



BSI Standards Publication

Gas meter — Thermal-mass flow-meter based gas meter

National foreword

This British Standard is the UK implementation of EN 17526:2021+A1:2025. It supersedes BS EN 17526:2021, which is withdrawn.

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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English Version

Gas meter - Thermal-mass flow-meter based gas meter

Compteurs de gaz - Compteur de gaz basé sur un débitmètre massique par effet thermique

Gaszähler - Thermische Massendurchflussgaszähler

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European foreword

This document (EN 17526:2021+A1:2025) 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of an identical text or by endorsement, at the latest by October 2025, and conflicting national standards shall be withdrawn at the latest by October 2025.

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 includes Amendment 1 approved by CEN on 15 December 2024.

This document supersedes EN 17526:2021.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZA, which is an integral part of this document.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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1 Scope

This document specifies requirements and tests for the construction, performance, safety and production of battery powered class 1,5 Capillary Thermal-Mass Flow sensor gas meters (hereinafter referred to as meter(s)). This applies to meters having co-axial single pipe, or two pipe connections, which are used to measure volumes of fuel gases of the 2nd and/or 3rd family, as given in EN 437:2018.

In general, the term “thermal mass flow meters” applies to a flow-measuring device using heat transfer to measure and indicate gas flowrate, as defined in ISO 14511.

NOTE 1 Although the word “mass” is present in the definition of the measurement principle, gas meters covered by this document provide measurement of gas at base conditions of temperature and pressure.

These meters have a maximum working pressure not exceeding 0,5 bar and a maximum flowrate not exceeding 160 m³/h over a minimum ambient temperature range of –10 °C to +40 °C and a gas temperature range as specified by the manufacturer with a minimum range of 40 °C.

This document applies to meters indicating volume at base conditions, which are installed in locations with vibration and shocks of low significance. It applies to meters in:

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

or, if specified by the manufacturer:

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

and in locations with electromagnetic disturbances likely to be found in residential, commercial and light industrial use.

For meters which indicate unconverted volume, reference can be made to Annex C.

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

Requirements for electronic indexes, valves and additional requirements for batteries incorporated in the meter and any other additional functionalities are given in EN 16314:2013.

Unless otherwise stated in a particular test, the tests are carried out on meters that include additional functionality devices intended by the manufacturer.

Clauses 1 to 13 are for design and type testing only.

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 437:2018, *Test gases — Test pressures — Appliance categories*

EN 549:2019, *Rubber materials for seals and diaphragms for gas appliances and gas equipment*

EN 1092-1:2018, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 16314:2013, *Gas meters — Additional functionalities*

EN ISO 228-1:2003, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation (ISO 228-1:2000)*

EN ISO 1518-1:2019, *Paints and varnishes — Determination of scratch resistance — Part 1: Constant-loading method (ISO 1518-1:2019)*

EN ISO 2409:2020, *Paints and varnishes — Cross-cut test (ISO 2409:2020)*

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 4892-3:2016, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps (ISO 4892-3:2016)*

EN ISO 6270-1:2018, *Paints and varnishes — Determination of resistance to humidity — Part 1: Condensation (single-sided exposure) (ISO 6270-1:2017)*

EN ISO 6272-1:2011, *Paints and varnishes — Rapid-deformation (impact resistance) tests — Part 1: Falling-weight test, large-area indenter (ISO 6272-1:2011)*

EN ISO 9227:2017, *Corrosion tests in artificial atmospheres — Salt spray tests (ISO 9227:2017)*

EN ISO/CIE 11664-4:2019, *Colorimetry — Part 4: CIE 1976 L*a*b* colour space (ISO/CIE 11664-4:2019)*

EN 50561-1:2013, *Power line communication apparatus used in low-voltage installations — Radio disturbance characteristics - Limits and methods of measurement — Part 1: Apparatus for in-home use*

EN 55032:2015, *Electromagnetic compatibility of multimedia equipment — Emission Requirements*

EN IEC 60079-0:2018¹, *Explosive atmospheres — Part 0: Equipment — General requirements (IEC 60079-0:2017)*

EN 60079-10-1:2015, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres (IEC 60079-10-1:2015)*

EN 60079-11:2012, *Explosive atmospheres — Part 11: Equipment protection by intrinsic safety “i” (IEC 60079-11:2011)*

EN IEC 60079-15:2019, *Explosive atmospheres — Part 15: Equipment protection by type of protection “n” (IEC 60079-15:2017)*

¹ As impacted by EN IEC 60079-0:2018/AC:2020-02.

EN 60529:1991², *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

EN 60695-11-5:2017, *Fire hazard testing — Part 11-5: Test flames — Needle-flame test method - Apparatus, confirmatory test arrangement and guidance (IEC 60695-11-5:2016)*

EN 60695-11-10:2013³, *Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods (IEC 60695-11-10:2013)*

EN 60730-1:2016⁴, *Automatic electrical controls — Part 1: General requirements (IEC 60730-1:2013 , modified + COR1:2014)*

EN 61000-4-2:2009, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test (IEC 61000-4-2:2008)*

EN 61000-4-3:2006⁵, *Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test (IEC 61000-4-3:2006)*

EN 61000-4-8:2010, *Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test (IEC 61000-4-8:2009)*

EN 61000-6-1:2007, *Electromagnetic compatibility (EMC) — Part 6-1: Generic standards — Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1:2005)*

EN 61000-4-9:2016, *Electromagnetic compatibility (EMC) — Part 4-9: Testing and measurement techniques — Impulse magnetic field immunity test (IEC 61000-4-9:2016)*

EN IEC 61000-6-2:2019, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity standard for industrial environments*

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)*

ISO 834-1:1999, *Fire resistance tests — Elements of building construction — Part 1: General requirements*

ISO 12213-2:2006, *Natural gas — Calculation of compression factor — Part 2: Calculation using molar-composition analysis*

ASTM D 1003-13, *Standard Test Method for Haze and Luminous Transmittance of transparent plastics*

² As impacted by EN 60529:1991/AC:2006-12, EN 60529:1991/A1:2000, EN 60529:1991/A2:2013 and EN 60529:1991/A2:2013/AC:2019-02.

³ As impacted by EN 60695-11-10:2013/AC:2014.

⁴ As impacted by EN 60730-1:2016/A1:2019.

⁵ As impacted by EN 61000-4-3:2006/A1:2008, EN 61000-4-3:2006/A2:2010 and EN 61000-4-3:2006/IS1:2009.

3 Terms, definitions and symbols

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 Terms and definitions

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

additional functionality

functions over and above that within the meter, which can be integral to the meter, or included within a connected device

3.1.3

additional functionality device

device that carries out additional functionalities

3.1.4

base conditions

fixed conditions to which a volume of gas is converted (e.g. base gas temperature 273,15 K plus 15 K at base gas pressure of 1 013,25 mbar)

3.1.5

class 1,5 meter

accuracy achieved by a meter, which has an error of indication between -3% and $+3\%$ for flow rates Q , where $Q_{\min} \leq Q < Q_t$, and an error of indication between $-1,5\%$ and $+1,5\%$ for flow rates Q , where $Q_t \leq Q \leq Q_{\max}$, where $Q_{\max}$ to $Q_{\min} > 150$ and $Q_{\max}$ to $Q_t \geq 10$ and Q_t to $Q_{\max}$ is 1,2

3.1.6

contaminants

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

3.1.7

display

device which shows information from the meter (e.g. liquid crystal that displays registers, volume or flags)

3.1.8

distributed gas

locally available gas

3.1.9**disturbance**

influence quantity having a value within the limits specified but outside the specified rated operating conditions of the measuring instrument

Note 1 to entry: An influence quantity is a disturbance if the rated operating conditions for that influence quantity are not specified.

3.1.10**durability**

ability of an instrument to maintain its performance characteristics over a specified period of use

3.1.11**error of indication**

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 value:

Note 1 to entry:

$$\varepsilon = 100 \frac{V_i - V_c}{V_c}$$

where

V_i is the indicated volume;

V_c is the volume which has actually flowed through the meter.

3.1.12**event**

condition requiring action or to log an action

3.1.13**external leak tightness**

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

3.1.14**galvanic connection/interface**

hard wired serial connection or pulse output from the meter

3.1.15**gas meter**

instrument designed to measure, memorize and display the volume of fuel gas that has passed through it

3.1.16**gauge pressure**

absolute pressure minus atmospheric pressure

3.1.17**index**

current reading of the total volume passed through the meter

3.1.18

maximum operating pressure

maximum pressure at which a system can be operated continuously under normal conditions

Note 1 to entry: Normal conditions are no fault in any device or stream.

3.1.19

maximum error shift

maximum mean error shift at any of the tested flow rates

3.1.20

maximum flow rate

highest flow rate at which the gas meter provides indications that satisfy the requirements regarding maximum permissible error (MPE)

3.1.21

maximum permissible error

extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications for a given measurement, measuring instrument, or measuring system

3.1.22

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

3.1.23

mean error

arithmetic mean of consecutive errors of indication at a flow rate

3.1.24

memory

element which stores digital information

3.1.25

meter case

pressure containing structure of the meter

3.1.26

meter class

class to which a meter belongs, according to the metrological requirements of this document, i.e. class 1,5

3.1.27

meter error curve

plot of average error of indication against actual flow rate

3.1.28

minimum flow rate

lowest flowrate at which the gas meter provides indications that satisfy the requirements regarding MPE

3.1.29**normal conditions of use**

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 and gas temperature range;
- with the distributed gas

3.1.30**pressure absorption**

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

3.1.31**pressure measuring point**

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

3.1.32**operating mode**

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

3.1.33**optical port**

serial data port using an infra-red transmitter and receiver

3.1.34**overload flow rate**

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

3.1.35**reference conditions**

condition of use prescribed for testing the performance of a measuring instrument or for inter-comparison of results of measurements

3.1.36**register**

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

3.1.37**sensor**

element of a measuring instrument or measuring chain that is directly affected by the measurand

3.1.38**software identifier**

sequence of characters, that identifies the software; the identifier is logically considered a part of the software

3.1.39**starting flow rate**

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

3.1.40

storage temperature range

range of temperatures at which the meter can be stored without being adversely affected

3.1.41

thermal mass flow-meter

TMF meter

flow-measuring device which uses heat transfer to measure and indicate mass flowrate

Note 1 to entry: The term thermal mass flowmeter also applies to the measuring portion of a thermal mass flow controller and not the control function.

[SOURCE: ISO 14511:2019, 3.2.3]

3.1.42

transitional flow rate

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, each zone having a characteristic MPE

3.1.43

volume

volume without specifying whether it is a corrected volume at measurement conditions or an uncorrected volume at measurement conditions

3.1.44

working pressure

difference between the pressure of the gas at the inlet of the meter and the atmospheric pressure

3.2 Symbols

D	outside diameter of the pipe in millimetres (mm)
g	acceleration due to gravity, in metres per square second ($\text{m} \cdot \text{s}^{-2}$)
H_i	lower calorific value
H_s	upper calorific value
MPE	maximum permissible error, in percent (%)
p_b	base pressure to which the indicated volume is referred
$p_{\max}$	maximum operating pressure
$Q_{\max}$	maximum flow rate
$Q_{\min}$	minimum flow rate
Q_r	overload flow rate
Q_{start}	starting flow rate
Q_t	transitional flow rate
Q_x	distributed air or gas flow, referred to the base conditions of the meter, with $x = \text{min, max, } t, r$; as described below
t_b	base reference temperature to which the indicated volume is referred
t_g	gas temperature

t_m	ambient temperature
t_{max}	maximum operating temperature
t_{min}	minimum operating temperature
t_{sp}	specified centre temperature for a temperature converted meter
V_b	volume read by the meter, at base conditions
W_i	lower Wobbe index
W_s	upper Wobbe index
ε	error of indication

4 Working conditions

4.1 General

If no specific requirements are given, the test equipment shall be traceable to a national or international reference standard error of and the uncertainty shall be equal or better than:

- a) for type evaluation: 1/5 of the maximum permissible error (*MPE*);
- b) for verifications: 1/3 of the maximum permissible error (*MPE*).

4.2 Base conditions

Base conditions of temperature (t_b) and pressure (p_b) shall be specified by the manufacturer and marked on the data plate of the meter.

In particular, the following formula applies for the conversion of test volumes to the base conditions of the meter under test:

$$V_{t_b, p_b} = V_a \cdot \frac{t_b (^\circ C) + 273,15}{t_a (^\circ C) + 273,15} \cdot \frac{p_a (bar)}{p_b (bar)} \quad \text{where } p_a = p_{amb} + p_{gauge} \quad (1)$$

where

- p_a is the absolute inlet pressure of the meter under test, i.e. the sum of two pressure contributes defined as follows:
 - p_{amb} : barometric pressure during test;
 - p_{gauge} : inlet gauge pressure of meter under test;
- t_a is the steady temperature of the test volume;
- V_a is the volume at actual condition.

4.3 Flow range

The flow rate range shall be one of those given in Table 1.

Table 1 — Flow rate range

$Q_{\max}$ (m ³ /h)	Upper limits of $Q_{\min}$ (m ³ /h)	Upper limit of Q_t (m ³ /h)	Q_r (m ³ /h)
2,5	0,016	0,25	3,0
4	0,025	0,4	4,8
6	0,040	0,6	7,2
10	0,060	1,0	12,0
16	0,10	1,6	19,2
25	0,16	2,5	30,0
40	0,25	4,0	48,0
65	0,40	6,5	78,0
100	0,65	10,0	120,0
160	1,00	16,0	192,0

A gas meter may have a lower value for the minimum flow rate, $Q_{\min}$, than that shown in Table 1, but this lower value shall be equal to one of the values shown in the table or to a decimal submultiple of these values.

The values given in Table 1 ensure the minimum turndown ratio given in Table 2.

Table 2 — Turndown ratio

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

4.4 Maximum working pressure

The manufacturer shall declare the maximum working pressure of the meter which shall not exceed 0,5 bar.

4.5 Temperature range

4.5.1 General

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

4.5.2 Ambient temperature range

All meters shall be designed for a minimum ambient temperature range of -10 °C to $+ 40$ °C. This shall be verified by conforming with the requirements given in Clause 5 and Clause 6.

The manufacturer can declare a wider design temperature range but shall use the minimum and maximum temperature limits as specified in Table 3 and Table 4.

Table 3 — Upper temperature limit

Upper temperature limit of $t_{\max}$			
30 °C	40 °C	55 °C	70 °C

Table 4 — Lower temperature limit

Lower temperature limit of $t_{\min}$			
5 °C	– 10 °C	– 25 °C	– 40 °C

4.5.3 Gas temperature range

All meters shall be designed for a gas temperature range equal to, or within, the ambient temperature range, with a minimum span of 40 °C. Upper and lower limit of gas temperature shall be chosen in accordance with Table 3 and Table 4. This shall be verified by conforming with the requirements of 5.3.1 and 5.9.

4.5.4 Storage temperature range

All meters shall be designed for a storage temperature range of –20 ° to 60 °C, and in any case shall have a range equal to or wider than the declared ambient temperature range. This shall be verified by conforming with the requirement of 6.9.

4.6 Range of gases

The manufacturer shall specify the range of gases for which the meter has been designed, in terms of gas families, for at least one group in accordance with EN 437:2018.

Additionally, the meter shall also be designed for working on air; therefore fulfilling air-gas relationship requirements specified in 5.4.

Conformity to gas families, or pertaining groups, for which the meters have been designed, shall be included in the technical design file of the instrument.

Therefore, the meter shall be tested with:

- a) air;
- b) test gases representing the variability of distributed gases within the respective groups (see Annex B).

4.7 Installation orientation

Where more than one installation orientation is specified in the manufacturer's instruction manual, meters shall be tested in all these orientations.

5 Metrological performance

5.1 General

Where the manufacturer declares that the meter can be used in two directions (forward and reverse flow) then all tests shall be performed in both directions.

The flow rate shall be determined using sampling times that are not readily predictable within discrete time intervals.

These time intervals (T) shall not exceed 2 s, unless the manufacturer can demonstrate that a proposed longer time interval will not cause the metrological characteristics of the meter to be affected by unsteady flow conditions.

Irrespective of whether the discrete time intervals are longer than 2 s, the requirements specified in 5.13.2 shall still be applied.

Provision shall be made for synchronizing the start and finish of test periods (with test equipment), according to manufacturer specification, e.g. via a galvanic connection or optical port.

Any failure in synchronizing test equipment with the meter under test may introduce an error contribution, calculated as follows:

$$\varepsilon_{\%}^{\text{MAX}}(\tau, t) = 2 \cdot \frac{\tau}{t} \cdot 100 \quad (2)$$

where

τ is the maximum sampling time of the meter under test, in seconds;

t is the test time, in seconds.

Where τ is not specified by manufacturer, $\tau = 2$ s shall be used in the calculation.

The meter shall have a mode, providing volume resolution of at least 0,1 dm³.

The meter shall have a fast sampling mode with sampling time not exceeding 0,5 s.

NOTE This mode can be accessible via the display even without any external tools, e.g. by means of a dedicated display menu. In operative conditions, the meter can be protected by password and not accessible to final user.

All modes other than the normal mode shall only be active for a maximum time of 24 h before reverting to normal operating mode.

5.2 Test mode comparison

5.2.1 General

When the meter has one or more fast sampling modes in addition to the normal operating mode, then provided the requirements in 5.2.2 are met, all subsequent tests requiring steady flow profiles in this document shall be carried out using the same test mode. If the requirements in 5.2.2 are not satisfied, then all subsequent tests shall be performed in normal operating mode.

Where specific modes of measurement for managing flow outside the controlled range are present in the normal operating mode, these can be disabled in test mode, unless otherwise specified in this document.

Provision shall be made to ensure that any test gas is properly detected by the meter under test. In particular, where the meter has a gas detection system that occurs at a fixed time interval, the gas detection procedure shall also be performed whenever the test mode is activated.

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 normal operating mode and the test mode shall not exceed the following limits:

- 0,6 % for any flow rate $Q_{\min} \leq Q < Q_t$;
- 0,3 % for any flow rate between $Q_t \leq Q \leq Q_{\max}$.

In both modes, the mean error shall be within the maximum permissible errors as specified in Table 5.

5.2.3 Test

Test the meter in the normal operating mode and in the test mode in accordance with 5.3.2, Table 6, Test a). Calculate the difference in mean error at each flow rate, and ensure that requirements in 5.2.2 are met.

5.2.4 Test mode in flow (optional)

5.2.4.1 General

Where the meter provides instantaneous flow rate readings, these can be used as an alternative to volume for calculating the error of measurement at steady flow profiles, unless otherwise specified in this document.

5.2.4.2 Requirements

Select the test mode, and carry out the test in accordance with 5.2.4.3 at a given steady test flow rate. The difference of the mean errors of the normal operating mode and the test mode shall not exceed the limits given in 5.2.2, as detailed below:

- 0,6 % for any flow rate $Q_{\min} \leq Q < Q_t$;
- 0,3 % for any flow rate between $Q_t \leq Q \leq Q_{\max}$.

5.2.4.3 Test

Test the meter in the normal operating mode and in the test mode in flow in accordance with 5.3.2, Table 6, Test a).

Calculate the difference in mean error at each flow rate, using the following equations, and ensure that error is within the limits specified in 5.2.4.2.

$$E_x = \frac{V_b - V_c}{V_c} \cdot 100; \quad \varepsilon_x = \frac{Q_b - Q_c}{Q_c} \cdot 100 \quad (3)$$

where

- E_x is the mean error in volume, expressed as a percentage;
- ε_x is the mean error in flow, expressed as a percentage;
- V_b is the volume read by the meter, at base conditions;
- V_c is the volume read by the reference instrument, converted to meter under test base conditions;
- Q_b is the flow rate read by the meter, at base conditions;
- Q_c is the flow rate read by the reference instrument, converted to meter under test base conditions. Q_c can be either measured directly or inferred by ratio $Q_c = V_c / t_x$ where t_x is the test duration at any given steady test flowrate.

5.3 Permissible errors

5.3.1 Requirements

The meter shall be adjusted as given in Method a) and b).

The manufacturer shall declare which of the following two methods has been adopted:

Method a): Weighted Mean Error (WME) between $-0,6\%$ and $0,6\%$; or

Method b): when the errors between Q_t and $Q_{\max}$ all have the same sign, not exceeding $1,3\%$.

When tested in accordance with 5.3.2, the mean error E_x for both air and test-gases shall be within the maximum permissible errors specified in Table 5. This also shall apply to measurements at maximum operating pressure and at minimum and maximum declared temperature including any additional test temperature comprised between $T_{\min}$ and $T_{\max}$.

As the meter provides converted volume at base conditions, the *MPE* of the meter shall be increased by $0,5\%$ in a range of $30\text{ }^{\circ}\text{C}$ extending symmetrically around the temperature t_{sp} specified by the manufacturer that lies between $15\text{ }^{\circ}\text{C}$ and $25\text{ }^{\circ}\text{C}$ (for instance between $0\text{ }^{\circ}\text{C}$ and $30\text{ }^{\circ}\text{C}$ if $t_{\text{sp}} = 15\text{ }^{\circ}\text{C}$). Outside this range, an additional increase of $0,5\%$ is permitted in each interval of $10\text{ }^{\circ}\text{C}$.

Table 5 — Maximum Permissible Errors for volume at base conditions

Flow rate	Maximum Permissible Error for volume at base conditions
$Q_{\min} \leq Q < Q_t$	$\pm 3,5\% [= \pm(3,0 + 0,5)\%]$
$Q_t \leq Q \leq Q_{\max}$	$\pm 2,0\% [= \pm(1,5 + 0,5)\%]$

Where the manufacturer declares the meter measures actual volume, Annex C can be applied.

5.3.2 Test

5.3.2.1 General

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

Pass a volume of air or gas, the actual volume of which is measured by a reference standard, through the meter and note the volume indicated by the meter. The minimum volume of air or gas to be passed through the meter is specified by the manufacturer and agreed with the test house.

Carry out the tests specified in 5.3.2.4 and 5.3.2.5 in any order, then record n errors at each of the flow rates, and calculate their mean value.

5.3.2.2 Method a)

If method a) is chosen (see 5.3.1), calculate the WME using the mean values at different flow rates, in accordance with the following Formula (4):

$$WME = \frac{\sum_{i=1}^n k_i E_i}{\sum_{i=1}^n k_i} \quad \text{with } k_i = \begin{cases} \frac{Q_i}{Q_{\max}} & \text{for } Q_i \leq 0,7Q_{\max} \\ 1,4 - \frac{Q_i}{Q_{\max}} & \text{for } 0,7Q_{\max} < Q_i \leq Q_{\max} \end{cases} \quad (4)$$

where

k_i is the weighting factor at the flow rate Q_i ;

E_i is the error at the flow rate Q_i .

5.3.2.3 Method b)

If method b) is chosen (see 5.3.1), determine whether any errors between Q_t and $Q_{\max}$ all have the same sign, not exceeding 1 %.

5.3.2.4 Air and gas errors

Test the meter using air and the test gases specified by the manufacturer in accordance with 5.3.2, Table 6, Test a).

5.3.2.5 Temperature errors

Test the meter on air at $T_{\min}$ and $T_{\max}$ (see 4.5) in accordance with 5.3.2, Table 6, Test b).

Table 6 — Error test on air and gases

Test	Test flow rates	Number of consecutive tests in air (n)	Minimum number of consecutive tests in gas (n) ^a
a)	$Q_{\min}, 3 Q_{\min}, 5 Q_{\min}, 10 Q_{\min}, 0,1 Q_{\max}, 0,2 Q_{\max}, 0,4 Q_{\max}, 0,7 Q_{\max}, Q_{\max}$	6	2
b)	$Q_{\min}, 3 Q_{\min}, 5 Q_{\min}, 10 Q_{\min}, 0,1 Q_{\max}, 0,2 Q_{\max}, 0,4 Q_{\max}, 0,7 Q_{\max}, Q_{\max}$	3	2
c)	$Q_{\min}, 0,1 Q_{\max}, Q_{\max}$	3	2
d)	$0,1 Q_{\max}, Q_{\max}$	3	2
^a Refer to 5.4.1 below.			

5.4 Gas-air relationship

5.4.1 General

Where meters fulfil the requirements in 5.4.2, all of the following tests shall be carried out on air only.

5.4.2 Requirements

The difference between the mean errors (i.e. the error of indication of the meter) on the test gases and on air, at each of the flow rates, shall be within the limits specified in Table 7.

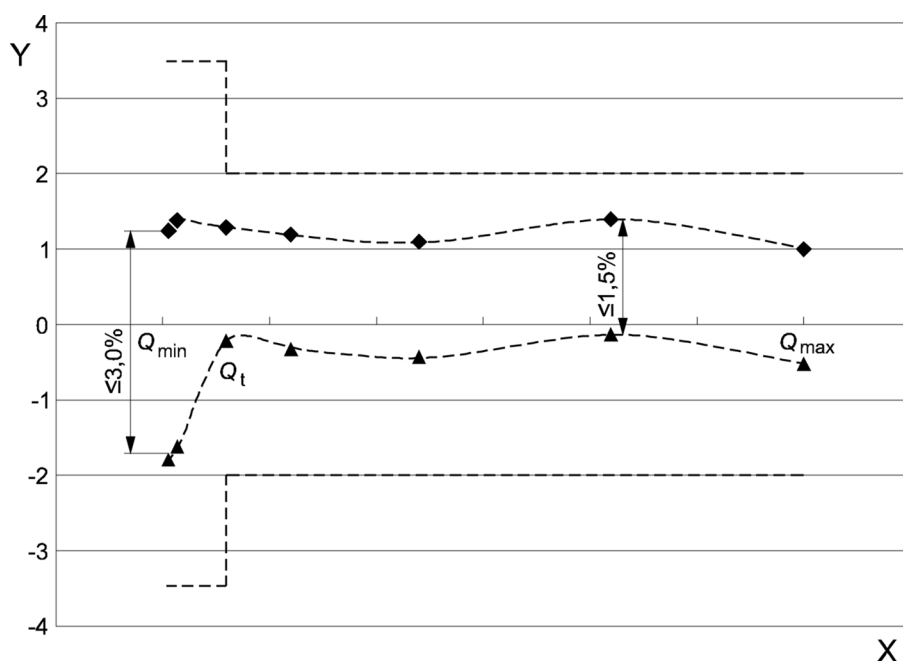
If the requirements given in Table 7 are not fulfilled, then all subsequent tests shall be carried out using both air and test gases. See Figure 1.

Table 7 — Mean error difference between air and gas at given flow rate

Flow rate	Maximum mean error difference for class 1,5
$Q_{\min} \leq Q < Q_t$	3,0 %
$Q_t \leq Q \leq Q_{\max}$	1,5 %

5.4.3 Test

Apply the requirements of 5.4.2 to the results from testing the meter in air and gas in accordance with 5.3.2, Table 6, Test a).



Key

- X flow rate
- Y error %
- class 1,5
- maximum mean error difference
- ◆— error curve on air
- ▲— error curve on gas

Figure 1 — Maximum mean error difference between air and gas for class 1,5

5.5 Pressure absorption

5.5.1 Requirements

The pressure absorption of a meter with a flow of air with a density of $1,2 \text{ kg}\cdot\text{m}^{-3}$, at a flow rate equal to $Q_{\max}$, shall not exceed the values given in Table 8.

Table 8 — Pressure absorption

$Q_{\max} \text{ (m}^3/\text{h)}$	Maximum permissible values for pressure absorption	
	Initial (mbar)	Endurance (mbar)
$2,5 \leq Q_{\max} \leq 16$	2,0	2,2
$25 \leq Q_{\max} \leq 65$	3,0	3,3
$Q_{\max} = 100, Q_{\max} = 160$	4,0	4,4

5.5.2 Test

Supply the meter under test with a flow of air at a flow rate equal to $Q_{\max}$ and measure the differential pressure across the meter using a suitable measuring instrument, accurate to 0,1 mbar.

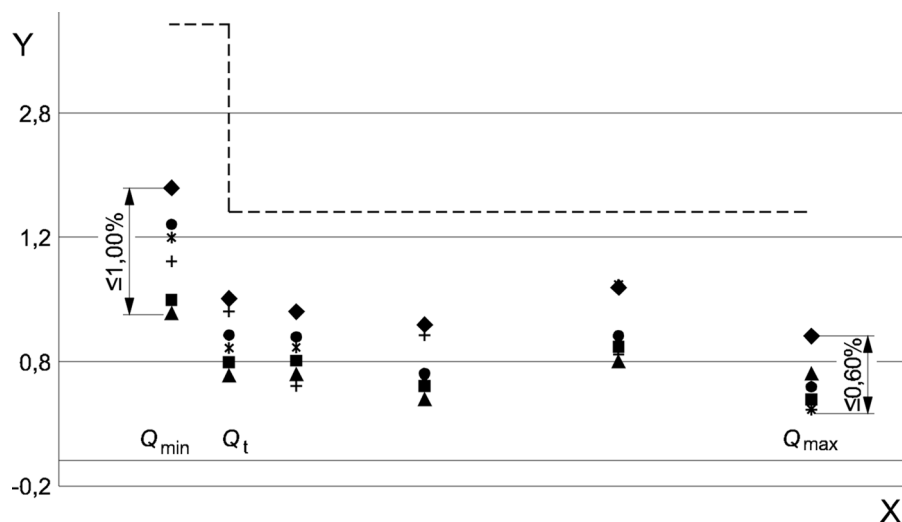
The distance between the pressure test points and the meter connections shall not exceed three times the nominal internal connection diameter of the meter connection points for two pipe meters and shall not exceed three times the nominal internal diameter of the minimum typically installed supply pipe to coaxial, single pipe meters.

5.6 Metrological stability

Compare the results from 5.3.2.4 for each consecutive test and confirm that the difference between any two of the errors of indication at each flow rate does not exceed the value given in Table 9. See Figure 2.

Table 9 — Difference of error between any two of the errors of indication

Flow range	Difference of error
$Q_{\min} \leq Q < Q_t$	1,0 %
$Q_t \leq Q \leq Q_{\max}$	0,6 %



Key

- X flow rate
- Y error %
- class 1,5
- ◆ test 1
- test 2
- ▲ test 3
- + test 4
- * test 5
- test 6

Figure 2 — Maximum difference between errors of indication

5.7 Immunity to contaminants in gas stream (dust test)

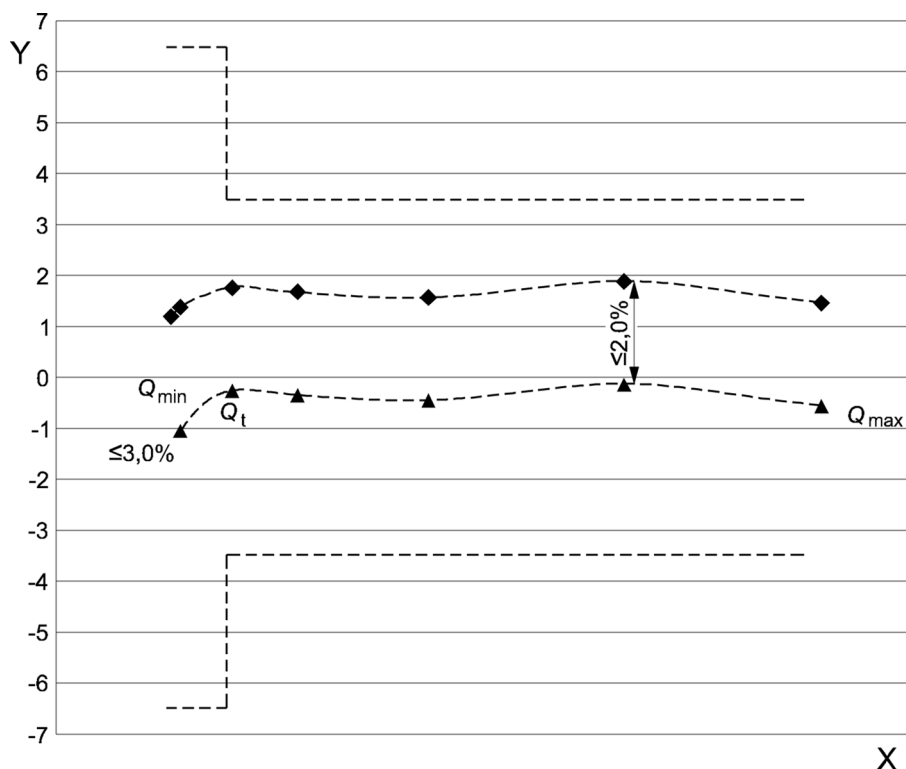
5.7.1 Requirements

When tested in accordance with 5.7.3, the errors of the meter shall not exceed the limits specified in Table 10.

Table 10 — Maximum permissible error after immunity to contaminants tests

Flow range	Maximum Permissible Error (for volume at base conditions)	Maximum error shift
$Q_{\min} \leq Q < Q_t$	$\pm 6,5 \% [= \pm(2 \times 3,0 + 0,5) \%]$	-
$Q_t \leq Q \leq Q_{\max}$	$\pm 3,5 \% [= \pm(2 \times 1,5 + 0,5) \%]$	2 %

Following the test given in 5.7.3 below, test the meter in accordance with 5.5.2, the pressure absorption shall not exceed the values for endurance given in Table 8. See Figure 3.



Key

- X flow rate
- Y error %
- class 1,5
- maximum mean error shift
- ◆- initial error curve
- ▲- error curve after dust test

Figure 3 — Errors and error shift after dust test

NOTE Figure 3 shows an example of the initial error and shifted error resulting from being subjected to resistance to contaminants test.

5.7.2 Specification of contamination dust to be used in test 5.7.3

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

- | | | | | |
|----|--------|----|--------|-----------------------------|
| a) | 20 µm | to | 100 µm | Average size (50 ± 10) µm; |
| b) | 100 µm | to | 200 µm | Average size (150 ± 10) µm; |
| c) | 200 µm | to | 300 µm | Average size (250 ± 10) µm; |
| d) | 300 µm | to | 400 µm | Average size (350 ± 10) µm; |

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

- Black iron oxide (Fe_3O_4) 79 %;
- Red iron oxide (Fe_2O_3) 12 %;
- Mineral silica flour (SiO_2) 8 %;
- Paint residual flake 1 %.

5.7.3 Test

Test a minimum of 3 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 does not require absolute traceability provided that each meter is calibrated on equipment that does have such traceability prior to commencing the test. An example of typical test rig is given in Figure 4.

- dry the dust at 60 °C for 24 h in an open container before use;
- allow the dust to cool down and use it within 8 h in a laboratory with a relative humidity of less than 50 %.

The test procedure is a continuous process, with the meter remaining in place, as follows:

- 1) test the meter in accordance with 5.3.2, Table 6, Test c);
- 2) attach the meter to the dust rig that has 10 D of vertical pipe before the meter and pass air through the meter for 5 min at Q_{max} ; using the appropriate value of D from Table 11;
- 3) stop the air supply and add a quantity from Table 12 of (300 to 400) µm grade dust to the rig inlet. Restart the air supply and maintain a flow of Q_{max} for a further 5 min. Repeat this procedure with a further quantity from Table 12 of each dust grade in the order (200 to 300) µm, (100 to 200) µm and (20 to 100) µm;
- 4) test the meter in accordance with 5.3.2, Table 6, Test c).