INTERNATIONAL STANDARD

ISO 4373

Third edition
2008-10-15

Hydrometry — Water level measuring devices

Hydrométrie — Appareils de mesure du niveau de l'eau

Reference number
ISO 4373:2008(E)

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 4373 was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 5, *Instruments, equipment and data management*.

This third edition cancels and replaces the second edition (ISO 4373:1995), which has been technically revised.

Hydrometry — Water level measuring devices

1 Scope

This International Standard specifies the functional requirements of instrumentation for measuring the level of water surface (stage), primarily for the purpose of determining flow rates. This International Standard is supplemented by an annex providing guidance on the types of water level measurement devices currently available and the measurement uncertainty associated with them (see Annex A).

2 Normative references

The following referenced documents are indispensable for the application 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 772, *Hydrometry — Vocabulary and symbols*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60079-10, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 772 apply.

4 Instrument specification

4.1 Performance classifications

The parameters of performance of a water level measuring device shall be described by the classification categories of uncertainty, temperature range and relative humidity so that the overall performance of the equipment may be summarized in three digits.

4.2 General

Water level measuring devices shall be classified in accordance with the performance classes given in Table 1 that account for the resolution to be achieved and the limits of uncertainty required over specified ranges.

It should be made clear whether these levels of attainment can only be achieved by the use of special works, for example installation within stilling wells. It is also important to remember that in the measurement of stage, uncertainty expressed as a percentage of range gives rise to worst case uncertainty in the determination of stage at low values of stage. This is highly significant for the measurement of low flows and should be taken into account in the design of equipment for this purpose.

The manufacturer has to state the physical principle of the measuring device in order to allow the user to judge the device's suitability for the proposed environment.

Table 1 — Performance classes of water level measuring devices

Class	Resolution	Range	Nominal uncertainty
Performance class 1	1 mm	1,0 m	⩽ ±0,1 % of range
	2 mm	5,0 m	
	10 mm	20 m	
Performance class 2	2 mm	1,0 m	⩽ ±0,3 % of range
	5 mm	5,0 m	
	20 mm	20 m	
Performance class 3	10 mm	1,0 m	⩽ ±1 % of range
	50 mm	5,0 m	
	200 mm	20 m	

4.3 Maximum rate of change

As water levels may rise and fall rapidly in some applications, in order to provide guidance on suitability, the manufacturer shall state on the equipment specification sheet and in the instruction manual:

a) the maximum rate of change which the instrument can follow without damage;

b) the maximum rate of change which the instrument can tolerate without suffering a change in calibration;

c) the response time of the instrument.

4.4 Environment

4.4.1 General

Water level measuring devices shall operate within the ranges of temperature in 4.4.2 and the ranges of relative humidity in 4.4.3.

4.4.2 Temperature

Water level measuring devices shall operate within the following temperature classes:

Temperature class 1: –30 °C to +55 °C;

Temperature class 2: –10 °C to +50 °C;

Temperature class 3: 0 °C to +50 °C.

4.4.3 Relative humidity

Water level measuring devices shall operate within the following relative humidity classes:

Relative humidity class 1: 5 % to 95 % including condensation;

Relative humidity class 2: 10 % to 90 % including condensation;

Relative humidity class 3: 20 % to 80 % excluding condensation.

4.5 Timing

4.5.1 General

Where timing, either analogue or digital, is part of the instrument specification, the timing method used shall be clearly stated on the instrument and in the instruction manual.

NOTE It is recognized that digital timing is inherently more accurate than analogue timing.

4.5.2 Digital

The uncertainty of digital timing devices used in water level measuring devices shall be within ±150 s at the end of a period of 30 days, within the range of environmental conditions defined in 4.4.

4.5.3 Analogue

The uncertainty of analogue timing devices used in water level measuring devices shall be within ±15 min at the end of a period of 30 days, within the range of environmental conditions defined in 4.4.

5 Recording

5.1 Chart recorders

Where a chart recorder is to be used as the primary source of data, the resolution and uncertainty parameters shall take account of changes in the dimensions of the recording medium due to atmospheric variables.

NOTE Chart recorders have been superseded to a large extent by data logging devices. However, they are still used as back-up units or to provide rapid visual assessment of flow changes on site.

5.2 Data loggers

A data logger shall be able to store at least the equivalent of four digits per reading. Where a data logger includes the interface electronics, the resolution and uncertainty shall relate to the stored value.

6 Enclosure

The performance of the enclosure shall be stated in terms of the IP classification system in accordance with IEC 60529. It shall be stated whether or not any parts in contact with water are suitable for contact with potable water. It shall be stated whether or not the equipment may be used in a potentially explosive environment in accordance with IEC 60079-10.

7 Installation

The manufacturer shall provide clear instructions for the installation of water level measuring devices.

8 Estimation of measurement uncertainty

8.1 General

The uncertainty of a value derived from primary measurements may be due to

a) unsteadiness of the value being measured (waves on the water surface), or

b) resolution of the measurement process (the eye's resolution of submillimetre distance).

Two methods of estimation, Type A and Type B, are described in the *Guide to the expression of uncertainty in measurement* for relating the dispersion of values to the probability of "closeness" to mean value.

8.2 Type-A estimation

A Type-A estimation is determined directly from the standard deviation of a large number of measurements. (Note that the distribution of these results need not be Gaussian.) Type-A estimations can be readily computed from continuous measurements when the dispersion is not masked by hysteresis of the measurement process. Of course, the dispersion must exceed by a significant margin the resolution of the measurement process.

8.3 Type-B estimation

A Type-B estimation is assigned to a measurement process for which large numbers of measurements are not available or to a measurement with defined limits of resolution. To define a Type-B uncertainty, the upper and lower limits of the dispersion or the upper and lower limits of resolution are used to define the limits of a probability diagram whose shape is selected to represent the dispersion, i.e. uniform dispersions would have a rectangular distribution; dispersions with most measurements congregated about the mean value would have a triangular distribution.

Allocation of probability distributions is described in Annex A.

The relationship between the uncertainty of primary measurements and the value of the uncertainty of the result is derived from the formula defining the relationship between the value and its primary measurements. Sensitivities are the partial derivatives of the value with respect to each primary measurement.

In the case of level, its relationship to primary measurement is generally linear. Sensitivity coefficients would then be equal to 1.

8.4 Level measurement datum

Level measurement is not absolute measurement; it is always relative to a datum, for example a local benchmark or the elevation of a weir crest. The uncertainty associated with the datum should be combined with the uncertainty of the derived value.

8.5 Combining primary measurement uncertainties

To determine the uncertainty of the derived value, U, it is necessary to combine the uncertainties of all primary measurements, u, thus,

$$U(\text{level}) = \sqrt{u(\text{level datum})^2 + u(\text{level measurement})^2}$$

This illustrates the method when combining the uncertainty of a reference level datum value. Other components of measurement uncertainty are added by inclusion of their squared value within the brackets.

Annex A
(informative)

Types of water level measuring devices

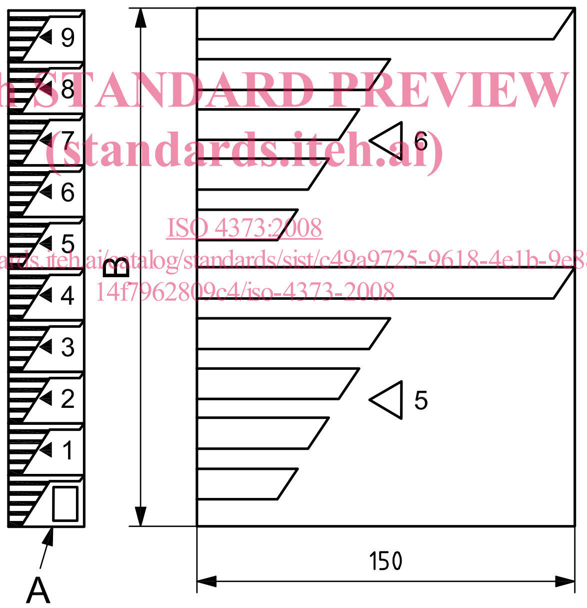
A.1 Reference gauges

A.1.1 Staff and ramp gauges

A.1.1.1 Description

A staff gauge (see Figure A.1) comprises a scale marked on, or securely attached to, a suitable vertical. Where the range of water levels exceeds the capacity of a single vertical gauge, other gauges may be installed in the line of a cross-section normal to the direction of flow. The scales on such a series of stepped staff gauges should overlap by not less than 15 cm.

Dimensions in millimetres



Key

A detachable plate for metre numeral, coloured red

B 10 mm divisions

Figure A.1 —Staff gauge

A ramp gauge (see Figure A.2) consists of a scale marked on, or securely attached to, a suitable inclined surface, which conforms closely to the contour of the riverbank. Throughout its length, the ramp gauge may lie on one continuous slope or may be a compound of two or more slopes. The ramp gauge should lie on the line of a cross-section normal to the direction of flow.

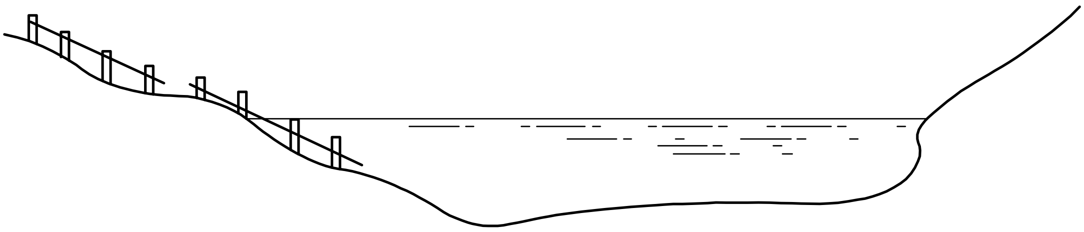


Figure A.2 — Ramp gauge installed in parallel sections

A.1.1.2 Materials

A staff or ramp gauge is constructed of durable material, able to cope with alternating wet and dry conditions. It resists the accretion of both vegetable and mineral matter. The markings should be resistant to wear or fading.

A.1.1.3 Strengths

A staff or ramp gauge is an inexpensive, simple, robust and absolute method of determining water level. It can be utilized by relatively unskilled staff. A ramp gauge provides, in addition, the opportunity to achieve a higher resolution.

A.1.1.4 Weaknesses

A staff gauge can only be used for spot measurements. It is difficult to obtain readings in the field with a true resolution higher than ±5 mm. Most staff gauge locations are such that the gauges require regular cleaning. Ramp gauges amplify surges and ripples. Whilst a stilling box may reduce this, it may also introduce a bias due to flow across the gauge.

A.1.1.5 Uncertainty

A triangular distribution applies to the uncertainty, u, associated with reading a staff or ramp gauge, x, so that

$$u\left(x_{\text{mean}}\right)=\frac{1}{\sqrt{16}}\frac{\left(x_{\text{max}}-x_{\text{min}}\right)}{2} \quad \text{(A.1)}$$

where

x_{max} is the discernible upper limit;

x_{min} is the discernible lower limit.

EXAMPLE If, from inspection, the discernible upper limit is 0,150 and the discernible lower limit is 0,145, then the best estimate is 0,147 5 with an uncertainty of 0,001.

A.1.2 Wire or tape weight gauge

A.1.2.1 Description

A wire or tape weight gauge consists of a weight that is manually lowered until the weight touches the surface of the water. The wire or tape may be wound on a drum attached to a winding mechanism or it may be a hand reel.

A.1.2.2 Materials

Corrosion-resistant materials.

A.1.2.3 Strengths

The equipment is robust.

A.1.2.4 Weaknesses

The equipment may be difficult to use in dark conditions or where the line of sight is difficult. It may be difficult to resolve to disturbed surfaces.

A.1.2.5 Uncertainty

A triangular distribution applies to the uncertainty associated with reading a wire/tape weight gauge, so that Equation (A.1) applies.

EXAMPLE If, from inspection, the discernible upper limit is 0,225 and the discernible lower limit is 0,222, then the best estimate is 0,223 5 with an uncertainty of 0,000 6.

A.1.3 Hook and point gauges

A.1.3.1 Description

A hook or point gauge (see Figure A.3) comprises a hook or point and a means of determining its exact vertical position relative to a datum. The instrument may be portable in which case a datum plate or bracket is fixed at each site on which the instrument is to be used. The vertical position may be determined by, for example, a graduated scale with a vernier arrangement or a digital indicator. If the sensing head is suspended by a tape or wire, it is generally referred to as a dipper (see A.1.4).

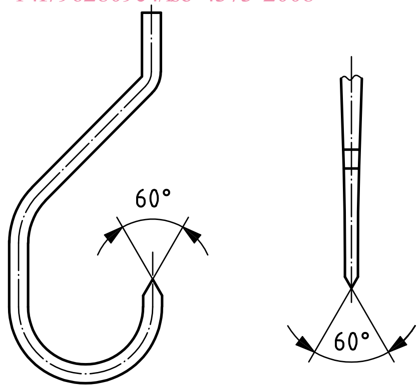


Figure A.3 — Hook gauge and point tips

A.1.3.2 Materials

A hook or point gauge and its ancillary parts are made throughout of durable, corrosion-resistant materials.

A.1.3.3 Strengths

A hook or point gauge is potentially the most accurate of the level determination devices and the preferred technique for use under laboratory conditions.