



BSI Standards Publication

Ultrasonic domestic gas meters

National foreword

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Ultrasonic domestic gas meters

Compteurs de gaz domestiques à ultrasons

Ultraschall-Haushaltsgaszähler

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European foreword

This document (EN 14236:2018) has been prepared by Technical Committee CEN/TC 237 “Gas meters”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2019 and conflicting national standards shall be withdrawn at the latest by April 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 14236:2007.

Changes from previous editions include:

- conformity with the MID 2014/32/EU regarding declared errors of the same sign.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2014/32/EU.

For relationship with EU Directive 2014/32/EU, see informative Annex ZA, which is an integral part of this document.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies requirements and tests for the construction, performance and safety of class 1,0 and class 1,5 battery powered ultrasonic gas meters (hereinafter referred to as meters), having co-axial single pipe, or two pipe connections, used to measure volumes of distributed fuel gases of the second and/or third family, as given in EN 437, at maximum working pressures not exceeding 0,5 bar¹⁾ and maximum actual flow rates of up to 10 m³/h over a minimum ambient temperature range of -10 °C to +40 °C, and minimum gas temperature span of 40 K, for domestic applications. This European Standard applies to meters where the measuring element and the register(s) are enclosed in the same case.

This European Standard applies to meters with and without built-in temperature conversion, that are installed in locations with vibration and shocks of low significance and in

- closed locations (indoor or outdoor with protection as specified by the manufacturer) with condensing or with non-condensing humidity

or, if specified by the manufacturer,

- open locations (outdoor without any covering) with condensing humidity or with non-condensing humidity

and in locations with electromagnetic disturbances.

Unless otherwise stated, all pressures given in this European Standard are gauge pressures.

When more than one meter type is submitted for testing, then each meter type is required to be tested against this European Standard.

Clauses 1 to 15 and Annex C are for design and type testing only.

NOTE See Annex A for production requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

EN 55032, *Electromagnetic compatibility of multimedia equipment - Emission Requirements (CISPR 32)*

EN 60068-2-5, *Environmental testing - Part 2: Tests - Test Sa: Simulated solar radiation at ground level (IEC 60068-2-5)*

EN 60068-2-30, *Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle) (IEC 60068-2-30)*

EN 60079-0, *Explosive atmospheres - Part 0: Equipment - General requirements (IEC 60079-0)*

EN 60079-10, *(all parts), Explosive atmospheres - Part 10: Classification of areas (IEC 60079-10, all parts)*

¹⁾ 1 bar = 1 000 mbar = 10⁵ Pa.

EN 60079-11, *Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i" (IEC 60079-11)*

EN 60079-15, *Explosive atmospheres - Part 15: Equipment protection by type of protection "n" (IEC 60079-15)*

EN 60086-1, *Primary batteries - Part 1: General (IEC 60086-1)*

EN 60086-4, *Primary batteries - Part 4: Safety of lithium batteries (IEC 60086-4)*

EN 60529, *Degrees of protection provided by enclosures (IP Code) (IEC 60529)*

EN 60695-11-5, *Fire hazard testing - Part 11-5: Test flames - Needle-flame test method - Apparatus, confirmatory test arrangement and guidance (IEC 60695-11-5)*

EN 60695-11-10, *Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods (IEC 60695-11-10)*

EN 60730-1:2000, *Automatic electrical controls for household and similar use - Part 1: General requirements (IEC 60730-1:1999)*

EN 61000-4-2, *Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test (IEC 61000-4-2)*

EN 61000-4-3, *Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test (IEC 61000-4-3)*

EN 61000-4-8, *Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test (IEC 61000-4-8)*

EN 61000-4-9, *Electromagnetic compatibility (EMC) - Part 4-9: Testing and measurement techniques — Impulse magnetic field immunity test (IEC 61000-4-9)*

EN 61000-6-1, *Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1)*

EN 61000-6-2, *Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments (IEC 61000-6-2)*

EN 62056-21:2002, *Electricity metering - Data exchange for meter reading, tariff and load control - Part 21: Direct local data exchange (IEC 62056-21:2002)*

EN ISO 1518 (all parts), *Paints and varnishes - Determination of scratch resistance (ISO 1518)*

EN ISO 2409, *Paints and varnishes - Cross-cut test (ISO 2409)*

EN ISO 2812-1:2017, *Paints and varnishes - Determination of resistance to liquids - Part 1: Immersion in liquids other than water (ISO 2812-1:2017)*

EN ISO 4628-2:2016, *Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 2: Assessment of degree of blistering (ISO 4628-2:2016)*

EN ISO 4628-3:2016, *Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 3: Assessment of degree of rusting (ISO 4628-3:2016)*

EN ISO 4892-3, *Plastics - Methods of exposure to laboratory light sources - Part 3: Fluorescent UV lamps (ISO 4892-3)*

EN ISO 6270-1, *Paints and varnishes - Determination of resistance to humidity - Part 1: Condensation (single-sided exposure) (ISO 6270-1)*

EN ISO 6272-1, *Paints and varnishes - Rapid-deformation (impact resistance) tests - Part 1: Falling-weight test, large-area indenter (ISO 6272-1)*

EN ISO 9227, *Corrosion tests in artificial atmospheres - Salt spray tests (ISO 9227)*

ISO 834-1, *Fire-resistance tests - Elements of building construction - Part 1: General requirements*

ISO 7724-3, *Paints and varnishes - Colorimetry - Part 3: Calculation of colour differences*

ASTM D471, *Standard Test Method for Rubber Property - Effect of Liquids*

ASTM D1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

actual flow rate

flow rate at the gas pressure and gas temperature conditions prevailing in the gas distribution line in which the meter is fitted, at the meter inlet

3.1.2

base conditions

fixed conditions to which a volume of gas is converted (i.e. base gas temperature 15 °C, base gas pressure 1 013,25 mbar)

3.1.3

contaminants

gas borne dust, vapour and other substances that could affect the operation of the meter

3.1.4

communications port

galvanic or optical serial data port

3.1.5

display

device (e.g. liquid crystal display) which shows the contents of a memory (e.g. registered volume or flags)

3.1.6**distributed gas**

gas locally available

3.1.7**error of indication (ϵ)**

value which shows the relationship in percentage terms of the difference between the volume indicated by the meter and the volume which has actually flowed through the meter, to the latter volume:

$$\epsilon = \frac{V_i - V_c}{V_c} \times 100$$

where

V_i is the indicated volume in cubic metres (m³);

V_c is the volume in cubic metres (m³) that has actually flowed through the meter

3.1.8**external leak tightness**

leak tightness of the gas carrying components of the gas meter with respect to the atmosphere

3.1.9**flag**

single alphabetic character on the index giving a visual signal of significant events and/or change(s) in the operation of the meter

3.1.10**galvanic connection/interface**

hard wired serial connection or pulse output from the meter

3.1.11**index**

all that which is viewed through the index window, including the display

3.1.12**index window(s)**

area(s) of transparent material through which the index can be read

3.1.13**maximum error shift**

maximum mean error shift at any of the tested flow rates

3.1.14**maximum working pressure**

upper limit of the working pressure for which the meter has been designed, as declared by the manufacturer and marked on the index or the data plate

3.1.15**mean error**

arithmetic mean of consecutive errors of indication at a flow rate

3.1.16

measuring element

part of the meter which produces an electrical signal proportional to the gas flow rate

3.1.17

memory

element which stores digital information

3.1.18

meter case

complete meter, not casing only

3.1.19

meter class

class to which a meter belongs, according to the metrological requirements of this European Standard, i.e. class 1,5 or class 1,0.

3.1.20

meter cover

rigid enclosure on the front of the meter made either wholly of transparent material, or of opaque material provided with index window(s)

3.1.21

normal conditions of operation

conditions referring to the meter operating:

- at a pressure up to the maximum working pressure (with or without a flow of gas);
- within the range of flow rates;
- within the ambient temperature range;
- within the gas temperature range;
- with the distributed gas

3.1.22

operating mode

method (sample frequency and timing) of obtaining volume flow measurements

3.1.23

optical port

serial data port using an infra-red transmitter and receiver

3.1.24

pressure absorption

difference between the pressure measured at the inlet and outlet connections of the meter whilst the meter is operating

3.1.25

pressure measuring point

permanent fitting on the meter outlet enabling a direct measurement of the outlet pressure to be obtained

3.1.26**range of mean errors**

difference between the minimum and maximum mean errors over a specified flow range

3.1.27**regression line**

straight line, generated using a statistical method, to give a graphical representation of a set of results

3.1.28**register**

electronic device comprising both memory and display, which stores and displays information

3.1.29**segment**

individual part of a display which is able to show a portion of a character

3.1.30**starting flow rate**

lowest flow rate at which the meter is able to indicate a volume of gas passed

3.1.31**temperature conversion device**

device which converts the measured volume to a corresponding volume at base gas temperature

3.1.32**Test House**

organization used to perform prescribed tests on meters, in accordance with this standard

3.1.33**thermal cut-off valve**

heat sensitive valve used to cut off the flow of gas to the meter if the ambient temperature rises above a predetermined level for a specified time

3.1.34**ultrasonic gas meter**

gas meter that uses ultrasound and that is designed to measure, memorise and display the fuel gas volume that has passed through it

3.1.35**ultrasonic transducer**

device used to generate and detect the ultrasound signals within the meter

3.1.36**working pressure**

pressure of the gas at the inlet of the meter

3.2 Symbols**3.2.1****D**

outside diameter of the pipe in millimetres (mm)

3.2.2

g

acceleration due to gravity, in metres per square second ($\text{m} \cdot \text{s}^{-2}$)

3.2.3

MPE

maximum permissible error, in percent (%)

3.2.4

p_{max}

maximum working pressure

3.2.5

Q_{max}

maximum flow rate, specified in cubic metres per hour (m^3/h) for which the meter has been designed

3.2.6

Q_{min}

minimum flow rate, specified in cubic metres per hour (m^3/h) for which the meter has been designed

3.2.7

Q_r

overload flow rate, the highest flow rate at which the meter operates for a short period of time without deteriorating

3.2.8

Q_{start}

lowest flow rate at which the meter is capable of registering the passage of gas, as declared by the manufacturer

3.2.9

Q_t

transitional flow rate, occurring between the maximum and minimum flow rates at which the flow rate range is divided into two zones, the 'upper zone' and the 'lower zone'

NOTE Each zone has a characteristic maximum permissible error.

3.2.10

t_b

base gas temperature

3.2.11

$t_{b,i}$

base gas temperature for meters declared suitable for differential temperature and intermittent operation

3.2.12

T_i

temperature at meter inlet

3.2.13 t_m

ambient temperature of the meter

3.2.14 t_g

gas temperature range of the meter

3.2.15 t_{sp}

specified centre temperature for a temperature converted meter

4 Normal operating conditions**4.1 Flow range**

The values of maximum flow rates and those corresponding values of the upper limits of the minimum flow rates shall be those given in Table 1.

Table 1 — Flow range

Q_{max} m ³ /h	Upper limits of Q_{min} m ³ /h
2,5	0,016
4	0,025
6	0,040
10	0,060

The definitions of the meter classifications applicable in this European Standard are given in Table 2.

Table 2 — Flow rate ranges by meter classification

Class	Q_{max}/Q_{min}	Q_{max}/Q_t	Q_r/Q_{max}
1,5	≥ 150	≥ 10	$\geq 1,2$
1,0	≥ 150	≥ 5	$\geq 1,2$

4.2 Maximum working pressure

The manufacturer shall declare the maximum working pressure of the meter and this pressure shall be marked on the index or data plate of the meter. This pressure shall not exceed 0,5 bar.

4.3 Temperature range

Unless otherwise stated, all temperatures given in this document shall be measured to within ± 1 °C.

All meters shall be capable of meeting the requirements for a minimum ambient temperature range of -10 °C to +40 °C (see 5.14), a minimum gas temperature span of 40 K and a storage

temperature of $\leq -20\text{ °C}$ to $\geq +60\text{ °C}$. The gas temperature range shall be within the ambient temperature range.

The manufacturer shall declare the gas temperature range and the ambient temperature range.

The manufacturer can declare a wider ambient temperature range using a minimum temperature of -10 °C , -25 °C or -40 °C and a maximum temperature of 40 °C , 55 °C or 70 °C and/or a wider storage temperature range. The meter shall be capable of meeting the requirements over this declared wider range.

If the manufacturer declares that the meter is resistant to high ambient temperatures, the meter shall also be capable of meeting the requirements of the heat resistance test and shall be marked accordingly (see 7.2.1 and 9.1).

4.4 Range of gases

4.4.1 Test gases

The manufacturer shall specify the range of gases for which the meter is suitable, from Table 3.

Table 3 — Gas groups from EN 437

Second family	Groups	H	L	E
Third family	Groups	P/B	P	B
Additional	Air			

Meters suitable for:

- second family gases shall be tested with air and 99,5 % CH₄.
- third family gases shall be tested with air and 99,5 % Propane and/or 99,5 % Butane, as appropriate.

By agreement with the Test House any other test gas can be included. The additional gases shall be marked on the meter as defined in 9.1.

NOTE For further information on test gases see Annex A.

4.5 Orientation

Where meters can be installed in orientations other than with the connection ports vertical, meters shall be tested in those other orientations, for durability and as agreed with the Test House.

5 Metrological performance

5.1 General

Provision shall be made for synchronizing the start and finish of test periods with test equipment, either via a galvanic connection or optical port.

The test equipment shall generate an event that starts the test. The measured response (volume reading) from the meter shall be synchronous with its sampling instant. To achieve this, the meter shall delay its measured response until the next sample period after it has received a start command.

The sampling instant shall be synchronous with the start of the data transmission string.

NOTE This is used to start/stop an independent timer of sufficient resolution to accurately time the period between successive measure periods.

If it is intended to use the meter in two directions (forward and reverse flow) then all tests shall be performed in both directions.

5.2 Mode comparison

5.2.1 General

If the meter has a normal operating (sampling) mode and one or more test (fast sampling) modes then, provided that the requirement in 5.2.2 is met, all subsequent tests in this European Standard shall be carried out in the test-mode. If the requirement is not satisfied then all subsequent tests shall be performed in the normal operating mode.

5.2.2 Requirements

The accuracy of the measurements shall not be influenced by different sampling modes.

The difference of the mean errors of the standard mode and the test-mode shall not exceed 0,3 % for $Q_t \leq Q \leq Q_{\max}$ and 0,6 % for $Q_{\min} \leq Q < Q_t$.

If this requirement is not satisfied, subsequent tests shall be undertaken in the normal operating mode.

5.2.3 Test

Test the meter in the standard mode and in the test-mode in accordance with 5.3.2 a).

Calculate the difference in mean error at each flow rate.

5.3 Permissible errors

5.3.1 Requirements

The meter, including any additional functionality devices intended by the manufacturer, shall have the error adjusted as close to zero as the adjustments allow, without systematically favouring any party.

When tested in accordance with 5.3.2 a) the mean error shall be within the maximum permissible errors specified in Table 4 and the range of mean errors shall be within the limits specified in Table 5.

When the errors between Q_t and $Q_{\max}$ all have the same sign, they shall not exceed 1 % for class 1,5 and 0,5 % for class 1,0.

When tested in accordance with 5.3.2 b) the mean error shall be within the maximum permissible errors specified in Table 4 and the range of mean errors shall be within the limits specified in Table 5 for each individual test gas at each test temperature.

If the manufacturer has declared a wider ambient and gas temperature range, then the extreme temperatures declared shall be substituted for -10 °C and +40 °C, as appropriate.

After the meter has been subjected to other influences, given by the individual clauses of this European Standard, the mean errors shall be within the error limits specified within those clauses when tested by the methods given in 5.3.2 a) or 5.3.2 b).

5.3.2 Test

a) Error on air

Thermally stabilize the meter to be tested to the temperature of the test laboratory.

Pass a volume of air at 20 °C, the actual volume of which is measured by a reference standard, through the meter and note the volume indicated by the meter. This indicated volume can be obtained via the communication port. The minimum volume of air to be passed through the meter is specified by the manufacturer and agreed with the Test House.

Carry out six consecutive tests at each of the following flow rates in ascending or descending order $Q_{\min}$, $3 Q_{\min}$, $5 Q_{\min}$, $10 Q_{\min}$, $0,1 Q_{\max}$, $0,2 Q_{\max}$, $0,4 Q_{\max}$, $0,7 Q_{\max}$, $Q_{\max}$.

Calculate the six errors of indication (see 3.1.7) at each of the flow rates, the mean of the six errors and note it as a point on the error curve. Then, calculate the difference of the arithmetic mean of the errors of indication at each of the flow rates.

b) Error on gas (excluding air)

Carry out the test as described in 5.3.2 a) and additionally at -10 °C and +40 °C (or that wider temperature range declared by the manufacturer) using the test gases in turn specified in 4.4.1 and any other test gas by agreement with the Test House, which shall be marked on the meter (see 9.1).

Table 4 — Maximum permissible errors, class 1,5 and class 1,0

Flow rate m^3/h	Maximum permissible errors	
	Class 1,5	Class 1,0
$Q_{\min} \leq Q < Q_t$	$\pm 3 \%$	$\pm 2 \%$
$Q_t \leq Q \leq Q_{\max}$	$\pm 1,5 \%$	$\pm 1 \%$

Table 5 — Maximum difference between errors

Flow rate range m^3/h	Maximum range of mean errors	
	Class 1,5	Class 1,0
$Q_{\min} \leq Q < Q_t$	4 %	$1\frac{1}{3} \%$
$Q_t \leq Q < Q_{\max}$	2 %	$\frac{2}{3} \%$

5.4 Gas — air relationship

5.4.1 General

Where meters satisfy the requirements in 5.4.2, air shall be used for subsequent tests as the test medium.

5.4.2 Requirements

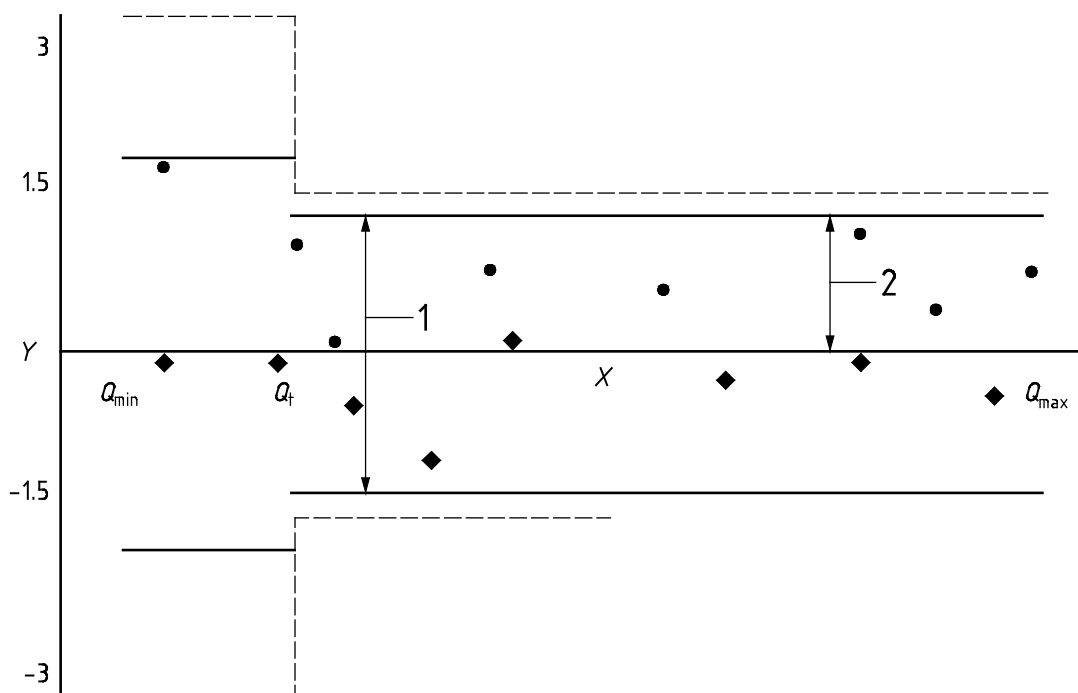
When tested in accordance with 5.4.3 the range of mean errors on all test gases combined (including air) shall be within the limits specified in Table 5 (see X in Figure 1).

The difference between the mean error on the test gases and that on air at each flow rate shall satisfy the limits specified in Table 6 (see Y in Figure 1).

Table 6 — Mean error difference between gas and air

Flow rate m ³ /h	Maximum mean error difference	
	Class 1,5	Class 1,0
$Q_{\min} \leq Q < Q_t$	$\pm 3 \%$	2 %
$Q_t \leq Q \leq Q_{\max}$	$\pm 1,5 \%$	1 %

NOTE Figure 1 represents a graphical explanation of the requirements given in 5.3 and 5.4.

**Key**

- 1 error %
- 2 flow rate Q
- error on gas
- ◆ error on air

NOTE All points are the mean of at least 3 measurements.

Figure 1 — Relationship between defined errors**5.4.3 Test**

Apply the requirements of 5.4.2 to the results from testing the meter in accordance with 5.3.2 a) and 5.3.2 b).

5.5 Pressure absorption**5.5.1 Requirements**

The pressure absorption of the meter with a flow of air of density 1,2 kg/m³, at a flow rate equal to $Q_{\max}$, shall not exceed 2,0 mbar.

5.5.2 Test

Pass air through the meter with a flow of air of density $1,2 \text{ kg/m}^3$, at a flow rate equal to $Q_{\max}$, and measure the differential pressure across the meter with a suitable measuring instrument.

5.6 Metrological stability

5.6.1 Requirements

The difference between any two of the six errors of indication at each flow rate greater than or equal to Q_t shall not exceed 0,6 % and at each flow rate less than Q_t the difference shall not exceed 1,0 %.

5.6.2 Test

Apply the requirements of 5.6.1 to the results from testing the meter in accordance with 5.3.2 a).

5.7 Immunity to contaminants in gas stream

5.7.1 Requirements

When meters are tested in accordance with 5.7.2, the errors of these meters shall not exceed the following:

- Class 1,5 Mean error: 2 *MPE*; Error shift: 2 % between Q_t to $Q_{\max}$;
- Class 1,0 Mean error: *MPE*; Error shift: one third of the *MPE* in Table 4.

After the test in 5.7.2, the pressure absorption tested in accordance with 5.3.2 a) shall not exceed 2,2 mbar.

5.7.2 Test

Test a minimum of 6 meters. Where more than one installation orientation is specified by the manufacturer, test a minimum of 3 meters in each orientation.

The test equipment used for this test need not have absolute traceability provided that each meter is calibrated on equipment that does have such traceability prior to commencing the test.

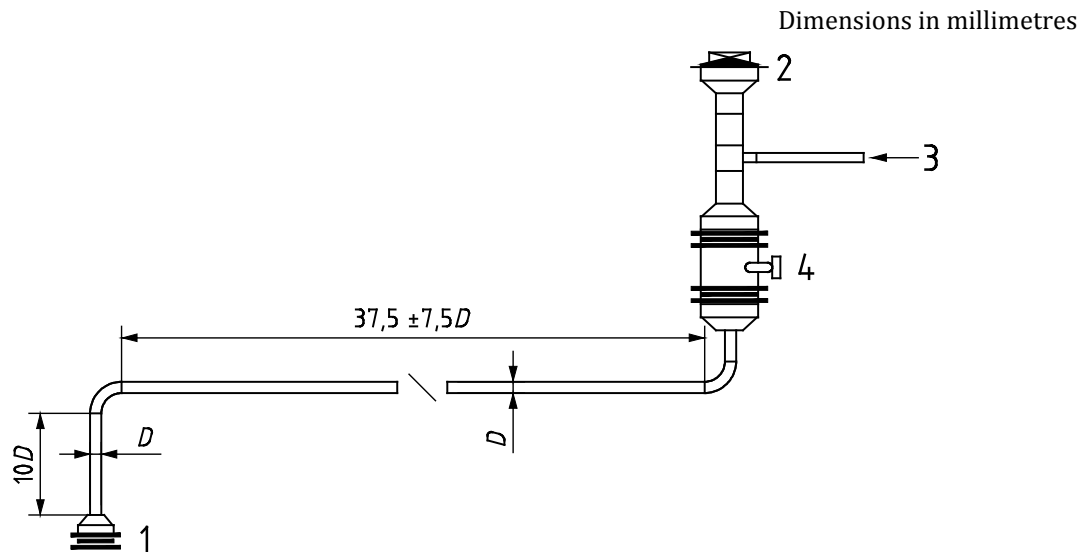
Test the meter in accordance with 5.3.2 a).

Attach the meter to a dust rig that has 10 *D* of vertical pipe before the meter and pass air through the meter for 5 min at $Q_{\max}$. Stop the air supply and add 5 g of 300 to 400 grade dust to the rig inlet. Start the air supply and maintain a flow of $Q_{\max}$ for a further 5 min.

Repeat this procedure with 5 g of each dust grade in the order 200 to 300, 100 to 200 and 0 to 100.

Test the meter in accordance with 5.3.2 a).

For meters covered by this European Standard, $D = 15 \text{ mm}$.



Key

- 1 meter connection
- 2 dust inlet (screwed plug)
- 3 air supply (fan)
- 4 fast acting full bore valve

Figure 2 — Example of a typical test rig for the addition of dust

Referring to Figure 2, the apparatus consists of the following components:

- a) 10 D of vertical parallel bore pipe, to connect to the meter inlet;
- b) a removable screwed plug, for the addition of dust;
- c) a ball valve, to release the dust;
- d) a length of straight pipe 30 D to 45 D in length, to ensure that all dust is airborne before entering the meter;
- e) copper pipework with soldered or compression fittings is preferred. Steel pipe fittings are not recommended as the dust will adhere to the screw threads.

Other designs of test rig can be used, at the discretion of the Test House. Check the effectiveness of a test rig design on a regular basis, using a test box. This is to ensure that when 20 g of dust is added using the procedure mentioned above at least 18 g is deposited inside the test box fitted to the rig outlet. Ensure that the test box has a similar volume and shape to the meter to be tested and fitted with a filter on the outlet to minimize the dust passing through the outlet.

5.7.3 Specification of contamination dust

Four separate batches of dust shall be used with 95 % of the particles in each batch in the appropriate size range given below:

- a) 0 μm to 100 μm Average size $(50 \pm 10) \mu\text{m}$;
- b) 100 μm to 200 μm Average size $(150 \pm 10) \mu\text{m}$;
- c) 200 μm to 300 μm Average size $(250 \pm 10) \mu\text{m}$;
- d) 300 μm to 400 μm Average size $(350 \pm 10) \mu\text{m}$.

Each of the above batches shall have a composition by mass of:

Black iron oxide (Fe_3O_4)	79 %;
Red iron oxide (FeO)	12 %;
Mineral silica flour (SiO_2)	8 %;
Paint residual flake	1 %.

5.8 Installation effects

5.8.1 Requirements

When tested in accordance with 5.8.2, the mean errors at all flow rates shall remain within the *MPE* and the mean error difference at each flow rate shall not exceed one third of the *MPE* specified in Table 4. The meter shall recover from the flow disturbance to be within the *MPE*, specified in Table 4.

5.8.2 Test

Test the meter in accordance with 5.3.2 a) with a straight pipe of length no less than $10 D$ connected to the meter inlet.

Repeat the test, with a pipe of the same diameter as the nominal connection diameter of the meter, but with two 90° elbows with their planes at right angles and not more than $2 D$ apart. Connect this to the meter inlet with the first bend not more than $2 D$ from the inlet.

Repeat the test in accordance with 5.3.2 a) with a straight pipe of length not less than $10 D$ connected to the meter inlet.

5.9 Zero flow

5.9.1 Requirements

Neither the meter display nor the internal register shall change in value (increase or decrease) when the meter is tested by the method given in 5.9.2.

5.9.2 Test

This test is carried out at -10°C , $+20^\circ\text{C}$ and $+40^\circ\text{C}$. If the manufacturer has declared a wider ambient and gas temperature range, then the extreme temperatures declared are substituted for -10°C and $+40^\circ\text{C}$ above as appropriate.

Record the meter display and the internal register of the meter. Fill the meter with dry pure methane at atmospheric pressure and seal the inlet and outlet ports of the meter with gas tight fittings. Allow the meter to stabilize at the test temperature and then store for 24 h at the test temperature. Record the meter display and internal register and subtract the respective first readings from the second readings to indicate any registration change. Repeat the test at each test temperature.

5.10 Reverse flow

5.10.1 Requirements

If the meter has been designed to only be used in one direction, then when tested in accordance with 5.10.2 the register shall neither increase nor decrease. Where an additional reverse flow register is fitted, this shall indicate the passage of the test volume during the test described in 5.10.2.

5.10.2 Test

A test volume of $0,2 Q_{\max}$ is passed through the meter in the reverse direction at a nominal flow rate of $Q_{\max}$. The index reading is recorded before and after the test.

5.11 Low flow registration

5.11.1 Requirements

When tested by the method given in 5.11.2, the starting flow rate shall not be greater than $0,25 Q_{\min}$.

The meter shall also register the passage of gas.

5.11.2 Test

Test the meter in accordance with 5.3.2 a), except that the test shall be carried out at $1,2 Q_{\text{start}}$ with a test volume of $0,01 \text{ m}^3$.

5.12 High flow registration

5.12.1 Requirement

When tested in accordance with 5.12.2 the mean error shall not exceed the *MPE*, specified in Table 4.

5.12.2 Test

Test the meter in accordance with 5.3.2 a) but at $1,2 Q_{\max}$.

5.13 Pulsed (unsteady) flow

5.13.1 General

The normal operating mode of the meter shall have a sample period (T) that does not exceed 2 s, randomised to $\pm 2 \text{ s}$, unless the manufacturer can demonstrate that a proposed longer sampling rate will not cause the metrological characteristics of the meter to be significantly impaired by pulsed or unsteady flow. Where the mean sample period is longer than 2 s, the tests of 5.13.3 shall still be applied.

5.13.2 Requirements

The difference between the cumulative volume at the ends of test runs 2 and 6, (see Table 7), and the cumulative volume at runs 1 and 5 respectively, shall not exceed two thirds of the total *MPE* range specified in Table 4.

The difference between the cumulative volume at the ends of test runs 3, 4, 7 and 8, (see Table 7), and the cumulative volume at runs 1 and 5 respectively shall not exceed one third of the total *MPE* range specified in Table 4.

The observed standard deviation of the error with stepping flow shall be within a range of 0,75 to 1,25 times the calculated standard deviation of the error.

Test 5.13.3 shall be performed with the meter in its normal operating mode.

5.13.3 Test

Subject the meter to flow conditions specified in Table 7 with either continuous or square wave airflow at the on/off timings and flow rates, for a duration of 24 h, recording the start and end index volumes of each test.

Table 7 — Unsteady flow runs

Run	Flow rate	Flow (wave form) where T = sampling period
1	$0,375 Q_{\max}$	Continuous
2	$0,375 Q_{\max}$	1,05 T on, 1,05 T off
3	$0,375 Q_{\max}$	5,25 T on, 5,25 T off
4	$0,375 Q_{\max}$	10,5 T on, 10,5 T off
5	$0,07 Q_{\max}$	Continuous
6	$0,07 Q_{\max}$	1,05 T on, 1,05 T off
7	$0,07 Q_{\max}$	5,25 T on, 5,25 T off
8	$0,07 Q_{\max}$	10,5 T on, 10,5 T off

The following formula is used to calculate the standard deviation (s_d) as a percentage of the total volume of gas passed during a test:

$$s_d = \frac{50 \cdot T}{S \cdot N^{1/2}}$$

where

- T is the sampling period, in seconds (s);
- S is the duration of each 'on period', in seconds (s);
- N is the number of 'on periods' during the test.

5.14 Temperature sensitivity

5.14.1 Requirements

When tested in accordance with 5.14.2 the meter shall meet the following requirements:

- that all results shall be within the errors shown in Table 4;
- that no error of indication shall differ from its regression line by more than 1 % for class 1,5 and $\frac{2}{3}$ % for class 1,0.

5.14.2 Test

Install the meter on an appropriate test rig, see Figure C.1, and stabilize the meter at the starting temperature of the test for a period of 3 h prior to commencing the change of temperature at the rate specified below.

Test the meter in accordance with 5.3.2 b) at a flow rate of $0,05 Q_{\max}$ using test gas as specified in 4.4.1, according to meter type. Repeat this test at a frequency of three or four tests per hour while changing the ambient temperature from $-10\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$ at a rate of $2\text{ }^{\circ}\text{C/h}$ with the relative humidity not exceeding 50 %.

Calculate the regression lines of the errors of indication over temperature.

6 Construction and materials

6.1 General

The gas meter shall be constructed in such a way that any mechanical interference capable of affecting the measuring accuracy results in permanently visible damage to the gas meter or the verification or protection marks.

Any means of adjusting the performance characteristics of the meter shall be effectively secured and protected against unauthorized interference.

Electronic seals shall comply with the following requirements:

- access shall only be obtained by using a password or a code that can be updated, or by using a specific device;
- the last intervention, at least, shall be registered in the memory, including date and time of intervention and a specific element to identify the intervention;
- it shall be possible to have access to the intervention(s) registered in the memory for a minimum period of two years.

The meter connections shall be fitted with suitable non-sealing caps or covers to protect any threads and to prevent the entry of foreign matter during transit and storage.

A sealing drawing shall be part of the documentation for type approval. It shall include the metrological sealing as well as all other tamper evident seals.

6.2 Robustness of meter case

6.2.1 General

Parts of the meter case in direct contact with the ambient air on the outside and with the gas on the inside shall be of sufficient thickness to meet the requirements of 6.2.

The meter case shall be constructed and arranged so that any non-permanent deformation cannot prevent the satisfactory operation of the meter.

The meter shall have a meter case that can be sealed in such a way that the internal parts of the meter are accessible only after breaking the metrological seal(s) or causing clear evidence of interference.

6.2.2 Protection against penetration of dust and water

6.2.2.1 Requirements

The meter shall be designed in such a way that it gives protection against the ingress of dust and water so that it conforms, as a minimum, to the IP 54 degree of protection, in accordance with EN 60529.