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Liquid Positive Displacement Flowmeter

液体容积式流量计

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Verification Regulation of Liquid Positive Displacement Flowmeter

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Verification Regulation of Liquid Positive Displacement Flowmeter

1 Scope

This Regulation applies to type evaluation, initial verification, subsequent verification, and in-service inspection of liquid positive displacement flowmeter (hereinafter referred to as flowmeter).

2. Cited references

Provisions contained in following standards and regulations become provisions of this Regulation by citing.

GB 3836.1-2000 Electrical apparatus for explosive gas atmospheres - Part 1: General requirements

GB 3836.2-2000 Electrical apparatus for explosive gas atmospheres - Part 2: Flameproof enclosure d

GB 3836.3-2000 Electrical apparatus for explosive gas atmospheres - Part 3: Increased safety e

GB/T 17288-2009 Liquid hydrocarbons - Volumetric measurement by displacement meter systems

GB/T 17612-1998 Measurement of liquid flow in closed conduits - Weighing method

JJF 1001-1998 General Terms in Metrology and Their definitions

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

JB/T 9242-1999 General technical specifications for positive displacement flowmeter

JB/T 10564-2006 Basic parameters for flow measuring instruments

OIML R120-1996 Standard capacity measures for testing measuring systems or liquids other than water

It shall pay attention to use current valid versions of above cited references.

3 Terms and definitions

3.1 Liquid positive displacement flowmeter

Meter composed of chamber with a known volume and moving parts that are driven by liquid. It is used to measure fluid flow based on the number of times that the chamber is repeatedly filled-discharged of liquid.

3.2 Coefficient *K*

Number of pulses that is emitted by flowmeter when liquid of unit volume flows through the flowmeter.

3.3 Meter factor

Coefficient that flowmeter indicating value is corrected after verification. The value of which is the ratio of standard device indicating value and flowmeter indicating value, expressed by symbol *F*.

4 Overview

4.1 Working principles

Liquid will generate a certain pressure between flowmeter inlet and outlet when passing through flowmeter. Moving parts will move this pressure difference and discharge the liquid from inlet to outlet. In this process, chamber of flowmeter is repeatedly filled with liquid. Volume of this chamber is definite under given conditions; accumulated volume flow rate may be obtained as long as the number of movements of moving parts is measured.

4.2 Classification

Flowmeters referred in this Regulation include the following ones:

a) Waist wheel (also known as roots) flowmeter

b) Oval gear flowmeter

c) Sliding vane flowmeter

d) Rotary piston flowmeter

e) Reciprocating piston flowmeter

f) Disc flowmeter

g) Screw flowmeter

h) Double-rotor flowmeter

i) Other types of positive displacement meters

c) Manufacturing serial number

d) Manufactured measuring instrument license logo and number

e) Nominal diameter

f) Flow range

g) Maximum working pressure

h) Accuracy class

i) Explosion-proof grade and explosion-proof certificate number (applicable to explosion-proof meter)

j) Protection grade (used for outdoor installation)

k) Manufacture year and month

And other relevant technical indicators.

6.2.3 Flowmeter shall have seal-applied mechanism.

6.2.4 If flowmeter has supporting auxiliary mechanism, the auxiliary mechanism shall have following marks:

a) Manufacturer's name and (or) factory logo

b) Name and model

c) Manufacturing number

d) Supporting flowmeter number (only applicable to dedicated auxiliary mechanism), etc.

6.3 Appearance

6.3.1 Flowmeter shall look good; sealing surface shall be smooth and without damage.

6.3.2 Marks shall be correct, distinct and clear.

6.3.3 Protective glass of indicating mechanism with a dial shall be free of bubbles, cracks, apparent scratches, and other detects that may affect readings and appearances.

6.3.4 Indicating mechanism of having digital wheels shall have clear figures, correct position and normally operating character wheel; and cannot have clamping stagnation phenomenon.

6.3.5 Indicating mechanism with electrical display shall have regular eye-catching numbers

verification at any point of test piping system and flowmeter shall be higher than the saturated vapor pressure. For easily vaporized liquid, there shall be a certain back-pressure at downstream of flowmeter. Recommended back-pressure is 2 times flowmeter pressure loss at maximum flow rate plus 1.25 times saturated vapor pressure of liquid for verification at maximum verification pressure.

7.1.6 Liquid for verification

7.1.6.1 Liquid for verification shall be clean and free of particles, fibers and other substances.

7.1.6.2 Test pipeline shall be full of liquid; liquid shall not be mixed with gases.

7.1.6.3 During one-time verification, temperature variation of verification medium shall not exceed ±0.5°C.

7.1.7 Viscosity of liquid

7.1.7.1 Viscosity of liquid shall be consistent with the viscosity of actually measured by flowmeter to the greatest extent. When other liquids are adopted, error of flowmeter from the difference between liquid for verification and actually measured viscosity of liquid generally shall not exceed 1/3 of maximum permissible error of flowmeter.

7.1.7.2 If the viscosity of working fluid of flowmeter is not greater than 2 mPa • s, or accuracy class is not higher than grade 0.5 (including grade 0.5), and viscosity of liquid for work is not greater than 5 mPa • s; under the premise without causing flowmeter corrosion and damage, it is allowed to use water for verification.

7.1.7.3 If the viscosity of working liquid of flow meter is (5~50) mPa• s, the viscosity of liquid for verification shall not be less than 5 mPa • s, and the difference with the viscosity of working fluid of flow meter shall be generally not greater than 9 mPa • s.

7.1.7.4 If the viscosity of working liquid of flowmeter is greater than 50 mPa • s, then the viscosity of liquid for verification is only required to be not less than 50 mPa • s.

7.1.7.5 If one set of flowmeter is used to measure liquids of various viscosities, respectively use liquids with applicable minimum (or near minimum) and maximum (or near maximum) viscosities for verification.

7.1.7.6 When the liquid for verification cannot meet the provisions of article 7.1.7.1~7.1.7.5, viscosity correction may be carried out based on viscosity correction formula (or correction curve, correction data sheet provided in product instructions of flowmeter) for viscosity correction.

7.1.8 Requirements for supporting equipment

7.1.8.1 Counter

The frequency range of counter is generally (0~10) kHz.

7.1.8.2 When liquid density measurement is required, there shall be densimeter at appropriate accuracy class.

a) For flowmeter that accuracy class is higher than grade 0.5, second-grade standard densitmeter shall be adopted;

b) For flowmeter that accuracy class is grade 0.5 or below, ordinary densimeter may be adopted, division value of densimeter shall not be greater than 0.1% of measured value.

7.1.8.3 When liquid viscosity measurement is required, there shall be viscometer at appropriate accuracy class; and the accuracy of measurement results generally does not exceed 5% of viscosity of measured liquid.

7.1.9 Environmental conditions

Verification shall be generally carried out in following environmental conditions:

a) Atmospheric temperature: (5~35)°C;

b) Relative humidity: 35%~85%;

c) Atmospheric pressure: (86~106) kPa.

7.1.10 During verification, impact of mechanical vibration on flowmeter shall be small enough to be negligible.

7.1.11 Impact of external magnetic field on flowmeter shall be small enough to be negligible.

7.1.12 Online verification requirements

See annex B for online verification requirements.

7.2 Verification items

Verification items of initial verification, subsequent verification and in-use verification are shown in table 2.

standard device (or the recording function of standard device) and flowmeter-to-be-verified (or output function of flowmeter-to-be-verified) simultaneously;

(4) Record the final indicating value of standard device and flowmeter-to-be-verified;

(5) Calculate accumulated flow values recorded by flowmeter and standard device respectively.

7.4 Calculation method

7.4.1 Calculation of standard values

Verify successively based on verification points; respectively calculate actual volumes of liquid at standard device measured during verification. Actual volume *V* of standard devices in common use is calculated as follows.

(1) Pipe prover method

$$V = V_s\left(1 + \frac{D}{E_s e} p_s\right) \cdot [1 + \beta_s (t_s - 20)] \qquad (1)$$

Where,

V_s — Read-out volume of standard device, L;

p_s — Average pressure values of liquid gauge at standard device, Pa;

D — Inner diameter of pipe prover, mm;

e — Wall thickness of pipe prover, mm;

E_s — Elasticity modulus of pipe prover, Pa;

β_s — Coefficient of volume expansion of standard device, $°C^{-1}$;

t_s — Average temperature values of liquids at standard device , °C.

(2) Volume method (measuring vessel has an open structure)

$$V = V_s[1 + \beta_s (t_s - 20)] \qquad (2)$$

(3) Weighing method (weighing container has an open architecture)

$$V = \frac{M}{\rho_s} \cdot C_f \qquad (3)$$

Where,

Annex A

Type Evaluation Program of Liquid Positive Displacement Flowmeter

A.1 Scope

This program applies to type evaluation of liquid positive displacement flowmeter (hereinafter referred to as flowmeter).

A.2 Cited references

Provisions contained in following standards and regulations become provisions of this Regulation by citing.

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

JJF 1016-2009 The Rules for Drafting Program of Pattern Evaluation of Measuring Instruments

GB 4208-2008 Degrees of protection provided by enclosure (IP code)

GB/T 17626.2-2006 Electromagnetic compatibility (EMC) - Testing and measurement techniques - Electrostatic discharge immunity test

GB/T 17626.4-2008 Electromagnetic compatibility - Testing and measurement techniques - Electrical fast transient/burst immunity test

GB/T 17626.5-2008 Electromagnetic compatibility - Testing and measurement techniques - Surge immunity test

GB/T 17626.8-2006 Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test

GB/T 17626.11-2008 Electromagnetic compatibility - Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests

JB/T 9329-1999 Basic environmental conditions and testing methods for instruments transportation and storage in the transportation

When using this Regulation, it shall pay attention to current valid versions of above cited references.

A.3 Technical information and test prototype submitted by application organization

A.3.1 Based on requirements in chapter 5 of JJF 1015.

A.3.2 For flowmeter of which the caliber is less than or equal to 100 mm, 3 sets of prototypes shall be provided; for flowmeter of which the diameter is 100mm~300 mm, 2 prototypes shall be provided; for flowmeter of which the diameter is greater than or equal to 300 mm, 1 prototype shall be provided.

A.3.3 For flowmeter series products for type evaluation, 1/3 products that are of representative specifications including minimum caliber and maximum caliber shall be selected for prototype test.

A.3.4 If technical data review results show any serious defect or shortage, then data and prototype shall be sent back to application organization, and request for correction.

A.4 Legal management requirements

A.4.1 Requirement for unit of measurement

Flowmeter shall adopt legal unit of measurement. Preferred unit of flow measurement is m^3/h; unit of volume is m^3; unit of pressure is MPa or kPa; unit of temperature is °C.

A.4.2 Requirements for accuracy class (maximum permissible error)

Provisions on accuracy class of flowmeter shall meet the requirements in clause 5.1 of this Regulation.

A.4.3 Requirements for legal measuring marks and logos of measuring instruments

Legal measuring marks and logos of measuring instruments must be clearly indicated on nameplate, panel, header, or other distinct parts of flowmeter; the marks and numbers (space shall be left if manufacturing license number is temporarily not available) must be clearly visible, firm and reliable.

A.4.4 Requirements for design of exterior structure

For flowmeter that are not allowed to adjust by users voluntarily, it is necessary to adopt closed structure design or leave space for seal; any man-made mechanical interference that can affect measurement accuracy shall generate permanent physical damage to flowmeter or verification protection mark or protection mark.

A.4.5 If mistakes or non-conformities are found in data check, application organization shall be informed for correction.

A.5 Measurement requirements

A.5.1 Metrological performance indicators of flowmeter shall generally include flow range, accuracy class (maximum permissible error), working pressure range, and applicable viscosity range. These contents shall be explicitly indicated on exterior of flowmeter; other metrological performances shall be indicated in operation instructions.

A.5.2 Maximum permissible error and repeatability of flowmeter shall comply with the provisions in 5.1 and 5.2 of this Regulation.

A.6 Technical requirements

A.6.1 General technical requirements

A.6.1.1 Besides conforming to the requirements in 6.1 of this Regulation, technical data submitted shall also include prototype photo, product standards (including inspection method), rest report of manufacturing unit or technical institution, etc.

A.6.1.2 Check the identification and appearance of flowmeter, which shall conform to the requirements in 6.2 and 6.3 of this Regulation.

A.6.1.3 Shell protection

Protection grade of flowmeters with electronic device shall not be lower than IP54 in GB 4208-2008.

A.6.1.4 Air tightness shall meet the requirements in 6.4 of this Regulation.

A.6.2 Environmental suitability requirements

Flowmeter with electronic device shall comply with following provisions:

When ambient temperature changes to any temperature between -10°C~50°C from (20±2)°C, accumulated flow error of electronic display part of flowmeter shall not exceed 1/3 of basic error limit of accumulated flow.

For each 10°C change of ambient temperature, change of instantaneous flow indicating value of flowmeter shall not exceed 1/3 of basic error absolute value of instantaneous flow.

A.6.3 Alternating damp heat test

Place flowmeter into constant temperature humidity chamber, temperature of which alternates between 25°C and 55°C; keep above 95% relative humidity at lower limit of temperature, while keep 93% relative humidity at upper limit of temperature; when temperature rises, surface of electronic device may have condensed water. The test include two 24-hour cycles; both cycles shall follow the procedures specified in GB/T 2423.4-2008.

A.6.4 Requirement for resistance to transport and storage

Flowmeter in packaging conditions shall be able to withstand following tests according to the provisions of JB/T 9329-1999; the performances after test shall still conform to requirements of this Regulation.

1) High-temperature test (+55°C ± 2°C);

For AC powered flow meter, place for some time long enough in power supply state; adjust power supply voltage within a range of (187~242) V. Prototype shall work properly during test process.

A.6.7.2 DC reverse polarity protection

Two-wire-system DC powered flowmeter shall be free from damage after 1.1 times nominal voltage value is applied between power supply terminals in reverse direction, and kept for 1 min.

A.6.7.3 Power under-voltage protection

Data in flowmeter shall be able to be kept for a long time and not affected by low voltage, battery replacement, etc.

After flowmeter receives above test, retest the indication error of flow points of q_{min}, $0.5q_{max}$ and q_{max}; the results shall conform to the provisions in clause 5.1 of this Regulation.

A.7 Type evaluation conditions and method

A.7.1 Type evaluation conditions

A.7.1.1 Flow standard device for type evaluation test shall meet the requirements in 7.1.1 of this Regulation.

A.7.1.2 Test liquid for type evaluation test shall meet the requirements in 7.1.7 of this Regulation.

A.7.1.3 Environmental conditions for type evaluation test shall meet the requirements in 7.1.9 of this Regulation.

A.7.2 Legal management

Check visually the items, one by one, according to the requirements of A.4.

A.7.3 Accompanying documents, logos and appearance inspection

Check visually, which conforms to the requirements of A.6.1.1 and A.6.1.2.

A.7.4 Shell protection performance test

Shell protection performance test follows the provisions of A.6.1.3 and the method prescribed in GB 4208-2008.

A.7.5 Safety performance impact test

A.7.5.1 Compressive strength test

Fill cavity and channel of flowmeter with test liquid; then increase the pressure to 1.5 times

nominal pressure gradually; maintain for 5 min; flow meter shall be free of damage leakage. Flow meter shall conform to the provisions in A.6.5.2 of this Regulation.

A.7.5.2 Dielectric strength test

A.7.5.3 Insulation resistance test

In general test conditions, insulation resistance test is carried out through 500 V megameter according to the provisions of A.6.5.4, stabilized for 5 s.

A.7.6 Metrological performance test

A.7.6.1 Select test conditions that meet the requirements in A.7.1.

A.7.6.2 Carry out air tightness inspection according to 7.3.1.3 of this Regulation.

A.7.6.3 Select 5 flow points evenly; each flow point receives at least 6 tests.

A.7.6.4 Carry out test based on the method in 7.3 of this Regulation.

A.7.6.5 Calculate relative indication error and repeatability of flowmeter according to the method in 7.4 of this Regulation.

A.7.7 Climatic environment test

Test on impact of ambient temperature changes shall be carried out based on following temperature sequence: +20°C, +40°C, +20°C, 0°C, -10°C, 20°C; each temperature tolerance is ± 2°C; holding time is not less than 2 hours; two cycles are carried out continuously, without any adjustments between them. Test results shall comply with the requirements in A.6.2.

A.7.8 Test on performance of resistance to transport and storage

Test according to the requirements in A.6.4 of this Regulation and the method specified in JB/T 9329-1999.

A.7.9 Electromagnetic compatibility test

A.7.9.1 Electrical transient burst immunity test

In accordance with requirements in A.6.6.1 of this Regulation; pulse rise time is 1 ns; and pulse duration is 50 ns.

A.7.9.2 Electrostatic discharge immunity test

In accordance with requirements in A.6.6.2 of this Regulation, test for 10 times, there is certain time interval between any two discharges.

A.7.9.3 Power frequency magnetic field immunity test

In accordance with the requirements in A.6.6.3 of this Regulation, apply continuous magnetic field to prototype; test field strength is 10 A/m.

A.7.9.4 Surge immunity test

According to the requirements in A.6.6.4 of this Regulation, add positive polarity and negative polarity respectively for at least five times to selected points; repetition rate is not more than once per minute. Surge strength applied is line-line interference 0.5 kV that lasts for 50 μs and line-ground inference 1.0 kV that lasts for 50 μs.

A.7.9.5 Power outage test

According to the requirements in A.6.6.5 of this Regulation, in normal power supply status, power supply is interrupted for 10 times; each interruption interval shall be at least 10 s.

A.7.10 Other electrical performance test

Conduct in accordance with the requirements in A.6.7 of this Regulation and according to the specified items.

A.7.11 Metrological performance test

According to the requirements in A.6.8, each point is verified for 3 times; verification results shall meet the requirements in 5.1 of main-text.

A.7.12 Determination principles

A.7.12.1 Prototype testing process shall meet the requirements in A.6.2~A.6.6 of this Regulation.

A.7.12.2 Prototype with electronic equipment functions shall not have procedure disorders and malfunction; parameters and historical data in prototype shall not change before and after disturbed is applied.

A.8 Determination of type evaluation results

A..8.1 Type evaluation items are divided into major items and non-major items, which are shown in table A.2.

Annex D

Format of inner pages of notice of verification result

(I) Verification conditions

Liquid for verification:

Liquid temperature during verification = °C

Liquid gauge pressure during verification = Pa

Liquid viscosity during verification = mPa·s

(II) Verification results

Flow range: m^3/h

K coefficient = 1/ m^3 or 1/L (only for flowmeter with pulse output)

coefficient K of the last cycle before verification = 1/ m^3 or 1/L

Maximum indication error = %

Repeatability = %

(III) Non-conforming items

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