INTERNATIONAL RECOMMENDATION

OIML R 137-1 & 2

Edition 2012 (E)

Including Amendment 2014

Gas meters

Part 1: Metrological and technical requirements
Part 2: Metrological controls and performance tests

Compteurs de gaz

Partie 1: Exigences métrologiques et techniques
Partie 2: Contrôles métrologiques et essais de performance

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ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

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12.5 TYPE EVALUATION PROCEDURES

12.5.1 Software evaluation

The software evaluation procedure concerns evaluation of compliance to the requirements as described in part 2 Annex I and comprises a combination of analysis and validation methods and tests as shown in Table 6. The explanation of the abbreviations used and the relation to the methods as described in detail in OIML D 31 is shown in Table 7.

Table 1 Software validation procedures applicable for verification of compliance

Requirement		Evaluation procedure
I.1.1	Software identification	AD + VFTSw
I.1.2	Correctness of algorithms	AD + VFTSw
I.1.3	Fraud protection	AD + VFTSw + DFA/CIWT/SMT[1]
	Parameter protection	AD + VFTSw + DFA/CIWT/SMT[1]
I.2.1	Separation of electronic devices and sub-assemblies	AD
I.2.2	Separation of software parts	AD
I.2.3	Storage of data, transmission via communication systems	AD + VFTSw + CIWT/SMT[1]
I.2.3.1	Data protection with respect to time of measurement	AD + VFTSw + SMT[1]
I.2.4	Automatic storage	AD + VFTSw
I.2.3.4	Transmission delay	AD + VFTSw
I.2.3.5	Transmission interruption	AD + VFTSw
	Time stamp	AD + VFTSw

Table 2 Cross references of evaluation procedures to those described in Annex E

Abbreviation	Description	Related Annex E and OIML D 31:2008 Clause
AD	Analysis of the documentation and validation of the design	Annex E (E1) ➔ D 31 (6.3.2.1)
VFTM	Validation by functional testing of metrological functions	Annex E (E2) ➔ D 31 (6.3.2.2)
VFTSw	Validation by functional testing of software functions	Annex E (E3) ➔ D 31 (6.3.2.3)
DFA[1]	Metrological data flow analysis	Annex E (E4) ➔ D 31 (6.3.2.4)
CIWT[1]	Code inspection and walkthrough	Annex E (E5) ➔ D 31 (6.3.2.5)
SMT[1]	Software module testing	Annex E (E6) ➔ D 31 (6.3.2.6)

[1)] If one of the three cases below applies, the execution of the evaluation methods DFA, CIWT and SMT is not necessary:

- Case 1: no data transmission interface is incorporated in the gas meter, or
- Case 2: a transmission interface is incorporated but only provides measurement data output from the gas meter, or
- Case 3: no transmission of measurement data in open systems is possible.

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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 Project Groups linked to Technical Committees or Subcommittees which comprise representatives from OIML 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 2012 - was developed by Technical Subcommittee TC 8/SC 7 *Gas meters*. It was approved online for final publication by the International Committee of Legal Metrology in 2012 and will be submitted to the International Conference of Legal Metrology in 2012 for formal sanction. It supersedes OIML R 137-1 (2006).

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Part 1: Metrological and technical requirements

1 Introduction

After OIML R 137-1 *Gas meters* was published, the responsibility for this Recommendation was transferred to OIML TC 8/SC 7 and the secretariat began drafting Part 2 *Metrological controls and performance tests*. It was identified that this would require some changes to the contents of Part 1.

The separation of R 137 into Parts 1 and 2 was introduced to comply with the draft general format for OIML Recommendations, and ultimately has resulted in the drafting of the present publication which comprises both parts. The major changes since the 2006 edition of R 137 are:

- the scope of the Recommendation has been amended to also include residential meters with internal temperature compensation;
- the Terminology section has been amended to comply with OIML V 2-200:2012 *International Vocabulary of Metrology – Basic and General Concepts and Associated Terms*;
- software requirements and evaluation methods from OIML D 31 *General requirements for software controlled measuring instruments* have been implemented;
- several influence quantity tests extracted from OIML D 11 *General requirements for electronic measuring instruments* have been updated;
- the test methods regarding the influences of flow disturbances have been amended.

This Recommendation comprises 3 parts:

- Part 1: Metrological and technical requirements;
- Part 2: Metrological controls and performance tests;
- Part 3: Report format for type evaluation.

The present publication comprises both Part 1 and Part 2; Part 3 will be published separately.

2 Scope

This Recommendation applies to gas meters based on any measurement technology or principle that is used to measure the quantity of gas that has passed through the meter at operating conditions. The quantity of gas can be expressed in units of volume or mass.

This Recommendation applies to gas meters intended to measure quantities of gaseous fuels or other gases. It does not cover meters used for gases in the liquefied state, multi-phase, steam and compressed natural gas (CNG) used in CNG dispensers.

Built-in correction devices and devices for internal temperature compensation are included in this scope as well as any other (electronic) devices that may be attached to the gas meter.

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 laid down in OIML R 140 *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) [1] and the *International Vocabulary of Terms in Legal Metrology* (VIML) [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. flow rate, Reynolds number (curve linearization), or density, 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 flow rates, 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 (see 3.5.2) for each meter size and using the same metrological software routines (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 passed through the gas meter over time, which is expressed as volume V or mass m, disregarding the time taken. The quantity of gas is the measurand concerned (see 3.1.2)

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

Note: The presented VIM definition of (measurement) error is often interpreted as the definition for an absolute error. However, when expressing a parameter as a percentage or in dB this definition could also be applied to a relative error. Since in all cases in this document the errors are expressed in relative values it was decided that a separate definition for a relative error is not needed.

3.2.5 weighted mean error (WME)

the weighted mean error (WME) within the scope of this Recommendation is defined as:

$$WME = \frac{\sum_{i=1}^{n} k_i E_i}{\sum_{i=1}^{n} k_i} \qquad \text{with} \qquad k_i = \frac{Q_i}{Q_{max}} \qquad \text{for } Q_\mathrm{i} \le 0.7\, Q_{max}$$

$$k_i = 1.4 - \frac{Q_i}{Q_{max}} \qquad \text{for } 0.7\, Q_{max} < Q_\mathrm{i} \le Q_{max}$$

where:

k_i = weighting factor at the flow rate Q_i;

E_i = the error at the flow rate Q_i.

3.2.6 intrinsic error (OIML D 11, 3.7)

error determined under reference conditions

3.2.7 fault (OIML D 11, 3.9)

difference between the error of indication and the intrinsic error of a measuring instrument

Note 1: 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.

Note 2: "measuring instrument" is to be interpreted as a "gas meter" within the scope of this Recommendation.

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 measurement precision (VIM 2.15)

closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions

3.2.12 repeatability (VIM 2.21)

measurement precision under a set of repeatability conditions of measurement

3.2.13 repeatability of error

repeatability under reference conditions and not changing the flow rate between the measurements

3.2.14 reproducibility (VIM 2.25)

measurement precision under reproducibility condition of measurement

3.2.15 reproducibility of error

reproducibility under reference conditions and changing the flow rate between the measurements

3.2.16 operating conditions

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

3.2.17 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

3.2.18 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

3.2.19 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.

3.2.20 test element (of an indicating device)

device to enable precise reading of the measured gas quantity

3.2.21 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.

3.2.22 (instrumental) drift (VIM 4.21)

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

3.3 Operating conditions

Note: For the definition of operating conditions, see 3.2.16.

3.3.1 flow rate, 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 flow rate, Q_{max}

highest flow rate 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 flow rate, Q_{min}

lowest flow rate 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 flow rate, Q_t

flow rate which occurs between the maximum flow rate Q_{max} and the minimum flow rate Q_{min} that divides the flow rate 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 unacceptable deterioration of its metrological performance

3.3.7 specified temperature, t_{sp}

median temperature for gas meters with built-in conversion devices, used as a reference for the determination of the applicable operating temperature range

Note: The difference between t_{sp} and the gas temperature has an influence on the value of the MPE

3.3.8 working pressure, p_w

pressure of the gas to be measured at the gas meter

3.3.9 minimum and maximum working pressure, p_{min} and p_{max}

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

3.3.10 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

3.3.11 working density, ρ_w

density of the gas flowing through the gas meter, corresponding to ρ_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 that 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

conditions outside the rated operating conditions (including flow rate, temperature, pressure, humidity and electromagnetic interference) that a gas meter is required to withstand without deterioration.

3.4.4 test (OIML D 11, 3.20)

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

3.4.5 test procedure (OIML D 11, 3.20.1)

detailed description of the test operations

3.4.6 test program (OIML D 11, 3.20.2)

description of a series of tests for a certain type of equipment

3.4.7 performance test (OIML D 11, 3.20.3)

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 ancillary equipment, as far as it is subject to metrological control, is considered part of the gas meter, unless the ancillary equipment is approved and verified separately.

3.5.2 electronic device (OIML 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 device used to affect electrons and/or their associated fields in their movement through a medium or 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

<table>
<tr><th colspan="4">Rated operating conditions for a gas meter shall be as follows:</th></tr>
<tr><td rowspan="2">a)</td><td rowspan="2">Ambient temperature
(Temperature range chosen shall at least cover 50 K)</td><td>low</td><td>–40 °C, –25 °C, –10 °C and +5 °C (1)</td></tr>
<tr><td>high</td><td>+30 °C, +40 °C, +55 °C and +70 °C (1)</td></tr>
<tr><td>b)</td><td>Ambient relative humidity</td><td colspan="2">As specified by the manufacturer; at least up to 93 %</td></tr>
<tr><td>c)</td><td>Atmospheric pressure</td><td colspan="2">As specified by the manufacturer;
at least covering 86 kPa – 106 kPa</td></tr>
<tr><td>d)</td><td>Vibration less than</td><td colspan="2">10 Hz – 150 Hz, 1.6 ms^{-2}, 0.05 m^2s^{-3}, –3dB/octave</td></tr>
<tr><td>e)</td><td>DC mains voltage (3)</td><td colspan="2">As specified by the manufacturer</td></tr>
<tr><td>f)</td><td>AC mains voltage (3)</td><td colspan="2">U_{nom} – 15 % to U_{nom} + 10 %</td></tr>
<tr><td>g)</td><td>AC mains frequency (3)</td><td colspan="2">f_{nom} – 2 % to f_{nom} + 2 %</td></tr>
<tr><td>h)</td><td>Flow rate range</td><td colspan="2">Q_{min} to Q_{max} inclusive</td></tr>
<tr><td>i)</td><td>Type of gases</td><td colspan="2">The family of natural gases, industrial gases, or supercritical gases; to be specified by the manufacturer (2),</td></tr>
<tr><td>j)</td><td>Working pressure range:</td><td colspan="2">p_{min} to p_{max} inclusive</td></tr>
<tr><td colspan="4">(1) These values are to be decided by the national authority, as it depends on the climatic conditions and the expected conditions of application (indoors, outdoors, etc.) that are different in different countries.
(2) Supercritical refers to the situation where there is no distinction between the gaseous and liquefied state of the fluid
(3) If applicable</td></tr>
</table>

5.2 Values of Q_{max}, Q_t and Q_{min}

The flow rate characteristics of a gas meter shall be defined by the values of Q_{max}, Q_t and Q_{min}
Their ratios and relations shall be within the ranges as stated in Table 1.

Table 1 Flow rate characteristics

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

5.3 Accuracy classes and maximum permissible errors (MPE)

5.3.1 General

A gas meter shall be designed and manufactured such that its errors do not exceed the applicable MPE under rated operating conditions.

5.3.2 Accuracy classes

Gas meters may be divided in three accuracy classes: 0.5, 1 and 1.5. A gas meter shall be classified according its accuracy in one of these classes. The value of the MPE is dependent on the applicable accuracy class as listed in Table 2 below.

5.3.3 Correction for known errors

A gas meter may be equipped with a correction device, intended to reduce the errors as close as possible to the zero value. Such a correction device shall not be used for the correction of a pre-estimated drift.

5.3.4 Maximum permissible errors (MPE)

Table 2 Maximum permissible errors of gas meters

Flow rate Q	During type evaluation and initial verification			During subsequent verification and In-service *		
	Accuracy class			Accuracy class		
	0.5	1	1.5	0.5	1	1.5
$Q_{min} \leq Q < Q_t$	± 1 %	± 2 %	± 3 %	± 2 %	± 4 %	± 6 %
$Q_t \leq Q \leq Q_{max}$	± 0.5 %	± 1 %	± 1.5 %	± 1 %	± 2 %	± 3 %

* *Note:* National Authorities may decide to implement maximum permissible errors for subsequent or in-service verification.

5.3.5 Gas meter with a built-in conversion device

For a gas meter with a built-in conversion device and displaying the volume at base conditions only, the maximum permissible errors as indicated in Table 2 are increased by 0.5 % in the temperature range of (t_{sp} – 15) °C to (t_{sp} + 15) °C. Outside this temperature range an additional increase of 0.5 % per additional interval of 10 °C is permitted to this extended MPE. The temperature t_{sp} is specified by the manufacturer.

Note 1: The conversion may be based on temperature and/or pressure measurements.

Note 2: Gas meters indicating both actual volume and volume at base conditions are considered gas metering systems for which OIML R 140 is also applicable.

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

Flow rate Q	During type evaluation and initial verification			During subsequent verification and in-service		
	Accuracy class			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 components of the gas meter which affect the metrological behavior or after 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

For flow rates equal to or greater than Q_t the reproducibility of error at the specific flow rate shall be less than or equal to one third of the maximum permissible error.

5.7 Repeatability

The repeatability of error of three consecutive measurements at the specific flow rate 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.

5.9 Temperature

The requirements as mentioned in 5.3 shall be fulfilled over the whole temperature range, where the ambient temperature equals the gas temperature within 5 °C.

For gas meters indicating the volume at base conditions only, the double maximum permissible error limits for flow rates equal to or above Q_t apply when the ambient temperature differs by 20 °C or more from the gas temperature.

5.10 Durability

A gas meter shall meet the following requirements after being subjected to a flow with rate between 0.8 Q_{max} and Q_{max} comprising a quantity that is equivalent to a flow at Q_{max} during a period of 2 000 hours:

- the maximum permissible errors as specified in Table 2 for subsequent verification and in-service, and
- for flow rates from Q_t up to Q_{max} a fault of less than or equal to:
  - 1.0 times the maximum permissible error applicable during type evaluation for class 1.5 or
  - 0.5 times the maximum permissible error applicable during type evaluation for other classes.

5.11 Overload flow

A gas meter shall meet the following requirements, after being exposed to an overload of 1.2 Q_{max} for a period of 1 hour:

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

5.12 Vibrations and shocks

A gas meter 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 Hz – 20 Hz:	1 m^{2}s^{-3}
ASD level 20 Hz – 150 Hz:	–3 dB/octave

5.12.2 shocks:

height of fall:	50 mm

The fault after the application of vibrations and shocks shall be less than 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 manufacturer of the meter specifies that the meter will only operate correctly while installed in certain orientations and if the meter is marked as such, the metrological requirements mentioned in 5.3 and 5.4 shall be fulfilled for these orientations only.

In the absence of such marks the meter shall fulfill these requirements for all orientations.

5.13.2 Flow direction

If the meter is marked as being able to measure the flow in both directions, the metrological requirements mentioned in 5.3 and 5.4 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 due to these disturbances shall not exceed one third of the maximum permissible error. In case such a gas meter is specified to be installed in specific piping arrangements producing only mild flow disturbances, the meter shall be marked as such and may only be installed in those specific piping configurations for which its accuracy has proven to stay within this requirement.

5.13.4 Drive shaft (torque)

For types of gas meters with one or more drive shafts, any fault which results from the application of the maximum torque, as specified by the manufacturer, 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 intended 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 applicable during type evaluation, 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 and Table 5 apply.

5.13.8 Influences from ancillary devices

Gas meters provided with ancillary devices shall be designed such that all functions of the ancillary devices (e.g. provisions for communication purposes) do not affect the metrological behavior.

Table 4 Requirements for gas meters containing electronic components

No.	Influence factor	Range	Error limit
a	Dry heat	upper temperature specified	MPE
b	Cold	lower temperature specified	MPE
c	Damp heat, steady state (non-condensing)	upper temperature specified, 93 % relative humidity	MPE
d	DC mains voltage variation [(1)]	as specified by the manufacturer	MPE
e	AC mains voltage variation [(1)]	85 % & 110 % of the rated voltage	MPE
f	Low voltage of internal battery [(1)]	as specified by the manufacturer	MPE
[(1)] If applicable			

Table 5 Immunity requirements for gas meters containing electronic components

No.	Disturbance	Required immunity	Fault limit / test condition [3]
a	Damp heat, cyclic (condensing)	upper temperature, specified 93 % relative humidity	½ MPE / NSFa
b	Vibrations (random)	total frequency range: 10 Hz – 150 Hz total RMS level: 7 $m.s^{-2}$ ASD level 10 Hz–20 Hz: 1 $m^2.s^{-3}$ ASD level 20 Hz–150 Hz: –3dB/octave	½ MPE / NSFa
c	Mechanical shock	50 mm	½ MPE / NSFa
d	Radiated, RF, electromagnetic fields	10 V/m, up to 3 GHz	MPE / NSFd
e	Conducted (common mode) currents generated by RF EM fields	10 V (e.m.f.), up to 80 MHz	MPE / NSFd
f	Electrostatic discharges	6 kV contact discharge 8 kV air discharge	½ MPE / NSFa+d
g	Bursts (transients) on signal, data and control lines	Amplitude 1 kV Repetition rate 5 kHz	½ MPE / NSFd
h	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	½ MPE / NSFd
i	AC mains voltage dips and short interruptions [1]	½ cycle 0 % 1 cycle 0 % 10/12 [2] cycles 40 % 25/30 [2] cycles 70 % 250/300 [2] cycles 80 %	½ MPE / NSFd
j	DC mains voltage dips and short interruptions [1]	40 % and 70 % of the rated voltage during 0.1 s and 0 % of rated voltage during 0.01 s	½ MPE / NSFd
k	Bursts (transients) on AC and DC mains	Amplitude 2 kV Repetition rate 5 kHz	½ MPE / NSFd
l	Surges on AC and DC mains	line to line 1.0 kV line to ground 2.0 kV	½ MPE / NSFa+d
m	Ripple on DC mains power [1]	2 % of nominal DC voltage	½ MPE / NSFd
[1] If applicable [2] For 50 Hz/ 60 Hz respectively [3] NSFa: No significant fault shall occur after the disturbance. NSFd: No significant fault shall occur during the disturbance.			

6 Technical requirements

6.1 Construction

6.1.1 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 correctly fulfill its intended purposes throughout its life.

6.1.2 Soundness of cases

The case of a gas meter shall be gas-tight as specified according to national or international standards and requirements concerning safety and at least 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.

6.1.3 Condensation/climate provisions

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

6.1.4 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.

6.1.5 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 for customers and consumers.

6.1.6 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.

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

6.1.7 Connections between electronic parts

Connections between electronic parts shall be reliable and durable.

6.1.8 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 (see 5.13.6). Such components shall be identified by the manufacturer by their own unique part numbers/identifiers.

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.

6.1.9 Zero flow

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

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

6.2 Flow direction

6.2.1 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.

6.2.2 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.

6.2.3 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.

6.2.4 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 concerning forward flow measurements.

6.2.5 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.

6.3 Indicating device

6.3.1 General provisions

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

The indicating device may be:

a) a mechanical indicating device as described in 6.3.4,

b) an electromechanical or electronic indicating device as described in 6.3.5,

c) a combination of a) and b).

Indicating devices shall be non-resettable 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, this fraction shall be separated from the integer value by a clear decimal sign.

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

6.3.2 Indicating range

The indicating device shall be able to record and display the indicated quantity of gas corresponding to at least 1 000 hours of operation at the maximum flow rate Q_{max}, without returning to the original reading.

6.3.3 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 (e.g. 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.

6.3.4 Mechanical indicating device

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

The last element (i.e. the decade with the least significant scale interval) of a mechanical indicating device may deviate in manner of display from the other decades.

In the case of drum indicating devices 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.

6.3.5 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.

6.3.6 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.

6.4 Test element

6.4.1 General

A gas meter 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.

6.4.2 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 the integral test element. Through either physical or electronic means a specific test mode may be entered in which the number of digits can be increased or some alternative method can be applied for gaining resolution.

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.

6.4.3 Pulse generator

A pulse generator may be used as a test element if the value of one pulse, expressed in units of volume or mass, 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.

6.4.4 Attachable test device

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

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

6.4.5 Increment of test element or pulse

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

6.5 Ancillary devices

6.5.1 General

The gas meter may include ancillary devices, which may be permanently incorporated or added temporarily. Examples of applications 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 an ancillary device is not subject to legal metrology control this shall be clearly indicated.

6.5.2 Protection of drive shafts

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

6.5.3 Torque overload

The connection between the measuring transducer and the intermediate gearing shall not break or alter if a torque of three times the permissible torque as indicated in 7.1.3 b) and 7.1.3 c) is applied.

6.6 Power sources

6.6.1 Types of power sources

Gas meters may be powered by:

- mains power sources,
- non-replaceable power sources, or
- replaceable power sources.

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

Note: For the purpose of this Recommendation, rechargeable power sources are considered replaceable.

6.6.2 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, although National Authorities may require continuation of such registration.

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

6.6.3 Non-replaceable power source

The manufacturer shall ensure that the indicated lifetime of the power source guarantees that the meter functions correctly for at least as long as the operational lifetime of the meter which shall be marked on the meter or, alternatively, the remaining battery capacity in units of time can be presented on the electronic indicating device.

6.6.4 Replaceable power source

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

The date by which the power source is to be replaced shall be indicated on the meter. Alternatively, the estimated remaining life of the power source shall be displayed or a warning shall be given when the estimated remaining life of the power source is at or below 10 %.

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

It shall be possible to replace the power source without breaking the metrological seal.

The compartment of the power source shall be capable of being secured from tampering.

6.7 Checks, limits and alarms for electronic gas meters

6.7.1 Checks

An electronic gas meter is required to check:

- the presence and correct functioning of transducers and critical devices,
- the integrity of stored, transmitted and indicated data, and
- 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.

6.7.2 Limits

The gas meter may also have the capability 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.

6.7.3 Alarms

If malfunctions are registered while checking the items as indicated in 6.7.1 or if the conditions as indicated in 6.7.2 are detected, the following actions shall be performed:

- a visible and/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, or density; and
- registration in a log (if applicable).

6.8 Software

The requirements concerning the software applied in the gas meters within the scope of this Recommendation are presented in the mandatory Annex I.

7 Inscriptions

7.1 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.

As relevant, the following information shall be marked on the casing or on an identification plate. Alternatively, the markings presented with an asterisk (*) could be made visible via the electronic indicating device in a clear and unambiguous manner.

7.1.1 General applicable markings for gas meters

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 flow rate Q_{max} = … <unit>;

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

h) Transition flow rate 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>. (*)

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) Character 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 6.2.1 and 6.2.2);

n) Character M, as applicable, if the meter is designed only to be installed in piping arrangements where only mild flow disturbances may occur;

o) Measurement point for the working pressure according to 10.1.4; and

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

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

a) Base temperature t_b = … <unit>; (*)

b) Base pressure p_b=.... <unit> (if applicable); (*)

c) Temperature t_{sp} = … <unit> specified by the manufacturer according to 5.3.5. (*)

7.1.3 Additional markings for gas meters with output drive shafts

a) 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";

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

c) 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";

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

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

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 characterized 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) is 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.

7.1.4 Additional markings for gas meters with electronic devices

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

b) For a non-replaceable power source: the operational lifetime of the measuring device or, alternatively, the remaining battery capacity in units of time can be presented on the electronic indicating device; (*)

c) For a replaceable battery: the latest date by which the battery is to be replaced or, alternatively, the remaining battery capacity can be presented on the electronic indicating device; (*)

Note: In case an automatic alarm indicates when the battery life is below 10 %, the above markings are not required.

d) Software identification of the firmware. (*)

8 Operating instructions

8.1 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 another 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) a specification of the required voltage (-range) and frequency (-range) for instruments powered by an external power source,
g) any specific installation conditions, 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, repair, storage, transport and permissible adjustments (this can be in a separate document, not intended for the user/owner),
j) conditions for compatibility with interfaces, sub-assemblies (modules) or other measuring instruments.

8.2 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,
- leveling and orientation,
- flow disturbances (including minimum upstream and downstream pipe lengths),
- 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 pipe work,
- other relevant installation conditions.

9 Sealing

9.1 Verification marks and protection devices

9.1.1 General provision

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

In any case, memorized quantities of gas measured (volume or mass) shall be sealed to prevent unauthorized access.

Where applicable, the design of verification marks and seals is subject to national or regional legislation.

9.1.2 Verification marks

Verification marks indicate that the gas meter has successfully passed the initial verification.

9.1.3 Hardware sealing (if applicable)

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.

c) Seals shall be able to withstand outdoor conditions

9.1.4 Electronic sealing (if applicable)

9.1.4.1 When the access to parameters that contribute in the determination of results of measurements needs to be protected, and electronic sealing is permitted by national authorities, the protection shall fulfill the following provisions:

a) Only authorized people are allowed to enter the configuration mode to modify these parameters using securing means such as a code (password) or special device (hard key, etc.)

   - for access prior to changing the parameters, after which the instrument may be put into use “in sealed condition” again without any restriction, or
   - for confirmation after the parameters have been changed, in order to bring the instrument back into service being the “in sealed condition” (similar to classical sealing).

b) The code (password) shall be alterable.

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
   - an event counter or date and time of the intervention as generated by the internal clock.

In addition to the above-mentioned data the following data is to be stored:

- the old value of the changed parameter, and
- the totals of the registers.

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.

9.1.4.2 For gas meters of which parts may be disconnected, the following provisions shall be fulfilled:

a) Access to the parameters that contribute to the determination of results of measurements shall not be possible via a disconnected port unless the provisions in 9.1.4 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 gas meters shall be equipped with provisions which do not allow the meter to operate if the various parts are not configured according to the manufacturer's specifications.

Note: An unauthorized disconnection (such as by the user) may be prevented, for example by means of a device that blocks the execution of any measurement after disconnecting and reconnecting.

10 Suitability for testing

The instrument shall be designed such as to allow initial and subsequent verification and metrological supervision.

10.1 Pressure tappings

10.1.1 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 designed to avoid the effect of potential condensation.

Note: This requirement is not mandatory for meters for direct mass measurement or for meters with a built-in pressure sensor.

10.1.2 Bore

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

10.1.3 Closure

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

10.1.4 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".

Annex I: Requirements for software controlled gas meters

(Mandatory)

The specific software terminology is defined in OIML D 31:2008 Chapter 3.

I.1. General requirements

I.1.1. Software identification

The legally relevant parts of the software of a gas meter and/or its constituents shall be clearly identified with the software version or any other token. The identification may apply to more than one part but at least one part shall be dedicated to the legal purpose.

The identification shall be inextricably linked to the software and shall be:

- presented or printed on command, or
- displayed during operation, or
- displayed at switch-on for those gas meters that can be switched on and off.

If a constituent of the gas meter has no display, the identification shall be sent to some other device via a communication interface in order to be displayed on this device.

As an exception, an imprint of the software identification on the gas meter shall be an acceptable solution if it satisfies the following three conditions:

1) The user interface does not have any control capability to activate the indication of the software identification on the display, or the display does not technically allow the identification of the software to be shown (analogue indicating device or electromechanical counter).
2) The gas meter does not have an interface to communicate the software identification.
3) After production of the gas meter a change of the software is not possible, or only possible if the hardware or a hardware component is also changed.

The software identification and the means of identification shall be stated in the type approval certificate.

I.1.2 Correctness of algorithms and functions

The measuring algorithms and functions of the gas meter and/or its constituents shall be appropriate and functionally correct.

It shall be possible to examine algorithms and functions either by metrological tests, software tests or software examination.

I.1.3 Software protection (against fraud)

The legally relevant software part shall be secured against unauthorized modification, loading, or changes by swapping the memory device. In addition to mechanical sealing, technical means may be necessary to protect gas meters equipped with an operating system or an option to load software.

Only clearly documented functions are allowed to be activated by the user interface, which shall be realized in such a way that it does not facilitate fraudulent use.

Parameters that fix the legally relevant characteristics of the gas meter shall be secured against unauthorized modification. For the purpose of verification, displaying of the current parameter settings shall be possible.

Note: Device-specific parameters may be adjustable or selectable only in a special operational mode of the instrument. They may be classified as those that should be secured (unalterable) and those that may be accessed (alterable parameters) by an authorized person, e.g. the instrument owner or product vendor.

Software protection comprises appropriate sealing by mechanical, electronic and/or cryptographic means, making an unauthorized intervention impossible or evident.

I.1.3.1 Support of fault detection

The detection by the checking facilities of significant faults may be achieved by software. In such a case, this detecting software is considered legally relevant.

The documentation to be submitted for type evaluation shall contain a list of the anomalies that might result in a significant fault but that will be detected by the software. The documentation shall include information on the expected reaction and in case needed for understanding its operation, a description of the detecting algorithm.

I.2. Requirements for specific configurations

I.2.1 Specifying and separating relevant parts and specifying interfaces of parts

Metrologically relevant parts of a gas meter – whether software or hardware parts – shall not be inadmissibly influenced by other parts of the gas meter.

This requirement applies if the gas meter and/or its constituents have interfaces for communicating with other electronic devices, with the user, or with other software parts next to the metrological critical parts.

I.2.1.1 Separation of constituents of a gas meter

I.2.1.1.a Constituents of a gas meter that perform functions which are relevant to legal metrology shall be identified, clearly defined, and documented. These form the legally relevant part of the gas meter.

I.2.1.1.b It shall be demonstrated that those relevant functions and data of constituents cannot be inadmissibly influenced by commands received via an interface.

This implies that there is an unambiguous assignment of each command to all initiated functions or data changes in the constituent.

I.2.1.2 Separation of software parts

I.2.1.2.a All software modules (programs, subroutines, objects, etc.) that perform functions which are relevant to legal metrology or that contain legal metrology relevant data domains are considered to be legal metrology relevant software part of a gas meter. This part shall be made identifiable as described in I.1.1.

If the separation of the software is not possible, all software is considered legally relevant.

I.2.1.2.b If the legal metrology relevant software part communicates with other software parts, a software interface shall be defined. All communication shall be performed exclusively via this interface. The legal metrology relevant software part and the interface shall be clearly documented. All legally relevant functions and data domains of the software shall be described to enable a type evaluation authority to decide whether this software is sufficiently separated.

The interface comprises program code and dedicated data domains. Defined coded commands or data are to be exchanged between the software parts through storing to the dedicated data domain by one software part and reading from it by the other. Writing and reading program code is considered part of the software interface.

The data domain forming the software interface shall be clearly defined and documented and include the code that exports from the legally relevant part to the interface and the code that imports from the interface to this legally relevant part. The declared software interface shall not be circumvented.

The manufacturer is responsible for respecting these constraints. Technical means (such as sealing) of preventing a program from circumventing the interface or programming hidden commands shall not be possible. The programmer of the legal metrology relevant software part as well as the programmer of the legally non-relevant part shall be provided with instructions concerning these requirements by the manufacturer.

I.2.1.2.c There shall be an unambiguous assignment of each command to all initiated functions or data changes in the legally relevant part of the software. Commands that communicate through the software interface shall be declared and documented. Only documented commands are allowed to be activated through the software interface. The manufacturer shall state the completeness of the documentation of commands.

I.2.1.2.d Where legal metrology relevant software has been separated from non-relevant software, the legal metrology relevant software shall have priority using the resources over non-relevant software. The measurement task (realized by the legal metrology relevant software part) must not be delayed or blocked by other tasks.

The manufacturer is responsible for respecting these constraints. Technical means for preventing a legally non-relevant program from disturbing legally relevant functions shall be provided. The programmer of the legally relevant software part as well as the programmer of the legal metrology non-relevant part shall be provided with instructions concerning these requirements by the manufacturer.

I.2.2 Shared indications

A display may be employed for presenting both information from the legal metrology relevant part of software and other information.

Software that realizes the indication of measurement values and other legally relevant information belongs to the legally relevant part.

I.2.3 Storage of data, transmission via communication systems

If measurement values will be used at a location different from the place of measurement or at a stage later than the time of measurement, they may need to be retrieved from the gas meter and be stored or transmitted in an insecure environment before they are used for legal purposes. In that case the following requirements apply:

I.2.3.1 The measurement value stored or transmitted shall be accompanied by all relevant information necessary for the future legally relevant use.

I.2.3.2 The data shall be protected by software means to guarantee the authenticity, integrity and, if necessary, the correctness of the information concerning the time of measurement. The software that displays or further processes the measurement values and the accompanying data shall check the time of measurement, authenticity, and integrity of the data after having read them from the insecure storage or after having received them from an insecure transmission channel.

The memory device shall be fitted with a checking facility to ensure that if an irregularity is detected, the data shall be discarded or marked unusable.

Software modules that prepare data for storing or sending, or that check data after reading or receiving are considered part of the legally relevant software.

I.2.3.3 When transferring measurement values through an open network, it is necessary to apply cryptographic methods. Confidentiality key-codes employed for this purpose shall be kept secret and secured in the measuring instruments, electronic devices, or sub-assemblies involved. Security means shall be provided whereby these keys can only be input or read if a seal is broken.

I.2.3.4 Transmission delay

The measurement shall not be inadmissibly influenced by a transmission delay.

I.2.3.5 Transmission interruption

If communication network services become unavailable, no measurement data shall be lost. The loss of measurement data shall be prevented.

I.2.4 Automatic storage

When, considering the application, data storage is required, measurement data must be stored automatically, i.e. when the final value used for the legal purpose has been generated.

The storage device must have sufficient permanency to ensure that the data are not corrupted under normal storage conditions. There shall be sufficient memory storage for any particular application.

When the final value used for the legal purpose results from a calculation, all data that are necessary for the calculation must be automatically stored with the final value.

I.2.5 Deleting of data

Stored data may be deleted when the transaction is settled.

Only after this condition is met and insufficient memory capacity is available for storage of successive data, it is permitted to delete memorized data when both the following conditions are met:

- the sequence of deletion of data will be in the same order as the recording order (fifo) while the rules established for the particular application are respected;
- the required deletion will start either automatically or after a specific manual operation.

I.3 Maintenance and re-configuration

Updating the legally relevant software of a gas meter in service shall be considered as:

- a modification of the gas meter, when exchanging the software with another approved version;
- a repair of the gas meter, when re-installing the same version.

A gas meter which has been modified or repaired while in service may require initial or subsequent verification, dependant on national regulations.

This clause does not concern software which has or will have no influence on metrological relevant functions or functioning of the gas meter.

Part 2 Metrological controls and performance tests

11 Metrological controls

11.1 General procedures

11.1.1 Test method

All tests shall be carried out under the installation conditions (straight sections of piping upstream and downstream of the meter, flow conditioners, etc.) stipulated by the supplier of the type of meter to be tested.

All equipment used **and incorporated** as part of **the execution of** the test procedure shall be suitable for the testing of the meter(s) under test. The working range of all equipment and reference standards shall equal or exceed that of the meter(s) under test. All reference standards used shall be traceable to national and/or international standards of measurement.

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 reference standard; otherwise 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 on the meter(s) under test and on the reference standard.

11.1.2 Uncertainty

When a test is conducted, the expanded uncertainty[1] 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 : $\pm\left({}^{6}\!/_{5} \cdot MPE - U\right)$
- for verifications : $\pm\left({}^{4}\!/_{3} \cdot MPE - U\right)$

  while U≤ MPE

The estimation of the expanded uncertainty U is made according to the *Guide to the expression of uncertainty in measurement* (GUM) [6] with a level of confidence of approx. 95 %.

Example: When assuming that during testing for type evaluation of an accuracy class 1 gas meter the test result has an expanded uncertainty U of 0.3 % ($k = 2$) the test results can be accepted if the error is between ± (6/5 × 1.0 – 0.3) % = ± 0.9 %.

1 As defined in OIML G 001-100 clause 2.3.5

12 Type evaluation

12.1 General

A submitted type of gas meter is subject to the type evaluation procedure.

Any modification to an approved type not covered by the type approval certificate shall lead to a re-evaluation of the type.

The calculator (including the indicating device) and the measuring transducer (including flow, volume or mass 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 of these parts.

A type approval certificate is issued only for the complete gas meter.

12.2 Documentation

Applications for type evaluation of a gas meter shall be accompanied by the following documentation:

- Identification of the type, including:
  - name or trademark of the manufacturer and type designation;
  - version(s) of hardware and software;
  - drawing of name plate.
- Metrological characteristics of the meter, including:
  - a description of the principle(s) of measurement;
  - metrological specifications such as accuracy class and rated operating conditions;
  - any steps which should be performed prior to testing the meter.
- The technical specification for the meter, including:
  - a block diagram with a functional description of the components and devices;
  - drawings, diagrams and general software information, explaining the construction and operation, including interlocks;
  - description and position of seal or other means of protection;
  - documentation related to durability characteristics;
  - specified clock frequency;
  - any document or other evidence that supports the assumption that the design and construction of the meter complies with the requirements of this Recommendation.
- User manual
- Installation manual
- A description of the checking facilities to prevent significant faults to occur, if applicable.

In addition, if software is employed the documentation shall include:

- a description of the legally relevant software and how the requirements are met, comprising:
  - a list of software modules that belong to the legally relevant part including a declaration that all legally relevant functions are included in the description;
  - a description of the software interfaces of the legally relevant software part and of the commands and data flows via this interface including a statement of completeness;
  - a description of the generation of the software identification;
  - depending on the validation method chosen: the source code;
  - a list of parameters to be protected and description of protection means;

- a description of a suitable hardware system configuration and minimal required resources for the software to operate as intended;
- a description of security means for protection of entering the operating system (password, etc. if applicable);
- a description of the (software) sealing method(s);
- an overview of the system hardware, e.g. topology block diagram, type of computer(s), type of network, etc.
- identification of those hardware components that are deemed legally relevant or that perform legally relevant functions;
- a description of the accuracy of the algorithms (e.g. filtering of A/D conversion results, price calculation, rounding algorithms, etc.);
- a description of the user interface, menus and dialogues;
- identification of the software and instructions for obtaining this identification from an instrument in use;
- list of commands of each hardware interface of the measuring instrument (or its constituents) including a statement of completeness;
- list of potential significant errors that will be detected and acted upon by the software and if necessary for understanding, a description of the detecting algorithms;
- a description of data sets stored or transmitted;
- if fault detection is realized in the software, a list of faults that are detected and a description of the detecting algorithm;
- the operating manual.

12.3 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, 5, 0, 8, 9 and 10).

12.4 Number of specimens

The applicant shall deliver the requested number of specimens of 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. (See Annex D: Type evaluation of a family of gas meters).

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

In order to accelerate the test procedure, the testing laboratory may carry out different tests simultaneously on different units. In this case, the testing laboratory shall ensure that all submitted instruments are of the same type.

In general all accuracy and influence tests shall be performed on the same unit, but disturbance tests may be carried out on additional instruments. In this case, the testing laboratory decides which test(s) to be carried out on which unit.

If a specimen does not pass a specific test and as a result needs to be modified or repaired, the applicant shall apply this modification to all the specimens submitted for the test. These modified specimen(s) shall again be subjected to this particular test. If the testing laboratory has well-founded reasons to believe that the modification could have a negative impact on the result of another test or tests already performed, these tests shall be repeated as well.

12.5 Type evaluation procedures

12.5.1 Software evaluation

The software evaluation procedure concerns evaluation of compliance to the requirements as described in part 2 Annex I and comprises a combination of analysis and validation methods and tests as shown in Table 6. The explanation of the abbreviations used and the relation to the methods as described in detail in OIML D 31 is shown in Table 7.

Table 6 Software validation procedures applicable for verification of compliance

Requirement		**Evaluation procedure**
I.1.1	Software identification	AD + VFTSw
I.1.2	Correctness of algorithms	AD + VFTSw
I.1.3	Fraud protection	AD + VFTSw + DFA/CIWT/SMT
	Parameter protection	AD + VFTSw + DFA/CIWT/SMT
I.2.1	Separation of electronic devices and sub-assemblies	AD
I.2.2	Separation of software parts	AD
I.2.3	Storage of data, transmission via communication systems	AD + VFTSw + CIWT/SMT
I.2.3.1	Data protection with respect to time of measurement	AD + VFTSw + SMT
I.2.4	Automatic storage	AD + VFTSw
I.2.3.4	Transmission delay	AD + VFTSw
I.2.3.5	Transmission interruption	AD + VFTSw
	Time stamp	AD + VFTSw

Table 7 Cross references of evaluation procedures to those described in Annex E

Abbreviation	**Description**	**Related Annex E and OIML D 31:2008 Clause**
AD	Analysis of the documentation and validation of the design	Annex E (E1) ➔ D 31 (6.2.3.1)
VFTM	Validation by functional testing of metrological functions	Annex E (E2) ➔ D 31 (6.2.3.2)
VFTSw	Validation by functional testing of software functions	Annex E (E3) ➔ D 31 (6.2.3.3)
DFA	Metrological data flow analysis	Annex E (E4) ➔ D 31 (6.2.3.4)
CIWT	Code inspection and walkthrough	Annex E (E5) ➔ D 31 (6.2.3.5)
SMT	Software module testing	Annex E (E6) ➔ D 31 (6.2.3.6)

12.5.2 Hardware evaluation

12.5.2.1 Reference conditions

All influence quantities, except for the influence quantity being tested, shall be kept 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 kPa – 106 kPa;
Ambient relative humidity:	60 % ± 25 %;
Power voltage (AC/DC mains):	
* 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.

12.5.2.2 Flow rates

The flow rates at which the errors of the gas meters need to be determined shall be distributed over the measuring range at regular intervals and include Q_{min} and Q_{max} and preferably Q_t.

Based on three test points per decade the minimum number (N) of test points, ranking from $i = 1$ to $i = N$ can be calculated according to:

$$N = 1 + 3 \cdot \log\left(\frac{Q_{max}}{Q_{min}}\right)$$

Where $N \geq 6$, and rounded to the nearest integer.

For flow rates covering two decades or more the following formula presents an adequate regular distribution of flow rates for $i = 1$ to $i = N–1$ and $Q_N = Q_{min}$.

$$Q_i = \left(\sqrt[3]{10}\right)^{1-i} \cdot Q_{max}$$

12.5.2.3 Test gases

a) Required gases for type evaluation tests

All the tests listed in 12.6 may 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 12.6.7 it is important that the gas be dry.

Gas meters intended to measure different gases (as stated in 12.6.12) are to be tested with the gases specified by the manufacturer.

b) Evaluation for the use of an alternative test gas during verification

When gas meters are to be verified (at initial or subsequent verification) with air the type evaluation test as stated in 12.6.13 shall include air.

When gas meters are to be verified with a type of gas different from that at operating conditions, the type evaluation test as stated in 12.6.3 shall include such type of gas.

In both cases mentioned the maximum differences between the error curves of the intended test gas and the gas in-use are calculated and the need to use correction factors during verification test (see 13.1.3) is established as follows:

- If these differences stay within 1/3 MPE, the initial or subsequent verification may be performed with the alternative gas.
- If these differences exceed 1/3 MPE the initial or subsequent verification may only be performed with the alternative gas if a correction for the differences is applied.

The authority responsible for type evaluation shall document whether the initial or subsequent verification may be performed with air (or the other gas(-es)) and whether correction factors must be applied.

12.6 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.

12.6.1 Error

The error of the gas meter shall be determined, while using the flow rates according to the prescriptions stated in 12.5.2.2. 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 obtain 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 6.4.2.
- the pulse factor of the gas meter, if applicable, according to the provisions of 6.4.3.

12.6.2 Reproducibility

Compliance with the reproducibility of error requirement stated in 5.6 is determined at the flow rates in conformity with 12.5.2.2, equal to or greater than Q_t. For each of these flow rates, the errors shall normally be determined six times independently, while varying the flow rate between each consecutive measurement. The reproducibility of error at each flow rate shall be determined.

In case the reproducibility of error of the first three measurements is equal to or smaller than 1/6 MPE the requirement is deemed to be met.

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

12.6.3 Repeatability

Compliance with the repeatability of error requirement stated in 5.7 is determined at the flow rates Q_{min}, Q_t, and Q_{max}. At each of these flow rates, the errors are determined three times and the difference between the minimum and maximum 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.

12.6.4 Orientation

Unless specified by the manufacturer that the gas meter is to be used only in certain mounting orientations it shall be established whether the orientation of the meter influences the measuring behavior.

The following orientations shall be examined:

- horizontal,
- vertical flow-up,
- vertical flow-down,

and the accuracy measurements as stated in 12.6.1 are performed in these orientations.

If only certain orientations are stipulated by the manufacturer only those orientations shall be examined.

The results of the different accuracy measurements are evaluated with the requirements as laid down in 5.13.1 without intermediate adjustments.

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 *7.1.1 l).*

12.6.5 Flow direction

The accuracy measurements as stated in 12.6.1 are performed in both flow directions, if applicable. The results of the different accuracy measurements are evaluated with the requirements as laid down in 5.13.2 without intermediate adjustments.

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 6.2.

12.6.6 Working pressure

The accuracy measurements as stated in 12.6.1 are performed at least at the minimum and at the maximum operating pressure.

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

If the requirements are not fulfilled for the operating pressure range without intermediate adjustments, when putting into use either the operating pressure range can be reduced or the operating pressure range can be split into several ranges. Alternatively pressure correction can be applied.

For technologies that are proven to be insensitive to pressure or diaphragm meters this test is not applicable.

12.6.7 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

The flow tests are performed with a gas temperature equal to the ambient temperature as specified in 12.6.7.1. For gas meters with a built-in conversion device showing the volume at base conditions only also the flow tests are to be performed with a gas temperature different from the ambient temperature as specified in 12.6.7.2.

b) Monitoring the unsuppressed flow rate output of the meter at no-flow conditions at different temperatures

At no-flow conditions the unsuppressed flow rate 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, and at the minimum and maximum operating temperatures. 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 flow rate shift on the meter curve.

Example: The unsuppressed flow rate 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.

Note: The unsuppressed flow rate is defined as the flow rate at which the low flow cut-off (if present) is not active.

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.

For residential meters flow tests are mandatory (method a).

12.6.7.1 Flow tests with equal gas and ambient temperatures

The flow tests are performed at the flow rates determined in 12.5.2.2, in the range Q_t up to Q_{max}, with the gas temperature equal to the ambient temperature (within 5 °C), sequentially at:

- reference temperature;
- maximum ambient temperature;
- minimum ambient temperature;
- reference temperature.

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

12.6.7.2 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 and sequentially:

- the gas temperature at 40° C;
- the gas temperature at 0 °C.

The error is determined at Q_{t} and $Q_{\max}$. Determination of errors shall be performed only after the temperature of the gas is stabilized.

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

Note: Instead of the above-mentioned temperature test, alternatively the test may be performed while using the following temperature conditions:

- gas temperature at 20 °C and the gas meter at 40° C;
- gas temperature at 20 °C and the gas meter at 0 °C.

12.6.8 Flow disturbance

Gas meters of which the accuracy is affected by flow disturbances shall be submitted to the tests as specified in Annex B. During the tests the meters shall be installed according to the manufacturer's specifications.

If such gas meters are specified and marked not to be inserted in piping arrangements producing severe disturbances they shall only to be tested according to Annex B B2 (Mild flow disturbances).

The piping arrangements as presented in Table B.1a–g are considered to produce only mild flow disturbances.

The requirements as laid down in 5.13.3 are applicable.

12.6.9 Durability

All gas meters with internal moving parts and gas meters without internal moving parts having a maximum equivalent volume flow rate up to and including 25 m^3/h are submitted to the durability test. This test comprises exposure to a continuous flow during the required period of time, while using gases for which the meters are intended to be used. In case the manufacturer has demonstrated that the material composition 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 applied flow rate is at least 0.8 Q_{max}. This test may be performed at the minimum working pressure.

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 of the same type to be submitted for the durability test from the options given in Table 8 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.

In case the application for evaluation concerns a family of meters according to the criteria stated in Annex D (D2) the selection of meters is to be performed according to D3.

Table 8 Number of meters to be tested

Maximum equivalent volume flow rate [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 are tested at flow rates as determined in 12.5.2.2.

The gas meters shall comply with the requirements laid down in 5.10 (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).

12.6.10 Drive shaft (torque)

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 is evaluated at Q_{min}.

The requirements as laid down in 5.13.4 are applicable.

Where a type of gas meter includes various sizes, this test only needs to 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.

12.6.11 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 12.5.2.2.

The requirements as laid down in 5.11 are applicable.

12.6.12 Different gases

Gas meters which are intended to be used for different gases are submitted to accuracy measurements as stated in 12.6.1 with the gases specified by the manufacturer.

Taking into consideration the manufacturer's proposal, the authority responsible for the type evaluation shall decide which gases are to be used during the examination, depending on the application purpose of the gas meter under test.

The requirements as laid down in 5.13.5 are applicable.

If the requirements are not fulfilled for all different gases without intermediate adjustments, the authority responsible for type evaluation shall report on this observation and specify this range of operating gases for which the gas meter has fulfilled the requirements.

12.6.13 Vibration and shocks

Gas meters having a maximum mass of 10 kg are submitted to vibrations and shocks. For gas meters exceeding this weight only the electronic part of the meter is to be tested. Before and after these tests the intrinsic error of the gas meter is determined according to 12.5.2.2 over the whole flow rate range.

The requirements as laid down in 5.12 are applicable.

12.6.14 Interchangeable components

For gas meters of which some components are intended to be interchangeable, as specified by the manufacturer, 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 accuracy test is performed at each of the three stages in the following sequence:

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

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

12.6.15 Electronics

For gas meters containing electronic components, additionally the requirements as described in 5.13.7 are applicable. Performance tests shall be executed using the test methods described in Part 2 *Metrological controls and performance tests*. An overview of the requirements is shown in Table 4 and Table 5. 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 this 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 and Table 5 are to be performed under the following conditions:

- The meter under test is powered up, except when performing the vibration and mechanical shock test;
- The dependency of the gas meter's performance shall be evaluated in one of the flow modes stated below, ranked in the following preferred order:
    1. During actual flow, or
    2. At no-flow conditions while monitoring the unsuppressed flow rate output of the meter.

In the latter case, compliance with the requirements indicated in Table 4 and Table 5 is checked while taking into account the influence of the flow rate shift on the meter curve.

Note: Most electronic meters have a cut-off for low flow rates. This cut-off must be switched off for this test so that the flow rate output corresponds to the unsuppressed flow rate.

12.6.16 Influences from ancillary devices

The effect of all functions of ancillary devices is determined by performing an accuracy test at Q_{min}, with and without applying the specific function. The effect shall be negligible (=< 0.1MPE).

12.7 Type approval certificate

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

- name and address of the company to whom the type approval certificate is issued;
- name of the manufacturer;
- type of the gas meter and/or commercial designation;
- 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), 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;
- type approval mark;
- period of validity of the type approval (if applicable);
- for meters equipped with drive shafts: the characteristics of the drive shafts;
- environmental classification;
- information on the location of the marks and inscriptions required in 7.1, initial verification marks and seals (where applicable, in the form of photographs or drawings);
- list of the documents accompanying the type approval certificate;
- any special comments.

12.8 Provisions for performing initial verification

The authority issuing the type approval certificate may give specific instructions for performing the initial verification, 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 flow rates.

13 Initial verification and subsequent verification

13.1 General

Individual gas meters within the scope of this Recommendation may require initial verification when newly produced according to the approved type and/or may require periodic subsequent verification when in service.

National authorities generally will decide on such need.

Initial verification and subsequent verification may be carried out either on the individual meters or groups of meters, where the latter may be statistically assessed, using the method described in 13.2.

Suitable and sufficient accurate measurement references shall be used during such assessments.

The calibration of these references shall be valid and the traceability to international measurement standards shall be proven.

The requirements during initial and subsequent verification of a gas meter shall conform to those described in part 1 of this Recommendation.

The object of the initial verification is to verify the compliance of the individual gas meter (or group of gas meters when statistically assessed) with these requirements before putting into service.

Applicable examinations and tests may be carried out at the production plant of the gas meter, on the ultimate mounting location or on any other intermediate testing site that provides sufficient and adequate means for performing the required examinations and tests.

The following minimum program shall be carried out for both the individual and statistical verification.

13.1.1 Conformity with the approved type

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

13.1.2 Submission

A gas meter shall be operational when submitted for initial verification and the required space shall be available on the meter for placing the verification mark and sealing.

13.1.3 Test conditions

The accuracy requirements of 5.3 and 5.4 shall be verified while the gas conditions are kept as close as possible to the intended operating conditions (pressure, temperature, gas type) of the meter after being put into use.

The verification may also be performed with a type of gas (e.g. air) other than the type for which the meter is intended to be used, if the authorities responsible for the verification are convinced that comparable results will be gained by either the outcome of the evaluation test with different gases (see 12.5.2.3) or by the technical construction of the meter under test.

If needed, correction factors for the differences between the gases shall be applied.

13.1.4 Flow rates

A gas meter shall be tested at the flow rates specified in 12.5.2.2.

The initial verification may be performed at a reduced number of flow rates, provided this option is supported by instructions for performing the verifications (see 12.8).

Note 1: Verification of diaphragm gas meters may in all cases be restricted to performance of tests at the flow rates Q_{max}, $0.2 \cdot Q_{max}$ and Q_{min}.

Note 2: Concerning rotary piston gas meters, national authorities may decide to reduce the number of test points.

13.1.5 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 was examined, proven and reported in the approval certificate that the meter performance is independent from the meter orientation (requirement 5.13.1 is fulfilled) and/or the flow direction (requirement 5.13.2 is fulfilled).

13.1.6 Adjustments

If the error curve or the WME does not fulfill 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.

Note 1: 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 flow rate and calculate the other error values from the previous ones.

Note 2: For high pressure applications adjustment is performed while taking into account the operating conditions.

13.1.7 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.

13.2 Additional requirements for verification on statistical basis

This chapter contains the requirements additional to 13.1 for initial verification on a statistical basis.

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

13.2.1 Lot

A lot shall be established consisting of meters considered having homogeneous characteristics. In particular, the type approval identification, meter type, and meter range shall be identical. The batches in a lot shall not cover a period of more than one year of production.

13.2.2 Samples

Samples shall be randomly taken from a lot.

Note: The number of samples can be freely chosen, taking into account the requirement in 13.2.3.

13.2.3 Statistical testing

The statistical procedure shall meet the following requirements:

When the statistical control is 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.

13.3 Additional requirements for in-service inspections

Guidance for in-service inspections of utility meters is within the scope of OIML TC 3/SC 4 *Application of statistical methods*. At the time of publication of this Recommendation a project is ongoing to draft a guide.

Inspection on statistical basis is suggested as being most adequate. [8]

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 gas meters containing electronics 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 kept within the limits of the reference conditions.

A.2 Test levels

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

The metrological authority carries out performance tests at the test levels corresponding to these environmental conditions.

A.3 Reference conditions

See 12.5.2.1.

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]	
Object of the test	Verification of compliance under conditions of high environmental temperature	
Test procedure in brief	The test comprises 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 %.	
Temperature	upper temperature specified	°C
Duration	2	h

A.4.1.2 Cold: influence test		
Applicable standards	IEC 60068-2-1 [9]	
Object of the test	Verification of compliance under conditions of low environmental temperature	
Test procedure in brief	The test comprises 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.	
Temperature	lower temperature specified	°C
Duration	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]	
Object of the test	Verification of compliance under conditions of high environmental humidity and constant temperature	
Test procedure in brief	The test comprises exposure to the specified temperature and the specified constant relative humidity for a certain fixed period of 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 hours after the decrease of temperature.	
Temperature	upper temperature specified	°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]	
Object of the test	Verification of compliance under conditions of high environmental humidity combined with cyclic temperature changes	
Test procedure in brief	The test comprises exposure to cyclic temperature variation between 25 °C and the appropriate upper temperature while maintaining the relative humidity above 95 % during the temperature change and low temperature phases, and at or above 93 % at the upper temperature phases. Condensation is expected to occur on the EUT during the temperature rise. The 24 hours cycle consists of: 1) Temperature rise during 3 hours. 2) Temperature maintained at upper temperature level until 12 hours from the start of the cycle. 3) Temperature lowered to the lower temperature level within a period of 3 to 6 hours, the rate of fall during the first hour and a half being such that the lower temperature level would be reached in 3 hours. 4) Temperature maintained at lower temperature level until the 24 hours cycle is completed. The stabilizing period before and recovery period after the cyclic exposure shall be such that the temperature of all parts of the EUT is within 3 °C of its final value. During the test the instrument is switched on; gas flow is not required. The gas meter shall be subjected to an accuracy test both: - at reference conditions, before the increase of temperature and - at reference conditions, at least 4 hours after the last cycle.	
Upper temperature	upper temperature specified	°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]
Object of the test	Verification of compliance under conditions of random vibration
Test procedure in brief	The test comprises exposure to the level of vibration for the time specified. The EUT shall, subsequently, be tested in three, mutually perpendicular axes mounted on a rigid fixture by its normal mounting means. The EUT shall normally be mounted in such a way that the gravity vector points in the same direction as it would do in normal use. Where, based on the metering principle the effect of gravitational force can be assumed negligible 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 required to be powered up (switched on).
Total frequency range	10 Hz – 150 Hz
Total RMS level	7 $m \cdot s^{-2}$
ASD level 10 Hz – 20 Hz	1 $m^2 \cdot s^{-3}$
ASD level 20 Hz – 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]
Object of the test	Verification of compliance under conditions of mechanical shocks
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, RF, electromagnetic fields: disturbance test	
Applicable standard	IEC 61000-4-3 [19]
Object of the test	Verification of compliance of the EUT while being exposed to RF electromagnetic fields
Test procedure in brief	The EUT is exposed to electromagnetic fields having the required field strength level specified and the field uniformity as defined in the referred standard. The EUT shall be exposed to the modulated wave field. The frequency sweep shall be performed only pausing to adjust the RF signal level or to switch RF-generators, amplifiers and antennas if necessary. Where the frequency range is swept incrementally, 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 expected most critical frequencies (e.g. clock frequencies) shall be analyzed separately. (1)
Frequency range	80 MHz – 3 GHz [(2), (4)] 26 MHz – 3 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 [19] only specifies test levels above 80 MHz. For frequencies in the lower range the test methods for conducted radio frequency disturbances are preferred (test A.6.1.2). [(3)] For EUT lacking any cabling as is needed for applying the test specified in A.6.1.2 the lower frequency limit for this test A 6.1.1 shall be 26 MHz (refer to Annex H of IEC 61000-4-3 [19]). (In all other cases both A.6.1.1 and A.6.1.2 apply). [(4)] For the frequency range 26 MHz – 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 the event 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]
Object of the test	Verification of compliance of the EUT while being exposed to RF electromagnetic fields
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 for when the EUT has no mains power supply or other copper wired input/output port. (2) If the EUT comprises several devices, the tests shall be performed at each extremity of the cable if both devices are part of the EUT. (3) For the frequency range 26 MHz – 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 the event 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]	
Object of the test	Verification of compliance in case of direct exposure to discharging of electrostatic charged objects or persons on the EUT of such discharges in the neighborhood of the EUT	
Test procedure in brief	An ESD generator as defined in the referred standard shall be used and the test setup shall comply with the dimensions, materials used and conditions as specified in this standard. Before starting the tests, the performance of the generator shall be verified. At each pre-selected discharge location on the EUT at least 10 discharges shall be applied. The time interval between successive discharges shall be at least 1 second. For EUTs not equipped with a ground terminal, the EUT shall be fully discharged between the discharges applied using the ESD generator. Contact discharge is the preferred test method. Air discharges are less reproducible and therefore shall be used only 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]	
Object of the test	Verification of compliance of the EUT to conditions where electrical bursts are superimposed on I/O and communication ports	
Test procedure in brief	A burst generator as defined in the referred standard shall be used The characteristics of the generator shall be verified before connecting the EUT. The test comprises the 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 1 000 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]		
Object of the test	Verification of compliance during conditions where electrical surges are superimposed on I/O and communication ports		
Test procedure in brief	A surge generator as defined in the referred standard shall be used. The characteristics of the generator shall be verified before connecting the EUT. The test comprises 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. At least 3 positive and 3 negative surges shall be applied. The applicable injection network depends on the kind of wiring 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]
Object of the test	Verification of compliance during conditions of DC mains network changes between upper and lower limit
Test procedure in brief	The test comprises exposure to the specified power supply condition for a period sufficient for achieving temperature stability and subsequently performing the required measurements.
Test severity	The upper limit is the DC level at which the EUT is claimed and proven to have been manufactured to automatically detect high-level conditions. The lower limit is the DC level at which the EUT is claimed and proven to have been manufactured 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]	
Object of the test	Verification of compliance during conditions of AC mains network voltage changes between upper and lower limit	
Test procedure in brief	The test comprises 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]						
Object of the test	Verification of compliance during conditions of short time mains voltage reductions						
Test procedure in brief	A test generator is to be used which is suitable to reduce the amplitude of the AC mains voltage for the required period of time. The performance of the test generator shall be verified before connecting the EUT. The mains voltage reduction tests shall be repeated 10 times with intervals of at least 10 seconds between the tests. 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.						

<table>
<tr><th colspan="4">A.7.4 Voltage dips, short interruptions and voltage variations on DC mains power disturbance test</th></tr>
<tr><td colspan="2">Applicable standard</td><td colspan="2">IEC 61000-4-29 [25]</td></tr>
<tr><td colspan="2">Object of the test</td><td colspan="2">Verification of compliance during conditions of DC mains voltage dips, variations and short time reductions</td></tr>
<tr><td colspan="2">Test procedure in brief</td><td colspan="2">A test generator as defined in the referred standard shall be used.
Before starting the tests, the performance characteristics of the generator shall be verified.
The EUT shall be exposed to voltage dips and short interruptions for each of the selected combinations of amplitude and duration, using a sequence of three dips/interruptions and intervals of at least10 seconds between each test event.
The most common operating modes of the EUT shall be tested three times at 10 second intervals for each of the specified voltage variations.
If the EUT is an integrating instrument, the test pulses shall be continuously applied during the measuring time.</td></tr>
<tr><td colspan="2">Test severity level</td><td>The following levels shall be applied:</td><td>Unit</td></tr>
<tr><td rowspan="2">Voltage dips</td><td>Amplitude</td><td>40 and 70</td><td>% of the rated voltage</td></tr>
<tr><td>Duration (1)</td><td>10; 30; 100</td><td>ms</td></tr>
<tr><td rowspan="3">Short interrup-tions (4)</td><td>Test condition</td><td>High impedance and/or low impedance</td><td></td></tr>
<tr><td>Amplitude</td><td>0</td><td>% of the rated voltage</td></tr>
<tr><td>Duration (1)</td><td>1; 3; 10</td><td>ms</td></tr>
<tr><td rowspan="2">Voltage variations</td><td>Amplitude</td><td>85 and 120</td><td>% of the rated voltage</td></tr>
<tr><td>Duration (1)</td><td>0.1; 0.3; 1; 3; 10</td><td>s</td></tr>
<tr><td colspan="2">Notes</td><td colspan="2">(1) All intervals are to be tested</td></tr>
</table>

<table>
<tr><th colspan="2">A.7.5 Bursts (transients) on AC and DC mains: disturbance test</th></tr>
<tr><td>Applicable standards</td><td>IEC 61000-4-4 [20]</td></tr>
<tr><td>Object of the test</td><td>Verification of compliance during conditions where electrical bursts are superimposed on the mains voltage</td></tr>
<tr><td>Test procedure in brief</td><td>A burst generator as defined in the referred standard shall be used.
The characteristics of the generator shall be verified before connecting the EUT.
The test comprises 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 1 000 Ω loads are defined in the referred standard.
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.</td></tr>
<tr><td>Amplitude (peak value)</td><td>2 kV</td></tr>
<tr><td>Repetition rate</td><td>5 kHz</td></tr>
</table>

A.7.6 Surges on AC and DC mains: disturbance test		
Applicable standard:	IEC 61000-4-5 [21]	
Object of the test	Verification of compliance during conditions where electrical surges are superimposed on the mains voltage	
Test procedure in brief	A surge generator as defined in the referred standard shall be used.. The characteristics of the generator shall be verified before connecting the EUT. The test comprises exposure to electrical surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and the minimum time interval between two successive pulses are defined in the referred standard. At least 3 positive and 3 negative surges shall be applied. On AC mains supply lines, surges shall be synchronous with the AC supply frequency and shall be repeated such that injection of surges on all the 4 phase shifts with 0°, 90°, 180° and 270° with the mains frequency is covered. The injection network circuitry depends on the applicable conductors 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]
Object of the test	Verification of compliance during conditions where electrical surges are superimposed on the mains voltage
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 comprises subjecting the EUT to ripple voltages such as those generated by traditional rectifier systems and/or auxiliary service battery chargers overlaying on DC power supply sources. The frequency of the ripple voltage is the applicable power frequency or its multiple (2, 3 or 6), dependent on the rectifier system used for the mains. 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.
Object of the test	Verification of compliance during low battery voltage conditions.
Test procedure in brief	The test comprises exposure of the EUT to the specific low battery level condition during a period sufficient for achieving temperature stability and for performing the required measurements. The maximum internal impedance of the battery and the minimum battery supply voltage level (U_{bmin}) are to be specified by the manufacturer of the instrument. In case of simulating the battery by using an alternative power supply source such as in bench testing, the internal impedance of the specified type of battery shall also be simulated. The alternative power supply shall be capable of delivering sufficient current at the applicable supply voltage. The test sequence is as follows: - Let the power supply stabilize at a voltage as defined within the rated operating conditions and apply the measurement and/or loading condition. - Record: a) the data defining the actual measurement conditions including date, time and environmental conditions, b) the actual power supply voltage. - Perform measurements and record the error(s) and other relevant performance parameters. - Verify compliance with the requirements - Repeat the above procedure with actual supply voltage at U_{bmin} and again at 0.9 U_{bmin} - Verify compliance with the requirements. 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 flow rates 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 the one size which is considered as worst case situation for the meter family.

Tests are also to be performed on other sizes if considered necessary.

B.2 Mild flow disturbances

B.2.1 Flow disturbance tests shall be executed using each of the applicable piping configurations as presented in Table B.1, mounted upstream of the meter, whereby the meter is installed according to the manufacturer's mounting specifications.

B.2.2 The test conditions e, f and g in Table B.1 do not apply to gas meters that are intended to be used in residential areas. All other test conditions in Table B.1apply regardless of the environment (both residential and non-residential).

B.2.3 During each of the tests mentioned in B.2.1 the shift of the error curve of the gas meter shall meet the requirement as stated in 5.13.3.

A flow conditioner according to the manufacturer's specifications may be used to meet the requirements. In such a case the flow conditioner shall be specified in the type approval certificate.

B.2.4 If a specific minimum length of straight upstream piping L_{min} is necessary to meet the requirement as indicated in B.2.3 this L_{min} shall be applied during the tests and its value shall be stated in the type approval certificate.

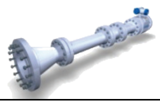
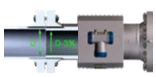
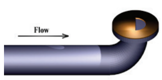
B.2.5 For ultrasonic gas meters the requirements as stated in 5.13.3 shall be met as well when adding an extra 10 D straight pipe length to the minimum length of straight upstream piping L_{min} for each test mentioned in B.2.1.

B.3 Severe flow disturbances

B.3.1 For severe disturbance tests the piping configurations c and d as specified in Table B.1 shall be used with an addition of a half pipe area plate, shown as + in Table B.1 installed upstream after the first bend of the applicable test piping configuration and with the half-moon opening toward the outside radius of this first bend.

B.3.2 The provisions of B.2.2, B.2.3, B 2.4 and B 2.5 apply accordingly.

Table B.1 Piping configurations for flow disturbances

Test		Test conditions	Remarks	Turbine	Ultrasonic	Thermal mass	Vortex
a		Reference conditions	approx. 80 D straight line		×	×	×
			approx. 10 D straight line (see Note)	×			
b		A single 90° bend	radius elbow: 1.5 D	×	×	×	×
c		Double out-of-plane bend	rotating right; radius elbows: 1.5 D	×	×	×	×
d		Double out-of-plane bend	rotating left; radius elbows:1.5 D	×	×	×	×
e		Expander	one step difference of the pipe diameter is applied		×	×	×
f		Reducer	angle of expansion/reduction part: ≤ 15°		×	×	×
g		Diameter step on the upstream flange	approx. +3 % and –3 %	×	×		×
+		Half pipe area plate	image shows first bend in piping and mounting of half-moon plate.	×	×		

Note:
Any turbine meter will need to be equipped with a flow director (straightener and nose cone) in the upstream part. For this reason the influence of extending the upstream part with a straight line beyond the 10 D value will be negligible.

Annex C: Overview of requirements and applicable tests for different metering principles

(Mandatory)

C.1 General

This Annex shows the requirements and applicable tests required for a number of different metering principles.

Requirements apply to all metering principles. The necessity of performing the related tests depends on the sensitivity of such physical metering principle to the phenomenon as described in the requirement.

The arguments for omitting a test shall contain independent and international accepted and published evidence of insensitivity of the metering principle to the phenomenon.

For those metering principles not listed in the table the applicability of each test shall be determined.

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 considered pure mechanical meters.

If electronics, software and/or ancillary devices are added to these mechanical meters, the tests on electronics, software and/or ancillary devices apply as well.

Table C.1 Overview of requirements and applicable evaluation tests for the different metering principles

Evaluation topic	Requirement clause	Test clause	**Diaphragm**	**Rotary piston**	**Turbine**	**Ultrasonic**	**Coriolis**	**Thermal mass**	**Vortex**
Design inspection	6	12.3	×	×	×	×	×	×	×
Error	5.3 5.4	12.6.1	×	×	×	×	×	×	×
Reproducibility	5.6	12.6.2	×	×	×	×	×	×	×
Repeatability	5.7	12.6.3	×	×	×	×	×	×	×
Orientation	5.13.1	12.6.4	-	×	×	-	×	-	-
Flow direction	5.13.2	12.6.5	-	×	×	×	×	-	-
Working pressure	5.8	12.6.6	-	×	×	×	×	×	×
Temperature	5.9	12.6.7	×	×	×	×	×	×	×
Flow disturbance	5.13.3	12.6.8	-	-	×	×	-	×	×
Durability	5.10	12.6.9	×	×	×	if applicable	-	if applicable	-
Drive shaft test (torque)	5.13.4	12.6.10	-	if applicable	if applicable	-	-	-	-
Overload flow test	5.11	12.6.11	×	×	×	-	-	-	-
Different gases (if applicable)	5.13.5	12.6.12	×	×	×	×	×	×	×
Vibrations and shocks	5.12	12.6.13	×	×	×	×	×	×	×
Interchangeable components	5.13.6	12.6.14	-	if applicable	if applicable	if applicable	-	-	-
Electronics	5.13.7	0 + Annex A	-	-	-	×	×	×	×
Influences from ancillary devices	5.13.8	12.6.16	-	-	-	×	×	×	×

Annex D: Type evaluation of a family of gas meters

(Mandatory)

D.1 Families of gas meters

This Annex describes the criteria to be applied by the evaluating authority in deciding whether a group of gas meters can be considered to be from the same family for type evaluation purposes, for which only selected samples of meter sizes are to be tested.

D.2 Definition

A family of meters is a group of gas meters of different sizes and/or different flow rates, in which all the meters shall have the following characteristics:

- the same manufacturer;
- geometric similarity of the parts in contact with the gas;
- the same metering principle;
- the same accuracy class;
- the same temperature range;
- the same electronic device for each meter size;
- a similar standard of design and component assembly;
- the same materials for those components that are critical to the performance of the meter;
- the same installation requirements relative to the meter size, e.g. 10 D (pipe diameter) of straight pipe upstream of the meter and 5 D of straight pipe downstream of the meter.

D.3 Meter selection

When considering which sizes of a family of gas meters should be tested, the following rules shall be followed:

- the evaluating authority shall declare the reasons for including and omitting particular meter sizes from testing;
- the smallest meter in any family of meters shall always be tested;
- meters which have the most extreme operating parameters within a family shall be considered for testing, e.g. the largest flow rate range, the highest peripheral speed of moving parts, etc;
- if practical, the largest meter in any family of meters should always be tested. However, if the largest meter is not tested, then any meter having a $Q_{max} > 2 \times Q_{max}$ of the largest meter tested shall not be considered part of the family concerned;
- durability tests shall be applied to meters where the highest wear is expected;
- for meters with no moving parts in the measurement transducer, the smallest size shall be selected for durability tests;
- all performance tests relating to influence quantities shall be carried out on one size from a family of meters;
- the family members underlined in Figure D.1 may be considered as an example for testing

(*Note:* Each row represents one family, meter 1 being the smallest).

1

1 2

1 2 **3**

1 2 **3** 4

1 2 **3** 4 **5**

1 2 **3** 4 **5** 6

Figure D.1: Family of meters pyramid

Annex E: Description of selected validation methods

E.1 Analysis of documentation and specification and validation of the design (AD)

Application:

Basic procedure, applicable during all software validation assessments.

Description:

The examiner evaluates the functions and features of the measuring instrument using the description in text and graphical representations and decides whether these comply with the requirements of the relevant OIML Recommendation. Metrological requirements as well as software-functional requirements (e.g. fraud protection, protection of adjustment parameters, disallowed functions, communication with other devices, update of software, fault detection, etc.) have to be considered and evaluated. This task may be supported by the Software Evaluation Report Format as presented in OIML D 31 Annex B.

References:

For further details refer to OIML D 31 6.3.2.1.

E.2 Validation by functional testing of the metrological functions (VFTM)

Application:

To validate the correctness of algorithms for calculating the measurement value from raw data, for linearization of a characteristic, compensation of environmental influences, rounding in price calculation, etc.

Description:

Most of the evaluation and test methods described in OIML Recommendations are based on reference measurements under various conditions. Their application is not restricted to a certain technology of the instrument. Although not aimed primarily at validating the software, the test results can be interpreted as a validation of some parts of the software, in general those that are metrologically the most important ones. If the tests described in the relevant OIML Recommendation cover all the metrologically relevant features of the instrument, the corresponding software parts can be regarded as being validated. In general, no additional software analysis or test has to be applied to validate the metrological features of the measuring instrument.

References:

For further details refer to OIML D 31 6.3.2.2 and the various specific OIML Recommendations.

E.3 Validation by functional testing of the software functions (VFTSw)

Application:

For validation of e.g. protection of parameters, indication of a software identification, software supported fault detection, configuration of the system (especially of the software environment), etc.

Description:

Required features described in the operating manual, instrument documentation or software documentation is checked in practice. If software controlled and functioning correctly, they are to be regarded as validated without any further software analysis.

References:

For further details refer to OIML D 31 6.3.2.3 and the various specific OIML Recommendations.

E.4 Metrological dataflow analysis (DFA)

Application:

For analysis of the software design concerning the control of the data flow of measurement values through the data domains that are subject to legal control, including the examination of the software separation.

Description:

It is the aim of this analysis to find all parts of the software that are involved in the calculation of the measurement values or that may have an impact on it.

References:

For further details refer to OIML D 31 6.3.2.4.

E.5 Code inspection and walk through (CIWT)

Application:

Any feature of the software may be validated with this method if enhanced examination intensity is considered necessary.

Description:

The examiner walks through the source code assignment by assignment, evaluating the respective part of the code to determine whether the requirements are fulfilled and whether the program functions and features are in compliance with the documentation.

The examiner may also concentrate on algorithms or functions that he has identified as complex, error-prone, insufficiently documented, etc. and inspect the respective part of the source code by analyzing and checking.

References:

For further details refer to OIML D 31 6.3.2.5.

E.6 Software module testing (SMT)

Application:

Only if a high level of security and protection against fraud is required. This method is to be applied when routines of a program cannot be examined exclusively on the basis of written information and is appropriate and economically advantageous in validating dynamic measurement algorithms.

Description:

The software module under test is integrated in a test environment, i.e. a specific test program module that calls the module under test and provides it with all necessary input data. The test program compares the output data from the module under test with the expected reference values.

References:

For further details refer to OIML D 31 6.3.2.6.

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