
**Hydrometric determinations —
Measurement of suspended sediment
transport in tidal channels**

*Déterminations hydrométriques — Mesurage du transport solide dans les
canaux à marée*

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11329 was prepared by Technical Committee ISO/TC 113, *Hydrometric determinations*, Subcommittee SC 6, *Sediment transport*.

This second edition cancels and replaces the first edition (ISO 11329:1998), which has been technically revised.

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Introduction

Estuaries and creeks have become regions of major developments pertaining to port and harbour facilities, navigation, reclamation and effluent disposal. Human interference with water bodies, for example, providing navigational channels, installing major or minor structures and reclaiming land, need thorough examination of their impact on morphological changes, stability of banks and channels, the consequences of capital and maintenance dredging, and the selection of disposal grounds. For these purposes, it is necessary to estimate the suspended sediment transport rates in tidal channels, which can be based on data on morphological characteristics of the channel, flowrates and the corresponding suspended sediment concentration.

In comparison to the situation in unidirectional flow, the flow as well as sediment concentration at different locations along tidal channels are much more complex. The salt water flow from the sea at one end and the fresh water flow from the river at the other end are responsible for spatial and temporal variations in water and sediment movement in tidal channels. When measuring the flowrate and suspended sediment concentrations for estimating sediment transport rates, these factors need to be considered.

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Hydrometric determinations — Measurement of suspended sediment transport in tidal channels

1 Scope

This International Standard deals with the method and techniques for the sampling of suspended sediment and estimation of sediment transport rates in natural and man-made channels influenced by tidal action.

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 772, *Hydrometric determinations — Vocabulary and symbols*.

ISO 2425, *Measurement of liquid flow in open channels under tidal conditions*.

3 Terms and definitions

ISO 11329:2001

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

3.1

mixed tides

tides which have two markedly unequal successive high waters, or two markedly unequal successive low waters, or both, during most of each month

3.2

divergence

deviation of the angle between the flood and ebb axes from 180°

NOTE In a straight reach, the flood and ebb flow directions are ideally expected to lie on the same axis but in the opposite direction, i.e. the change in flow direction is 180°. However, in most situations the directions of flood and ebb flows are not along the same axis, due to prevailing approach conditions from either side.

3.3

flood [ebb] predominance

net flow, in the flood [ebb] direction, resulting when the flood [ebb] velocity-time curve is such that the net flow integrated over a tidal period, either at a point or over a vertical, is not zero

NOTE In a typical situation, one part of a tidal channel may have flood predominance whereas the other may have ebb predominance.

3.4

creek

inlet or arm of a river or a small stream joining the coast

4 Salient features of sediment transport in tidal channels

Measurement of discharge and estimation of corresponding suspended sediment concentration by analysis of water samples are essential to estimating the rate of sediment transport through a channel section. The following aspects shall be taken into account when planning the collection of data and estimation of sediment transport.

- a) Flow is two-way in tidal channels as a result of tidal fluctuation in the sea. During the flood phase, the water level rises and water flows from the sea upstream, whereas during the ebb phase, the water level falls and water flows toward the sea.
- b) The extent of tidal excursion, magnitude and direction of tidal current, and flood and ebb periods (at any cross-section) differ from tide to tide depending on the tidal range and freshwater discharge.
- c) The variation in water level from section to section in a tidal channel depends on the freshwater discharge, tidal range in the sea, the channel bed slope and frictional resistance at the bed and banks of the channel.
- d) All the above aspects result in temporal and spatial variation in the sediment transport at all points in a tidal channel.
- e) The quantity and type of sediment which enters a tidal channel depends on the freshwater discharge, the wave climate and tides in the sea. As a result, there can be a large variation in the amount of suspended load in tidal channels.
- f) The variation in the strength of the current from spring to neap or from neap to spring results in significant changes in the bed configuration along the channel. Variation in the freshwater discharge also causes such changes.
- g) The directions of flood and ebb currents in a cross-section of the tidal channel do not necessarily differ by 180° (i.e. complete reversal) as the flow is governed by the bed and bank configurations upstream of flow. Furthermore, the flood flow may dominate one part of the cross-section whereas the ebb flow dominates the other part.
- h) The time of reversal and the direction of transport are commonly different across the cross-section of the tidal channel and at different depths on a vertical.
- i) In a wide channel near the mouth, the time of reversal from flood to ebb or from ebb to flood differs appreciably from one part to another in the section, resulting in a large circulation.
- j) The difference in densities of sea water and river water affects the mixing characteristics of tidal and freshwater flows, depending on their relative magnitudes. The flow in the channel can be well-mixed, partially mixed or stratified.
- k) Water level is affected by atmospheric pressure fluctuations and wind drag.
- l) Biological effects can determine the erosivity within an estuary, which can affect the suspended sediment concentrations in time and space.
- m) Variations in temperature change water viscosity and also affect the settling velocity of different sediments, thus affecting the suspended sediment load throughout the year.
- n) Human activities, such as dredging, disposal and trawling, will also influence the amount of suspended sediment within the water column.

5 Guidelines for measurement and estimation of suspended sediment transport

Consideration should be given to the following points for the measurement and estimation of suspended sediment transport in a tidal channel.

- a) Long-term measurements of flow and simultaneous water sampling are required for estimating sediment transport in tidal channels. For regular semidiurnal tides, data should be collected for a minimum of 13 h. However, in the case of diurnal tides or where there is a strong diurnal component (mixed tides), an observation period of 25 h is recommended. The time interval between the observations shall also be kept as small as possible (no more than 0,5 h) due to the unsteady nature of tidal flow.
- b) The period of data collection may need to cover various ranges of tide, from neap to spring, to account for the variation in velocity and suspended sediment concentration if morphological changes are to be estimated.

- c) During the preliminary survey, the mixing characteristics of the tidal channel shall be identified by taking simultaneous observations at the surface and at the bed. If the flow is stratified, it may be necessary to extend the observation period to cover a period from neap to spring tides.
- d) As the presence of freshwater discharge affects the flow field and sediment transport, collection of data is necessary to cover both dry and freshet seasons.
- e) Items a) through d) emphasize the need for long-term observations. Depending on the hydraulic conditions, a decision should be taken on the required period and time of observations necessary to serve the purpose for which the investigation is undertaken. It may also be possible to limit the field observations if suitable numerical models are available to simulate the range of prevailing hydraulic conditions.
- f) The scatter in data for suspended sediment concentration is more than for unidirectional flow in tidal channels, due to the variable nature of the flow. Repeated observations for the same tidal conditions are therefore necessary to arrive at a reliable estimation of sediment transport.
- g) The sampling points on a vertical need to be changed with variation in flow depth in a tidal cycle. The sampling points should be selected on the basis of depth of stratification for stratified flow.
- h) The level of the sampling point with respect to the water surface is easily measured. However, the elevation of water surface itself changes with time. This change shall be taken into account while analysing and interpreting the data in absolute terms. The simultaneous measurement of water level with respect to a known datum is necessary.
- i) Simultaneous observations are desirable at several verticals in a section of the tidal channel, as well as at a number of sections, depending on the reach to be covered. This requires more resources with respect to boats, equipment and personnel so as to determine the effects of variations on flows.
- j) Point sampling is better than depth-integrated sediment sampling in tidal channels.
- k) During the collection of data over long observation periods (even covering one tidal cycle), problems may arise due to ships in the navigation channel and dredging activity. Considering these problems, as well as the limitation of resources in carrying out simultaneous observations at a number of locations, it may be necessary to utilize data collected from different tides of the same range to cover the different locations, keeping at least one common observation station for reference.
- l) Though the values of suspended sediment flux during the flood and ebb phases can be very large, the value of the net flux (algebraic sum of flood and ebb fluxes) can be very small. Errors in the estimation of flood and ebb sediment fluxes may therefore result in a significant error in the magnitude and perhaps even in the direction of the net flux. Therefore great care shall be taken to minimize errors in the basic measurements.

6 Selection of sampling site in the tidal channel

6.1 Choice of cross-section

It is desirable to carry out a preliminary survey to choose a suitable site preferably satisfying the conditions given below, in addition to those conforming to ISO 2425.

- a) The banks of the cross-section of the tidal channel should not be too flat, in order to avoid large intertidal variation in water-surface width.
- b) There should not be appreciable divergence between predominant flood and ebb flow directions. Sections involving multiple channels should be avoided.
- c) There should not be abrupt variation in bed levels across the cross-section of the tidal channel.
- d) The minimum depth of water at the lowest level of water in the section of the tidal channel should be sufficient for submergence of the equipment, namely the currentmeter and the sediment sampler. A minimum depth of 2 m is desirable.

These conditions are broadly specified and are intended to serve as a guideline. Site-specific conditions, as well as the requirement for the estimation of transport in a specific reach of interest, may not permit strict adherence to all these conditions.