IS 9922 (2010): Measurement of Liquid Flow in Open Channels - General Guidelines for Selection of Method [WRD 1: Hydrometry]

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भारतीय मानक

खुले चैनलों में द्रव प्रवाह मापन की पद्धति के चयन की सामान्य मार्गदर्शिका

(पहला पुनरीक्षण)

Indian Standard

MEASUREMENT OF LIQUID FLOW IN OPEN CHANNEL — GENERAL GUIDELINES FOR SELECTION OF METHOD

(First Revision)

ICS 17.120.20

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Hydrometry Sectional Committee, WRD 1

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydrometry Sectional Committee had been approved by the Water Resources Division Council.

This standard provides guidance on selection of method for measurement of flow in open channels. As there are quite a few methods available, it is important that the method to be used, in a particular instance, is best suited to the conditions under which the measurement is to be carried out.

This standard was first published in 1981. The standard was based on ISO 8363 : 1980 'Guide for selection of method for measuring flow in open channels'. Since the publication of IS 9922 : 1981, development has taken place and an advancement in the related technology has been made in the international scenario. In order to ensure compatibility with the revised ISO/TR 8363 : 1997, the present revision has been taken up.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

MEASUREMENT OF LIQUID FLOW IN OPEN CHANNEL — GENERAL GUIDELINES FOR SELECTION OF METHOD

(First Revision)

1 SCOPE

This standard provides general guidelines for the selection of a suitable method for measurements of liquid flow in open channels, with specific provisions relevant to each method.

2 REFERENCES

The following standards contain provisions which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1192 : 1981	Velocity-area methods for measurement of flow in open channels (*first revision*)
2912 : 1999	Liquid flow measurement in open channels — Slope-area method
6330 : 1971	Recommendation for liquid flow measurement in open channels by weirs and flumes — End depth method for estimation of flow in rectangular channels with a free overfall (approximate method)
9108 : 1979	Liquid flow measurement in open channels using thin plate weirs
13083 :1991/ ISO 4377 : 1990	Liquid flow measurement in open channels — Flat-V weirs
14574 : 1998/ 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)
14673 : 1999	Liquid flow measurement in open channels by weirs and flumes — Triangular profile weirs
14869 : 2000/ ISO 4359 : 1983	Liquid flow measurement in open channels — Rectangular, trapezoidal and U-shape flumes
14974 : 2001	Liquid flow measurement in open channels by weirs and flumes — Rectangular broad-crested weirs
14975 : 2001	Measurement of fluid flow in open channels — Stream lined triangular profile weirs
15123 : 2002/ ISO 4362 : 1999	Hydrometric determination — Flow measurement in open channels using structures — Trapezoidal broad — crested weirs
15353 : 2003/ ISO 8333 : 1985	Liquid flow meaurement in open channels by weirs and flumes — V-shaped broad-crested weirs

3 METHODS OF MEASUREMENT

Methods which are suitable for measurements of liquid flow in open channels and which form the subjects of International Standards 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).
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).

4 PRINCIPLES OF MEASUREMENT

4.1 Velocity — Area Methods

4.1.1 *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.

4.1.2 *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, angle of the resultant velocity of water and boat with reference to transit line, 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.

4.1.3 *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.

4.1.4 *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.

4.1.5 *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 with the cross-sectional area of flow.

4.2 Measuring Structures

4.2.1 *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.

4.2.2 *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.

4.2.3 *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.

4.3 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.

4.4 Other Methods

4.4.1 *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 estimation of roughness by examination and measurement of bed features is often difficult to quantify. In fact a few sample observation of velocity by current meter and concurrent water surface slope at various stages would enable realistic estimation of channel roughness. The discharge is determined by measuring the water level at two or three sections at known distance apart and inserting the slope, breadth, depth and roughness in an open channel flow equation (for example that of Chezy or Manning).

4.4.2 *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.

5 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 Application Conditions

Sl No.	Method		Criteria						Uncertainty	
	Description	Ref to IS No.	Width	Depth	Velocity	Sedi-ment Load	Approach Condition	Time Factor	Minimum Percentage	Comment
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	Velocity-area, by wading	IS 1192	L, M, S	S	S	—	b, c, d	J, K	±5	A, B
ii)	Velocity-area, from bridge	IS 1192	L, M, S	L, M, S	L, M, S	—	b, c, d	J, K	±5	A, B, C, D
iii)	Velocity-area, cableway	IS 1192	L, M, S	L, M, S	L, M, S	—	b, c, d	J, K	±5	A, B, C
iv)	Velocity-area, static boat	IS 1192	L, M, S	L, M	L, M, S	—	b, c, d	J, K	±5	A, B, C, E
v)	Velocity-area, moving boat	IS 1192	L	L, M	L, M	—	b, c, d	J, K	±10	A, B, E
vi)	Velocity-area, floats	IS 1192	L, M, S	L, M, S	L, M, S	—	b, c, d	K, N	±10	F
vii)	Slope-area	IS 2912	L, M, S	L, M, S	L, M	—	b, c, d	G, J	±10	Q
viii)	Ultrasonic	—	L, M, S	L, M	L, M, S	R	b, c, d	G, J	±5	H, U
ix)	Electromagnetic	—	M, S	L, M, S	L, M, S	—	b, d	K, N	±5	—
x)	Dilution, chemical tracer	—	M, S	M, S	M, S	—	c, g, k	K	±3	—
xi)	Dilution, radioactive tracer	—	M, S	M, S	M, S	—	c, g, k	K	±3	—
xii)	Dilution, fluorescent tracer	—		M, S	M, S	—	c, g, k	K	±3	—
xiii)	Cubature	—						K	±10	—
xiv)	Thin-plate weirs, sharp crest, V-notch	IS 9108	S	S	S	I	a, b, e, j	J, G	±1	—
xv)	Thin-plate weirs, sharp crest, rectangular, suppressed	IS 9108	M,S	S	S	I	a, b, e, f, j	J, G	±3	—
xvi)	Thin-plate weirs, sharp crest, rectangular	IS 9108	M, S	S	S	I	a, b, e, f, j	J, G	±3	—
xvii)	Weirs, broad-crested with sharp upstream edge	IS 14974	M, S	S	M, S	I	a, b, e, f, j	J, G	±5	—
xviii)	Weirs, broad-crested with rounded upstream edge	—	M, S	M, S	M, S	I	a, b, e, f, j	J, G	±5	—
xix)	Weirs, triangular profile	IS 14673	M, S	M, S	M, S	I	a, b, e, f, j	J, G	±5	—

Table 1 (*Concluded*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
xx)	Weirs, streamlined triangular profile	IS 14975	M, S	M, S	M, S	I	a, b, e, j	J, G	±5	—
xxi)	Weirs, triangular profile, float-V	IS 13083	M, S	M, S	M, S	I	a, b, e, j	J, G	±5	—
xxii)	Weirs, V-shaped, broad-crested	IS 15353	M, S	M, S	M, S	I	a, b, i	J, G	±5	—
xxiii)	Weirs, trapezoidal profile	IS 15123	M, S	M, S	M, S	I	a, b, e	J, G	±5	—
xxiv)	Flumes, rectangular	IS 14869	M, S	M, S	M, S	I	a, b	J, G	±5	—
xv)	Flumes, trapezoidal	IS 14869	M, S	M, S	M, S	I	a, b	J, G	±5	—
xvi)	Flumes, U-shaped	IS 14869	M, S	M, S	M, S	I	a, b, i	J, G	±5	—
xvii)	Flumes, Parshall and SANIIRI	IS 14869	M, S	S	M, S	I	a, b, e, i	J, G	±5	—
xviii)	Free overfalls, rectangular and non-rectangular channels (end-depth method)	IS 6330 and IS 14574	M,S	M,S	M,S		a, b, e, j	J, G	±10	—

Table 2 Explanation of Symbols Used in Table 1

(*Clause* 5)

Sl No. (1)	Symbol (2)	Definition (3)
i)	a	Flow should be subcritical
ii)	b	Flow should have no cross-currents
iii)	c	Channel should be relatively free from vegetation
iv)	d	Channel should be fairly straight and uniform in cross-section
v)	e	Channel should be fairly straight and symmetrical in cross-section for about 10 channel widths upstream
vi)	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
vii)	g	Flow in the channel should be turbulent (even including a hydraulic jump) to ensure mixing
viii)	h	Channel should be rectangular for a distance upstream of at least twice the maximum head
ix)	i	Channel should be nearly U-shaped
x)	j	Velocity distribution should be fairly uniform
xi)	k	Channel should be free from recess in the banks and depressions in the bed
xii)	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 percent
xiii)	B	For velocity-area method, with velocity observed at surface, the minimum uncertainty may be up to 10 percent
xiv)	C	Corrections may be required because of distance or air- and wet-line effects
xv)	D	Major error can be caused by Pier effects
xvi)	E	Major error can be due to drift, obstruction of boat and heaving action
xvii)	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
xviii)	G	Method suitable for more frequent discharge measurements
xix)	H	Method suitable for reverse flows
xx)	I	Heavy sediment concentration not permissible
xxi)	J	Quick method (less than 1 h)
xxii)	K	Slow method (1 h to 6 h)
xxiii)	L	Large width (more than 50 m) or high velocity (more than 3 m/s) or large depth (more than 5 m)
xxiv)	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)
xxv)	N	Very slow method (more than 6 h)
xxvi)	Q	Approximate method used when velocity-area method not feasible and slope can be determined with sufficient accuracy
xxvii)	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
xxviii)	S	Narrow width (less than 5 m) or shallow depth (less than 1 m) or low velocity (less than 1 m/s)
xix)	T	May be used in rivers with weed growth and moving bed material
xxx)	U	Measuring section must have stable bed

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Amendments Issued Since Publication

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