline, the welding equipment can not be grounded through this measuring device.

1.3 操作安全

• 本测量设备的设计满足先进的安全要求，已经通过出厂测试，可放心使用。本设备遵守相关的法规和欧洲标准。

• 制造商保留在修改技术参数时不提前通知的权利。安徽天康(集团)股份有限公司产品销售经理将为您提供本《使用说明书》的最新信息和更新材料。

• 必须遵循设备上附带的警告标志、铭牌和接线图中所含的信息。这些信息包括允许的操作条件、测量设备应用范围以及材料参数。

• 如果设备不是用在常温环境中，则必须符合随附的设备文档中所规定的相关边际条件。

• 必须按照布线图和接线图中的规定对设备进行接线。必须允许互连。

• 设备的所有部件都必须纳入系统的电势平衡考虑范围内。

• 电缆、经鉴定的缆塞和经鉴定的堵头必须经得起普遍存在的操作条件的考验，例如过程温度范围。未使用的外壳孔必须用堵头加以密封。

• 本设备仅可用在绝不会腐蚀任何接液部件的流体中。对于特殊流体(包括清洁用流体)，安徽天康(集团)股份有限公司将很乐意帮助您确认接液材料的耐腐蚀性。但是，过程中的温度、浓度或污染度的轻微变化可能会导致接液部件耐腐蚀性能发生改变。因此，安徽天康(集团)股份有限公司对在特定应用中发生的接液材料的耐腐蚀性问题不承担任何责任。用户应妥善选择接液材料。

• 当高温流体流经测量管时，外壳的表面温度会升高。特别是传感器部分，用户应预料到外壳表面温度可能会接近流体温度。如果流体温度较高，应采取足够的防护措施，避免灼伤或烫伤。

• 危险区域可在危险区域中使用的测量设备的铭牌上有相应的标记。在危险区内操作设备时，必须遵守相关的国家规定。包装上的Ex防爆文档是设备文档的组成部分。必须遵守该Ex防爆文档中提供的安装规范、连接参数以及安全说明。

• 在卫生领域的应用用于卫生领域的测量设备具有专用的标记。使用此类设备时，必须遵守相关的国家规定。

• 安徽天康(集团)股份有限公司非常乐意帮助您解答有关认证、应用领域以及具体实施中的问题。

1.3 Operational safety

The design of the measurement equipment to meet the advanced safety requirements has passed the factory test, can be assured that use. This device complies with applicable regulations and European standards.

The manufacturer reserves the right not to notify in advance when modifying the technical parameters. Your product sales manager of Anhui Tiankang (Group) Co., Ltd. will provide you with the latest information and updated materials of this User's Manual.

You must follow the information contained in the warning signs, nameplates, and wiring diagrams that come with the device. This information includes the permissible operating conditions, the range of measurement equipment, and the material parameters.

If the equipment is not used in a normal temperature environment, it must comply with the relevant marginal conditions specified in the accompanying documentation.

The equipment must be wired as specified in the wiring diagram and wiring diagram. Interconnection must be allowed.

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All components of the equipment must be included in the system's potential balance.
The cable, the identified cable plug, and the identified plug must withstand the prevailing operating conditions, such as the process temperature range. Unused housing holes must be sealed with plugs.

This equipment may only be used in fluids that will never corrode any of the wetted parts. For special fluids (including cleaning fluids), Anhui Tiankang (Group) Co., Ltd. will be happy to help you confirm the corrosion resistance of the wetted material. However, minor changes in temperature, concentration, or contamination may cause the corrosion resistance of the wetted parts to change. As a result, Anhui Tiankang (Group) Co., Ltd. does not assume any responsibility for the corrosion resistance of the wetted material that occurs in a particular application. Users shall choose the wetted material.

When the high temperature fluid flows through the measuring tube, the surface temperature of the shell will rise. In particular, the sensor section, the user shall expect the surface temperature of the shell may be close to the fluid temperature. If the fluid temperature is high, adequate precautions shall be taken to avoid burns or burns.

Hazardous areas may be marked on the nameplate of the measuring equipment used in the hazardous area. When operating the equipment in a hazardous area, the relevant national regulations must be observed. The Ex explosion proof document on the package is part of the device documentation. The installation instructions, connection parameters, and safety instructions provided in the Ex explosion proof document must be observed.

Applications in the field of health The measurement equipment used in the health field has a dedicated marking. When using such equipment, the relevant national regulations must be observed.

Anhui Tiankang (Group) Co., Ltd. is very happy to help you answer questions about certification, application areas and specific implementation.

1.4 安全图标

⚠ 警告！“警告”表示，如果某个操作或过程执行不当，将会导致人身伤害或安全事故。请严格遵守规范，谨慎操作。

⚠ 注意！“注意”表示，如果某个操作或过程执行不当，将会导致设备操作故障或设备损坏。请严格遵守规范。

💡 提示！“提示”表示，如果某个操作或过程执行不当，会间接影响设备运行或触发设备某部分发生意外响应。

1.4 security icon

⚠ WARNING! "WARNING" indicates that if an operation or process is performed improperly, it will result in personal injury or safety. Please strictly observe the norms, careful operation.

⚠ CAUTION! "Caution" means that if an operation or process is performed improperly, it will cause malfunction of the equipment or damage to the equipment. Please strictly observe the specifications.

💡 PROMPT! "Prompt" means that if an operation or process is improperly executed, it will indirectly affect the device to run or trigger a part of the device accidental response.

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二、TK2000型涡街流量计 TK2000 Vortex Shedding Flow Meter

2.1 概述

TK2000系列涡街流量计是我公司在吸收国外先进技术的基础上，全新开发的一种全数字化的高性能仪表，可对不同介质的流量参数进行测量。仪表具有结构简单、通用性好和稳定性高的特点。

TK 2000系列涡街流量计可用于各种气体、液体和蒸汽的流量检测及计量。

TK2000系列涡街流量计可以与本公司生产的智能流量积算仪配套使用，也可以和其它仪表厂商生产的智能仪表配套使用，具有通用性强的特点。

2.1 Overview

TK2000 vortex shedding flow meter is a newly developed full-digital high-performance instrument based on the foreign advanced technology, which can be used to measure the flow parameters of different media. The instrument has the characteristics of simple structure, good versatility and high stability.

TK 2000 vortex shedding flow meter can be used for the flow detection and measurement of a variety of gas, liquid and steam.

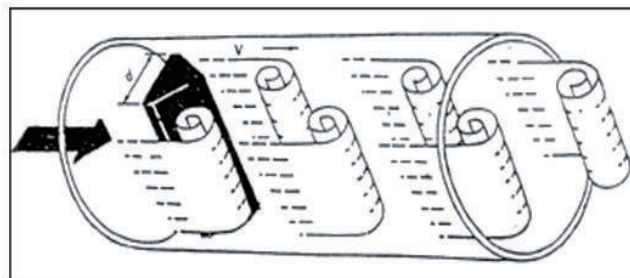
TK2000 vortex shedding flow meter can be used combined with the intelligent flow totalizer developed by our company, or intelligent instruments of other instrument manufacturers, which has a strong universality.

2.2 工作原理

在流体中设置非流线型旋涡发生体（阻流体），则从旋涡发生体两侧交替地产生两列有规则的旋涡，这种旋涡称为卡曼涡街，如图（一）所示。

2.2 Working principle

In the case of a non-streamlined vortex generator (bluff body), two lines of regular vortices are generated alternately from both sides of the vortex generator, known as the Kaman vortex, as shown in Fig.1



图（一）
Fig.1

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旋涡列在旋涡发生体下游非对称地排列。设旋涡的发生频率为 f ，被测介质来流的平均速度为 V ，旋涡发生体迎流面宽度为 d ，表体通径为 D ，根据卡曼涡街原理，有如下关系式：

The vortex columns are arranged asymmetrically in the downstream of vortex generator. The frequency of the vortex is set as f , the average velocity of the measured medium is set as V , the stream surface width of vortex generator body is set as d , and the diameter of body is set as D ; according to the principle of Kaman vortex, the relationship is as follows:

$$f = St \cdot \frac{V}{d}$$

公式 (1) 式中： f —发生体一侧产生的卡门旋涡频率 St —斯特罗哈尔数（无量纲数） V —流体的平均流速 d —旋涡发生体的宽度

由此可见，通过测量卡门涡街分离频率便可算出瞬时流量。其中，斯特罗哈尔数 (St) 是无因次未知数，

图 (二) 表示斯特罗哈尔数 (St) 与雷诺数 (Re) 的关系。

In Formula (1):

f —Kaman vortex frequency on one side of generating body

St —Strohal number (dimensionless number)

V —Average flow rate of the fluid

D —Width of vortex generator

It can be seen that the instantaneous flow can be calculated by measuring the frequency of Kaman vortex. And the Strohard number (St) is the zero-dimension unknown number;

Figure (b) shows the relationship between Strohard number (St) and Reynolds number (Re).

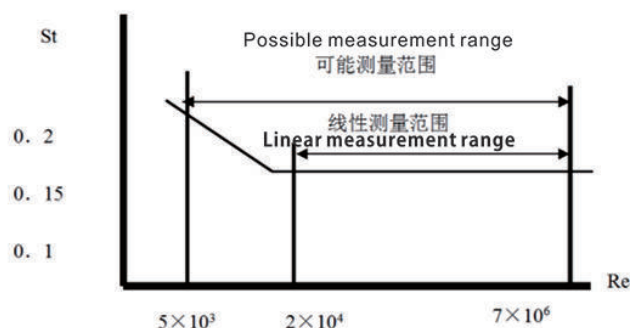


图 (二)
Fig.2

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在曲线表中 $St=0.17$ 的平直部分，漩涡的释放频率与流速成正比，即为涡街流量传感器测量范围度。只要检测出频率 f 就可以求得管内流体的流速，由流速 V 求出体积流量。所测得的脉冲数与体积量之比，称为仪表常数 (K)，见式 (2)

$K = N/Q$ (1/m³) 公式 (2) 式中： K = 仪表常数 (1/m³)。

N = 脉冲个数

Q = 体积流量 (m³)

In the straight part of $St=0.17$ in curve Table, the vortex release frequency is proportional to the flow rate, indicating the measurement range of vortex flow sensor. As long as the frequency f is detected, the flow rate in the tube can be obtained, and the volumetric flow rate is obtained using the flow velocity V . The ratio of pulse measured to volume is known as the meter constant (K), shown in formula (2)

In formula (2), K = meter constant (1/m³).

N = number of pulses

Q = volume flow (m³)

2.3 产品特点

1. 应用范围广，蒸汽、气体、液体的流量均可测量；
2. 测量结果与流速分布、流体压力、温度、密度、粘度等物理参数无关；
3. 无可动部件，可靠性高，长期运行稳定；
4. 耐磨、耐脏污，无须机械维修，使用寿命长，安全防爆，适用于恶劣环境；
5. 传感器测量探头采用特殊工艺封装，耐高温可达350℃；
6. 传感器采用补偿设计，提高仪表抗震性；
7. 采用低功耗高新技术，电池供电的现场显示型流量计，不断电运行可达五年以上；
8. 电隔离型电流输出，共模干扰抑制能力良好；
9. 抗振性能好，零点无漂移，有效消除外界振动影响；
10. 表面贴装工艺电路，结构紧凑，可靠性高，测量范围宽，量程比可达10:1，15:1，20:1，30:1；
11. 压损小，动态测量范围宽，运行费用低，不锈钢材质表体，耐腐蚀性强；
12. 脉冲输出、4~20mA输出或HART通讯 / Modbus协议通讯，可与工业自动化系统连接；
13. 现场液晶显示，同时瞬时流量显示、累计总量显示；
14. 密度计算、温度、压力补偿计算，补偿计算公式在线检验，就地按键设置，方便参数调整，无需手持通讯器。

2.3 Product features

1. Wide range of applications; measure the steam, gas and liquid flow;
2. The measurement results are independent of the physical parameters, such as velocity distribution, fluid pressure, temperature, density, viscosity.
3. No moving parts with high reliability and long-term stable operation;
4. Resistant to wear and dirt, no need for mechanical maintenance, long service life, safe and anti-explosion, suitable for harsh environments;
5. Sensor measurement probe adopts the special process with the high temperature resistance up to 350 °C;

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6. The sensor adopts the compensation design, enhancing the instrument shock resistance;
7. Micro-power high-tech, battery-powered on-site display, constant operation up to more than five years;
8. Electric isolation current output, good common mode interference suppression;
9. Good anti-vibration performance, no drift in zero; effectively eliminate the external vibration;
10. Surface mounting circuit, compact structure, high reliability, wide measuring range, and range ratio up to 10: 1, 15: 1, 20: 1 and 30: 1;
11. Small pressure loss, wide dynamic measurement range, low operating costs, stainless steel body, and strong corrosion resistance;
12. Pulse output, 4-20mA output or HART communication/Modbus protocol communication; can be connected with the industrial automation system;
13. On-site LCD display, instantaneous flow display and cumulative display;
14. Density calculation, temperature, pressure compensation calculation, online inspection of compensation calculation formula, local button settings, simple parameter adjustment and no handheld communication device.

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2.4 主要技术指标

涡街流量计TK2000		
测量流体	气体、蒸汽	液体
精度	±1.0%, ±1.5% (插入式±2.5%)	±0.75%±1.0% (插入式±2.0%)
重复性	±0.3%	±0.25%
雷诺数	2X104~7X106	
介质温度	扩展	-40℃~+350℃
	标准	-40℃~+250℃
量程比	10:1; 15:1; 20:1; 30:1	
口径范围	DN15~DN1500	
工作压力	1.0MPa / 1.6MPa / 2.5MPa / 4.0MPa其他	
流速范围	5~70m/s	0.5~7m/s
接液材料	304不锈钢 / 316L不锈钢	
法兰材料	碳钢法兰 / 304法兰 / 316L法兰	
螺栓材料	碳钢	
检测探头	316L不锈钢	
连杆支架	304不锈钢	
散热器	铝合金/不锈钢	
安装形式	夹持式/法兰式/插入式	
防护等级	IP65/IP67/IP68	
电源	24VDC (18~30V) / 电池供电	
信号输出	4~20mA、数字脉冲	
通讯	HART通讯/Modbus协议	
电气接口	2×M20*1.5 (其他需定制)	
防爆形式	非防爆型/本安/隔爆	
结构形式	一体型/分体型	
环境温度	带LCD: -10~60℃/无LCD: -20~60℃	
相对湿度	湿度5%~90%	
产品标准	参照JB/T 9249-2015	

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2.4 Main technical indicators

VSF TK2000		
Fluid measured	Gas, steam	Liquid
Accuracy	±1.0% , ±1.5% (Plug-in±2.5%)	±0.75%±1.0% (Plug-in±2.0%)
Repeatability	±0.3%	±0.25%
Reynolds number	2X104-7X106	
Medium temperature	Extended	-40℃~+350℃
	Standard	-40℃~+250℃
Range ratio	12 : 1;16:1;24:1;32:1	
Caliber range	DN15~DN1500	
Working pressure	1.0MPa/1.6MPa/2.5MPa/4.0MPa others	
Flow rate range	5~70m/s	0.5~7m/s
Liquid material	304 stainless steel/316L stainless steel	
Flange material	Carbon steel flange/304 flange/316L flange	
Bolt material	Carbon steel	
Detection probe	316L stainless steel	
Connecting rod bracket	304 stainless steel	
Heat sink	Aluminum alloy/stainless steel	
Installation form	Clamp/Flange/Plug-in	
Protection level	IP65/IP67/IP68	
Power supply	24VDC(18~30V)/ Battery power	
Signal output	4-20mA, digital pulse	
Communication	HART communication/Modbus protocol	
Electrical interface	2×M20*1.5(Other need to be customized)	
Explosion proof form	Non-explosion type/intrinsically safe/flameproof	
Structure type	All-in-one/separated	
Ambient temperature	With LCD:-10~60℃/without LCD: -20~60℃	
Relative humidity	Humidity 5%-90%	
Product standards	Based on JB/T 9249-2015	

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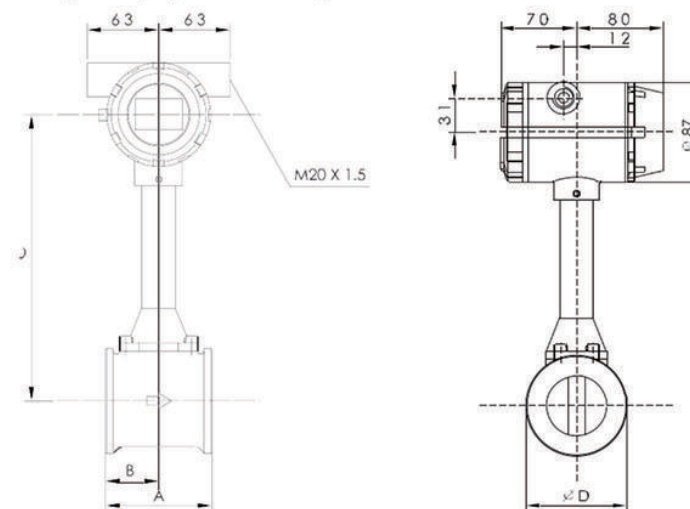


2.5 涡街流量计尺寸图

2.5.1 法兰夹持型涡街流量计外形尺寸

2.5 Vortex shedding flow meter dimensional drawing

2.5.1 Flange clamping vortex shedding flow meter dimensions



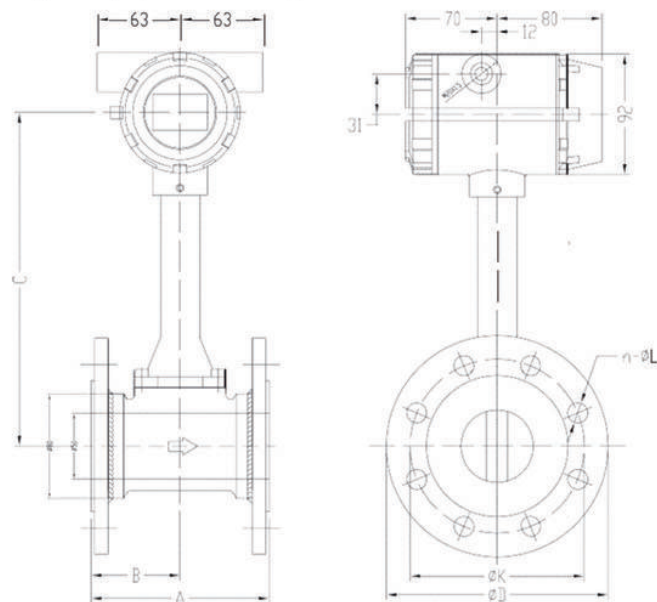
流量计通径 Flow meter diameter	A	B	C	φ D
DN	A	B	C	φ D
15	56	28	360	88
20	56	28	360	88
25	56	28	360	88
32	56	28	360	88
40	56	28	360	88
50	66	33	365	98
65	66	33	370	113
80	70	35	380	128
100	70	35	390	148
125	80	40	410	173
150	88	44	420	198
200	98	98	435	248
250	114	114	480	298
300	130	130	525	348

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2.5. 2法兰夹涡街流量计外形尺寸

2.5.2 Flange clamping vortex shedding flow meter dimensions



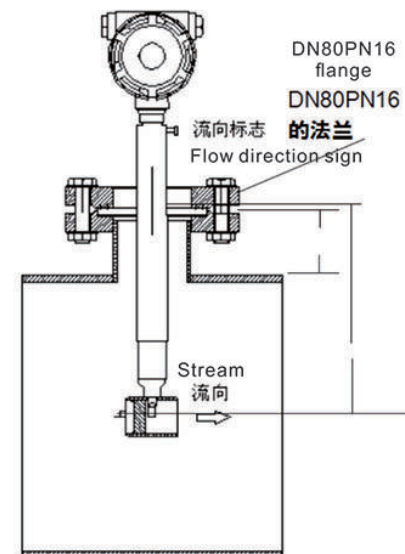
DN	A	B	C	ϕD	ϕK	n- ϕL
15	200	100	360	95	65	4-14
20	200	100	360	105	75	4-14
25	200	100	360	115	85	4-14
32	200	100	360	140	100	4-18
40	200	100	360	150	110	4-18
50	200	100	365	165	125	4-18
65	200	100	370	185	145	8-18
80	200	100	380	200	160	8-18
100	250	125	390	220	180	8-18
125	250	95	410	250	210	8-18
150	300	100	420	285	240	8-22
200	350	125	435	340	295	12-22
250	400	150	480	405	355	12-26
300	450	175	525	460	410	12-26

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2.5. 3插入式涡街流量计外形尺寸

2.5.3 Plug-in vortex shedding flow meter dimensions



DN	H	L1	L2	L2高温型/在线安装型 L2 high temperature type/online installation type
250	100	225	500	725
300	100	250	525	750
350	100	250	525	750
400	100	250	525	750
500	100	250	525	750
600	100	250	525	750
700	100	250	525	750
800	100	250	525	750
900	100	250	525	750
1000	100	250	525	750
1200	100	250	525	750
1400	100	250	525	750
1500	100	250	525	750
2000	100	250	525	750

三、仪表口径选择

Selection Of Instrument Caliber

仪表选型是仪表应用中非常重用的工作,仪表选型的正确与否将直接影响到仪表是否能够正常运行.因此用户和设计单位在选用本公司产品时,请仔细阅读本节资料,认真核对流体的工艺参数并随时可与我公司的销售或技术支持部门联系,以确保选型正确。

Instrument selection is very important in the application of instrumentation, whether the instrument is correct or not will directly affect if the instrument can run properly. Therefore, users and design units shall carefully read the information in the selection of the company's products, carefully check the fluid process parameters and contact the company's sales or technical department at any time, so as to ensure that the selection is correct.

3.1 适用流量范围和仪表口径的确定

仪表口径的选择,根据流量范围来确定。不同口径涡街流量仪表的测量范围是不一样的。即使同一口径流量表,用于不同介质时,它的测量范围也是不一样的。实际可测的流量范围需要通过计算确定。

3.1 Determination of applicable flow range and instrument caliber

The selection of meter diameter is determined by the flow range. Different caliber vortex flow meters have different measurement ranges. Even if the caliber meter is the same, its measurement range for different media is also not the same. The actual measurable flow range needs to be determined via calculation.

3.1.1 参比条件下空气及水的流量范围,见表(二),参比条件如下:

1. 气体: 常温常压空气, $t=20^{\circ}\text{C}$, $P=0.1\text{MPa}$ (绝压), $\rho=1.205\text{kg/m}^3$, $\nu=15\times 10^{-6}\text{m}^2/\text{s}$ 。

2. 液体: 常温水, $t=20^{\circ}\text{C}$, $\rho=998.2\text{kg/m}^3$, $\nu=1.006\times 10^{-6}\text{m}^2/\text{s}$ 。

3.1.1 Air and water flow range under reference conditions; see Table 2, the reference conditions are as follows:

1. Gas: normal pressure and temperature air, $t=20^{\circ}\text{C}$, $P=0.1\text{MPa}$ (absolute pressure), $\rho=1.205\text{kg/m}^3$, $\nu=15\times 10^{-6}\text{m}^2/\text{s}$ 。

2. Liquid: normal temperature water, $t=20^{\circ}\text{C}$, $\rho=998.2\text{kg/m}^3$, $\nu=1.006\times 10^{-6}\text{m}^2/\text{s}$ 。

3.1.2 确定流量范围和仪表口径的基本步骤:

1. 明确以下工作参数。

- (1) 被测介质的名称、组份
- (2) 工作状态的最小、常用、最大流量
- (3) 介质的最低、常用、最高压力和温度
- (4) 工作状态下介质的粘度

2. 涡街流量仪表测量的是介质的工作状态体积流量,因此应先根据工艺参数求出介质的工作状态体积流量,相关公式如下:

(1) 已知气体标准状态体积流量,可通过以下公式求出工况体积流量

$$Q_v = Q_o \times \frac{0.131025}{0.101325 + P} \times \frac{273.15 + t}{293.15} \quad \text{公式 (3)}$$

(2) 已知气体标准状态密度 ρ , 可通过以下公式求出工况密度

$$\rho = \rho_o \times \frac{0.101325 + P}{0.101325} \times \frac{273.15}{273.15 + t} \quad \text{公式 (4)}$$

(3) 已知质量流量 Q_m 换算为体积流量 Q_v

$$Q_v = Q_m \times 10^3 / \rho \quad \text{公式 (5)}$$

式中:

Q_v : 介质在工况状态下的体积流量 (m^3/h)

($Q_v=3600f/K$ K:仪表系数)

Q_o : 介质在标准状态下的体积流量 (Nm^3/h) Q_m : 质量流量 (t/h)

ρ : 介质在工况状态下的密度 (kg/m^3)

ρ_o : 介质在标准状态下的密度 (kg/m^3), 常用气体介质的标准状态密度, 见表 (三)

P: 工况状态表压 (Mpa)

t: 工况状态温度 ($^{\circ}\text{C}$)

3. 仪表下限流量的确定。涡街流量仪表的上限适用流量一般可不计算, 涡街流量仪表口径的选择主要是对流量下限的计算。下限流量的计算应该满足两个条件: 最小雷诺数不应低于界限雷诺数 ($Re=2\times 10^4$); 对于应力式涡街流量仪表在下限流量时产生的旋涡强度应大于传感器旋涡强度的允许值 (旋涡强度与升力 ρv^2 成比例关系)。这些条件可表示如下:

由密度决定的工况可测下限流量:

$$Q_p = Q_o \times \sqrt{\rho_o / \rho} \quad \text{公式 (6)}$$

由运动粘度决定的线性下限流量:

$$Q_v = Q_o \times \nu / \nu_o \quad \text{公式 (7)}$$

式中:

Q_p : 满足旋涡强度要求的最小体积流量 (m^3/h)

ρ_o : 参比条件下介质的密度

Q_v : 满足最小雷诺数要求的最小线性体积流量 (m^3/h)

ρ : 被测介质工况密度 (kg/m^3)

Q_o : 参比条件下仪表的最小体积流量 (m^3/h)

ν : 工作状态下介质的运动粘度 (m^2/s)

ν_o : 参比条件下介质的运动粘度 (m^2/s)

通过公式 (6)、(7) 计算出 Q_p 和 Q_v 。比较 Q_p 和 Q_v , 确定流量仪表可测下限流量和线性下限流量:

$Q_v \geq Q_p$: 可测流量范围为 $Q_p \sim Q_{\max}$, 线性流量范围为 $Q_v \sim Q_{\max}$

$Q_v < Q_p$: 可测流量范围和线性流量范围为 $Q_p \sim Q_{\max}$

$Q_{\max}$: 涡街流量仪表的上限体积流量 (m^3/h)

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4. 仪表上限流量以表(二)中的上限流量为准。气体的上限流速应该小于 70m/s, 液体的上限流速应该小于 7m/s

5. 当用户测量的介质为蒸汽时, 常采用的计量单位是质量流量, 即: t/h 或 kg/h。由于蒸汽(过热蒸汽和饱和蒸汽)在不同温度和压力下的密度是不同的, 因此蒸汽流量范围的确定可由公式(8)进行计算得出

$$Q_{\text{蒸汽}} = 1.5 Q_{\text{空气}} \times \rho \times 10^3 \times \sqrt{\rho_0 / \rho} \quad \text{公式 (8)}$$

式中:

ρ : 蒸汽的密度 (kg/m³)

ρ_0 : 1.205 kg/m³

$Q_{\text{蒸汽}}$: 蒸汽质量流量 (t/h)

计算压力损失, 检测压力损失对工艺管线是否有影响, 公式(单位: Pa):

$$\Delta p = C_d \rho V^2 / 2 \quad \text{公式 (9)}$$

式中:

ρ : 工况介质密度 (kg/m³)

V : 平均流速 (m/s)

6. 被测介质为液体时, 为防止气化和气蚀, 应使管道压力符合以下要求

$$p \geq 2.7 \Delta p + 1.3 p_0 \quad \text{公式 (10)}$$

式中:

Δp : 压力损失 (Pa)

p_0 : 工作温度下液体的饱和蒸汽压 (Pa绝压)

p : 流体的蒸汽压力 (Pa绝压)

7. 涡街流量计不适合测量高粘度液体。当计算出的可测流量下限不满足设计工艺要求时, 应该考虑选用其它类型流量计。

8. 通过计算如果有两种口径都可满足要求, 为了提高测量效果、降低造价, 应选用口径较小的表。应该注意的是, 尽可能使常用量处在流量范围上限的 1/2 ~ 2/3

Δp : 压力损失 (Pa) C_d : 压力损失系数

3.1.2 Basic steps of determining the flow range and meter caliber:

1. Identify the following operating parameters.

(1) The name and components of the measured medium

(2) The minimum, commonly used and maximum flow of working state

(3) The minimum, commonly used and maximum pressure and temperature of media

(4) The viscosity of medium in the working state

2. The vortex flow meter measures the volume flow of media under working state, so the flow rate of medium under working state shall be obtained according to the process parameters. The relevant formula is as follows:

(1) Under the known gas standard state volume flow, the flow volume under the working state can be obtained by the following formula

$$Q_v = Q_o \times \frac{0.131025}{0.101325 + P} \times \frac{273.15 + t}{293.15} \quad \text{Formula 3}$$

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(2) Under the known gas standard state density ρ , the density under the working state can be obtained by the following formula

$$\rho = \rho_o \times \frac{0.101325 + P}{0.101325} \times \frac{293.15}{273.15 + t} \quad \text{Formula 4}$$

(3) Under the known mass flow Q_m , it is converted to the volume flow rate Q_v

$$Q_v = Q_m \times 10^3 / \rho \quad \text{Formula 5}$$

In the formula

Q_v : Volume flow rate of the media under the working condition (m³/h)

($Q_v = 3600 f / K$ K: meter factor)

Q_o : Volume flow rate of the media under the standard state (m³/h)

Q_m : Mass flow (t/h)

P : Density of media under working condition (kg/m³)

P_o : Density of media under standard state (kg/m³), the standard state density of commonly used gas media is shown in Table 3

P : Working condition gage pressure (Mpa)

T : Working condition temperature (°C)

3. Determination of lower limit flow. The upper limit applicable flow of vortex flow meter cannot be calculated, and the selection of vortex flow meter diameter is mainly based on the lower limit of flow. The lower limit flow calculation shall meet two conditions: the minimum Reynolds number shall not be lower than the limit Reynolds number ($Re = 2 \times 10^4$); the vortex intensity of stress vortex shedding flow meter shall be greater than the allowable vortex strength of sensor (the vortex intensity is proportional to the lift force $C_p v^2$). These conditions can be presented as follows:

The lower limit flow can be measured under the working conditions determined by the density:

$$Q_p = Q_o \times \sqrt{\rho_o / \rho} \quad \text{Formula 6}$$

Linear lower limit flow rate determined by kinematic viscosity:

$$Q_v = Q_o \times \nu / \nu_o \quad \text{Formula 7}$$

In the formula:

Q_p : Minimum volumetric flow rate (m³/h) meeting the vortex strength requirements

P_o : Density of media under reference conditions

Q_v : Minimum linear volume flow meeting the minimum Reynolds number (m³/h)

ρ : Working density of measured media (kg/m³)

Q_o : Minimum volumetric flow of the instrument under reference conditions (m³/h)

ν : Kinematic viscosity of media under working state (m²/s)

ν_o : Kinematic viscosity of media under reference conditions (m²/s)

Q_p and Q_v are calculated via formulas (6) and (7). Compare Q_p and Q_v and measure the lower limit flow and linear lower limit flow via the flow meter:

$Q_u \geq Q_p$: Measurable flow range Q_p - Q_{max} , linear flow range Q_u - Q_{max}

$Q_u < Q_p$: Measurable flow range and linear flow range Q_p - Q_{max}

Q_{max} : upper volume flow of vortex flow meter (m³/h)

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4. The upper limit flow rate of the meter in Table (2) shall prevail: The upper limit rate of gas shall be less than 70m/s, while the upper limit rate of liquid shall be less than 7m/s

5. When the media to be measured are steam, the mass flow is often used in the measurement, namely t/h or kg/h. Since the density of steam (superheated steam and saturated steam) is different at different temperatures and pressures, the steam flow range can be calculated via Formula (8)

$$Q_{\text{蒸汽}} = 1.5Q_{\text{空气}} \times \rho \times 10^3 \times \sqrt{\rho_o / \rho} \quad \text{Formula 8}$$

ρ : Density of steam (kg/m³)

ρ_o : 1.205 kg/m³

Q_{Steam} : Steam mass flow (t/h)

Calculate the pressure loss, and detect if the pressure loss has an impact on the process pipeline, the formula (unit: Pa):

$\Delta p = C_d \rho V^2 / 2$ Equation (9)

In the formula:

ρ : Media density under working condition (kg/m³)

V : Average flow rate (m/s)

6. When the measured medium is liquid, the piping pressure shall meet the following requirements in order to prevent gasification and cavitation

$P \geq 2.7\Delta p + 1.3p_o$ Formula (10)

In the formula:

Δp : pressure loss (Pa)

p_o : Saturated vapor pressure of liquid under operating temperature (Pa absolute pressure)

p_o : Vapor pressure of fluid (Pa absolute pressure)

7. Vortex flow meter is not suitable for measuring high-viscosity liquids. When the measurable lower-limit flow rate does not meet the design requirements, please consider other types of flow meter.

8. If there are two calibers meeting the requirements, choose the smaller diameter in order to improve the measurement results and reduce the cost. Note that the flow shall be at 1/2 to 2/3 of the upper limit

Δp : pressure loss (Pa) C_d : pressure loss factor

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3. 2表 (二) 参比条件下涡街流量传感器工况流量范围

3.2 Flow range of the vortex flow sensor under reference conditions in Table 2

公称通径DN (mm) Nominal diameter DN (mm)	流量范围 (m ³ /h) flow range (m ³ /h)		
	液体 Liquid	气体 Gas	蒸汽 Steam
15	0.4-4	4-30	3.2-18
20	0.7-7	6-40	5-32
25	1-10	11-70	9-60
32	1.5-15	17-150	15-130
40	2-25	24-240	20-200
50	3-45	37-370	32-320
65	5.5-75	65-650	55-540
80	8.5-110	95-950	81-810
100	16-180	150-1500	130-1300
125	25-270	245-2400	200-2000
150	35-350	360-3600	290-2900
200	60-600	600-6000	550-5000
250	90-900	900-9000	800-8000
300	135-1350	1350-13500	1150-11500
350	185-1850	1850-18500	1550-15500
400	240-2400	2400-24000	2100-21000
450	300-3000	3000-30000	2600-26000
500	380-3800	3800-38000	3300-33000
600	550-5500	5500-55000	5100-51000
700	750-7500	7500-75000	7000-70000
800	950-9500	9500-95000	9000-90000
900	1200-12000	12000-137000	11000-110000
1000	1400-1400	14000-140000	13500-135000
1200	2000-20000	20000-200000	19500-195000
1300	2200-22000	22000-220000	21000-210000
1400	2750-27500	27500-275000	27000-270000
1500	3150-31500	31500-315000	31000-310000

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3.3表(三) 常用气体介质的标准状态密度 (0℃, 绝压 P=0.1MPa)

3.3 The standard state density of commonly used gas media in Table 3 (0℃, absolute pressure P=0.1MPa)

气体名称 Gas name	密度(kg/m ³) Density (kg/m ³)	气体名称 Gas name	密度(kg/m ³) Density (kg/m ³)
空气(干) Air (dry)	1.2928	乙炔 Acetylene	1.1717
氮气 Nitrogen	1.2506	乙烯 Ethylene	1.2604
氧气 Oxygen	1.4289	丙烯 Propylene	1.9140
氩气 Argon	1.7840	甲烷 Methane	0.7167
氦气 Argon	0.9000	乙烷 Ethane	1.3567
氨气 Ammonia	0.7710	丙烷 Propane	2.0050
氢气 Hydrogen	0.08988	丁烷 Butane	2.7030
一氧化碳 Carbon monoxide	1.97704	天然气 Natural gas	0.8280
二氧化碳 Carbon dioxide	1.3401	煤制气 Coal gas	0.8020

3.4选型举例

例一：已知气体压力和温度及标况下的流量时 某压缩空气，标况流量范围为 QN=1200-12000Nm³/h, 压力 P=0.7MPa(表压)，温度 t=30℃。试确定流量计口径。

步骤一：计算压缩空气的工况体积流量 由公式(3)：

工况使用下限体积流量为：

工况使用流量上限为：Q_{vmax}=1570(m³/h)

步骤二：根据使用工况流量范围157-1570m³/h，查表(二)，满足下限流量条件的流量计为DN80、DN100和DN125，考虑到上限流量1270m³/h及使用效果和经济成本，初选DN100，DN100流量计的工况流量范围是100-1700m³/h，接近使用流量范围，初选DN100流量计，但应具体核算DN100流量计在该工况条件下的可测下限流量。核算DN100流量计在该工况条件下的可测下限流量：

由公式(4)及公式(6)：

$$Q_p = Q_o \times \sqrt{\rho_o / \rho}$$

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$$= 100 \times \sqrt{\frac{0.101325 \times (273.15 + 30)}{(0.101325 + 0.7) \times 293.15}}$$

$$= 37.46 (\text{m}^3/\text{h})$$

即，流量计在该工况条件下的可测下限流量是37.46m³/h，远小于要求的工况下限流量157m³/h，确定选用DN100流量计。

例二：已知蒸汽压力和温度及工况流量时测量介质为过热蒸汽，蒸汽温度为320℃，压力为1.5MPa(绝压)，流量范围为3t/h~25t/h，试确定流量计口径。

步骤一：计算蒸汽的等效空气参比条件下的体积流量范围，经查附表(二)，该状态下蒸汽的密度为：5.665kg/m³，由公式(8)：

$$Q_{\text{空气}} = Q_{\text{蒸汽}} \times 10^3 / 1.5 \sqrt{\rho_o \rho}$$

$$Q_{\text{空气 min}} = 3000 / 1.5 \times \sqrt{5.665 \times 1.205}$$

$$= 765 (\text{m}^3/\text{h})$$

$$Q_{\text{空气 max}} = 6379 (\text{m}^3/\text{h})$$

步骤二：根据等效参比流量范围765-6379m³/h，查表(二)，比较适合该流量范围为DN200口径。

3.4 Example of model selection

Example 1: under the known gas pressure and temperature and the compressed air under standard condition, the standard flow rate range is QN=1200-12000Nm³/h, pressure P=0.7MPa (gauge pressure) and the temperature t=30℃. The flow meter caliber is determined.

Step 1: Calculate the volume flow of compressed air using the formula (3):

The lower limit of flow rate is:

$$Q_{vmin} = QN \times 0.101325 \times (273.15 + t) / 293.15 / (P + 0.1)$$

$$= 1200 \times 0.101325 \times (273.15 + 30) / 293.15 / (0.7 + 0.1)$$

$$= 157 (\text{m}^3/\text{h})$$

The upper limit of flow rate is: Q_{vmax}=1570 (m³/h)

Step 2: According to the operating flow range 157-1570m³/h, check Table (2), the flow meter meeting the lower limit flow conditions includes DN80, DN100 and DN125; considering the upper limit flow 1270m³/h and the cost and economic costs, DN100 flow meter is selected with the flow range of 100-1700m³/h, close to the flow range; the lower limit flow of DN100 flow meter under the working conditions shall be specifically calculated. The lower limit flow of DN100 flow meter under the working conditions is calculated:

Formula (4) and Formula (6):

$$Q_p = Q_o \times \sqrt{\rho_o / \rho}$$

$$= 100 \times \sqrt{\frac{0.101325 \times (273.15 + 30)}{(0.101325 + 0.7) \times 293.15}}$$

$$=37.46(\text{m}^3/\text{h})$$

That is, the flow meter in the conditions of the lower limit of the flow is 37.46m³/h, far less than the required operating conditions under the limit flow of 157m³/h, determine the choice of DN100 flow meter.

Example 2: known steam pressure and temperature and flow conditions when the measurement medium for the superheated steam, steam temperature of 320°C, the pressure of 1.5MPa (absolute pressure), the flow range of 3t/h-25t/h, try to determine the flow meter caliber.

Step 1: Calculate the volumetric flow range under the equivalent air reference conditions of the steam. The density of the steam in this condition is 5.665 kg/m³, and the equation (8)

$$Q_{\text{空气}} = Q_{\text{蒸汽}} \times 10^3 / 1.5 \sqrt{\rho_o \rho}$$

$$Q_{\text{空气 min}} = 3000 / 1.5 \times \sqrt{5.665 \times 1.205}$$

$$=765(\text{m}^3/\text{h})$$

$$Q_{\text{空气 max}} = 6379(\text{m}^3/\text{h})$$

Step 2: According to the equivalent reference flow range 765-6379m³/h, look-up Table (b), more suitable for the flow range DN200 caliber.

四、安装 Installation

4.1 安装注意事项

- 在测量液体时, 务必使流量计传感器始终完全充满介质, 无夹带气体。
- 在仪表上下游提供足够的直管段并确保非弯曲的对称外形。尽可能在仪表下游安装阀门。
- 垂直安装通常是优先选择的, 向上流动的液体能确保仪表总是满管, 且介质中的固态成分能够均匀分布。
- 如有可能产生气泡, 应提供气体分离器。
- 在易于振动的长管路中进行安装时, 应在流量计的上下游安装消除器。
- 对于蒸汽应用, 仪表安装应避免安装在U形弯底部, 避免因吸收冷凝而在开车时导致的水锤现象, 水锤的强度导致传感机构过分受力, 致使传感器永久损坏。

4.1 Installation Precautions

- When measuring the liquid, make sure that the flow meter sensor is always fully filled with media and free of entrained gas.
- Provide adequate straight pipe sections upstream and downstream of the instrument and ensure a non-curved symmetrical profile. Install the valve as far as possible below the instrument.
- Vertical installation is usually preferred, and the upward flow of liquid ensures that the meter is always full and the solid components in the medium can be evenly distributed.
- If possible, create a gas separator.
- When installing in a long pipe that is easy to vibrate, install the eliminator upstream and downstream of the flow meter.
- For steam applications, the instrument shall be installed in the bottom of the U-shaped bend, to avoid the absorption of condensation caused by the water hammer caused by the phenomenon, the water hammer strength caused by excessive force sensor, resulting in permanent damage to the sensor.

特别注意

- 传感器安装点的上游较近处若装有阀门, 不断地开关阀门, 对传感器的使用寿命影响极大, 非常容易对传感器造成永久性损坏。
- 传感器尽量避免在架空的非常长的管道上安装, 这样时间一长后, 由于传感器的下垂非常容易造成传感器与法兰间的密封泄露, 若不得已要安装时, 必须在传感器的上下游2D处分别设置管道紧固装置。

Note

- Sensor installation point near the upstream if equipped with valves, constantly switching valves, the impact of the great impact on the sensor, the sensor is very easy to cause permanent damage.
- Sensor to avoid the installation of very long in the overhead pipeline, so a long time, due to the sensor sagging is very easy to cause the seal between the sensor and flange leakage, if forced to install, must be in the sensor upstream and downstream 2D Respectively, set up pipe fastening device.

The diagrams illustrate four types of pipe fittings with their respective dimensions and labels:

- Reducing pipe:** Shows a pipe with a smaller diameter section in the middle. The upstream distance is labeled $>15D$ and the downstream distance is labeled $>5D$. The Chinese label is 渐缩管 (Jiàn suō guǎn).
- Expanding tube:** Shows a pipe with a larger diameter section in the middle. The upstream distance is labeled $>35D$ and the downstream distance is labeled $>5D$. The Chinese label is 扩管 (Kuò guǎn).
- One 90° bending tube:** Shows a pipe with a single 90-degree bend. The upstream distance is labeled $>40D$ and the downstream distance is labeled $>5D$. The Chinese label is 一个90°弯管 (Yí ge 90° wān guǎn).
- Two 90° bending tubes on one plane:** Shows a pipe with two 90-degree bends in the same plane. The upstream distance is labeled $>40D$ and the downstream distance is labeled $>5D$. The Chinese label is 在同一个平面上有两个90°弯管 (Zài tóng yí gè píng miàn shàng yǒu liǎng ge 90° wān guǎn).



涡街流量计使用说明书

Vortex Shedding Flow meter Operation Instruction



测量饱和蒸汽时, 可选用温度补偿或压力补偿, 流量积算仪查表功能进行运算, 流量积算仪根据涡街流量计提供的体积流量输出信号值、温度补偿测量值或压力补偿测量值 (饱和蒸汽测量中, 补偿信号只需选择温度补偿或压力补偿一种即可), 流量积算仪自动查对其内部预置的饱和蒸汽密度补偿表格进行高精度的补偿运算, 最终显示、输出饱和蒸汽质量累积值。

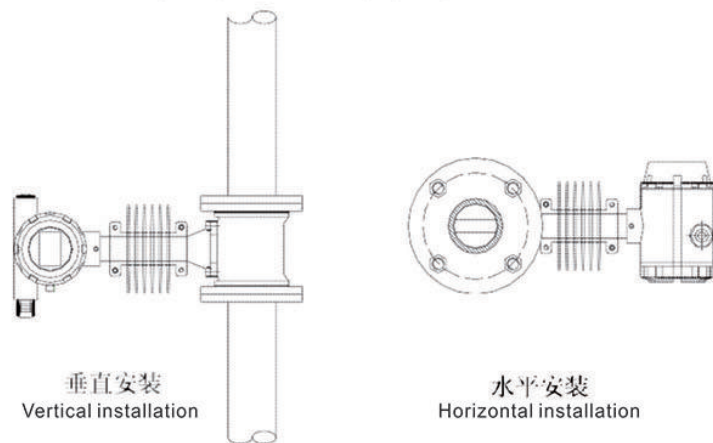
测量过热蒸汽时, 流量积算仪查表功能进行运算。流量积算仪根据涡街流量计提供的体积流量输出信号值、温度补偿测量值和压力补偿测量值 (过热蒸汽测量中, 温度补偿和压力补偿同时选择, 两者缺一不可), 流量积算仪自动查对其内部预置的过热蒸汽密度补偿表格进行高精度的补偿运算, 最终显示、输出过热蒸汽质量累积值。

When the saturated steam is measured, the temperature compensation or pressure compensation can be used. The flow totalizer can be used to calculate the volume flow output signal value, the temperature compensation measurement value or the pressure compensation measurement value (VCS) according to the vortex flow meter. Saturated steam measurement, the compensation signal only need to select the temperature compensation or pressure compensation can be a), the flow totalizer automatically check the internal preset saturation steam density compensation Table for high precision compensation operation, the final display, the output saturation Steam mass accumulation value.

When measuring overheating steam, the flow totalizer Table lookup function is calculated. The flow totalizer is based on the volumetric flow output signal value, the temperature compensation measurement value and the pressure compensation measurement value (the temperature compensation and the pressure compensation are selected at the same time, both are indispensable) The instrument automatically checks the internal preset superheated steam density compensation Table for high precision compensation operation, the final display, the output overheated steam mass accumulation value.

4. 4高温度介质的安装(图5)

4.4 Installation of high temperature media (Figure 5)



涡街流量计使用说明书

Vortex Shedding Flow meter Operation Instruction

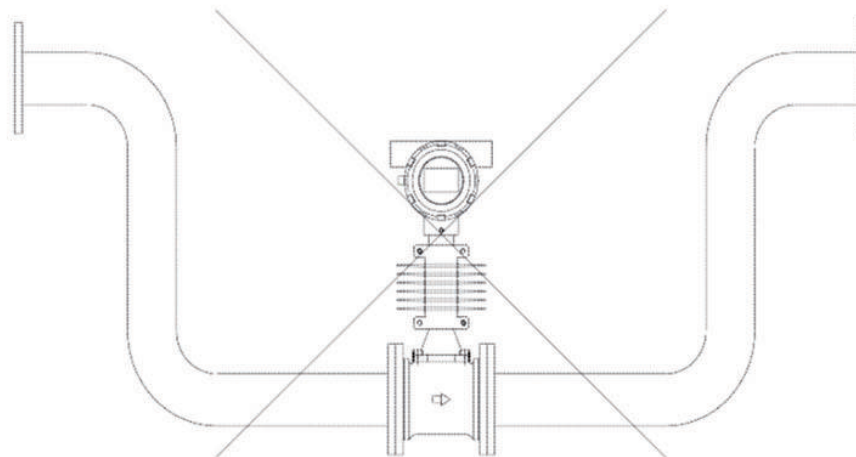


高介质温度时仪表的安装应使得电子部件在管道的一侧或管道的下方, 在管道周围要求隔热使得温度保持在65℃以下

At high medium temperatures, the instrument shall be installed so that the electronic components are located on the side of the pipe or below the pipe, requiring insulation around the pipe to keep the temperature below 65 °C

4. 5蒸汽测量时应该避免以下安装方式

4.5 The following installation shall be avoided during steam measurement



4. 6插入式安装方式

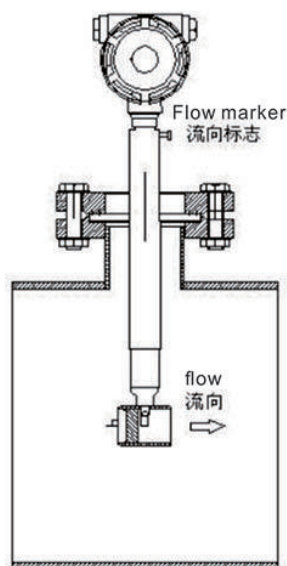
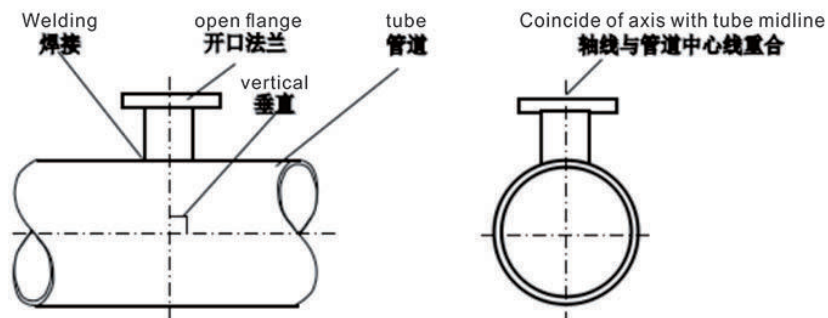
插入式涡街流量计安装在管道上, 需要在安装处开一个 $\phi 87$ 的圆孔。在圆孔处焊上随流量计提供的连接法兰, 要求开口法兰短管必须垂直管道并且短管的轴线与管道中心线重合。如图五所示。

连接法兰的短管上有加工的凸台, 凸台和管道外壁对齐, 然后进行焊接。

4.6 Plug-in installation

Plug-in vortex flow meter installed in the pipeline, you need to install a $\phi 87$ hole in the installation. The connecting flange provided with the flow meter at the round hole requires that the flanged spool must have a vertical pipe and the axis of the spool coincides with the pipe centerline. As shown in Figure 5.

The flange of the connecting flange has a machined boss, the boss and the outer wall of the pipe are aligned and then welded.



五、连接

Connect

5.1 电气连接

电气特性:

工作电压范围: DC30V~DC24V

最大负载能力: 300Ω (随电源电压减小而减小)

工作温度范围: -10℃~+50℃

工作湿度范围: ≤95%

脉冲输出外接电压范围: DC24V~DC30V

脉冲输出负载电流: 5 mA

5.1 Electrical connection

Electrical characteristics:

Operating voltage range: DC30V-DC24V

Maximum load capacity: 300Ω (reduced as the supply voltage decreases)

Operating temperature range: -10℃-+50 °C

Working humidity range: ≤ 95%

Pulse output External voltage range: DC24V-DC30V

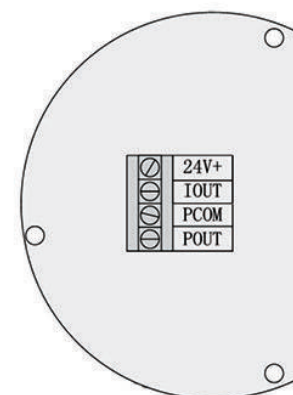
Pulse output load current: 5mA

端子板接线说明

普通端子

Terminal board wiring instructions

Ordinary terminal



5.1 涡街普通端子
5.1 Vortex ordinary terminal

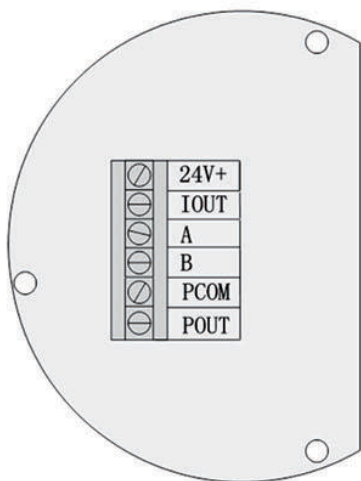
涡街流量计使用说明书 Vortex Shedding Flow meter Operation Instruction



用户使用此端子板时：如只需要二线制电流输出，24V+为电源正，IOUT为电源地，其他端子不用接线；如用户要脉冲输出时可再接脉冲输出端POUT脉冲地端PCOM（脉冲输出接线方法详见图5.4）

When the user uses this terminal board: If only two-wire current output is required, 24V + is the power supply positive, IOUT is the power supply ground, the other terminals need not be wired; if the user wants to pulse output, then the pulse output terminal POUT pulse ground PCOM (pulse output wiring method shown in Figure 5.4)

Rs485通讯端子
RS485 communication terminal



5. 2涡街RS485通讯端子
5.2 Vortex RS485 communication terminals

用户使用此端子板时：如只需要485通讯，24V+为电源正，IOUT为电源地，A为通讯+，B为通讯-。其他端子不用接线；如用户要脉冲输出时可再接脉冲输出端POUT脉冲地端PCOM（脉冲输出接线方法详见图5.4）

注意：485通讯时仪表不能用4~20mA，波特率更改后，要2分钟的寻址，才能通讯正常。

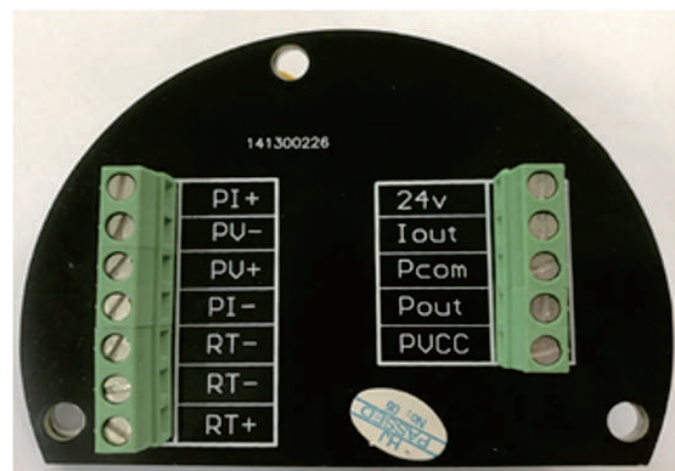
Users use this terminal board: If only 485 communication, 24V + for the power is, IOUT for the power ground, A for the communication +, B for the communication -. Other terminals do not have wiring; if the user wants to pulse output can be followed by pulse output POUT pulse ground PCOM (pulse output wiring method shown in Figure 5.4)

Note: 485 communication instruments can not use 4-20mA, baud rate changes, to 2 minutes of addressing, in order to communicate properly.

涡街流量计使用说明书 Vortex Shedding Flow meter Operation Instruction



温压补偿端子
Temperature compensation terminal



5. 3温压补偿端子
5.3 Temperature and pressure compensation terminal

右侧端子和上面普通型涡街端子职能相同。PV+PV-分别接入电流信号源的正负两端，拨码开关拨到ON，如果是压力传感器的桥路，则对应接到PI+，PI-PV+和PV-。热电偶的单端接到端子上的RT+，RT-接到热电偶的另外两条引线。

The right side of the terminal and the above ordinary vortex terminal functions the same. PV + PV- are connected to the positive and negative ends of the current signal source, DIP switch to ON, if the pressure sensor bridge, then the corresponding received PI+, PI-PV+ and PV-. The single terminal of the thermocouple is connected to the RT + on the terminal, and the other two leads of the thermocouple are connected.

涡街转换器脉冲输出接线
Vortex converter pulse output wiring

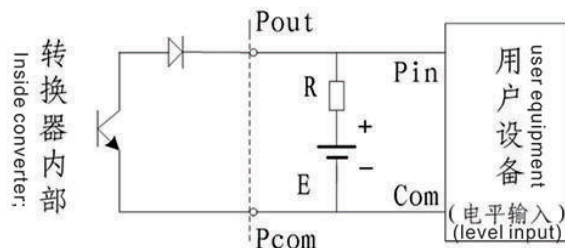


图5.4 无源脉冲输出接线
Figure 5.4 Passive pulse output wiring

涡街转换器电流输出接线
Vortex converter current output wiring

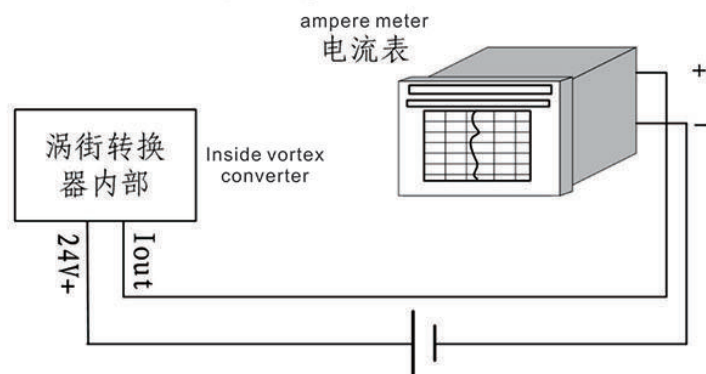


图5.5 二线制电流输出接线
Figure 5.5 Two-wire current output wiring

六、基本操作 Basic Operation

TK2000系列涡街流量计采用LCD大屏幕，人性化操作介面，易于使用，可显示瞬时流量、累积流量以及各类报警信息，正常显示时，上行显示瞬时流量，下行显示累积流量。

TK2000 series vortex flow meter with LCD large screen, user-friendly interface, easy to use, can display instantaneous flow, cumulative flow and various types of alarm information, the normal display, the uplink shows the instantaneous flow, and the downstream shows the cumulative flow.

涡街流量计转换器显示画面定义
Vortex flow meter converter display screen definition

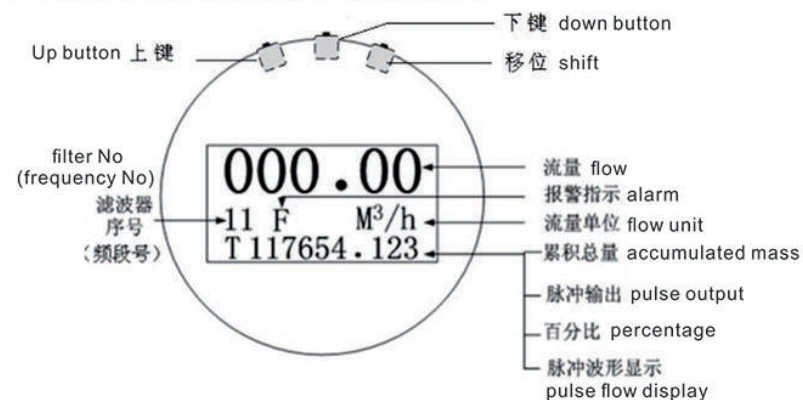


图6.1 涡街流量计转换器显示画面
Figure 6.1 Vortex Flow Meter Converter Display

备注：在正常显示状态，累积总量、脉冲输出、百分比及脉冲波形显示四个画面，可通过按键“下键”来转换！

Note: In the normal display state, the cumulative total, pulse output, percentage and pulse waveform display four pictures, through the button "down key" to switch!

涡街流量计使用说明书 Vortex Shedding Flow meter Operation Instruction



涡街流量计转换器温压补偿显示画面定义
Vortex flow meter converter temperature and pressure compensation display screen definition

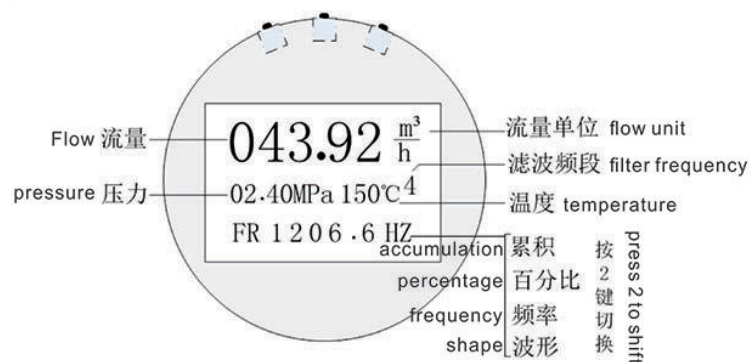


图6.2 涡街流量计转换器稳压补偿显示画面
Figure 6.2 Vortex flow meter converter regulator compensation display

上方为流量，右侧显示单位，可供选择的单位有m³/h, Ltr/h, t/m, kg/m, NKm/m, Nm/m, NL/m, km³/m, mm³/m, Ltr/m, t/h, kg/h, NKm/h, Nm/h, NL/h, km³/h共16个单位选择，显示数值范围0.0000-59999。

中间显示位前方为压力显示 中间显示温度，右侧显示频段。

下方显示“T”的为累计量，按中间按键可以切换显示“FR”为频率，“Fp”显示空管比，另外一个画面为涡街转换器所测得波。

Above for the flow, the right side of the display unit, available units are available M3/m, Ltr/h, t/m, kg/m, NKm/m, Nm/m, NL/m, km³/m. M³/m for the flow and the right display units. , Ltr/m, t/h, kg/h, NKm/h, Nm/h, NL/h, km³/h were selected for 16 units, showing the range of 0.0000-59999.

The middle shows the front of the display pressure for the middle of the display temperature, the right shows the band.

The bottom shows "T" for the cumulative amount, press the middle button to switch display "FR" for the frequency, "FP" shows the air flow control ratio, the other screen for the vortex converter measured wave.

涡街流量计使用说明书 Vortex Shedding Flow meter Operation Instruction



6.2 涡街转换器参数
6.2 Vortex converter parameters
参数设置画面定义
Parameter setting screen definition

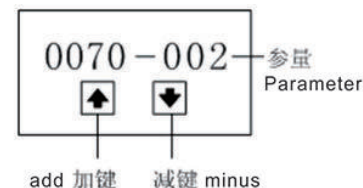


图6.3 参数设置画面
Figure 6.3 Parameter setting screen

参数项选择

按“移位”键进入“00000”状态，输入密码（联系厂家获取）将光标移到“”键下方，按一下“”键后进入参数设置，再按“移位”键进入当前参数项，按“”进入下一级菜单，按“”进入下一项菜单。按“移位”键“”光标下，在按“”退出此项菜单。

Parameter selection

Press the "Shift" key to enter the "00000" state, enter the password (contact manufacturers to obtain) the cursor to the "" key below, press the "" key to enter the parameter settings, press the "shift" key to enter the current parameter, Press "" to enter the next level menu, press "" to enter the next menu. Press the "Shift" key "" cursor, press "" to exit the menu.

仪表调试

第一步：按说明书接好每条接线，并复查；

第二步：按传感器口径设置好频率范围、仪表系数（单位为L/P）、流量单位、流量范围。仪表所有参数修改后，应将仪表重新上电，以保证仪表正常工作！

第三步：将流量调到希望的下限流量，稳定运行5分钟以上；

第四步：调试仪表增益，一键设置不灵敏区及噪声切除。

Instrument debugging

The first step: according to the instructions connected to each wiring, and review;

Step 2: Set the frequency range, instrument scale (unit L/P), flow unit, and flow range according to the sensor caliber. After all the parameters of the instrument changes, the instrument shall be re-powered to ensure that the instrument work!

The third step: the flow to the desired lower limit flow, stable operation for more than 5 minutes;

The fourth step: debugging instrument gain, a key to set the insensitive area and noise removal.

涡街流量计使用说明书

Vortex Shedding Flow meter Operation Instruction



一键设置不灵敏区及噪声切除系数方法：

在下限流量，调仪表增益调整，使信号强度约20~30左右，（见图6.4），注意：如已超过则不用调整；然后将光标移动到“一键设置控制”下方，用“下键”将其调成“9”，仪表出现图6.6画面，此时仪表自动设置不灵敏区为信号强度的1/4，噪声切除系数为噪声强度的2/3。当进度条刷新完成自动恢复原画面时，设置完成。

A key to set the insensitive area and noise cutoff method:

In the lower limit flow, adjust the instrument gain adjustment, so that the signal strength of about 20-30 or so (See Figure 6.4). Note: If you have exceeded, you do not need to adjust; then move the cursor to "under a key setting control", use the "down key" to adjust the gain of the instrument, "To tune it into" 9, the instrument appears Figure 6.6 screen, this time the instrument automatically set the insensitive area for the signal strength of 1/4, the noise cutoff factor for the noise intensity of 2/3. When the progress bar refresh is completed automatically restore the original screen, the setting is complete.

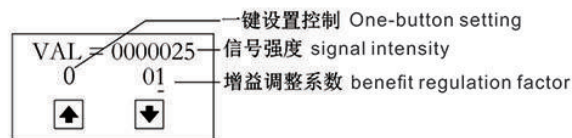


图6.4 仪表增益调试画面
Figure 6.4 Instrument Gain Debug Screen

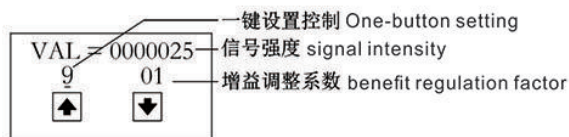


图6.5 一键设置画面
Figure 6.5 A key setup screen

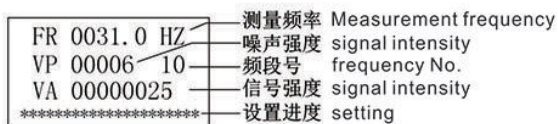


图6.6 一键设置过程画面
Figure 6.6 A key setup process screen

如按上述设置，仪表工作不理想时可在进行手动设置仪表增益，不灵敏区及噪声切除。设置方法如下：

在下限流量，调仪表增益调整，使信号强度约30左右，（见图6.4）；注意：如已超过则不用调整；

涡街流量计使用说明书

Vortex Shedding Flow meter Operation Instruction



在下限流量，调不灵敏区参数，观察信号强度显示值（见图6.7），调整不灵敏区数为信号强度值的1/3~1/6左右，然后观察脉冲波形显示，不应出现多脉冲或少脉冲现象。

在下限流量条件下调试噪声切除常数，抑制掉干扰噪声。首先将仪表调到噪声切除常数调试画面后，手离开仪表键盘等待10~20秒钟（回避人体干扰测量信号），使参量检出值（即噪声强度值）稳定显示，记下该值，此时再调整噪声切除常数，使噪声切除常数为噪声强度的2/3~4/5左右即可（见图6.8）。

According to the above settings, the instrument work is not ideal when you can manually set the instrument gain, insensitive area and noise removal. Set up as follows:

In the lower limit of the flow, adjust the instrument gain adjustment, so that the signal strength of about 30 (see Figure 6.4); Note: If you have exceeded, do not have to adjust;

In the lower limit flow, adjust the parameters of the sensitive area, observe the signal strength display value (See Figure 6.7), adjust the number of insensitive areas for the signal strength value of about 1/3 to 1/6 or so, and then observe the pulse waveform display, shall not appear more than the number of signals, Pulse or less pulse phenomenon.

Debug the noise cutoff constant under the lower limit flow conditions to suppress the disturbance noise. First, the instrument transferred to the noise cut constant debugging screen, hand away from the instrument keyboard wait 10 to 20 seconds (to avoid the human interference measurement signal), so that the parameter detection value (i.e., noise intensity) stable display, note the value of this And then adjust the noise removal constant, so that the noise cut constant for the noise intensity of about 2/3-4/5 or so (see Figure 6.8).

其他仪表调试工作，由转换器自动完成。

显示反映涡街波形的实际情况，信号小或噪声高时，显示的脉冲波形可能不规则。

Other instrument debugging work automatically completed the converter.

Display the actual situation of the vortex waveform, the signal is small or the noise is high, the displayed pulse waveform may be irregular.

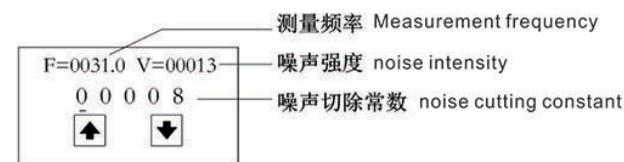


图6.7 噪声切除常数调试画面
Figure 6.7 Noise cutoff constant debug screen

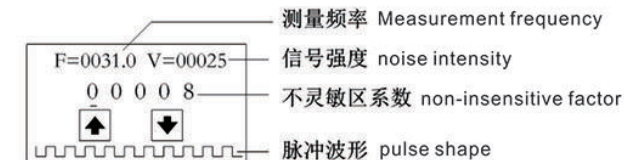


图6.8 不灵敏区调整调试画面
Figure 6.8 Unnecessary area adjustment debug screen

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6. 3基本参数

6.3 Basic parameters

参数分类

TK2000系列涡街转换器参数分三类，第一类为选择类参数，一般只需选择传感器口径值、流体类型选择、流量单位、频率范围选择和流量范围设置即可。

第二类参数为调试类参数（详见快速调试手册），仅三个：仪表增益调整、仪表不灵敏区调整、噪声切除常数。

第三类参数为流量标定参数：仪表系数（单位为L/P）。

Parameter classification

TK2000 series vortex converter parameters are divided into three categories, the first category for the selection of class parameters, generally only need to select the sensor caliber, fluid type selection, flow unit, frequency range selection and flow range settings can be.

The second type of parameters for the debugging parameters (see the quick commissioning manual), only three: instrument gain adjustment, instrument sensitive area adjustment, noise removal constant.

The third parameter is the flow calibration parameter: meter factor (in units of L/P).

电流零点修正

由于元器件的离散性，用户需软件修正一下转换器电流输出“0”点，用户用一块高精度万用表（电流表）测转换器输出电流，然后调整“电流零点修正”参数，使电流表指示为4mA。

Current zero correction

Due to the discrete components, the user needs to correct the converter current output "0" point, the user with a high-precision multi-meter (ammeter) measured converter output current, and then adjust the "current zero correction" parameters, so that the ammeter is 4mA The

电流满度修正

用户调整好电流零点修正参数后，进行电流满度修正，电流的满度即为20mA，调整“电流满度修正”参数，使电流表指示为20mA。

Current full scale correction

The user adjust the current zero correction parameters, the current full-scale correction, the full-scale current is 20mA, adjust the "current full-scale correction" parameters, so that the ammeter is 20mA.

电流输出设置

用户调整好电流零点和满度后，输入百分比，例如050.00，仪表会计算出相应电流值。

正常情况下出厂时电流满度已经修正好，用户不需重新修改此参数。仪表调整参数中其它参数用于温压补偿，暂时为预留参数不做介绍。

Current output setting

After the user adjusts the current zero and full scale, enter the percentage, such as 050.00, the meter will calculate the corresponding current value.

Under normal circumstances the factory current full scale has been amended, the user

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does not need to re-modify this parameter. Other parameters in the instrument adjustment parameters for temperature and pressure compensation, temporarily for the reservation parameters are not introduced

温压补偿参数

在“流量参数”菜单中的“稳压补偿方式”中分别有饱和蒸汽温补，蒸汽稳压补偿，气体稳压补偿，密度系数补偿，设定饱和温补，设定蒸汽温压，设定气体温补共7个选项。

温压补偿涡街流量计温度及压力标定方式

进入通讯参数选项，下的“通讯地址设置，地址设为1”

进入仪表调整参数项下

Temperature compensation parameters

In the "flow parameter" menu in the "regulator compensation mode" were saturated steam temperature compensation, steam regulator compensation, gas regulator compensation, density coefficient compensation, set the saturated steam temperature, set the steam temperature and pressure, set the gas temperature of a total of seven options.

Temperature and pressure compensation vortex flow meter temperature and pressure calibration method

Enter the communication parameter options, under the "communication address settings, address set to 1"

Into the instrument under the adjustment parameters

1. 进入“温度信道增益”项

增益一般选择2，增益大温度输入范围要小。

2. 温度零点调整

①将热电阻Pt1000接入仪表RT+接Pt1000单端，RT-接Pt1000另外两个引线；

②将Pt1000阻值设为1000Ω，调整系数使显示值为0。

3. 温度满度修正

①将Pt100输入500℃的电阻后280.98Ω；

②调整系数使测量值显示5000。

4. 压力通道增益调整

如果是4-20mA电流输入，不用设增益。仪表有默认值对压力传感器。根据传感器输出的信号大小设置量程。

5. 压力信号方式

压力信号方式有4-20mA输入和压力传感器输入。

如果没4-20mA输入，在端子上应将两位开关拨到on上。

6. 压力零点修正

①将端子P0+P0-分别接入电流信号源的正负两端，4-20mA输入4mA；

②压力传感器输入0mPa压力。

7. 压力满度修正

①4-20mA输入20mA信号；

②调整修正系数，使显示值为压力量程；

③对压力传感器加压力，调整修正系数使显示值为压力值。

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1. Enter the "Temperature Channel Gain" item
Gain generally choose 2, the gain of large temperature input range to be small
2. Temperature zero adjustment
 - ① Thermal resistance Pt1000 access meter RT + then Pt1000 single-ended, RT-then Pt1000 two other lead
 - ② Set the Pt1000 resistance to 1000Ω, adjust the coefficient so that the display value is 0
3. Temperature full scale correction
 - ① Pt100 input resistance of 500°C after 280.98Ω.
 - ② Adjust the coefficient to make the measured value display 5000
4. Pressure channel gain adjustment
If it is 4-20mA current input, do not set the gain. The instrument has a default value for the pressure sensor. Set the range according to the signal size of the sensor output
5. Pressure signal mode
The pressure signal is 4-20mA input and pressure sensor input
If there is no 4-20mA input, the two switches shall be set on the terminal
6. Pressure zero correction
 - ① Terminal PO + PO- are connected to the positive and negative ends of the current source, 4-20mA input 4mA
 - ② Pressure sensor input 0mPa pressure
7. Pressure fullness correction.
 - ① 4-20mA input 20mA signal
 - ② Adjust the correction factor, so that the display value for the pressure range
 - ③ Pressure on the pressure sensor, adjust the correction factor so that the display value for the pressure value

温压参数和密度计的验证

通过查饱和蒸汽密度表和过热蒸汽密度表可查密度, 程序内置过热蒸汽密度表和饱和蒸汽密度表, 输入对应温度压力, 密度自动显示, 我们可以在“稳压补偿方式”中选择饱和蒸汽温补项, 之后在测试密度计算菜单中进行验证, 测试模式允许打开, 之后输入温度和压力, 然后密度会对应显示。

例如: 温压补偿方式设为“蒸汽温压补偿”用电阻箱代替热电偶, 用4-20mA信号源代替压力传感器。

给定温度调节滑动电阻箱调节到210°C, 调节信号源使压力为5.4MPa, 出入频率f为195Hz. 仪表系数K设为0.2. 仪表显示流量为4640 NKm/h

$$M=3.6f.K.p$$

$$4640=3.6 \times 195 \times 0.2 \times p$$

$$\text{算的 } p=33.048$$

$$\text{通过查表 } p=33.034$$

Temperature and pressure parameters and density meter verification

By checking the saturated steam density meter and superheated steam density Table to check the density, the program built-in superheated steam density meter and saturated steam

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density Table, the input corresponding to the temperature and pressure, density automatically displayed, we can in the "regulator compensation mode" in the choice of saturated steam temperature And then verify the test density in the test density calculation menu, the test mode is allowed to open, then enter the temperature and pressure, and then the density will be displayed accordingly.

For example: the temperature and pressure compensation method set to "steam temperature and pressure compensation" with a resistance box instead of thermocouple, with 4-20mA signal source instead of pressure sensor.

Set the temperature adjustment sliding resistance box adjusted to 210 , adjust the signal source to make the pressure of 5.4MPa, the access frequency f is 195Hz. Meter coefficient K is set to 0.2. The meter shows a flow of 4640 NKm/h

$$M=3.6f.K.p$$

$$4640=3.6 \times 195 \times 0.2 \times p$$

$$P=33.048$$

$$\text{By looking at the Table } p=33.034$$

设定压力或温度情况下的参数设置项

当现场的压力传感器或温度传感器不能工作需要内置参数时, 我们会选择稳压补偿选项中的设定补偿, 然后根据实际温度压力置入参数, 显示密度和接入压力温度补偿后的一样。

Set the parameter setting item for pressure or temperature

When the on-site pressure sensor or temperature sensor does not work requires built-in parameters, we will select the setting compensation in the regulator compensation option and then place the parameters according to the actual temperature and pressure, showing the same density as the input pressure temperature compensation.

总量清零设置

进入“积算总量设置”菜单中第一个参数“总量清零”, 默认显示“00000”, 当将其设置成“00002”且自动变成“00000”后完成总量清零。

滤波模式选择

Tk2000系列涡街有两种滤波方式可供用户选择: 滤波1、滤波2、滤波3、滤波4

滤波方式1:

频谱分析涡街信号频率, 10频段带通滤波器动态滤波, 信号增量分析获取涡街脉冲。该方式抗干扰能力较强, 对于尖峰性干扰和流体噪声类低频干扰有较好的抑制能力。

滤波方式2:

频谱分析涡街信号频率, 10频段带通滤波器动态滤波, 电平比较方式获取涡街脉冲。该方式对尖峰性干扰有较好的抑制能力。

滤波方式3:

单频段带通滤波器, 覆盖涡街信号高频至低频范围, 电平比较方式获取涡街脉冲。该方式等同于一般涡街信号处理板的信号处理方式。

滤波方式4:

频谱分析涡街信号频率, 10频段三阶带通滤波器动态滤波器, 信号跟踪方式获取涡街脉冲。该方式对流体噪声类低频干扰有较好的抑制能力。

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Set the total amount to zero

The first parameter "Total Clear" is entered in the "Total Settings" menu. The default display "00000" will be cleared when it is set to "00002" and automatically becomes "00000".

Filter mode selection

TK2000 Vortex Street has two kinds of filtering methods for users to choose: Filter 1, filter 2, filter 3, filter 4

Filter mode 1:

Spectrum analysis vortex signal frequency, 10 band pass filter dynamic filtering, signal increment analysis to obtain vortex pulse. The method has strong anti-interference ability, and has good ability to suppress spike interference and low-frequency interference of fluid noise.

Filter mode 2:

Spectrum analysis vortex signal frequency, 10 band pass filter dynamic filtering, level comparison mode to obtain vortex pulse.

This method has a good ability to suppress spikes.

Filter mode 3:

Single band pass filter, covering vortex signal high frequency to low frequency range, level comparison mode to obtain vortex pulse. This method is equivalent to the general vortex signal processing board signal processing.

Filter mode 4:

Spectrum analysis vortex signal frequency, 10-band third-order band-pass filter dynamic filter, signals tracking method to obtain vortex pulse. This method has a good ability to suppress the low noise interference of fluid noise.

频率范围选择

测量频率上限指在用户流量范围内，涡街传感器的振动频率上限TK2000系列涡街转换器的测量频率上限共有18、23、30、37、45、60、75、90、120、150、180、240、300、360、480、600、720、960、1020、1200、1430、1820、2300、2730共24个范围可供选择。

选择涡街测量频率上限的原则是：以只要能满足测量上限频率即可，尽可能为测量下限频率留有足够的余地。

Frequency range selection

The upper limit of the measurement frequency is within the range of user flow. The upper limit of the vibration frequency of the vortex sensor TK2000 series vortex converter is 18,23,30,37,45,60,75,90,120,150,180, 240,300,360,400,600, 720,960, 1020, 1200,1430,1820,2300,2730 A total of 24 ranges to choose from.

The principle of selecting the upper limit of the frequency of the vortex measurement is that there is sufficient room for measuring the lower limit frequency as long as the upper limit frequency can be met.

注意：频率范围选择完成后仪表需重新上电。

Note: After the frequency range is selected, the instrument needs to be powered back again.

滤波时间选择

这是一个对流量测量数据进行滤波的时间参数，滤波时间长，仪表显示和输出均波动小，但响应也慢，反之亦然。用户应根据具体应用情况设置。

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小，但响应也慢，反之亦然。用户应根据具体应用情况设置。

Filter time selection

This is a time parameter for filtering the flow measurement data, the filter time is long, the meter display and the output are both small, but the response is slow, and vice versa. Users shall be set according to the specific application.

振动抑制时间

对于随机突发振动，涡街板采用延时判别方法，若振动时间小于振动抑制时间时，随机突发振动不被检出；反之，被认为是涡街信号。注意：振动抑制时间影响仪表的滤波时间，选择时应适当。

输出模式选择

TK2000系列涡街有三种输出方式可供用户选择：电流、脉冲、频率。其中脉冲为直接脉冲，电流和频率按百分比输出。输出模式选择后需将仪表重新上电。

输出频率设置

输出频率设置范围为0~2000HZ（可设），频率输出对应的是流量百分比。计算公式如下：

Vibration suppression time

For random burst vibration, the vortex board uses the delay discrimination method, if the vibration time is less than the vibration suppression time, the random burst vibration is not detected; otherwise, is considered vortex signal. Note: The vibration suppression time affects the instrument's filter time, which shall be appropriate.

Output mode selection

TK2000 series vortex has three kinds of output mode for users to choose: current, pulse, frequency. Where the pulse is a direct pulse, the current and frequency are output as a percentage. Output mode selection need to re-power the instrument.

Output frequency setting

Output frequency setting range is 0-2000HZ (can be set), the frequency output corresponds to the flow percentage. Calculated as follows:

$$F = \frac{\text{Measured value}}{\text{满量程值}} \cdot \text{频率范围}$$

测量值 频率范围 frequency range
满量程值 full-range measurement

流量参数

仪表系数单位

仪表系数单位用来调整仪表系数小数位的有效位数。

仪表系数数值

仪表系数有效位是5位数字，可设范围0.0000~59999，单位为L / P，仪表系数由估算或标定而得，建议用户先根据经验估算设置仪表系数，然后再根据标定结果，精确修正仪表系数。

传感器口径值

管道口径即为传感器口径，仪表内有20、25、32、40、50、65、80、100、125、150、

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200、250、300mm共13种口径供客户选用。

流体类型选择

流体类型中有两种方式，液体，气体，用户可根据实际测量

介质选择。（注意：当选择完流体类型后，流体密度小数位即被确定气体时范围是00.000~59.999，液体时范围是0000.0~5999.9。）

Flow parameter

Meter factor unit

The unit of the meter is used to adjust the effective digits of the decimal places of the meter factor.

Meter factor

The effective part of the instrument is 5 digits, can be set to 0.0000-59999, the unit is L/P, the meter coefficient is estimated or calibrated. It is recommended that the user set the meter coefficient according to the experience and then calibrate the instrument according to the calibration result coefficient.

Sensor caliber value

Pipe diameter is the sensor caliber, the instrument has 20, 25, 32, 40, 50, 65, 80, 100, 125, 150, 200, 250, 300 mm a total of 13 kinds of caliber for customers to choose.

Fluid type selection

There are two ways of fluid type, liquid, gas, the user can choose the media according to the actual measurement. (Note: When the fluid type is selected, the fluid density fraction is determined when the gas is in the range 00.000 to 59.999 and the liquid range is 0000.0 to 5999.9.)

流量积算单位

流量积算单位即流量累积的有效小数位选择，其单位与瞬时流量单位一致。

流体密度

对于气体流量测量，若用户需要质量流量显示，应设置流体密度参数。流体密度单位为 kg/m^3 ，参数范围为：当选择完流体类型后，流体密度小数位即被确定气体时范围是00.000~59.999，液体时范围是0000.0~5999.9。

Flow total unit

The total unit of flow is the effective decimal place of the flow accumulation, and its unit is consistent with the instantaneous flow unit.

Fluid density

For gas flow measurement, if the user needs mass flow display, shall set the fluid density parameters. The density of the fluid is in the range of 00.000 to 59.999 when the fluid density is determined, and the liquid is in the range of 0000.0 to 5999.9.

流量范围设置

为了使电流、频率输出对应流量范围，用户应设置流量量程上限。量程上限确定后即可确定流量量程范围，对应4~20mA电流和频率输出。

小信号切除值

按流量大小切除，单位同流量单位。

压缩系数

体积流量计算时的补偿系数，最大可设59.999。

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Flow range setting

In order to make the current and frequency output corresponding to the flow range, the user shall set the upper limit of the flow range, the upper limit of the range can be determined after the flow range, corresponding to 4-20mA current and frequency output.

Small signal cutoff

According to the size of the flow cut, the unit with the flow unit;

Compression factor

Volume compensation of the flow rate calculation, the maximum can be set to 59.999.

频谱分析参数

量程比例选择

涡街转换器可根据用户现场环境选择量程比，软件中设置了12:1、16:1、24:1、32:1共四种比例方式，若现场环境噪声较大，可将量程比例调小一点。

频段衰减系数

TK2000系列涡街信号处理采用功率谱分析方法确定信号主频段，在一般情况下，信号处理软件能够准确的分析出信号频段，如若涡街信号中含有较强干扰，致使干扰功率谱大于信号功率谱，会造成软件分析出错，此时，可使用频段衰减系数解决。衰减系数中间值为1.000。若某个频段上出现干扰，可以将该频段的衰减系数减小，防止信号处理软件锁定干扰频段。例如：DN300水标90方下限流量时，管道轻微震动，其震动频率落到第02号频段，由于该振动的存在，仪表应锁定12号频段，但是被该震动干扰拉到第02号频段，为此，将02号频段衰减系数降低，设在了0.700~0.800之间，该问题得以解决。

Spectrum analysis parameters

Range selection

Vortex converter can be selected according to the user site environment than the range, the software set, 12:1, 16:1, 24:1, 32:1 a total of four proportions, if the scene of the larger ambient noise, Keep a little smaller.

Frequency attenuation factor

TK2000 series vortex signal processing using power spectrum analysis method to determine the main frequency band of the signal, in general, the signal processing software can accurately analyze the signal frequency band, if the vortex signal contains strong interference, resulting in interference power spectrum is greater than the signal power spectrum, cause software analysis error, this time, you can use the band attenuation coefficient to solve. The attenuation factor is 1.000. If there is interference in a band, you can reduce the attenuation coefficient of the band to prevent the signal processing software to lock the interference band. For example: DN300 water standard 90 square lower limit flow, the pipeline slightly vibration, the vibration frequency falls to the 02 frequency band, due to the existence of the vibration, the instrument shall be locked 12 frequency band, but by the vibration interference to 02 band, To this end, the 02 band attenuation coefficient is reduced, located between 0.700-0.800, the problem can be solved.

线性修正参数

线性修正允许

选择累参数允许是线性修正起作用，禁止时不起作用

修正流量点及修正系数值

TK2000系列涡街转换器采用计算速度较快的折线修正法，流量从高到低分为Q4点……Q1点，对应的修正系数为P3……P1。按实际标定Q4点和Q0即为理想流量点，所以

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P4及P0为100%; Q4点为起始修正流量点, Q4至Q3之间用P4到修正系数P3成线性修正, Q3至Q2之间用修正系数P3到修正系数P2成线性修正, 依此类推, 最后, Q1频率点至0频率点之间用修正系数P1到P0成线性修正。这样, 对应每一个流量修正区间, 有一个流量修正系数。

设流量修正点为 QX, 实际标出的各点流量为FaX, 而希望的流量为CX, 各点的流量修正系数为 PX,

$$PX = CX / FaX \times 100\%$$

示意图如下:

Linear correction parameters

Linear correction is allowed

Select the tired parameter to allow the linear correction to work, and disable it when it does not work

Correct the flow point and the correction factor

Tk2000 series vortex converter using a faster calculation of the polyline correction method, the flow from high to low is divided into Q4 ... Q1 point, the corresponding correction factor for P3 ... P1. Q4 and Q0 are the ideal flow points, so P4 and P0 are 100%; Q4 points for the initial correction flow point, Q4 to Q3 between the P4 to the correction coefficient P3 linear correction, Q3 to Q2 between With the correction coefficient P3 to the correction coefficient P2 linear correction, and so on, and finally, Q1 frequency point to 0 frequency points with the correction coefficient P1 to P0 linear correction. In this way, corresponding to each flow correction interval Set the flow correction point for the QX, the actual real standard out of the flow point for the FaX, and the hope for the flow of CX, the point of the flow correction factor for the PX,

$$PX = CX / FaX \times 100\%$$

The diagram is as follows:

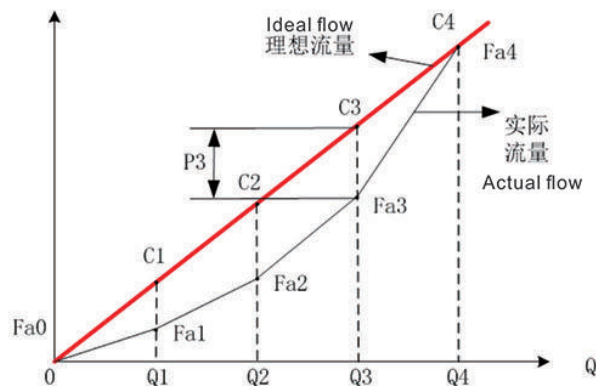


图5.1 非线性修正示意图

Figure 5.1 Schematic diagram of non-linear correction

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例如: 选Q4~ Q3区间, 需要设置P3修正系数, 如图所示修正系数可用如下公式计算出:

$$P3 = C3 / Fa3 \times 100\%$$

然后, 在区间两端用P3计算验证流量是否超差; 依此类推, 计算出其它各点的流量修正系数。

For example: choose Q4-Q3 interval, you need to set the P3 correction factor, as shown in the correction coefficient can be calculated using the following formula:

$$P3 = C3 / Fa3 \times 100\%$$

Then, at both ends of the interval with P3 calculation to verify whether the flow is out of tolerance; and so on, calculate the other points of the flow correction coefficient.

通讯参数

语言

Tk2000系列涡街有两种语言显示: 中文、英文。

通讯地址设置

TK2000系列涡街转换器HART通讯时地址要设置成非0, 地址范围01~99

通讯速率设置

Tk2000系列涡街转换器有300、600、1200、2400、4800、9600、19200、38400共八种波特率供用户选择

通讯模式选择

TK2000系列涡街转换器有方式0和方式1两种方式。方式0为预留; 方式1: 为Hart通讯/485通讯。

Modbus协议通讯

1. 涡街流量计MODBUS寄存器地址定义

涡街流量计MODBUS寄存器地址定义

Communication parameters

Language

TK2000 series vortex street in two languages: Chinese, English.

Communication address setting

TK2000 series vortex converter HART communication address to be set to non-0, address range 01-99

Communication rate setting

TK2000 series vortex converter has 300, 600, 1200, 2400, 4800, 9600, 19200, 38400 a total of eight baud rate for the user to choose

Communication mode selection

TK2000 series vortex converter with way 0 and mode 1 in two ways. Mode 0 is reserved; mode 1: for Hart communication/485 communication.

Modbus protocol communication

1. Vortex flow meter MODBUS register address definition

Vortex flow meter MODBUS register address definition

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Protocol Addresses (Decimal)	Protocol Addresses (HEX)	数据格式	寄存器定义
4112	0x1010	Float Inverse	瞬时流量浮点表示
4114	0x1012	Float Inverse	保留
4116	0x1014	Float Inverse	流量百分比浮点表示
4118	0x1016	Float Inverse	保留
4120	0x1018	Float Inverse	正向累积数值整数部分
4122	0x101A	Float Inverse	正向累积数值小数部分
4124	0x101C	Float Inverse	保留
4126	0x101E	Float Inverse	保留
4128	0x1020	Unsigned short	瞬时流量单位 (表3)
4129	0x1021	Unsigned short	累积总量单位 (表4/表5)
4130	0x1022	Unsigned short	保留
4131	0x1023	Unsigned short	保留
4132	0x1024	Unsigned short	保留
4133	0x1025	Unsigned short	保留
4134	0x1026	Float Inverse	保留
4136	0x1028	Unsigned short	保留
4137	0x1029	Float Inverse	保留
4139	0x102B	Unsigned short	保留
4141	0x102D	Float Inverse	脉冲

Protocol Addresses (Decimal)	Protocol Addresses (HEX)	Data Format	Register definition
4112	0x1010	Float Inverse	Instantaneous flow floating point representation
4114	0x1012	Float Inverse	Retained
4116	0x1014	Float Inverse	Flow percentage floating point representation
4118	0x1016	Float Inverse	Retained
4120	0x1018	Float Inverse	Positive cumulative value integer part
4122	0x101A	Float Inverse	Positive cumulative fractional part

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Protocol Addresses (Decimal)	Protocol Addresses (HEX)	Data Format	Register definition
4124	0x101C	Float Inverse	Retained
4126	0x101E	Float Inverse	Retained
4128	0x1020	Unsigned short	Instantaneous flow units (Table 3)
4129	0x1021	Unsigned short	Accumulated units of total (Table 4/Table 5)
4130	0x1022	Unsigned short	Retained
4131	0x1023	Unsigned short	Retained
4132	0x1024	Unsigned short	Retained
4133	0x1025	Unsigned short	Retained
4134	0x1026	Float Inverse	Retained
4136	0x1028	Unsigned short	Retained
4137	0x1029	Float Inverse	Retained
4139	0x102B	Unsigned short	Retained
4141	0x102D	Float Inverse	Pulse

PLC地址设置说明

PLC设置时如果没有功能码设置项时, 使用功能04应在寄存器地址前面加3。另PLC寄存器地址的基址是从1开始, 所以PLC设置寄存器地址时应在原地址上加1。

例:

流量计MODBUS寄存器地址为4112 (0x1010), MODBUS功能码为4时, PLC寄存器地址为34113。

PLC address setting instructions

If the function code is not set when the PLC is set, use function 04 to add 3 to the register address. The base address of the other PLC register address is from 1, so the PLC set the register address shall be added to the original address.

Example:

Flow meter MODBUS register address is 4112 (0x1010), MODBUS function code is 4, PLC register address is 34113.

组态王地址设置说明

组态王设置时没有功能码设置项, 不同的驱动设置方法不同。

以PLC-莫迪康-modbus (RTU) 驱动为例, 使用功能04应在寄存器地址前面加8。另组态王寄存器地址的基址是从1开始, 所以组态王设置寄存器地址时应在原地址上加1。

流量计MODBUS寄存器地址为4112 (0x1010), MODBUS功能码为4时, 组态王寄存器地址为84113。

涡街流量计使用说明书

Vortex Shedding Flow meter Operation Instruction



温压补偿涡街流量计MODBUS寄存器地址定义

2. 温压补偿涡街流量计MODBUS寄存器地址定义

Configuration king address set instructions

King of the configuration is not set when the function code settings, different drive settings are different.

Take the PLC-Modi-modbus (RTU) driver as an example, use function 04 to add 8 in front of the register address. The base address of the other king register address is from 1, so the configuration gate shall set the register address to 1 on the original address.

Flow meter MODBUS register address is 4112 (0x1010), MODBUS function code is 4, the configuration king register address is 84113.

Temperature Compensated Vortex Flow meter MODBUS Register Address Definitions

2. Temperature and pressure compensation vortex flow meter MODBUS register address definition

Protocol Addresses (Decimal)	Protocol Addresses (HEX)	数据格式	寄存器定义
4112	0x1010	Float Inverse	瞬时体积流量浮点表示
4114	0x1012	Float Inverse	瞬时质量流量浮点表示
4116	0x1014	Float Inverse	体积流量百分比浮点表示
4118	0x1016	Float Inverse	质量流量百分比浮点表示
4120	0x1018	Float Inverse	涡街信号频率
4122	0x101A	Float Inverse	频谱分析频段号
4124	0x101C	Float Inverse	涡街噪声强度
4126	0x101E	Float Inverse	涡街信号强度
4128	0x1020	Float Inverse	计算流体密度值
4130	0x1022	Float Inverse	计算流体热焓值
4132	0x1024	Long Inverse	体积总量整数部分
4134	0x1026	Float Inverse	体积总量小数部分
4136	0x1028	Long Inverse	质量总量整数部分
4138	0x102A	Float Inverse	质量总量小数部分
4140	0x102C	short	瞬时流量单位
4141	0x102D	short	总量单位

涡街流量计使用说明书

Vortex Shedding Flow meter Operation Instruction



Protocol Addresses (Decimal)	Protocol Addresses (HEX)	Data Format	Register definition
4112	0x1010	Float Inverse	Instantaneous volume flow floating point representation
4114	0x1012	Float Inverse	Instantaneous mass flow floating point representation
4116	0x1014	Float Inverse	Volume flow percentage floating point representation
4118	0x1016	Float Inverse	Mass flow percentage floating point representation
4120	0x1018	Float Inverse	Vortex signal frequency
4122	0x101A	Float Inverse	Spectrum analysis band number
4124	0x101C	Float Inverse	Vortex noise intensity
4126	0x101E	Float Inverse	Vortex signal strength
4128	0x1020	Float Inverse	Calculate fluid density values
4130	0x1022	Float Inverse	Calculate the enthalpy of the fluid
4132	0x1024	Long Inverse	Volume total integer part
4134	0x1026	Float Inverse	Total volume fraction of the volume
4136	0x1028	Long Inverse	Total mass of the volume
4138	0x102A	Float Inverse	Total mass fraction
4140	0x102C	short	Instantaneous flow units
4141	0x102D	short	Total unit

涡街流量计使用说明书

Vortex Shedding Flow meter Operation Instruction



PLC地址设置说明

PLC设置时如果没有功能码设置项时，使用功能04应在寄存器地址前面加3。另PLC寄存器地址的基址是从1开始，所以PLC设置寄存器地址时应在原地址上加1。

例：

流量计MODBUS寄存器地址为4112 (0x1010)，MODBUS功能码为4时，PLC寄存器地址为34113。

组态王地址设置说明

组态王设置时没有功能码设置项，不同的驱动设置方法不同。

以PLC-莫迪康-modbus (RTU) 驱动为例，使用功能04应在寄存器地址前面加8。另组态王寄存器地址的基址是从1开始，所以组态王设置寄存器地址时应在原地址上加1。

流量计MODBUS寄存器地址为4112 (0x1010)，MODBUS功能码为4时，组态王寄存器地址为84113。

仪表保密编码

无论使用哪级密码，用户均可以察看仪表参数。但用户若想改变仪表参数，则使用不同级别的密码。保密码1：33332 (察看)；保密码2：55555 (修改参数)。

备注：1、仪表所有参数修改后，应将仪表重新上电，以保证仪表正常工作！

2、温压补偿型涡街软件内置PT1000分度表，温度压力直接换算后显示，附录蒸汽密度表仅供参考！

PLC address setting instructions

If the function code is not set when the PLC is set, use function 04 to add 3 to the register address. The base address of the other PLC register address is from 1, so the PLC set the register address shall be added to the original address.

Example:

Flow meter MODBUS register address is 4112 (0x1010), MODBUS function code is 4, PLC register address is 34113.

Configuration king address set instructions

King of the configuration is not set when the function code settings, different drive settings are different.

Take the PLC-Modi-modbus (RTU) driver as an example, use function 04 to add 8 in front of the register address. The base address of the other king register address is from 1, so the configuration gate shall set the register address to 1 on the original address.

Flow meter MODBUS register address is 4112 (0x1010), MODBUS function code is 4, the configuration king register address is 84113.

Instrument confidentiality code

Regardless of the password used, the user can view the instrument parameters. But users want to change the instrument parameters; you have to use different levels of password. Security code 1:33332 (view); security code 2:55555 (modify parameters).

Note: 1. All parameters of the instrument changes, the instrument shall be re-power to ensure that the instrument work!

2. Temperature and pressure compensation type vortex software built-in PT1000 index Table, the temperature and pressure directly after the conversion shows that the annex to the steam density Table only for reference!

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Vortex Shedding Flow meter Operation Instruction



附录

Appendix

附录一 过热蒸气密度表 (kg/m3)

Appendix I Superheated vapor density meter

压力(绝压) Pressure (absolute) Mpa	温度(°C) temperature (°C)							
	150	170	190	210	230	250	270	290
0.10	0.5164	0.4925	0.4707	0.4507	0.4323	0.4156	0.4001	0.3857
0.15	0.7781	0.7412	0.7079	0.6777	0.6500	0.6246	0.6010	0.5795
0.20	1.0423	0.9918	0.9466	0.9056	0.8684	0.8342	0.8027	0.7736
0.25	1.3089	1.2444	1.1869	1.1349	1.0849	1.0445	1.0048	0.9682
0.30	1.5783	1.4990	1.4287	1.3653	1.3079	1.2540	1.2077	1.1634
0.40	2.1237	2.0141	1.9166	1.8297	1.7513	1.6527	1.6152	1.5554
0.50	2.6658	2.5380	2.4121	2.2997	2.1992	2.1081	2.0255	1.9495
0.80	4.3966	4.1676	3.9372	3.7400	3.5665	3.4110	3.2718	3.1453
1.10	6.1313	5.8332	5.5342	5.2356	4.9719	4.7459	4.5445	4.3612
1.40	7.8795	7.5163	7.1540	6.7913	6.4288	6.1147	5.8437	5.6006
1.70	9.8464	9.3688	8.9273	8.4130	7.9352	7.5219	7.1713	6.8607
2.00	11.6295	11.0985	10.5676	10.0366	9.5054	8.9744	8.5350	8.1447
2.50	15.1890	14.4516	13.7150	12.9776	12.2406	11.5036	10.8794	10.3500
3.00	18.4168	17.5709	16.7243	15.8776	15.0367	14.1842	13.3377	12.6359

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Vortex Shedding Flow meter Operation Instruction



压力(绝压) Pressure (absolute) Mpa	温度(°C) temperature (°C)							
	150	170	190	210	230	250	270	290
3.50	22.7008	21.5713	20.4427	19.3131	18.2266	17.0530	15.9243	15.0163
4.00	27.164	25.7470	24.3303	22.9129	21.4954	20.0778	18.6603	17.4997
4.50	30.3852	28.9163	27.4475	25.9784	24.5096	23.0407	21.5717	20.1028
5.00	35.4243	33.6293	31.8342	30.0384	28.2433	26.4483	24.6532	22.8580
6.00	43.8954	41.7475	39.5988	37.4508	35.3020	33.1541	31.0062	28.8574
4.00	56.7201	53.6991	50.6780	47.6561	44.6352	41.6133	38.5922	35.5704
8.00	65.4713	62.1800	58.8883	55.5968	52.3061	49.0145	45.7231	42.4316
8.00	84.5457	79.8261	75.1061	70.3863	65.6665	60.9465	51.5077	51.5077
10.00	108.6250	102.0289	95.4346	88.8412	82.2486	75.6543	65.7699	62.4676
12.50	158.3486	148.7516	139.1578	129.5629	119.9781	110.3842	95.7769	91.1964
15.00	206.4175	194.4276	182.4477	170.4577	158.4766	146.4967	127.6820	122.5268
17.50	250.3934	236.6910	222.8603	209.1592	195.4568	181.6261	163.4280	154.2312
20.00	327.8165	309.9521	391.2953	273.4409	255.5786	236.9217	219.0574	201.2031
21.50	384.6647	363.2975	341.9027	320.5455	299.1880	277.7931	256.4260	235.0688

涡街流量计使用说明书
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压力(绝压) Pressure (absolute) Mpa	温度 (°C) temperature (°C)							
	310	330	350	370	390	410	430	450
0.10	0.3724	0.3600	0.3484	0.3375	0.3272	0.3176	0.3086	0.4357
0.15	0.5594	0.5404	0.5230	0.5066	0.4912	0.4767	0.4631	0.4502
0.20	0.7465	0.7214	0.6980	0.6759	0.6553	0.6360	0.6178	0.6005
0.25	0.9343	0.9027	0.8732	0.8456	0.8198	0.7955	0.7726	0.7507
0.30	1.1224	1.0844	1.0488	1.0156	0.9845	0.9552	0.9277	0.8989
0.40	1.5000	1.4701	1.4010	1.3563	1.3144	1.2753	1.2377	1.2035
0.50	1.8802	1.8147	1.7545	1.6983	1.6456	1.5961	1.5498	1.5060
0.80	3.0283	2.9215	2.8227	2.7305	2.6440	2.5635	2.4884	2.4171
1.10	4.1943	4.0419	3.9030	3.7722	3.6512	3.5384	3.4335	3.3345
1.40	5.3794	5.1777	4.9945	4.8260	4.6673	4.5220	4.3857	4.2575
1.70	6.5815	6.3309	6.0998	5.7779	5.6936	5.5120	5.3441	5.1863
2.00	7.8061	7.4955	7.2186	6.9619	6.7260	6.5117	6.3090	6.1203
2.50	9.8888	9.4806	9.1139	8.7802	8.4750	8.1938	7.9332	7.6898
3.00	11.9979	11.5143	11.0494	10.6308	10.2493	9.9000	9.5775	9.2816

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压力(绝压) Pressure (absolute) Mpa	温度(°C) temperature (°C)					
	310	330	350	370	390	410
3.50	14.2565	13.8501	13.0286	12.6162	12.0528	11.6308
4.00	16.5527	15.749	15.0539	14.4392	13.8862	13.3077
4.50	18.9333	17.9608	17.1279	16.4018	15.7527	14.7579
5.00	21.4221	20.2508	19.2627	18.4108	17.6565	16.3719
6.00	26.7091	25.0502	23.7006	22.5570	21.5629	20.6900
4.00	32.5488	30.2231	28.4037	29.9035	25.6330	24.5224
8.00	39.1399	35.8485	33.4179	31.4825	29.8698	28.4969
9.00	46.7877	42.0680	38.8083	36.3217	34.3044	32.2947
10.00	59.6648	49.2802	44.7560	41.5274	39.0006	36.9344
12.50	81.6034	72.0105	62.4178	56.1496	51.8212	48.5015
15.00	110.5369	98.5531	86.5688	74.5840	66.8341	61.5530
17.50	140.3919	126.6895	116.3142	100.8176	85.3228	76.6185
20.00	182.5462	174.3185	166.0907	137.7965	108.5430	94.4945
21.50	213.6739	192.3164	171.8651	150.0074	128.1614	106.6360

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Vortex Shedding Flow meter Operation Instruction



附录二 饱和水蒸气密度表 (kg/m³)

单位-ρ=kg/m³; 压力(绝压)-p=MPa; 温度-T=°C

Appendix II Saturated water vapor density meter (kg/m³)

Unit -ρ=kg/m³; pressure (absolute pressure) -p=MPa; temperature -T=°C

温度 Temperature (t, °C)	0		1		2	
	压力(P) pressure(P)	密度(ρ) Density (ρ)	压力(P) pressure(P)	密度(ρ) Density (ρ)	压力(P) pressure(P)	密度(ρ) Density (ρ)
100	0.1013	0.5977	0.1050	0.6180	0.1088	0.6338
110	0.1433	0.8265	0.1481	0.8528	0.1532	0.8798
120	0.1985	1.122	0.2049	1.155	0.2114	1.190
130	0.2701	1.497	0.2783	1.539	0.2867	1.583
140	0.3464	1.967	0.3718	2.019	0.3823	2.073
150	0.4760	2.5487	0.4888	2.613	0.5021	2.679
160	0.6181	3.260	0.6339	3.339	0.6502	3.420
170	0.7920	4.123	0.8114	4.218	0.8310	4.316
180	1.0197	5.160	1.0259	5.274	1.0496	5.391
190	1.2551	6.397	1.2829	6.532	1.3111	6.671
200	1.5548	7.864	1.5876	8.025	1.6210	8.188
210	1.9077	9.593	1.9462	9.782	1.9852	9.974
220	2.3198	11.62	2.3645	11.84	2.4098	12.07
230	2.7975	14.00	2.8491	14.25	2.9010	14.52
240	3.3477	16.76	3.4070	17.06	3.4670	17.37

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Vortex Shedding Flow meter Operation Instruction



饱和蒸汽密度表二

Saturated steam density Table II

温度 Temperature (t, °C)	3		4		5	
	压力(P) pressure(P)	密度(ρ) Density(ρ)	压力(P) pressure(P)	密度(ρ) Density(ρ)	压力(P) pressure(P)	密度(ρ) Density(ρ)
100	0.1127	0.6601	0.1167	0.6821	0.1208	0.7046
110	0.1583	0.9075	0.1636	0.9359	0.1691	0.9650
120	0.2182	1.225	0.2250	1.261	0.2321	1.298
130	0.2953	1.627	0.3041	1.672	0.3130	1.719
140	0.3931	2.129	0.4042	2.185	0.4155	2.242
150	0.5155	2.747	0.5292	2.816	0.5433	2.886
160	0.6666	3.502	0.6835	3.586	0.7008	3.671
170	0.8501	4.415	0.8716	4.515	0.8924	4.618
180	1.0737	5.509	1.0983	5.629	1.1233	5.75
190	1.3397	6.812	1.3690	6.955	1.3987	7.100
200	1.6548	8.354	1.6892	8.522	1.7242	8.694
210	2.0248	10.17	2.0650	10.37	2.1059	10.57
220	2.4559	12.30	2.5026	12.53	2.5500	12.76
230	2.9546	14.78	3.0085	15.05	3.0631	15.33
240	3.5279	17.68	3.5897	17.99	3.6522	18.31

涡街流量计使用说明书
Vortex Shedding Flow meter Operation Instruction



饱和蒸汽密度表三

Saturated steam density Table III

温度 Temperature (t, °C)	6		7		8		9	
	压力(P) pressure(P)	密度(ρ) Density(ρ)	压力(P) pressure(P)	密度(ρ) Density(ρ)	压力(P) pressure(P)	密度(ρ) Density(ρ)	压力(P) pressure(P)	密度(ρ) Density(ρ)
100	0.1250	0.7277	0.1294	0.7515	0.1339	0.7758	0.1385	0.8008
110	0.1746	0.9948	0.1804	0.1025	0.1863	1.057	0.1923	1.089
120	0.2393	1.336	0.2467	1.375	0.2543	1.415	0.2621	1.455
130	0.3222	1.766	0.3317	1.815	0.3414	1.864	0.3513	1.915
140	0.4271	2.301	0.4389	2.361	0.4510	2.422	0.4633	2.484
150	0.5577	2.958	0.5723	3.032	0.5872	3.106	0.6025	3.182
160	0.7183	3.758	0.7362	3.847	0.7544	3.937	0.7730	4.029
170	0.9137	4.723	0.9353	4.829	0.9573	4.937	0.9797	5.048
180	1.1487	5.877	1.1746	6.003	1.2010	6.312	1.2278	6.264
190	1.4289	7.248	1.4596	7.398	1.4909	7.551	1.5225	7.706
200	1.7597	8.868	1.7959	9.045	1.8326	9.225	1.8699	9.408
210	2.1474	10.77	2.1896	10.98	2.2323	11.19	2.2757	11.41
220	2.5981	13.00	2.6469	13.24	2.6963	13.49	2.7466	13.74
230	3.1185	15.61	3.1746	15.89	3.2316	16.18	3.2892	16.47
240	3.7155	18.64	3.7797	18.97	3.8448	19.30	3.9107	19.64