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Ultrasonic Flowmeters

超声流量计

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Verification Regulation of Ultrasonic Flowmeters

1 Scope

This Regulation is applicable to the type evaluation, initial verification, subsequent verification and in-use inspection of ultrasonic flowmeters for closed pipes (hereinafter referred to as flowmeters), which takes time difference method as the principle.

This Regulation is not applicable to the verification of ultrasonic flow measuring instrument in open channels and closed conduits.

2 References

Through reference, the clauses included in the following standards and regulations become the clauses of this Regulation.

JJF 1001-1998 *General Terms in Metrology and Their Definitions*

JJF 1004-2004 *Metrological Terms and Their Definitions for Flow Rate*

GB 3836 *Electrical Apparatus for Explosive Gas Atmospheres*

GB/T 18604-2001 *Measurement of Natural Gas Flow by Ultrasonic Flow Meter*

GB 17820-1999 *Natural Gas*

GB 50251-2003 *Code for Design of Gas Transmission Pipeline Engineering*

GB/T 13609-1999 *Natural Gas - Sampling Guidelines*

GB/T 13610-2003 *Analysis of Natural Gas by Gas Chromatography*

GB/T 17747.2-1999 *Natural Gas - Calculation of Compression Factor - Part 2: Calculation Using Molar - Composition Analysis*

ISO 17089: 2004 *(CD) Measurement of Fluid Flow in Closed Conduits - Ultrasonic Meters for Gas; Meters for Fiscal and Allocation Measurement*

ISO/TR 12765: 1997 *Measurement of Fluid Flow in Closed Conduits - Methods Using Transit Time Ultrasonic Flowmeters*

AGA Report-1992 No.8 *Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases*

AGA Report No.9-1998 *Measurement of Gas by Multipath Ultrasonic Meters*

Single-path meter refers to a flowmeter that merely has one pair of transducers.

3.9 Dual-paths Meter

Dual-paths meter refers to a flowmeter that has two pairs of transducers.

3.10 Multiple-paths Meter

Multiple-paths meter refers to a flowmeter that has above two pairs of transducers.

3.11 Meter Body

Meter body refers to a pipe section which is adopted for the installation of components like ultrasonic transducer; can comply with the stipulations of relevant standards in all the aspects after going through special manufacture.

3.12 Zero-flow Reading

Zero-flow reading refers to flowmeter's maximum flowrate reading when the medium is under a stationary state.

3.13 Pulse Factor

Pulse factor refers to pulse count sent out by a flowmeter when a unit volume of fluid flows through the flowmeter. Generally speaking, it is also known as *K* factor, which shall be expressed in symbol *K*.

3.14 Flow Conditioner

Flow conditioner refers to a component that can reduce vortex and improve the distribution of speed.

3.15 Signal Processing Unit

Signal processing unit is constituted of electronic components and microprocessor system. It is a part of flowmeter.

3.16 Transition Flowrate (q_t)

Transition flowrate refers to a flow value between the maximum flow and the minimum flow. It segments the range of flow into two zones with different allowable errors, namely, "high zone" and "low zone".

3.17 Meter Factor

Meter factor refers to a factor that is used to correct the value indicated by flowmeter in accordance with the result of actual flow verification of the flowmeter. The value is the ratio of the value indicated by the standard to the value indicated by flowmeter. Generally speaking, it is expressed in symbol *F*.

6 General Technical Requirements

6.1 Product Documents

6.1.1 Flowmeter shall be accompanied by an instruction for use.

6.1.2 In terms of clamp-on ultrasonic meters, the instruction for use shall describes flowmeter's installation methods and operating requirements in details.

6.1.3 The instruction for use of flowmeter shall provide the operating pressure range and operating temperature range of transducers; provide the geometric dimensions of the installation of transducers. In the product documents, wetted ultrasonic meters shall include an inspection report of geometric dimensions of the flowmeters in exit-factory inspection.

6.1.4 Flowmeters, which are under periodic verification, shall also have the previous verification certificate and the inspection report of various in-use inspections after the previous verification.

6.2 Nameplate and Marking

6.2.1 Flowmeter shall have marking of flow direction.

6.2.2 Flowmeter shall have a nameplate. Generally speaking, meter body or nameplate shall indicate:

a. Name of manufacturer;

b. Product name and model;

c. Exit-factory serial number;

d. Marking and serial number of permit of manufacturing metrological instruments;

e. Pressure rating (merely restricted to wetted flowmeter);

f. Nominal diameter or applicable pipe diameter range;

g. Applicable operating pressure range and operating temperature range;

h. The maximum, minimum flow or flow rate under operating conditions;

i. Transitional flowrate (when flowmeter has this index);

j. Grade of accuracy;

k. Explosion-proof grade and explosion-proof certificate number (merely restricted to explosion-proof flowmeter);

subsequent verification and in-use inspection. Appendix A stipulates the test conditions, items and methods of type evaluation. Appendix B stipulates the special requirements of on-site verification. Appendix C stipulates the test conditions, items and methods of in-use inspection.

7.1 Verification Conditions

7.1.1 Requirements of flow calibration device

7.1.1.1 Flow calibration device (hereinafter referred to as device) and its matching instrument shall have valid verification certificate.

7.1.1.2 Uncertainty of the measurement result of the device shall be not larger than 1/3 of the absolute value of the maximum allowable error of the flowmeter being verified.

7.1.1.3 When the vapor pressure of liquid used for verification is higher than the ambient atmospheric pressure, the device shall be sealed.

7.1.1.4 When the temperature of fluid that flows through the flowmeter needs to be measured, temperature measurement may be conducted directly through the temperature-measuring holes on the meter body. If there is no temperature-measuring hole on the meter body, it shall, according to the requirements of the flowmeter and relevant stipulations, determine the measurement location of temperature. If there is no special requirement, in terms of one-way measurement flowmeter, the location for temperature measurement shall be set up at the downstream (3 ~ 5)*D* area (*D* signifies internal diameter of pipeline) of the flowmeter; in terms of two-way measurement flowmeter, the location for temperature measurement shall be set up at least 5*D* away from the flowmeter. The influence of measurement error of the used thermometer on the verification result shall be within 1/5 of the maximum allowable error of the flowmeter.

7.1.1.5 When the pressure of fluid that flows through the flowmeter needs to be measured, directly take pressure from pressure ports on the flowmeter body. If there are no pressure ports on the flowmeter body, it shall, according to the requirements of the flowmeter, determine the measurement location of pressure. If there are no special requirements, the device shall install pressure meter at 10*D* area on the upstream side of the flowmeter. The axes of the pressure ports shall be vertical to the axes of the measuring pipe; the diameter shall be (4 ~ 12) mm. The influence of measurement error of the used pressure meter on the verification result shall be within 1/5 of the maximum allowable error of the flowmeter.

7.1.2 Fluid for verification

7.1.2.1 Universal conditions

(1) Fluid used for verification shall be single-phase gas or liquid. Use it to fill test

(5) When gas used for verification is natural gas, during the verification process, gas component shall be relatively stable. The sampling of natural gas shall comply with GB/T 13609; the composition analysis of natural gas shall comply with GB/T 13610.

(6) During the verification process of each flow point, pressure fluctuation shall not exceed ± 0.5%.

7.1.3 Verification environment conditions

7.1.3.1 Generally speaking, ambient temperature is (5 ~ 45) °C; humidity is (35 ~ 95) % RH; atmospheric pressure is (86 ~ 106) kPa.

7.1.3.2 AC power supply voltage shall be (220 ± 20) V; power frequency shall be (50 ± 2.5) Hz. Or, in accordance with the requirements of flowmeter, suitable AC power or DC power may be used (for example, 24 V DC).

7.1.3.3 The external magnetic field shall be so small that its influence on flowmeter can be neglected.

7.1.3.4 Mechanical vibration and noise shall be so small that its influence on flowmeter can be neglected.

7.1.3.5 When flammable or explosive fluid, for example, natural gas, is used as the medium for verification, all the verification devices and their auxiliary equipment, and verification site shall comply with the requirements in GB 50251. All the equipment and environment conditions must comply with relevant safety explosion-proof requirements in GB 3836.

7.1.4 Installation conditions

7.1.4.1 The installation of flowmeter shall comply with the requirements in Appendix D.

7.1.4.2 During verification, in principle, all the components that constitute flowmeter shall be submitted for verification.

7.1.5 Each measurement time shall be not less than the allowed shortest measurement time of the device and the flowmeter being verified.

7.1.6 When the pulse output of the flowmeter being verified is adopted for verification, the pulse count recorded in one verification shall not be less than 10 times of the reciprocal of the absolute value of the maximum allowed error.

7.1.7 All the electrical apparatus used for verification shall be grounded in the same point.

7.2 Verification Items and Verification Methods

Appendix A

Type Evaluation of Ultrasonic Flowmeter

A.1 Scope

It is applicable to type evaluation of ultrasonic flowmeters.

A.2 References

Through reference, the causes included in the following standards and regulations become clauses of this Regulation.

JJF 1015-2002 *General Norm for Pattern Evaluation and Pattern Approval of Measuring Instruments;*

JJF 1016-2002 *The Rules for Drafting Program of Pattern Evaluation of Measuring Instruments;*

GB/T 2423.1-2001 *Environmental Testing for Electric and Electronic Products - Part 2: Test Methods - Tests A: Cold;*

GB/T 2423.2-2001 *Environmental Testing for Electric and Electronic Products - Part 2: Test Methods - Tests B: Dry Heat;*

GB/T 2423.3-2006 *Environmental Testing for Electric and Electronic Products - Part 2: Testing Methods - Test Cab: Damp Heat Steady State;*

GB/T 2423.4-1993 *Basic Environmental Testing Procedures for Electric and Electronic Products: Test Db: Damp Heat, Cyclic;*

GB/T 2423.10-1995 *Environmental Testing for Electric and Electronic Products - Part 2: Testing Methods - Test Fc and Guidance: Vibration (sinusoidal);*

GB 4208-1993 *Degrees of Protection Provided by Enclosure (IP code);*

GB/T 4857.2-2005 *Packaging - Basic Tests for Transport Packages - Part 2: Temperature and Humidity Conditioning;*

GB/T 4857.5-1992 *Packaging - Transport Packages - Vertical Impact Test Method by Dropping;*

GB/T 17626.2-2006 *Electromagnetic Compatibility (EMC) - Testing and Measurement Techniques - Electrostatic Discharge Immunity Test;*

GB/T 17626.4-1999 *Electromagnetic Compatibility (EMC) - Testing and Measurement*

The stipulations of the accuracy grade of flowmeter shall comply with the requirements in Clause 5.1 in this Regulation.

A.4.3 Metrological mark and marking of measuring instrument

Metrological mark and marking of measuring instrument must be left on obvious parts (such as nameplate, panel or header) of flowmeter. The nameplate and the mark must be clearly identifiable, steady and reliable.

A.4.4 External structural design

In terms of flowmeter that does not allow users' self-adjustment, sealed structural design shall be adopted, or, a location of affixed seal must be retained. Any artificial mechanical interference that would affect the accuracy of measurement will leave permanent tangible damage traces on flowmeter, or the protective mark or safeguard mark of verification.

A.4.5 Installation marking

On the flowmeter body, there shall be marking of installation instruction.

A.4.6 If errors or content that does not comply with the requirements are found in the review of the technical information, timely inform the applicant and request for corrections.

A.5 Requirements of Measurement

A.5.1 The main metrological performance of flowmeter is: flow range, accuracy grade (maximum allowable error), operating pressure range and operating temperature range. These contents shall be clearly indicated on the external part of flowmeter. Other metrological performance shall be stated in the instruction for use.

A.5.2 The maximum allowable error and measurement repeatability of flowmeter shall comply with the stipulations of Clause 5.1 and Clause 5.2 in this Regulation.

A.5.3 Zero-flow reading

A.5.3.1 Gas flowmeter

In terms of each acoustic path, zero-flow reading of gas flowmeter shall be not more than 12 mm/s.

A.5.3.2 Liquid flowmeter

In terms of each acoustic path, zero-flow reading of liquid flowmeter shall be not more than 4 mm/s.

A.5.4 Except from the listed test items, in accordance with prototype product standards

In accordance with flowmeter product standards and the technical requirements of type evaluation, determine test items and test requirements, such as: output, software, inspection and supervision function, and alarm, etc.

A.6.5 Environmental requirements

A.6.5.1 Low-temperature storage

Low-temperature storage shall comply with the requirements of “Test Ad” in GB/T 2423.1.

A.6.5.2 High-temperature storage

High-temperature storage shall comply with the requirements of “Test Bd” in GB/T 2423.2.

A.6.5.3 Damp heat steady state storage

Damp heat steady state storage shall comply with the requirements of “Test Ca” in GB/T 2423.3.

A.6.5.4 Cyclic damp heat storage

Cyclic damp heat storage shall comply with the requirements of “Test Db” in GB/T 2423.4.

A.6.6 Mechanical vibration

A.6.6.1 Sinusoidal vibration test

Sinusoidal vibration test shall comply with the requirements of “Test Fc” in GB/T 2423.10.

A.6.6.2 Transport package dropping test

In terms of flowmeter being tested, put its transport package in the state of ready-to-be transported. In accordance with the stipulations of Condition 6 in Clause 2.1 in GB/T 4857.2, conduct pre-treatment for 4 h. In accordance with the requirements in Clause 3.5 in GB/T 4857.5, tilt one side of the bottom of the transport package to the height of 25 mm. Then, let it freely drop to a rigid ground. Randomly take 4 surfaces; each surface shall drop once. After the test, the prototype shall manifest no breakage or distortion on the surface; the electric circuit part shall manifest no phenomena like open welding or de-soldering.

A.6.7 Power supply

A.6.7.1 Power supply voltage variation test

Under the state of power supply, place it for sufficient time. Respectively adjust the

requirements in Clause 7.1.2 in this Regulation.

A.7.1.3 Environmental conditions in type evaluation test shall comply with the requirements in 7.1.3 in this Regulation.

A.7.2 Requirements of legal management

In accordance with the requirements in Clause A.4 in this Regulation, conduct visual inspection item by item.

A.7.3 Product documents and appearance inspection

Conduct visual inspection, which shall comply with the requirements in A.6.1.1, A.6.1.2 and A.6.2.1.

A.7.4 Safety performance impact test

A.7.4.1 Resistance to internal pressure

Slowly inject fluid into flowmeter to 1.5 times of the maximum operating pressure; maintain for 5 min. Then, slowly relieve the pressure. In the pressure-holding stage, the indicated pressure shall not drop. The various parts of meter body and the connecting parts shall have no breakage or leakage.

A.7.4.2 Air-tightness

Slowly inject gas into flowmeter to the maximum operating pressure. The various parts of the meter body and the connecting parts shall have no leakage.

A.7.4.3 Insulation resistance

Conduct insulation resistance test right after damp heat steady state storage test is completed. Use megameter to measure the insulation resistance between flowmeter's power supply terminal and grounding terminal; between output terminal and grounding terminal, which shall satisfy the requirements in A.6.2.3.

A.7.4.4 Dielectric strength

Conduct dielectric strength test right after insulation resistance test is completed. It shall comply with the requirements in A.6.2.4.

A.7.5 Flow computer

In accordance with the requirements of flowmeter instruction, conduct inspection item by item. The result shall comply with the requirements in A.6.3.

A.7.6 Metrological performance test

A.7.6.1 Zero-flow reading

In accordance with the requirements in A.6.5.4, place flowmeter in a constant temperature and humidity chamber. The temperature shall alternatively change between 25 °C and 55 °C. In the lower limit of the temperature, maintain above 95% relative humidity; in the upper limit of the temperature, maintain 93% relative humidity. When temperature rises, the surface of the electronic device might generate condensate water. Test time shall be two 24 h cycles; each cycle shall comply with the stipulated procedures in GB/T 2423.4.

A.7.8 Mechanical environment test

A.7.8.1 Sinusoidal vibration test

In accordance with the requirements in A.6.6.1, accelerated speed shall be 2 m/s^2. At the frequency multiplication of 1/min, within the vibration frequency of (10 ~ 150) Hz, conduct sinusoidal vibration test. Respectively vibrate in three axial directions that are mutually vertical.

A.7.8.2 Transport package drop test

Conduct the test in accordance with the requirements in A.6.6.2. After the test, check the damage of the package; inspect the sample being tested.

A.7.9 Power supply

A.7.9.1 Power supply voltage variation test

Conduct the test in accordance with the requirements in A.6.7.1.

A.7.9.2 DC reverse protection test

Conduct the test in accordance with the requirements in A.6.7.2

A.7.10 Electromagnetic compatibility test

A.7.10.1 Electric transient burst immunity test

Conduct the test in accordance with the requirements in A.6.8.1. Pulse rise time is 1 ns. Pulse duration is 50 ns.

A.7.10.2 Electrostatic discharge immunity test

Conduct the test in accordance with the requirements in A.6.8.2. Test for 10 times. There shall be certain time interval between electrostatic discharges.

A.7.10.3 Power frequency magnetic field immunity test

Conduct the test in accordance with the requirements in A.6.8.3. Apply continuous magnetic field to prototype. Test field strength is 10 A/m.

Appendix B

Special Requirements of On-site Verification

This Appendix is applicable to on-line verification on the site of usage of ultrasonic flowmeters. This Appendix is not applicable to type evaluation or initial verification.

B.1 Requirements of Standard Device

B.1.1 Flow standard shall have complete legal files.

B.1.2 The measurement range of flow standard shall be able to cover the on-site flow range of the flowmeter being verified.

B.1.3 Standard flowmeter shall be verified in accordance with a certain cycle and have valid verification certificate. Standard flowmeter shall have satisfying recurring performance.

B.1.4 The uncertainty of the measurement result of flow standard shall be not larger than 1/3 of the absolute value of the maximum allowable error of the flowmeter being verified.

B.1.5 Standard devices used in explosion-proof areas shall have corresponding explosion-proof certificate.

B.2 Installation Conditions of Flow Standard

B.2.1 Flow standard shall adapt to variations of flow, pressure and temperature, and the type of the medium being tested. If necessary, protective equipment shall be installed, so as to guarantee that flow standard can normally function under the designed conditions.

B.2.2 The installation of flow standard shall satisfy the lowest requirements of relevant national standards, or, be consistent with flow standard manufacturer's requirements (manufacturer's requirements shall be not lower than relevant national standards).

B.2.3 The distance between flow standard and flowmeter being verified shall be as short as possible, as long as they do not cause mutual interference. The difference between the diameter of connecting pipeline and the diameter of the standard flowmeter shall be within 1%, so as to guarantee the flow profile that is required by the standard flowmeter in the verification.

B.2.4 Temperature and pressure transmitter installed on the pipe sections of flow standard shall satisfy the stipulations of 7.1.1.4 and 7.1.1.5 in this Regulation.

Appendix C

In-use Inspection

In-use inspection of ultrasonic flowmeter is used to inspect the reliability of the metrological performance of flowmeter within the verification cycle after the verification on actual flow device is completed. In-use inspection has two methods: one is to on-line adopt 1 standard flowmeter for comparison; the other is to take the comparison of sound speed as the basis to conduct on-line inspection of flowmeter.

C.1 Technical Requirements

C.1.1 Time arrangement of inspection

Within 1 month after the flowmeter to be inspected is installed on pipeline and put into use, conduct the first inspection. After that, conduct the inspection in accordance with the cycle of at least once a year.

C.1.2 In in-use inspection of flowmeter, the previous inspection report of the flowmeter must be taken along.

C.1.3 Check whether flowmeter factor changes after the previous verification.

C.2 Standard Flowmeter Comparison Method

C.2.1 Requirements of standard flowmeter

C.2.1.1 Standard flowmeter shall comply with the requirements in B.1.2 and B.1.4 in the Appendix of this Regulation.

C.2.1.2 Standard flowmeter shall have satisfying recurring performance; its accuracy grade shall be not lower than the accuracy grade of the flowmeter being inspected.

C.2.2 Installation conditions of standard flowmeter

Installation conditions of standard flowmeter shall comply with the requirements in B.2 in the Appendix of this Regulation.

C.2.3 Inspection method

Operating procedure is the same as B.3 of this Regulation.

C.2.4 Inspection result calculation

C.2.4.1 Measurement deviation

C.3.4.1 Pre-operation inspection: connect, initiate, pre-heat; inspect in accordance with the method appointed in the instruction of standard equipment; confirm whether the parameter setting of all the standard equipment is correct.

C.3.4.2 Mechanical inspection: in accordance with the verification regulation and national standard (or manufacturer's enterprise standard), inspect the installation and pipe diameter of the flowmeter to be verified on the site; conduct other mechanical and electronic testing, so as to confirm that the flowmeter is correctly installed.

C.3.4.3 Flowmeter status inspection

C.3.4.3.1 Inspection of alarm files

Flowmeter shall have fault alarm function and record, including the time, type and status record of fault alarm, etc. Inspect the alarm records. Confirm that there are no alarms caused by flowmeter itself but sufficient to trigger metrological errors.

C.3.4.3.2 Signal inspection

Manufacturer shall provide the following diagnostic measurement data through computer communication or on-site display; inspect the following indexes and compare them with the data of the previous inspection; the deviation shall be within the allowable range in the product instruction. If excessive deviation exists, the flowmeter shall be submitted for inspection.

a. Gain value of each acoustic path signal, namely, strength of signal sent out (received) by the probe that is installed on the flowmeter body;

b. Percentage of received signal of each acoustic path;

c. Signal to noise ratio of each acoustic path.

C.3.4.4 Inspection of sound speed measurement

C.3.4.4.1 Flow points of inspection

Under general circumstance, flow points of inspection shall select: the minimum flowrate of flowmeter, or, the minimum flowrate that the system can reach (q_{min}), transition flowrate (q_t), the maximum flow (q_{max}) that the system can reach; 1 ~ 2 equant flow points in the middle of transition flowrate and q_{max}.

If the system cannot implement flow regulation and the flowmeter is used in fixed points, then, inspection flow points may choose actually used flow points; the inspection report shall indicate: use in fixed points.

C.3.4.4.2 Times of inspection point: comply with 7.2.3.4.

C.3.4.4.3 Operating procedures

Appendix D

Installation Requirements of Ultrasonic Flowmeter

D.1 Installation Environment

D.1.1 Temperature

Under general circumstances, the ambient temperature of the installation of ultrasonic flowmeter shall be within the range of -20 °C ~ 55 °C. When the ambient temperature of installation exceeds the above-mentioned range, adopt thermal insulation and anti-freezing measures on the flowmeter. In terms of flowmeters that are exposed in the field, rain-proof and sunscreen measures shall also be adopted.

D.1.2 Vibration

The installation of flowmeter shall try to avoid locations with strong impact from mechanical vibration, especially environment that might trigger resonance of parts like flowmeter's signal processing unit, ultrasonic transducer and flow measurement pipe, etc.

D.1.3 Electromagnetic or electronic interference

In the installation of flowmeter and relevant wires of flowmeter, try to avoid environment where strong electromagnetic or electronic interference might exist, otherwise, necessary protection shall be implemented on the flowmeter.

Flowmeter signal cable shall avoid parallel arrangement with the power cable. Meanwhile, shielded signal cable shall be adopted.

D.1.4 Acoustic noise interference

In the installation of flowmeter, try to avoid approaching the source of noise. In the installation, necessary measures shall be adopted to eliminate the interference of ambient acoustic noise.

D.2 Installation of Flowmeter

D.2.1 Installation mode

Flowmeter shall be horizontally installed. Other installation modes may be appointed by flowmeter manufacturer. When other installation modes are adopted, install the flowmeter in the rising section of the pipeline, so as to guarantee that the pipeline can be filled with fluid.

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