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Agricultural irrigation equipment — Meters for irrigation water

Matériel d'irrigation agricole — Compteurs pour l'eau d'irrigation

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 18, *Irrigation and drainage equipment and systems*.

This second edition cancels and replaces the first edition (ISO 16399:2014), which has been technically revised.

The main changes are as follows:

— the range of pressure regulators sizes has been extended up to DN 100 (4");

— the water temperature of the irrigation system has been harmonized to 60 °C;

— the normative references have been updated;

— the terms and definitions have been updated;

— the testing water temperature range has been updated to 4 °C to 35 °C;

— the face-to-face distance of the flanged bodies of the pressure regulators has been updated to ±4 mm for plastics-body regulators.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Agricultural irrigation equipment — Meters for irrigation water

1 Scope

This document specifies the requirements and certification procedures for water meters, irrespective of the design technologies used to meter the actual volume of cold water or heated water flowing through a fully charged closed conduit. These water meters incorporate devices, which indicate the integrated volume. It applies to water meters intended for irrigation use (herein after referred to as water meters), regardless of the water quality used for this purpose.

This document 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 water. It provides metrological requirements for electronic ancillary devices when they are subject to metrological control.

NOTE Clean water meters are different from irrigation water meters. This document is based on clean water meters standards but, it is important to develop a specific standard for irrigation water meters indicating their specific requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4064-1:2014, *Water meters for cold potable water and hot water — Part 1: Metrological and technical requirements*

ISO 4064-2:2014, *Water meters for cold potable water and hot water — Part 2: Test methods*

ISO 9644, *Agricultural irrigation equipment — Pressure losses in irrigation valves — Test method*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
actual volume
total volume of water passing through the meter, disregarding the time taken

Note 1 to entry: The actual volume is calculated from a reference volume as determined by a suitable measurement standard taking into account differences in metering conditions, as appropriate.

3.2
adjustment device
part of the meter that allows adjustment of the indicated values such that the error curve of the meter is generally shifted parallel to itself to find in the envelope of *maximum permissible errors* (3.17)

3.3
ancillary device
device intended to perform a specific function, directly involved in elaborating, transmitting or displaying measured values

Note 1 to entry: 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;

h) self-service device;

i) flow sensor movement detector (for detecting movement of the flow sensor before this is clearly visible on the indicating device);

j) remote reading device (which may be incorporated permanently or added temporarily).

3.4
bounce
momentary re-opening of a contact after initial closing, or a momentary closing after initial opening

3.5
bounce time
interval of time between the instant of the first closing (or opening) and the instant of the final closing (or opening) of the *reed contact unit* (3.28)

3.6
calculator
part of the meter that transforms the output signals from the measurement transducer(s) and, possibly, form associated measuring instruments and, if appropriate, stores the results in memory until they are used

Note 1 to entry: The gearing is considered to be the calculator in a mechanical meter.

Note 2 to entry: The calculator may be capable of communicating both ways with ancillary devices.

3.7
correction device
device connected to or incorporated in the meter for automatic correction of the volume of water at metering conditions, by taking into account the *flow rate* (3.10) and/or the characteristics of the water to be measured and the pre-established calibration curves

3.8
durability
ability of a meter to maintain its performance characteristics over a period of use

3.9
error
measured quantity value minus a reference quantity value

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

3.10
flow rate
volume of water flowing through the meter per unit time

3.11
indicating device
part of the meter that provides an indication corresponding to the volume of water passing through the meter

3.12
indicated volume
volume of water indicated by the meter, corresponding to the *actual volume* (3.1)

3.13
influence factor
influence variable (3.14) having a value within the *rated operating conditions* (3.27) specified for a *water meter* (3.32)

3.14
influence variable
quantity that, in a direct measurement, does not affect the quantity that is actually measured, but affects the relation between the indication and the measurement result

3.15
maximum admissible pressure
maximum internal pressure that the meter can withstand permanently, within its *rated operating conditions* (3.27), without deterioration of its metrological performance

Note 1 to entry: MAP is equivalent to nominal pressure (PN).

3.16
maximum admissible temperature
MAT
maximum water temperatures that a meter can withstand permanently, within its *rated operating conditions* (3.27), without deterioration of its metrological performance

3.17
maximum permissible error
MPE
extreme value of error, with respect to a known reference quantity value, permitted by the specifications given in this document

3.18
measurement transducer
part of the meter that transforms the *flow rate* (3.10) or volume of water to be measured into signals which are passed to the *calculator* (3.6) and includes the *sensor* (3.29)

Note 1 to entry: The measurement transducer may function autonomously or use an external power source and may be based on a mechanical, electrical or electronic principle.

3.19
metering conditions
conditions of the water, the volume of which is to be measured, at the point of measurement

EXAMPLE Water temperature, water pressure.

3.20
minimum admissible temperature
mAT
minimum water temperatures that a meter can withstand permanently, within its *rated operating conditions* (3.27), without deterioration of its metrological performance

3.21
minimum flow rate
Q_1
lowest *flow rate* (3.10) at which the meter is designed to operate within the *maximum permissible error* (3.17)

3.22
nominal diameter
alphanumeric designation of the size of pipe work components, used for reference purposes, comprising the letters DN followed by a dimensionless round number which is loosely related to the effective dimensions, in millimetres, of the bore or external diameter of the end connections

3.23
operate position time
interval of time between the instant the *reed contact unit* (3.28) is in the operate position and the instant of the removal of the applied magnetic field to the contact

Note 1 to entry: It includes the closing *bounce time* (3.5) in a normally open contact or the opening bounce time in a normally closed contact.

3.24
overload flow rate
Q_4
highest *flow rate* (3.10) at which the *water meter* (3.32) is designed to operate for a short period of time within its *maximum permissible error* (3.17), while maintaining its metrological performance when it is subsequently operating within the *rated operating conditions* (3.27)

3.25
permanent flow rate
Q_3
highest *flow rate* (3.10) within the *rated operating conditions* (3.27) at which the meter is designed to operate within the *maximum permissible errors* (3.17)

3.26
pressure loss
difference in pressure due to water flow between two specified points in a system or in part of a system

3.27
rated operating condition
operating conditions requiring fulfilment during measurement in order that a meter performs as designed

[SOURCE: VIM:2012, 4.9]

3.28
reed contact unit
assembly containing contact blades, some or all of magnetic material, hermetically sealed in an envelope and controlled by means of externally generated magnetic field (e.g. a pulse generator)

3.29
sensor
element of a meter that is directly affected by a phenomenon, body or substance carrying a quantity to be measured

Note 1 to entry: For a water meter, the sensor may be a disc, piston, wheel or turbine element, the electrodes on an electromagnetic meter, or another element. The element senses the flow rate or volume of water passing through the meter an is referred to as a "flow sensor" or "volume sensor".

3.30
test flow rate
mean *flow rate* (3.10) during a test, calculated from the indications of a calibrated reference device

3.31
transitional flow rate
Q_2
flow rate (3.10) between the *permanent flow rate* (3.25) and the *minimum flow rate* (3.21) that divides the flow rate range into two zones, the upper zone and the lower zone, each characterized by its own *maximum permissible error* (3.17)

3.32
water meter
instrument intended to measure continuously, memorize and display the volume of water passing through the measurement transducer at metering conditions

Note 1 to entry: When a device claiming to be a water meter has the intended use of documenting water flow for payment purposes, then that device must include, 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. Water meters not intended for payment purposes only need to be compatible, in some way, with all the aforementioned three devices.

[SOURCE: OIML R49-1:2006]

3.33
working pressure
average water pressure in the pipe measured upstream and downstream of the meter

3.34
working temperature
T_w
water temperature in the pipe measured upstream of a *water meter* (3.32)

[SOURCE: OIML R49-1:2006]

4 Metrological requirements

4.1 Values of Q_1, Q_2, Q_3 and Q_4

4.1.1 Permanent flow rate (Q_3)

The value of Q_3, in (m^3/h), shall be chosen from the following list:

1,0	1,6	2,5	4,0	6,3
10	16	25	40	63
100	160	250	400	630
1 000	1 600	2 500	4 000	6 300

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

4.1.2 Measuring range

The measuring range for the flow rate is defined by the ratio (R) Q_3/Q_1. The values 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

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

4.1.3 Relationship between permanent flow rate (Q_3) and overload flow rate (Q_4)

The overload flow rate is defined by Formula (1):

$$Q_4/Q_3 = 1{,}25 \tag{1}$$

4.1.4 The ratio Q_2/Q_1 shall be 1,6

The transitional flow rate is defined by Formula (2):

$$Q_2/Q_1 = 1{,}6 \tag{2}$$

e.g.: $Q_3 = 100$; $Q_3/Q_1 = 10$ (R10); $Q_2/Q_1 = 1{,}6$; $Q_4/Q_3 = 1{,}25$

where

Q_3 100 m^3/h;

Q_1 10 m^3/h;

Q_2 16 m^3/h;

Q_4 125 m^3/h.

4.2 Maximum permissible error (MPE)

4.2.1 Formulation

The error is expressed as a percentage, and is calculated using Formula (3):

$$\varepsilon = \frac{(V_i - V_a)}{V_a} \times 100\ (\%) \tag{3}$$

where

V_i is the indicated volume;

V_a is the actual volume.

4.2.2 Accuracy class

4.2.2.1 General

A water meter shall be designed and manufactured such that its errors do not exceed the maximum permissible errors (MPE).

A water meter shall be designated as either accuracy class 1 or accuracy class 2, according to the requirements of 4.2.2.2 or 4.2.2.3, respectively.

The meter manufacturer shall specify the accuracy class.

The requirements relating to the MPEs shall be met for all temperature and pressure variations occurring within the rated operating conditions of a water meter.

The two accuracy classes are providing the end users with the option to choose the right meter that best fits their application (flow ranges and measuring accuracy.

4.2.2.2 Accuracy class 1 water meters

The MPE for the upper flow rate zone ($Q_2 \leq Q \leq Q_4$) is ±1 %, for temperatures from 0,1 °C to 30 °C, and 2 % for temperatures greater than 30 °C.

The MPE for the lower flow rate zone ($Q_1 \leq Q < Q_2$) is ±3 % regardless of the temperature range.

4.2.2.3 Accuracy class 2 water meters

The MPE for the upper flow rate zone ($Q_2 \leq Q \leq Q_4$) is ±2 %, for temperatures from 0,1 °C to 30 °C, and 3 % for temperatures greater than 30 °C.

The MPE for the lower flow rate zone ($Q_1 \leq Q < Q_2$) is ±5 % regardless of the temperature range.

4.2.3 Meter temperature classes

The meters form water temperature classes corresponding to the various ranges, chosen by the manufacturer from the values given in Table 1.

The water temperature shall be measured at the inlet of the meter.

Table 1 — Temperature classes

Class	mAT (°C)	MAT (°C)
T30	0,1	30
T50	0,1	50

4.2.4 Reverse flow

For meters designed to measure reverse flow, the permanent flow rate and the measuring range may be different in each direction.

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

If the meter is designed to measure reverse flow, the volume passed during reverse flow shall either be subtracted from the indicated volume or the meter shall record it separately. The MPE of 4.2.2.2 or 4.2.2.3 shall be met for both forward and reverse flow. For meters designed to measure reverse flow, the permanent flow rate and the measuring range may be different in each direction.

If the meter is not designed to measure reverse flow, the meter shall either prevent reverse flow or it shall not calculate or report reverse flow if it occurs and any accidental reverse flow shall not change the indicated volume reported by the meter. Additionally, a meter that is not designed to measure reverse flow shall not have any deterioration or change in its metrological properties for forward flow if exposed to reverse flows up to the nominal maximum flow rate.

4.2.5 Absence of flow or of water

The water meter totalization shall not change in the absence either flow or of water.

4.2.6 Static pressure

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

a) 1,6 times the maximum admissible pressure applied for 15 min;

b) twice the maximum admissible pressure applied for 1 min.

4.3 Requirements for meters and ancillary devices

The meters with electronic parts and/or ancillary devices shall comply with the requirements establish in ISO 4064-1:2014, 4.3.

5 Water meters equipped with electronic devices

The meters equipped with electronic devices shall comply with the requirements stablish in ISO 4064-1:2014, Clause 5.

6 Technical characteristics

6.1 Materials and construction of water meters

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

A water meter shall be manufactured from materials, which shall not be adversely affected by the water temperature variations, within the working temperature range.

All parts of a 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.

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.

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

Where there is a risk of condensation forming on the underside of the window of a water meter indicating device, the water meter shall incorporate devise for prevention or elimination of condensation.

A water meter shall be of such design, composition, and construction that it does not facilitate the perpetration of fraud.

A water meter shall be fitted with a metrologically controlled display. The display shall be readily accessible to the customer, without requiring the use of a tool.

A water meter shall be of such design, composition, and construction that it does not exploit the MPE or favour any party.

6.2 Adjustment and correction

A water meter may be fitted with an adjustment device, and/or a correction device. Any adjustment shall be performed in such a way as to adjust the errors of the water meter to values as close as practical to zero so that the meter may not exploit the MPE or systematically favour any party.

If the devices are mounted on the outside of the water meter, provision for sealing shall be made (see 6.8.2).

6.3 Installation conditions

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

Under specific installation conditions, a strainer or filter, fitted at the inlet of a meter or in the upstream pipeline, may be required.

Provision may be made on a water meter to allow it to be correctly levelled during installation.

If the accuracy of a water meter is affected by disturbance in the upstream or downstream pipeline (e.g. 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 low straightener, as specified by the manufacturer, so that the indications of the installed water meter meet the requirements of 4.2.2.2 or 4.2.2.3.

A meter manufacturer shall specify the flow profile sensitivity class indicating:

— Sensitivity to irregularity in the upstream velocity profiles:

U**X**, where X is replaced with the manufacturer's nominal diameter requirement, rounded up to the nearest whole number.

When a straightener is required by the manufacturer, the class shall be U**X**S, where X is replaced with the manufacturer's nominal diameter requirement (with the straightener), rounded up to the nearest whole number.

If a straightener is optional, both UX and UXS forms shall be used.

— Sensitivity to irregularity in the downstream velocity profiles:

D**X**, where X is replaced with the manufacturer's nominal diameter requirement, rounded up to the nearest whole number.

When a straightener is required by the manufacturer, the class shall be D**X**S, where X is replaced with the manufacturer's nominal diameter requirement (with the straightener), rounded up to the nearest whole number.

If a straightener is optional, both UX and DXS forms shall be used.

6.4 Rated operating conditions

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

a) ambient temperature range (T_{amb}): 0,1 °C ≤ T_{amb} < 60 °C;

b) pressure (P): 0,03 MPa (0,3 bar) to at least 1 MPa (10 bar), except for meters of DN ≥ 500, where the maximum admissible pressure (MAP) shall be at least 0,6 MPa (6 bar);

c) Water temperature range [working temperature (T_w)]: 0,1 °C ≤ T_w < 30 °C;

d) Flow rate range (Q): Q_1 (minimum flow rate) < $Q \leq Q_3$ (permanent flow rate).

6.5 Pressure loss

The pressure loss through a water meter, including its filter or strainer and/or straightener, where either of these forms an integral part of the water meter, shall not be greater than the maximum value of the pressure loss corresponding to the class declared by the manufacturer, between Q_1 and Q_3.

The pressure loss class is selected by the manufacturer from values taken from Table 2.

Table 2 — Pressure-loss classes

Class	Maximum pressure-loss	
	(kPa)	(bar)
Δp 100	100	1,00
Δp 63	63	0,63
Δp 40	40	0,40
Δp 25	25	0,25
Δp 16	16	0,16
Δp 10	10	0,10

NOTE Maximum head loss can differ and be higher to the Q_3 corresponding head loss.

6.6 Marks and inscriptions

A 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 the meter cover, if it is not detachable. These markings shall be visible without dismantling the water meter after the instrument has been placed on the market or put into use.

a) Unit of measurement.

b) Accuracy class, where it differs from accuracy class 2.

c) Numerical value of Q_3 and the ratio Q_3/Q_1: if the meter measures reverse flow and the values of Q_3 and the ratio Q_3/Q_1 are different in the two directions, both values of Q_3 and Q_3/Q_1 shall be inscribed; the direction of flow to which each pair of values refers shall be clear. The ratio Q_3/Q_1 may be expressed as R, e.g. "R40". If the meter has different values of Q_3/Q_1 in horizontal and vertical positions, both values of Q_3/Q_1 shall be inscribed, and the orientation to which each value refers shall be clear.

d) Name or trademark of the manufacturer.

e) Year of manufacture, the last two digits of the year of manufacture, or the month and year of manufacture.

f) Serial number (as near as possible to the indicating device).

g) Direction of flow, by means of an arrow (shown on both sides of the body or on one side only provided the direction of flow arrow is easily visible under all circumstances).

h) Maximum admissible pressure (MAP) if it exceeds 1 MPa (10 bar) or 0,6 MPa (6 bar) for DN ≥ 500.

i) Letter V or H, if the meter can only be operated in the vertical or horizontal position.

j) The pressure loss class where it differs from Δp 100.

k) The installation sensitivity class where it differs from U0/D0.

For a water meter 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 by which the battery shall be replaced.

n) For a non-replaceable battery: the latest date by which the meter shall be replaced.

o) Environmental classification.

p) Electromagnetic environmental class.

The environmental classification and electromagnetic environmental class may be given on a separate datasheet, unambiguously related to the meter by a unique identification, and not on the meter itself.

An example of the required marks and inscriptions for a meter without electronic devices follows:

EXAMPLE *Q*3 63; R 125; H; → 123456; 08; ABC

— Q_3 = 63 m^3/h;

— Q_3/Q_1 = 125;

— horizontal mounting;

— pressure loss class Δp 63;

— maximum admissible pressure: 1 MPa (10 bar);

— flow profile sensitivity class U0/D0;

— serial number: 123456;

— year of manufacture: 2008;

— manufacturer ABC.

6.7 Indicating device

6.7.1 General requirements

6.7.1.1 Function

The indicating device shall always guarantee reading of volumes without ambiguity.

6.7.1.2 Unit of measurement

The indicated volume of water shall be expressed preferably, in cubic meters. The other units that can be used are: litres, mega litres, acre-feet, acre-inches, gallons, or thousands of gallons. The manufacturer shall include documentation describing the units, the symbol used to identify the units, and a conversion factor to compute an equivalent value of cubic meters. When a meter's indicating device is capable of displaying different units, the display device must clearly indicate what units are used at any given time.

6.7.1.3 Indicating range

This requirement is set in Table 3.

Table 3 — Indicating range

Q_3 m³/h	Indicating range (minimum values) m³
$Q_3 \le 6{,}3$	9 999
$6{,}3 < Q_3 \le 63$	99 999
$63 < Q_3 \le 630$	999 999
$630 < Q_3 \le 6\,300$	9 999 999

6.7.1.4 Colour coding for indicating devices

The colour black shall be used to indicate the cubic metre and its multiples.

The colour red shall be used to indicate sub-multiples of a cubic metre.

These colours shall be applied to the pointers, indices, numbers, wheels, discs, dials or aperture frames.

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

6.7.2 Types of indicating device

6.7.2.1 General

Any of the following types shall be used.

6.7.2.2 Type 1 – Analogue device

The indicated volume is indicated by continuous movement of

a) one or more pointers moving relative to graduated scales, or

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 multiplication factor (x0,001; x0,01; x0,1; x1; x10; x100; x1 000, etc.).

6.7.2.3 Type 2 – Digital device

The indicated volume is 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 0 to 0. The apparent height of the digits shall be at least 4 mm.

For non-electronic devices:

a) if the lowest value decade has a continuous movement, the aperture shall be large enough to permit a digit to be read unambiguously.

For electronic devices:

b) either permanent or non-permanent displays are permitted – for non-permanent displays, the volume shall be able to be displayed at any time for at least 10 s;

c) the meter shall provide visual checking of the entire display which shall have the following sequence:

   1) for seven segment type displaying all the elements (e.g. an “eights” test);

   2) for seven segment type blanking all the elements (a “blanks” test);

   3) for graphical displays, an equivalent test to demonstrate that display faults cannot result in any digit being misinterpreted.

Each step of the sequence shall last at least 1 s.

6.7.2.4 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.

6.8 Sealing and security

6.8.1 Meter security and protection against manipulations

A water meter shall include protection devices or methods which can be sealed or activated 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.

The display of the total quantity supplied or the displays from which the total quantity supplied can be derived shall not be resettable while the meter is in service to a single customer.

6.8.2 Mechanical protection devices

Water meters shall incorporate protective devices, such as seals, that prevent that the water meter from being disassembled or altered without permanently damaging the seal or the protective device.

6.8.3 Electronic sealing devices

When access to modify parameters that influence the determination of the results of measurements is not protected by mechanical sealing devices, the protection shall fulfil the provisions described in ISO 4064-1:2014, 6.8.2.

6.9 Other devices

Water meters can incorporate other devices as, for example, reed switches. In such case, the manufacturer shall ensure that the devices do not affect the metrological characteristics of the water meter and that such devices have full compatibility with the water meter.

For example, in order to ensure full compatibility between a reed contact unit and a water meter, the manufacturer can carry out the tests described in Annex A.

7 Performance tests

7.1 General conditions for the tests

7.1.1 Water quality

Conduct water meter tests using water from the public clean water supply or water that meets the same requirements.

Ensure that the water does not contain anything capable of damaging the water meter or adversely affecting its operation. Avoid entrapped air.

If water is being recycled, measurements shall be taken to prevent residual water in the meter from becoming harmful to human beings.

7.1.2 Reference conditions

Table 4 — Reference conditions

Condition	Admissible range
Water temperature range	4 °C to 35 °C
Working pressure range	0,03 MPa to 1 MPa except DN > 500 that is 0,6 MPa
Ambient temperature range	4 °C to 60 °C
Ambient relative humidity range	35 % to 90 %
Ambient atmospheric pressure range	86 kPa to 106 kPa (0,86 bar to 1,06 bar)
Power supply voltage (mains AC)	Nominal voltage, U_{nom} ±5 %
Power supply frequency	Nominal frequency, f_{nom} ±2 %
Power supply voltage (battery)	A voltage V in the range $U_{bmin} \leq V \leq U_{bmax}$

During each test, the temperature and relative humidity shall not vary by more than 5 °C or 10 %, respectively, within the reference range. The reference conditions (see Table 4) are permitted to deviate from the defined tolerance values during the performance tests if evidence can be given that the type of meter under consideration is not affected by the deviation of the condition in question. The actual values of deviating condition, however, shall be measured and documented as part of the performance test documentation.

7.1.3 General rules concerning test installation and location

7.1.3.1 Freedom from spurious influences

Test rigs shall be so designed, constructed, and used, that the performance of the rig itself shall not contribute significantly to the test error. To this end, high standards of rig maintenance, plus adequate supports and fittings, are necessary to prevent vibration of the meter, the test rig, and its accessories.

7.1.3.2 Group testing of meters

Meters are tested either individually or in groups. In the latter case, the individual characteristics of the meters shall be precisely determined. The presence of any meter in the test rig shall not contribute significantly to the test error of any other meter.

7.2 Static pressure test

7.2.1 General

To verify that the water meter can withstand the specified hydraulic test pressure for the specific time, without leakage or damage.

7.2.2 Preparation

a) Install the water meters in the test bench either individually or in groups.

b) Bleed the test bench pipe-work and the water meter of air.

c) Ensure that the test bench is free from leaks.

d) Ensure that the supply pressure is free from pressure pulsations.

7.2.3 Test procedure

a) Increase the hydraulic pressure to 1,6 times the maximum admissible pressure of the water meter and hold it for 15 min.

b) Examine the water meters for physical damage, for external leaks and for leaks into the indicating device.

c) Increase the hydraulic pressure to twice the maximum admissible pressure and hold it for 1 min. Ensure that the flow rate is zero during the test.

d) Examine the water meters for physical damage, for external leaks and for leaks into the indicating device.

Additional requirements:

e) Increase and decrease the pressure gradually without pressure surges.

7.2.4 Acceptance criteria

There shall be no leakage from the water meter or leakage into the indicating device, or physical damage, resulting from any of the pressure tests.

7.3 Determination of errors

7.3.1 General

To verify that the water meter complies with the requirements in 4.2.2 and to determine the effects of the water meter orientation on the error.

7.3.2 Preparation

7.3.2.1 Description of the test rig

The method described here for determining the water meter errors is the so-called “collection” method, in which the quantity of water passed through the water meter is collected in one or more collecting vessels and that quantity is determined volumetrically or by weighing. Other methods may be used, provided the requirements of uncertainty are met.

The error is checked by comparing the volume indications given by the water meter under reference conditions against a calibrated reference device.

For the purpose of these tests, the water meter should be tested without its temporary supplementary devices attached (if any) unless the device is essential for the testing of the meter.

The test rig consists, typically, of:

a) a water supply (non-pressurized tank, pressurized tank, pump, etc.);

b) pipework;

c) a calibrated reference device (calibrated volumetric tank, weighing system, reference meter, etc.);

d) means for measuring the time of the test;

e) devices for automating the tests (if required);

f) means for measuring water temperature;

g) means for measuring water pressure;

h) means to determine density, if necessary;

i) means to determine conductivity, if necessary.

7.3.2.2 Pipework

7.3.2.2.1 Description

Pipework shall include:

a) a test section in which the meter(s) is (are) placed;

b) means for establishing the desired flow rate;

c) one or two isolating devices;

d) means for determining the flow rate;

And if necessary:

e) means for checking that the pipework is filled to a datum level before and after each test;

f) one or more air bleeds;

g) a non-return device;

h) an air separator:

i) a filter.

During the test, flow leakage, flow input and flow drainage shall not be permitted either between the meter(s) and the reference device or from the reference device.

7.3.2.2.2 Test section

The test section shall include, in addition to the meter(s):

a) one or more pressure tappings for the measurement of pressure, of which one pressure tapping is situated upstream of, and close to, the (first) meter;

b) means for measuring the temperature of the water close to the entry to the (first) meter.

The presence of any pipe components or devices placed in or near the measuring section shall not cause cavitation or flow disturbances capable of altering the performance of the meters or causing errors.

7.3.2.2.3 Precautions to be taken during tests

a) Check that the operation of the test rig is such that, during a test, the actual volume of water that flows through the meter(s) is equal to that measured by the reference device.

b) Check that the pipe (e.g. the swan-neck in the outlet pipe) is filled to the same datum level at the beginning and at the end of the test.

c) Bleed all air from the interconnecting pipework and the meter(s). The manufacturer may recommend a procedure that ensures that all air is bled from the meter.

d) Take all precautions necessary to avoid the effects of vibration and shock.

7.3.2.2.4 Special arrangements for the installation of meters

7.3.2.2.4.1 Avoidance of erroneous measurements

The following reminder of the most frequent causes of erroneous measurements and the necessary precautions for the installation of water meters on the test bench is prompted by the need to achieve a test installation in which:

a) the hydrodynamic flow characteristics cause no discernible difference to the meter functioning when compared with hydrodynamic flow characteristics which are undisturbed; and

b) the expanded uncertainty of the method employed does not exceed the stipulated value (see 7.3.2.2.6.1).

7.3.2.2.4.2 Need for straight lengths of pipe or a flow straightener

The accuracy of non-volumetric water meters can be affected by upstream disturbance caused, for example, by the presence of bends, tees, valves or pumps.

In order to counteract these effects:

a) the meter shall be installed in accordance with the manufacturer's instructions;

b) the connection pipework shall have an internal diameter matched to the relevant meter connection; and

c) if necessary, a flow straightener shall be installed upstream of the straight pipe length.

7.3.2.2.4.3 Common causes of flow disturbance

A flow can be subject to two types of disturbance: velocity-profile distortion and swirl, both of which may affect the errors of a water meter.

Velocity-profile distortion is typically caused by an obstruction partially blocking the pipe, e.g. the presence of a partly closed valve or a misaligned flange joint. This can easily be eliminated by careful application of installation procedures.

Swirl can be caused by two or more bends in different planes or by a single bend in combination with an eccentric reducer or partially closed valve. This effect can be controlled either by ensuring an adequate length of straight pipe upstream of the water meter, or by installing a flow straightening device, or by ca combination of the two. However, where possible, these types of pipework configurations should be avoided.

7.3.2.2.4.4 Volumetric water meters

Some types of water meter, e.g. volumetric water meters (i.e. involving measuring chambers with mobile walls), such as oscillating piston or nutating disc meters, are considered insensitive to upstream installation conditions; hence no special conditions are required.

7.3.2.2.4.5 Meters employing electromagnetic induction

Meters employing electromagnetic induction as a measuring principle may be affected by the conductivity of the test water.

The conductivity of the water used for testing this type of meter should be within the operational range of conductivity specified by the meter manufacturer.

7.3.2.2.4.6 Other measuring principles

Other types of meter may require flow conditioning when measuring the errors and, in such cases, the manufacturer's recommended installation requirements shall be followed (see 7.6).

7.3.2.2.5 Errors of test commencement and termination

7.3.2.2.5.1 General

Adequate precautions shall be taken to reduce the uncertainties resulting from operation of test rig components during the test.

Details of the precautions to be taken are given in 7.3.2.2.5.2 and 7.3.2.2.5.3 for two cases encountered in the "collection" method.

7.3.2.2.5.2 Test with readings taken with the meter at rest

This method is generally known as the standing-start-and-finish method.

Flow is established by opening a valve, situated downstream of the meter, and it is stopped by closure of this valve. The meter is read when the registration is stationary.

Time is measured between the start of the opening movement of the valve and the close of the closing movement. While flow is beginning and during the period of running at the specified constant flow rate, the error of the meter varies as a function of the changes in flow rate (the error curve).

While the flow is being stopped, the combination of the inertia of the moving parts of the meter and the rotational movement of the water inside the meter may cause an appreciable error to be introduced in certain types of meter and for certain test flow rates.

It has not been possible, in this case, to determine a simple empirical rule, which lays down conditions so that this error may always be negligible.

In case of doubt, it is advisable:

a) to increase the volume and duration of the test;

b) to compare the results with those obtained by one or more other methods, and in particular the method specified in 7.3.2.2.5.3, which eliminates the causes of uncertainty given in the preceding.

For some types of electronic water meters with pulse outputs that are used for testing, the response of the meter to changes in flow rate may be such that valid pulses are emitted after closure of the valve. In this case, means shall be provided to count these additional pulses.

Where pulse outputs are used for testing meters, the correspondence of the volume indicated by the pulse count to the volume displayed on the indicating device shall be checked.

7.3.2.2.5.3 Test with readings taken under stable flow conditions and diversion of flow

This method is generally known as the flying-start-and-finish method.

The measurement is carried out when flow conditions have stabilized.

A switch diverts the flow into a calibrated vessel at the beginning of the measurement and diverts it away at the end.

The meter is read while in motion.

The reading of the meter is synchronized with the movement of the flow switch.

The uncertainty introduced into the volume may be considered negligible if the times of motion of the flow switch in each direction are identical within 5 % and if this time is less than 1/50 of the total time of the test.

7.3.2.2.6 Calibrated reference device

7.3.2.2.6.1 Expanded uncertainty of the value of measured actual volume

When a test is conducted, the expanded uncertainty in the determination of the actual volume passing through a water meter shall not exceed one-third of the applicable maximum permissible error.

NOTE The uncertainty of the measured actual volume does not include a contribution from the water meter.

The estimated uncertainty shall be made according to ISO/IEC Guide 98-3 with a coverage factor, $k = 2$.

7.3.2.2.6.2 Minimum volume of the calibrated reference device

The minimum volume permitted depends on requirements determined by the test start and end effects (timing error), and the design of the indicating device (value of the verification scale interval).

7.3.2.2.7 Major factors affecting the measurement of errors

7.3.2.2.7.1 General

Variations in the pressure, flow rate and temperature in the test rig, and uncertainties in the precision of measurement of these physical quantities, are the principal factors affecting the measurement of the errors of a water meter.

7.3.2.2.7.2 Supply pressure

The supply pressure shall be maintained at a constant value throughout the test at the chosen flow rate.

When testing water meters which are designated $Q_3 \leq 16$ m^3/h, at test flow rates $\leq 0,1\ Q_3$, constancy of pressure at the inlet of the meter (or at the inlet of the first meter of a group being tested) is achieved if the test rig is supplied through a pipe from a constant head tank. This ensures an undisturbed flow.

Any other methods of supply shown not to cause pressure pulsations exceeding those of a constant head tank may be used (e.g. a pressurized tank).

For all other tests, the pressure upstream of the meter shall not vary by more than 10 %. The maximum uncertainty ($k = 2$) in the measurement of pressure shall be 5 % of the measured value.

The estimated uncertainty shall be made according to ISO/IEC Guide 98-3 with a coverage factor, $k = 2$.

Pressure at the entrance to the meter shall not exceed the maximum admissible pressure for the meter.

7.3.2.2.7.3 Flow rate

The flow rate shall be maintained at a constant value throughout the test at the chosen value.

Ensure that the relative variation in the flow rate during each test (not including starting and stopping) does not exceed:

— ±2, 5 % from Q_1 to Q_2 (not inclusive);

— ±5, 0 % from Q_2 (inclusive) to Q_4.

The flow rate value is the actual volume passed during the test divided by the time.

This flow rate variation condition is acceptable if the relative pressure variation (in flow to free air) or the relative variation of pressure loss (in closed circuits) does not exceed:

— ±5 % from Q_1 to Q_2 (not inclusive);

— ±10 % from Q_2 (inclusive) to Q_4.

7.3.2.2.7.4 Temperature

Ensure that the temperature of the water during the test does not change by more than 5 °C.

Ensure that the maximum uncertainty in the measurement of temperature does not exceed ±1 °C.

The estimated uncertainty shall be made according to the ISO/IEC Guide 98-3 with a coverage factor, $k = 2$.

7.3.2.2.7.5 Orientation of water meter(s)

Ensure that the position of the water meters (spatial orientation) is as indicated by the manufacturer and that they are mounted in the test rig as appropriate.

a) If the water meters are marked ‘H’, mount the connecting pipework with the flow axis in the horizontal plane during the test (indicating device positioned on top).

b) If the water meters are marked ‘V’, mount the connecting pipework with the flow axis in the vertical plane during the test:

   1) at least one meter from the sample shall be mounted with the flow axis vertical, with flow direction from bottom to top;

   2) at least one meter from the sample shall be mounted with the flow axis vertical, with flow direction from top to bottom.

c) If the water meters are not marked either ‘H’ or ‘V’:

   1) mount at least one water meter from the sample with the flow axis vertical, with flow direction from bottom to top;

   2) mount at least one water meter from the sample with the flow axis vertical and flow direction from top to bottom;

   3) mount at least one water meter from the sample with the flow axis at an intermediate angle to the vertical and horizontal (chosen at the discretion of the approving authority);

   4) mount the remaining water meters from the sample with the flow axis horizontal.

d) Where the water meters have an indicating device which is integral with the body of the water meter, at least one of the horizontally mounted water meters shall be oriented with the indicating device positioned at the side and the remaining water meters shall be oriented with the indicating device positioned at the top.

e) Ensure that the tolerance on the position of the flow axis for all water meters, whether horizontal, vertical or at an intermediate orientation is ±5°.

Where fewer than four meters are presented to test, supplementary meters shall be taken from the basis population or the same meter shall be tested in different positions.

7.3.3 Test procedure

a) Determine the intrinsic errors of the water meter (in the measurement of the actual volume), for at least the following six flow rates, the error at each flow rate being measured three times for 1), 2) and 5) and twice for the other flow rate ranges:

1) between Q_1 and 1,1 Q_1;

2) between Q_2 and 1,1 Q_2;

3) between 0,33 ($Q_2 + Q_3$) and 0,37 ($Q_2 + Q_3$);

4) between 0,67 ($Q_2 + Q_3$) and 0,74 ($Q_2 + Q_3$);

5) between 0,9 Q_3 and Q_3;

6) between 0,95 Q_4 and Q_4.

NOTE Three points are always required for 1), 2) and 5), since it is at these flow rates that the repeatability is calculated.

b) Test the water meter without its supplementary devices attached (if any).

c) Measure the errors at other flow rates if the shape of the error curve indicates that the MPE may be exceeded.

d) Calculate the relative error for each flow rate.

7.3.4 Acceptance criteria

a) The errors observed for each of the six flow rates shall not exceed the maximum permissible errors. If the error observed for one or more meters is greater than the maximum permissible error at one flow rate only, then if only two results have been taken at that flow rate, repeat the test at that flow rate. The test shall be declared satisfactory if two out of the three results lie within the maximum permissible error and the arithmetic mean of the results for the three tests at that flow rate is less than or equal to the maximum permissible error.

b) If all the errors of the water meter have the same sign, at least one of these errors shall not exceed one- half of the maximum permissible error. In all cases, this requirement shall be applied equitably with respect to the water supplier and the consumer.

c) The standard deviation for 7.3.3 a) 1), 2) and 5) shall not exceed one third of the maximum permissible error given in 4.2.2.

7.4 Pressure loss test

7.4.1 General

The objective of the test is to determine the maximum pressure loss through the water meter at any flow rate between Q_1 and Q_3 and verify that the water meter complies with the requirements in 6.5.

To determine the maximum pressure loss through the water meter at any flow rate between Q_1 and Q_3. To verify the maximum pressure loss is less than 0,1 MPa (1,00 bar). The pressure loss is defined as the pressure lost by the flowing fluid passing through the water meter under test, the water meter consisting of the meter and connections but excluding the pipework making up the test section. The test is required for forward flow and where appropriate for reverse flow (see 7.5).

7.4.2 Preparation

The installation conditions shall be in accordance with ISO 9644.

7.4.3 Test procedure

7.4.3.1 Determination of installed pressure loss

The water meter should be installed in the measuring section in the test facility. Flow is established and all air purged from the test section. Adequate back pressure should be ensured at the downstream pressure tapping at the maximum flow rate Q_3. As a minimum, a static pressure downstream of the meter under test of 100 kPa (1 bar) is recommended to avoid cavitation or air release. All air should be removed from the pressure tappings and transmitter connecting pipes. The water should be allowed to stabilize at the required temperature. While monitoring the differential pressure, vary the flow between Q_1 and Q_3. Record the flow rate showing the largest pressure loss, Q_t, along with the measured pressure loss and water temperature. Normally, Q_t will be found to be equal to Q_3.

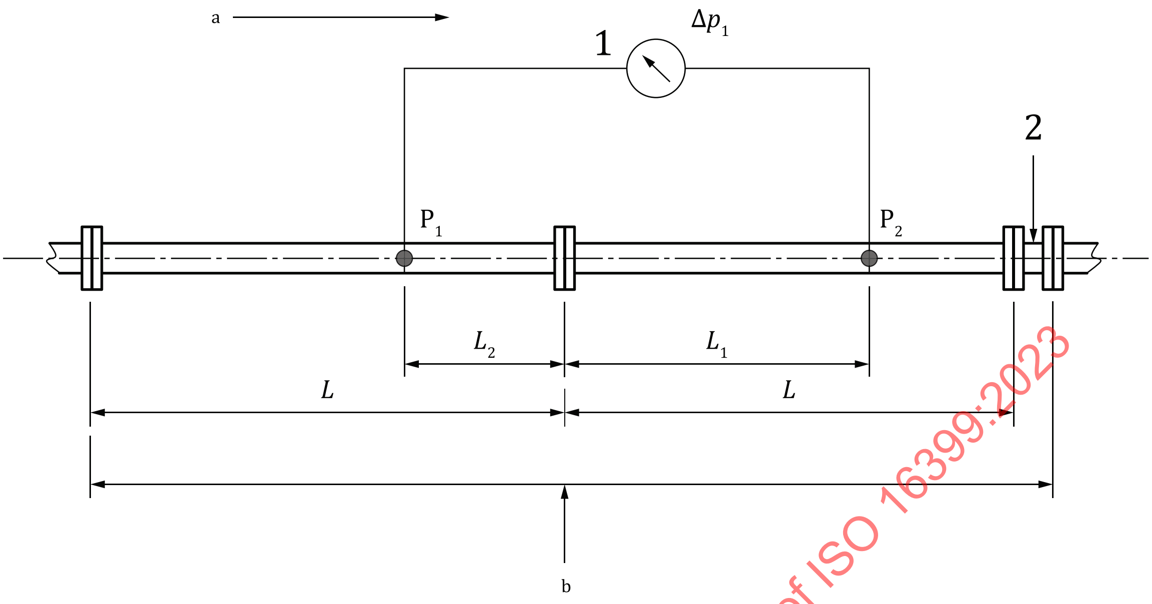
The maximum pressure loss should be measured with a maximum expanded uncertainty of 5 %, with a coverage factor of $k = 2$.

7.4.3.2 Determination of pressure loss attributable to test section

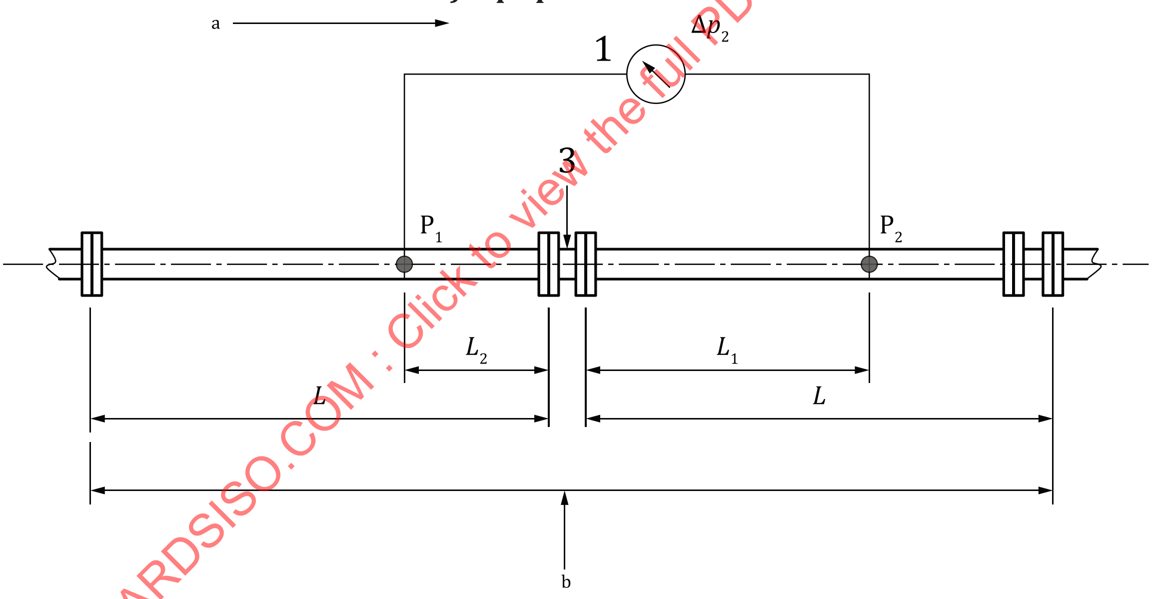
As some pressure is lost due to friction in the test section pipe between the pressure tappings, this should be determined and subtracted from the measured pressure loss across the meter. If the pipe diameter, roughness and length between the tappings are known, the pressure loss may be calculated from standard pressure loss formulae. It may, however, be more effective to measure the pressure loss across the pipes. The test section can be rearranged as shown in Figure 1.

This is done by joining the upstream and downstream pipe faces together in the absence of the meter (carefully avoiding joint protrusion into the pipe bore or misalignment of the two faces), and measuring the pressure loss of the pipe measuring section for the specified flow rate.

Measure the pressure loss for the pipe lengths at the previously determined flow rate Q_t.



a) Pipe pressure loss



b) (Pipe and water meter) pressure loss

Key

1	differential manometer
2	water meter in downstream position
Δp_1	pressure loss of up- and downstream pipe lengths
Δp_2	pressure loss of up- and downstream pipe lengths and water meter
3	water meter
P_1, P_2	planes of the pressure tappings
a	Flow direction.
b	Measuring section.

Figure 1 — Installation conditions for pressure loss test

7.4.4 Calculation of the actual Δp of a water meter

Calculate the pressure loss, Δp_t, of the water meter at Q_t by using Formula (4):

$$\Delta p_t = \Delta p_{m+p} - \Delta p_p \tag{4}$$

where

Δp_{m+p} is the measured pressure loss at Q_t with the meter in place;

Δp_p is the pressure loss measured without the meter at Q_t.

If the measured flow rate either during the test or during the determination of the pipe pressure loss is not equal to the selected test flow rate, the measured pressure loss can be corrected to that expected at Q_t by reference to the square law as follows [see Formula (5)]:

$$\Delta p_{Q_t} = \frac{Q_t^2}{Q_{meas}^2} \Delta p_{Q_{meas}} \tag{5}$$

where

Δp_{Q_t} is the calculated pressure loss at Q_t;

$\Delta p_{Q_{meas}}$ is the measured pressure loss at a flow rate Q_{meas}.

7.4.5 Acceptance criteria

The pressure loss measurement at any flow rate within the rated operating conditions shall not exceed the maximum value of the pressure loss corresponding to the class declared by the manufacturer.

7.5 Reverse flow test

7.5.1 General

To verify that the meter satisfies the requirement of 4.2.3 when reverse flow occurs.

Meters which are designed to measure reverse flow shall record the reverse flow volume accurately.

Meters which allow reverse flow, but which are not designed to measure it, shall be subjected to reverse flow. The error shall subsequently be measured for forward flow, to check that there is no degradation in metrological performance caused by reverse flow.

Meters which are designed to prevent reverse flow (e.g. by means of an integral non-return valve) are subjected to the application of the maximum admissible pressure of the meter applied to the outlet connection and the measurement errors are subsequently measured for forward flow to ensure that there is no degradation in metrological performance caused by the pressure acting on the meter.

7.5.2 Preparation

The installation and operational requirements described in 7.3.2 shall apply.

7.5.3 Test procedure

7.5.3.1 Meters designed to measure reverse flow

1) Measure the error of at least one meter at each of the following reverse flow rates:

   a) between Q_1 and 1,1 Q_1

b) between Q_2 and 1,1 Q_2

c) between 0,9 Q_3 and Q_3

2) During each test, all other influence factors shall be maintained at reference conditions.

3) Calculate the error for each flow rate.

4) In addition, the following tests shall be carried out: pressure loss test (7.4), flow disturbance test (7.6) and endurance test (7.7).

7.5.3.2 Water meters not designed to measure reverse flows

1) Subject the meter to a reverse flow of 0,9 Q_3 for 1 minute.

2) Measure the error of at least one meter at each of the following forward flow rates:

   a) between Q_1 and 1,1 Q_1

   b) between Q_2 and 1,1 Q_2

   c) between 0,9 Q_3 and Q_3

3) During each test, all other influence factors shall be maintained at reference conditions.

4) Calculate the error for each flow rate.

7.5.3.3 Water meters which prevent reverse flows

1) Meters which prevent reverse flow should be subjected to the maximum admissible pressure in the reverse flow direction for 1 min.

2) Check that there is no significant leak past the valve.

3) Measure the error of at least one meter at each of the following forward flow rates:

   a) between Q_1 and 1,1 Q_1

   b) between Q_2 and 1,1 Q_2

   c) between 0,9 Q_3 and Q_3

4) During each test, all other influence factors shall be maintained at reference conditions.

5) Calculate the relative error for each flow rate.

7.5.4 Acceptance criteria

In the tests described in 7.5.3 the error of the water meter shall not exceed the applicable maximum permissible error.

7.6 Flow disturbance tests

7.6.1 General

Some kinds of water meters, for instance volumetric water meters, are considered insensitive to installation conditions, so this test is not to be applied.

The manufacturer shall specify the flow profile disturbance sensitivity class for the water meter. This class will never imply lengths longer than 15 DN upstream, and 5 DN downstream.

7.6.2 Objective of the test

The objective of the test is to verify that the water meter complies with the requirements in 6.3.

NOTE 1 The effects on the error of a water meter, of the presence of specified, common types of disturbed flow upstream and downstream from the water meter are measured.

NOTE 2 Types 1 and 2 disturbance devices are used in the tests to create left-handed (sinistrorsum - counterclockwise) and right-handed (dextrorsum-clockwise) rotational velocity profiles (swirl), respectively. The flow disturbance is of a type usually found downstream from two 90° bends directly connected. A type 3 disturbance device creates an asymmetric velocity profile usually found downstream from a protruding pipe joint or a gate valve not fully opened.

7.6.3 Preparation

In addition to the installation and operational requirements described in 7.3.2, the conditions described in 7.6.4 also apply.

7.6.4 Test procedure

a) Using the Types 1, 2 and 3 flow disturbers specified in Annex B, determine the error of the water meter at a flow rate between 0,9 Q_3 and Q_3, for each one of the six installation conditions specified in Figure 2.

b) During each test, hold all other influence factors at the reference conditions of 7.1.2.

Additional requirements:

c) When a minimum straight pipe length of 5 × DN downstream from the water meter is specified by the manufacturer, perform only tests for installation conditions 1, 3 and 5 shown in Figure 2.

d) Where water meter installations with external flow straighteners are to be used, the manufacturer shall specify and deliver the straightener together with the water meters to accommodate testing of its technical characteristics and its position in the installation relative to the water meter.

e) A device within a water meter having flow straightening functions is not considered to be a “straightener” in the context of these tests.

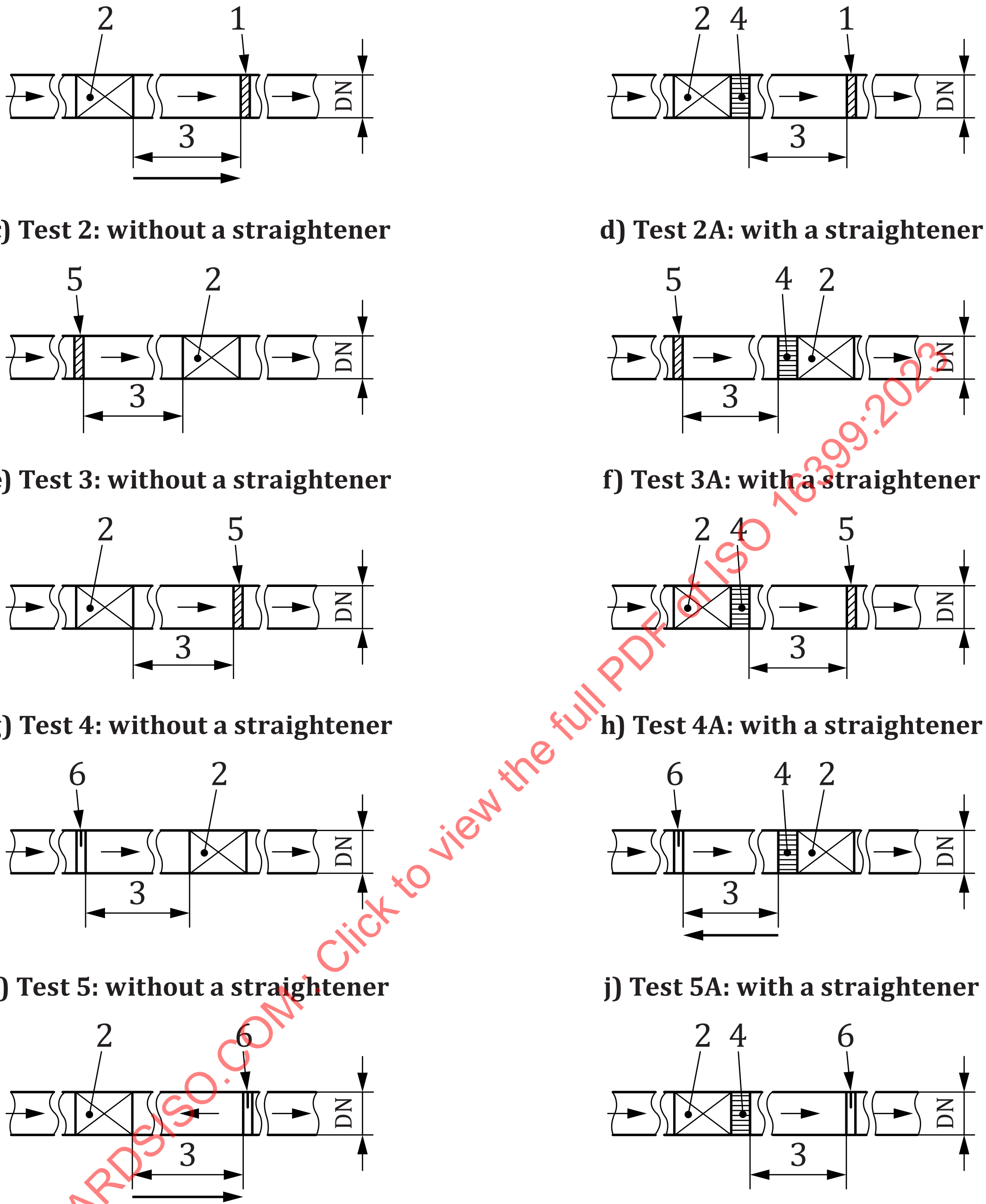
f) Some types of water meter which have been proven to be unaffected by flow disturbances upstream and downstream of the meter may be exempted from this test.

g) The straight lengths upstream and downstream of the meter depend on the flow profile sensitivity class of the meter and shall be in accordance with Tables 1 and 2, respectively.

7.6.5 Acceptance criteria

The relative error of the meter shall not exceed the applicable maximum permissible error for any of the flow disturbance test.

a) Test 1: without a straightener **b) Test 1A: with a straightener**



c) Test 2: without a straightener

d) Test 2A: with a straightener

e) Test 3: without a straightener

f) Test 3A: with a straightener

g) Test 4: without a straightener

h) Test 4A: with a straightener

i) Test 5: without a straightener

j) Test 5A: with a straightener

k) Test 6: without a straightener

l) Test 6A: with a straightener

Key

type 1 disturber – Swirl generator sinistrorsum (anticlockwise)

type 2 disturber – Swirl generator dextrorsum (clockwise)

type 3 disturber – Velocity profile flow disturber

1 type 1 disturber

2 water meter

3 straight lengths

4 straightener

5 type 2 disturber

6 type 3 disturber

Figure 2 — Flow disturbance scheme

7.7 Endurance tests

7.7.1 Durability test

7.7.1.1 General

During durability tests, the rated operating conditions of the meter shall be met. The test is required for forward flow and where appropriate for reverse flow (see 7.5.3.1).

The orientation(s) of the meters under test shall be set with reference to the meter orientation(s) claimed by the manufacturer.

Table 5 — Endurance test

Temperature class	Permanent flow rate (Q_3)	Test flow rate	Type of test	Number of interruptions	Duration of pauses	Period of operation at test flow rate	Duration of start up and run down
T30 and T50	$Q_3 \leq 16\ m^3/h$	Q_3	Discontinuous	100 000	15 s	15 s	0,15 [Q_3] [a] s with a minimum of 1 s
		Q_4	Continuous	—	—	100 h	—
	$Q_3 > 16\ m^3/h$	Q_3	Continuous	—	—	800 h	—
		Q_4	Continuous	—	—	200 h	—

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

7.7.1.2 Continuous flow test

7.7.1.2.1 General

The objective of the test is to verify that the water meter is durable when subjected to continuous, permanent and overload flow conditions.

The test consists of subjecting the water meter to a constant flow rate of even Q_3 or Q_4 as set out in Table 5. For the convenience of laboratories, the test can be divided up into periods of at least 6 h.

7.7.1.2.2 Preparation

In addition to the water meter or water meters to be tested, the pipework comprises:

a) a flow-regulating device;

b) one or more isolating valves;

c) a device for measuring the water temperature at the water meter inlet;

d) means for checking the flow rate and duration of the test;

e) devices for measuring pressure at the inlet and outlet.

The various devices shall not cause cavitation or other types of parasitic wear of the meter(s).

7.7.1.2.3 Test procedure

7.7.1.2.3.1 General

a) Before commencing the continuous endurance test, measure the errors of the meters as described in 7.3 and at the same flow rates as in 7.3.3.

b) Mount the water meter(s) either individually or in batches in the test rig in the same orientations as those used in the determination of the intrinsic error tests (7.3.2.2.7.5).

c) Carry out the following tests:

   1) for water meters with $Q_3 \leq 16$ m^3/h, run the meter at a flow rate of Q_4 for a period of 100 h;

   2) for water meters with $Q_3 > 16$ m^3/h, run the meter at a flow rate of Q_3 for a period of 800 h then at Q_4 for a period of 200 h.

d) During the endurance tests, hold the water meter(s) within their rated operating conditions and ensure that the pressure at the outlet of each meter is high enough to prevent cavitation.

e) After the continuous endurance test, measure the errors of the water meters as described in 7.3 and at the same flow rates.

f) Calculate the relative errors for each flow rate.

g) For each flow rate, subtract the error obtained before the test [step a)] from the error obtained after the test [step f)].

7.7.1.2.3.2 Tolerance on flow rate

Ensure that the relative variation of the flow rate values during each test shall not exceed ±10 % (except when starting and stopping).

7.7.1.2.3.3 Tolerance on test timing

The specified duration of the test is a minimum value.

7.7.1.2.3.4 Tolerance on discharged volume

The volume indicated at the end of the test shall not be less than that determined from the product of the specified flow rate of the test and the specified duration of the test.

To satisfy this condition, monitor to the flow rate frequently. The water meter(s) on test may be used to check the flow rate.

7.7.1.2.3.5 Test readings

During the test, record the following readings from the test rig at least once every 24 h period, or once for every shorter period if the test is so divided:

a) water pressure upstream from the water meter(s);

b) water pressure downstream from the water meter(s);

c) water temperature upstream from the water meter(s);

d) flow rate through the meter(s) under test;

e) readings of the test water meter(s);

f) volume passed through the water meter(s).

7.7.1.2.4 Acceptance criteria

7.7.1.2.4.1 For accuracy class 1 water meters

After the continuous endurance test:

a) The variation in the error curve shall not exceed:

— ±2 % for flow rates in the lower zone ($Q_1 \leq Q < Q_2$); and

— ±1 % for flow rates in the upper zone ($Q_2 \leq Q \leq Q_4$).

For the purpose of determining these requirements, the mean values of the errors at each flow rate, shall apply.

b) The error curves shall not exceed a maximum error limit of:

— ±4 % for flow rates in the lower zone ($Q_1 \leq Q < Q_2$); and

— ±1, 5 % for flow rates in the upper zone ($Q_2 \leq Q \leq Q_4$) for T30 meters or

— ±2, 5 % for flow rates in the upper zone ($Q_2 \leq Q \leq Q_4$) for other than T30.

7.7.1.2.4.2 For accuracy class 2 water meters

After the continuous endurance test:

a) The variation in the error curve shall not exceed:

— ±3 % for flow rates in the lower zone ($Q_1 \leq Q < Q_2$); and

— ±1,5 % for flow rates in the upper zone ($Q_2 \leq Q \leq Q_4$).

For the purpose of determining these requirements, the mean values of the errors at each flow rate, shall apply.

b) The error curves shall not exceed a maximum error limit of:

— ±6 % for flow rates in the lower zone ($Q_1 \leq Q < Q_2$); and

— ±2, 5 % for flow rates in the upper zone ($Q_2 \leq Q \leq Q_4$) for T30 meters or

— ± 3, 5 % for flow rates in the upper zone ($Q_2 \leq Q \leq Q_4$) for other than T30.

7.7.1.3 Discontinuous flow test

7.7.1.3.1 General

This test is applied only to water meters with $Q_3 \leq 16$ m^3/h and combination water meters.

The objective of the test is to verify that the water meter is durable when subjected to cyclic flow conditions.

The test consists of subjecting the water meter to the specified number of starting and stopping flow rate cycles of short duration, the constant test flow rate phase of each cycle being kept at the specified flow rate (Q_3) throughout the duration of the test. For the convenience of laboratories, the test can be divided into periods of at least 6 h.

7.7.1.3.2 Preparation

The water meters can be arranged in series or in parallel, or the two systems can be combined.

The piping system consists of:

a) one flow-regulating device (per line of water meters in series, if applicable);

b) one or more isolating valves.

c) a device for measuring the temperature of the water upstream of the water meters;

d) means for checking the flow rate, the duration of cycles and the number of cycles;

e) one flow-interrupting device for each line of water meters in series;

f) devices for measuring pressure at the inlet and outlet.

The various devices shall not cause cavitation or other types of wearing due to the test procedure of the water meter(s).

Bleed air from the water meter(s) and connecting pipe.

Ensure that flow variation during the repeated opening and closing operations is progressive, to prevent water hammer.

7.7.1.3.3 Flow rate cycles

A complete cycle includes the following four phases:

a) Period from zero to test flow rate Q_3.

b) Period at constant test flow rate Q_3.

c) Period from the test flow rate Q_3 to zero.

d) Period at zero flow rate.

The test program shall specify the number of flow rate cycles, the duration of each of the four phases of a cycle, and the total volume to be discharged.

7.7.1.3.4 Test procedure

7.7.1.3.4.1 For all types of meters

a) Before commencing the discontinuous endurance test, measure the errors of the water meters as described in 7.3 and at the same flow rates as in 7.3.3.

b) Mount the water meters either individually or in batches in the test rig in the same orientations as those used in the determination of the intrinsic error tests (7.3.2.2.7.5).

c) During the tests, hold the water meter(s) within their rated operating conditions and with the pressure downstream of the meters high enough to prevent cavitation in the meters.

d) Adjust the flow rate to within the specified tolerances.

e) Run the water meters at the conditions shown in Table 6.

f) Following the discontinuous endurance test, measure the final errors of the water meters as described in 7.3 and at the same flow rates as in 7.3.3.

g) Calculate the relative errors for each flow rate.

h) For each flow rate, subtract the value of intrinsic error obtained before the test (step a)) from the error obtained after the test [step g)].

7.7.1.3.4.2 Tolerance on flow rate

The relative variation of the flow values shall not exceed ±10 % outside the opening, closing and stopped periods.

The water meters on test may be used to check the flow rate.

7.7.1.3.4.3 Tolerance on test timing

The tolerance on the specified duration of each phase of the flow cycle shall not exceed ±10 %.

The tolerance on the total test duration shall not exceed ±5 %.

7.7.1.3.4.4 Tolerance on the number of cycles

The number of cycles shall not be less than that stipulated, but shall not exceed this number by more than 1 %.

7.7.1.3.4.5 Tolerance on discharged volume

The volume discharged throughout the test shall be equal to half the product of the specified nominal test flow times the total theoretical duration of the test (operating periods plus transient and stopped periods) with a tolerance of ±5 %.

This precision can be obtained by closely monitoring the instantaneous flows and operating periods and making adjustments, if required.

7.7.1.3.4.6 Test readings

During the test, record the following readings from the test rig at least once every 24 h period or once for every shorter period if the test is so divided:

a) water pressure upstream from the water meter(s);

b) water pressure downstream from the water meter(s);

c) water temperature upstream from the water meter(s);

d) flow rate through the meter(s) under test;

e) duration of the four phases of the cycle of the discontinuous flow test;

f) number of cycles;

g) readings of the test water meter/s;

h) volume passed by the water meters;

7.7.1.3.5 Acceptance criteria

7.7.1.3.5.1 For accuracy class 1 water meter

After the cyclic endurance test:

a) The variation in the error curve shall not exceed:

— ±2 % for flow rates in the lower zone ($Q_1 \leq Q < Q_2$); and

— ±1 % for flow rates in the upper zone ($Q_2 \leq Q \leq Q_4$).

For the purpose of determining these requirements the mean values of the errors at each flow rate, shall apply:

b) The error curves shall not exceed a maximum error limit of:

— ±4 % for flow rates in the lower zone ($Q_1 \le Q < Q_2$); and

— ±1,5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for T30 meters or

— ± 2, 5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for other than T30.

7.7.1.3.5.2 For accuracy class 2 water meter

After the cyclic endurance test:

a) The variation in the error curve shall not exceed:

— ±3 % for flow rates in the lower zone ($Q_1 \le Q < Q_2$); and

— ±1,5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$).

For the purpose of determining these requirements the mean values of the errors at each flow rate, shall apply:

b) The error curves shall not exceed a maximum error limit of:

— ±6 % for flow rates in the lower zone ($Q_1 \le Q < Q_2$); and

— ±2,5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for T30 meters or

— ±3, 5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for other than T30.

7.7.2 Resistance to solid particles test

7.7.2.1 General

The objective of the test is to prove that a water meter is able to withstand a water flow carrying solid particles passing through it, without showing damage.

7.7.2.2 Test conditions

Resistance to solid particles test shall be arranged following the conditions described in Table 7, using the water quality described in Table 6.

Table 6 — Particle characterization

Shape	Spheres
Material	Glass or ceramic porcelain spheres
Density	2, 5-3 Mg/m^3
Quantity	10 g/l – 20 g/l
Size	80 % of the particles between 100 µm and 300 µm

Table 7 — Test conditions

Flow rate	Test type	Duration
Q_3	Constant flow rate	600 hours

7.7.2.3 Test procedure

Testing procedure is similar to the one put forward in 7.7.1.1 for continuous flow rate endurance tests.

7.7.2.4 Acceptance criteria

Following the resistance to solid particles test, measure the final errors of the water meters as described in 7.3 and at the same flow rates as in 7.3.3 4), 5) and 6).

4) between 0,67 (Q_2 + Q_3) and 0,74 (Q_2 + Q_3);

5) between 0,9 Q_3 and Q_3;

6) between 0,95 Q_4 and Q_4.

Calculate the relative errors for each flow rate.

For each flow rate, subtract the value of intrinsic error obtained before the test [step a)] from the error obtained after the test [step g)].

7.7.2.4.1 For accuracy class 1 water meter

After the resistance to solid particles test:

a) The variation in the error curve shall not exceed:

— ±2 % for flow rates in the lower zone ($Q_1 \le Q < Q_2$); and

— ±1 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$).

For the purpose of determining these requirements the mean values of the errors at each flow rate, shall apply:

b) The error curves shall not exceed a maximum error limit of:

— ±4 % for flow rates in the lower zone ($Q_1 \le Q < Q_2$); and

— ±1,5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for T30 meters or

— ±2, 5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for other than T30.

7.7.2.4.2 For accuracy class 1 water meter

a) The variation in the error curve shall not exceed:

— ±3 % for flow rates in the lower zone ($Q_1 \le Q < Q_2$); and

— ±1,5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$).

For the purpose of determining these requirements, the mean values of the errors at each flow rate shall apply:

b) The error curves shall not exceed a maximum error limit of:

— ±6 % for flow rates in the lower zone ($Q_1 \le Q < Q_2$); and

— ±2,5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for T30 meters or

— ±3, 5 % for flow rates in the upper zone ($Q_2 \le Q \le Q_4$) for other than T30.

7.7.2.5 Water meters classification

Water meters will be classified according to the result of the current test:

— Class A: If they pass the resistance test.

— Class B: If they fail the resistance test.

7.8 Magnetic field testing

All water meters where the mechanical components may be influenced by a static magnetic field (e.g. equipped with a magnetic coupling in the drive to the readout or with a magnet-driven pulse output) an all meters with electronic components shall be tested to show that they are able to withstand the influence of a static magnetic field.

This shall be tested according to the provisions of ISO 4064-2:2014, 8.16.

7.9 Test on ancillary devices of a water meter

This shall be tested according to the provisions of ISO 4064-2:2014, 7.13.

8 Tests related to the influence quantities and perturbations

The aim of these tests is to verify that the water meters work as expected in a specified ambient, and under established conditions.

These tests, according to their type, shall be conducted according to the procedures and requirements established in ISO 4064-2:2014, Clause 8. It shall be considered that a meter for irrigation water works in a:

— environmental classification B and C.

— electromagnetic environment E1.

The tests for each water meter type are as defined in ISO 4064-2:2014, Clause 8.

Annex A
(informative)

Pulse input solutions

A.1 General

When the signals generated by the flow sensor are in the form of pulses, each pulse representing a volume. The pulse generation, transportation and counting shall meet the requirements of A.2.

NOTE A pulse generator is considered as a reed contact unit.

A.2 Tests

A.2.1 Correct counting of pulses

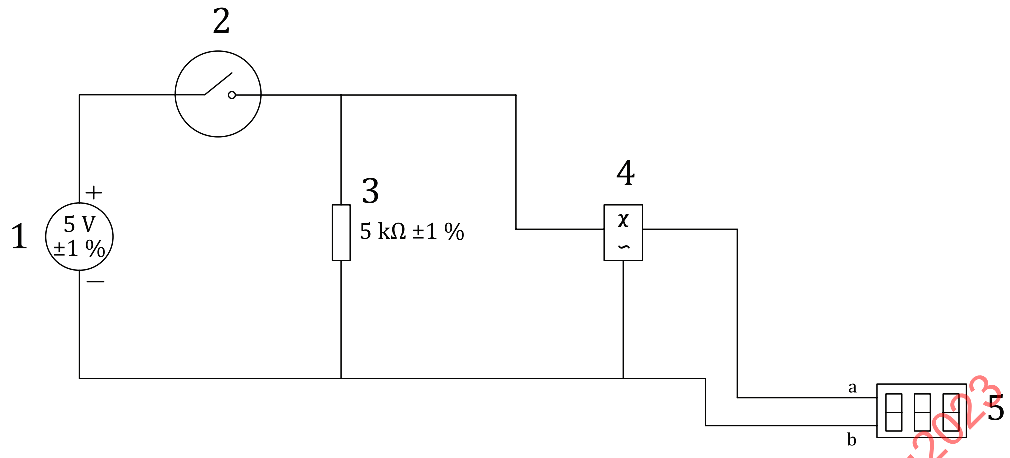
A.2.1.1 General

The objective of this test is to check the correct operation of a pulse generator associated to a water meter.

A.2.1.2 Test conditions

Install the water meter together with the pulses generator as set out in the manufacturer's recommendations, in the same system used for carrying out the precision test.

Install a digital totalizer as shown in Figure A.1 in order to count the total number of pulses.



Key

1 power supply
2 pulse generator under test
3 resistor
4 filter 50 ms
5 digital totalizer
a IN
b GND

Figure A.1 — Connection diagram

Conduct the test under the test conditions set out in Table A.1.

Table A.1 — Test conditions

Test flow rates	Number of pulses
Q_4	50
Q_3	50

The total number of pulses given by the digital totalizer is equal to the difference between the number of pulses at any point in time and the number of pulses at the beginning of the test.

Carry out the test twice for each flow rate.

Parameters to be taken down are the following:

— water meter identification.

— pulse generator identification.

— test flow rate.

— volume/Pulse ratio.

— difference between initial and final volume of water shown in the water meter.

— number of pulses in the digital totalizer.

— difference between the number of pulses displayed in the totalizer and the real value of pulses that should be indicated (calculated according to the difference between initial and final volume of water shown in the water meter and the ratio volume/pulse).

A.2.1.3 Validity criteria for the correct counting of pulses

Test result shall be considered satisfactory when the number of pulses displayed in the totalizer is equal to the real value of pulses that should be indicated (calculated as the difference between initial and final volume of water shown in the water meter and the volume/pulse ratio).

A.2.2 Determination of the operate position time

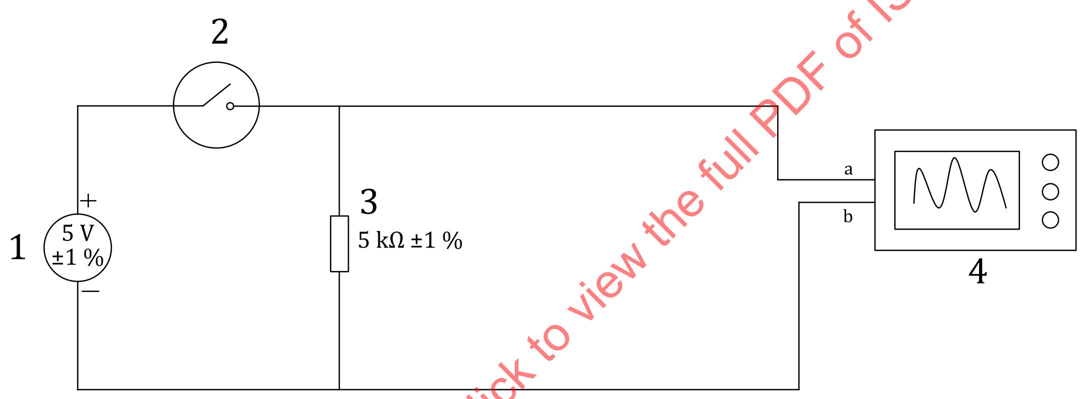
A.2.2.1 General

The objective of the test is to determine the operate position time.

A.2.2.2 Test conditions

Install the water meter, together with the pulses generator, as set out in the manufacturer's recommendations, in the same system used for carrying out the precision test.

Connect the oscilloscope, the resistor, the adjustable water source and the pulse generator as shown in Figure A.2.



Key

1 power supply

2 pulse generator under test

3 resistor

4 oscilloscope

a IN

b GND

Figure A.2 — Connection diagram

Record data when the oscilloscope's screens displays two rising flanks of a pulse. Measure both the period and the amplitude of the pulse.

Capture the screens for the flow rates Q_4, Q_3 and Q_1.

Conduct the test under the test conditions set out in Table A.2.

Table A.2 — Test conditions

Test flow rates	Number of pulses
Q_4	10
Q_3	10

Run the test employing the flying-start-and-finish method (test with readings taken under stable flow conditions and diversion flow) to guarantee getting complete pulses.

For the average flow rate, calculate the operate position time in relation to the period of one full pulse, expressed as a percentage (T_{ON}/T).

Record the following parameters:

— water meter identification.

— pulse generator identification.

— test flow rate.

— number of measurements or repetitions carried out under the same conditions.

— operate position time and period of one pulse.

And, for every flow rate:

— T_{ON} minimum.

— T_{ON} maximum.

— T_{ON} average.

Compute each value for (T_{ON}/T), as a percentage.

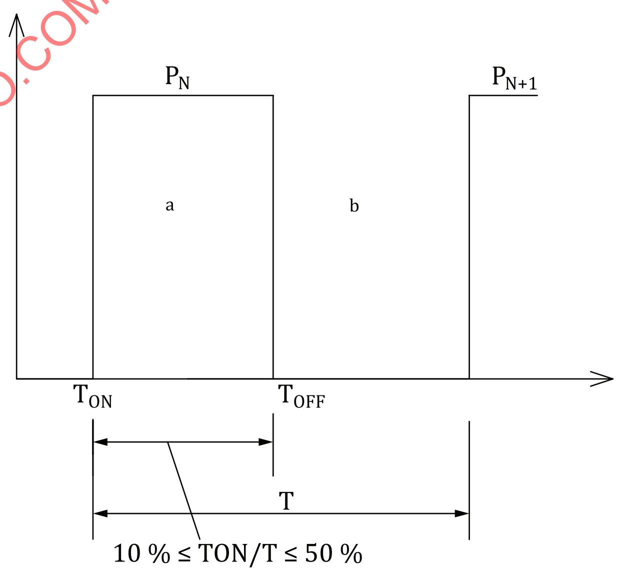
A.2.2.3 Validity criteria for the determination of the operate position time

The relation T_{ON}/T, expressed as a percentage, shall remain within the following limits:

— Maximum: 50 %

— Minimum: 10 %

See Figure A.3.



Key

a ON

b OFF

Figure A.3 — Determination of the time during which the socket is closed

A.2.3 Determination of electrical bounce time

A.2.3.1 General

The objective of the test is to determine the duration of the electrical bounce, that is, the time elapsed from the start of the first flank of the pulse until it stabilizes.

A.2.3.2 Test conditions

Install the water meter, together with the pulse generator is installed as set out in the manufacturer's recommendations, in the same system used for carrying out the precision test.

Connect the oscilloscope as shown in Figure A.2.

Record data when the oscilloscope's screens display rising or falling flanks of a pulse.

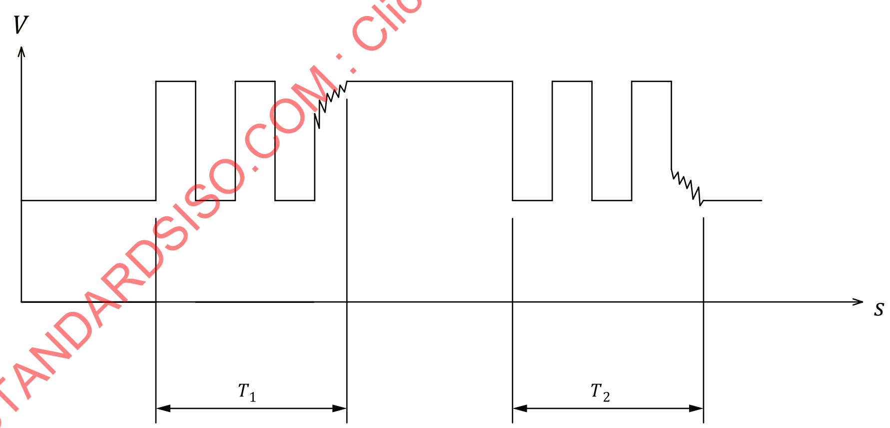
Ensure that the record of the screens is captured for the flow rates Q_4, Q_3 and Q_1.

Conduct the test under the test conditions set out in Table A.3.

Table A.3 — Test conditions

Test flow rate	Number of pulses
Q_4	10
Q_3	10
Q_1	5

For each case, obtain the duration of the rebounds, both for the rising and the falling flanks. Record the elapsed time from the beginning of the first rising flank of the pulse until the signal is stabilized on the top (stabilized electrical shut off) and the elapsed time from the beginning of the first falling flank of the pulse until the signal is stabilized on the bottom (stabilized electrical opening).



Key

v voltage (V)

s time (s)

Figure A.4 — Bounce time

Record the following parameters:

— water meter identification;

— pulses generator.

And, for each flow rate:

a) Pulse rising flank:

— T_1 minimum

— T_1 maximum

— T_1 medium

b) Pulse falling flank:

— T_2 minimum

— T_2 maximum

— T_2 medium

A.2.3.3 Validity criteria for determining the bounce time

The duration of the rebounds (T_1 and T_2) shall not exceed 0,1 % of the shortest time between pulses.

A.2.4 Classification according to the covering or the socket

— Type 1: Without any special covering

— Type 2: With gold covering

Non-covered relays need at least 1 mA electrical current to be capable of transmitting the electrical signals, whereas it is considered that those relays with gold covering are capable to transmitting electrical current whenever there is mechanical contact.

A.3 Other technologies

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

Annex B
(normative)

Flow disturbers

B.1 Irregularity in water velocity profile

Some water meters are affected by flow disturbances if the meter is not preceded and followed by certain straight lengths of piping, with the same nominal diameter as the meter.

A flow can be influenced by two types of disturbances: swirl and velocity profile distortion.

Swirl may be caused in several ways. For example, by two or more bends of the pipe in different planes, by centrifugal pumps, by tangential inlet of supply line into the main line in which the irrigation water meter is installed, etc.

Velocity profile distortion is typically caused by an obstruction partially blocking the pipe, for example, the presence of a single bend, a partly closed valve, a butterfly valve, a check valve, an orifice, a flow or pressure regulator, etc. Maximum velocity zones may be found either at the centre of the section, or in one or several zones tangents to the circumference of the section.

Both two types of disturbances can be controlled by ensuring adequate straight lengths of pipe, upstream and downstream from the water meter. The length of these straight lengths of pipe can be decreased by installing a flow straightener or a flow conditioner.

When a flow straightener is installed, upstream or downstream from the water meter, it is necessary to mount a specified length of straight pipe of uniform internal diameter between the flow straightener and the water meter.

B.2 Flow disturbers

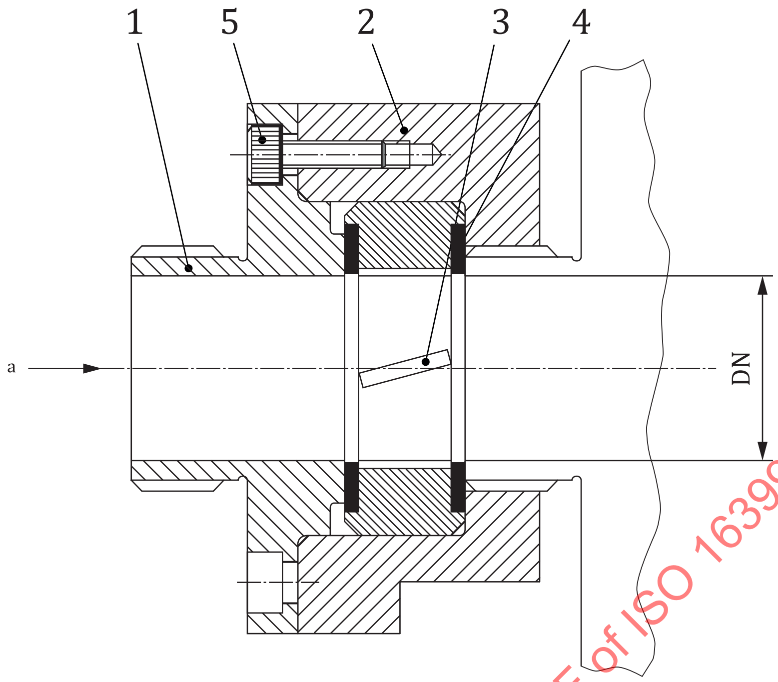
Figures B.1 to B.4 show the types of flow disturber to be used in the tests described in 7.5. The following figures show flow disturber types to be used in tests as described in 7.5.

All dimensions shown in the figures are in mm unless otherwise stated.

Machined dimensions to ±0,25 mm unless otherwise specified.

B.3 Threaded type disturbance generators

Figure B.1 shows an arrangement of swirl generator units for a threaded type disturbance generator.

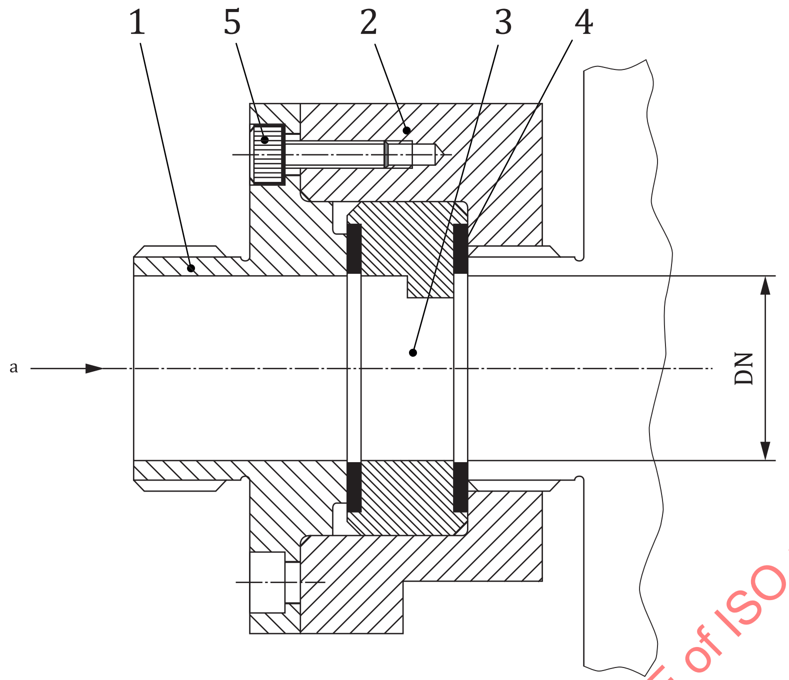


Item	Description	Qty.	Material
1	Cover	1	Stainless steel
2	Body	1	Stainless steel
3	Swirl generator	1	Stainless steel
4	Gasket	2	Fibre
5	Hexagon socket head cap screw	4	Stainless steel
a	Flow	–	–

Type 1 disturber – Swirl generator sinistrorsum
Type 2 disturber – Swirl generator dextrorsum

Figure B.1 — Threaded type disturbance generators — Arrangement of swirl generator units

Figure B.2 shows an arrangement of velocity profile disturbance units for a threaded type disturbance generator.

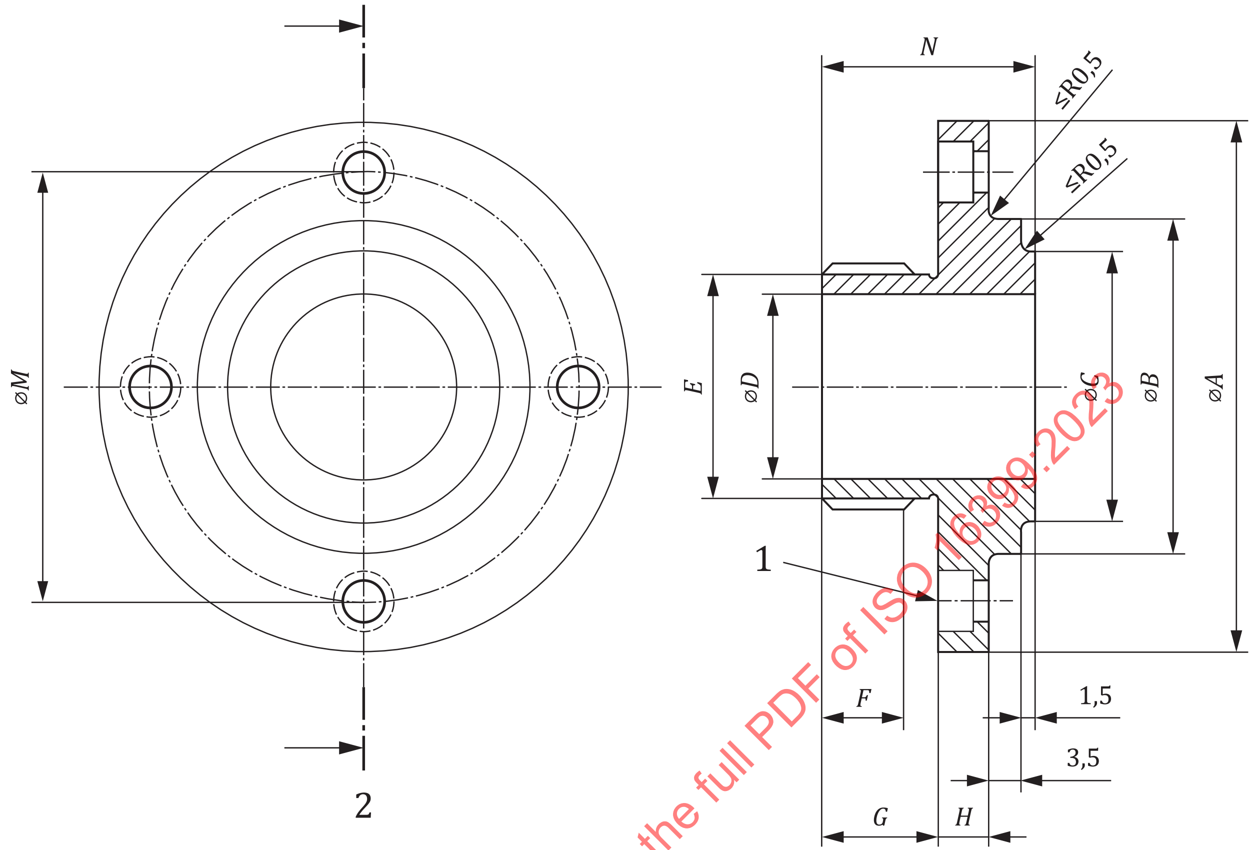


Item	Description	Qty.	Material
1	Cover	1	Stainless steel
2	Body	1	Stainless steel
3	Flow disturber	1	Stainless steel
4	Gasket	2	Fibre
5	Hexagon socket head cap screw	4	Stainless steel
a	Flow	–	–

Type 3 disturber – Velocity profile flow disturber

Figure B.2 — Threaded type disturbance generator — Arrangement of velocity profile disturbance units

Figure B.3 illustrates the cover of a threaded type disturbance generator, with dimensions as set out in Table B.1.



Key

1 4 holes ØJ bore ØK × L

2 machine surface roughness 3,2 µm all over

Figure B.3 — Cover for a threaded type disturbance generator

Table B.1 — Dimensions for the cover for a threaded type disturbance generator

DN	Threaded connection	A	B (e9[a])	C	D	E[(b)]	F	G	H	J	K	L	M	N
15	G ¾'' B	52	29,960 29,908	23	15	¾'' BSP	10	12,5	5,5	4,5	7,5	4	40	23
20	G 1'' B	58	35,950 35,888	29	20	1" BSP	10	12,5	5,5	4,5	7,5	4	46	23
25	G 1 ¼'' B	63	41,950 41,888	36	25	1 ¼'' BSP	12	14,5	6,5	5,5	9,0	5	52	26
32	G 1 ½'' B	76	51,940 51,866	44	32	1 ½'' BSP	12	16,5	6,5	5,5	9,0	5	64	28
40	G 2'' B	82	59,940 59,866	50	40	2'' BSP	13	18,5	6,5	5,5	9,0	5	70	30
50	G 2 ½'' B	102	69,940 69,866	62	50	2 ½'' BSP	13	20,0	8,0	6,5	10,5	6	84	33

[a] See ISO 286-2.

[b] See ISO 228-1.