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Hydrometry — Rotating-element current-meters

Hydrométrie — Moulinets à élément rotatif

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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.

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 2537 was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 5, *Instruments, equipment and data management*.

This fourth edition cancels and replaces the third edition (ISO 2537:1988), which has been technically revised.

Hydrometry — Rotating-element current-meters

1 Scope

This International Standard specifies the operational requirements, construction, calibration, and maintenance of rotating-element devices for the measurement of flow velocities in open channels.

ISO 748 gives information on the use of these devices.

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, *Hydrometric determinations — Vocabulary and symbols*

ISO 3454, *Hydrometry — Direct depth sounding and suspension equipment*

ISO 3455, *Hydrometry — Calibration of current-meters in straight open tanks*

3 Terms and definitions

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

3.1
propeller pitch
distance the propeller current-meter relatively moves through the water during one revolution

4 Principle of operation

4.1 Proportionality

The rotating element of a current-meter is driven by the fluid at an angular velocity that is proportional to the local velocity of the fluid at the point of immersion when that velocity exceeds a critical value.

4.2 Flow velocity

In order to determine the velocity of the fluid, a current-meter is placed at a point in a stream and the number of revolutions of the rotor during a specified time interval is counted or the time required by the rotor to turn a given number of revolutions is observed. The velocity is obtained from the current-meter calibration table or calibration equation(s), established experimentally during its calibration (Clause 9). The number of current-meter revolutions (rotations) may be determined by sensing the signals emitted (such as electrical pulses) through the rotation of the rotor by using a suitable counting device. The velocity can be determined from a direct reading of the speed of rotation of the rotating element by means of equipment designed for this purpose.

5 Types of current-meters

5.1 General

The current-meters are generally classified depending upon the type of rotating element used, i.e. vertical axis cup-type and horizontal axis propeller-type.

5.2 Cup-type current-meter

The rotor of the cup-type current-meter is constructed out of conical cups, or curved vanes attached at equal intervals around the perimeter of a hub, which rotates when placed in a fluid flow. Usually, the rotor is mounted with the axis vertical.

5.3 Propeller-type current-meter

The propeller-type current-meter is an assembly consisting of a number of straight or angled vanes attached at equal intervals around the perimeter of a hub, or two or more helical screw blades formed around a hub that rotates about a horizontal axis when placed in a fluid flow.

6 Operational requirements

6.1 Positioning

The current-meter shall maintain alignment with the flow in such a way that the rotating element responds to flow movement as intended. It shall balance in the stream with its longitudinal axis parallel to the water surface. If a pivoted suspension is incorporated within the current-meter, it shall permit freedom in the vertical plane to ensure correct alignment with the stream flow. Alignment in the horizontal plane may be affected by the correct choice of suspension equipment (see ISO 3454).

Current-meters of conventional construction are intended to operate in a horizontal or near-horizontal position. Current-meters designed to operate in other positions are not covered by this International Standard.

6.2 Resistance to flow

The current-meter shall offer minimum resistance to the force of the flow.

6.3 Limits of use

The rotating element of the current-meter shall be such that, when driven by the fluid, it rotates at an angular velocity, which has a known relation to the velocity of the flow within the calibrated velocity range stated by the manufacturer or rating laboratory. The suspension system shall be used as specified by the manufacturer.

The current-meter shall respond rapidly and consistently to the changes in velocity. The manufacturer shall state the expected response rates.

The current-meter shall be used only in liquids with properties similar to those in which it was calibrated. If the liquid properties are significantly different, the current-meter shall be recalibrated in a liquid with properties similar to that in which the current-meter is to be used.

Unless otherwise indicated, the current-meter shall be capable of being used in waters containing suspended sediment and in saline waters.

The manufacturer shall state the maximum hydrostatic pressure to which the instrument may be subjected.

The manufacturer shall also furnish information on the temperature limits as applicable to the use of current-meter with oil-lubricated bearings.

7 Characteristics of cup-type and propeller-type current-meter

7.1 General

There is no significant difference between the accuracies of the velocities registered by cup-type and propeller-type current-meters. Their characteristics can be summarized as follows.

7.2 Cup-type current-meter

a) This is a robust instrument requiring less maintenance; the rotor is replaceable in the field without affecting the calibration.

b) It operates at lower velocities than the propeller-type current-meter.

c) The bearings are well protected from silty water.

d) A single rotor serves for the entire range of velocities.

e) When held rigidly by rod suspension and pointing upstream at right angles to the measuring section, the current-meter may over- and under-register oblique flows with error generally increasing as the velocity and angle of the flow increases.

f) Vertical components of velocity may cause rotation of a hollow cup-type current-meter. When there is considerable turbulence in a stream or where there are otherwise significant vertical components of velocity, hollow cup-type current-meters may over-register. Usually, the over-registration will be small unless large vertical components of velocity relative to the horizontal components are encountered.

7.3 Propeller-type current-meter

a) This current-meter disturbs flow less than the cup-type current-meter.

b) The propeller is less likely to become entangled with debris than the cup-type current-meter.

c) Bearing friction is less than for vertical shaft rotors because any bending moment on the rotor is eliminated.

d) The commonly used propeller-type current-meter may give correct registration of velocity in oblique flow for incidence angle less than 5° with an error about 1 %. For precise measurement of flow in oblique or convergent flow, a special type of component (self-compensating) propeller-type current-meter is used which measures directly the axial component of velocity with an error less than 1 % for greater angle of incidence up to 45°.

e) Propeller-type current-meters are not as susceptible to vertical currents as cup-type current-meters and therefore give better results when used for stream flow measurement in large rivers by moving boat method (ISO 4369) to minimize errors created by the pitching or vertical motion of the boat.

8 Construction features

See Annex A.

9 Calibration (rating)

9.1 General

In order to determine the velocity of the stream from the revolution of the rotor of the conventional current-meter, a relation between the angular velocity of the rotor and the velocity of the water that spins the rotor has to be established experimentally. The relation so established experimentally is known as calibration (rating) of the

current-meter. The results of the calibration are provided in the form of a calibration table. In addition, a calibration curve with calibration equation(s) may be provided.

The calibration of the current-meter shall normally be valid only for that range of velocities for which it has been manufactured and calibrated, and for use with a similar liquid to that which was used in its calibration. Extrapolation is permissible to higher velocities provided that sufficient calibration data exist for current-meters of a similar type at these higher velocities and that a greater uncertainty is accepted.

Attention shall be paid to possible variation in the calibration due to liquid density and viscosity.

9.2 Conformity of calibration

Calibration of new current-meter and recalibration of old current-meter in use shall be carried out at the recognized rating laboratory in accordance with the ISO 3455.

9.3 Minimum speed of response

The minimum speed of response (also called the threshold, or stall velocity) of a rotating-element current-meter is defined as the minimum speed at which the rotor of the current-meter attains continuous and uniform angular motion during calibration. This speed shall be determined in the rating laboratories. The lower the speed of response of a current-meter, the lower the speed of flow that is measurable with confidence. However, the uncertainties of measurement at the minimum speed of response are high. It is therefore desirable that the current-meter shall be used in the field for stream velocities greater than twice its minimum speed of response.

9.4 Calibration table

For the new current-meter, the manufacturer shall supply the calibration table based on the calibration tests conducted at the rating laboratory. The calibration table shall be in the form suitable to the gauging technique in use. It shall also specify the calibration equation(s) and the following information:

a) the name and address of the rating laboratory;

b) the date of calibration;

c) the calibration job number;

d) the make and type of current-meter;

e) the serial number of the current-meter and each rotor;

f) spin time of cup-type current-meter;

g) type of suspension of current-meter on carriage (cable or rod suspension);

h) the details of sinker weight if used during calibration;

i) the position of the current-meter in the cross-section of the tank;

j) a statement indicating the minimum speed of response;

k) the limits of calibration;

l) any remarks regarding modifications made to the current-meter;

m) the water temperature during calibration;

n) the viscosity of the bearing oil;

o) standard deviation and percentage deviation indicating accuracy of calibration equation(s);

p) the signature of a responsible member of the staff at the rating laboratory.

9.5 Types of calibration

9.5.1 General

The current-meters are calibrated individually or a group (standard) calibration is established from a group of current-meters of uniform manufacture.

9.5.2 Individual calibration

In the case of individual calibration, the relationship of velocity and rate of rotor revolutions is established for a particular current-meter. Individual calibration is necessary when a very high standard in manufacture is not guaranteed.

9.5.3 Group (standard) calibration

Group calibration shall be based on the calibration of a group of current-meters of uniform manufacture. The sample of current-meters calibrated shall be adequate in number and shall comprise, if possible, both new current-meters and well-maintained used current-meters. The manufacturer shall make available a description of the original calibration and of the current-meters used in the calibration. In addition, they shall check the validity of the standard calibration on a sample comprising at least 10 % of newly manufactured meters selected at random, and again shall give similar details of the check calibration. The cost saving in adopting a group calibration is significant but the confidence levels are lower than for an individual calibration. Strict control of manufacture's tolerances is an essential requirement for the implementation of a group calibration and careful vigilance by the user is necessary.

9.6 Recalibration

The current-meter shall be recalibrated whenever its performance is doubtful. In practice, recalibration for individually rated current-meters shall be carried out at yearly intervals or after 300 h of use, whichever is the shorter. Before undertaking recalibration of any used current-meter, it shall be ensured that the current-meter is properly repaired, its worn out parts are replaced and the shape of rotor is in order.

9.7 Type of suspension

The performance of a current-meter may be affected by its mode of suspension and the sinker (sounding) weight used (see ISO 3454). For individual calibration, it is advisable that the calibration be carried out using the same means of suspension and the sinker weight intended to be used during the subsequent field measurement. The distance from the bottom of the sinker weight to the current-meter, for the calibrated configuration, shall be specified by the rating laboratory or the manufacturer.

The differences between calibrations made on rod and cable suspensions depend on the dimensions and shape of section of rod and on the size and type of sinker (sounding) weight used.

For a given velocity, the rotor of a cup-type current-meter may rotate faster with rod suspension than with cable suspension, whereas in the case of a propeller-type current-meter, the propeller of the rod suspended meter may rotate slower than that of a cable suspended current-meter.

In order to correct for the effects of different sinker weights and different means, size and shape of suspension, the coefficients derived in the rating laboratories shall be used. Such coefficients are applicable only to the specific combination for which data have been experimentally obtained. However, when high precision in gauging is required, the same suspension method as proposed to be used in field measurements shall be used during calibration.