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Liquid flow measurement in open channels — Flow measurements under ice conditions

*Mesure de débit des liquides dans les canaux découverts — Mesurage
de débit dans des conditions de glace*



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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 voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9196 was prepared by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*, Subcommittee SC 7, *Special problems and methods of measurements*.

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Liquid flow measurement in open channels — Flow measurements under ice conditions

1 Scope

This International Standard deals with water discharge measurements in rivers and channels under ice conditions and provides information additional to that published in previous International Standards.

This International Standard does not specify measuring instruments and equipment, which are dealt with in other International Standards.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 555-1:1973, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 1: Constant-rate injection method*.

ISO 555-2:1987, *Liquid flow measurement in open channels — Dilution methods for the measurement of steady flow — Part 2: Integration method*.

ISO 748:1979, *Liquid flow measurement in open channels — Velocity-area methods*.

ISO 772:1988, *Liquid flow measurement in open channels — Vocabulary and symbols*.

ISO 1100-2:1982, *Liquid flow measurement in open channels — Part 2: Determination of the stage-discharge relation*.

ISO 1438-1:1980, *Water flow measurement in open channels using weirs and Venturi flumes — Part 1: Thin-plate weirs*.

ISO 3846:1989, *Liquid flow measurement in open channels by weirs and flumes — Rectangular broad-crested weirs*.

ISO 3847:1977, *Liquid flow measurement in open channels by weirs and flumes — End-depth method for estimation of flow in rectangular channels with a free overfall*.

ISO 4359:1983, *Liquid flow measurement in open channels — Rectangular, trapezoidal and U-shaped flumes*.

ISO 4360:1984, *Liquid flow measurement in open channels by weirs and flumes — Triangular profile weirs*.

ISO 4377:1990, *Liquid flow measurement in open channels — Flat-V weirs*.

ISO 5168:1978, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement*.

WMO (World Meteorological Organisation) Technical Note No. 117 (WMO No. 280), *Use of weirs and flumes in stream gauging*.

3 Definitions

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

4 Methods of water discharge measurement under ice conditions

Discharges of water can be measured under ice conditions using velocity-area methods, representative vertical methods, dilution gauging methods and by means of notches, weirs and flumes.

4.1 Velocity-area method

The principle of this method is described in ISO 748. For channels in which a surface layer of ice exists, the cross-sectional area of water flowing is taken as the area bounded by the bed line (or wetted perimeter) and the lower edge of the ice cover or slush. When flow is between layers of ice, the cross-sectional area also includes the area bounded by the lower ice layer and the lower surface of the ice cover or slush.

4.1.1 Selection of site

Discharge measurements under ice conditions are usually conducted at the same sites used for open channel measurements. The site may be unsuitable for observations if

- a) more than 25 % of the cross-section is filled with slush, which is distributed unevenly over the cross-section;
- b) dead zones occupy more than 10 % of the cross-section;
- c) there are large areas with very low stream velocities (less than 0,3 m/s) which cannot be measured using current meters;
- d) it is located in the backwater zone downstream of an ice gorge or ice jam;
- e) there is a large open water area that remains unfrozen throughout the winter (but see 4.1.7);
- f) it is liable to ice up owing to the freezing of water flowing through cracks on the surface of the ice cover indicating a possible breakup of the ice.

During the open water period, i.e. the period when there is no ice cover, sites additional to those normally used for water discharge measurements should be selected and marked on the banks. After the ice cover at the river reach selected for measurements has stabilized, a preliminary survey shall be made to select a longitudinal profile with a length equal to several widths and an appropriate number of holes shall be drilled along the profile to determine the occurrence of slush and its distribution. In channels in which slush is found to be present, and when it is impossible to select another measurement reach, the measurement site shall be located at the centre of a uniform river reach.

Following the preliminary choice of the site, four or five holes shall be drilled across the river at equal distances to determine whether a regular velocity distribution exists and to establish the slush and ice thickness over the cross-section. Sites in which slush divides the river into separate streams shall be avoided. Braided channels which, in the open

water period, are unsuitable for the measurement of discharge owing to the multiplicity of channels, may be suitable under winter conditions since the shallower channels may become blocked by slush or ice, leaving the main channel unblocked and flowing.

4.1.2 Frequency of water discharge measurements

The frequency of water discharge measurements during the winter period shall be such as to ensure a reliable estimation of the discharge. If conditions of stable ice cover exist, methods of hydraulic interpolation of winter flow may be used. However, under difficult conditions (such as those of unstable ice cover and incomplete freezing) measurements shall be taken as frequently as possible, since in this case the discharge is computed by the interpolation of the observed discharges. The time at which the daily discharge measurement shall be made shall be determined from experimental data to ensure that a discharge measurement as close as possible to the daily mean value, in rivers with considerable daily variations in discharge, is obtained.

4.1.3 Measurements of ice cover thickness

The ice cover thickness shall be measured using ice-measuring sticks which are lowered into holes drilled by hand or using mechanical drills. A zero reading may also be obtained.

4.1.4 Measurements of slush depth

For small depths of slush, measurements may be made using an ice-measuring stick. The slush depth is indicated by a change in the resistance to clockwise and anticlockwise rotation of the stick during its rise, i.e. the resistance to rotation increases when the slush layer is reached. For thicker depths of slush, measurements may be made in a similar manner using a special rod with a stop plate or a perforated disc attached to its end. In addition, current meters are frequently used for slush depth measurements. The current meter is lowered below the slush layers and is then gradually lifted until a zero reading is obtained. It should be borne in mind, however, that the actual slush depth may be somewhat smaller than that obtained by measurement, because a zero reading will also be obtained when the flow velocity decreases to 0,03 m/s to 0,04 m/s.

4.1.5 Determination of the effective depth

In an ice-covered channel, the effective depth is computed by subtracting the distance between the water surface and the bottom of the ice layer or slush from the total depth. The total water depth in the channel is measured using a rod or a cable-suspended sounding weight which is lowered using a winch; the latter method is similar to the depth