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Measurement of liquid flow in open channels — General guidelines for selection of method

Mesure de débit des liquides dans les canaux découverts — Lignes directrices générales pour la sélection de la méthode

ISO

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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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 8363, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 113, *Hydrometric measurements,* Subcommittee SC 1, *Velocity area methods.*

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.6.2.2 of part 1 of the IEC/ISO Directives) as a "prospective standard for provisional application" in the field of hydrometric measurements because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

This first edition cancels and replaces the first edition of ISO 8363:1986, which has been technically revised.

Annex A of this Technical Report is for information only.

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Measurement of liquid flow in open channels — General guidelines for selection of method

1 Scope

This Technical Report gives general guidelines for the selection of a suitable method for measurements of liquid flow in open channels. More specific guidelines are contained in International Standards relevant to each method.

2 Methods of measurement

Methods which are suitable for measurements of liquid flow in open channels and which form the subjects of International Standards[1)] are as follows:

1) Velocity-area method by wading.

2) Velocity-area method from a bridge.

3) Velocity-area method using a cableway.

4) Velocity-area method using a static boat.

5) Velocity-area method using a moving boat.

6) Velocity-area method using floats.

7) Slope-area method.

8) Ultrasonic method.

9) Electromagnetic method.

10) Dilution method with a chemical tracer.

11) Dilution method with a radioactive tracer.

12) Dilution method with a fluorescent tracer.

13) Cubature method.

14) Thin-plate weirs (sharp crest, V-notch).

15) Thin-plate weirs (sharp crest, rectangular, with suppressed side contractions).

16) Thin-plate weirs (sharp crest, rectangular, with side contractions).

1) See annex A for a list of these International Standards.

17) Weirs (broad-crested with sharp upstream edge).

18) Weirs (broad-crested with rounded upstream edge).

19) Weirs (triangular profile).

20) Weirs (streamlined triangular profile).

21) Weirs (triangular profile, flat-V).

22) Weirs (V-shaped, broad-crested).

23) Weirs (trapezoidal profile).

24) Flumes (rectangular-throated).

25) Flumes (trapezoidal-throated).

26) Flumes (U-shaped throat).

27) Flumes (Parshall and SANIIRI).

28) Free overfalls, end-depth method (rectangular and non-rectangular channels).

3 Principles of measurement

3.1 Velocity-area methods

3.1.1 Methods using stationary meters

The cross-section of an open channel is divided into several segments. The width of each segment and the depth and mean velocity at a vertical in each segment are measured. The total discharge through the cross-section is then the sum of the products of velocity, width and depth of each segment.

3.1.2 Moving boat method

The moving boat method is a modification of the velocity-area method using a stationary current meter. A current meter is suspended from a boat at a constant depth below the water surface while the boat crosses the river on a chosen transit line. During the crossing, the current meter reading, depth, distance from bank and time of observation are recorded at intervals. The velocities near the surface are adjusted to give the mean velocity perpendicular to the transit line at each position across the channel. The total discharge through the channel at the transit line is the sum of the products of the mean velocity, width and depth of each segment in which a velocity was recorded.

3.1.3 Method using floats

When measurements using current meters are not feasible, the velocity can be estimated by noting the time taken for a float to travel a known distance.

3.1.4 Ultrasonic method

The velocity of sound in water is measured by simultaneously transmitting pulses in both directions through the water from transducers located in the bank on each side of the river. Alternatively, the two transducers can be on the same bank with a reflector or transponder on the other. The transducers are located so that the pulses in one direction travel against the flow and in the other direction with the flow. The difference between the velocities of the ultrasonic waves is related to the speed of the flowing water at the elevation of the transducers. This velocity can be related to the average velocity of flow over the whole cross-section, and by relating the cross-sectional area and water level, the discharge may be deduced from measurements of water velocity and stage.

3.1.5 Electromagnetic method using a full channel width coil

Small electrical potentials are set up between opposite banks of a river by means of electromagnetic induction as the water flows through a vertical magnetic field. The field is set up by a coil buried below the bed or bridged across the river. The potential generated is proportional to the width of the river, the magnetic field and the mean velocity in the cross-section. The discharge is then obtained by multiplying this mean velocity of the cross-sectional area of flow.

3.2 Measuring structures

3.2.1 Weirs

A relation between head over the crest of the weir and the discharge is established, usually in a laboratory and applied to the field installation. The head over the weir is measured and this value inserted in the appropriate formula to obtain a value of discharge. If the flow is non-modular (the water level downstream is sufficiently high to influence the water level upstream of the weir and the discharge), the head over the weir and the head at the crest or downstream are measured to determine discharge.

3.2.2 Flumes

A relation between the head upstream of the throat of the flume and the discharge is established. Thereafter, as with weirs, the discharge is determined from the measurement of the upstream water level. If the flow is non-modular, measurements of head both upstream and downstream are necessary.

3.2.3 Free overfalls (end-depth method)

In a device creating abrupt drop in the flow, the channel depth at the brink of the drop and the flow area of the channel at the brink section are measured. The discharge is then determined using the appropriate equation.

3.3 Dilution methods

A tracer liquid is injected into a stream, and at a point further downstream, where turbulence has mixed the tracer uniformly throughout the cross-section, the water is sampled. The ratio of the concentrations between the solution injected and the water at the sampling station is a measure of the discharge.

3.4 Other methods

3.4.1 Slope-area method

The cross-section of a channel is measured at several sections along a reach which is as straight and as uniform as practicable. The roughness of the channel is estimated after examination of the channel or measurement of the bed features. The discharge is determined by measuring the water level at two or three sections a known distance apart and inserting the slope, breadth, depth and roughness in an open channel flow equation (for example that of Chezy or Manning).

3.4.2 Cubature method

This method is restricted to situations where flow causes a change in water level and the volume of stored water. The water level and surface area of the stored water are measured on two occasions at a known time interval. The mean discharge is obtained by dividing the volume of water stored, or released from storage, by the time interval.

4 Applicable conditions for selection of method

The selection of the most suitable method for measuring discharge should be based on the applicable conditions indicated in table 1. If the relevant International Standards are complied with, the minimum uncertainties in the measurements will generally be within the limits quoted. The symbols used in table 1 are explained in table 2.

Table 1 — Applicable conditions

Method			Criteria						Uncertainty	
No.	Description	Relevant International Standard	Width	Depth	Velocity	Sediment load	Approach condition	Time factor	Minimum percentage	Comment
1	Velocity-area, by wading	ISO 748	L, M, S	S	S		b, c, d	J, K	± 5	A, B
2	Velocity-area, from bridge	ISO 748	L, M, S	L, M, S	L, M, S		b, c, d	J, K	± 5	A, B, C, D
3	Velocity-area, cableway	ISO 748	L, M, S	L, M, S	L, M, S		b, c, d	J, K	± 5	A, B, C
4	Velocity-area, static boat	ISO 748	L, M, S	L, M	L, M, S		b, c, d	J, K	± 5	A, B, C, E
5	Velocity-area, moving boat	ISO 4369	L, M	L, M	L, M, S		b, c, d	J	± 10	A, B, E
6	Velocity-area, floats	ISO 748	L, M, S	L, M, S	L, M, S		b, c, d	J, K	± 10	F
7	Slope-area	ISO 1070	L, M	L, M	L, M		b, c, d	K, N	± 10	Q
8	Ultrasonic	ISO 6416	L, M, S	L, M	L, M, S	R	b, c, d	G, J	± 5	H, U
9	Electromagnetic	ISO 9213	M, S	L, M, S	L, M, S		b, d	G, J	± 5	H, I
10	Dilution, chemical tracer	ISO 9555-1 and ISO 9555-3	M, S	M, S	M, S		c, g, k	K, N	± 3	
11	Dilution, radioactive tracer	ISO 9555-1 and ISO 9555-2	M, S	M, S	M, S		c, g, k	K	± 3	
12	Dilution, fluorescent tracer	ISO 9555-1 and ISO 9555-4	M, S	M, S	M, S		c, g, k	K	± 3	
13	Cubature	ISO 2425						K	± 10	H
14	Thin-plate weirs, sharp crest, V-notch	ISO 1438-1	S	S	S	I	a, b, e, j	J, G	± 1	
15	Thin-plate weirs, sharp crest, rectangular, suppressed	ISO 1438-1	M, S	S	S	I	a, b, e, f, j	J, G	± 3	
16	Thin-plate weirs, sharp crest, rectangular	ISO 1438-1	M, S	S	S	I	a, b, e, f, j	J, G	± 3	
17	Weirs, broad-crested with sharp upstream edge	ISO 3846	M, S	S	M, S	I	a, b, e, f, j	J, G	± 5	
18	Weirs, broad-crested with rounded upstream edge	ISO 4374	M, S	S	M, S	I	a, b, e, h, j	J, G	± 5	
19	Weirs, triangular profile	ISO 4360	M, S	M, S	M, S	I	a, b, e, h, j	J, G	± 5	
20	Weirs, streamlined triangular profile	ISO 9827	M, S	M, S	M, S	I	a, b, e, j	J, G	± 5	
21	Weirs, triangular profile, flat-V	ISO 4377	M, S	M, S	M, S	I	a, b, e, j	J, G	± 5	
22	Weirs, V-shaped, broad-crested	ISO 8333	M, S	M, S	M, S	I	a, b, i	J, G	± 5	
23	Weirs, trapezoidal profile	ISO 4362	M, S	M, S	M, S	I	a, b, e	J, G	± 5	
24	Flumes, rectangular	ISO 4359	M, S	M, S	M, S	I	a, b	J, G	± 5	
25	Flumes, trapezoidal	ISO 4359	M, S	M, S	M, S	I	a, b	J, G	± 5	
26	Flumes, U-shaped	ISO 4359	M, S	M, S	M, S	I	a, b, i	J, G	± 5	
27	Flumes, Parshall and SANIIRI	ISO 9826	M, S	S	M, S	I	a, b, e, i	J, G	± 5	
28	Free overfalls, rectangular and non-rectangular channels (end-depth method)	ISO 3847 and ISO 4371	M, S	M, S	M, S		a, b, e, j	J, G	± 10	

Table 2 — Explanation of symbols used in table 1

Symbol	Definition
a	Flow should be subcritical
b	Flow should have no cross-currents
c	Channel should be relatively free from vegetation
d	Channel should be fairly straight and uniform in cross-section
e	Channel should be fairly straight and symmetrical in cross-section for about 10 channel widths upstream
f	Channel should have vertical walls and a level floor for a distance upstream of not less than 10 times the width of the nappe at maximum head
g	Flow in the channel should be turbulent (even including a hydraulic jump) to ensure mixing
h	Channel should be rectangular for a distance upstream of at least twice the maximum head
i	Channel should be nearly U-shaped
j	Velocity distribution should be fairly uniform
k	Channel should be free from recess in the banks and depressions in the bed
A	For velocity-area method, with velocity observed at 0,6 times the depth, or with two-point method, the minimum uncertainty may be up to 5 %
B	For velocity-area method, with velocity observed at surface, the minimum uncertainty may be up to 10 %
C	Corrections may be required because of distance or air- and wet-line effects
D	Major error can be caused by pier effects
E	Major error can be due to drift, obstruction of boat and heaving action
F	This method is recommended for use only when the effect of the wind is small and where no other will serve. Such conditions are likely to be so variable that no representative accuracies can be quoted, but usually the accuracy of this method is lower than conventional methods using current-meters and higher than the slope-area method
G	Method suitable for more frequent discharge measurements
H	Method suitable for reverse flows
I	Heavy sediment concentration not permissible
J	Quick method (less than 1 h)
K	Slow method (1 h to 6 h)
L	Large width (more than 50 m) or high velocity (more than 3 m/s) or large depth (more than 5 m)
M	Medium width (between 5 and 50 m) or medium velocity (between 1 m/s and 3 m/s) or medium depth (between 1 m and 5 m)
N	Very slow method (more than 6 h)
Q	Approximate method used when velocity-area method not feasible and slope can be determined with sufficient accuracy
R	Suspended material concentration should continue to be low in order to avoid too large a loss of acoustic signal; for the same reason, the flow should be free from bubbles
S	Narrow width (less than 5 m) or shallow depth (less than 1 m) or low velocity (less than 1 m/s)
T	May be used in rivers with weed growth and moving bed material
U	Measuring section must have stable bed

Annex A
(informative

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