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Liquid flow measurement in open channels — Rotating element current-meters

Mesure de débit des liquides dans les canaux découverts — 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

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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International Standard ISO 2537 was prepared by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels.*

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This third edition cancels and replaces the second edition (ISO 2537 : 1985), of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Liquid flow measurement in open channels — Rotating element current-meters

1 Scope and field of application

This International Standard specifies the operational requirements, construction, calibration, and maintenance of rotating element devices for the measurement of flow velocities in open channels. This International Standard does not define the form of the signal produced by the equipment or the signal receiving equipment.

For the use of these devices, refer to ISO 748.

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2 References

ISO 748, *Liquid flow measurement in open channels — Velocity-area method.*

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ISO 772, *Liquid flow measurement in open channels — Vocabulary and symbols.*

ISO 3454, *Liquid flow measurement in open channels — Direct depth sounding and suspension equipment.*

ISO 3455, *Liquid flow measurement in open channels — Calibration of rotating-element current-meters in straight open tanks.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 772 apply.

4 Principle of operation

4.1 Proportionality

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

4.2 Positioning

The axis of the rotating element may be at right angles or it may be parallel to the direction of flow.

4.3 Types of current-meter

4.3.1 Cup-type current-meters

Cups or curved vanes attached at equal intervals around the perimeter of a hub comprise an assembly which will rotate when placed in a fluid flow. It is usual to mount the rotor with the axis vertical.

4.3.2 Propeller-type current-meters

An assembly consisting of a number of straight, angled vanes attached at equal intervals around the perimeter of a hub, or two or more helical screw blades formed around a hub that will rotate about a horizontal axis when placed in a fluid flow.

4.4 Flow velocity

The velocity of the fluid is determined by counting the number of revolutions of the rotor during a specified time interval or by observing the time required by the rotor to turn a given number of revolutions and consulting the meter calibration table or rating equation. The velocity of fluid movement may be determined from the sensing of signals emitted (such as electrical pulses) through the rotation of the rotor. The velocity may be determined from a direct reading of the speed of rotation of the rotating element by means of equipment designed for this purpose.

5 Operational requirements

5.1 Positioning

The equipment should maintain alignment with the flow in such a way that the rotating element responds to flow movement as intended. If a pivoted suspension is incorporated within the current-meter, it should permit freedom in the vertical plane to ensure correct alignment with the liquid 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.

5.2 Resistance to flow

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

5.3 Relationship of rotor movement and stream velocity

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

5.4 Limits of use

5.4.1 Various liquids

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

5.4.2 Cup-type current-meters

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 meters may over-register. Usually the over-registration will be small unless large vertical components of velocity relative to the horizontal components are encountered.

6 Construction features

6.1 General

6.1.1 Cup-type current-meters

A cup-type current-meter shall generally consist of

a) a rotor revolving about a vertical shaft;

b) a hub assembly;

c) bearings;

d) a main frame or yoke;

e) a chamber containing the signal generation mechanism;

f) tail fins;

g) a means of attaching the instrument to the suspension equipment.

6.1.2 Propeller-type current-meters

A propeller-type current-meter shall consist of

a) a rotor that is either a propeller revolving about a fixed axis or a revolving set composed of the propeller and axis;

b) two bearings;

c) a device giving a signal indicating movement of the rotor;

d) a streamlined body;

e) a means of attaching the instrument to the suspension equipment.

A means of providing directional control to the meter in the current will generally be provided. This may be either a part of the suspension equipment or an integral part of the meter.

6.2 Rotor

6.2.1 Cup-type current-meters

The rotor will generally be constructed of six hollow or solid conical cups, fixed in the same horizontal plane at equally spaced intervals (equal angles) to a frame mounted on a vertical shaft. This assembly shall be retained in the yoke by means of the upper shaft bearing and a lower pointed bearing consisting of a central pivot and a bearing cup.

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6.2.2 Propeller-type current-meters

The current-meter may be provided with a single propeller or with several interchangeable propellers each having a different pitch and/or diameter. Each propeller shall consist of two or more vanes or helical screw blades that generally rotate about a horizontal axis. The propellers should be made from a material which will not allow them to be easily distorted.

6.3 Bearings

The resisting torque of the bearings shall be as small as possible and shall be constant during use. Bearings shall be lubricated as stated by the manufacturer. Provision shall be made to ensure that silt and water do not enter the bearings except as required for water-lubricated bearings.

6.4 Means of counting rotor revolutions

6.4.1 Signals

The revolutions of the rotor shall, by means of mechanical contacts or by means of magnetic, optical or other devices, generate a clear and positive signal at all velocities within the effective range of the meter. If electrical connections are used, they should be appropriately waterproofed.

Manufacturers should stipulate the maximum conductivity of water in which the meter can be used.

6.4.2 Adjustable frequency signals

For the measurement of low velocities, it shall be possible to choose the frequency of signals transmitted to the counting mechanism in such a way as to reduce to a minimum the errors entailed in measurements of normal duration.

Rotation of the rotor shall, by means of mechanical contacts or by means of magnetic, optical or other principles, produce a clear and positive signal of movement at all velocities within the effective calibrated range of the meter. It is permissible to provide a means of multiplying or dividing the signal pulse rate to suit counting equipment with a limited range of operation. If electrical connections are used in the equipment, they should be appropriately protected against short-circuiting.

6.5 Mounting

The body of the current-meter shall provide means for mounting on a cable suspension or the slide support of a rod (see ISO 3454). If an adaptor is necessary, the meter should be calibrated for such conditions.

6.6 Directional control

Directional control shall be provided by means of tail fins or other devices to enable the meter to align itself with the streamflow and to remain stable in that position throughout the full range of calibrated velocities. The directional control may be either provided by the suspension system or provided by tail fins or other devices that are attached to, or are an integral part of, the meter.

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6.7 Rate of response

The manufacturer shall identify the minimum speed of response, which is defined as the lowest speed at which the current-meter will initiate and maintain steady motion. The manufacturer shall also state the consistency of response, together with tolerances to changes in velocity.

6.8 Hydrostatic pressure

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

6.9 Interchangeability of parts

Spare parts shall be fully interchangeable so as to have uniform functional characteristics, to cause less than a 2 % divergence from the normal rating curve, and to facilitate easy replacement of worn or damaged elements.

6.10 Durability

Current-meters shall be constructed of corrosion-resistant materials throughout or of materials that are effectively protected against conditions encountered in natural waters. The manufacturer should provide information on the materials used in the construction of meters that may be used in fluids having properties different from those of most natural waters. In such cases, it is the responsibility of the user to determine whether the meter is suitable for the proposed use. The meter shall be of sufficiently rugged construction to maintain calibration under conditions normally encountered (see 7.6). The use of the meter in silty or saline waters may reduce the life of the meter.

7 Calibration

7.1 General

The calibration of current-meters consists in establishing by experiment the relationship between velocity of flow and rotor speed, usually expressed in revolutions per second and provided as a calibration curve or table and as a formula.

The rating of a current-meter will 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 meters of a similar type at these higher velocities and that a greater uncertainty is accepted.

7.2 Conformity

All calibration shall be carried out in accordance with ISO 3455.

7.3 Type of rating

Current-meters may be calibrated individually or a group rating may be supplied. A current-meter may have an individual rating where the relation of velocity to response is based on a rating of that particular meter. A manufacturer may supply a group rating for a particular type of meter manufactured, provided that the manufacturing is homogeneous and a sufficient number of single calibrations have been made under well-defined conditions.

7.4 Formula

From the calibration data, manufacturers or rating laboratories shall supply a rating table for convenience for use in the field and shall also specify the formula of the rating curve derived from the data and the minimum speed necessary to produce a representative sensing of the fluid motion. This speed is the lowest speed at which the current-meter will initiate and maintain steady motion. The actual limits of the rating shall be stated.

7.5 Sample for rating

7.5.1 Individual rating

Each meter shall be calibrated to produce individual ratings.

7.5.2 Group rating

Group ratings 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 old 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.

7.6 Recalibration

Meters shall be recalibrated whenever their performance is suspect. In practice, for individually rated meters, recalibration is sometimes carried out at yearly intervals or after 300 h of use, whichever is the shorter.

7.7 Type of suspension

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

It is possible to derive by experiment coefficients which can be applied to gauging data to correct for the effects (if any) of different sounding weights and different means, size, and shape of suspension.

Such coefficients are applicable only to the specific combination for which data have been experimentally obtained.

7.8 Uncertainty

As a check for goodness of fit of the rating curve, the manufacturer or rating laboratories shall state the standard error of the data for the lower and upper limits of calibration, and for at least two intermediate points. The standard error shall be stated as a percentage of the mean velocity class and shall be related to the 95 % confidence limits.

The scatter of the points about the rating curve for each velocity class shall be approximately normal so that the errors will be compensating.

7.9 Operating conditions

Attention should be paid to possible variations in the rating due to changes in liquid density or viscosity.

8 Maintenance

8.1 General

Under conditions of normal operation, the user should follow recommended check procedures before and after each discharge measurement, as laid down in the manufacturer's operations and servicing manual. In the event of more comprehensive instructions not being provided, the procedures specified in 8.1.1 to 8.1.3 should be followed.

8.1.1 Examination

The meter shall be examined, before and after each discharge measurement, for worn or damaged bearings, proper shaft alignment, correct operation of contact points and deformation of the yoke or cup-wheel in the case of cup-type meters, or of the propeller in the case of propeller-type meters. All moving parts should be carefully inspected and checks performed to ensure operation in accordance with specifications. Particular attention should be paid to equipment which has been in storage for a long period of time.

8.1.2 Inspection

For inspection, it shall be possible to dismantle and reassemble the current-meter assembly in the field, without specialized workshop facilities and by personnel without specialist training. Such tools as are required to carry out this operation shall be supplied as standard accessories.

On-site removal and replacement of the rotor on its shaft shall be possible with minimum disturbance to the bearing assembly, and preferably without removing the bearing assembly from the instrument.

8.1.3 Signal test

Before use, the meter shall be tested for correct operation. By turning the rotor slowly, the number of rotations shall be compared with the number of pulses received. For current-meters with a generator, it shall be checked that output varies with rotor speed.

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8.2 Spin test

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8.2.1 Current-meters with ball bearings or with a pivot bearing

If no special instructions are provided by the manufacturer, the test described below may be carried out, after the meter has been lubricated and assembled ready for use.

Place the meter in the normal operating attitudes, with the rotor protected from air currents. Spin the rotor by hand. As it nears its stopping point, observe its motion carefully to see whether the stop is abrupt or gradual. If the stop is abrupt, the cause shall be found and corrected before the meter is used. A pre-specified minimum spin time should be observed for a meter in good condition.

8.2.2 Current-meters without ball bearings

The design of meters without ball bearings prevents the meter from working properly in air. The manufacturer shall recommend a simple check procedure to ensure proper operation.

8.3 Cleaning and lubrication

After each discharge measurement, or more frequently for extended measurements, all bearing surfaces (including any pivot) shall be thoroughly cleaned and, where appropriate, lubricated. If bearings require lubrication to be applied for use of the current-meter in the field, the lubricant used shall have the same viscosity characteristics as the lubricant used at the time of calibration; this lubricant shall have the same or equivalent specifications as that recommended by the manufacturer.

8.4 Transport and storage

A suitable protective instrument case shall be provided by the manufacturer on request in which the current-meter may be stored when not in use. Suitable storage shall also be provided in the case for the tools required for instrument maintenance.

Provision shall be made for the storage and transportation of the current-meter and its components in such a manner that the bearings and other parts of the meter can be protected from wear and from damage resulting from vibration or shock.

9 Operational and servicing manual

A comprehensive operational and servicing manual should be supplied with each instrument. It should present full instructions, illustrated where necessary, and include appropriate circuit diagrams with component values. The manual should contain sections on the following:

a) normal maintenance, servicing on site, checking procedures including recommended screw torques;

b) spares list, including a list of contributing manufacturers;

c) lubricant and sealant details, including lubricant and compound specifications;

d) preparations necessary for transport and storage;

e) details of power source, if any, and appropriate rates and duration of recharge;

f) details of electrical and(or) electronic circuitry (including component values) with circuit diagrams and test procedures.

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