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Hydrometry — Measurement of liquid flow in open channels —

Part 1: Guidelines for selection, establishment and operation of a gauging station

Hydrométrie — Mesurage du débit des liquides dans les canaux découverts —

Partie 1: Lignes directrices pour la sélection, l'établissement et l'exploitation d'une station hydrométrique

[Revision of second edition (ISO 1100-1:1996) and ISO/TR 8363:1997]

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ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO-lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five-month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

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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 1100-1 was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 1, *Velocity Area Method*.

This third edition of ISO 1100-1 cancels and replaces ISO 1100-1:1996 and ISO/TR 8363:1997, which have been merged & technically revised.

ISO 1100 consists of the following parts, under the general title *Hydrometry — Measurement of liquid flow in open channels*:

— *Part 1: Guidelines for selection, establishment and operation of a gauging station*

— *Part 2: Determination of the stage – discharge relationship*

Hydrometry — Measurement of liquid flow in open channels —

Part 1:
Guidelines for selection, establishment and operation of a gauging station

1 Scope

1.1 This part of ISO 1100 gives guidelines for the establishment and operation of a gauging station for the measurement of stage and/or discharge of a lake, reservoir, river or canal or other artificial open channel. It also describes how a gauging station utilising one of the measurement methods listed should be operated and maintained.

1.2 Requirements are specified for stage only measurement stations, stage – discharge stations and direct discharge measurement stations in natural channels, as well as for stage discharge stations with artificial structures. Additionally, some recommendations are given for measurements under difficult conditions such as under ice conditions.

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 reference, the latest edition of the referenced document (including any amendments) applies.

ISO 748:2007 *Hydrometry -- Measurement of liquid flow in open channels using current-meters or floats*

ISO 772:2011 *Hydrometry -- Vocabulary and symbols*

ISO 1070:1992 *Liquid flow measurement in open channels -- Slope-area method*

ISO 1100-2:2010 *Hydrometry -- Measurement of liquid flow in open channels -- Part 2: Determination of the stage-discharge relationship*

ISO 1438:2008 *Hydrometry -- Open channel flow measurement using thin-plate weirs*

ISO 2425: 2010 *Hydrometry – Measurement of liquid flow in open channels under tidal conditions*

ISO 3846:2008 *Hydrometry -- Open channel flow measurement using 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 4360:2008 *Hydrometry -- Open channel flow measurement using triangular profile weirs*

ISO 4362:1999 *Hydrometric determinations -- Flow measurement in open channels using structures -- Trapezoidal broad-crested weirs*

ISO 4371:1984	*Measurement of liquid flow in open channels by weirs and flumes -- End depth method for estimation of flow in non-rectangular channels with a free overfall (approximate method)*
ISO 4373:2008	*Hydrometry -- Water level measuring devices*
ISO 4374:1990	*Liquid flow measurement in open channels -- Round-nose horizontal broad-crested weirs*
ISO 4375:2000	*Hydrometric determinations -- Cableway systems for stream gauging*
ISO 4377:2002	*Hydrometric determinations -- Flow measurement in open channels using structures -- Flat-V weirs*
ISO 6416:2004	*Hydrometry -- Measurement of discharge by the ultrasonic (acoustic) method*
ISO 8333:1985	*Liquid flow measurement in open channels by weirs and flumes -- V-shaped broad-crested weirs*
ISO 8368: 1999	*Hydrometric determinations – Flow measurements in open channels using structures – Guidelines for selection of structure*
ISO 9213:2004	*Measurement of total discharge in open channels -- Electromagnetic method using a full-channel-width coil*
ISO 9555-1:1994	*Measurement of liquid flow in open channels -- Tracer dilution methods for the measurement of steady flow -- Part 1: General*
ISO 9555-3:1992	*Measurement of liquid flow in open channels -- Tracer dilution methods for the measurement of steady flow -- Part 3: Chemical tracers*
ISO 9555-4:1992	*Measurement of liquid flow in open channels -- Tracer dilution methods for the measurement of steady flow -- Part 4: Fluorescent tracers*
ISO 9826:1992	*Measurement of liquid flow in open channels -- Parshall and SANIIRI flumes*
ISO 9827:1994	*Measurement of liquid flow in open channels by weirs and flumes -- Streamlined triangular profile weirs*
ISO 13550: 2002	*Hydrometric determinations -- Flow measurements in open channels using structures – Use of vertical underflow gates and radial gates*
ISO 14139: 2000	*Hydrometric determinations -- Flow measurements in open channels using structures – Compound gauging structures*
ISO 15769:2010	*Hydrometry -- Guidelines for the application of acoustic velocity meters using the Doppler and echo correlation methods*

3 Definitions

For the purposes of this part of ISO 1100, the definitions and symbols given in ISO 772 apply.

4 Units of measurement

The units of measurement used in this part of ISO 1100 are SI units in accordance with the appropriate parts of ISO 80000.

5 General requirements and considerations

Before commencing work on establishment and operation of a gauging station, the following requirements should be identified:

a) The range of levels required to be measured;
b) The range of flows required to be measured;
c) The customer's requirements for type of data;
d) The customer's requirements for timeliness of data;
e) The allowable uncertainty in the results;
f) Other potential users of the data;
g) Life expectancy of the station;
h) Available budget.

In addition to the above requirements, other constraints should be identified including the following:

a) local environmental issues;
b) accessibility of the site under all conditions of flow;
c) availability of power and communication links;
d) stability of the watercourse embankments;
e) stability of the watercourse bed;
f) identification of any proposed hydraulic modifications planned for the future; e.g. bridges, tunnels (including pipe crossings), harbours or piers.
g) potential of vandalism.
h) influence of submergence of the gauging site due to downstream impounding structures (lakes, dams, weirs)
i) potential stream losses in karst areas
j) aquatic weed growth in the watercourse

Knowledge of the above requirements and local constraints will ensure the provision of appropriate measurement and recording facilities as well as the adoption of an appropriate maintenance philosophy.

6 Water level (Stage) only gauging stations

6.1 Preliminary survey and selection criteria

The site selected for determination of stage should be selected according to the purpose for which the readings are required. Accessibility of the site and the availability of an observer if the gauge is to be non-recording are important criteria as is the availability of an appropriate power supply and data communication capabilities if the gauge is to be recording.

Gauges on lakes and reservoirs are normally located near the outlet, but should be located sufficiently far away from the zone where an increase in velocity causes a drawdown in water level. Gauges on large bodies of water should also be located so as to reduce the effect of strong winds which may cause misleading data which may not be representative of the body of water being measured. Hydraulic conditions (preferably a sufficiently long uniform stretch of water channel with

uniform bed topography) are an important factor in site selection in open channels, particularly where water levels may later be used in the computation of discharge. To ensure repeatability of the readings, ideally a bed or channel control shall be present, which itself should be stable and sensitive to changes in the level of the water. (For the purpose of monitoring water levels e.g. for flood warning purposes, this may not be a strict requirement).

6.1.1 Preliminary survey

A detailed examination of a large scale map of the area is required in the first instance; supported by an aerial survey if necessary although these may not be cost effective. This may be necessary if the area is not easily accessible by other means. Aerial surveys and or satellite imagery can be used as a basis for selecting potential sites, which can then be evaluated more precisely by ground reconnaissance. This will include a detailed visual examination. Enquiries should be made to determine whether or not any plans exist for the modification of the river reach which would modify the stream bed regime and would have an impact on the proposed gauging station.

Enquiries should also be made into any known past flow history including low water events, floods and other high water events, existence of any overflow area leading to flow by-passing the site, and very importantly, any knowledge of bed instability.

It may be appropriate to discuss any outline proposals at an early stage with the owners of the site identified to ensure they are amenable to the proposed installation.

Surveys of channel geometry and flow velocity patterns using an Acoustic Doppler Current Profiler may provide useful information.

Collection of data from hydrometric measurement stations is dominated by the use of telemetry; availability and quality of methods of data transmission should be investigated.

6.1.2 Selection criteria

A list of potential sites shall be established with their advantages and disadvantages identified. Site selection can then be made according to the criteria identified in 5 above. The establishment of the gauge zero shall be chosen so as to avoid negative readings. Thus it shall be set well below the level of the control feature. This zero point shall be correlated with a national datum through a station benchmark and should be checked annually with respect to this benchmark. This will ensure that, should loss or damage to the reference gauge occur, it can be replaced at exactly the same level.

The benchmark itself should be checked regularly in order to confirm that it still represents the national datum. The frequency of such checks shall be dependent on local soil dynamics.

6.2 Stage measurement and recording

6.2.1 General

The reading of stage may be required as a single instantaneous measurement, as a short series of instantaneous measurements or as a continuous or practically continuous record of the fluctuations of stage. The basis of any of the above should include the installation of a vertical staff gauge, a ramp gauge, or a wire-weight gauge.

6.2.2 Vertical staff gauge

A vertical staff gauge comprises a scale (normally 1 metre in length with graduations of 5 or 10 mm) marked on or securely attached to a suitable and stable vertical surface. The gauge should be made

of material with a low coefficient of expansion. Where the range of measurement required exceeds the capacity of a single vertical gauge, other gauges should be installed on the line of a cross-section normal to the direction of flow. The scales on such a series of stepped staff gauges should overlap by not less than 15 cm in order to safeguard continuity of readings and also to confirm their consistency with each other.

6.2.3 Ramp or inclined gauge

A ramp or inclined gauge consists of a scale marked on or securely attached to a suitable and stable inclined surface, which conforms closely to the contour of the river bank. The gauge should be made of material with a low coefficient of expansion. Throughout its length the gauge may lie on one continuous slope or may be a compound of two or more slopes. The gauge should lie on a line of a cross-section normal to the direction of flow.

6.2.4 Wire or tape weight gauge

A wire or tape weight gauge consists of a weight which is manually lowered until the weight touches the surface of the water. The wire or tape may be wound on a drum attached to a winding mechanism or it may be a hand reel. The wire or tape gauge can be equipped with electrical contacts to improve measurements, when there is a large vertical distance between the measuring point and the water surface.

6.2.5 Other methods

It may be appropriate in some cases to use alternative methods for single or continuous determinations of water level. Such methods, including maximum level gauges, are described in ISO 4373:2008.

6.2.6 Stage recording

Customer requirements shall dictate the method of recording stage. It may be that a single record of stage taken daily and read manually will suffice in which case a suitable person to do this work should be identified.

It is more common to provide a continuous record of stage utilising water level sensors, such as floats, pressure transducers, and echo sounders, interfaced with a digital recorder (logger or telemetry) or analogue recorder (chart). Details of such systems, including the use of stilling wells, can be found in ISO 4373: 2008.

When a recorder is used, visits by the observer should be made from time to time to ensure satisfactory performance of the sensor and recorder. It is recommended that the observer notes the time and date of such checks along with the staff gauge and recorder values. It is essential that the staff gauge itself is maintained in such a way as to be safely accessible and directly legible to the observer.

Comments on the state of the channel, river banks, presence of any obstruction, prevailing flow conditions, etc. should also be noted.

The frequency of such visits shall be subject to local rules but it is important that a site visit should follow a major hydraulic event to confirm continued measurement and recording of data.

7 Stage-discharge gauging stations

7.1 Principle

When records of water level are to be used as a basis for computation of discharge, the relation between water level and flow must be determined.

In a stable channel with an appropriate control feature which is stable and sensitive, a single relation may exist between water level and discharge. In this case, the relation can be determined by taking discharge measurements throughout the range of levels and flows required to be measured.

Several techniques are available for this purpose including, but not limited to, current meter gauging and float gauging (ISO 748), dilution gauging (ISO 9555-1, ISO 9555-3, ISO 9555-4), transit time acoustic methods (ISO 6416), Doppler velocity meters (ISO 15769), electromagnetic current meters (ISO/TS 15768) or acoustic Doppler current meters (ISO/TS 24154).

The frequency of any maintenance or operational performance shall be such that the accuracy and timeliness of data provision meets the user's requirements.

7.2 Main elements of a stage – discharge gauging station

7.2.1 General

The main elements required for the purpose of determining discharge in a stream from water level records are as follows:

a) a stage measuring device (see 6.2.1 above)
b) a stage sensing and recording device (see 6.2.6 above)
c) a control section or reach (see 7.2.2)
d) a section suitable for discharge measurements (see 7.1 and 7.2.3)
e) discharge measurements for defining a stage-discharge relation (see 7.2.4)

7.2.2 Control section or control reach

A control section or control reach of a channel is a natural or artificial section or reach whose physical characteristics can be measured and used to determine the relationship between stage and discharge.

In a control section any change in the stage downstream of the control does not affect the stage upstream of the control. Whatever the discharge in the control section, a critical stage can be determined.

It shall be stable, i.e. no change shall occur over time to its physical characteristics. Regular inspection of the control section shall be carried out to ensure that no changes have taken place which would alter the relationship between stage and discharge at this site.

More than one control section may be required for discharge measurement at one gauging station particularly when the range of levels and flows is substantial. For example, under certain flow conditions a downstream control reach may create a water level which submerges an upstream weir which had been acting as a control.

The sensitivity of a control section or reach shall be such that any significant change in discharge shall result in either a measurable change in stage (for control sections) or a measurable change in stage at one extremity of the control reach.

7.2.3 Section suitable for discharge measurements

Regardless of the method of measurement, the discharge through the discharge measuring section shall be the same as the discharge normal to the reference staff gauge, over the range of flows to be measured. Different measuring sections or different methods of measurement may be used to cover the range of flows required.

A full description of a site suitable for measurement of discharge using current meters or floats is given in ISO 748. Site requirements for dilution gauging are given in ISO 9555 Parts 1, 3, and 4. Site requirements for the application of acoustic transit time velocity measurement techniques are given in ISO 6416. Site requirements for the application of acoustic velocity meters using the Doppler and echo correlation techniques are given in ISO 15769. Site requirements for the application of electromagnetic techniques are given in ISO 9213.

7.2.4 Discharge measurements

Discharge measurements using the above techniques shall be related to a stage reading taken at the beginning and end of the discharge measurement and during the measurement if the stage is changing rapidly or inconsistently. When sufficient numbers of discharge measurements have been taken, a stage discharge relationship can be computed (see ISO 1100-2). Subsequent to the formulation of this stage-discharge relationship, only occasional discharge measurements need be taken at flows in the normal range to confirm the robustness of the relationship unless the site is subject to shifting control conditions. Opportunities should be taken to carry out discharge measurements in extreme events in order to extend the stage discharge relationship.

Discharge measurements made using the velocity-area methods can be performed using rotating-element current meters, electromagnetic current meters, acoustic Doppler velocimeters, or acoustic Doppler current profilers. These can be made by wading the stream or small river with the meter mounted to a wading rod or by suspending the meter and a sounding weight from a bridge, cableway (see ISO 4375) or stationary boat. Velocity-area methods using floats are another option when the presence of floating debris or very turbulent conditions precludes the use of current meters. Acoustic Doppler current profilers deployed from powerboats, remote-control boats, or tethered rafts also can be used (see ISO/TS 24154). Tethered rafts typically are deployed from bridges or cableways. Another variation of velocity area methods is the slope-area method, which is typically used to compute flood discharge indirectly by surveying the cross-sectional properties and water-surface profile after the flood (see ISO 1070). The applicable conditions for using the different equipment and techniques are listed in Annex-1

Where a pre-surveyed cross-section is used for the purpose of discharge measurement, then the section shall be checked following any major hydraulic events e.g. over and above a bank full flow.

7.2.5 Tracer dilution methods for measuring discharge

Dilution techniques using chemical or fluorescent tracers can be used in small and medium-sized mountain stream, which do not have suitable reaches for making a discharge measurement using velocity-area methods. See Annex-1 for applicable conditions.