
Water meters intended for the metering
of cold potable water

Part 1: Metrological and technical requirements

Compteurs d'eau destinés au mesurage de l'eau potable froide

Partie 1: Exigences métrologiques et techniques



INTERNATIONAL RECOMMENDATION OIML R 49-1
WATER METERS INTENDED FOR THE METERING OF COLD POTABLE WATER
Part 1: Metrological and technical requirements
(Edition 2000 - English version only)

ERRATUM 1 (2001.04.23)

On page 19 the following sentence must be added to the end of subclause 6.2.7:

After each of these tests the errors of the water meter shall again be measured at the flowrates given in 6.2.4.1 and the criteria given in 6.2.7.1 or 6.2.7.2 shall be applied.

INTERNATIONAL RECOMMENDATION OIML R 49-1 - Edition 2000 (E)

Water meters intended for the metering of cold potable water

Part 1: Metrological and technical requirements

Amendment N° 1 (2001.04.23)

The IEC tests listed in the References in Annex A of OIML R 49-1 Edition 2000 (E) shall be replaced by the current IEC tests listed below.

Test	Current Standard
A.5.1 Dry heat	IEC 60068-2-2 (1974-01) IEC 60068-2-2-am1 (1993-02) IEC 60068-2-2-am2 (1994-05) IEC 60068-3-1 (1974-01) IEC 60068-3-1A (1978-01) IEC 60068-1 (1988-06) IEC 60068-1-am1 (1992-04)
A.5.2 Cold	IEC 60068-2-1 (1990-05) IEC 60068-2-1-am1 (1993-02) IEC 60068-2-1-am2 (1994-06) IEC 60068-3-1 (1974-01) IEC 60068-3-1A (1978-01) IEC 60068-1 (1988-06) IEC 60068-1-am1 (1992-04)
A.5.3 Damp heat, cyclic	IEC 60068-2-28 (1990-03) IEC 60068-2-30 (1980-01) IEC 60068-2-30-am1 (1985-01)
A.5.4 Power voltage variation	IEC/TR3 61000-2-1 (1990-05) IEC 61000-2-2 (1990-05) IEC 61000-4-1 (2000-04)
A.5.4.2 Water meters powered by primary batteries	IEC 60654-2 (1979-01) IEC 60654-2-am1 (1992-09)
A.5.5 Vibration (sinusoidal)	IEC 60068-2-6 (1995-03) IEC 60068-2-6 corr.1 (1995-03) IEC 60068-2-47 (1999-10)
A.5.6 Short time power reductions	IEC/TR3 61000-2-1 (1990-05) IEC 61000-2-2 (1990-05) IEC 61000-4-1 (2000-04)
A.5.7 Bursts	IEC/TR3 61000-2-1 (1990-05) IEC 61000-2-2 (1990-05) IEC 61000-4-1 (2000-04) IEC 61000-4-4 (1995-01) IEC 61000-4-4-am1 (2000-11)
A.5.8 Electrostatic discharge	IEC/TR3 61000-2-1 (1990-05) IEC 61000-2-2 (1990-05) IEC 61000-4-1 (2000-04) IEC 61000-4-2 (1999-05) IEC 61000-4-2-am2 (2000-11)
A.5.9 Electromagnetic susceptibility	IEC/TR3 61000-2-1 (1990-05) IEC 61000-2-2 (1990-05) IEC 61000-4-1 (2000-04) IEC 61000-4-3 (1998-11) IEC 61000-4-3-am2 (2000-11)

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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 two 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; the OIML Member States shall implement these Recommendations to the greatest possible extent;
- **International Documents (OIML D)**, which are informative in nature and intended to improve the work of the metrological services.

OIML Draft Recommendations and Documents are developed by technical committees or subcommittees which are formed by the Member States. Certain international and regional institutions also participate on a consultation basis.

Cooperative agreements are established between OIML and certain institutions, such as ISO and IEC, with the objective

of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may apply simultaneously OIML publications and those of other institutions.

International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

This publication - reference OIML R 49-1, edition 2000 - was developed by the Subcommittee TC 8/SC 5 *Water meters*. It was approved for final publication by the International Committee of Legal Metrology in 1999 and will be submitted to the International Conference of Legal Metrology in 2000 for formal sanction. It supersedes the previous edition dated 1977.

OIML publications may be obtained from the Organization's headquarters:

Bureau International de Métrologie Légale
11, rue Turgot - 75009 Paris - France

Telephone: 33 (0)1 48 78 12 82 and 42 85 27 11

Fax: 33 (0)1 42 82 17 27

E-mail: biml@oiml.org

Internet: www.oiml.org

Water meters intended for the metering of cold potable water

Part 1: Metrological and technical requirements

1 Scope

1.1 This Recommendation applies to water meters used to meter the actual volume of cold potable water flowing through a fully charged, closed conduit. These water meters shall incorporate devices which indicate the integrated volume.

1.2 This Recommendation sets out the conditions with which the water meters shall comply to meet the requirements of the Services of Legal Metrology in countries where these instruments are subject to State controls.

1.3 This Recommendation also applies to water meters based on electrical or electronic principles, and to water meters based on mechanical principles incorporating electronic devices, used to meter the actual volume flow of cold potable water. It also applies to electronic ancillary devices. As a rule ancillary devices are optional. However, national or international regulations may make some ancillary devices mandatory in relation to the utilization of the water meter.

1.4 In addition to the metrological and technical requirements included in this Part 1 (R 49-1) the methods of examination and testing are included in Part 2 (R 49-2) and the test report format is included in Part 3 (R 49-3).

2 Terminology

Many of the definitions used in this Recommendation conform to the *International Vocabulary of Basic and General Terms in Metrology* (VIM) [1], the *OIML Vocabulary of Legal Metrology* (VML) [2] and OIML International Document D 11 [3]. For the purposes of this Recommendation, the definitions below shall apply.

2.1 Water meter and its constituents

2.1.1 Water meter

An instrument intended to measure continuously, memorize and display the volume of water passing through the measurement transducer at metering conditions.

Note: A water meter includes at least a measurement transducer, a calculator (including adjustment or correction devices if present) and an indicating device. These three devices may be in different housings.

2.1.2 Measurement transducer

A part of the meter which transforms the flow or the volume of the water to be measured into signals which are passed to the calculator. It can be based on a mechanical or an electrical or an electronic principle. It may be autonomous or use an external power source.

Note: For the purposes of this Recommendation, the measurement transducer includes the flow sensor or volume sensor.

2.1.3 Flow sensor or volume sensor

That part of the water meter (such as a disc, piston, wheel, turbine element, or electromagnetic coil) which senses the flow rate or volume of water passing through the meter.

2.1.4 Calculator

A part of the meter which receives the output signals from the transducer(s) and, possibly, from 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.

2.1.5 Indicating device

A part of the 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.

2.1.6 Adjustment device

A device incorporated in the meter, that only allows the error curve to be shifted generally parallel to itself, with a view to bringing errors (of indication) within the maximum permissible errors.

2.1.7 Correction device

A device connected to or incorporated in the meter for automatically correcting the volume at metering conditions, by taking into account the flowrate and/or the characteristics of the water to be measured (e.g. temperature and pressure) and the pre-established calibration curves. The characteristics of the water to be measured may either be measured using associated measuring instruments, or be stored in a memory in the instrument.

2.1.8 Ancillary device

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

The main ancillary devices are:

- (a) zero setting device;
- (b) price indicating device;
- (c) repeating indicating device;
- (d) printing device;
- (e) memory device;
- (f) tariff control device;
- (g) pre-setting device; and
- (h) self service device.

Note: An ancillary device may or may not be subject to legal metrological control according to national regulations.

2.1.9 Tariff control device

A device that allocates measurement results into different registers depending on tariff or other criteria, each register having the possibility to be displayed individually.

2.1.10 Pre-setting device

A device which permits the selection of the quantity to be measured and which automatically stops the flow of the water at the end of the measurement of the selected quantity.

2.1.11 Associated measuring instruments

Instruments connected to the calculator, the correction device or the conversion device, for measuring certain quantities which are characteristic of water, with a view to making a correction and/or a conversion.

2.1.12 Meter for two constant partners

A meter permanently installed and only used for deliveries from one supplier to one customer.

2.2 Metrological characteristics

2.2.1 Actual volume, V_a

Total volume of water passing through the water meter, disregarding the time taken. This is the measurand.

2.2.2 Indicated volume, V_i

Volume of water indicated by the meter, corresponding to the actual volume.

2.2.3 Primary indication

An indication (displayed, printed or memorized) which is subject to legal metrological control.

2.2.4 Error (of indication)

Indicated volume minus the actual volume [adapted from VIM 5.20].

2.2.5 Relative error (of indication)

Error (of indication) divided by the actual volume [adapted from VIM 3.12].

2.2.6 Maximum permissible error (mpe)

The extreme values of the relative error (of indication) of a water meter permitted by this Recommendation [adapted from VIM 5.21].

2.2.7 Intrinsic error

The error (of indication) of a water meter determined under reference conditions [adapted from VIM 5.24].

2.2.8 Initial intrinsic error

The intrinsic error of a water meter as determined prior to all performance tests.

2.2.9 Fault

The difference between the error (of indication) and the intrinsic error of a water meter [adapted from D 11 T.8].

2.2.10 Significant fault

A fault the magnitude of which is greater than one half of the maximum permissible error in the “upper zone” [adapted from D 11 T.9].

The following are not considered to be significant faults:

- faults arising from simultaneous and mutually independent causes in the water meter itself or in its checking facilities; and
- transitory faults being momentary variations in the indication which cannot be interpreted, memorized or transmitted as a measurement result.

2.2.11 Durability

The capability of water meter to keep its performance characteristics over a period of use [adapted from D 11, T.16].

2.2.12 Metering conditions

The conditions of the water, of which the volume is to be measured, at the point of measurement (example: temperature and pressure of the water).

2.2.13 First element of an indicating device

The element which, in an indicating device comprising several elements, carries the graduated scale with the verification scale interval.

2.2.14 Verification scale interval

The lowest value scale division of the first element of an indicating device.

2.2.15 Resolution (of an indicating device)

The smallest difference between indications of an indicating device that can be meaningfully distinguished [adapted from VIM 5.12].

Note: For a digital device, this is the change in the indication when the least significant digit changes by one step.

2.3 Operating conditions**2.3.1 Flowrate, Q**

Quotient of the actual volume of water passing through the water meter and the time taken for this volume to pass through the water meter.

2.3.2 Permanent flowrate, Q_3 ⁽¹⁾

The highest flowrate within the rated operating conditions, at which the water meter is required to operate in a satisfactory manner within the maximum permissible error.

2.3.3 Overload flowrate, Q_4 ⁽¹⁾

The highest flowrate, at which a water meter is required to operate, for a short period of time, within its maximum permissible error, whilst maintaining its metrological performance when it is subsequently operated within its rated operating conditions.

2.3.4 Transitional flowrate, Q_2 ⁽¹⁾

Flowrate which occurs between the permanent flowrate Q_3 , and the minimum flowrate Q_1 , that divides the flowrate range into two zones, the “upper zone” and the “lower zone”, each characterized by its own maximum permissible error.

2.3.5 Minimum flowrate, Q_1 ⁽¹⁾

The lowest flowrate at which the water meter is required to operate within the maximum permissible error.

⁽¹⁾ Expressed in m³/h in this Recommendation.

2.3.6 Maximum admissible temperature

The maximum water temperature that a water meter can withstand permanently, within its rated operating conditions, without deterioration of its metrological performance.

2.3.7 Maximum admissible pressure

The maximum internal pressure that a water meter can withstand permanently, within its rated operating conditions, without deterioration of its metrological performance.

2.3.8 Working temperature, T_w

The average water temperature in the pipe measured upstream and downstream of the water meter.

2.3.9 Working pressure, P_w

The average water pressure in the pipe measured upstream and downstream of the water meter.

2.3.10 Pressure loss, Δp ⁽²⁾

The head loss, at a given flowrate, caused by the presence of the water meter in the pipeline.

2.4 Test conditions

2.4.1 Influence quantity

A quantity that is not the measurand but which affects the result of the measurement [VIM 2.7].

2.4.2 Influence factor

An influence quantity having a value within the rated operating conditions of the water meter, as specified in this International Recommendation.

2.4.3 Disturbance

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

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

2.4.4 Rated operating conditions

Conditions of use giving the range of values of the influence factors, for which the errors (of indication) of the water meter are required to be within the maximum permissible errors [adapted from VIM 5.5].

2.4.5 Reference conditions

A set of reference values, or reference ranges of influence quantities, prescribed for testing the performance of a water meter, or for the intercomparison of the results of measurements [adapted from VIM 5.7].

2.4.6 Limiting conditions

The extreme conditions, including flowrate, temperature, pressure, humidity and electromagnetic interference, that a water meter is required to withstand without damage, and without degradation of its error (of indication), when it is subsequently operated within its rated operating conditions [adapted from VIM 5.6].

2.4.7 Performance test

A test intended to verify whether the water meter (equipment under test, EUT) is capable of accomplishing its intended functions.

2.4.8 Endurance test

A test intended to verify whether the water meter is able to maintain its performance characteristics over a period of use.

2.5 Electronic and electrical equipment

2.5.1 Electronic device

A 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.

Note: Electronic devices, as defined above, may be complete meters or parts of meters, in particular such as those mentioned in 2.1.1 through 2.1.5 and 2.1.8.

⁽²⁾ The maximum pressure loss can differ from the pressure loss at the permanent flowrate Q_3 and at the overload flowrate Q_4 .

2.5.2 Electronic sub-assembly

A part of an electronic device, employing electronic components and having a recognizable function of its own.

2.5.3 Electronic component

The smallest physical entity which uses electron or hole conduction in semi-conductors, gases, or in a vacuum.

2.5.4 Checking facility

A facility which is incorporated in a water meter with electronic devices and which enables significant faults to be detected and acted upon.

Note: The checking of a transmission device aims at verifying that all the information which is transmitted (and only that information) is fully received by the receiving equipment.

2.5.5 Automatic checking facility

A checking facility operating without the intervention of an operator.

2.5.6 Permanent automatic checking facility (type P)

An automatic checking facility operating during the entire measurement operation.

2.5.7 Intermittent automatic checking facility (type I)

An automatic checking facility operating at certain time intervals or per fixed number of measurement cycles.

2.5.8 Non-automatic checking facility (type N)

A checking facility which requires the intervention of an operator.

2.5.9 Power supply device

A device which provides the electronic devices with the required electrical energy, using one or several sources of AC or DC.

3 Metrological requirements

3.1 Values of Q_1 , Q_2 , Q_3 and Q_4

3.1.1 The flowrate characteristics of a water meter shall be defined by the values of Q_1 , Q_2 , Q_3 , and Q_4 ⁽³⁾.

3.1.2 A water meter shall be designated by the numerical value of Q_3 in m³/h and the ratio Q_3 / Q_1 .

3.1.3 The values of Q_3 shall be chosen from the values that will appear in ISO 4064 - Part 1 [4], currently under revision. Until that time, the following values from the R5 line of ISO 3 [5] shall be used:

1	1.6	2.5	4	6.3
10	16	25	40	63
100	160	250	400	630
1 000	1 600	2 500	4 000	6 300

expressed in m³/h.

The list may be extended to higher or lower values in the series.

3.1.4 The value of the ratio Q_3 / Q_1 shall be chosen from the following list:

10	12.5	16	20	25	31.5	40	50	63	80
100	125	160	200	250	315	400	500	630	800

The list may be extended to higher values in the series.

3.1.5 The ratio Q_2 / Q_1 shall be 1.6.

However, for a transitional period of 5 years, Q_2 / Q_1 may be 2.5, or 4, or 6.3, provided that $Q_3 / Q_2 > 5$.

3.1.6 The ratio Q_4 / Q_3 shall be 1.25.

3.2 Accuracy class and maximum permissible error

Water meters shall be designed and manufactured such that their errors (of indication) do not exceed the maximum permissible errors as defined in 3.2.1 and 3.2.2 under rated operating conditions.

These requirements shall be met durably.

Water meters shall be designated as either accuracy class 1 or accuracy class 2, according to the requirements of 3.2.1 and 3.2.2.

⁽³⁾ Annex B describes these concepts and their relationship to the measurement performance of a water meter.

3.2.1 Accuracy class 1 water meters

The maximum permissible error for the upper flowrate zone ($Q_2 \leq Q \leq Q_4$) is $\pm 1\%$, for temperatures from 0.3 °C to 30 °C, and $\pm 3\%$ for temperatures greater than 30 °C.

The maximum permissible error for the lower flowrate zone ($Q_1 \leq Q < Q_2$) is $\pm 3\%$.

Accuracy class 1 designation shall be applied only to water meters with $Q_3 \geq 100 \text{ m}^3/\text{h}$.

3.2.2 Accuracy class 2 water meters

The maximum permissible error for the upper flowrate zone ($Q_2 \leq Q \leq Q_4$) is $\pm 2\%$, for temperatures from 0.3 °C to 30 °C, and $\pm 3\%$ for temperatures greater than 30 °C.

The maximum permissible error for the lower flowrate zone ($Q_1 \leq Q < Q_2$) is $\pm 5\%$.

Accuracy class 2 designation shall be applied to all water meters with $Q_3 < 100 \text{ m}^3/\text{h}$ and may be applied to water meters with values of $Q_3 \geq 100 \text{ m}^3/\text{h}$.

3.2.3 Water meters with separable calculator and measurement transducer

The calculator (including indicating device) and the measurement transducer (including flow sensor or volume sensor) of a water meter, where they are separable and interchangeable with other calculators and measurement transducers of the same or different designs, may be the subject of separate pattern approvals.

The maximum permissible errors of the combined indicating device and measurement transducer shall not exceed the values given in 3.2.1 and 3.2.2 according to the accuracy class of the meter.

3.2.4 The error (of indication) is expressed as a percentage, and is equal to:

$$\frac{(V_i - V_a)}{V_a} \times 100$$

3.2.5 The manufacturer shall specify whether or not the water meter is designed to measure reverse flow.

If a meter is designed to measure reverse flow, the actual volume passed during reverse flow shall either be subtracted from the indicated volume or the meter shall record it separately. The maximum permissible

error of 3.2.1 and 3.2.2 shall be met both for forward and reverse flow.

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

3.2.6 The requirements relating to the maximum permissible errors shall be met for all temperature and pressure variations occurring within the rated operating conditions of the water meter.

3.2.7 The water meter totalization shall not change when the flowrate is zero.

3.2.8 The maximum permissible errors of a water meter while in service shall be twice the maximum permissible errors given in 3.2.1 and 3.2.2 according to the accuracy class of the meter.

3.3 Requirements for meters and ancillary devices

3.3.1 Connections between electronic parts

The connections between the measurement transducer, the calculator and the indicating device shall be reliable and durable in accordance with 4.1.3 and 4.3.2.

These provisions shall also apply to connections between the primary and secondary devices of electromagnetic meters.

Note: Definitions of primary and secondary devices of electromagnetic meters are given in ISO 4006 [6].

3.3.2 Adjustment device

Meters may be provided with an electronic adjustment device, which may replace a mechanical adjustment device.

3.3.3 Correction device

Meters may be fitted with correction devices; such devices are always considered as an integral part of the meter. The whole of the requirements which apply to the meter, in particular the maximum permissible errors specified in 3.2, are therefore applicable to the corrected volume at metering conditions.

In normal operation, non-corrected volume shall not be displayed.

The aim of a correction device is to reduce the errors (of indication) to as close to zero as possible. Water meters with correction devices shall satisfy the performance tests of A.5.

All the parameters which are not measured and which are necessary for correcting shall be contained in the calculator at the beginning of the measurement operation. The pattern approval certificate may prescribe the possibility of checking parameters which are necessary for correctness at the time of verification of the correction device.

The correction device shall not allow the correction of a pre-estimated drift, for example in relation to time or volume.

Associated measuring instruments, if any, shall comply with the applicable International Standards or Recommendations. Their accuracy shall be good enough to permit the requirements on the meter to be met, as specified in 3.2.

Associated measuring instruments shall be fitted with checking devices, as specified in 4.3.6.

Correction devices shall not be used for adjusting the errors (of indication) of a water meter to values other than as close as practical to zero, even when these values are within the maximum permissible errors.

3.3.4 Calculator

All parameters necessary for the elaboration of indications that are subject to legal metrological control, such as a calculation table or correction polynomial, shall be present in the calculator at the beginning of the measurement operation.

The calculator may be provided with interfaces permitting the coupling of peripheral equipment. When these interfaces are used, the water meter's hardware and software shall continue to function correctly and its metrological functions shall not be capable of being affected.

3.3.5 Electronic indicating device

The continuous display of volume during the period of measurement is not mandatory. However, interruption of the display shall not interrupt the action of checking facilities, if present.

3.3.6 Ancillary devices

The relevant requirements of OIML R 117 [7] shall be applied when the water meter is equipped with any of the following devices:

- zero setting device;
- price indicating device;
- printing device;
- memory device;
- pre-setting device; and
- self-service device.

4 Water meters equipped with electronic devices

4.1 General requirements

4.1.1 Water meters with electronic devices shall be designed and manufactured in such a way that significant faults do not occur when they are exposed to the disturbances specified in A.5.

These requirements shall be met durably.

4.1.2 Water meters with electronic devices shall be provided with the checking facilities specified in 4.3, except in the case of non-resettable measurements between two constant partners.

Checking facilities are required only where the delivered volume of water is prepaid by the customer and cannot be confirmed by the supplier.

All meters equipped with checking facilities shall prevent or detect reverse flow, as specified in 3.2.5.

4.1.3 Water meters equipped with checking facilities are presumed to comply with the requirements in 3.2 and 4.1.1 if they pass the design inspection and performance tests specified in 6.2.11.1 and 6.2.11.2.

4.1.4 Water meters not equipped with checking facilities are presumed to comply with the requirements in 3.2 and 4.1.1 if they pass the design inspection and performance tests specified in 6.2.11.1 and 6.2.11.2 in the following conditions:

- five identical meters are submitted at pattern approval;
- at least one of these five meters is submitted to the whole set of tests; and
- no meter fails any test.

4.1.5 The meter shall also provide visual checking of the entire display which shall have the following sequence:

- displaying all the elements (e.g. an “eights” test); and
- blanking all the elements (a “blanks” test).

Each step of the sequence shall last at least one second.

4.2 Power supply device

Three different kinds of basic power supplies for water meters with electronic devices are covered by this Recommendation:

- external power supply;
- non-replaceable battery; and
- replaceable battery.

These three types of power supplies may be used alone or in combination. The requirements for each type of power supply are covered by the following paragraphs.

4.2.1 External power supply

4.2.1.1 Water meters with electronic devices shall be designed such that in the event of an external power supply failure (AC or DC), the meter indication of volume just before failure is not lost, and remains accessible for a minimum of one year.

The corresponding memorization shall occur at least either once per day or for every volume equivalent to 10 minutes of flow at Q_3 .

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

Note: Compliance with this clause will not necessarily ensure that the water meter will continue to register the volume consumed during a power supply failure.

4.2.1.3 The power supply shall be capable of being secured from tampering.

4.2.2 Non-replaceable battery

The manufacturer shall ensure that the indicated lifetime of the battery guarantees that the meter functions correctly for at least one year longer than the operational lifetime of the meter.

Note: It is anticipated that a combination of maximum allowable volume, displayed volume, indicated operational lifetime, remote reading and extreme temperatures will be considered when specifying a battery and during pattern approval.

4.2.3 Replaceable battery

4.2.3.1 Where the electrical power supply is a replaceable battery, the manufacturer shall give precise rules for the replacement of the battery.

4.2.3.2 The replacement date of the battery shall be indicated on the meter.

4.2.3.3 The properties and parameters of the meter shall not be affected by the interruption of the electrical supply when the battery is replaced.

Note: It is anticipated that a combination of maximum allowable volume, displayed volume, remote reading and extreme temperatures will be considered when specifying a battery and during pattern approval.

4.2.3.4 The operation of replacing the battery shall be carried out in a way which does not necessitate breaking the seal required for statutory metrological inspections.

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

4.3 Checking facilities

4.3.1 Action of checking facilities

The detection by the checking facilities of significant faults shall result in the following actions, according to the type:

For checking facilities of type P or I:

- automatic correction of the fault; or
- stopping only the faulty device when the water meter without that device continues to comply with the regulations; or
- a visible or audible alarm; this alarm shall continue until the cause of the alarm is suppressed.

In addition, when the water meter transmits data to peripheral equipment, the transmission shall be accompanied by a message indicating the presence of a fault. (This requirement is not applicable to the application of disturbances specified in A.5).

The instrument may also be provided with devices to estimate the volume of water having passed through the installation during the occurrence of the fault. The result of this estimate shall not be capable of being mistaken for a valid indication.

The visible or audible alarm is not allowed in the case of two constant partners, non-resettable and non-prepaid measurements, where checking facilities are used, unless this alarm is transferred to a remote station.

Note: The transmission of the alarm and repeated measured values from the meter to the remote station need not be secured if the measured values are repeated at that station.

4.3.2 Checking facilities for the measurement transducer

The objective of these checking facilities is to verify the presence of the measurement transducer, its correct operation and the correctness of data transmission.

The verification of correct operation includes detection or prevention of reverse flow. However, it is not necessary for the detection or prevention of reverse flow to be operated electronically.

4.3.2.1 When the signals generated by the flow sensor are in the form of pulses, each pulse representing an elementary volume, the pulse generation, transmission and counting shall fulfil the following tasks:

- correct counting of pulses;
- detection of reverse flow, if necessary; and
- checking of correct function.

This may be done by means of:

- three-pulse system with use of either pulse edges or pulse status;
- double-pulse line system with use of pulse edges plus pulse status; and
- double-pulse system with positive and negative pulses depending on the flow direction.

These checking facilities shall be of type P.

It shall be possible during pattern approval to verify that these checking facilities function correctly:

- by disconnecting the transducer; or
- by interrupting one of the sensor's pulse generators; or
- by interrupting the electrical supply of the transducer.

4.3.2.2 For electromagnetic meters only, where the amplitude of the signals generated by the measurement transducer is proportional to the flowrate, the following procedure may be used:

A simulated signal with a shape similar to that of the measurement signal is fed into the input of the secondary device, representing a flowrate between the minimum and maximum flowrate of the meter. The checking facility shall check the primary and the secondary device. The equivalent digital value is checked to verify that it is within predetermined limits given by the manufacturer and consistent with the maximum permissible errors.

This checking facility shall be of type P or I. For type I facilities, checking shall occur at least every five minutes.

Note: Following this procedure, additional checking facilities (more than two electrodes, double signal transmission, etc.) are not required.

4.3.2.3 The maximum permissible cable length between primary and secondary devices of an electromagnetic meter, as defined in ISO 6817:1992 [8], shall be not more than 100 metres or not more than the value L expressed in metres according to the following formula, whichever is smaller:

$$L = (k \times c) / (f \times C)$$

where:

$k = 2 \times 10^{-5}$ m;

c is the conductivity of the water, in S/m;

f is the field frequency during the measuring cycle, in Hz; and

C is the effective cable capacitance per metre, in F/m.

Note: It is not necessary to fulfill these requirements if the manufacturer's solutions ensure equivalent results.

4.3.2.4 For other technologies, checking facilities providing equivalent levels of security remain to be developed.

4.3.3 Checking facilities for the calculator

The objective of these checking facilities is to verify that the calculator system functions correctly and to ensure the validity of the calculations made.

No special means are required for indicating that these checking facilities function correctly.

4.3.3.1 The checking facilities for the functioning of the calculation system shall be of type P or I. For type I

the checking must occur at least either once per day or for every volume equivalent to 10 minutes of flow at Q_3 .

The objective of this checking facility is to verify that:

- (a) the values of all permanently memorized instructions and data are correct, by such means as:
- summing up all instruction and data codes and comparing the sum with a fixed value;
 - line and column parity bits (longitudinal redundancy check and vertical redundancy check);
 - cyclic redundancy check (CRC 16);
 - double independent storage of data; and
 - storage of data in “safe coding”, for example protected by checksum, line and column parity bits.
- (b) all procedures of internal transfer and storage of data relevant to the measurement result are performed correctly, by such means as:
- write-read routine;
 - conversion and re-conversion of codes;
 - use of “safe coding” (checksum, parity bit); and
 - double storage.

4.3.3.2 The checking facilities for the validity of calculations shall be of type P or I. For type I the checking must either occur at least once per day, or for every volume equivalent to 10 minutes of flow at Q_3 .

This consists of checking the correct value of all data related to the measurement whenever these data are internally stored or transmitted to peripheral equipment through an interface. This check may be carried out by such means as parity bit, check sum or double storage. In addition, the calculation system shall be provided with a means of controlling the continuity of the calculation program.

4.3.4 Checking facility for the indicating device

The objective of this checking facility is to verify that the primary indications are displayed and that they correspond to the data provided by the calculator. In addition, it aims at verifying the presence of the indicating devices when they are removable. These checking facilities shall either have the form as defined in 4.3.4.1 or that as defined in 4.3.4.2.

4.3.4.1 The checking facility of the indicating device is of type P; however, it may be of type I if a primary indication is provided by another device.

Means may include, for example:

- for indicating devices using incandescent filaments or light emitting diodes, measuring the current in the filaments;
- for indicating devices using fluorescent tubes, measuring the grid voltage; and
- for indicating devices using multiplexed liquid crystals, output checking of the control voltage of segment lines and of common electrodes, so as to detect any disconnection or short circuit between control circuits.

The checks mentioned in 4.1.5 are not necessary.

4.3.4.2 The checking facility for the indicating device shall include type P or type I checking of the electronic circuits used for the indicating device (except the driving circuits of the display itself); this checking facility shall meet the requirements of 4.3.3.2.

4.3.4.3 It shall be possible during pattern approval to determine that the checking facility of the indicating device is working, either:

- by disconnecting all or part of the indicating device; or
- by an action which simulates a failure in the display, such as using a test button.

4.3.5 Checking facilities for ancillary devices

An ancillary device (repeating device, printing device, memory device, etc.) with primary indications shall include a checking facility of type P or I. The aim of this checking facility is to verify the presence of the ancillary device, when it is a necessary device, and to verify correct functioning and correct transmission.

4.3.6 Checking facilities for the associated measuring instruments

Associated measuring instruments shall include a checking facility of type P or I. The aim of this checking facility is to ensure that the signal given by these associated instruments is inside a predetermined measuring range.

Examples:

- four wire transmission for resistance type temperature sensors; and
- control of the driving current for 4–20 mA pressure sensors.

5 Technical requirements

5.1 Materials and construction of water meters

5.1.1 The water meter shall be manufactured from materials of adequate strength and durability for the purpose for which the water meter is to be used.

5.1.2 The water meter shall be manufactured from materials which shall not be adversely affected by the water temperature variations, within the working temperature range (see 5.4).

5.1.3 All parts of the water meter in contact with the water flowing through it shall be manufactured from materials which are conventionally known to be non-toxic, non-contaminating and biologically inert ⁽⁴⁾.

5.1.4 The complete water meter shall be manufactured from materials which are resistant to internal and external corrosion, or which are protected by a suitable surface treatment.

5.1.5 The water meter indicating device shall be protected by a transparent window. A cover of a suitable type may also be provided as additional protection.

5.1.6 The water meter shall incorporate devices for elimination of condensation, where there is a risk of condensation forming on the underside of the window of the water meter indicating device.

5.2 Adjustment and correction

5.2.1 The water meter may be fitted with an adjustment device, and/or a correction device.

5.2.2 If these devices are mounted on the outside of the water meter, provision for sealing shall be made (see 5.8.2).

5.3 Installation conditions ⁽⁵⁾

5.3.1 A water meter shall be installed such that it is completely filled with water under normal conditions.

⁽⁴⁾ National regulations shall apply.

⁽⁵⁾ See International Document OIML D 4 *Installation and storage conditions for cold water meters* [9].

5.3.2 If the accuracy of the water meter is likely to be affected by the presence of solid particles in the water (turbine and displacement type water meters, for example), it shall be provided with a strainer or filter, fitted at its inlet or in the upstream pipeline ⁽⁶⁾.

5.3.3 Provision may be made on the water meter to allow the water meter to be correctly levelled during installation ⁽⁷⁾.

5.3.4 If the accuracy of the water meter is likely to be affected by disturbances in the upstream or downstream pipeline (for example due to the presence of bends, valves or pumps), the water meter shall be provided with a sufficient number of straight pipe lengths, with or without a flow straightener, as specified by the manufacturer, so that the indications of the installed water meter meet the requirements of 3.2.1 or 3.2.2 with respect to the maximum permissible errors and according to the accuracy class of the meter.

5.4 Rated operating conditions

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

Flowrate range:	Q_1 to Q_3 inclusive;
Ambient temperature range:	+ 5 °C to + 55 °C;
Ambient humidity range:	0 % to 100 %, except for remote indicating devices where the range shall be 0 % to 93 %;
Working temperature range:	0.3 °C to 30 °C. The maximum admissible water temperature may be greater than 30 °C if required by national regulations;
Working pressure range:	0.03 MPa (0.3 bar) ⁽⁸⁾ to at least 1 MPa (10 bar), except for meters of diameter ≥ 500 mm, where the maximum admissible pressure shall be 0.6 MPa (6 bar).

⁽⁶⁾ Installation engineers should note that solid particles will collect in the water meter, for example, following work on the pipework upstream from the meter.

⁽⁷⁾ This can be a flat surface against which a temporary or permanent levelling device can be placed.

⁽⁸⁾ The unit bar may be used where national regulations permit.

5.5 Pressure loss

The pressure loss through the water meter, including its filter where the latter forms an integral part of the water meter, shall not be greater than 0.1 MPa (1 bar)⁽⁸⁾ between Q_1 and Q_4 ⁽⁹⁾.

5.6 Marks and inscriptions

The water meter shall be clearly and indelibly marked with the following information, either grouped or distributed on the casing, the indicating device dial, an identification plate, or on the meter cover if it is not detachable.

- (a) Unit of measurement: cubic metre (see 5.7.1.2);
- (b) Accuracy class, where it differs from accuracy class 2;
- (c) Numerical value of Q_3 , the ratio Q_3/Q_1 , and the ratio Q_2/Q_1 where it differs from 1.6;
- (d) Pattern approval sign according to national regulations;
- (e) Name or trademark of the manufacturer;
- (f) Year of manufacture and serial number (as near as possible to the indicating device);
- (g) Direction of flow (shown on both sides of the body; or on one side only provided the direction of flow arrow will be easily visible under all circumstances);
- (h) Maximum admissible pressure if it exceeds 1 MPa (10 bar)⁽⁸⁾;
- (i) Letter V or H, if the meter can only be operated in the vertical or horizontal position;
- (j) Maximum admissible temperature if it exceeds 30 °C; and
- (k) The manufacturer may indicate the maximum pressure loss.

For water meters with electronic devices, the following additional inscriptions shall be applied where appropriate:

- (l) For an external power supply: the voltage and frequency;
- (m) For a replaceable battery: the latest date that the battery is to be replaced; and
- (n) For a non-replaceable battery: the latest date by which the meter is to be replaced.

⁽⁹⁾ The maximum pressure loss can differ from the pressure loss at the permanent flowrate Q_3 or at the overload flowrate Q_4 .

5.7 Indicating device

5.7.1 General requirements

5.7.1.1 Function

The indicating device of the water meter shall provide an easily read, reliable and unambiguous visual indication of the indicated volume.

The indicating device shall include visual means for testing and calibration.

The indicating device may include additional elements for testing and calibration by other methods, e.g. for automatic testing and calibration.

5.7.1.2 Unit of measurement, symbol and its placement

The indicated volume of water shall be expressed in cubic metres. The symbol m^3 shall appear on the dial or immediately adjacent to the numbered display.

5.7.1.3 Indicating range

The indicating device shall be able to record the indicated volume in cubic metres corresponding to at least 1 600 hours (rounded value) of operation at the permanent flowrate Q_3 , without passing through zero. This provision is formulated in Table 1.

Table 1 Indicating range of a water meter

Q_3 m^3/h	Indicating range (minimum values) m^3
$Q_3 \leq 6.3$	9 999
$6.3 < Q_3 \leq 63$	99 999
$63 < Q_3 \leq 630$	999 999
$630 < Q_3 \leq 6\,300$	9 999 999

5.7.1.4 Color coding for indicating devices

The color black should be used to indicate the cubic metre and its multiples.

The color red should be used to indicate sub-multiples of a cubic metre.

These colors shall be applied to either pointers, indexes, numbers, wheels, discs, dials or to the aperture frames.

Other means of indicating the cubic metre, its multiples and its sub-multiples may be used for electronic water meters, provided there is no ambiguity in distinguishing between the primary indication and alternative displays, e.g. sub-multiples for verification and testing.

5.7.2 Types of indicating device

Any of the following types shall be used.

5.7.2.1 Type 1 - Analogue device

The indicated volume is indicated by continuous movement of:

- (a) one or more pointers moving relative to graduated scales;
- (b) one or more circular scales or drums each passing an index.

The value expressed in cubic metres for each scale division shall be of the form 10^n , where n is a positive or negative whole number or zero, thereby establishing a system of consecutive decades. Each scale shall either be graduated in values expressed in cubic metres or accompanied by a multiplying factor ($\times 0.001$; $\times 0.01$; $\times 0.1$; $\times 1$; $\times 10$; $\times 100$; $\times 1\ 000$, etc.).

Rotational movement of the pointers or circular scales shall be clockwise.

Linear movement of pointers or scales shall be left to right.

Movement of numbered roller indicators (drums) shall be upwards.

5.7.2.2 Type 2 - Digital device

The indicated volume shall be given by a line of adjacent digits appearing in one or more apertures. The advance of a given digit shall be completed while the digit of the next immediately lower decade changes from 9 to 0.

Movement of numbered roller indicators (drums) shall be upwards.

The lowest value decade may have a continuous movement, the aperture being large enough to permit a digit to be read unambiguously.

The apparent height of the digits shall be at least 4 mm.

5.7.2.3 Type 3 - Combination of analogue and digital devices

The indicated volume is given by a combination of type 1 and type 2 devices and the respective requirements of each shall apply.

5.7.3 Supplementary devices

In addition to the indicating devices already described in 5.7.1 and 5.7.2, the water meter may include supplementary devices which may be permanently incorporated or added temporarily.

The device may be used to detect movement of the flow sensor before this is clearly visible on the indicating device.

Where national regulations permit, the device may be used for testing and verification and for remote reading of the water meter, provided that other means guarantee the satisfactory operation of the water meter.

5.7.4 Verification devices - First element of an indicating device - Verification scale interval

5.7.4.1 General requirements

Every indicating device shall provide means for visual, non-ambiguous verification testing and calibration.

The visual verification display may have either a continuous or a discontinuous movement.

In addition to the visual verification display, an indicating device may include provisions for rapid testing by the inclusion of complementary elements (e.g. star wheels or discs), providing signals through externally attached sensors.

5.7.4.2 Visual verification displays

5.7.4.2.1 Value of the verification scale interval

The value of the verification scale interval expressed in cubic metres shall be of the form: 1×10^n , or 2×10^n or 5×10^n , where n is a positive or negative whole number, or zero.

For analogue and digital indicating devices with continuous movement of the first element, the verification scale may be formed from the division into 2, 5 or 10 equal parts of the interval between two consecutive digits of the first element. Numbering shall not be applied to these divisions.

For digital indicating devices with discontinuous movement of the first element the verification scale

interval is the interval between two consecutive digits or incremental movements of the first element.

5.7.4.2.2 Form of the verification scale

On indicating devices with continuous movement of the first element, the apparent scale spacing shall not be less than 1 mm and not more than 5 mm. The scale shall consist of:

- either lines of equal thickness not exceeding one-quarter of the scale spacing and differing only in length; or
- contrasting bands of a constant width equal to the scale spacing.

The apparent width of the pointer at its tip shall not exceed one-quarter of the scale spacing and in no case shall it be greater than 0.5 mm.

5.7.4.2.3 Resolution of the indicating device

The sub-divisions of the verification scale shall be small enough to ensure that the resolution error of the indicating device does not exceed 0.25 % for class 1 meters, and 0.5 % for class 2 meters, of the actual volume passed during 1 hour 30 minutes at the minimum flowrate Q_1 .

Note: When the display of the first element is continuous, an allowance shall be made for a maximum error in each reading of not more than half the verification scale interval.

When the display of the first element is discontinuous, an allowance shall be made for a maximum error in each reading of not more than one digit of the verification scale.

5.8 Verification marks and protection devices

5.8.1 A place shall be provided on water meters for affixing the main verification mark, which shall be visible without dismantling the water meter.

5.8.2 Water meters shall include protection devices which can be sealed so as to prevent, both before and after correct installation of the water meter, dismantling or modification of the meter, its adjustment device or its correction device, without damaging these devices.

5.8.3 Electronic sealing devices

5.8.3.1 When access to parameters that influence the determination of the results of measurements is not protected by mechanical sealing devices, the protection shall fulfill the following provisions:

- (a) Access shall only be allowed to authorized people, e.g. by means of a code (key-word) or of a special device (e.g. a hard key). The code shall be capable of being changed; and
- (b) It shall be possible for at least the last intervention to be memorized. The record shall include the date and a characteristic element identifying the authorized person making the intervention (see (a) above). The traceability of the last intervention shall be assured for at least two years, if it is not overwritten on the occasion of a further intervention. If it is possible to memorize more than one intervention and if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

5.8.3.2 For meters with parts which may be disconnected one from another by the user and which are interchangeable, the following provisions shall be fulfilled:

- (a) It shall not be possible to access parameters that participate in the determination of results of measurements through disconnected points unless the provisions in 5.8.3.1 are fulfilled; and
- (b) Interposing any device which may influence the accuracy shall be prevented by means of electronic and data processing securities or, if this is not possible, by mechanical means.

5.8.3.3 For meters with parts which may be disconnected one from another by the user and which are not interchangeable, the provisions in 5.8.3.2 shall apply. Moreover, these meters shall be provided with devices which do not allow them to operate if the various parts are not connected according to the manufacturer's configuration.

Note: Disconnections which are not allowed to the user may be prevented, for example, by means of a device that prevents any measurement after disconnecting and reconnecting.

6 Metrological controls

6.1 Reference conditions

All influence quantities, except for the influence quantity being tested, shall be held to the following values during pattern approval tests on a water meter:

Flowrate:	$0.7 \times (Q_2 + Q_3) \pm 0.03 \times (Q_2 + Q_3)$;
Working temperature:	$(20 \pm 5) \text{ }^\circ\text{C}$;
Ambient temperature:	$(20 \pm 5) \text{ }^\circ\text{C}$;
Ambient relative humidity:	$(60 \pm 15) \%$;
Ambient atmospheric pressure:	86 kPa to 106 kPa [0.86 to 1.06 bar].

6.2 Pattern approval

6.2.1 Before undergoing pattern approval tests, each pattern of water meter submitted shall be inspected externally to ensure that it complies with the provisions of the relevant preceding clauses of this Recommendation.

6.2.2 The approval tests shall be made on the minimum number of samples of each pattern shown in Table 2 as a function of the water meter designation Q_3 of the pattern presented.

The service responsible for pattern approval may request further specimens.

Table 2 Number of water meters to be tested

Meter designation Q_3 (m ³ /h)	Minimum number of meters
$Q_3 \leq 160$	3
$160 < Q_3 \leq 1\ 600$	2
$1\ 600 < Q_3$	1

Note: Additional samples are required for meters equipped with electronic devices (see 4.1.4).

The requirements of 3.2.1 and 3.2.2 shall apply to all the meters tested, according to the accuracy class of the meter.

6.2.3 During the tests, the pressure at the water meter outlet shall be at least 0.03 MPa (0.3 bar).

6.2.4 Errors (of indication)

6.2.4.1 The errors (of indication) of the water meter (in the measurement of the actual volume) shall be determined for at least seven flowrates, measured twice, which shall be at the following flowrates:

- Between Q_1 and $1.1 Q_1$;
- Between $0.5 (Q_1 + Q_2)$ and $0.55 (Q_1 + Q_2)$ (for $Q_2 / Q_1 > 1.6$);
- Between Q_2 and $1.1 Q_2$;
- Between $0.33 (Q_2 + Q_3)$ and $0.37 (Q_2 + Q_3)$;
- Between $0.67 (Q_2 + Q_3)$ and $0.74 (Q_2 + Q_3)$;
- Between $0.9 Q_3$ and Q_3 ; and
- Between $0.95 Q_4$ and Q_4 ;

The errors (of indication) observed for each of the seven flowrates shall not exceed the maximum permissible errors given in 3.2.1 and 3.2.2. If the error (of indication) observed on one or more meters is greater than the maximum permissible error at one flowrate only, the test at that flowrate shall be repeated. The test shall be declared satisfactory if two out of the three results lie within the maximum permissible errors and the arithmetic mean of the results for the three tests at that flowrate is less than or equal to the maximum permissible error.

6.2.4.2 If all the errors (of indication) of the water meter have the same sign, at least one of the errors shall not exceed one half of the maximum permissible error.

6.2.4.3 If the meter is marked as only operating in certain orientations, then the meter shall be tested in these orientations.

In the absence of such marks the meter shall be tested in at least three orientations.

6.2.4.4 It is recommended that the characteristic error curve for each water meter be plotted in terms of error against flowrate, so that the general performance of the water meter over its flowrate range can be evaluated.

6.2.5 The water meter shall be capable of withstanding the following test pressures without leakage or damage:

- 1.6 times the maximum admissible pressure applied for 15 minutes; and
- twice the maximum admissible pressure applied for 1 minute.

6.2.6 The pressure loss values shall be determined at least at the overload flowrate Q_4 to check that this pressure loss complies with the provisions of 5.5.

If the maximum pressure loss occurs at a lower flowrate, then the pressure loss shall be measured at that flowrate.

6.2.7 The water meter shall undergo the endurance tests detailed in Table 3, according to the permanent flowrate Q_3 and the overload flowrate Q_4 of the meter, simulating service conditions.

6.2.7.1 Accuracy class 1 water meters

For class 1 water meters, the variation in the error (of indication) curve shall not exceed 2 % for flowrates in the lower zone ($Q_1 \leq Q < Q_2$), and 1 % for flowrates in the upper zone ($Q_2 \leq Q \leq Q_4$).

The error (of indication) curve shall not exceed a maximum error limit of ± 4 % for flowrates in the lower zone ($Q_1 \leq Q < Q_2$) and ± 1.5 % for flowrates in the upper zone ($Q_2 \leq Q \leq Q_4$).

For the purpose of these requirements the mean values of the errors (of indication) shall apply.

6.2.7.2 Accuracy class 2 water meters

For class 2 water meters, the variation in the error (of indication) curve shall not exceed 3 % for flowrates in the lower zone ($Q_1 \leq Q < Q_2$), and 1.5 % for flowrates in the upper zone ($Q_2 \leq Q \leq Q_4$).

The error (of indication) curve shall not exceed a maximum error limit of ± 6 % for flowrates in the lower zone ($Q_1 \leq Q < Q_2$) and ± 2.5 % for flowrates in the upper zone ($Q_2 \leq Q \leq Q_4$).

For the purpose of these requirements the mean values of the errors (of indication) shall apply.

6.2.8 Documentation

6.2.8.1 The application for pattern approval of a water meter or a calculator (including indicating device) or a measurement transducer shall include the following documents:

- a description giving the technical characteristics and the principle of operation;
- a drawing or photograph of the complete water meter or calculator or measurement transducer;
- a list of the parts with a description of their constituent materials when these parts have a metrological influence;
- an assembly drawing with identification of the different parts;
- for meters fitted with correction devices, a description of how the correction parameters are determined;
- a drawing showing the location of seals and verification marks; and
- a drawing of regulatory markings.

6.2.8.2 In addition, the application for pattern approval of a water meter with electronic devices shall include:

- a functional description of the various electronic devices;
- a flow diagram of the logic, showing the functions of the electronic devices; and
- any document or evidence which shows that the design and construction of the water meter with electronic devices comply with the requirements of this Recommendation, in particular sections 4.1 and 4.3.

Table 3 Endurance tests

Permanent flowrate of the water meter (Q_3)	Test flowrate	Type of test	Number of interruptions	Duration of pauses	Period of operation at test flowrate	Duration of start-up and run-down
$Q_3 \leq 16 \text{ m}^3/\text{h}$	Q_3	Discontinuous	100 000	15 s	15 s	0.15 (Q_3)* s with a minimum of 1 s
	Q_4	Continuous			100 h	
$Q_3 > 16 \text{ m}^3/\text{h}$	Q_3	Continuous			800 h	
	Q_4	Continuous			200 h	

* Q_3 is the number equal to the value of Q_3 expressed in m^3/h .

6.2.8.3 The applicant seeking pattern approval shall provide the body responsible for the evaluation with a meter or a calculator (including indicating device) or a measurement transducer which is representative of the final pattern.

Additional specimens of the pattern may be considered necessary by the body responsible for the pattern evaluation to estimate the reproducibility of the measurements.

6.2.9 Pattern approval certificate

The following information shall appear on the pattern approval certificate:

- name and address of the recipient of the certificate;
- name and address of the manufacturer, if it is not the recipient;
- type and/or commercial designation;
- principal metrological and technical characteristics;
- pattern approval mark;
- period of validity;
- environmental classification, if applicable (see A.2);
- information on the location of marks for pattern approval, initial verification and sealing (e.g. a picture or drawing);
- list of documents accompanying the pattern approval certificate; and
- specific remarks.

When applicable, the version of the metrological part of the evaluated software shall be indicated in the pattern approval certificate or in its annexes (technical file).

6.2.10 Modification of an approved pattern

6.2.10.1 The recipient of the pattern approval shall inform the body responsible for the approval of any modification or addition which concerns an approved pattern.

6.2.10.2 Modifications and additions shall be subject to a supplementary pattern approval when they influence, or are likely to influence, the measurement results or the meter's regulatory conditions of use.

The body having approved the initial pattern shall decide to which extent the examinations and tests described below shall be carried out on the modified pattern in relation to the nature of the modification.

6.2.10.3 If the body having approved the initial pattern judges that the modifications or additions are not

likely to influence the measurement results, this body shall allow the modified meters to be presented for initial verification without granting a supplementary pattern approval.

A new or supplementary pattern approval must be issued whenever the modified pattern no longer fulfills the provisions of the initial pattern approval.

6.2.11 Pattern approval of a water meter with electronic devices

In addition to the examinations or tests described in the preceding paragraphs, a water meter with electronic devices shall be subject to the following examinations and tests.

6.2.11.1 Design inspection

This examination of documents aims at verifying that the design of electronic devices and their checking facilities, if applicable, comply with the provisions of this Recommendation, clause 4 in particular. It includes:

- (a) An examination of the mode of construction and of the electronic sub-systems and components used, to verify their appropriateness for their intended use;
- (b) Consideration of faults likely to occur, to verify that in all considered cases these devices comply with the provisions of 4.1 and 4.3; and
- (c) Verification of the presence and effectiveness of the test device(s) for the checking facilities, if required.

6.2.11.2 Performance tests

The performance tests specified in Annex A aim at verifying that the water meter complies with the provisions of 3.2 and 4.1.1 with regard to influence quantities.

- (a) Performance under the effect of influence factors:

When subjected to the effect of influence factors as provided for in Annex A, the equipment shall continue to operate correctly and the errors (of indication) shall not exceed the applicable maximum permissible errors.

- (b) Performance under the effect of disturbances:

When subjected to external disturbances as provided for in Annex A, the equipment shall continue to operate correctly and significant faults shall not occur.

6.2.11.3 Equipment under test (EUT)

Where the electronic devices form an integral part of the water meter, tests shall be carried out on the complete water meter.

If the electronic devices of a water meter are in a separate housing, their electronic functions may be tested independently of the measurement transducer of the water meter by simulated signals representative of the normal operation of the meter, in which case the electronic devices shall be tested in their final housing.

In all cases, ancillary equipment may be tested separately.

6.3 Initial verification

6.3.1 Water meters shall undergo the initial verification tests indicated below. This verification shall be carried out after pattern approval has been granted.

6.3.2 Water meters of the same size and the same pattern may be tested in series; however in this case the requirements of 6.2.3 (concerning water meter outlet pressure) shall be met for each water meter, and there shall be no significant interaction between water meters.

6.3.3 The errors (of indication) of the water meters in the measurement of actual volume shall be determined for at least the following three flowrates:

- (a) Between Q_1 and $1.1 Q_1$;
- (b) Between Q_2 and $1.1 Q_2$; and
- (c) Between $0.9 Q_3$ and Q_3 .

However, depending on the shape of the error curve, alternative flowrates may be specified in the pattern approval certificate.

During a test, the water temperature range shall be $20\text{ °C} \pm 10\text{ °C}$ and all other influence factors shall be held within the rated operating conditions.

6.3.4 The errors (of indication) determined at each of the above flowrates shall not exceed the maximum permissible errors given in 3.2.1 and 3.2.2.

7 Test method and test report format

7.1 Test method

The methods of examination and testing described in Part 2 (R 49-2) shall apply to pattern approval and verification of a water meter [10].

In addition, the performance tests in Annex A shall apply to water meters with electronic devices.

7.1.1 Uncertainties in the test methods

When a test is conducted, the expanded uncertainty in the determination of the actual volume passing through the water meter shall not exceed one-fifth of the applicable maximum permissible error for pattern approvals, initial verifications and subsequent verifications.

The expanded uncertainty shall be estimated according to the *Guide to the expression of uncertainty in measurement* [11] with a coverage factor, $k = 2$.

When a test is conducted, the error arising from the resolution of the meter under test shall not exceed the values given in 5.7.4.2.3.

7.2 Test report format

The results of pattern approval and verification examinations and tests shall be presented in the format given in the test report format according to Part 3 (R 49-3) [12].

Annex A

Performance tests for water meters with electronic devices (Mandatory)

A.1 General

This Annex defines the program of performance tests intended to verify that water meters with electronic 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 intrinsic error.

These tests supplement any other prescribed test.

When the effect of one influence quantity is being evaluated, all other influence quantities are to be held relatively constant, at values close to reference conditions (see 6.1 and A.3).

A.2 Environmental classification (see [3])

For each performance test, typical test conditions are indicated which correspond to the climatic and mechanical environmental conditions to which water meters are usually exposed.

Water meters with electronic devices are divided into three classes according to climatic and mechanical environmental conditions:

- class B for fixed meters installed in a building;
- class C for fixed meters installed outdoors; and
- class I for mobile meters.

However, the applicant for pattern approval may indicate specific environmental conditions in the documentation supplied to the metrology service, based on the intended use of the instrument. In this case, the metrology service shall carry out performance tests at severity levels corresponding to these environmental conditions. If pattern approval is granted, the data plate shall indicate the corresponding limits of use. Manufacturers shall inform potential users of the conditions of use for which the meter is approved. The metrology service shall verify that the conditions of use are met.

A.3 Reference conditions

Ambient air temperature: $20\text{ °C} \pm 5\text{ °C}$
Ambient relative humidity: $60\% \pm 15\%$

Ambient atmospheric pressure: 86 kPa to 106 kPa
Power voltage: Nominal voltage
(U_{nom})
Power frequency: Nominal frequency
(f_{nom})

During each test, the temperature and relative humidity shall not vary by more than 5 °C or 10 % respectively within the reference range.

A.4 Pattern approval of a calculator

When an electronic calculator (including indicating device) is submitted for separate pattern approval, pattern approval tests shall be conducted on the calculator (including indicating device) alone, simulating different inputs with appropriate standards.

A.4.1 Accuracy tests include an accuracy test on the indications of measurement results. For this purpose, the error obtained on the indication of the result is calculated considering that the true value is the one which takes into account the value of the simulated quantities applied to inputs of the calculator and using standard methods for calculation. The maximum permissible errors are those given in 3.2.

A.4.2 The examinations and tests for electronic instruments described in 6.2.11 shall be performed.

A.5 Performance tests

The tests indicated in Table A.1 involve the electronic part of the water meter or its devices and may be carried out in any order.

The following rules shall be taken into consideration for these performance tests:

1) Test volumes

Some influence quantities should have a constant effect on measurement results and not a proportional effect related to the measured volume. The value of the

significant fault is related to the measured volume; therefore, in order to be able to compare results obtained in different laboratories, it is necessary to perform a test on a volume corresponding to that delivered in one minute at the overload flowrate Q_4 . Some tests, however, may require more than one minute, in which case they shall be carried out in the shortest possible time taking into consideration the measurement uncertainty.

2) Influence of the water temperature

Temperature tests concern the ambient temperature and not the temperature of the water used. It is therefore advisable to use a simulation test method so that the temperature of the water does not influence the test results.

Table A.1 Tests involving the electronic part of the water meter or its devices

Test	Nature of the influence quantity (by ref. to OIML D 11 [3])	Severity level for the class		
		B	C	I
A.5.1 Dry heat	Influence factor	3	3	3
A.5.2 Cold	Influence factor	1	3	3
A.5.3 Damp heat, cyclic	Influence factor	1	2	2
A.5.4 Power voltage variation	Influence factor	1	1	1
A.5.5 Vibration (sinusoidal)	Disturbance	-	-	3
A.5.6 Short time power reductions	Disturbance	1a & 1b	1a & 1b	1a & 1b
A.5.7 Bursts	Disturbance	2	2	2
A.5.8 Electrostatic discharge	Disturbance	1	1	1
A.5.9 Electromagnetic susceptibility	Disturbance	2, 5, 7	2, 5, 7	2, 5, 7

A.5.1 Dry heat

Test method:	Dry heat (non condensing)
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of high ambient air temperature.
References:	IEC 60068-2-2 (1974), -am1 (1993), -am2 (1994). Basic environmental testing, Test Bd: Dry heat, for heat-dissipating specimen with gradual change of temperature [13]. IEC 60068-3-1 (1974), -1A (1978). Basic environmental testing - Background information - Cold and dry heat tests [14]. IEC 60068-1 (1988), -am1 (1992). Basic environmental testing. General and guidance [15].
Test procedure in brief ⁽¹⁰⁾ :	The test consists of exposure of the EUT to a temperature of 55 °C under “free air” conditions for a 2-hour period, after the EUT has reached temperature stability. The EUT shall be tested at the reference flow rate (or simulated flowrate) and: <ul style="list-style-type: none"> • at the reference temperature of 20 °C following conditioning; • at the temperature of 55 °C, 2 hours after temperature stabilization; and • after recovery of the EUT at the reference temperature of 20 °C.
Test severities:	1) Temperature: severity level 3: 55 °C 2) Duration: 2 hours
Number of test cycles:	One cycle
Maximum allowable variations:	All functions shall operate as designed and all the errors (of indication) measured during the application of the influence factor shall be within the maximum permissible error of the “upper zone”.

A.5.2 Cold

Test method:	Cold
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of low ambient air temperature.
References:	IEC 60068-2-1 (1990), -am1 (1993), -am2 (1994). Basic environmental testing, Test Ad: Cold, for heat-dissipating specimen with gradual change of temperature [16]. IEC 60068-3-1 (1974), -1A (1978). Basic environmental testing - Background information - Cold and dry heat tests [14]. IEC 60068-1 (1988), -am1 (1992). Basic environmental testing. General and guidance [15].
Test procedure in brief:	The test consists of exposure of the EUT to a temperature of either – 25 °C (classes C or I) or + 5 °C (class B) under “free air” conditions for a 2-hour period after the EUT has reached temperature stability. The EUT shall be tested at the reference flow rate (or simulated flow rate):

⁽¹⁰⁾ This test procedure has been given in condensed form, for information only, and is adapted from the referenced IEC-Publication. Before conducting the test, the applicable publication should be consulted. This comment also applies to the test procedures hereafter.

- at the reference temperature of 20 °C following conditioning;
- at a temperature of – 25 °C or + 5 °C, 2 hours after temperature stabilization; and
- after recovery of the EUT at the reference temperature of 20 °C.

Test severities:	1) Temperature: severity level 1: + 5 °C severity level 3: – 25 °C
	2) Duration: 2 hours
Number of test cycles:	One cycle
Maximum allowable variations:	All functions shall operate as designed and all the errors (of indication) measured during application of the influence factor shall be within the maximum permissible error of the “upper zone”.

A.5.3 Damp heat, cyclic

Test method:	Damp heat, cyclic (condensing)
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of high humidity when combined with cyclic temperature changes.
References:	IEC 60068-2-30 (1980), -am1 (1985). Basic environmental testing procedures, Test Db and guidance - Damp heat, cyclic (12h + 12h cycle), test variant 1 [17]. IEC 60068-2-28 (1990). Basic environmental testing procedures. Part 2: Tests. Guidance for damp heat tests [18].
Test procedure in brief:	The test consists of exposure of the EUT to cyclic temperature variations between 25 °C and the upper temperature of 55 °C (classes C or I) or 40 °C (class B), maintaining the relative humidity above 95 % during the temperature changes and during the phases at low temperature, and at 93 % at the upper temperature phases. Condensation should occur on the EUT during the temperature rise. A standard stabilizing period before and recovery after the cyclic exposure is indicated in IEC 60068-2-30 [17]. The power supply is turned off when the influence factor is applied.
Test severities:	1) Upper temperature: severity level 1: 40 °C severity level 2: 55 °C
	2) Duration: 24 hours
Number of test cycles:	Two cycles
Maximum allowable variations:	After the application of the influence factor and recovery, all functions shall operate as designed and all the errors (of indication) measured shall be within the maximum permissible error of the “upper zone”.

A.5.4 Power voltage variation

A.5.4.1 Water meters powered by direct AC or AC/DC converters

Test method:	Variation in AC mains power supply (single phase)
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of varying AC mains power supply.

References:	IEC 61000-4-11 (1994): Electromagnetic Compatibility (EMC). Part 4: Testing and measurement techniques. Section 11: Voltage dips, short interruptions and voltage variations immunity tests [19].
Test procedure in brief:	The test consists of exposure of the EUT to power voltage variations, while the EUT is operating under normal atmospheric conditions.
Test severities:	Mains voltage: upper limit: $U_{\text{nom}} + 10 \%$ lower limit: $U_{\text{nom}} - 15 \%$
Maximum allowable variations:	All functions shall operate as designed and all errors (of indication) measured during the application of the influence factor shall be within the maximum permissible errors of the “upper zone”.

A.5.4.2 Water meters powered by primary batteries

Test method:	Variation in DC primary battery power supply
Objective of the test:	To verify compliance with the provisions in 3.2 under conditions of varying DC power supply.
References:	None available
Test procedure:	The meter error (of indication) shall be measured with the maximum and the minimum operating voltages of the battery, as specified by the water meter supplier, applied throughout the test.
Test severities:	Voltage: upper limit (battery maximum): U_{max} lower limit (battery minimum): U_{min}
Maximum allowable variations:	All functions shall operate as designed and all errors (of indication) measured during the application of the influence factor shall be within the maximum permissible errors of the “upper zone”.

A.5.5 Vibration (sinusoidal)

Test method:	Sinusoidal vibration
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of sinusoidal vibration. This test should normally apply to mobile installations only.
References:	IEC 60068-2-6 (1995). Basic environmental testing procedures. Part 2: Test. Test Fc and guidance: Vibration (sinusoidal) [20]
Test procedure in brief:	The EUT shall be tested by sweeping the frequency in the specified frequency range, at 1 octave/minute, at the specified acceleration level, with a specified number of sweep cycles per axis. The EUT shall be tested in its three, mutually perpendicular main axes, mounted on a rigid fixture by its normal mounting means. It shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use. The EUT shall not be operating when the disturbance is applied.
Test severities:	1) Frequency range: 10 Hz – 150 Hz 2) Maximum acceleration level: 20 m.s ⁻²
Number of test cycles:	20 sweep cycles per axis
Maximum allowable variations:	After the application of the disturbance and recovery, all functions shall operate as designed and all the errors (of indication) measured shall be within the maximum permissible errors of the “upper zone”.

A.5.6 Short time power reductions

Test method:	Short time interruptions and reductions in mains voltage
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of short time mains voltage interruptions and reductions.
References:	IEC 61000-4-11 (1994): Electromagnetic Compatibility (EMC). Part 4: Testing and measurement techniques. Section 11: Voltage dips, short interruptions and voltage variations immunity tests [19].
Test procedure in brief:	The test consists of subjecting the EUT to voltage interruptions from nominal voltage to zero voltage for a duration equal to half a cycle of line frequency, and reductions from nominal voltage to 50 % of nominal for a duration equal to one cycle of line frequency. The mains voltage interruptions and reductions shall be repeated ten times with a time interval of at least ten seconds.
Test severities:	100 % voltage interruption for a period equal to half a cycle. 50 % voltage reduction for a period equal to one cycle.
Number of test cycles:	At least ten interruptions and ten reductions, each with a minimum of ten seconds between tests. The interruptions and reductions are repeated throughout the time necessary to perform the whole test. For this reason, more than ten interruptions and reductions may be necessary.
Maximum allowable variations:	The difference between the error (of indication) during the test and the intrinsic error shall not exceed the value given in 2.2.10.

A.5.7 Bursts

Test method:	Electrical bursts
Object of the test:	To verify compliance with the provisions in 3.2 under conditions where electrical bursts are superimposed on the mains voltage.
References:	IEC 61000-4-4 (1995) level 2. Electromagnetic Compatibility (EMC). Part 4: Testing and measurement techniques - Electrical fast transient/burst immunity tests - Basic EMC publication. [21].
Test procedure in brief:	The test consists of subjecting the EUT to bursts of double exponential waveform transient voltages. Each spike shall have a rise time of 5 ns and a half amplitude duration of 50 ns. The burst length shall be 15 ms and the burst period (repetition time interval) shall be 300 ms. All bursts shall be applied during the same measurement or simulated measurement in symmetrical mode and asymmetrical mode.
Test severities:	Amplitude (peak value) 1 000 V
Number of test cycles:	At least ten positive and ten negative randomly phased bursts shall be applied at 1 000 V. The bursts are applied during all the time necessary to perform the test. For that reason more bursts than indicated above may be necessary.
Maximum allowable variations:	The difference between the error (of indication) during the test and the intrinsic error shall not exceed the value given in 2.2.10.

A.5.8 Electrostatic discharge

Test method:	Electrostatic discharge
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of direct and indirect electrostatic discharges.
References:	IEC 61000-4-2 (1995) level 3. Electromagnetic Compatibility (EMC). Part 4: Testing and measurement techniques - Section 2: Electrostatic discharge immunity tests - Basic EMC publication. -am1 (1998) [22].
Test procedure in brief:	<p>A capacitor of 150 pF is charged by a suitable DC voltage source. The capacitor is then discharged through the EUT by connecting one terminal to ground (chassis) and the other via 330 ohms to surfaces which are normally accessible to the operator. The test includes the paint penetration method, if appropriate.</p> <p>For direct discharges the air discharge method shall be used where the contact discharge method cannot be applied.</p>
Test severities:	8 kV for air discharges 6 kV for contact discharges
Number of test cycles:	<p>At each test point, at least ten direct discharges shall be applied at intervals of at least ten seconds between discharges, during the same measurement or simulated measurement.</p> <p>For indirect discharges, a total of ten discharges shall be applied on the horizontal coupling plane and a total of ten discharges for each of the various positions of the vertical coupling plane.</p>
Maximum allowable variations:	<p>The difference between the error (of indication) during the test and the intrinsic error shall not exceed the value given in 2.2.10.</p> <p>Where a meter has been proven to be immune from electrostatic discharges, within the rated operating conditions for flowrate, the metrological authority shall be free to choose a flowrate of zero during the electrostatic discharge test. During a zero flowrate test the meter totalization shall not change by more than the value of the verification scale interval.</p>

A.5.9 Electromagnetic susceptibility

Test method:	Electromagnetic fields (radiated)
Object of the test:	To verify compliance with the provisions in 3.2 under conditions of electromagnetic fields.
References:	IEC 61000-4-3 (1995). Electromagnetic Compatibility (EMC). Part 4: Testing and measurement techniques - Section 3: Radiated, radio frequency, electromagnetic field immunity tests. -am1 (1998) [23].
Test procedure in brief:	<p>The EUT shall be exposed to the electromagnetic field strength as specified by the severity level.</p> <p>The field strength can be generated in various ways:</p> <ul style="list-style-type: none">• the strip line is used at low frequencies below 30 MHz (or in some cases 150 MHz) for small EUT's;• the long wire is used at low frequencies (below 30 MHz) for larger EUT's;• dipole antennas or antennas with circular polarization placed 1 m from the EUT are used at high frequencies. <p>The specified field strength shall be established prior to the actual testing without the EUT in the field.</p>

The field shall be generated in two orthogonal polarizations and the frequency range shall be scanned slowly. If antennas with circular polarization i.e. log-spiral or helical antennas are used to generate the electromagnetic field, a change in the position of the antennas is not required.

When the test is carried out in a shielded enclosure, to comply with international laws prohibiting interference to radio communications, care should be taken to handle reflections from the walls. Anechoic shielding may be necessary.

Test severities:	Frequency range	26 MHz – 500 MHz	500 MHz – 1 000 MHz
	Field strength	3 V/m	1 V/m
	Modulation	80 % AM, 1 kHz sine wave	

Maximum allowable variations: The difference between the error (of indication) during the test and the intrinsic error shall not exceed the value given in 2.2.10.

Annex B

Terms used to characterize a water meter (Informative)

B.1 Definitions of terms used in Figure B.1

Q_1 , Q_2 , Q_3 , Q_4 are defining characteristics for the metrological control of water meters as described in clause 2 of this Recommendation.

Q_1 , Q_i , Q_c and Q_h are related to the actual error curve of a water meter and are defined below.

B.1.1 Continuous flowrate, Q_c

The highest flowrate at which a water meter can actually operate in a satisfactory manner, within maximum permissible error, under normal conditions of use, i.e. under steady or intermittent flow conditions.

B.1.2 High flowrate, Q_h

The highest flowrate at which a water meter can actually operate in a satisfactory manner, within the maximum permissible error, for a short period of time without deteriorating.

B.1.3 Low flowrate, Q_l

The lowest flowrate at which a water meter can give indications that satisfy requirements concerning the maximum permissible errors in the lower zone.

B.1.4 Intermediate flowrate, Q_i

The highest flowrate in the lower zone at which the water meter error (of indication) goes from above to below the maximum permissible error of the upper zone.

B.1.5 Permanent flowrate, Q_3

The highest flowrate within the rated operating conditions, at which the water meter is required to operate in a satisfactory manner within the maximum permissible error.

B.1.6 Overload flowrate, Q_4

The highest flowrate at which the water meter is required to operate for a short period of time, within its maximum permissible error, whilst maintaining its metrological performance when it is subsequently operated within its rated operating conditions.

B.1.7 Minimum flowrate, Q_1

The lowest flowrate at which the water meter is required to operate within the maximum permissible error.

B.1.8 Transitional flowrate, Q_2

Flowrate which occurs between the permanent flowrate Q_3 , and the minimum flowrate Q_1 , that divides the flowrate range into two zones, the "upper zone" and the "lower zone", each characterized by its own maximum permissible error.

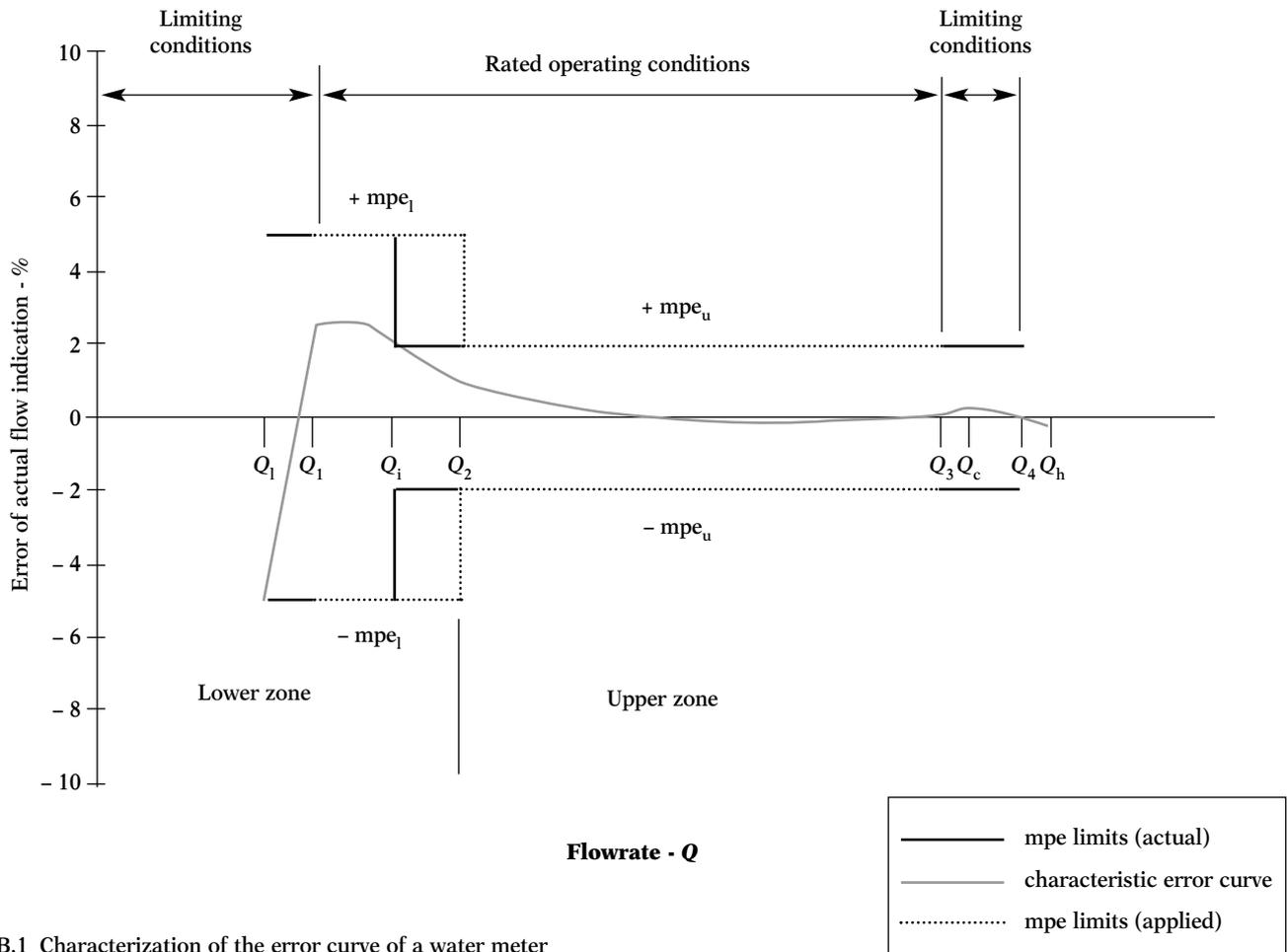


Fig. B.1 Characterization of the error curve of a water meter

B.2 Influence quantities

Influence quantities may alter the error characteristics and the correct functioning of a water meter. Figure B.2 shows a representation of some of the influence quantities relevant to water meters, where the points and their adjacent bars are examples of the reference values of influence quantities and their tolerances. The reference values and their tolerances lie within the rated operating conditions of the meter and are applied during performance tests.

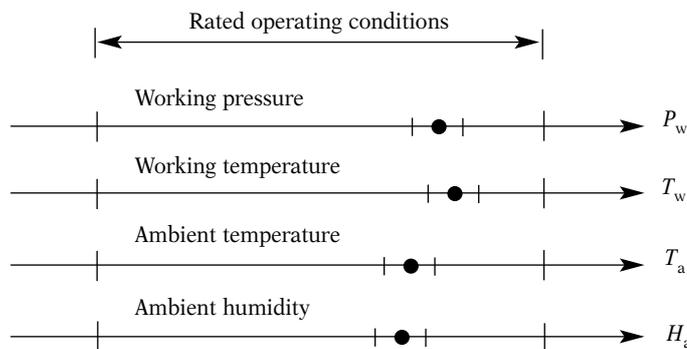


Fig. B.2 Examples of influence quantities

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