GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 75.180.30

E 98

GB/T 18604-2014

Replacing GB/T 18604-2001

Measurement of natural gas flow by gas ultrasonic flow meters

用气体超声流量计测量天然气流量

Issued on: February 19, 2014 **Implemented on: June 01, 2014**

Issued by: General Administration of Quality Supervision, Inspection and Quarantine;

Standardization Administration of the People's Republic of China.

Table of Contents

Measurement of natural gas flow by gas ultrasonic flow meters

1 Scope

This Standard specifies measurement performance requirements of gas ultrasonic flow meters, meter body requirements, installation and maintenance, field verification test requirements, and flow calculation methods and measurement uncertainty estimates.

This Standard is applicable to gas ultrasonic flow meters of plug-in transit-time difference method (hereinafter referred to as the flow meter), which are generally used for natural gas flow measurement in gathering devices, gas pipelines, storage facilities, gas distribution systems and customer metering systems. The use of external clamp-on gas ultrasonic flow meter can refer to this Standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB 3836.1, *Explosive atmospheres - Part 1: Equipment - General requirements*

GB 3836.2, *Explosive atmospheres - Part 2: Equipment protection by flameproof enclosures "d"*

GB 3836.4, *Explosive atmospheres - Part 4: Equipment protection by intrinsic safety "i"*

GB/T 4208, *Degrees of protection provided by enclosure (IP code) (IEC 60529)*

GB/T 11062-1998, *Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition*

GB/T 13610, *Analysis of natural gas by gas chromatography*

GB/T 17747 (all parts), *Natural gas - Calculation of compression factor* zone" (see Figure 2).

3.2.15 maximum peak-to-peak error

The difference between the upper limit maximum error point and the lower limit maximum error point (see Figure 2).

3.2.16 flow calibration factor

Flow meter coefficient that to conduct flow calibration on the flow meter and correct the test results according to a certain correction method, hereinafter referred to as the calibration factor.

3.2.17 maximum error shift with one path failed

At the same flow, the maximum difference BETWEEN the measurement error when all acoustic paths work AND the measurement error when one acoustic path fails.

3.2.18 speed of sound (SOS) deviation

The maximum relative deviation between average sound velocity obtained by the measurement of flow meter and theoretical sound velocity in the gas.

3.2.19 metering package

The component that consists of a flow meter, supporting upstream and downstream straight pipe sections, temperature measuring hole, pressure obtaining hole as well as flow conditioner.

4 Measurement principle

4.1 Fundamental principle

The gas ultrasonic flow meter of transit-time difference method is a velocity flow meter that measures high frequency sound pulse transit-time to obtain gas flow. The transit time is measured by the acoustic pulses that are transmitted and received between pairs of transducers outside the pipe or within the pipe. The acoustic pulse transits along the diagonal direction (see Figure 1). Acoustic pulses transmitted downstream are accelerated by airflow while acoustic pulses transmitted in reverse flow shall be decelerated. The transit-time difference is related to the mean axial fluid velocity. Use numerical calculation technique to calculate the mean axial fluid velocity and the flow that pass through the gas ultrasonic flow meter under working conditions. The flow meter that only has one acoustic path is called single-path gas ultrasonic flow meter. The flow meter that has two or more acoustic paths is called multi-path gas ultrasonic flow

a) CO_2 content exceeds 10%;

b) Work under conditions that are close to the critical density of natural gas mixture;

c) Total sulfur content exceeds 460mg/m^3, including mercaptans, hydrogen sulfide and elemental sulfur.

Under normal gas delivery conditions, the attachments (such as condensate or oil residue with processing impurities, ash and sand, etc.) inside the meter body shall reduce the flow area of the flow meter, which shall affect the measurement accuracy. Meanwhile, the attachments shall also obstruct or attenuate the ultrasonic transducer to emit and receive ultrasonic signals OR affect the reflection of ultrasonic signals on the inner wall of the meter body. Therefore, it shall regularly check and clean the flow meter.

5.2 Pressure

The ultrasonic transducer has certain requirements for gas minimum density (it is the function of pressure). The minimum working pressure shall ensure that the acoustic pulse can transit normally in natural gas.

5.3 Temperature

The manufacturer shall, according to the actual working condition requirements of the user, provide a flow meter that meets temperature range requirements. The working medium temperature of the flow meter is -20°C~60°C; the working environment temperature range is -40°C~60°C.

5.4 Flow range and flow direction

The flow measurement range of the flow meter is determined by the actual flow rate of gas. The typical flow rate of the measured natural gas is generally 0.3m/s ~ 30m/s. The user shall verify that the measured gas flow rate is within the flow range specified by the manufacturer. The corresponding measurement accuracy shall be in accordance with the provisions of Clause 6.

The flow meter has the ability to measure in both directions. The bidirectional measurements have the same accuracy. The user shall indicate if bidirectional measurement is required, so that the manufacturer can properly configure the signal processing unit parameters.

5.5 Velocity distribution

Under ideal conditions, the natural gas flow that goes into the flow meter shall be in symmetrically and fully-developed turbulent velocity distribution. The

6.2 Measurement performance requirements for single-path gas ultrasonic flow meter

The measurement performance requirements for single-path gas ultrasonic flow meter may be lower than the measurement performance requirements for multi-path gas ultrasonic flow meter. The specific indicators are provided by the manufacturer.

6.3 Influence of working conditions on measurement performance

Under the working conditions specified in Clause 5, the flow meter shall meet the measurement performance requirements specified in 6.1 and 6.2 without any manual adjustment. If the manual input of physical parameters is required to determine the physical parameters (such as density and viscosity) under natural gas flow conditions, the manufacturer shall give the sensitivity degree that the flow meter is affected by those parameters, so that when the working conditions are changed, the user can determine whether the influence brought by those changes is acceptable.

7 Flow meter requirements

7.1 Composition and basic provisions

7.1.1 Composition

The flow meter mainly consists of the following two parts:

a) meter body, ultrasonic transducer and its mounting parts;

b) signal processing unit (SPU) that is composed of electronic components and microprocessor system. It receives ultrasonic transducer signals and has functions such as processing measurement signals and displaying, outputting and recording measurement results. The electrical signal processing and conversing part located in the field is installed in the converter.

7.1.2 Basic provisions

Use the materials that are suitable for working conditions of the flow meter to design and manufacture the meter body and all other parts, including pressure members and external electronic components, in accordance with the process requirements for the metering system where they are. If the user has special requirements, it shall comply with the appropriate specifications or regulations

7.2.6 Pressure obtaining hole

There shall be at least one pressure obtaining hole on the meter body to measure the static pressure. The nominal diameter of each pressure obtaining hole shall be within 4mm~10mm. If the wall thickness of meter body is less than 20mm, the nominal diameter of the pressure obtaining hole shall be 4mm. And from the inner wall of meter body, at least within the length 2.5 times the diameter of pressure obtaining hole, it is cylindrical; and the axis of the pressure obtaining hole shall be perpendicular to the measuring tube axis. The edges of pressure obtaining hole of inner wall of meter body shall be right angle, without burrs and curls.

Each pressure obtaining hole shall have internal thread that can be equipped with isolation valve and swing space where it can directly mount the isolation valve on the pressure obtaining hole. The specification of the internal thread is better to be 1/4" NPTF or 1/2" NPTF. The pressure obtaining hole shall be set at the top, left or right of meter body. When necessary, the pressure obtaining hole can be added, so as to provide the flexibility to install pressure transmitter to the user, be conducive to maintenance and discharge the condensate in the pressure transmitter pressure tube back into the meter body.

7.2.7 Flow meter markings

A nameplate that contains the following information shall be set on the flow meter:

a) Manufacturer’s name, flow meter model, serial number and date of manufacture;

b) Nominal pressure and total mass;

c) Nominal diameter and inner diameter;

d) Highest and lowest storage temperature;

e) Working pressure and temperature range;

f) Maximum and minimum hourly flow under working state;

g) Positive direction of gas flow;

h) Explosion-proof level.

For easy identification, each ultrasonic transducer port shall be marked with a permanent unique mark. If a stamp mark on the meter body, it shall use low stress stamping form, i.e., round bottom print.

7.2.8 Appearance quality requirements

7.3.3 Replacement, dismantling and reinstallation

When the ultrasonic transducer is replaced, dismantled or reinstalled, it shall not obviously change the performance of the flow meter. That is, after replacing the ultrasonic transducer and making corresponding adjustment of signal processing unit software constant, the measurement performance of the flow meter shall also meet the requirements of Clause 6. The manufacturer shall specify the procedures for the replacement of the ultrasonic transducer and the mechanical, electrical and other tests and adjustments required.

7.3.4 Testing

The manufacturer shall test each ultrasonic transducer or each pair of ultrasonic transducers. The testing results shall be recorded and stored as a part of quality assurance system of ultrasonic flow meter in a form of document. Each ultrasonic transducer shall be marked with a permanent serial number. The manufacturer shall provide the technical parameters required by 7.3.1. If the signal processing unit requires particular characteristic parameters of the ultrasonic transducer, it shall provide testing documents of each ultrasonic transducer or each pair of ultrasonic transducers, including specialized calibration test data, calibration methods used, and characteristic parameters.

7.4 Electronic components

7.4.1 General requirements

The electronic components, that is, power supply, microprocessor, signal processing component, and ultrasonic transducer excitation circuit, can be assembled in one or more boxes and installed on or near the flow meter. They are unified as signal processing unit (SPU). The manufacturer shall give a mark of SPU's uniqueness. The testing of electronic components shall meet relevant requirements in Annex A "Type evaluation" of JJG 1030-2007.

Remote units such as power section and working interface can be installed in non-hazardous zone. Use shielded cable to connect it with the signal processing unit.

The signal processing unit shall work within the required range of indicators for flow meter's measurement performance specified in Clause 6 and the environmental conditions specified in Clause 5. And when the entire signal processing unit or any field replacement module is replaced, it shall not cause the obvious change of flow meter's measurement performance (see 7.3.3). The manufacturer shall remind the user that whether it shall obviously influence the measurement performance of flow meter when the entire SPU or its module is replaced.

Cable jackets, rubber, plastic and other exposed parts shall be resistant to UV light, grease and flame retardant.

7.4.4 Replacement of components

After ultrasonic transducer, cables, electronic components and software are replaced or re-installed, the manufacturer shall provide a set of reliable working procedures and enough data to the user, so as to ensure that after any component is replaced or re-installed, the measurement performance of the flow meter shall still meet the requirements of Clause 6 and the functions after replacement are not lower than the standard functions before replacement.

When these components are replaced but the flow meter is not re-calibrated, it may cause additional measurement uncertainty. Before the components are replaced, it shall store a set of reference data (see 7.5.5). After the components are replaced, the user shall compare the velocity ratio, sound velocity ratio between each path with the reference data, so as to ensure that the measurement performance of the flow meter still meet the requirements of Clause 6.

7.5 Flow computer

7.5.1 Hardware

The computer code that is used for flow meter control and operation shall be stored in non-volatile memory. All flow calculation constants and manually-input parameters shall also be stored in non-volatile memory.

The manufacturer shall store all records of hardware modifications, including modification serial number, date of modification, applicable flow meter model, board modification, and description of hardware changes.

The checker visually checks hardware module, display or data communication port to obtain hardware modification number, modification date, serial number, and number of checks.

The manufacturer may provide improved hardware at any time, so as to change the performance of the flow meter or add more features. The manufacturer shall inform the user whether the modification of the hardware affects the accuracy of the flowmeter calibrated by the real flow.

7.5.2 Configuration and maintenance software

The flow meter shall have the ability to perform local and remote configuration of the signal processing unit and monitor the operation of the flow meter. This software shall at least display and record the following data: instantaneous flow, axial average flow rate, average sound velocity, sound velocity along each path, through RS-232, RS-485 or equivalent serial communication port:

a) Automatic gain control level for each acoustic path;

b) Signal to noise ratio per acoustic path;

c) Average axial flow rate through the flow meter;

d) Flow rate per acoustic path (or equivalent to evaluating flow rate distribution);

e) Sound velocity along each acoustic path;

f) Average sound velocity;

g) Average time interval;

h) Percentage of pulses received per acoustic path;

i) State and measurement effect indication;

j) Alarm, fault indication and corresponding records.

7.5.6 Others

The flow computer shall have the function of theoretical sound velocity calculation under working conditions. The theoretical sound velocity calculation method shall be the sound velocity calculation method provided in AGA Report No. 10 or other methods that are the same as the calculation results. See GB/T 21446 Annex H “Basic technical requirements for natural gas flow computer system” for other technical requirements.

8 Installation requirements and maintenance

8.1 Installation influencing factors

8.1.1 Temperature

The ambient temperature of the installed flow meter shall comply with the provisions of 5.3. Meanwhile, it shall, according to the specific environment and working conditions of installation point, take necessary insulation, antifreeze and other protective measures (such as rain protection, sun protection) to the components of the flow meter.

8.1.2 Vibration

The installation of the flow meter shall avoid a vibration environment as far as installation of the flow conditioner, or when the user is unable to provide the expected installation conditions, in the absence of the flow conditioner, the upstream of the flow meter at least requires 50D straight pipe section; in the existence of the flow conditioner, the upstream of the flow meter at least requires 30D straight pipe section and the flow conditioner shall be installed at the upstream 10D of the flow meter. The length of the downstream straight pipe section of the flow meter shall at least be 5D.

8.2.3 Intrusion and alignment

The inner diameter of the flow meter, the connecting flange and its immediate upstream and downstream straight pipe sections shall have the same inner diameter. Its deviation shall be within 1% of the pipe diameter and does not exceed 3mm. When the flow meter and its adjacent straight pipe section are assembled, it shall be strictly aligned and ensure its internal circulation path smooth and straight. There shall be no obstacles in the connecting part, such as steps and protruding gaskets.

8.2.4 Internal surface

For the straight pipe section that matches the flow meter, there shall be no rust and other mechanical damages on its inner wall. Before assembly, the rust preventive oil or sandstone dust and other appendages in the flow meter and its connecting pipe shall be removed. During the use, it shall also keep the medium circulation path clean and smooth at any time.

8.2.5 Temperature measurement hole and sampling hole

If the flow meter is only for unidirectional flow measurement, the temperature measurement hole and sampling hole shall be placed 2D~5D between the downstream of the flow meter and the flange end face. If the flow meter is used for bidirectional flow measurement, the temperature measurement hole and sampling hole shall be placed 3D~5D between the downstream of the flow meter and the flange end face. Multiple temperature measurement holes shall not be arranged in a straight line. The manufacturer or supplier shall provide the best temperature measurement hole related to flow meter’s acoustic path arrangement to the user.

The manufacturer shall recommend the installation position of the temperature measurement hole relative to the acoustic path. Generally speaking, the axis of the temperature measurement hole is perpendicular to the axis of the pipe. The installation of the temperature measurement hole shall ensure that the heat transfer of the pipe, the accessory components of the temperature measurement jacket and the thermal radiation of the sun do not affect the measurement of the gas temperature. The insertion depth of the thermometer and the sampler shall be 1/3D. For large-mouth flow meter (DN300 and above), periodical check of the flow meter, for example, whether the signal processing unit and the timing system are working properly, whether the acoustic path is fault-free, whether the zero-flow measurement is accurate, whether the surface of the ultrasonic transducer is deposited with dirt, and whether the signal gain is significantly changed. It shall also, based on the actual situation, check whether there are deposits in adjacent pipes. Discharge sewage according to the check results.

9 Testing requirements for on-site verification

The manufacturer shall provide written documents for on-site verification testing of the flow meter to the user, so that when it requires to conduct on-site verification testing to the gas ultrasonic flow meter, it shall follow the following requirements.

9.1 Testing contents and steps

9.1.1 Appearance check

In appearance check, it shall carefully check whether the flow meter cavity and the ultrasonic transducer tip have dirt deposits, wear or other damage that may affect the performance of the flow meter.

9.1.2 Zero-flow testing

In the absence of a flowing medium, check whether the flow meter reading is zero or within the allowable range specified by the flow meter itself.

9.1.3 Sound velocity testing

During the on-site verification testing, when necessary, it can conduct the sound velocity testing. First, test the actual sound velocity under some working conditions. Then, according to the method provided by AGA Report No.10 or other methods that have same calculation results, calculate the theoretical sound velocity under the same working conditions. The difference between the two shall be in accordance with the provisions of 6.1.1.

9.2 Testing report

According to the testing of 9.1, check and analysis results, it shall give a testing report that contains flow meter name, model specification, manufacturer, commissioning date, on-site conditions (temperament, flow, pressure, temperature and installation method), test organization (personnel), testing content and method, testing results, abnormal situation analysis and recommendations measures.

q_e - Energy flow, in Joules per hour (J/h);

$\tilde{H}_s$ - Gas calorific value under standard reference conditions, in Joules per cubic meter (J/m^3).

10.2 Determination of measured flow value under standard reference conditions

The manufacturer has used the flow meter and relevant flow computer to make a flow measuring system. Its output function is complete and flexible, and the user can choose according to needs.

10.2.1 Output is flow under contract reference conditions

When the output is the flow under contract reference conditions, view whether the contract reference conditions are the same as the standard reference conditions. If they are same, then the output indicated value shall be the flow value under standard reference conditions. If they are different, calculate the flow under standard reference conditions according to formula (1) and formula (2). The calculated value shall be the measured flow value under standard reference conditions.

10.2.2 Output is flow under working conditions

When the output is the flow under working conditions, it shall calculate the flow under standard reference conditions according to formula (1) and formula (2). The calculated value shall be the measure flow value under standard reference conditions.

10.3 Flow calculation under working conditions

During type selection of flow meter, it shall calculate the flow under standard reference conditions q_n according to formula (1) as the flow under working conditions q_f according to formula (1). Reasonably select the specification of the flow meter.

10.4 Estimation of flow measurement uncertainty

10.4.1 Estimation of flow measurement uncertainty without flow calibration under standard reference conditions

According to formula (2), it may use formula (5) and formula (6) to estimate the extended uncertainty of flow measurement without flow calibration under standard reference conditions:

frequency, the sound pressure field has the properties of an acoustic beam, the width of which depends on the ratio of the wavelength of the acoustic wave to the diameter of the cylinder, that is, the larger the ratio, the wider the wavelength of the sound wave. Moreover, as it is absorbed in the gas, the sound waves shall attenuate. Although in some gases (such as carbon dioxide), absorption is more serious. However, in natural gas application, absorption effects are usually negligible in the path length.

The ultrasonic transducer shall be excited simultaneously or alternately as it emits one or more times in each direction. Acoustic frequency and pulse repeatability shall vary depending on the design structure.

A.3.4 Signal processing

Signal processing method can be divided into two categories: one method belongs to the time domain; the other method belongs to the frequency domain. Which of these two methods is used depends on the relationship between the transiting time and the ultrasound pulse period OR the relationship between the path length and the wavelength of the acoustic wave. For most flow meters used for natural gas measurement, the path length (0.1m~1m) is much larger than the acoustic wavelength (usually about 3mm), so the method of time domain is used.

In the methods of time domain, the most widely used methods are one-shot transiting time measurement method and related peak displacement method. The first method requires two important operations: detect the received pulse first and then estimate its arrival time. In fact, all detection techniques are implemented by identifying one or several predetermined zero-level intersections in the received pulse. The simple but common method is: give a trigger signal when the received pulse reaches a predetermined amplitude voltage; then detect the first zero-level intersection after it, as shown in Figure A.5. Use a wider pulse and detect several zero-level intersections in the pulse-stable portion, which can improve this technology. And it can avoid the pulse period change that occurs during the pulse transition phase. In addition, the transiting time of each pulse is calculated as the average of the individual transiting times corresponding to each zero-level intersection. The second method is more advanced. It is a waveform that uses a relatively constant amplitude during the pulse transition phase. The difference is the adoption of related technology, that is, the transmitting pulse and receiving pulse are associated. Calculate the transmitting time by the time corresponding to the peak correlation function.

Annex B

(normative)

Flow calibration of flow meter components

B.1 Overview

It shall use flow calibration equipment or calibration system traceable to national standards to perform flow calibration of flow meter components, so as to reduce flow measurement errors due to errors in meter path length, acoustic path angle, inner diameter of measuring tube, and acoustic path position. It can also use flow calibration to determine the flow meter coefficient. And through the flow calibration, judge whether the measurement performance of the flow meter meets the requirements of Clause 6.

B.2 Calibration conditions

B.2.1 Standard device requirements

B.2.1.1 Both the flow standard device and its auxiliary measuring instrument shall have an effective calibration certificate that is traceable to the corresponding national standard.

B.2.1.2 The uncertainty of the standard device is usually better than the uncertainty of the flow meter to be tested.

B.2.1.3 All electrical instruments of standard equipment shall be equipotential grounded.

B.2.2 Flow calibration fluid

The flow calibration fluid is natural gas or other gas. The composition shall be basically stable, and the natural gas temperament shall meet the requirements of 5.1. The physical property or thermal physical parameter values (such as density, compression factor, sound velocity, critical flow function, etc.) shall be calculated according to GB/T 17747.2 " Natural gas - Calculation of compression factor - Part 2: Calculation using molar composition analysis" and GB/T 11062. When performing flow calibration in the laboratory, the fluid temperature change shall not exceed 0.25°C within 100s, the pressure fluctuation shall not exceed 0.2%, and the flow fluctuation shall not exceed 3%. Online calibration can refer to this requirement.

B.2.3 Environment

Flow calibration environment: atmospheric temperature is generally -

pressure obtaining hole of its conversion pressure and the temperature measuring hole of the conversion temperature shall be correspondingly same with the flow meter to be calibrated or near it.

B.3.3.3 Testing flow points

It is recommended to test at least the following flow points for the flow calibration: q_{min}, 0.05 q_{max}, 0.10 q_{max}, 0.25 q_{max}, 0.40 q_{max}, 0.70 q_{max} and q_{max}. The designer can also add other flow points for additional flow calibration tests. The flow calibration of large-diameter flow meter may not reach the upper limit flow value. It may designate the range of flow calibration flow less than q_{max}. Generally, it shall reach above 0.4q_{max}. At this time, it shall use the maximum flow $q_{max,facility}$ that the standard device can actually reach as the maximum flow during calibration. The recommended test flow points are: q_{min}, 0.05 $q_{max,facility}$, 0.10 $q_{max,facility}$, 0.25 $q_{max,facility}$, 0.40 $q_{max,facility}$, 0.70 $q_{max,facility}$ and $q_{max,facility}$. During the testing process, the deviation of each testing flow rate of each flow point, compared with the discharge point flow, shall be no more than ±5%.

B.3.3.4 Testing times

During the flow calibration, at least test 6 times for each flow point.

B.3.3.5 Testing time

Each data collection time shall not be less than 100s.

B.3.3.6 Pre-operation

Before the flow calibration, the entire calibration system shall be pre-heated for at least 5min within a certain flow range. Calibrate after the pressure, the temperature and the flow are stable and reach B.2.2 requirements.

B.3.3.7 Content of data collection

During each testing process, in addition to the displayed value of the display instrument of the collection flow meter, the displayed value of the standard device and the testing time, it shall also, according to the needs, test and collect the fluid temperature, pressure and other information at the installation position of the flow meter. During the calibration process, it shall at least conduct an inspection of the speed of sound.

B.3.3.8 Bidirectional flow calibration

For the flow meter used for bidirectional flow measurement, it shall conduct the flow calibration in both forward and reverse flow directions.

B.3.4 Data processing

B.3.5 Adjustment method of calibration coefficient

B.3.5.1 The determination of calibration coefficient can use the following methods:

a) Arithmetic mean error method;

b) Flow weighted average error method;

c) Multi-point or polynomial algorithm, piecewise linear interpolation, etc.

B.3.5.2 Adjustment of calibration coefficient: it shall use the calibration correction factor to correct the reading error of the flow meter.

The methods of applying the calibration coefficient are:

a) Use flow weighted average error method within the specified flow range of the flow meter;

b) Use polynomial algorithm, piecewise linear interpolation or other approved methods, etc.

The adjustment amount of the calibration coefficient shall not exceed the corresponding maximum error requirement in 6.1. Through flow calibration, obtain new calibration coefficients and place into the flow meter. Correct the measurement errors of the flow meter. After the correction coefficients are applied, it shall at least test a verification flow point, so as to confirm that the correction calculation and correction application are correct. If a linearization algorithm is used to correct the performance of the flow meter, then it shall at least test two verification points. The confirmed calibration coefficient shall not be modified before the next flow calibration.

B.3.5.3 Simulation of on-site testing: for the flow meter after flow calibration, it can simulate the test that uses on-site installation conditions for installation impact. The additional reading error of the flow meter caused by installation impact shall not exceed ±0.3%.

B.3.5.4 For the flow meter for bidirectional measurement, it shall require the second set of calibration coefficients, so as for the measurement of reverse flow. If it establishes offset coefficient during the zero-flow inspection test, then it may correct it according to the results of flow calibration, so as to optimize the overall accuracy of the flow meter. The manufacturer shall record the change in this coefficient, so as to remind the user. In order to improve the accuracy of q_{min}, the zero-flow output may include some artificially introduced deviations.

B.3.5.5 Calibration certificate

It shall record each testing result in written report form and form a calibration

Annex C

(normative)

Exit-factory testing requirements

C.1 Overview

Before the flow meter exits the factory, the manufacturer shall perform exit-factory testing and inspection to each flow meter. The exit-factory testing and inspection shall refer to relevant provisions of JJG 1030 or relevant international standards. All testing and inspection results shall be recorded in the report of the manufacturer and submitted to user.

C.2 Strength test

It shall conduct strength test to the meter body. The test medium is water or kerosene. The test pressure is 1.5 times nominal pressure. And maintain at least 5min. After the inspection, there shall be no leakage and damage.

C.3 Tightness test

It shall conduct tightness test to the flow meter that has ultrasonic transducer and pressure obtaining isolation valve. The test medium is dry air or nitrogen. The test pressure is nominal pressure and at least maintain 5min. There shall be no leakage after inspection.

C.4 Geometric dimension measurement

C.4.1 Average inner diameter D of meter body

Use 12 inner diameter measured values of different directions (roughly equiangular to calculate the average inner diameter D of meter body. Or use a coordinate measuring instrument to determine its equivalent value. Respectively measure the inner diameters on three sections of meter body. The three sections are separately located at:

a) Ultrasonic transducer set near the upstream;

b) Ultrasonic transducer set near the downstream;

c) Middle of the two sets of ultrasound transducers.

C.4.2 Measurement of path length

It can directly measure. If the path length cannot be directly measured, it can

Annex D

(informative)

Documents available

D.1 Overview

In addition to the flow meter measurement accuracy, installation impact, electronic component inspection test, ultrasonic transducer and zero flow inspection test record file and flow calibration certificate provided by the requirements of other parts of this Standard, for the particular flow meter, the manufacturer shall provide necessary data, certificate and documents about the correct configuration, startup and use of the instrument to the user. These documents include user manuals, stress test certificates, material certificates, flow meter internal geometry measurement reports, and zero flow inspection certificates.

D.2 Recording documents

The manufacturer shall at least provide the recording documents that contain the following information to the user. All the recording documents shall be dated:

a) Description of flow meter, providing technical characteristics and working principle;

b) Axonometric view and photo of flow meter;

c) Names and materials of components;

d) Assembly drawing with component names and numbers;

e) Installation drawings with dimensions;

f) Diagram showing inspection marks and seal positions;

g) Dimensional drawing of components closely related to measuring;

h) Signage or panel and lettering layout;

i) Attaching device diagram;

j) Installation, operation, cycle maintenance and troubleshooting instructions;

k) Maintenance log files, including drawings for on-site maintenance;

l) Signal processing unit and its layout description and job description;

Annex E

(informative)

Generation and prevention measures of acoustic noise

E.1 Generation and influence of acoustic noise

Many factors related to airflow disturbances, such as high-speed airflow through pipes, protruding probes, flow conditioners, and regulating valves in the vicinity, may generate acoustic noise.

When the frequency range of the acoustic noise is close to the operating frequency of the flow meter, it may interfere with the acoustic pulse detection, thereby to interfere the measurement of transit time. If the flow meter cannot detect the acoustic pulse, the transiting time of the acoustic pulse between the transducers cannot be measured, so flow measurement cannot be performed. Acoustic noise interference can also cause pulse "false detection" to cause the wrong measurement of transit time, resulting in measurement error.

E.2 Assessment and prevention of acoustic noise

E.2.1 Assessment of acoustic noise

The manufacturer specifies the working frequency of ultrasonic transducer. The frequency range that the particular flow meter may be affected by the noise just based on the working frequency. Meanwhile, the flow meter has self-diagnostic output. The degree of influence of noise on the performance of the flow meter can be evaluated based on self-diagnosis information.

In general, the noise source is installed upstream of the ultrasonic flowmeter and has a greater influence on the flow meter than when it is installed downstream. Even if the pressure regulating valve and other noise-generating equipment are installed downstream of the flow meter, there is no guarantee that the flow meter's measurement performance shall not be affected.

Users shall consider whether there shall be noise interference under certain installation conditions, so that measures are taken at the station design stage to prevent noise interference from adversely affecting the performance of the flow meter. Special attention shall be paid to the use of a pressure regulating valve that is designed with a cage-type muffling structure. Due to its structural characteristics, the noise generated is beyond the human hearing range, but its frequency is often a multiple of the ultrasonic frequency. Therefore, it shall have a greater impact on the operating frequency of the ultrasonic transducer.

of the pressure regulating valve. Once the characteristics of this regulating valve are determined, a mathematical model containing flow meter, pipe installation conditions (bends, tees, and/or mufflers, etc.) can be defined. It also includes a method of calculating the weight coefficient of the pressure regulating valve. In order to evaluate the effect of acoustic noise on the performance of the flow meter under given conditions, the following parameters shall be measured or calculated:

a) The noise generated by the pressure regulating valve is a function of the working condition of the pressure regulating metering station;

b) Noise transmitting from the pressure regulating valve to flow meter (N_d);

c) Signal strength of flow meter (p_s);

d) Obtain the ratio of signal to noise from the flow meter. Compare the minimum signal-to-noise ratio (δ_{min}) required for flow meter and it shall be possible to predict the effect of acoustic noise on the performance of the flow meter.

E.3.2 Measurement and calculation of noise of pressure regulating valve

The sound pressure generated by the pressure regulating valve is proportional to the pressure drop of the pressure regulating valve and the square root of the flow rate. Therefore, it can user formula (E.1) to calculate the noise:

$$p_n = N_v \times dp \times \sqrt{q_n} \quad \cdots\cdots (E.1)$$

Where,

p_n - Sound pressure generated by the pressure regulating valve, in pascals (Pa);

N_v - Weighting coefficient of pressure regulating valve, without dimension;

dp - Pressure drop generated by the pressure regulating valve, in pascals (Pa);

q_n - Flow under standard reference conditions, in cubic meters per hour (m^3/h).

The pressure regulating coefficient of the pressure regulating valve reflects the degree of noise generated by the pressure regulating valve at a specific frequency and position (upstream or downstream). The larger the N_v value, the greater the noise generated by the regulating valve. In order to determine the weighting coefficient of the pressure regulating valve when the specific pressure regulating valve and piping arrangement are combined under operating conditions, it is necessary to measure the pressure drop, flow rate and sound pressure. Figure E.1 shows the installation diagram for noise measurement.

Annex F

(informative)

Performance verification tests of flow meter and flow conditioner

F.1 General rules

In order for the flow meter to meet the performance requirements of Clause 6 under different working conditions, the manufacturer shall perform performance verification tests and verify the test results according to the performance, provide the user with the minimum requirements for the upstream and downstream straight pipe lengths of the flow meter, and indicate whether the flow conditioner needs to be installed.

For verification testing, a set of standard turbulence assembly (see F.2.2) shall be installed at upstream of the flow meter to verify the flow meter's measurement performance. Test installation conditions shall be as identical as possible to the actual installation conditions of the flow meter.

F.2 Testing steps of performance verification

F.2.1 Testing of flow meter components under basic piping installation conditions

The basic piping installation conditions, i.e. the gas velocity distribution at the inlet of the flow meter assembly, are fully developed, symmetrical, vortex-free. Under this condition, at least 5 flow points including maximum and minimum flow rates need to be tested. If possible, the test pressure shall be as close as possible to the actual working pressure of the flow meter.

F.2.2 Turbulence test

Perform 4 turbulence tests at the same 5 flow points as the basic piping test, including:

a) Two compact, 90° long radius elbows that are not in the same plane are installed upstream of the flow meter assembly, so as to evaluate the effects of moderate vortex flow (with a vortex angle of 15°) and asymmetric velocity distribution;

b) An elbow is installed at upstream of the flow meter assembly, so as to evaluate the effects of strong secondary flow and asymmetric velocity distribution in the absence of vortex flow;

c) A half-open gate valve is installed at upstream of the flow meter assembly,

Annex G

(informative)

Monitoring and guarantee of on-site measurement performance of flow meter

G.1 General rules

The user shall follow up and check the flow meter, make full use of the self-diagnosis function of the flow meter, or use the method of serially checking the flow meter comparison to ensure that the flow meter can continuously meet the measurement performance requirements during use.

G.2 Storage of key files and key feature parameters

The user shall collect key files and key feature parameters generated during flow meter production, factory acceptance testing, calibration (including recalibration), and on-site monitoring and store in a form of file.

Key files mainly include:

a) Production license of flow meter;

b) Exit-factory testing certificate;

c) Calibration certificate;

d) Record of parameter change of flow meter;

e) Record of component change of flow meter;

f) Inspection report.

Key feature parameters mainly include:

a) Sound velocity versus time curve;

b) Gain settings and trends of other diagnostic data;

c) Results of comparison with verified flow meter (if applicable);

d) Log file.

G.3 Analysis of diagnostic information

G.3.1 Comparison of measured sound velocity and theoretical sound

------ The End ------