

Measurement of liquid flow in open channels under tidal conditions

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National foreword

This British Standard is the UK implementation of ISO 2425:1999+A1:2003. It supersedes BS 3680-6:1995 which is withdrawn.

The start and finish of text introduced or altered by ISO amendment 1 is indicated in the text by tags A1 A1.

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A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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*Mesure de débit des liquides dans les canaux découverts dans des
conditions de marée*



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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.

Amendment 1 to ISO 2425:1999 was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 1, *Velocity area methods*.

Introduction

The measurement of flow in tidal channels poses problems additional to those encountered in unidirectional streams. A tidal river reach will exhibit a range of conditions, from the backwater effect, when the flood tide impedes the freshwater river flow, through to the complete flow reversal.

The duration and extent of the tidal influence in an estuarial measurement station depend on the actual location of the station in the estuary.

Measurement of liquid flow in open channels under tidal conditions

1 Scope

This International Standard provides a summary of a selection of recommended methods available for the measurement of liquid flow in tidal channels, special consideration being given to those techniques that are either unique to or particularly appropriate for measurement under tidal conditions, including treatment of errors.

Reference is also made, where appropriate, to methods developed for measurement in non-tidal channels, but in such cases attention is drawn to their limitations with respect to practicality and/or accuracy.

This International Standard does not describe alternative methods, such as weirs, flumes, dilution gauging, salt velocity and floats, although they may be suitable under certain conditions, especially where the effect of tides only impedes and does not stop or reverse the passage of stream flow. These methods are described in detail in other International Standards.

The standard comprises two parts:

- a) techniques for single measurements of tidal flow;
- b) techniques appropriate for continuous measurement of tidal flow.

The cubature method of measurement, although currently not used, is included in annex A. Annex B presents methods suitable for measurement for tidal conditions, and annex C gives an example of the computation for a single vertical. Similar computations may be made for other verticals.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 748:1997, *Measurement of liquid flow in open channels — Velocity-area methods*.

ISO 772:1996, *Hydrometric determinations — Vocabulary and symbols*.

3 Terms and definitions

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

4 Principles of methods of measurement

4.1 General

Tidal-flow measurement can be an instantaneous rate of flow or a total volume of flow during a flood or ebb tide. The unsteady nature and change in direction of flow under tidal conditions create problems of measurement additional to those associated with the measurement of the discharge of unidirectional streams. The methods specified in ISO 748, ISO 1100, ISO 4369, ISO 9123, ISO 9823 and ISO 9825 cannot therefore always be applied to tidal channels. Any change in water quality brought about by tidal conditions may affect the methods specified in ISO 6416 and ISO 9213.

For various reasons, direct measurements of velocity in tidal channels are more liable to large errors than are those made under conditions of unidirectional flow.

The methods of measurement included in this International Standard may be grouped into either single or continuous measurements.

4.2 Single measurement methods

4.2.1 Velocity-area method

At a chosen gauging site, the velocity of flow and the area of cross-section of the channel are measured. The product of these measurements at any instant is the rate of flow or discharge past the gauging site at that instant. It is referred to as the Velocity-Area method and includes the following techniques:

- a) current meter from a fixed station;
- b) current meter from a moving station (moving boat).

4.2.2 Cubature method

In an area which includes a stretch of river channel and its flood plain, surface areas and rise in water level of stored water are measured at known time intervals. Volumes of stored water are computed, and the flow into the upstream stretch of river is estimated, from which the average rate of flow is determined (see annex A).

4.3 Continuous measurement methods

4.3.1 Ultrasonic method (ISO 6416)

Transducers are positioned on each bank of the river channel, such that the flight path is at an oblique angle to the direction of flow. The time taken for a pulse of sound to travel in both directions is measured and compared. From these two times, the mean velocity can be computed. $\overline{A_1}$ This value, when used in conjunction with the cross-sectional area, will provide an estimate of the flow in the channel. $\overline{A_1}$

4.3.2 Electromagnetic method (ISO 9213)

A horizontal coil is constructed above or below a river channel. A magnetic field is generated by an alternating current and voltages are induced in the flowing water which acts as an electrical conductor. After calibration, measurements of electrical parameters and water depth provide a means of $\overline{A_1}$ estimating $\overline{A_1}$ the discharge.

4.3.3 Unsteady-flow models

Unsteady-flow models may be used for computing continuous records of discharge in open channels in both tidal and non-tidal conditions. These models, however, are not applicable where a longitudinal density gradient, such as a salt-water wedge, is present.

Unsteady-flow models are based on the numerical solution of non-linear partial differential equations that describe gradually varied unsteady flow in open channels. The available models employ one or more of several numerical computation techniques. Data requirements, which can be substantial, depend on the numerical techniques employed by the model selected. It is necessary that techniques for the application of unsteady-flow models and the data requirements be clearly defined and understood for successfully computing discharges.

5 Special considerations and choice of method

5.1 Special considerations

Changes in water level at the mouth of a river due to tidal action cause backwater effects in the channel. These may alter water level only, or both water level and direction of flow. The whole flow may be reversed in direction, or only some of the flow may be reversed due to differences in density.

Most flow-gauging techniques are generally best suited to conditions closely approximating steady flow, but unsteady flow causes additional difficulties as follows.

- a) At any section, water levels continuously change;
- b) at any point on a vertical, velocities continuously change either with or without change in direction;
- c) in any vertical, the continuously changing velocities $\overline{A_1}$ could $\overline{A_1}$ create greater velocity gradients than in channels with steady uniform flow;
- d) during the period of transition in flow direction (flood to ebb or ebb to flood), zero velocity occurs at a succession of points over the changing velocity profile;
- e) high water and low water may not take place at the same time as the reversal in flow direction;
- f) the change in direction of flow does not take place at the same time throughout the wetted cross-section;
- g) when the direction of flow changes, the characteristics of the approach conditions from the upstream and the downstream may be different and may result in divergence (when the angle between the flood and the ebb flow is other than 180°) between the flood and ebb flow;
- h) flow may be stratified, with liquids of different densities in each layer. While the liquid in the upper stratum may flow in one direction, the more dense liquid in the lower stratum may flow at a different speed in the same or opposite direction. When such density difference due to a salt water wedge occurs, the maximum velocity in each layer may occur at different times;
- i) at any section in a channel, variations in water level may cause changes in width and cross-section of flow;
- j) an increase in the number of measurements required to make an estimate of discharge;
- k) during a tidal cycle there may be variations in salinity leading to changes in the speed of sound and conductivity of the water, and these may adversely affect ultrasonic and electromagnetic methods.

5.2 Choice of method

5.2.1 General

In channels with steady flow, one of the main factors affecting the choice of gauging method is the frequency of measurements of discharge in the channel. Observations may be repeated over months or years (continual or repeated measurements), or occasionally, often once only (occasional measurements). Under variable or unsteady conditions, the frequency of measurement, although affecting the $\overline{A_1}$ operational cost of each gauging station and important economically, may not be compromised. $\overline{A_1}$ The physical conditions of flow and waterway dominate the choice.

5.2.2 Physical conditions

The physical conditions which affect the choice of gauging method are:

- a) $\overline{A_1}$ tidal range including level, flow and velocity; $\overline{A_1}$
- b) width of channel;