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Gas meters
Part 1: Metrological and Technical Requirements
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Compteurs de gaz
Partie 1: Exigences métrologiques et techniques,
Partie 2: Contrôles métrologiques et essais de performance

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Explanatory note to the 1 CD

(Temporary section to be removed after finalization of the Recommendation)

After OIML R 137-1 *Gas meters* was approved by CIML in 2006 and effectively published in 2007, and the responsibility for this Recommendation was transferred to TC8/SC7, the secretary started the work on drafting Part 2 *Metrological controls and performance tests*.

During this work, it was identified that a few minor changes in Part 1 would be necessary, although there is no formal project for the revision of Part 1. Nevertheless, expecting that the current project for part 2 will also lead to a revised Part 1, the secretary investigated what further changes would be advisable. This lead to the following proposed changes in Part 1 (2006):

- Modification of terminology as to comply with the new (2007) edition of the "VIM".
- Removal of terminology not used in the document
- Separation in Parts 1 and 2 as to comply with the draft general format for OIML Recommendations (see Circular BIML 09 No. 273/RG/JFM dated 2009.05.29)

  Note:
  In part 1 only the requirements are listed, due to the fact this part will be used for legislation and therefore paragraph 5.13 is introduced.
  Also the previous chapters 3 up to and including 6 are reshuffled to make the document in line with the general OIML format.

- Extending of requirements for the mains voltage with clause 5.1, rated operating conditions
- Limiting the reproducibility requirement prescribed only to gas meters which are sensitive to hysteresis (meters with internal moving parts or meters based on the Vortex principle), and introducing a repeatability requirement for gas meters which are not sensitive to hysteresis (meters without internal moving parts) (5.6/5.7 & 11.4.2/11.4.3)
- Limiting the applicability of temperature test with gas temperature unequal to ambient temperature to mechanical gas meters with a built-in temperature converrsion device only (11.4.7 and 11.4.7.2).
  Furthermore, in 11.4.7 the first test method with flow tests is prescribed for domestic meters.
- *The requirements for the working pressure (**Error! Reference source not found.**) are stated for the whole pressure range. The specific requirement that the maximum difference between the error curves, obtained at different pressures, is limited to 0,5 times the maximum permissible error is removed.*
- *The damp heat, steady state and damp heat cyclic test are performed at the upper temperature* (Table 4).
- Better separation of the test 'Orientation and flow direction' into tests for 'Orientation' and 'flow direction' respectively (5.13.1 and 5.13.2).
- Amending annex B regarding the requirement for flow disturbances. The requirement is that the fault has to be < one third MPE. However, in Annex B still 0,33% was mentioned, which was not correct for class 0.5 or 1.5. Meters. This sentence in Annex B is removed.

- Updating Annex B requirements for flow disturbances.

- Simplifying the overview of documentation for type evaluation (11.2)
- Updating of the bibliography
- *AC mains voltage dips and, short interruptions and voltage variations is adapted to D11 (2004)*
- *The level of the surge test as specified in D11 is brought in line with R117-1.*
- *The DC ripple test as specified in D11(2004) is added (5.13.7), with severity level in line with R117-1*
- *DC mains voltage dips and short interruptions and variations test as specified in D11(2004) are added (5.13.7), in line with R117-1*
- *The test methods for some EMC tests, like ESD and surges are changed such, that during those EMC phenomena the meter under test has to fulfil the stated requirements, instead of afterwards. This is in line with the OIML R117-1.*
- Adding of Chapter 9
- Removal of the original Table 4, while moving the original Table 6 to part 1 (5.13.7).
- Extending tests for the influence of software functions (like communicaton possiblities) on the meter accuracy (5.13.8).
- *The scope of the document is changed such, that also domestic meters with internal temperature compensation are also covered.*

Additional work suggested:

- Further alining the document with the draft general OIML format

Contents

Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States. The main categories of OIML publications are:

- **International Recommendations (OIML R),** which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity. OIML Member States shall implement these Recommendations to the greatest possible extent;
- **International Documents (OIML D),** which are informative in nature and which are intended to harmonize and improve work in the field of legal metrology;
- **International Guides (OIML G),** which are also informative in nature and which are intended to give guidelines for the application of certain requirements to legal metrology; and
- **International Basic Publications (OIML B),** which define the operating rules of the various OIML structures and systems.

OIML Draft Recommendations, Documents and Guides are developed by Technical Committees or Subcommittees which comprise representatives from the Member States. Certain international and regional institutions also participate on a consultation basis. Cooperative agreements have been established between the OIML and certain institutions, such as ISO and the IEC, with the objective of avoiding contradictory requirements. Consequently, manufacturers and users of measuring instruments, test laboratories, etc. may simultaneously apply OIML publications and those of other institutions.

International Recommendations, Documents, Guides and Basic Publications are published in English (E) and translated into French (F) and are subject to periodic revision.

Additionally, the OIML publishes or participates in the publication of **Vocabularies (OIML V)** and periodically commissions legal metrology experts to write **Expert Reports (OIML E)**. Expert Reports are intended to provide information and advice, and are written solely from the viewpoint of their author, without the involvement of a Technical Committee or Subcommittee, nor that of the CIML. Thus, they do not necessarily represent the views of the OIML.

This publication - reference OIML R 137-1 & -2, Edition 200X - was developed by Technical Subcommittee TC 8/SC 7 *Gas meters*. It was approved for final publication by the International Committee of Legal Metrology in 200x and will be submitted to the International Conference of Legal Metrology in 200x for formal sanction. It supersedes the previous editions of OIML R 137-1 (2006).

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Part 1: Metrological and technical requirements

1 Introduction

2 Scope

This Recommendation applies to gas meters based on any principle, used to meter the quantity of gas in volume, mass or energy units that has passed through the meter at operating conditions. It applies also to gas meters intended to measure quantities of gaseous fuels or other gases, except gases in the liquefied state and steam.

Dispensers for compressed natural gas (CNG dispensers) are also excluded from the scope of this Recommendation.

This Recommendation also applies to correction devices, and other electronic devices that can be attached to the gas meter. This including devices for internal temperature compensation.

However, provisions for conversion devices, either as part of the gas meter or as a separate instrument, or provisions for devices for the determination of the superior calorific value and gas metering systems consisting of several components, are defined in the OIML Recommendation R140 *Measuring systems for gaseous fuel* [7].

3 Terminology

The terminology used in this Recommendation conforms to the International Vocabulary of Basic and General Terms in Metrology (VIM - Edition 2007) [1] and the International Vocabulary of Terms in Legal Metrology (VIML - Edition 2000) [2]. In addition and for the purposes of this Recommendation, the following definitions apply.

3.1 GAS METER AND ITS CONSTITUENTS

3.1.1 Gas meter

Instrument intended to measure, memorize and display the quantity of gas passing the flow sensor.

3.1.2 Measurand (VIM 2.3)

quantity intended to be measured.

3.1.3 Sensor (VIM 3.8)

element of a measuring system that is directly affected by a phenomenon, body, or substance carrying a quantity to be measured.

3.1.4 Measuring transducer (VIM 3.7)

device, used in measurement, that provides an output quantity having a specified relation to the input quantity.

3.1.5 Calculator

Part of the gas meter which receives the output signals from the measuring transducer(s) and, possibly, associated measuring instruments, transforms them and, if appropriate, stores the results in memory until they are used. In addition, the calculator may be capable of communicating both ways with ancillary devices.

3.1.6 Indicating or displaying device

Part of the gas meter which displays the measurement results, either continuously or on demand.

Note: A printing device, which provides an indication at the end of the measurement, is not an indicating device.

3.1.7 Correction device

Device intended for correction of known errors as a function of e.g. flowrate, Reynolds number (curve linearization), or pressure and/or temperature.

3.1.8 Ancillary device

Device intended to perform a particular function, directly involved in elaborating, transmitting or displaying measurement results.

The main ancillary devices are:

a) repeating indicating device;

b) printing device;

c) memory device; and

d) communication device.

Note 1: An ancillary device is not necessarily subject to metrological control.

Note 2: An ancillary device may be integrated in the gas meter.

3.1.9 Associated measuring instrument

Instrument connected to the calculator or the correction device for measuring certain gas properties, for the purpose of making a correction.

3.1.10 Equipment under test (EUT)

(Part of the) gas meter and/or associated devices which is exposed to one of the tests.

3.1.11 Family of gas meters

Group of gas meters of different sizes and/or different flowrates, in which all the meters shall have the following characteristics:

- the same manufacturer;
- geometric similarity of the measuring part;
- the same metering principle;
- roughly the same ratios Q_{max}/Q_{min} and Q_{max}/Q_t;
- the same accuracy class;
- the same electronic device for each meter size and using the same software (if applicable) for those components that are critical to the performance of the meter;
- a similar standard of design and component assembly; and
- the same materials for those components that are critical to the performance of the meter.

3.2 METROLOGICAL CHARACTERISTICS

3.2.1 Quantity of gas

Total quantity of gas obtained by integrating the flow over time, expressed as volume V, mass m or energy E passed through the gas meter, disregarding the time taken. This is the measurand (see 2.1.2).

3.2.2 Indicated value (of a quantity)

Value Y_i of a quantity, as indicated by the meter.

3.2.3 Cyclic volume of a gas meter (positive displacement gas meters only)

Volume of gas corresponding to one full revolution of the moving part(s) inside the meter (working cycle).

3.2.4 Error (VIM 2.16)

measured quantity value minus a reference quantity value

3.2.5 Weighted mean error (WME)

The weighted mean error (WME) is calculated as follows:

$$WME = \frac{\sum_{i=1}^{n}((Q_i / Q_{max}) \cdot e_i)}{\sum_{i=1}^{n}(Q_i / Q_{max})}$$

where:

- Q_i/Q_{max} is a weighting factor;
- e_i is the error at the flowrate Q_i;
- at $Q_i > 0.9 \cdot Q_{max}$ a weighting factor of 0.4 shall be used instead of 1.

3.2.6 Intrinsic error (OIML D 11, 3.7)

Error determined under reference conditions.

3.2.7 Fault Δe (OIML D 11, 3.9)

Difference between the error of indication and the intrinsic error of a measuring system or of its constituent elements.

Note: In practice this is the difference between the error of the meter observed during or after a test, and the error of the meter prior to this test, performed under reference conditions.

3.2.8 Maximum permissible error (MPE) (VIM 4.26)

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

3.2.9 Accuracy class (VIM 4.25)

class of measuring instruments or measuring systems that meet stated metrological requirements that are intended to keep measurement errors or instrumental uncertainties within specified limits under specified operating conditions .

3.2.10 Durability (OIML D 11, 3.17)

Ability of a measuring instrument to maintain its performance characteristics over a period of use.

3.2.11 Operating conditions

Conditions of the gas (temperature, pressure and gas composition) at which the quantity of gas is measured.

3.2.12 Rated operating conditions

Conditions of use giving the range of values of the measurand and the influence quantities, for which the errors of the gas meter are required to be within the limits of the maximum permissible error.

3.2.13 Reference conditions

Set of reference values, or reference ranges of influence quantities, prescribed for testing the performance of a gas meter, or for the intercomparison of the results of measurements.

3.2.14 Base conditions

Conditions to which the measured volume of gas is converted (examples: base temperature and base pressure).

Note: Operating and base conditions relate to the volume of gas to be measured or indicated only and should not be confused with "rated operating conditions" and "reference conditions" (VIM 4.9 and 4.11) which refer to influence quantities.

3.2.15 Test element (of an indicating device)

Device to enable precise reading of the measured gas quantity.

3.2.16 Resolution (of a displaying device) (VIM 4.15)

Smallest difference between displayed indications that can be meaningfully distinguished.

Note: For a digital device, this is the change in the indication when the least significant digit changes by one step. For an analogue device, this is half the difference between subsequent scale marks.

3.2.17 (Instrumental) drift (VIM 4.21)

continuous or incremental change over time in indication, due to changes in metrological properties of a measuring instrument.

3.3 OPERATING CONDITIONS

Note: For the definition of operating conditions, see 3.2.11.

3.3.1 Flowrate, Q

Quotient of the actual quantity of gas passing through the gas meter and the time taken for this quantity to pass through the gas meter.

3.3.2 Maximum flowrate, Q_{max}

Highest flowrate at which a gas meter is required to operate within the limits of its maximum permissible error, whilst operated within its rated operating conditions.

3.3.3 Minimum flowrate, Q_{min}

Lowest flowrate at which a gas meter is required to operate within the limits of its maximum permissible error, whilst operated within its rated operating conditions.

3.3.4 Transitional flowrate, Q_t

Flowrate which occurs between the maximum flowrate Q_{max} and the minimum flowrate Q_{min} that divides the flowrate range into two zones, the “upper zone” and the “lower zone”, each characterized by its own maximum permissible error.

3.3.5 Working temperature, t_w

Temperature of the gas to be measured at the gas meter.

3.3.6 Minimum and maximum working temperatures, t_{min} and t_{max}

Minimum and maximum gas temperature that a gas meter can withstand, within its rated operating conditions, without deterioration of its metrological performance.

3.3.7 Working pressure, p_w

Gauge pressure of the gas to be measured at the gas meter. The gauge pressure is the difference between the absolute pressure of the gas and the atmospheric pressure.

3.3.8 Minimum and maximum working pressure, p_{min} and p_{max}

Minimum and maximum internal gauge pressure that a gas meter can withstand, within its rated operating conditions, without deterioration of its metrological performance.

3.3.9 Static pressure loss or pressure differential, Δp

Mean difference between the pressures at the inlet and outlet of the gas meter while the gas is flowing.

3.3.10 Working density, ρ_w

Density of the gas flowing through the gas meter, corresponding to p_w and t_w

3.4 TEST CONDITIONS

3.4.1 Influence quantity (VIM 2.52)

quantity that, in a direct measurement, does not affect the quantity that is actually measured, but affects the relation between the indication and the measurement result.

3.4.2 Disturbance (OIML D 11, 3.13.2)

Influence quantity having a value within the limits specified in this Recommendation, but outside the specified rated operating conditions of the gas meter.

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

3.4.3 Overload conditions

Extreme conditions, including flowrate, temperature, pressure, humidity and electromagnetic interference that a gas meter is required to withstand without damage.

3.4.4 Test

Series of operations intended to verify the compliance of the equipment under test (EUT) with certain requirements.

3.4.5 Test procedure

Detailed description of the test operations.

3.4.6 Test program

Description of a series of tests for a certain type of equipment.

3.4.7 Performance test

Test intended to verify whether the equipment under test (EUT) is capable of accomplishing its intended functions.

3.5 ELECTRONIC EQUIPMENT

3.5.1 Electronic gas meter

Gas meter equipped with electronic devices.

Note: For the purposes of this Recommendation auxiliary equipment, as far as it is subject to metrological control, is considered part of the gas meter, unless the auxiliary equipment is approved and verified separately.

3.5.2 Electronic device (D 11, 3.2)

Device employing electronic sub-assemblies and performing a specific function. Electronic devices are usually manufactured as separate units and are capable of being tested independently.

3.5.3 Electronic component

Smallest physical entity in an electronic system used to affect the electrons or their associated fields in a desired manner within semi-conductors, gases or in a vacuum.

4 Units of measurement

4.1 MEASUREMENT UNITS

All quantities shall be expressed in SI units [3] or as other legal units of measurement [4], unless a country's legal units are different. In the next section the unit corresponding to the quantity indicated is expressed by <unit>.

5 Metrological requirements

5.1 RATED OPERATING CONDITIONS

The rated operating conditions for a gas meter shall be as follows:

Flowrate range:	Q_{min} to Q_{max} inclusive
Ambient temperature range:	lower temperature to be chosen from – 40 °C, – 25 °C, – 10 °C and + 5 °C upper temperature to be chosen from + 30 °C, + 40 °C, + 55 °C and + 70 °C
Ambient humidity range:	≤ 93 %
Working pressure range:	p_{min} to p_{max} inclusive
Gases:	the family of natural gases, industrial gases, or supercritical gases; to be specified by the manufacturer (Note 1)
DC mains or battery voltage:(Note 2)	as specified by the manufacturer
AC mains voltage:(Note 2)	U_{nom} –15% to U_{nom} +10%

Note 1: Supercritical refers to the situation where there is no distinction between the gaseous and liquefied state of the fluid.

Note 2: Whatever is applicable.

5.2 VALUES OF Q_{MAX}, Q_T AND Q_{MIN}

The flowrate characteristics of a gas meter shall be defined by the values of Q_{max}, Q_t and Q_{min} as stated in Table 1.

Table 1 Flowrate characteristics

Q_{max} / Q_{min}	Q_{max} / Q_t
≥ 50	≥ 10
≥ 5 and < 50	≥ 5

5.3 ACCURACY CLASSES AND MAXIMUM PERMISSIBLE ERRORS

5.3.1 General

Gas meters shall be designed and manufactured such that their errors do not exceed the limits of the applicable maximum permissible error under rated operating conditions, listed in 5.3.3.

5.3.2 Correction for known errors

Gas meters may be equipped with a correction device, which can be used to bring errors as close as possible to zero. A correction device can be used to improve the Accuracy Class specification. The correction device shall not be used for the correction of a pre-estimated drift.

5.3.3 Accuracy Classes and maximum permissible errors (MPE)

Gas meters shall be classified into the Accuracy Classes given in Table 2. The errors shall be within the applicable values given in Table 2.

Table 2 Maximum permissible errors of gas meters

Flowrate Q	During type evaluation and initial verification Accuracy Class			In-service * Accuracy Class		
	0.5	1	1.5	0.5	1	1.5
$Q_{min} \le Q < Q_t$	± 1 %	± 2 %	± 3 %	± 2 %	± 4 %	± 6 %
$Q_t \le Q \le Q_{max}$	± 0.5 %	± 1 %	± 1.5 %	± 1 %	± 2 %	± 3 %

* *Note: National Authorities may decide whether they will implement in-service maximum permissible errors or not.*

5.3.4 ~~Mechanical~~ Gas meter with a built-in ~~mechanical~~ temperature conversion device

For a ~~mechanical~~ gas meter with a built-in ~~mechanical~~ temperature conversion device, having only one indicating device (????) displaying the volume at base conditions, the maximum permissible errors as indicated in Table 2 are increased by 0.5 % in a range of 30 °C extending symmetrically around the temperature t_{sp} specified by the manufacturer. Outside this range an additional increase of 0.5 % is permitted in each interval of 10 °C. ~~Compliance with these requirements shall be verified at temperatures deviating by not more than 2 °C from the upper and lower limits of the specified intervals.~~

5.4 WEIGHTED MEAN ERROR (WME)

The weighted mean error (WME) shall be within the values given in Table 3.

Table 3 Maximum permissible weighted mean error

Flowrate Q	During type evaluation and initial verification Accuracy Class			In-service Accuracy Class		
	0.5	1	1.5	0.5	1	1.5
WME	± 0.2 %	± 0.4 %	± 0.6%	--	--	--

5.5 REPAIR AND DAMAGE OF SEALS

After repair of the gas meter or damage to the seals, the maximum permissible error shall comply with the errors on initial verification as stated in Table 2, as well as the maximum permissible weighted mean error as stated in Table 3.

5.6 REPRODUCIBILITY

Assuming that the results from reproducibility measurements of a gas meter will show normal distribution, the associated standard deviation, which can be estimated on basis of calculation of the experimental standard deviation, shall be less than or equal to 0.15 times the maximum permissible error, for flowrates equal to or greater than Q_t.

5.7 REPEATABILITY

The difference between the maximum and minimum error of consecutive measurements of gas meters, at reference conditions, during repeated measurements without changing the flowrate, shall be less than or equal to one third of the maximum permissible error.

5.8 WORKING PRESSURE

The requirements as mentioned in 5.3 shall be fulfilled over the whole working pressure range.

~~The maximum difference between the error curves, obtained at different pressures, is limited to 0.5 times the maximum permissible error.~~

5.9 TEMPERATURE

The requirements as mentioned in 5.3 shall be fulfilled over the whole temperature range, where the ambient temperature is equal to the gas temperature. In case the ambient temperature is unequal to the gas temperature the double maximum permissible error limits apply.

5.10 DURABILITY

Gas meters ~~with internal moving parts~~ shall meet the following requirements after being exposed to the equivalent of 2000 hours flow at Q_{max}:

- double the maximum permissible errors as mentioned in 5.3 and
- for flowrates from Q_t up to Q_{max} a fault of less then or equal to
  - 1.0 times the maximum permissible error for class 1.5 or
  - 0.5 times the maximum permissible error for other classes

5.11 OVERLOAD FLOW

Gas meters ~~with internal moving parts~~ shall meet the following requirements, after being exposed to an overload of 1.2 Q_{max} for 1 hour:

- the maximum permissible errors as mentioned in 5.3 and
- a fault of less then or equal to one third of the maximum permissible error

5.12 VIBRATIONS AND SHOCKS

Gas meters shall withstand vibrations and shocks with the following specifications:

5.12.1 vibrations :
total frequency range: 10 Hz - 150 Hz
total RMS level: 7 $m.s^{-2}$

ASD level 10-20 Hz: 1 m^2s^{-3}
ASD level 20-150 Hz: -3dB/octave

5.12.2 shocks:
height of fall: 50 mm

The fault after the application of vibrations and shocks shall be less then or equal to 0.5 times the maximum permissible error.

5.13 METROLOGICAL REQUIREMENTS SPECIFIC TO CERTAIN TYPES OF GAS METERS

5.13.1 Orientation

If the meter is specificatied by the manufacturer to only operate correctly while installed in certain orientations and marked as such, the metrological requirements as mentioned in 5.3 and 5.4 shall be fulfilled for these orientations only.
In the absence of such marks the meter shall fulfil these requirements for all orientations.

5.13.2 Flow direction

If the meter is marked as able to measure the flow in both directions, the metrological requirements ~~as~~ mentioned in 5.3 and 5.4 apply shall be fulfilled for each direction separately.

5.13.3 Flow disturbance

For types of gas meters of which the accuracy is affected by flow disturbances the shift of the error curve due to these (mild or severe flow) disturbances shall not exceed one third of the maximum permissible error.

5.13.4 Drive shaft (torque)

For types of gas meters provided with one or more drive shafts the fault at Q_{min} due to the application of the maximum torque shall not be more than one third of the maximum permissible error.

5.13.5 Different gases

The types of gas meters which are intended to be used for different gases shall comply with the metrological requirements as mentioned in 5.3 over the whole range of gases for which they are specified by the manufacturer.

5.13.6 Interchangeable components

For types of gas meters of which some components are meant to be interchangeable for operational purposes (e.g. ultrasonic transducers or meter cartridges), the fault due to the interchange of such a component, shall not be more than one third of the maximum permissible error, while the error shall in no case exceed the maximum permissible error for that range.

5.13.7 Electronics

If a gas meter includes electronic components, the requirements as presented in Table 4 apply

Table 4 Requirements for gasmeters containing electronic components

< Lay out still to be brought in line with the general OIML format>

No.	Test	Levels	I/D	**Requirement**
a	Dry heat	upper temperature specified	I	5.3
b	Cold	lower temperature specified	I	5.3
c	Damp heat, steady state (non-condensing)	upper temperature specified, 93% relative humidity	I	5.3
d	Damp heat, cyclic (condensing)	upper temperature, 93% relative humidity	D	$\Delta e \leq 0.5$ MPE after
e	Vibration (random)	total frequency range: 10 - 150 Hz total RMS level: 7 $m.s^{-2}$ ASD level 10-20 Hz: 1 $m^2.s^{-3}$ ASD level 20-150 Hz: -3dB/octave	D	$\Delta e \leq 0.5$ MPE after
f	Mechanical shock	50 mm	D	$\Delta e \leq 0.5$ MPE after
g	Radiated, radio-frequency, electromagnetic fields	up to 2 GHz, 10 V/m	I	5.3
h	Conducted radio-frequency fields	up to 80 MHz, 10 V (e.m.f.)	I	5.3
i	Electrostatic discharge	6 kV contact discharge 8 kV air discharge	D	$\Delta e \leq 0.5$ MPE during
j	Bursts (transients) on signal, data and control lines	Amplitude 1 kV Repetition rate 5 kHz	D	$\Delta e \leq 0.5$ MPE during
k	Surges on signal, data and control lines	unsymmetrical lines: line to line 0,5 kV line to ground 1,0 kV symmetrical lines: line to line NA line to ground 1,0 kV shielded I/O and communication lines: line to line NA line to ground 0,5 kV	D	$\Delta e \leq 0.5$ MPE during
l	DC mains voltage variation (1)	as specified by the manufacturer	I	5.3
m	AC mains voltage variation (1)	85 % & 110 % of the rated voltage	I	5.3
n	AC mains voltage dips and short interruptions (1)	0.5 cycles 0 % 1 cycle 0 % 10/12 (2) cycles 40 % 25/30 (2) cycles 70 % 250/300 (2) cycles 80 %	D	$\Delta e \leq 0.5$ MPE during

o	DC mains voltage dips and short interruptions (1)	40 % & 70 % of the rated voltage during 0,1 s and 0 % of rated voltage during 0.01 s	D	$\Delta e \leq 0.5$ MPE during
p	Bursts (transients) on AC and DC mains	Amplitude 2 kV Repetition rate 5 kHz	D	$\Delta e \leq 0.5$ MPE during
q	Surges on AC and DC mains	line to line 1.0 kV line to ground 2.0 kV	D	$\Delta e \leq 0.5$ MPE during
r	Low voltage of internal battery (1)	as specified by the manufacturer	I	5.3
s	Ripple on DC mains power (1)	2 % of nominal DC voltage	D	$\Delta e \leq 0.5$ MPE during
(1) If applicable (2) For 50 Hz/ 60 Hz respectively				

Note: The letter I refers to an influence test, D refers to a disturbance test.

5.13.8 Software

Gas meters provided with software shall be designed such that all functions of the software (like e.g. communication possibilities) do not affect the metrological behaviour.

< To be brought in line with D31 >

Technical requirements

5.14 CONSTRUCTION

5.14.1 Materials

A gas meter shall be made of such materials and be so constructed to withstand the physical, chemical and thermal conditions to which it is likely to be subjected and to fulfil correctly its intended purposes throughout its life.

5.14.2 Soundness of cases

The case of a gas meter shall be gas-tight up to the maximum working pressure of the gas meter. If a meter is to be installed in the open air it shall be impermeable to run-off water.

5.14.3 Condensation/climate provisions

The manufacturer may incorporate devices for the reduction of condensation, where condensation may adversely affect the performance of the device.

5.14.4 Protection against external interference

A gas meter shall be constructed and installed in such a way that mechanical interference capable of affecting its accuracy is either prevented, or results in permanently visible damage to the gas meter or to the verification marks or protection marks.

5.14.5 Indicating device

The indicating device can be connected to the meter body physically or remotely. In the latter case the data to be displayed shall be stored in the gas meter.

Note: National or regional requirements may contain provisions to guarantee access to the data stored in the meter for customers and consumers.

5.14.6 Safety device

The gas meter may be equipped with a safety device that shuts off the gas flow in the event of calamities, such as an earthquake or a fire. A safety device may be connected to the gas meter, provided that it does not influence the metrological integrity of the meter.

Note: A mechanical gas meter equipped with an earthquake sensor plus an electrical powered valve is not considered to be an electronic gas meter.

5.14.7 Connections between electronic parts

Connections between electronic parts shall be reliable and durable.

5.14.8 Components

Components of the meter may only be exchanged without subsequent verification if the type evaluation establishes that the metrological properties and especially the accuracy of the meter are not influenced by the exchange of the components concerned. Such components shall be identified at least by their own type indication.

Note: National bodies may require components to be marked with the model(s) of the meter(s) to which they may be attached and may require such exchange to be carried out by authorized persons.

5.14.9 Zero flow

The gas meter totalization shall not change when the flowrate is zero, while the installation conditions are free from pulsations and vibrations.

Note: This requirement refers to stationary operating conditions. This condition does not refer to the response of the gas meter to changed flowrates.

5.15 FLOW DIRECTION

5.15.1 Direction of the gas flow

On a gas meter where the indicating device registers positively for only one direction of the gas flow, this direction shall be indicated by a method which is clearly understood, e.g. an arrow. This indication is not required if the direction of the gas flow is determined by the construction.

5.15.2 Plus and minus sign

The manufacturer shall specify whether or not the gas meter is designed to measure bi-directional flow. In the case of bi-directional flow a double-headed arrow with a plus and minus sign shall be used to indicate which flow direction is regarded as positive and negative respectively.

5.15.3 Recording of bi-directional flow

If a meter is designed for bi-directional use, the quantity of gas passed during reverse flow shall either be subtracted from the indicated quantity or be recorded separately. The maximum permissible error shall be met for both forward and reverse flow.

5.15.4 Reverse flow

If a meter is not designed to measure reverse flow, the meter shall either prevent reverse flow, or it shall withstand incidental or accidental reverse flow without deterioration or change in its metrological properties.

5.15.5 Indicating device

A gas meter may be provided with a device to prevent the indicating device from functioning whenever gas is flowing in an unauthorized direction.

5.16 PRESSURE TAPPINGS

5.16.1 General

If a gas meter is designed to operate above an absolute pressure of 0.15 MPa, the manufacturer shall either equip the meter with pressure tappings, or specify the position of pressure tappings in the installation pipe work. In any case those tappings shall be self-draining to avoid condensation.

Note: This requirement is not mandatory for ~~coriolis~~ meters for direct mass measurement.

5.16.2 Bore

The bore of the pressure tappings shall be large enough to allow correct pressure measurements.

5.16.3 Closure

Pressure tappings shall be provided with a means of closure to make them gas-tight.

5.16.4 Markings

The pressure tapping on the gas meter for measuring the working pressure (3.3.7) shall be clearly and indelibly marked "p_m" (i.e. the pressure measurement point) or "p_r" (i.e. the pressure reference point) and other pressure tappings "p".

5.17 INDICATING DEVICE

5.17.1 General provisions

The indicating device associated with the gas meter shall indicate the quantity of gas measured (volume, mass or energy) in the corresponding units. The reading shall be clear and unambiguous.

The indicating device may be:

a) a mechanical indicating device as described in 5.17.4;

b) an electromechanical or electronic indicating device as described in 5.17.5;

c) a combination of a) and b).

Indicating devices shall be non-resetable and shall be non-volatile (i.e. they shall be able to show the last stored indication after the device has recovered from an intervening power failure).

Where the indicating device shows decimal submultiples of the quantity measured, these submultiples shall be separated by a clear decimal sign from those showing units.

It may be possible to use one display for other indications as well, as long as it is clear which quantity is being displayed.

5.17.2 Indicating range

The indicating device shall be able to record and display the indicated quantity of gas corresponding to at least 1000 hours of operation at the maximum flowrate Q_{max}, without returning to the original reading.

5.17.3 Resolution

The quantity corresponding to the least significant digit shall not exceed the quantity of gas passed during one hour at Q_{min}.

If the least significant digit (last drum) shows a decimal multiple of the quantity measured, the faceplate or electronic display shall bear:

a) either one (or two, or three, etc.) fixed zero(s) after the last drum or digit; or

b) the marking : "× 10 " (or "× 100 ", or "× 1 000 ", etc.),

so that the reading is always in the units mentioned in 4.1.

5.17.4 Mechanical indicating device

A mechanical indicating device shall consist of drums; the last element (i.e. the one with the smallest scale interval) may however be an exception to this rule.

The minimum height of the numerals shall be 4.0 mm and their minimum width shall be 2.4 mm.

The advance by one unit of a figure of any order shall take place completely while the figure of an order immediately below passes through the last tenth of its course.

5.17.5 Electromechanical or electronic indicating device

The continuous display of the quantity of gas during the period of measurement is not mandatory.

The electronic indicating device shall be provided with a display test.

5.17.6 Remote indicating device

If an indicating device is used remotely, the associated gas meter shall be clearly identified. The integrity of the communication between the instrument and the indicating device shall be checked.

Note: The serial number of the associated gas meter can be used for a clear identification.

5.18 TEST ELEMENT

5.18.1 General

Gas meters shall be designed and constructed incorporating:

a) an integral test element, or

b) a pulse generator, or

c) arrangements permitting the connection of a portable test unit.

5.18.2 Integral test element

The integral test element may consist of the last element of the mechanical indicating device in one of the following forms:

a) a continuously moving drum bearing a scale, where each subdivision on the drum is regarded as an increment of the test element;

b) a pointer moving over a fixed dial with a scale, or a disk with a scale moving past a fixed reference mark, where each subdivision on the dial or disk is regarded as an increment of the test element. On the numbered scale of a test element the value of one complete revolution of the pointer shall be indicated in the form: "1 rev = …. <unit>". The beginning of the scale shall be indicated by the figure zero.

The scale spacing shall not be less than 1 mm and shall be constant throughout the whole scale.

The scale interval shall be in the form 1×10^n, 2×10^n, or 5×10^n <unit> (n being a positive or negative whole number or zero).

The scale marks shall be fine and uniformly drawn.

With an electronic indicating device the last digit is used as integral test element. The number of digits may be increased via a specific test mode, which can be accessed through either physical or electronic buttons or switches.

If applicable to the gas meter, the test element shall allow the experimental determination of the cyclic volume. The difference between the measured value of the cyclic volume and its nominal value shall not exceed 5 % of the latter at reference conditions.

5.18.3 Pulse generator

A pulse generator may be used as a test element if the value of one pulse, expressed in units of volume, mass or energy, is marked on the gas meter.

The gas meter shall be constructed in such a way that the pulse value can be checked experimentally. The difference between the measured value of the pulse value and its value indicated on the gas meter, shall not exceed 0.05 % of the latter.

5.18.4 Portable test unit

An indicating device may include provisions for testing by inclusion of complementary elements (e.g. star wheels or discs), which provide signals for a portable test unit.

The portable test unit may be used as a test element if the value of one pulse, expressed in units of volume, mass or energy, is marked on the gas meter.

5.18.5 Increment of test element or pulse

The increment of the test element or pulse shall occur at least every 60 seconds at Q_{min}.

5.19 ANCILLARY DEVICES

5.19.1 General

The gas meter may include ancillary devices, which may be permanently incorporated or added temporarily. Examples of their use are:

- flow detection before this is clearly visible on the indicating device;
- means for testing, verification and remote reading;
- prepayment.

Ancillary devices shall not affect the correct operation of the instrument. If ancillary devices are not subject to legal metrology control this shall be clearly indicated.

5.19.2 Protection of drive shafts

When not connected to an attachable ancillary device, the exposed ends of the drive shaft shall be suitably protected.

5.19.3 Torque overload

The connection between the measuring transducer and the intermediate gearing shall not be broken or altered if a torque of three times the permissible torque as indicated in 6.1.3 (s) and 6.1.3 (t) is applied.

5.20 POWER SOURCES

5.20.1 Types of power sources

This Recommendation gives requirements for instruments powered by:

- mains power;
- non-replaceable battery;
- replaceable battery.

These three types of power sources may be used alone or in combination.

5.20.2 Mains power

An electronic gas meter shall be designed such that in the event of a mains power failure (AC or DC), the meter indication of the quantity of gas just before failure is not lost, and remains accessible for reading after failure without any difficulty.

Any other properties or parameters of the meter shall not be affected by an interruption of the electrical supply.

Note: Compliance with this requirement will not necessarily ensure that the gas meter will continue to register the quantity of gas that passed through the gas meter during a power failure.

The connection to the mains power source shall be capable of being secured from tampering.

5.20.3 Non-replaceable battery

The manufacturer shall ensure that the indicated lifetime of the battery guarantees that the meter functions correctly for at least as long as the operational lifetime of the meter.

5.20.4 Replaceable battery

If the instrument is powered by a replaceable battery, the manufacturer shall give detailed specifications for the replacement thereof.

The date by which the battery shall be replaced shall be indicated on the meter. Alternatively, the remaining battery life can be displayed or a warning can be given when 10 % of the estimated life of the battery remains.

The properties and parameters of the meter shall not be affected during replacement of the battery.

The battery shall be able to be replaced without breaking the metrological seal.

The battery compartment shall be capable of being secured from tampering.

5.21 CHECKS, LIMITS AND ALARMS FOR ELECTRONIC GAS METERS

5.21.1 Checks

An electronic gas meter is required to:

- detect the presence and correct functioning of transducers and devices;
- check the integrity of stored, transmitted and presented data; and
- check the pulse transmission (if applicable).

Note: Pulse transmission checks focus on missing pulses, or additional pulses due to interference. Examples are double pulse systems, three-pulse systems or pulse timing systems.

5.21.2 Limits

The gas meter may also be capable to detect and act upon:

- overload flow conditions;
- measurement results that are outside the maximum and minimum values of the transducers;
- measured quantities that are outside certain pre-programmed limits; and
- reverse flow.

If the gas meter is equipped with limit detection the correct functioning shall be tested during the type evaluation.

5.21.3 Alarms

If malfunctions are registered while checking the items as indicated in 5.21.1 or if the conditions as indicated in 5.21.2 are detected, the following actions shall be performed:

- a visible or audible alarm, which remains present until the alarm is acknowledged and the cause of the alarm is suppressed;
- continuation of the registration in specific alarm registers (if applicable) during the alarm, in which case default values may be used for the pressure, temperature, compressibility, density or superior calorific value; and
- registration in a log (if applicable).

6 Inscriptions

6.1 MARKINGS AND INSCRIPTIONS

All markings shall be easily legible and indelible under rated conditions of use.

Any marking other than those prescribed in the type approval document shall not lead to confusion.

6.1.1 General applicable markings for gas meters

As relevant, the following information shall be marked on the casing or on an identification plate, or clearly and unambiguously visible via the indicating device:

a) Type approval mark (according to national or regional regulation);

b) Name or trade mark of the manufacturer;

c) Type designation;

d) Serial number of the gas meter and its year of manufacture;

e) Accuracy class;

f) Maximum flowrate Q_{max} = … <unit>;

g) Minimum flowrate Q_{min} = … <unit>;

h) Transition flowrate Q_t = … <unit>;

i) Gas temperature range and pressure range for which the errors of the gas meter shall be within the limits of the maximum permissible error, expressed as:

$t_{min} - t_{max}$ = … - … <unit>;

$p_{min} - p_{max}$ = … - … <unit> gauge pressure.

j) The density range within which the errors shall comply with the limits of the maximum permissible error may be indicated, and shall be expressed as:

ρ = … - … <unit>

This marking may replace the range of working pressures (i) unless the working pressure marking refers to a built-in conversion device;

k) Pulse values of HF and LF frequency outputs (imp/<unit>, pul/<unit>, <unit>/imp);

Note: The pulse value is given to at least six significant figures, unless it is equal to an integer multiple or decimal fraction of the used unit.

l) Letter V or H, as applicable, if the meter can be operated only in the vertical or horizontal position;

m) Indication of the flow direction, e.g. an arrow (if applicable, see 5.15.1 and 5.15.2);

n) Measurement point for the working pressure according to 5.16.4; and

o) Environmental temperatures, if they differ from the gas temperature as mentioned in i).

6.1.2 Additional markings for mechanical gas meters with a built-in mechanical conversion device having only one indicating device

p) Base temperature t_b = … <unit>;

q) Temperature t_{sp} = … <unit> specified by the manufacturer according to 5.3.4.

6.1.3 Additional markings for gas meters with output drive shafts

r) Gas meters fitted with output drive shafts or other facilities for operating detachable additional devices shall have each drive shaft or other facility characterized by an indication of its constant (C) in the form "1 rev = … <unit>" and the direction of rotation. "rev" is the abbreviation of the word "revolution";

s) If there is only one drive shaft the maximum permissible torque shall be marked in the form "M_{max} = … N.mm";

t) If there are several drive shafts, each shaft shall be characterized by the letter M with a subscript in the form "M_1, M_2, … M_n";

u) The following formula shall appear on the gas meter:

$k_1M_1 + k_2M_2 + \ldots + k_nM_n \leq$ A N.mm,

where:

A is the numerical value of the maximum permissible torque applied to the drive shaft with the highest constant, where the torque is applied only to this shaft; this shaft shall be characterised by the symbol M_1,

k_i (i = 1, 2, … n) is a numerical value determined as follows: $k_i = C_1 / C_i$,

M_i (i = 1, 2, … n) represents the torque applied to the drive shaft characterized by the symbol M_i,

C_i (i = 1, 2, … n) represents the constant for the drive shaft characterized by the symbol M_i.

6.1.4 Additional markings for gas meters with electronic devices

v) For an external power supply: the nominal voltage and nominal frequency;

w) For a non-replaceable or replaceable battery: the latest date by which the battery is to be replaced, or the remaining battery capacity;

x) Software identification of the firmware.

7 Operating instructions

7.1 INSTRUCTION MANUAL

Unless the simplicity of the measuring instrument makes this unnecessary, each individual instrument shall be accompanied by an instruction manual for the user.
However, groups of identical measuring instruments delivered to the same customer do not necessarily require individual instruction manuals.

The instruction manual shall be in the official language(s) of the country (or an other generally accepted language according to national legislation) and easily understandable.
It shall include:

a) operating instructions;

b) maximum and minimum storage temperatures;

c) rated operating conditions;

d) warm-up time after switching on the electrical power (if applicable);

e) all other relevant mechanical and electromagnetic environmental conditions;

f) for instruments, powered by an external power converter: specifications of this power converter;

g) any specific installation conditions like for instance a limitation of the length of signal, data, and control lines;

h) if applicable: the specifications of the battery;

i) instructions for installation, maintenance, repairs, storage, transport and permissible adjustments (this can be in a separate document, not meant for the user/owner);

j) conditions for compatibility with interfaces, sub-assemblies (modules) or other measuring instruments.

7.2 INSTALLATION CONDITIONS

The manufacturer shall specify the installation conditions (as applicable) with respect to:

- the position to measure the working temperature of the gas;
- filtering;
- levelling and orientation;
- flow disturbances;
- pulsations or acoustic interference;
- rapid pressure changes;
- absence of mechanical stress (due to torque and bending);
- mutual influences between gas meters;
- mounting instructions;
- maximum allowable diameter differences between the gas meter and connecting pipework; and
- other relevant installation conditions.

8 Sealing

8.1 VERIFICATION MARKS AND PROTECTION DEVICES

8.1.1 General provision

Protection of the metrological properties of the meter is accomplished via hardware (mechanical) sealing or via electronic sealing devices.

In any case, memorized quantities of gas measured (volume, mass or energy) shall be protected by means of a hardware seal.

The design of verification marks and hardware seals is subject to national or regional legislation. Seals shall be able to withstand outdoor conditions.

8.1.2 Verification marks

Verification marks indicate that the gas meter has successfully passed the initial verification. Verification marks shall be realized as hardware seals.

8.1.3 Hardware sealing

In case of hardware sealing the location of the marks shall be chosen in such a way that the dismantling of the part sealed by one of these marks results in permanently visible damage to this seal.

Locations to be sealed with verification or protection marks shall be provided on the instrument:

a) On all plates which bear information prescribed by this Recommendation;

Note *This requirement is only necessary if the nameplate can be detached from the meter.*

b) On all parts of the case which cannot be otherwise protected against interference likely to affect the accuracy of the measurement.

8.1.4 Electronic sealing devices

8.1.4.1 When access to parameters that contribute to the determination of results of measurement needs to be protected, but is not protected by mechanical seals, the protection shall fulfil the following provisions:

a) Access shall only be allowed to authorized people, for example by means of a code (password) or special device (hard key, etc.) and, after changing parameters, the instrument may be put into use "in sealed condition" again without any restriction,

or

Unrestricted access is allowed but, after changing the parameters, the instrument shall be put back into use "in sealed condition" only by authorized persons, e.g. by using a "password" (similar to classical sealing).

b) The code (password) shall be changeable.

c) The device shall either clearly indicate when it is in the configuration mode (not under legal metrological control), or it shall not operate while in this mode. This status shall remain until the instrument has been put into use "in sealed condition" in accordance with clause (a).

d) Identification data concerning the most recent intervention shall be recorded in an event logger. The record shall include at least:

- an identification of the authorized person that implemented the intervention; and
- the date and time of the intervention.

Besides the above-mentioned items it is also recommended to store the following:

- an event counter;
- the old value of the changed parameter;
- totals of the registers; and
- an identification of the authorized person who implemented the intervention.

The traceability of the most recent intervention shall be assured. If it is possible to store the records of more than one intervention, and if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

8.1.4.2 For instruments with parts which may be disconnected one from another, whether these are interchangeable or not, the following provisions shall be fulfilled:

a) It shall not be possible to access parameters that participate in the determination of results of measurements through disconnected points unless the provisions in clause 8.1.4.1 are fulfilled;

b) Interposing any device which may influence the accuracy shall be prevented by means of electronic and data processing securities or, if not possible, by mechanical means.

c) Moreover, these instruments shall be provided with devices which do not allow them to operate if the various parts are not configured according to the manufacturer's specification.

Note: Unauthorized disconnections by the user may be prevented, for example by means of a device that prevents any measurement after disconnecting and reconnecting.

9 Suitability for testing

The design of the instrument shall be such that initial and subsequent verification and metrological supervision can be carried out on site, without unreasonable effort.

9.1 USE OF DIFFERENT GASES FOR TESTING

When gas meters are to be verified (at inital or subsequent verification) with a type of gas different from that at operating conditions the maximum mutual difference between the error curves of the gas meter, obtained as result of testing with different gases, is limited to 0.5 times the maximum permissible error.

Example In case it is the intention to perform the verifications with air while in practice under operating conditions the gas meter is used for natural gas.

Part 2 Metrological controls and performance tests

10 Metrological controls

10.1 GENERAL PROCEDURES

10.1.1 Test method

All tests shall be carried out under the installation conditions (e.g. straight sections of piping upstream and downstream of the meter) stipulated by the supplier for this type of meter.

The used test equipment shall be equipped with reference standards that are suitable for the testing of the gas meters. The working range of the reference standards shall match that of the meters to be tested.
The test equipment shall be traceable to national or international standards.

If meters are to be tested in series, there should be no significant interaction between the meters. This condition may be verified by testing every meter of the series once at each position in the line.

During the tests corrections shall be made for temperature and pressure differences between the meter(s) under test and the standard or these differences have to be taken into account in the uncertainty calculations. The temperature and pressure measurements have to be performed at a representative position at the meter(s) under test and the standard.

10.1.2 Uncertainty

When a test is conducted, the expanded uncertainty ($k = 2$) of the determination of errors of the measured gas quantity shall meet the following specifications:

- for type evaluation: less than one-fifth of the applicable MPE;
- for verifications: less than one-third of the applicable MPE.

However, if the above-mentioned criteria cannot be met, the test results can be approved alternatively by reducing the applied maximum permissible errors with the excess of the uncertainties. In this case the following acceptance criteria shall be used:

- for type evaluation: $\pm\left(\frac{6}{5}\cdot MPE - U\right)$;
- for verifications: $\pm\left(\frac{4}{3}\cdot MPE - U\right)$.

The estimation of the expanded uncertainty U is made according to the *Guide to the expression of uncertainty in measurement* (GUM, 2008 edition) [6] with a coverage factor $k = 2$.

Example: *During testing for type evaluation of an Accuracy Class 1 gas meter a test result has an uncertainty of 0.3 % (k = 2). In this case the test results can be accepted if the error is between ± (6/5 × 1.0 - 0.3) % = ± 0.9 %.*

11 Type evaluation

11.1 GENERAL

Each type of gas meter is subject to the type evaluation procedure.

Without authorization by the authority that issued the type approval certificate, no modification may be made to an approved type.

The calculator (including indicating device) and the measuring transducer (including flow, volume, mass or energy sensor) of a gas meter, where they are separable and interchangeable with other calculators and measuring transducers of the same or different designs, may be the subject of separate type evaluations.

11.2 DOCUMENTATION

Applications for type approval of gas meters shall be accompanied by the following documents:

- a description of the meter giving the technical characteristics, and the principle of its operation;
- a perspective drawing or photograph of the meter;
- mechanical drawings of the essential parts;
- a description of the electronic devices with drawings, diagrams and general software information explaining their characteristics and operation (if applicable);
- a drawing showing the location of the verification marks and seals;
- a drawing of regulatory markings;
- a declaration specifying that the meter is manufactured in conformity with requirements for safety, particularly those concerning the maximum working pressure as indicated on the data plates.

11.3 TYPE EVALUATION PROCEDURES

11.3.1 Number of samples

The applicant shall deliver the requested number of sample gas meters, manufactured in conformity with the type, at the disposal of the authority responsible for type evaluation.

If so requested by the authority responsible for the type evaluation, these meters shall include more than one size if simultaneous approval of a family of gas meters is requested.

Depending on the results of the tests, the authority responsible for the type evaluation may request further specimens.

11.3.2 Reference conditions

All influence quantities, except for the influence quantity being tested, shall be held to the following values during type evaluation tests on a gas meter:

Working (gas/air) temperature:	(20.0 ± 5.0) °C;
Ambient temperature:	(20.0 ± 5.0) °C;
Ambient atmospheric pressure:	86 - 106 kPa;
Ambient relative humidity:	60 % ± 15 %;
Power voltage (AC/DC mains / battery):	
* if one nominal voltage is specified:	this specified nominal voltage (U_{nom});

* if a voltage range is specified:	a typical voltage within this range; to be negotiated between the manufacturer and the test laboratory;
Power voltage (battery):	the nominal voltage of a new or fully charged battery (not under charge);
Power frequency (AC mains):	nominal frequency (f_{nom}).

Note: High pressure tests may be performed at conditions other than reference conditions.

11.3.3 Flowrates

The errors of the gas meters shall be determined at a minimum of 6 flowrates, which are distributed over the measuring range at regular intervals, including Q_{min}, Q_t and Q_{max}.

11.3.4 Test gases

All the tests listed in 11.4 can be performed with air or any other gas as specified by the manufacturer under the rated operating conditions stated in 5.1. For the temperature tests in 11.4.7 it is important that the gas be dry.

The test with different gases as stated in 11.4.12 is performed with the gases specified by the manufacturer.

11.4 TYPE EVALUATION TESTS

During the type evaluation gas meters are tested while applying the requirements as stated in chapter 5. Annex C shows an overview of the required tests for different measurement principles.

Design inspection

Each type of gas meter submitted shall be inspected externally to ensure that it complies with the provisions of the relevant preceding clauses of these requirements (4, 0, 6, 8 and 9).

11.4.1 Error

The error of the gas meter shall be determined, while using the flowrates according to the prescriptions stated in 11.3.3. The error curve as well as the WME (3.2.5) shall be within the requirements as specified in 5.3 and 5.4 respectively.

If a curve fit is made out of the observations a minimum of 6 degrees of freedom is required.

Note The number of degrees of freedom is the difference between the number of observations and the number of parameters or coefficients needed for the curve fit. For example, if a polynomial curve fitting is used with 4 coefficients, at least 10 measuring points are necessary in order to get a minimum of 6 degrees of freedom.

During the accuracy test applied on the gas meter, the following quantities shall be determined:

- the cyclic volume of the gas meter, if applicable, according to the provisions of the last sentence in 5.18.2.
- the pulse factor of the gas meter, if applicable, according to the provisions of 5.18.3.
- the maximum pressure differential at Q_{max} and density of the gas, used for this test.

11.4.2 Reproducibility

Gas meters, which are sensitive to hysteresis behaviour, are tested at flowrates equal to or greater than Q_t. The errors are determined independently at least six times, by varying the flowrate between each consecutive measurement. For each flowrate the experimental standard deviation of the, at least, six measurements is calculated.

Note Gas meters with internal moving parts or meters based on the Vortex principle may have a hysteresis behaviour.

Note For gas meters which are intended to be used at high pressures, this test may be performed at the lowest operating pressure.

11.4.3 Repeatability

Gas meters, which are not sensitive to hysteris behaviour, are tested at the flowrates Q_{min}, Q_t, and Q_{max}. At each flowrate the errors are determined at least three times. For each flowrate the difference between the maximum and minimum measured error is calculated.

Note For gas meters which are intended to be used at high pressures, this test may be performed at the lowest operating pressure.

11.4.4 Orientation

The accuracy measurements as stated in 11.4.1 are performed in all prescribed orientations. The results of the different accuracy measurements are evaluated with the requirements as laid down in 5.13.1 without intermediate adjustments.

Note *If the requirements are not fulfilled for all prescribed orientations without intermediate adjustments, the meter shall be marked in order to be used in a certain orientation only, as indicated in 6.1.1 l).*

11.4.5 Flow direction

The accuracy measurements as stated in 11.4.1 are performed in both flow directions. The results of the different accuracy measurements are evaluated with the requirements as laid down in 5.13.2 without intermediate adjustments.

Note *If the requirements are not fulfilled for both flow directions without intermediate adjustments, the meter shall be marked in order to be used in a certain direction only, as indicated in 5.15.*

11.4.6 Working pressure

The accuracy measurements as stated in 11.4.1 are performed at least at the minimum and at the maximum operating pressure. However, for specified maximum pressures above 5 MPa (50 bar) a test at 5 MPa (50 bar) is deemed to be acceptable.

The results of the different accuracy measurements are evaluated with the requirements as laid down in 5.8 without intermediate adjustments.

11.4.7 Temperature

The temperature dependency of the gas meter shall be evaluated in the temperature range specified by the manufacturer, by one of the methods stated below, ranked in the following preferred order:

a) Flow tests at different temperatures (for mechanical and electronic domestic meters)

The flow tests are performed with a gas temperature equal to the ambient temperature as specified in 11.4.7.1. For gas meters with a built-in temperature conversion device also flow tests are performed with a gas temperature different from the ambient temperature as specified in 11.4.7.2.

Note: National Authorities shall define which instruments are considered to be domestic meters.

b) Monitoring the unsuppressed flowrate output of the meter at no-flow conditions at different temperatures (for electronic meters)

At no-flow conditions the unsuppressed flowrate output of the meter is used in order to determine the temperature influence on the meter accuracy. The examination is performed at least at the reference temperature, the minimum and maximum operating temperature. The results of the measurements at the different temperatures are evaluated with the requirements as laid down in 5.9, while taking into account the influence of the flowrate shift on the meter curve.

Example: *The unsuppressed flowrate output of an Accuracy Class 1 gas meter is changed with +1 l/h due to temperature variations. The initial error at reference conditions of this meter was + 0.3 % at a Q_{min} of 200 l/h. The influence due to temperature variations at Q_{min} is 1/200 × 100 % = + 0.5 %. The final value of + 0.8 % remains within the limits of the applicable maximum permissible error.*

c) Evaluation of the construction of the meter

In cases when the meter cannot be tested to determine the effect of temperature, the uncertainty resulting from the expected influence of temperature on the meter construction shall be evaluated.

11.4.7.1 Flow tests with equal gas and ambient temperatures

The flow tests are performed in the flow range in the flow range Q_t up to Q_{max}, with the gas temperature equal to the ambient temperature, at:

- Maximum ambient temperature;
- Minimum ambient temperature;
- Reference temperature.

The requirements as laid down in 5.9 for equal gas and ambient temperature are applicable.

11.4.7.2 Flow tests with unequal gas and ambient temperatures

The flow tests are performed while keeping the gas meter under test at a constant ambient temperature equal to the reference temperature. The gas or air is heated such that the gas temperature at the meter inlet is 20 °C above the reference temperature. The error is determined at Q_t and Q_{max}.

Note: Instead of the above-mentioned temperature test some authorities may require the following test.

The flow tests are performed at Q_t while using the following temperatures:

- *Maximum ambient temperature and a gas temperature 30 °C below this ambient temperature;*
- *Minimum ambient temperature and a gas temperature 30 °C above this ambient temperature.*

The requirements for unequal gas and ambient temperature as laid down in 5.9 are applicable

11.4.8 Flow disturbance

The gas meters of which the accuracy is affected by flow disturbances are submitted to the tests as specified in Annex B. During the tests the meter shall be installed according to the manufacturer's specifications. The requirements as laid down in 5.13.3. are applicable

11.4.9 Durability

Gas meters with internal moving parts are submitted to the durability test. This test consists of periods of continuous running, while using gases for which the meters are intended to be used. If the manufacturer demonstrates that the material of the gas meter is sufficiently insensitive to the gas composition, the authority responsible for the type evaluation may decide to perform the durability test with air or another suitable type of gas. The test shall be finished within 120 days.

Before and after the test the same reference equipment shall be used.

The authority responsible for the type evaluation shall choose the number of meters to be submitted for the durability test from the options given in Table 5 in consultation with the applicant. If different sizes are included, the total number of meters to be submitted shall be as stated in option 2.

Table 5 Number of meters to be tested

Maximum equivalent volume flowrate [m^3/h]	Number of meters to be tested	
	Option 1	Option 2
$Q_{max} \leq 25$	3	6
$25 < Q_{max} \leq 100$	2	4
$Q_{max} > 100$	1	3

After the durability test the gas meters (with the exception of one of them if the durability test has been carried out on a number of gas meters according to option 2) shall comply with the requirements laid down in 5.10

11.4.10 Drive shaft (torque)

The gas meters with drive shafts are submitted to the maximum possible torque, while using a gas at a density of 1.2 kg/m^3. The fault at Q_{min} is evaluated. The requirements as laid down in 5.13.4. are applicable.

Where a type of gas meter includes various sizes, this test needs only be carried out on the smallest size, provided that the same torque is specified for the larger gas meters and the drive shaft of the latter has the same or greater output constant.

11.4.11 Overload flow

Gas meters with internal moving parts are submitted to the overload flow. Before and after the overload the error of the gas meter is determined for its whole flow rate range according to 11.3.3. The requirements as laid down in 5.11 are applicable

11.4.12 Different gases

Gas meters which are intended to be used for different gases are submitted to accuracy measurements as stated in 11.4.1 with the gases, specified by the manufacturer.

The authority responsible for the type evaluation shall decide which gases are to be used during the investigation, depending on the application purpose of the gas meter under test.

The requirements as laid down in 5.13.5 are applicable.

If as a result of these accuracy measurements the gas meter does not comply clause 9.1 the authority responsible for type evaluation shall report that initial verifications can only be performed with a gas equal to the one which is used at operating conditions.

11.4.13 Vibration and shocks

Gas meters with a maximum weight of 10 kg are submitted to vibrations and shocks, as well as only the electronics part of gas meters exceeding this weight. Before and after the tests the error of the gas meter is determined for its whole flow rate range according to 11.3.3. The requirements as laid down in 5.12 are applicable.

11.4.14 Interchangeable components

For the gas meters of which some components are meant to be interchanged the influence of interchange shall be determined at Q_t.

Note : The maximum permissible error limits of the upper flow range apply. ($Q \geq Q_t$)

This test consists of the following accuracy tests:

- while using the starting configuration;
- after interchange of the component;
- after reinstalling the original component.

The fault is established by calculation of the maximum difference between the results of any of the three accuracy tests. The requirements as laid down in 5.13.6 are applicable

11.4.15 Electronics

For gas meters containing electronic components, the tests as described in 5.13.7 shall be performed, using the test methods described in Annex A. An overview of the test program is shown in Table 4, with an indication per

test whether it is considered to be an influence test or a disturbance test. After each test it shall be verified that no loss of data has occurred.

If the electronic devices of a gas meter are located in a separate housing, their electronic functions may be tested independently of the measuring transducer of the gas meter by simulated signals representing the rated operating conditions of the meter, in which case the electronic devices shall be tested in their final housing. (?????)

In all cases, ancillary equipment may be tested separately.

The tests as indicated in Table 4 are performed under the following conditions:

- The meter under test is powered up, except for the vibration and mechanical shock test;
- The dependency of the gas meter shall be evaluated by one of the flow possibilities stated below, ranked in the following preferred order:

1. Flow tests; or
2. Monitoring the unsuppressed flowrate output of the meter at no-flow conditions.

In the case of monitoring the unsuppressed flowrate output of the meter, the requirements indicated in Table 4 are checked while taking into account the influence of the flowrate shift on the meter curve.

Note: Mostly, electronic meters have a cut-off for low flowrates. This cut-off must be switched off for this test so that the flowrate output corresponds to the unsuppressed flowrate.

11.4.16 Software

The effect of all functions of the software (like communication possibilities) is determined by performing an accuracy test at Q_{min}, with and without applying the specific function. The effect shall be negligible.

11.5 TYPE APPROVAL CERTIFICATE

The following information and data shall appear on the type approval certificate:

- the name and address of the company to whom the type approval certificate is issued;
- the name of the manufacturer;
- the type of the gas meter and/or commercial designation;
- the principal metrological and technical characteristics, such as Accuracy Class, unit(s) of measurement, values of Q_{max}, Q_{min} and Q_t, the rated operating conditions (5.1), the maximum working pressure, nominal internal diameter of the connecting pieces and, in the case of volumetric gas meters, the nominal value of the cyclic volume;
- the type approval sign;
- the period of validity of the type approval (if applicable);
- for meters equipped with drive shafts: the characteristics of the drive shafts;
- the environmental classification;
- information on the location of the marks and inscriptions required in 6.1, initial verification marks and seals (where applicable, in the form of photographs or drawings);
- a list of the documents accompanying the type approval certificate;
- any special comments.

11.6 DIRECTIONS FOR PERFORMING INITIAL VERIFICATION

The authority issuing the type approval certificate may give specific instructions for performing the initial verifications, which may be dependent on the technology of the meter and supported by test results of the type evaluation.

Note *Examples are the type of gas to be used, zeroing of coriolis meters or the use of specific flowrates.*

12 Initial verification and subsequent verification

12.1 GENERAL

Initial verification and subsequent verification shall be carried out either individually or statistically, as described in 12.2. In all cases a meter shall conform to the requirements of this Recommendation. The following minimum program shall be carried out for both the individual and statistical verification.

12.1.1 Conformity with the approved type

A gas meter shall be examined to ascertain whether it conforms to its approved type.

12.1.2 Submission

A gas meter shall be submitted to initial verification in working order and shall be provided with the required space for the application of the verification and protection marks.

12.1.3 Test conditions

The accuracy requirements of chapter 5.3 and 5.4 shall be verified while using the conditions of the gas as close as possible to the operating conditions (pressure, temperature, gas type) under which the meter will be put into use.

The verification may also be performed with a type of gas (e.g. air) other than that the meter is intended to be used with, if the authorities responsible for the verification are convinced by either the outcome of the tests with different gases as described in 11.4.12 or the technical construction of the meter under test, that comparable results will be gained.

12.1.4 Flowrates

A gas meter is tested at the flowrates specified in 11.3.3.

If supported by instructions for performing verifications (see 11.6) authorities may perform the initial verification at a reduced number of flowrates or at flowrates differing from those prescribed in 11.3.3.

Notes: 1. *For a diaphragm meter, verification may be performed at Q_{max}, $0.2 \cdot Q_{max}$ and Q_{min}.*

2. *Countries may also decide to use a reduced number of test points for rotary piston gas meters.*

12.1.5 Orientation and flow direction

If the gas meter can be used in more than one flow direction and/or meter orientation, the verification shall be performed in both flow directions and/or the meter orientations specified by the manufacturer, unless during the type evaluation it is examined that the meter performance appeared to be independent on the meter orientation (see 11.4.4) and/or the flow direction (see 11.4.5).

12.1.6 Adjustments

If the error curve or the WME is outside the requirements specified in 5.3 and 5.4 respectively, the gas meter shall be adjusted such that the WME is as close to zero as the adjustment and the maximum permissible error allow.

Notes: *After changing the adjustment while using single point adjustment it is not necessary to repeat all the tests. It is sufficient to repeat a test at one flowrate and calculate the other error values from the previous ones.*

For high-pressure applications adjustment is performed while taking into account the operating conditions.

12.1.7 Output shafts

If the gas meter is intended to incorporate ancillary devices operated by the output shafts, these devices shall be attached during the verification, unless attachment after verification is explicitly authorized.

12.2 ADDITIONAL REQUIREMENTS FOR STATISTICAL VERIFICATIONS

This chapter contains the requirements additional to 12.1 for initial verification on a statistical basis.

Note: National or regional authorities may decide whether the use of statistical methods is allowed or not.

12.2.1 Lot

A lot shall consist of 1000 meters maximum, with homogeneous characteristics. In particular, the type approval identification, meter type, meter range and year of manufacture shall be identical.

12.2.2 Samples

Samples shall be randomly taken from a lot.

Note: The number of samples can be freely chosen, taking into account the requirement in 12.2.3. From the table at the end of 12.2.3 it follows that the minimum number of samples is 40.

12.2.3 Statistical testing

The statistical procedure shall meet the following requirements:

The statistical control will be based on attributes. The sampling system shall ensure:

- an Acceptance Quality Level (AQL) of not more than 1 %; and
- a Limiting Quality (LQ) of not more than 7 %.

The AQL is the maximum percentage of non-conforming items in a lot at which the lot has a probability of 95 % to be accepted.

The LQ is the percentage of non-conforming items in a lot at which the lot has a maximum probability of 5 % to be accepted.

Note: This requirement gives the testing laboratory substantial freedom in organizing the test. Examples are given in the table below. If 70 meters are tested and 1 meter appears to be non-conforming on one of the attributes, the lot passes.

Number of instruments to be tested	40	70	100	1000
Maximum number of non-conforming instruments	0	1	2	10

12.3 ADDITIONAL REQUIREMENTS FOR IN-SERVICE INSPECTIONS

Guidance for in-service inspections of utility meters is now being drafted by OIML TC 3/SC 4 [8].

(To be updated before publication)

Annex A: Environmental tests for electronic instruments or devices

(Mandatory)

A.1 General

This Annex defines the program of performance tests intended to verify that electronic gas meters and their ancillary devices may perform and function as intended in a specified environment and under specified conditions. Each test indicates, where appropriate, the reference conditions for determining the error.

These tests supplement any other prescribed tests.

When the effect of one influence quantity is being evaluated, all other influence quantities are to be held within the limits of the reference conditions.

A.2 Severity levels

For each performance test, typical test conditions are indicated. They correspond to the climatic and mechanical environment conditions to which instruments are usually exposed.

The metrology service carries out performance tests at severity levels corresponding to these environmental conditions. If type approval is granted, the documentation supplied by the manufacturer or its representative to the client or user shall indicate the corresponding limits of use. Manufacturers shall inform potential clients or users of the conditions of use for which the instrument is approved. The metrology service shall verify that the conditions of use are met.

A.3 Reference conditions

See 11.3.

A.4 Performance tests (climatic)

A.4.1 Static temperatures

A.4.1.1 Dry heat (non condensing): influence test					
Applicable standards	IEC 60068-2-2 [10]				
Test procedure in brief	The test consists of exposure to the specified high temperature under "free air" conditions for the time specified (the time specified is the time after the EUT has reached temperature stability). The change of temperature shall not exceed 1 °C/min during heating up and cooling down. The absolute humidity of the test atmosphere shall not exceed 20 g/m^3. When testing is performed at temperatures lower than 35 °C, the relative humidity shall not exceed 50 %.				
Severity levels	1	2	3	4	unit
Temperature	30	40	55	70	°C
Duration	2	2	2	2	h

A.4.1.2 Cold: influence test					
Applicable standards	IEC 60068-2-1 [9]				
Test procedure in brief	The test consists of exposure to the specified low temperature under "free air" conditions for the time specified (the time specified is the time after the EUT has reached temperature stability). The change of temperature shall not exceed 1 °C/min during heating up and cooling down. IEC specifies that the power to the EUT shall be switched off before the temperature is raised.				
Severity levels	1	2	3	4	unit
Temperature	5	-10	-25	-40	°C
Duration	2	2	2	2	h

A.4.2 Damp heat

A.4.2.1 Damp heat, steady-state (non condensing): influence test		
Applicable standards	IEC 60068-2-78 [15]	
Test procedure in brief	The test consists of exposure to the specified temperature and the specified constant relative humidity for a certain fixed time. The EUT shall be handled such that no condensation of water occurs on it. The gas meter shall be subjected 3 times to an accuracy test: - at reference conditions, before the increase of temperature; - at the end of the upper temperature phase; - at reference conditions, 24 h after the decrease of temperature.	
Temperature	upper temperature	°C
Relative humidity (RH)	93	%
Duration	4	days

A.4.2.2 Damp heat, cyclic (condensing): disturbance test		
Applicable standards	IEC 60068-2-30 [11]	
Test procedure in brief	The test consists of exposure to cyclic temperature variation between 25 °C and the appropriate upper temperature, maintaining the relative humidity above 95 % during the temperature change and low temperature phases, and at 93 % at the upper temperature phases. Condensation should occur on the EUT during the temperature rise. The 24 h cycle consists of: 1) Temperature rise during 3 h. 2) Temperature maintained at upper value until 12 h from the start of the cycle. 3) Temperature lowered to lower value within 3 h to 6 h, the rate of fall during the first hour and a half being such that the lower value would be reached in 3 h. 4) Temperature maintained at lower value until the 24 h cycle is completed. The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EUT are within 3 °C of their final temperature. During the test the instrument is under power; no gas flow is necessary. The gas meter shall be subjected 2 times to an accuracy test: - at reference conditions, before the increase of temperature; - at reference conditions, at least 4 h after the last cycle.	
Upper temperature	upper temperature	°C
Duration	2	cycles

A.5 Performance tests (mechanical)

A.5.1 Vibration (random): disturbance test	
Applicable standard	IEC 60068-2-47 [13], IEC 60068-2-64 [14]
Test procedure in brief	The test consists of exposure to the vibration level for a time sufficient for testing the various functions of the EUT during the exposure. The EUT shall, in turn, be tested in three, mutually perpendicular axes mounted on a rigid fixture by its normal mounting means. The EUT shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use. Where the effect of gravitational force is not important the EUT may be mounted in any position. Example: a diaphragm gas meter always has to be tested in an upright position, for each direction in which the meter has to be tested. During the test the instrument is not powered up.
Total frequency range	10 - 150 Hz
Total RMS level	7 $m \cdot s^{-2}$
ASD level 10-20 Hz	1 $m^2 \cdot s^{-3}$
ASD level 20-150 Hz	-3 dB/octave
Number of axes	3
Duration per axis	2 minutes

A.5.2 Mechanical shock: disturbance test	
Applicable standard	IEC 60068-2-31 [12]
Test procedure in brief	The EUT, placed in its normal position of use on a rigid surface, is tilted towards one bottom edge and is then allowed to fall freely onto the test surface. The height of fall is the distance between the opposite edge and the test surface. However, the angle made by the bottom and the test surface shall not exceed 30°. During the test the instrument is not powered up.
Height of fall	50 mm
Number of falls (on each bottom edge)	1

A.6 Performance tests (electrical, general)

A.6.1 Radio frequency immunity tests

A.6.1.1 Radiated, radio frequency, electromagnetic fields: influence test	
Applicable standard	IEC 61000-4-3 [19]
Test procedure in brief	The EUT shall be exposed to electromagnetic field strength as specified by the severity level and a field uniformity as defined by the referred standard. The frequency ranges to be considered are stepped incrementally with the modulated signal, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. The step size shall not exceed 1 % of the preceding frequency value. The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0.5 s. The sensitive frequencies (e.g. clock frequencies) shall be analyzed separately. (1)
Frequency range	80 MHz - 2 GHz [(2), (4)] 26 MHz - 2 GHz [(3)]
Field strength	10 V/m
Modulation	80 % AM, 1 kHz, sine wave
Notes	[(1)] Usually, these sensitive frequencies can be expected to be the frequencies emitted by the EUT. [(2)] IEC 61000-4-3 (1995-03) [19] only specifies test levels above 80 MHz. For frequencies in the lower range the test methods for conducted radio frequency disturbances are recommended (test A.6.1.2). [(3)] However, for EUT having no mains or other input port available the lower limit of the radiation test should be 26 MHz taking into account that the test specified in A.6.1.2 cannot be applied (refer to Annex H of IEC 61000-4-3 [19]). In all other cases both A.6.1.1 and A.6.1.2 shall apply. [(4)] For the frequency range 26 - 80 MHz, the testing laboratory can either carry out the test according to A.6.1.1 or according to A.6.1.2. But in case of a dispute, the results according to A.6.1.2 shall prevail.

A.6.1.2 Conducted radio-frequency fields: influence test	
Applicable standard	IEC 61000-4-6 [22]
Test procedure in brief	Radio frequency EM current, simulating the influence of EM fields shall be coupled or injected into the power ports and I/O ports of the EUT using coupling/decoupling devices as defined in the referred standard. The performance of the test equipment consisting of an RF generator, (de-)coupling devices, attenuators, etc. shall be verified.
RF amplitude (50 Ω)	10 V (e.m.f.)
Frequency range	0.15 - 80 MHz
Modulation	80 % AM, 1 kHz sine wave
Notes	(1) This test is not applicable when the EUT has no mains or other input port. (2) If the EUT is composed of several elements, the tests shall be performed at each extremity of the cable if both of the elements are part of the EUT. (3) For the frequency range 26 - 80 MHz, the testing laboratory can either carry out the test according to A.6.1.1 or according toA.6.1.2. But in case of a dispute, the results according to A.6.1.2 shall prevail.

A.6.2 Electrostatic discharge: disturbance test		
Applicable standard	IEC 61000-4-2 [18]	
Test procedure in brief	An ESD generator shall be used with a performance as defined in the referred standard. Before starting the tests, the performance of the generator shall be verified. At least 10 discharges shall be applied. The time interval between successive discharges shall be at least 10 seconds. For EUT not equipped with a ground terminal, the EUT shall be fully discharged between discharges. Contact discharge is the preferred test method. Air discharges shall be used where contact discharge cannot be applied. Direct application: In the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EUT. In the air discharge mode on insulated surfaces, the electrode is approached to the EUT and the discharge occurs by spark. Indirect application: The discharges are applied in the contact mode to coupling planes mounted in the vicinity of the EUT.	
Test voltage	Contact discharge (1)	6 kV
	Air discharge (1)	8 kV
Notes	(1) Contact discharges shall be applied on conductive surfaces. Air discharges shall be applied on non-conductive surfaces.	

A.6.3 Bursts (transients) on signal, data and control lines: disturbance test		
Applicable standards	IEC 61000-4-4 [20]	
Test procedure in brief	A burst generator shall be used with the performance characteristics as specified in the referred standard. The test consist of exposure to bursts of voltage spikes for which the repetition frequency of the impulses and peak values of the output voltage on 50 Ω and 1000 Ω load are defined in the referred standard. The characteristics of the generator shall be verified before connecting the EUT. Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity. For the coupling of the bursts into the I/O and communication lines, a capacitive coupling clamp as defined in the standard shall be used. The test pulses shall be continuously applied during the measuring time.	
Test voltage	Amplitude (peak value)	1 kV
	Repetition rate	5 kHz

A.6.4 Surges on signal, data and control lines: disturbance test			
Applicable standard:	IEC 61000-4-5 [21]		
Test procedure in brief	A surge generator shall be used with the performance characteristics as specified in the referred standard. The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referred standard. The characteristics of the generator shall be verified before connecting the EUT. At least 3 positive and 3 negative surges shall be applied. The injection network depends on the lines the surge is coupled into and is defined in the referred standard. The test pulses shall be continuously applied during the measuring time.		
Test voltage	Unsymmetrical lines	Line to line: 0.5 kV	Line to ground: 1.0 kV
	Symmetrical lines	Line to line: NA	Line to ground: 1.0 kV
	Shielded I/O and communication lines	Line to line: NA	Line to ground: 0.5 kV

A.7 Performance tests (electrical, mains power)

A.7.1 DC mains voltage variation: influence test	
Applicable standard	IEC 60654-2 [16]
Test procedure in brief	The test consists of exposure to the specified power supply condition for a period sufficient for establishing stability.
Test severity	The upper limit will be the DC level, which the electronic instrument has been manufactured for to automatically detect high-level conditions. The lower limit will be the DC level, which the electronic instrument has been manufactured for to automatically detect low-level conditions. The instrument shall comply with the specified maximum permissible error at supply voltage levels between the two levels.

A.7.2 AC mains voltage variation: influence test		
Applicable standards	IEC/TR 61000-2-1 [17]	
Test procedure in brief	The test consists of exposure to the specified power condition for a period sufficient for achieving temperature stability and for performing the required measurements.	
Mains voltage (1), (2)	upper limit	U_{nom} + 10 %
	lower limit	U_{nom} - 15 %
Notes	(1) In the case of three-phase power supply, the voltage variation shall apply for each phase successively. (2) The values of U are those marked on the measuring instrument. In case a range is specified, the "-" relates to the lowest value and the "+" to the highest value of the range.	

A.7.3 AC mains voltage dips and short interruptions: disturbance test							
Applicable standards	IEC 61000-4-11 [23], IEC 61000-6-1 [26], IEC 61000-6-2 [27]						
Test procedure in brief	A test generator suitable to reduce the amplitude of the AC mains voltage for a defined period of time is used. The performance of the test generator shall be verified before connecting the EUT. The mains voltage reductions shall be repeated 10 times with an interval of at least 10 seconds. The test pulses shall be continuously applied during the measuring time.						
Test (1, 2)		test a	test b	test c	test d	test e	unit
Voltage reduction	Reduction to	0	0	40	70	80	%
	Duration	0.5	1	10 / 12 (1)	25 / 30 (1)	250 / 300 (1)	cycles
Notes	(1) These values are for 50 Hz / 60 Hz, respectively. (2) All 5 tests (a, b, c, d and e) are applicable; it is possible that any of the tests fail while the other tests pass.						

A.7.4 Voltage dips, short interruptions and voltage variations on DC mains power			
Applicable standard		IEC 61000-4-29 [25]	
Test procedure in brief		A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified. The voltage dips and short interruptions shall be tested on the EUT, for each selected combination of test level and duration, with a sequence of tree dips/interruptions with intervals of 10 s minimum between each test event. The EUT shall be tested for each of the specified voltage variations, three times at 10 s intervals in the most representative operating modes. If the EUT is an integrating instrument, the test pulses shall be continuously applied during the measuring time.	
Test severities		The following levels shall be applied:	Unit
Voltage dips	Test levels	40 and 70	% of the rated voltage
	Duration (1)	10; 30; 100	ms
Short interrup-tions (4)	Test condition	High impedance and/or low impedance	
	Test levels	0	% of the rated voltage
	Duration (1)	1; 3; 10	ms
Voltage variations	Severity levels	1 (1)	
	Test level	85 and 120	% of the rated voltage
	Duration (1)	0.1; 0.3; 1; 3; 10	s
Notes		(1) All durations are to be tested	

A.7.5 Bursts (transients) on AC and DC mains: disturbance test	
Applicable standards	IEC 61000-4-4 [20]
Test procedure in brief	A burst generator shall be used with the performance characteristics as specified in the referred standard. The test consists of exposure to bursts of voltage spikes for which the repetition frequency of the impulses and peak values of the output voltage on 50 Ω and 1000 Ω load are defined in the referred standard. The characteristics of the generator shall be verified before connecting the EUT. Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity. The injection network on the mains shall contain blocking filters to prevent the burst energy from being dissipated in the mains. The test pulses shall be continuously applied during the measuring time.
Amplitude	peak value: 2 kV
Repetition rate	5 kHz

A.7.6 Surges on AC and DC mains: disturbance test		
Applicable standard:	IEC 61000-4-5 [21]	
Test procedure in brief	A surge generator shall be used with the performance characteristics as specified in the referred standard. The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referred standard. The characteristics of the generator shall be verified before connecting the EUT. On AC mains supply lines at least 3 positive and 3 negative surges shall be applied synchronously with AC supply voltage in angles 0°, 90°, 180° and 270°. On DC power lines, at least 3 positive and 3 negative surges shall be applied. The injection network depends on the lines the surge is coupled into and is defined in the referred standard. The test pulses shall be continuously applied during the measuring time.	
Test voltage	Line to line: 1.0 kV	Line to ground: 2.0 kV

A.7.7 Ripple on DC mains power	
Applicable standard	IEC 61000-4-17 [24]
Test procedure in brief	A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified. The test consist subjecting the EUT to ripple voltages such as those generated by rectifier systems and/or auxiliary service battery chargers overlaying on DC power supply sources. The frequency of the ripple is the power frequency or its multiple 2, 3 or 6, as specified in the product specification. The waveform of the ripple, at the output of the test generator, has a sinusoid-linear character. The test shall be applied for at least 10 min or for the time period necessary to allow a complete verification of the EUT's operating performance.
Percentage of the nominal DC voltage [(1)]	2
Notes	[(1)] The test levels are a peak-to-peak voltage expressed as a percentage of the nominal DC voltage. [(2)] This test does not apply to instruments connected to battery charger systems incorporating switch mode converters.

A.8 Performance test (battery powered instrument)

A.8 Low voltage of internal battery (not connected to the mains power): influence test	
Applicable standards	There is no reference to standards for this test.
Test procedure	The test consists of exposure to the specified condition of the battery(s) for a period sufficient for achieving temperature stability and for performing the required measurements. If an alternative power source (standard power supply with sufficient current capacity) is used in bench testing to simulate the battery, it is important that the internal impedance of the specified type of battery also be simulated. The maximum internal impedance of the battery is to be specified by the manufacturer of the instrument.
Lower limit of the voltage	The lowest voltage at which the instrument functions properly according to the specifications.
Number of cycles	At least one test cycle for each functional mode.

Annex B: Flow disturbance tests (Mandatory)

B.1 General

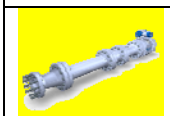
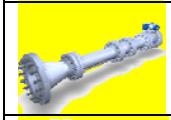
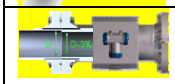
B.1.1 The test specified in this Annex shall be carried out with air at atmospheric pressure, at flowrates of 0.25 Q_{max}, 0.4 Q_{max} and Q_{max}. Alternatively, the test may be performed with a suitable gas at a pressure within the pressure range of the gas meter.

B.1.2 If the design of the type of the gas meter is similar for all pipe sizes, it is sufficient to perform the full set of tests on one size. If necessary tests are also performed with other sizes.

B.2 Flow disturbances

B.2.1 The piping configurations are presented in the following table B.1, whereby for each of the meters those configurations are chosen for which the meters are the most sensitive.

Table B.1 - Piping configurations for flow disturbances

	Test conditions	Remarks	Turbine	Ultrasonic	Vortex
	Reference conditions	Approx. 80 D straight line	X	X	X
	a single 90°-bend		X	X	X
	Double out-of-plane bend			X	X
	Double out-of-plane bend	rotating right	X		
	Double out-of-plane bend	rotating left	X		
	Expander			X	X
	Reducer			X	X
	Diameter step on the upstream flange	approx. +3% and –3%	X	X	X

B.2.2 For each of the perturbations the minimum length whereby the additional error - above Q_t - in respect to the reference conditions is less than or equal to one third of the maximum permissible error, must be determined.
To meet the requirements a flow conditioner specified by the manufacturer may be used.

B.2.3 During each test mentioned in table B.1 the shift of the error curve of the gas meter shall not exceed one third of the maximum permissible error.

Annex C: Overview of tests applicable for different metering principles (Mandatory)

C.1 General

This Annex shows the tests required for the different metering principles. In Table C.1 the diaphragm gas meter, the Temperature Compensated (TC) diaphragm gas meter, the rotary piston gas meter and the turbine gas meter are purely mechanical meters.

If electronics and/or software are added to these mechanical operating principles, the electronic and software tests will apply as well.

Table C.1 Overview of applicable tests for different metering principles

Test	Clause	**Diaphragm**	**TC diaphragm**	**Rotary piston**	**Turbine**	**Ultrasonic**	**Coriolis**	**Thermal mass**	**Vortex**
Design inspection	0	X	X	X	X	X	X	X	X
Error	11.4.1	X	X	X	X	X	X	X	X
Reproducibility	11.4.2	X	X	X	X	-	-	-	X
Repeatability	11.4.3	-	-	-	-	X	X	X	-
Orientation	11.4.4	-	-	X	X	-	X	-	-
Flow direction	11.4.5	-	-	X	X	X	X	-	-
Working pressure	11.4.6	X	X	X	X	X	X	X	X
Temperature	11.4.7	X	X	X	X	X	X	X	X
Flow disturbance	11.4.8	-	-	-	X	X	-	-	X
Durability	11.4.9	X	X	X	X	-	-	-	-
Drive shaft test (torque)	11.4.10	-	-	if applicable	if applicable	-	-	-	-
Overload flow test	11.4.11	X	X	X	X	-	-	-	-
Different gases	11.4.12	X	X	X	X	X	X	X	X
Vibrations and shocks	11.4.13	X	X	X	X	X	X	X	X
Interchangeable components	11.4.14	-	-	if applicable	if applicable	if applicable	-	-	-
Electronics	11.4.15 + Annex A	-	-	-	-	X	X	X	X
Software	11.4.16	-	-	-	-	X	X	X	X

Annex D: Bibliography

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