INTERNATIONAL STANDARD

ISO 8368

Second edition
1999-04-01

Hydrometric determinations — Flow measurements in open channels using structures — Guidelines for selection of structure

Déterminations hydrométriques — Mesure de débit dans les canaux découverts au moyen de structures — Lignes directrices pour le choix des structures

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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.

International Standard ISO 8368 was prepared by Technical Committee ISO/TC 113, *Hydrometric determinations*, Subcommittee SC 2, *Notches, weirs and flumes*.

This second edition cancels and replaces the first edition (ISO 8368:1985). This second edition of ISO 8368 was prepared in order to bring the techniques described up to date. The format has been improved to make the information easier to interpret.

Hydrometric determinations — Flow measurements in open channels using structures — Guidelines for selection of structure

1 Scope

This International Standard gives guidelines for selection of a particular type of flow-gauging structure for measurement of liquid flow in open channels. It sets out the factors, and summarizes the parameters which may influence such a selection.

NOTE In general, a flow-gauging structure is used when high accuracy is required for continuous records of flow.

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 listed below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

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

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

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

ISO 3847, *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, *Liquid flow measurement in open channels — Rectangular, trapezoidal and U-shaped flumes.*

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

ISO 4362, *Measurement of liquid flow in open channels — Trapezoidal profile weirs.*

ISO 4371, *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 4374, *Liquid flow measurement in open channels — Round-nose horizontal broad-crested weirs.*

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

ISO 8333, *Liquid flow measurement in open channels by weirs and flumes — V-shaped broad-crested weirs.*

ISO 9826:1992, *Measurement of liquid flow in open channels — Parshall and SANIIRI flumes.*

ISO 9827, *Measurement of liquid flow in open channels by weirs and flumes — Streamlined triangular-profile weirs.*

ISO 13550 , *Hydrometric determinations — Flow measurements in open channels using structures — Use of vertical underflow gates and radial gates.*

ISO 14139, *Hydrometric determinations — Flow measurements in open channels using structures — Compound gauging structures.*

3 Terms, definitions and symbols

For the purposes of this International Standard, the terms, definitions and symbols together with the corresponding units of measurement given in ISO 772 apply.

4 Types of structure

The following types of structure can be used for the purpose of liquid flow measurement:

a) thin-plate weirs:

   1) rectangular;

   2) V-notch.

b) broad-crested weirs:

   1) round-nose horizontal;

   2) rectangular horizontal;

   3) V-shaped.

c) triangular-profile weirs.

d) streamlined triangular-profile weirs.

e) flat-V weirs.

f) flumes:

   1) rectangular;

   2) trapezoidal;

   3) U-throated;

   4) Parshall and SANIIRI.

g) end-depth method:

   1) rectangular channel;

   2) non-rectangular channel (approximate method).

h) trapezoidal-profile weirs.

i) compound gauging structures.

j) vertical underflow gates and radial gates.

Diagrams showing the construction of a particular type of flow-gauging structure are given in the appropriate International Standard listed in clause 2.

5 Factors affecting choice

5.1 General

The factors which affect choice can be considered under the following headings:

a) purpose;

b) range of flow;

c) afflux;

d) size and nature of channel;

e) channel slope and sediment load;

f) operation and maintenance;

g) environmental impact;

h) passage of fish;

i) cost.

5.2 Purpose

Table 1 tabulates the various structures and indicates some of the purposes for which they may be applicable, together with guidelines to their limitations.

The purpose for which the structure is required will determine the range of flows and accuracies which is necessary. The accuracy in a single determination of discharge depends upon the estimation of the component uncertainties involved.

In broad terms, thin-plate weirs will have a range of uncertainties from 1 % to 4 %, flumes and certain types of weirs will have a range from 2 % to 5 % and end methods and other weirs will have a range from 4 % to 10 %. Deviations from the construction, installation or use as laid down in the appropriate International Standard will result in measurement errors.

5.3 Range of flow

It is necessary to consider the relation between maximum flow and minimum flow when deciding which type of structure to use, and an indication of the range of some typical structures is given in Table 2. For the best overall accuracy over a wide range of small discharges, a thin-plate V-notch weir should be used in preference to a thin-plate rectangular notch or rectangular full-width weir. For a wide range of larger discharges, a trapezoidal flume, a flat-V weir or a triangular-profile weir should be used in preference to a broad-crested weir, free overfall or rectangular-throat flume.

5.4 Afflux

The rise in level immediately upstream of, and due to, a structure may interfere with the flow system and cause drainage problems, or limit the effectiveness of irrigation systems, or cause extra pumping costs. In addition, the aquatic habitat upstream of the structure may be adversely affected. A number of structures have been developed with high coefficients of discharge and whose accuracy is relatively unimpaired by high submergence ratios. The triangular-profile and flat-V weirs, and flumes are examples of this type of structure.

Table 1 — Applications and limitations of structures

Type	International Standard	Typical uncertainties in computed discharge, %	Modular[1] limit	Limitations	Typical application
Thin-plate weirs	ISO 1438-1	1 to 4	[2]	2 [3]	Laboratory, pump tests, sediment free water, small streams, and for use in hydraulics laboratories.
Broad-crested weirs a) rectangular profile b) round-nose horizontal crest c) V-shaped	 ISO 3846 ISO 4374 ISO 8333	3 to 5	 66 % 80 % 80 %	 1,5 [3] 1,5 [3] 1,5 3,0 [3]	Broad-crested weirs are best used in rectangular channels, but they can be used with good accuracy in non-rectangular channels if a smooth, rectangular approach channel extends upstream of the weir for a distance not less than twice the maximum head. Irrigation channels with little fall available and wide range of flow.
Triangular-profile weirs	ISO 4360	2 to 5	75 %	3,5 [3]	Hydrometric networks and principal irrigation channels
Streamlined triangular-profile weirs	ISO 9827	2 to 5	?	?	Irrigation works and minor channels
Flat-V weirs	ISO 4377	2 to 5	70 %	2,5 [3]	Hydrometric works with wide range of flow
Compound gauging structures	ISO 14139	2 to 5	Varies	Vary	Hydrometric works with wide range of flow
Trapezoidal-profile weirs	ISO 4362	4 to 8	65 % to 85 % [4]	1,3 [3]	Where ease of construction is an important factor. Irrigation works and minor channels.
Vertical underflow gates and radial gates	ISO 13550	4 to 8	[2]	See ISO 13550	Situations where a near constant upstream water level is required.
End-depth method a) rectangular b) non-rectangular	 ISO 3847 ISO 4371	 5 to 10	[2]	[6]	Where accuracy may be relaxed for simplicity and economy.
Long-throated flumes	ISO 4359	2 to 5	74 %	0,7	Flumes can be used in channels of any shape if flow conditions in the approach channel are reasonably uniform and steady. Sediment-laden channels, flow with debris, flow with migratory fish, conduits and partially filled pipes, flow in sewers.
Parshall and SANIIRI flumes	ISO 9826	4 to 8	60 % to 80 %	See ISO 9826	Flumes can be used in channels of any shape if flow conditions in the approach channel are reasonably uniform and steady. Hydrometric networks and water distribution channels.

[1] The modular limit of each device requires careful consideration. The submergence ratio should be checked for the whole range of flows to be measured and compared with values for the modular limit given in Table 1.

[2] Nappe to be fully aerated.

[3] Maximum H/p, where H is the total upstream head and p is the height of the weir.

[4] Depends on geometry.

[5] Maximum A_t/A_u, where A_t and A_u are the cross-sectional areas of the throat and approach channel, respectively.

[6] Not applicable.

Table 2 — Comparative discharges for various weirs and flumes

Structure	***D***[1)] m	***p***[1)] m	***b***[1)] m	***m***[1)] (slope)	***L***[1)] m	**Discharge** m³/s min.	max.
Weirs							
Thin-plate, full width	- -	0,2 1,0	1,0 1,0	- -	- -	0,005 0,005	0,67 7,70
Thin-plate, contracted	- -	0,2 1,0	1,0 1,0	- -	- -	0,009 0,009	0,45 4,90
Thin-plate, V-notch	-	-	θ = 90°	-	-	0,001	1,80
Round-nose broad-crest	- -	0,15 1,0	1,0 1,0	- -	0,6 5,00	0,030 0,100	0,18 3,13
Rectangular broad-crested	- -	0,2 1,0	1,0 1,0	- -	0,8 2,0	0,030 0,130	0,26 3,07
V-shaped broad-crested	- -	0,30 0,15	θ = 90° θ = 150°		1,50 1,50	0,002 0,007	0,45 1,68
Triangular profile	- -	0,2 1,0	1,0 1,0	- -	- -	0,010 0,010	1,17 13,00
Flat-V	- -	0,2 1,0	4 80	1 : 10 1 : 40	- -	0,014 0,055	5,00 630
Flumes							
Rectangular	-	0,0	1,0	-	2,0	0,033	1,70
Trapezoidal	-	0,0	1,0	5 : 1	4,0	0,270	41,00
U-throated	0,3 1,0	0,0 0,0	0,3 1,0	- -	0,6 2,0	0,002 0,019	0,07 1,40

NOTE Dimensions are given as examples for comparison purposes only.

1) *D*: diameter of U-shaped throat; *p*: height of weir; *b*: breadth of weir or flume throat; *m*: side slopes: 1 vertical; *m* horizontal; *L*: length of flume throat or weir crest.