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Hydrometry — Open channel flow measurement using triangular profile weirs

Hydrométrie — Mesure de débit des liquides dans les canaux découverts au moyen de déversoirs à profil triangulaire

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 2, *Flow measurement structures*.

This fourth edition cancels and replaces the third edition (ISO 4360:2008), which has been technically revised.

The main changes compared to the previous edition are as follows.

— The calculations and examples have been updated to correct an error in the previous edition.

— A URN has been added containing a spreadsheet that has been developed to support the standard and facilitate calculation of discharge and uncertainty (see Annex C).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Hydrometry — Open channel flow measurement using triangular profile weirs

1 Scope

This document specifies methods for the measurement of the flow of water in open channels under steady flow conditions using triangular profile weirs. The flow conditions considered are steady flows which are uniquely dependent on the upstream head and non-modular (drowned) flows which depend on downstream as well as upstream levels.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 772, *Hydrometry — Vocabulary and symbols*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols

Symbol	Unit of measurement	Quantity
α	dimensionless	Coriolis coefficient
A	m^2	area of approach channel
B	m	width of approach channel
b	m	breadth of weir crest perpendicular to flow direction
C_d	dimensionless	coefficient of discharge
C_v	dimensionless	coefficient of velocity
$C_v f$	dimensionless	combined coefficient of velocity for non-modular flow
f	dimensionless	non-modular (drowned) flow reduction factor
g	m/s^2	acceleration due to gravity
H	m	total head relative to crest level
h	m	gauged head relative to crest level (upstream head is inferred if no subscript is used)
N	dimensionless	number of measurements in a set
p	m	height of weir (difference between upstream mean bed level and crest level)
Q	m^3/s	volumetric rate of flow
$u(\ )$	as parameter	standard uncertainty in parameter specified in parentheses

Symbol	Unit of measurement	Quantity
$u^*(\ )$	%	percentage uncertainty in parameter specified in parentheses
$\bar{v}$	m/s	mean velocity
U	%	expanded percentage uncertainty

Subscripts:

0 datum

1 upstream

2 downstream

c combined

p measured crest tapping head above crest level

max maximum

min minimum

5 Principle

The discharge over a triangular profile weir is a function of the upstream head on the weir (for modular flow), upstream and downstream head (for non-modular flow), the geometrical properties of the weir and approach channel and the dynamic properties of the water.

6 Installation

6.1 General

The required conditions regarding selection of site, installation conditions, the measuring structure, the approach channel, the downstream channel, maintenance, measurement of head, and gauge wells which are generally necessary for flow measurement are given in the following subclauses.

6.2 Selection of site

A preliminary survey shall be made of the physical and hydraulic features of the proposed site, to check that it conforms (or can be made to conform) to the requirements necessary for accurate measurement by a weir.

Particular attention should be paid to the following features in selecting the site:

a) availability of an adequate length of channel of regular cross-section;

b) the existing velocity distribution;

c) the avoidance of a steep channel, if possible;

d) the effects of any raised upstream water level due to the measuring structure;

e) conditions downstream including such influences as tides, confluences with other streams, sluice gates, mill dams and other controlling features which might cause submerged flow;

f) the impermeability of the ground on which the structure is to be founded, and the necessity for piling, grouting or other means of controlling seepage;

g) the necessity for flood banks to confine the maximum discharge to the channel;

h) the stability of the banks, and the necessity for trimming and/or revetment in natural channels;

i) the clearance of rocks or boulders from the bed of the approach channel;

j) the effect of wind; wind can have a considerable effect on the flow in a river or over a weir, especially when these are wide and the head is small and when the prevailing wind is in a transverse direction.

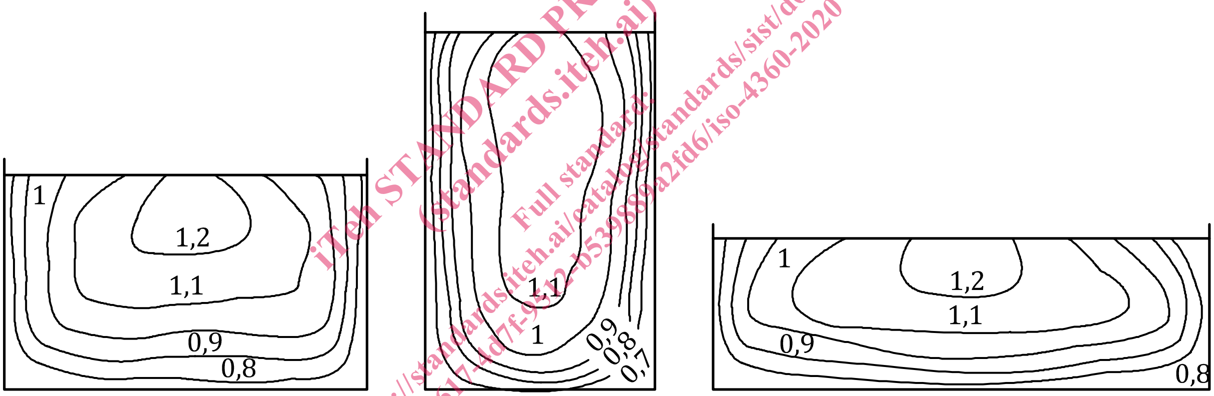
If the site does not possess the characteristics necessary for satisfactory measurement, the site shall be rejected unless suitable improvements are practicable.

If an inspection of the stream shows that the existing velocity distribution is regular, then it may be assumed that the velocity distribution will remain satisfactory after the construction of a weir.

If the existing velocity distribution is irregular and no other site for a gauge is feasible, due consideration shall be given to checking the distribution after the installation of the weir and to improving it if necessary.

A complete and quantitative assessment of velocity distribution may be made by means of a current-meter, other point velocity measurement technique or an acoustic Doppler profiler. Information about the use of current-meters is given in ISO 748[1] and information on Doppler profilers in ISO 24578[2].

Figure 1 gives examples of satisfactory velocity distributions.



NOTE The contours refer to values of local flow velocity relative to the mean cross-sectional velocity.

Figure 1 — Examples of satisfactory velocity distributions

6.3 Installation conditions

6.3.1 General

The complete measuring installation consists of an approach channel, a measuring structure and a downstream channel. The conditions of each of these three components affect the overall accuracy of the measurements.

Installation requirements include features such as the surface finish of the weir, the cross-sectional shape of the channel, the channel roughness and the influence of control devices upstream or downstream of the gauging structure.

The distribution and direction of velocity have an important influence on the performance of the weir, these factors being determined by the features mentioned above.

Once an installation has been installed, the user shall prevent any change which could affect the discharge characteristics.

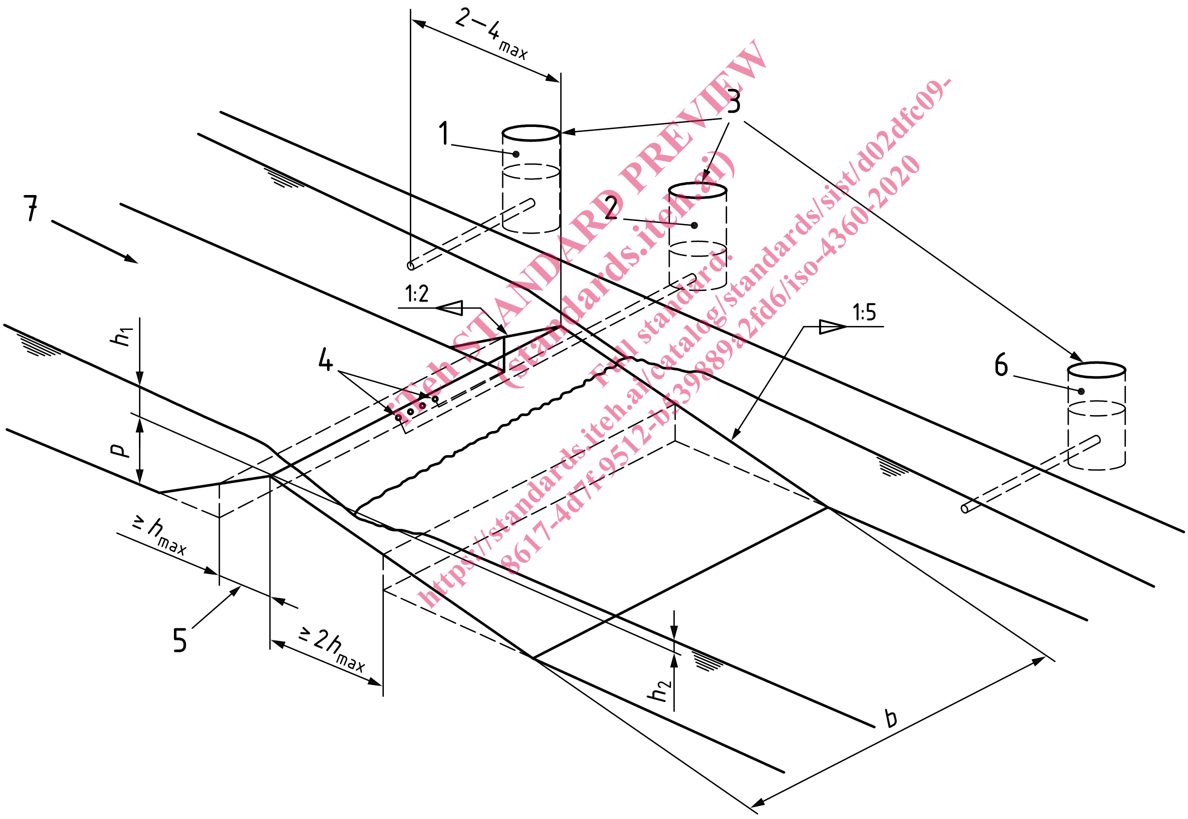
6.3.2 Measuring structure

The structure shall be rigid and watertight and capable of withstanding flood flow conditions without distortion or fracture. It shall be at right angles to the direction of flow and shall conform to the dimensions given in the relevant clauses.

The weir comprises an upstream slope of 1 (vertical) to 2 (horizontal) and a downstream slope of 1 (vertical) to 5 (horizontal). The intersection of these two surfaces forms a straight line crest, horizontal and at right angles to the direction of flow in the approach channel. Particular attention shall be given to the crest itself, which shall possess a well-defined corner of durable construction. The crest may be made of pre-formed sections, carefully aligned and jointed, or may have a non-corrodible metal insert, as an alternative to in situ construction throughout.

The dimensions of the weir and its abutments shall conform to the requirements indicated in Figure 2. Weir blocks may be truncated but not so as to reduce their dimensions in plan to less than h_{max} for the 1:2 slope and 2 h_{max} for the 1:5 slope.

Figure 2 shows the general arrangement of the triangular profile weir.



Key

1 upstream head measurement

2 crest tapping head measurement

3 gauge wells

4 crest tappings

5 limit of truncated sections

6 downstream head measurement

7 direction of flow

Figure 2 — General arrangements of the triangular profile weir

6.3.3 Approach channel

On all installations, the flow in the approach channel shall be smooth, free from disturbance and shall have a velocity distribution as satisfactory as possible over the cross-sectional area. This can usually be verified by inspection or measurement. In the case of natural streams or rivers, this can only be attained by having a long straight approach channel free from projections into the flow. Figure 1 gives examples of satisfactory velocity distributions.

The following general requirements shall be complied with.

a) As the altered flow conditions due to the construction of the weir might cause a build-up of shoals of debris upstream of the structure, which in time might affect the flow conditions, the likely consequential changes in the water level shall be taken into account in the design of gauging stations.

b) In an artificial channel, the cross-section shall be uniform and the approach channel shall be straight for a length equal to at least 5 times its water-surface width.

c) In a natural stream or river, the cross-section shall be reasonably uniform and the approach channel shall be straight for a sufficient length to ensure a satisfactory velocity distribution.

d) If the entry to the approach channel is through a bend, or if the flow is discharged into the channel through a conduit or a channel of smaller cross-section, or at an angle, then a longer length of straight approach channel is likely to be required to achieve a regular velocity distribution.

e) Flow conditioning devices such as baffles and flow straighteners shall not be installed closer to the points of measurement than a distance 10 times the maximum head to be measured.

f) Under certain conditions, a standing wave can occur upstream of the gauging device, for example if the approach channel is steep. Provided that this wave is at a distance of not less than 30 times the maximum head upstream, flow measurement is feasible, subject to confirmation that a regular velocity distribution exists at the gauging station and that the Froude number in this section is no more than 0,6.

If a standing wave occurs within this distance, the approach conditions and/or the gauging device shall be modified.

6.3.4 Downstream channel

The channel downstream from the structure is usually of no importance if the weir has been designed so that the flow is modular (i.e. unaffected by tailwater level) under all operating conditions. A downstream gauge may be provided to measure tailwater levels to determine if and when non-modular flow occurs. The downstream gauge shall be installed sufficiently far downstream to avoid excessively disturbed flow and be truly representative of downstream channel conditions. This shall be determined on a site by site basis.

In the event of the possibility of scouring downstream, which phenomenon can also lead to the instability of the structure, particular measures to prevent this happening should be adopted. The design of such measures is outside the scope of this document.

A crest tapping and separate gauge well shall be fitted if the weir is designed to operate in a non-modular condition or if there is a possibility that the weir could drown in the future.

The latter circumstance could arise if the altered flow conditions due to the construction of the weir have the effect of building up shoals of debris immediately downstream of the structure or if river works are carried out downstream at a later date.

Fish passage baffles can be installed on the downstream face of the weir to improve fish passage as set out in ISO/TR 19234[3].