International Standard ISO 8363

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Liquid flow measurement in open channels — General guidelines for the selection of methods

Mesure de débit des liquides dans les canaux découverts — Principes directeurs généraux pour le choix d'une méthode

First edition — 1986-11-01

UDC 532.57 : 532.543 **Ref. No. ISO 8363-1986 (E)**

Descriptors : liquid flow, water flow, open channel flow, flow measurement.

Price based on 6 pages

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8363 was prepared by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Liquid flow measurement in open channels — General guidelines for the selection of methods

1 Scope and field of application

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

2 Methods of measurement

Methods which are suitable for liquid flow measurements 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 (continuous injection).

11) Dilution method with a chemical tracer (sudden injection).

12) Dilution method with a radioactive tracer (sudden injection).

13) Dilution method with a radioactive tracer (continuous injection).

14) Cubature method.

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

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

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

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

19) Weirs (broad crested with rounded upstream edge).

20) Weirs (triangular profile).

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

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

23) Flumes (rectangular throated).

24) Flumes (trapezoidal throated).

25) Flumes (U-shaped throat).

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

3 Principles of measurement

3.1 Velocity-area methods

3.1.1 Methods using current-meters

The velocity and cross-sectional area of flow in an open channel are measured. The discharge is determined from the product of this velocity and area.

The velocity may be measured by a current-meter. When measurements using current-meters are not feasible, the velocity is measured by floats.

3.1.2 Moving boat method

The moving boat method employs a modification of the conventional current-meter measurements in the velocity-area

1) See the bibliography for a list of these International Standards.

method of determining discharge. The method requires no fixed installation and lends itself to the use of alternative sites if conditions make this desirable. It may be required to make corrections to the velocities for the varying directions of flow, particularly in the presence of a salt water wedge.

3.1.3 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.

3.1.4 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 average velocity in the cross-section. The discharge is then obtained by multiplying this average 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 Limiting conditions and selection of methods

The selection of the most suitable method for measuring discharge should be based on the limiting 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 — Limiting 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, M		b, c, d	J, K	± 3	A, B
2	Velocity-area, from bridge	ISO 748	M, L	M, L	M, L		b, c, d	K	± 3	A, B, C, D
3	Velocity-area, cableway	ISO 748	M, L	M, L	M, L		b, c, d	K	± 4	A, B, C
4	Velocity-area, static boat	ISO 748	M, L	M, L	M, L		b, c, d	K	± 4	A, B, C, E
5	Velocity-area, moving boat	ISO 4369	L	M, L	M, L		b, c, d	K	± 6	A, B, E
6	Velocity-area, floats	ISO 748	M, L	M, L	M, L, S		b, c, d	K	± 10	F
7	Slope-area	ISO 1070	M, L	M, L	M, L		b, c, d	K, N	± 10	Q
8	Ultrasonic	ISO 6416	M, L	M, L	M, L, S	R	b, c, d	G, J, H	± 5	
9	Electromagnetic	ISO/TR 9213	M, S	S, M	S, M		b, d	G, H, J	± 5	T
10	Dilution, chemical, continuous injection	ISO 555/1	S, M	S, M	S, M		c, g, k	K, N	± 3	
11	Dilution, chemical, sudden injection	ISO 555/2	S, M	S, M	S, M		c, g, k	K	± 3	
12	Dilution, radioactive, tracer, sudden injection	ISO 555/3	S, M	S, M	S, M		c, g, k	K	± 3	
13	Dilution, radioactive tracer, continuous injection	ISO 555/3	S, M	S, M	S, M		c, g, k	K, N	± 3	
14	Cubature	ISO 2425						K	± 10	H
15	Thin-plate weirs, sharp crest, V-notch	ISO 1438/1	S	S	M, S	I	a, b, e, j	J, G	± 3	
16	Thin-plate weirs, sharp crest, rectangular, suppressed	ISO 1438/1	S	S	M, S	I	a, b, e, f, j	J, G	± 1	
17	Thin-plate weirs, sharp crest, rectangular	ISO 1438/1	S	S	M, S	I	a, b, e, f, j	J, G	± 1	
18	Weirs, broad-crested with sharp upstream edge	ISO 3846	M, S	S	M, S	I	a, b, e, h, j	J, G	± 5	
19	Weirs, broad-crested with rounded upstream edge	ISO 4374	M, S	S	M, S	I	a, b, e, h, j	J, G	± 5	
20	Weirs, triangular profile	ISO 4360	M, S	S	M, S	I	a, b, e, j	J, G	± 5	
21	Weirs, triangular profile, flat-V	ISO 4377	M, S	S	M, S	I	a, b, e, j	J, G	± 5	
22	Weirs, V-shaped, broad-crested	ISO 8333	M, S	S	M, S	I	a, b, i	J, G	± 5	
23	Flumes, rectangular	ISO 4359	M, S	S	M, S	I	a, b	J, G	± 5	
24	Flumes, trapezoidal	ISO 4359	M, S	S	M, S	I	a, b	J, G	± 5	
25	Flumes, U-shaped	ISO 4359	M, S	S	M, S	I	a, b, i	J, G	± 5	
26	Free overfalls, rectangular channels (end-depth method)	ISO 3847	M, S	M, S	M, S		a, b	J, G	± 10	
27	Free overfalls, non-rectangular channels (end-depth method)	ISO 4371	M, S	M, S	M, S		a, b	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 tidal waterways
I	Heavy sediment concentration not permissible
J	Quick method (less than 1 h)
K	Slow method (1 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 and 3 m/s) or medium depth (between 1 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

Bibliography : International Standards dealing with methods for liquid flow measurements in open channels

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

ISO 555/2, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 2 : Integration (sudden injection) method.*

ISO 555/3, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 3 : Constant rate injection method and integration method using radioactive tracers.*

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

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

ISO 1070, *Liquid flow measurement in open channels — Slope-area method.*

ISO 1088, *Liquid flow measurement in open channels — Velocity-area methods — Collection of data for determination of errors in measurement.*

ISO 1100/1, *Liquid flow measurement in open channels — Part 1 : Establishment and operation of a gauging station.*

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

ISO 1438, *Liquid flow measurement in open channels using thin-plate weirs and venturi flumes.*

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

ISO 2425, *Measurement of flow in tidal channels.*

ISO 2537, *Liquid flow measurement in open channels — Cup-type and propeller-type current-meters.*

ISO 3454, *Liquid flow measurement in open channels — Direct depth sounding and suspension equipment.*

ISO 3455, *Liquid flow measurement in open channels — Calibration of rotating-element current-meters in straight open tanks.*

ISO 3716, *Liquid flow measurement in open channels — Functional requirements and characteristics of suspended sediment load samplers.*

ISO 3846, *Liquid flow measurement in open channels by weirs and flumes — Free overfall weirs of finite crest width (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 4363, *Liquid flow measurement in open channels — Methods for measurement of suspended sediment.*

ISO 4364, *Liquid flow measurement in open channels — Bed material sampling.*

ISO 4365, *Liquid flow measurement in open channels — Sediment in streams and canals — Determination of concentration, particle size distribution and relative density.*

ISO 4366, *Echo sounders for water depth measurements.*

ISO 4369, *Measurement of liquid flow in open channels — Moving-boat method.*

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 4373, *Measurement of liquid flow in open channels — Water level measuring devices.*

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

ISO 4375, *Measurement of liquid flow in open channels — Cableway system for stream gauging.*

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

ISO 6416, *Liquid flow measurement in open channels — Measurement of discharge by the ultrasonic (acoustic) method.*

ISO 6418, *Liquid flow measurement in open channels — Ultrasonic (acoustic) velocity meters.*

ISO 6419/1, *Hydrometric data transmission systems — Part 1 : General.*

ISO 6420, *Liquid flow measurement in open channels — Position fixing equipment for hydrometric boats.*

ISO/TR 7178, *Liquid flow measurement in open channels — Velocity-area methods — Investigation of total error.*

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

ISO 8368, *Liquid flow measurement in open channels — Guidelines for the selection of flow gauging structures.*

ISO/TR 9213, *Liquid flow measurement in open channels — Measurement of total discharge by the electromagnetic method using a full channel width coil.* [1)]

1) At present at the stage of draft.