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Liquid flow measurement in open channels using thin-plate weirs and venturi flumes

Mesure de débit des liquides dans les canaux découverts au moyen de déversoirs en mince paroi et de canaux venturi

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FOREWORD

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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.

International Standard ISO 1438 was drawn up by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*, and circulated to the Member Bodies in June 1968.

It has been approved by the Member Bodies of the following countries :

India	New Zealand	Switzerland
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Italy	South Africa, Rep. of	United Kingdom
Japan	Spain	U.S.A.
Netherlands	Sweden	

The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

Belgium
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Liquid flow measurement in open channels using thin-plate weirs and venturi flumes

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies methods for the measurement of liquid flow in open channels using rectangular thin-plate weirs, triangular thin-plate weirs (V-notch) and venturi flumes. The flow conditions considered are limited to steady flows which are uniquely dependent on the upstream head. Thus, submerged flows, which depend on downstream as well as upstream water levels, are not considered herein.

2 REFERENCES

ISO/R 541, *Measurement of fluid flow by means of orifice plates and nozzles.*

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

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

3 DEFINITIONS

For the purposes of this International Standard, the definitions given in ISO 772 apply.

4 UNITS OF MEASUREMENT

The units of measurement used in this International Standard are seconds and metres (feet).

5 PRINCIPLE OF THE METHOD OF MEASUREMENT

5.1 Thin-plate weirs

The discharge is measured by interposing a thin-plate weir with an opening and observing the head over the weir and employing a known unique functional relationship between the rate of flow and the head over the weir.

The original basic discharge equation is attributable to Poleni and may be expressed in the form :

$$Q = Cbh^{3/2}$$

where

Q is the discharge;

C is the coefficient of discharge;

b is the width of the opening;

h is the measured head over the weir.

In the case of triangular thin-plate weirs, for the sake of convenience b is replaced in terms of h and the tangent of the angle of the apex.

5.2 Standing-wave or Free-flowing venturi flumes

The discharge is measured by building a streamlined structure to form a contraction and observing only the upstream head and then employing a functional relationship between the rate of flow and the upstream head, since under the conditions in which critical flow occurs at the throat, the discharge depends only on the upstream head.

6 INSTALLATION

6.1 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 may be made to conform) to the requirements necessary for measurement by weirs or flumes.

Particular attention shall 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 increased upstream water levels due to the measuring structure;

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

f) the impermeability of the ground on which the structure is to be founded, and the necessity for piling, grouting or other sealing-in river installations;

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 channels;

j) effect of wind, which can have a considerable effect on the flow over a river, weir or flume, 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 (see figure 1 for typical regular open-channel velocity distribution), then it may be assumed that the velocity distribution will remain satisfactory after the construction of the weir or flume.

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 or flume, and to improving it if necessary.

Several methods are available for obtaining a more precise indication of irregular velocity distribution : velocity-rods, floats or concentrations of dye can be used in small channels, the latter being useful in checking conditions at the bottom of the channel. A complete and quantitative assessment of velocity distribution may be made by means of a current-meter. Complete information about the use of current-meters is given in ISO 748.

6.2 Installation conditions

6.2.1 *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.

Velocity profile obtained in 360 cm (12 ft) wide channel
Actual width = 358,75 cm (11 ft 11 1/2 in)
Depth of water = 74 cm (29.6 in)

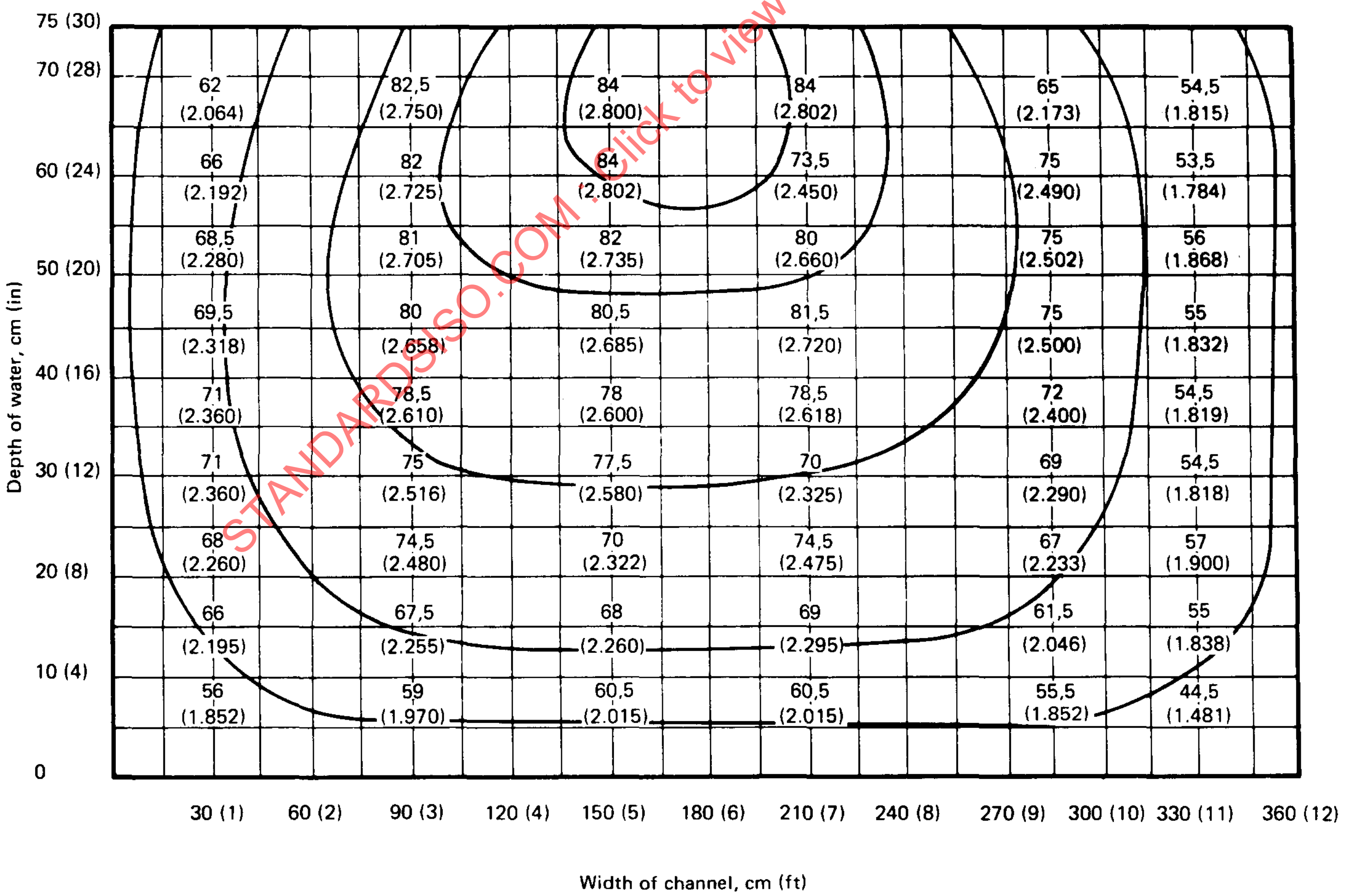


FIGURE 1 — **Example of a regular velocity profile in the approach channel**

Installation requirements include such features as finish of the weir or flume, cross-sectional shape of channel, channel roughness, 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 a weir or flume, these being determined by the features mentioned above.

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

6.2.2 *Approach channel*

On all installations the flow in the approach channel shall be smooth and free from disturbance and shall have a velocity distribution as normal 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 either at the side or on the bottom. Unless otherwise specified in the appropriate clauses, the following general requirements shall be complied with.

The altered flow-conditions due to the construction of the weir or flume might have the effect of building up 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 the gauging stations.

In an artificial channel the cross-section shall be uniform and the channel shall be straight for a length equal to at least 10 times its width, if the width of the weir or flume throat is equal to or greater than half the width of the channel. The length of the channel can be reduced if the width of the weir or flume throat is less than half the width of the channel.

In a natural stream or river the cross-section shall be reasonably uniform and the channel shall be straight for a length as required for an artificial channel.

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

In an artificial channel where there is no debris or matter carried in suspension, suitable flow conditions can often be provided by suitably placed baffles formed by vertical laths, but there shall be no baffle nearer to the point of measurement than 10 times the maximum head to be measured.

Under certain conditions, a standing wave may occur upstream of the gauging device, for example, if the approach channel is steep. Provided this wave is at a distance of not less than 30 times the maximum head upstream, flow measurement will be feasible, subject to confirmation that a regular velocity distribution exists at the gauging station. (See 11.1.4 e) for exception in case of venturi flumes.)

If a standing wave occurs within this distance, the approach conditions and/or gauging device shall be modified if measurement errors are to be avoided.

6.2.3 *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.

NOTE — In the case of a thin-plate weir, the wall on which it is built shall be free from projections, and its upstream face shall not protrude beyond the face of the weir. On the downstream side, the structure shall be such that it does not interfere with the aeration of the nappe.

6.2.4 *Downstream of the structure*

The channel downstream of the structure is usually of no importance as such, provided that the weir or flume has been so designed that it cannot become drowned under the operating conditions.

The altered flow conditions due to the construction of the weir or flume might have the effect of building up shoals of debris immediately downstream of the structure, which in time might raise the water level sufficiently to drown the weir or flume. Any accumulation of debris downstream of the structure shall therefore be removed.

7 MAINTENANCE — GENERAL REQUIREMENTS

Maintenance of the measuring structure and the approach channel is important to secure accurate continuous measurements.

It is essential that the approach channels to both weirs and flumes be kept clean and free from silt and vegetation as far as practicable for at least the distance specified in 6.2.2. The float-well, and the entry from the approach channel shall also be kept clean and free from deposits.

The throat and the curved entry to a flume shall be kept clean and free from algal growths.

The weir structure shall be kept clean and free from clinging debris and care shall be taken in the process of cleaning to avoid damage to the weir crest. Thin-plate weirs shall be examined periodically for damage.

8 MEASUREMENT OF HEAD

8.1 General

The head upstream of the measuring structure may be measured by a hook-gauge, point-gauge or staff-gauge where spot measurements are required, or by a float-operated recording-gauge where a continuous record is required. The location of the head measurement station is dealt with in 9.3, 10.3 and 11.1.5, and in many cases it is preferable to measure heads in a separate stilling-well to reduce the effects of surface irregularities.

The discharges given by the working equation are volumetric figures, and the liquid density does not affect the volumetric discharge for a given head **provided** the operative head is gauged in liquid of identical density. If the gauging is carried out in a separate well, a correction for the difference in density may be necessary if the temperature in the well is significantly different from that of the flowing liquid. However, it is assumed herein that the densities are equal.

8.2 Stilling-well or float-well

Where provided, the stilling-well shall be vertical and have a minimum margin of 60 cm (2 ft) over the maximum water level estimated to be recorded in the well.

It shall be connected to the river by an inlet pipe or slot, large enough to permit the water in the well to follow the rise and fall of head without significant delay.

The connecting pipe or slot shall, however, be as small as possible consistent with ease of maintenance, or shall alternatively be fitted with a constriction, to damp out oscillations due to short amplitude wave. This will be necessary for example, if the chart of the recorder canot be read to within ± 6 mm (0.02ft).

The well and the connecting pipe or slot shall be watertight. Where provided for the accomodation of the float of a level recorder, the well shall be of adequate diameter and depth to accommodate the float.

The well shall also be deep enough to accommodate any silt which may enter, without the float grounding. The float-well arrangement may include an intermediate chamber between the stilling-well and the approach channel of similar proportions to the stilling-well to enable silt and other solids to settle out.

8.3 Zero setting

A means of checking the zero setting of the head-measuring device shall be provided consisting of a pointer with its points set exactly level with the sill of the weir or the invert of the flume throat and fixed permanently in the approach channel or alternatively in the stilling-well or float-well where provided.

A zero check based on the level of the water when the flow ceases is liable to serious errors from surface tension effects and shall not be used.

As the size of the weir or flume and the head on it reduces, small errors in construction and in the zero setting and reading of the head measuring device become of greater importance.

9 TRIANGULAR THIN-PLATE WEIRS (V-NOTCHES)

9.1 Specifications for the standard weir

Within the range of conditions for which the available experimental data are competent, the triangular thin-plate weir (V-notch) is one of the most precise flow-measuring devices. It is inexpensive and simple to construct and install. A standard triangular thin-plate weir (V-notch) is shown in figure 2.

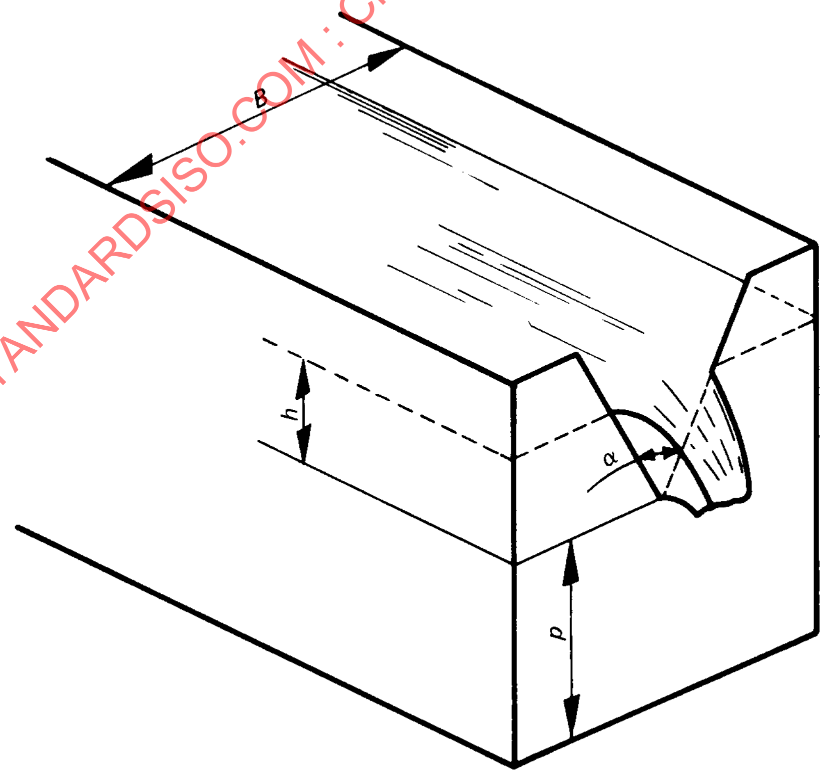


FIGURE 2 — **Triangular thin-plate weir, V-notch**

The standard weir shall consist of a symmetrical, V-shaped notch in a vertical, thin-plate. The line which bisects the angle of the notch shall be vertical and equidistant from the sides of the approach channel. The weir plate shall be smooth and plane, especially on the upstream side, and it shall be perpendicular to the sides as well as the bottom of the channel.

NOTE — In this International Standard a "smooth" surface shall be equivalent in surface finish to that of rolled sheet metal.

The crest surfaces shall be plane surfaces of width (measured perpendicular to the upstream face of the plate) between 1 and 2 mm (0.04 and 0.08 in), which shall form a sharp right-angled edge at their intersection with the upstream face of the weir plate. These surfaces shall be machined (or filed) perpendicular to the upstream face; the edges shall be free from burrs and scratches, and untouched by abrasive cloth or paper. The downstream edges of the weir shall be chamfered if the weir plate is thicker than the allowable crest width. The surface of the chamfer shall make an angle of not less than 45° with the crest surface. The weir plate is usually made of metal, preferably of that kind of metal which can resist erosion and corrosion.

9.2 Specifications for the installation

In addition to the requirements specified in clause 6, the following conditions shall be satisfied :

The weir shall be located in a straight, smooth, horizontal (level-bottomed), rectangular channel. As an exception, when the effective opening of the weir is so small in comparison with the upstream channel that the approach velocity is negligible, the shape of the channel is not of significance. The channel upstream from the weir, described hereinafter as the standard approach channel, shall be of sufficient length to develop the normal (uniform flow) velocity distribution for all discharges, or it shall be so arranged and equipped with baffles and screens as to simulate the normal velocity distribution and normal turbulence in the approach channel (see 6.2.2).

9.3 Location of the head-gauge section

Piezometers or a point-gauge station for the measurement of the head on the weir shall be located a sufficient distance upstream from the weir to avoid the region of surface draw-down. On the other hand, they shall be close enough to the weir for the energy loss between the section of measurement and the weir to be negligible. It is recommended that the head-measurement section be located at a distance equal to three to four times the maximum head ($3h_{max}$ to $4h_{max}$) upstream from the weir.

9.4 Provision for ventilated, free flow

Provisions for ventilation of the discharging jet shall ensure that the pressure on the nappe surface is atmospheric. The tailwater level shall be low enough not to interfere with the ventilation or free discharge of the jet.

NOTE — Free (unsubmerged) flow is defined here as flow which is independent of variations in tailwater level. It is recommended that the tailwater level should be at least 0,1 m (0.3 ft) below the lowest point of the notch.

9.5 Basic discharge equation (Kindsvater-Shen)

The basic equation of discharge for the triangular thin-plate weir, (V-notch) is the equation of Kindsvater-Shen.

$$Q = C_e \frac{8}{15} \sqrt{2g} \operatorname{tg} \frac{\alpha}{2} h_e^{5/2} \qquad \ldots (1)$$

where

Q is the discharge volume rate in cubic metres per second (cubic feet per second);

C_e is the coefficient of discharge (non-dimensional);

g is the acceleration of free fall in metres per second squared (feet per second squared);

α is the angle included between the sides of the notch (radians or degrees);

h_e is the effective piezometric head referred to the vertex of the notch in metres (feet).

For water at ordinary temperatures, i.e. 5 to 30 °C (40 to 85 °F) the coefficient of discharge, C_e, has been determined by experiment as a function of three variables,

$$C_e = f\left(\frac{h}{p}, \frac{p}{B}, \alpha\right) \qquad \ldots (2)$$

where

h is the measured head in metres (feet);

p is the apex height in metres (feet);

B is the width of the upstream channel in metres (feet).

The effective head, b_e in equation (1), is defined by the equation

$$h_e = h + k_h \qquad \ldots (3)$$

where k_h is an experimentally determined quantity in metres (feet) which compensates for the influence of surface tension and viscosity.

9.5.1 *Evaluation of C_e and k_h*

Experimentally determined values of the coefficients required to describe the flow of water over a full practical range of values of h/p and p/B are available for only one value of α i.e. 90°.

It is recommended that a constant value of k_h = 0,85 mm (0.002 8 ft) be used with the values of C_e shown in figure 3.

Triangular thin-plate weirs (V-notches) covering a range of values of α from 10° to 120° have been studied by a large number of investigators. However, the range of values of p/B and h/p covered by the available data is quite limited. The conditions covered by virtually all of the experimental data available for triangular thin-plate weirs (V-notches) covering a range of values of α from 10° to 120° (except those for $\alpha = 90°$) are within limits in which C_e is a function of α alone. For such weirs, which can be described as "fully contracted", the available experimental data give the values of C_e shown in figure 4. The corresponding values of k_h are shown in figure 5. In both figures, the curves are shown with dashed lines for values of α less than 20° or greater than 100°. Within the range α = 20° to 100°, coefficients are recommended for standard flow measurements. Outside this range the coefficients are not well defined.

9.5.2 *Practical limitations on h/p, p/B, h and p*

Practical limitations on h/p and p/B are related to the observation that head-measurement difficulties and errors result from surges and waves which occur in the approach channel when the velocity of approach is large in comparison with the depth of flow. The available experimental data are not adequate to establish the limiting values of h/p and p/B which are associated with this condition. The range of values of h/p and p/B represented by the curves in figure 3 (for $\alpha = 90°$ only) is a full, practical range.

NOTE — Limitations on h/p corresponding to smaller values of p/B have not been established, but it is assumed that the maximum permissible value of h/p increases as p/B decreases. Limitations on h/p shall be determined on the basis of the flow characteristics and related conditions which influence the accuracy of head measurement.

Practical limitations on the magnitude of h are related to the "clinging nappe" phenomenon which characterizes low heads. To ensure a freely discharging stable nappe, a minimum value of h = 0,06 m (0.2 ft) is recommended for notch angles between 20° to 100°. It is recommended that p be limited to values greater than 0,1 m (0.3 ft).

9.6 Effect of velocity distribution in the approach channel

The specifications for the standard installation include the requirement that the velocity in the channel upstream from the weir be such as to simulate the normal velocity distribution in a smooth, horizontal, rectangular channel. When the velocity distribution in the approach channel differs considerably from the normal, the discharge characteristics are altered. Consequently, flow measurements made with non-standard weir installations are subject to error.

In the range of conditions represented by figure 4, the influence of approach channel velocity distribution may be considered to be negligible.

9.7 Accuracy of measurement

The relative accuracy of flow measurements made with a standard triangular thin-plate weir (V-notch) depends on the accuracy of the head measurement, the notch-angle measurement, and on the accuracy of the coefficients as they apply to the weir in use.

With reasonable care and skill in the construction and installation of a standard weir, the error in the coefficient of discharge can be expected to be of the order of 1,0 %.

The method by which the error in the coefficients is to be combined with other sources of error is explained in clause 13 which deals with the estimation of errors.

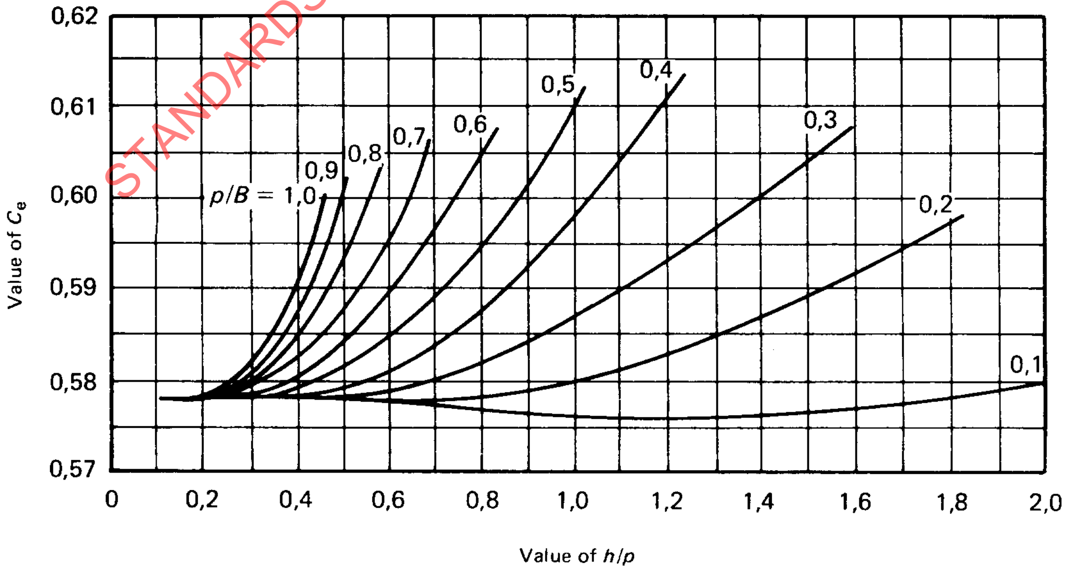


FIGURE 3 — **Coefficient of discharge** C_e ($\alpha = 90°$)

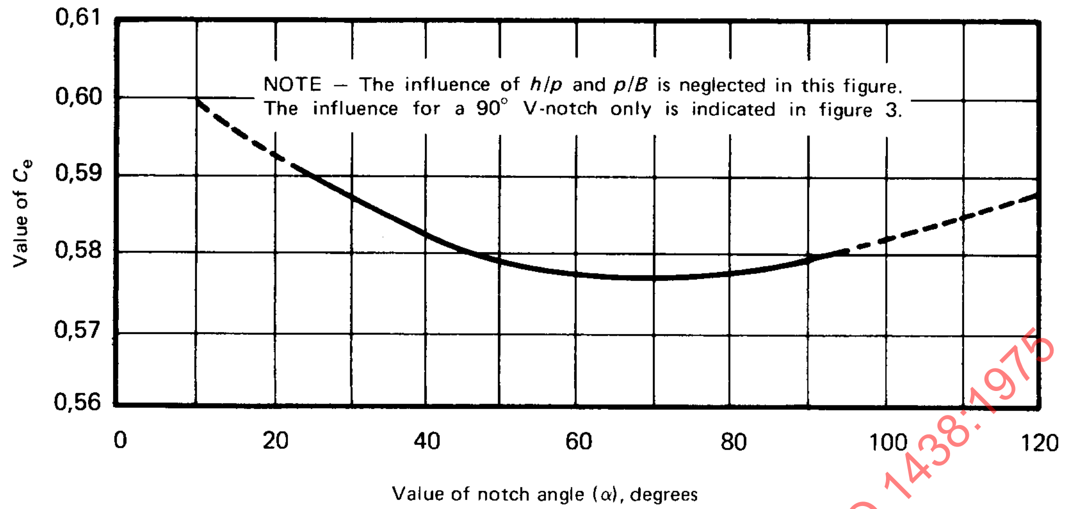


FIGURE 4 – **Coefficient of discharge C_e related to notch angle**

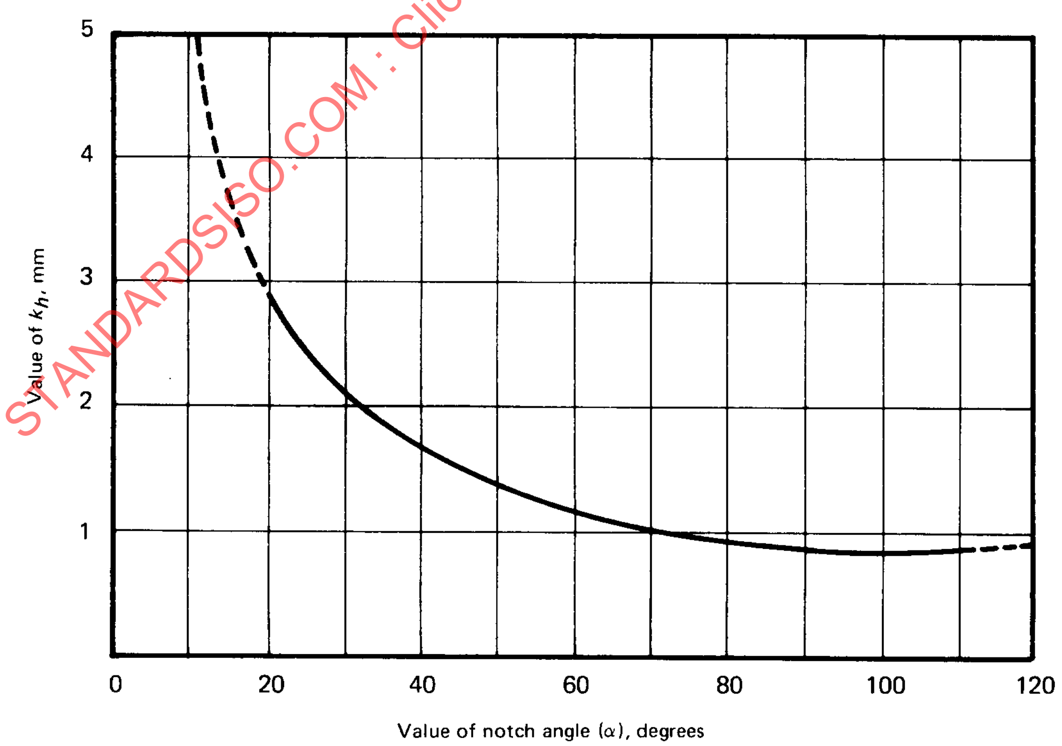


FIGURE 5 – **Value of k_h related to notch angle**

In general, calibration experiments have been carried out on model structures of small dimensions and when transferred to larger structures there may be small changes in the discharge coefficients due to scale effect.

9.8 Alternative coefficients and corresponding discharges for 90°, 1/2 90° and 1/4 90° triangular thin-plate weirs (V-notch)

Three sizes of triangular thin-plate weir (V-notch) are recommended :

a) The 90° notch in which the dimension across the top is twice the vertical depth [$\text{tg}\ (\alpha/2) = 1$].

b) The 1/2 90° notch ($\alpha = 53° 8'$) in which the dimension at the top is equal to the vertical depth [$\text{tg}\ (\alpha/2) = 0{,}5$].

c) The 1/4 90° notch ($\alpha = 28° 4'$) in which the dimension across the top is equal to half the vertical depth [$\text{tg}\ (\alpha/2) = 0{,}25$].

If the bed and walls of the approach channel are remote from the notch, the channel boundaries have no significant influence on the contraction of the nappe, which may then be said to be fully contracted. As an alternative to the equation given in 9.5 and the associated coefficients given in figures 4 and 5, the following equations may be used :

90° notch $$Q = C_e \frac{8}{15}\sqrt{2g}\, h^{5/2} \quad \ldots (4)$$

1/2 90° notch $$Q = C_e \frac{4}{15}\sqrt{2g}\, h^{5/2} \quad \ldots (5)$$

1/4 90° notch $$Q = C_e \frac{2}{15}\sqrt{2g}\, h^{5/2} \quad \ldots (6)$$

The coefficient values are given in tables 1, 2 and 3 together with the corresponding discharge values.

NOTE — The values for C_e and Q given in tables 1, 2 and 3 are based on the actual values of measured head, h, and therefore do not require a correction in h, C_e or Q.

The general installation conditions shall comply with 9.1 to 9.4. The following practical limitations on h, p, h/p, B and h/B are to be observed in the application of the alternative coefficient and discharge values given in tables 1, 2 and 3 :

a) h shall not be less than 0,05 m (2 in) or more than 0,38 m (15 in);

b) p shall exceed 0,45 m (1.5 ft);

c) h/p shall be less than or equal to 0,4;

d) B shall exceed 1,2 m (4.0 ft);

e) h/B shall be less than or equal to 0,20.

With reasonable skill and care in the construction and installation of a standard triangular weir (V-notch), the tables for the coefficients are expected to have an accuracy of 1,0 %.

The method by which the error in the coefficient is to be combined with the other sources of error is explained in clause 13 which deals with the estimation of errors.

TABLE 1 – **Discharge of water over a 90° V-notch**

a) **METRIC UNITS**

$$Q = 2{,}362\,5\, C_e\, h^{5/2}$$

$$(g = 9{,}806\,6 \text{ m/s}^2)$$

Head h	Coefficient C_e	Discharge Q
m		$m^3/s \times 10$
0,060	0,603 2	0,012 57
0,061	0,602 8	0,013 09
0,062	0,602 3	0,013 62
0,063	0,601 9	0,014 17
0,064	0,601 5	0,014 73
0,065	0,601 2	0,015 30
0,066	0,600 8	0,015 88
0,067	0,600 5	0,016 48
0,068	0,600 1	0,017 10
0,069	0,599 8	0,017 72
0,070	0,599 4	0,018 36
0,071	0,599 0	0,019 01
0,072	0,598 7	0,019 67
0,073	0,598 3	0,020 35
0,074	0,598 0	0,021 05
0,075	0,597 8	0,021 76
0,076	0,597 5	0,022 48
0,077	0,597 3	0,023 22
0,078	0,597 0	0,023 97
0,079	0,596 7	0,024 73
0,080	0,596 4	0,025 51
0,081	0,596 1	0,026 30
0,082	0,595 8	0,027 10
0,083	0,595 5	0,027 92
0,084	0,595 3	0,028 76
0,085	0,595 0	0,029 61
0,086	0,594 8	0,030 48
0,087	0,594 5	0,031 36
0,088	0,594 2	0,032 25
0,089	0,594 0	0,033 16
0,090	0,593 7	0,034 09
0,091	0,593 5	0,035 03
0,092	0,593 3	0,035 98
0,093	0,593 1	0,036 96
0,094	0,592 9	0,037 95
0,095	0,592 7	0,038 95
0,096	0,592 5	0,039 97
0,097	0,592 3	0,041 01
0,098	0,592 1	0,042 06
0,099	0,591 9	0,043 12
0,100	0,591 7	0,044 20
0,101	0,591 4	0,045 30
0,102	0,591 2	0,046 41
0,103	0,591 0	0,047 54
0,104	0,590 8	0,048 69
0,105	0,590 6	0,049 85
0,106	0,590 4	0,051 03
0,107	0,590 2	0,052 22
0,108	0,590 1	0,053 44
0,109	0,589 9	0,054 67
0,110	0,589 8	0,055 92
0,111	0,589 7	0,057 19
0,112	0,589 6	0,058 47
0,113	0,589 4	0,059 77
0,114	0,589 2	0,061 08
0,115	0,589 1	0,062 42
0,116	0,589 0	0,063 77
0,117	0,588 9	0,065 14
0,118	0,588 8	0,066 53
0,119	0,588 6	0,067 93

Head h	Coefficient C_e	Discharge Q
m		$m^3/s \times 10$
0,120	0,588 5	0,069 35
0,121	0,588 3	0,070 79
0,122	0,588 2	0,072 24
0,123	0,588 1	0,073 72
0,124	0,588 0	0,075 22
0,125	0,588 0	0,076 73
0,126	0,587 9	0,078 27
0,127	0,587 8	0,079 82
0,128	0,587 7	0,081 39
0,129	0,587 6	0,082 98
0,130	0,587 6	0,084 58
0,131	0,587 5	0,086 21
0,132	0,587 4	0,087 85
0,133	0,587 3	0,089 51
0,134	0,587 2	0,091 19
0,135	0,587 2	0,092 89
0,136	0,587 1	0,094 61
0,137	0,587 0	0,096 34
0,138	0,586 9	0,098 10
0,139	0,586 9	0,099 87
0,140	0,586 8	0,101 67
0,141	0,586 7	0,103 48
0,142	0,586 7	0,105 32
0,143	0,586 6	0,107 17
0,144	0,586 6	0,109 04
0,145	0,586 5	0,110 93
0,146	0,586 4	0,112 84
0,147	0,586 3	0,114 76
0,148	0,586 2	0,116 71
0,149	0,586 2	0,118 67
0,150	0,586 1	0,120 66
0,151	0,586 1	0,122 67
0,152	0,586 0	0,124 71
0,153	0,586 0	0,126 76
0,154	0,585 9	0,128 83
0,155	0,585 9	0,130 93
0,156	0,585 9	0,133 04
0,157	0,585 8	0,135 17
0,158	0,585 8	0,137 32
0,159	0,585 7	0,139 50
0,160	0,585 7	0,141 69
0,161	0,585 7	0,143 91
0,162	0,585 6	0,146 14
0,163	0,585 6	0,148 40
0,164	0,585 5	0,150 67
0,165	0,585 5	0,152 97
0,166	0,585 5	0,155 29
0,167	0,585 4	0,157 63
0,168	0,585 4	0,159 99
0,169	0,585 3	0,162 37
0,170	0,585 3	0,164 77
0,171	0,585 3	0,167 19
0,172	0,585 2	0,169 64
0,173	0,585 2	0,172 10
0,174	0,585 1	0,174 59
0,175	0,585 1	0,177 09
0,176	0,585 1	0,179 63
0,177	0,585 1	0,182 19
0,178	0,585 1	0,184 78
0,179	0,585 1	0,187 38

TABLE 1 *(continued)*

Head h (m)	Coefficient C_e	Discharge Q ($m^3/s \times 10$)	Head h (m)	Coefficient C_e	Discharge Q ($m^3/s \times 10$)
0,180	0,585 1	0,190 01	0,240	0,584 6	0,389 73
0,181	0,585 1	0,19[illegible] 66	0,241	0,584 6	0,393 80
0,182	0,585 [illegible]	0,195 [illegible]	0,242	0,584 6	0,397 90
0,183	0,585 [illegible]	0,19[illegible] 00	0,243	0,584 6	0,402 02
0,184	0,585 0	0,200 71	0,244	0,584 6	0,406 17
0,185	0,585 0	0,203 45	0,245	0,584 6	0,410 34
0,186	0,585 0	0,206 21	0,246	0,584 6	0,414 54
0,187	0,585 0	0,208 99	0,247	0,584 6	0,418 77
0,188	0,585 0	0,211 8[illegible]	0,248	0,584 6	0,423 02
0,189	0,585 0	0,214 [illegible]	0,249	0,584 6	0,427 30
0,190	0,585 0	0,217 4[illegible]	0,250	0,584 6	0,431 60
0,191	0,585 0	0,220 3[illegible]	0,251	0,584 6	0,435 93
0,192	0,584 [illegible]	[illegible]	0,252	0,584 6	0,440 28
0,193	0,584 9	0,226 12	0,253	0,584 6	0,444 66
0,194	0,584 9	0,229 08	0,254	0,584 6	0,449 07
0,195	0,584 9	[illegible]	0,255	0,584 6	0,453 5[illegible]
0,196	0,584 9	[illegible]	0,256	0,584 6	0,457 9[illegible]
0,197	0,584 9	[illegible]	0,257	0,584 6	0,462 45
0,198	0,584 9	0,241 06	0,258	0,584 6	0,466 96
0,199	0,584 9	0,244 1[illegible]	0,259	0,584 6	0,471 50
0,200	0,584 9	0,247 19	0,260	0,584 6	0,476 06
0,201	0,584 9	0,250 26	0,261	0,584 6	0,480 65
0,202	0,584 8	0,253 39	0,262	0,584 6	0,485 27
0,203	0,584 8	0,256 52	0,263	0,584 6	0,489 91
0,204	0,584 8	0,259 69	0,264	0,584 6	0,494 58
0,205	0,584 8	0,262 88	0,265	0,584 6	0,499 28
0,206	0,584 8	0,266 10	0,266	0,584 6	0,504 00
0,207	0,584 8	0,269 34	0,267	0,584 6	0,508 76
0,208	0,584 8	0,272 61	0,268	0,584 6	0,513 53
0,209	0,584 8	0,275 90	0,269	0,584 6	0,518 34
0,210	0,584 8	0,279 21	0,270	0,584 6	0,523 17
0,211	0,584 8	0,282 54	0,271	0,584 6	0,528 02
0,212	0,584 8	0,285 88	0,272	0,584 6	0,532 91
0,213	0,584 7	0,289 24	0,273	0,584 6	0,537 82
0,214	0,584 7	0,292 64	0,274	0,584 6	0,542 76
0,215	0,584 7	0,296 07	0,275	0,584 6	0,547 72
0,216	0,584 7	0,299 53	0,276	0,584 6	0,552 72
0,217	0,584 7	0,303 01	0,277	0,584 6	0,557 74
0,218	0,584 7	0,306 51	0,278	0,584 6	0,562 82
0,219	0,584 7	0,310 04	0,279	0,584 7	0,567 94
0,220	0,584 7	0,313 59	0,280	0,584 7	0,573 06
0,221	0,584 7	0,317 17	0,281	0,584 7	0,578 19
0,222	0,584 7	0,320 77	0,282	0,584 7	0,583 35
0,223	0,584 7	0,324 39	0,283	0,584 7	0,588 53
0,224	0,584 7	0,328 03	0,284	0,584 7	0,593 75
0,225	0,584 6	0,331 68	0,285	0,584 7	0,598 99
0,226	0,584 6	0,335 35	0,286	0,584 7	0,604 25
0,227	0,584 6	0,339 07	0,287	0,584 7	0,609 55
0,228	0,584 6	0,342 82	0,288	0,584 7	0,614 87
0,229	0,584 6	0,346 59	0,289	0,584 7	0,620 23
0,230	0,584 6	0,350 39	0,290	0,584 7	0,625 60
0,231	0,584 6	0,354 21	0,291	0,584 7	0,631 01
0,232	0,584 6	0,358 06	0,292	0,584 7	0,636 45
0,233	0,584 6	0,361 93	0,293	0,584 7	0,641 95
0,234	0,584 6	0,365 82	0,294	0,584 8	0,647 48
0,235	0,584 6	0,369 74	0,295	0,584 8	0,653 03
0,236	0,584 6	0,373 69	0,296	0,584 8	0,658 58
0,237	0,584 6	0,377 66	0,297	0,584 8	0,664 16
0,238	0,584 6	0,381 66	0,298	0,584 8	0,669 76
0,239	0,584 6	0,385 68	0,299	0,584 8	0,675 39

TABLE 1 (*continued*)

Head h	Coefficient C_e	Discharge Q
m		m^3/s × 10
0,300	0,584 8	0,681 06
0,301	0,584 8	0,686 75
0,302	0,584 8	0,692 46
0,303	0,584 8	0,698 21
0,304	0,584 8	0,703 98
0,305	0,584 8	0,709 80
0,306	0,584 8	0,715 68
0,307	0,584 9	0,721 59
0,308	0,584 9	0,727 50
0,309	0,584 9	0,733 41
0,310	0,584 9	0,739 36
0,311	0,584 9	0,745 34
0,312	0,584 9	0,751 35
0,313	0,584 9	0,757 38
0,314	0,584 9	0,763 44
0,315	0,584 9	0,769 54
0,316	0,584 9	0,775 66
0,317	0,584 9	0,781 81
0,318	0,584 9	0,788 02
0,319	0,585 0	0,794 28
0,320	0,585 0	0,800 57
0,321	0,585 0	0,806 85
0,322	0,585 0	0,813 14
0,323	0,585 0	0,819 47
0,324	0,585 0	0,825 83
0,325	0,585 0	0,832 22
0,326	0,585 0	0,838 63
0,327	0,585 0	0,845 08
0,328	0,585 0	0,851 55
0,329	0,585 0	0,858 06
0,330	0,585 0	0,864 59
0,331	0,585 0	0,871 16
0,332	0,585 0	0,877 75
0,333	0,585 0	0,884 38
0,334	0,585 0	0,891 03
0,335	0,585 0	0,897 72
0,336	0,585 0	0,904 48
0,337	0,585 1	0,911 28
0,338	0,585 1	0,918 11
0,339	0,585 1	0,924 91
0,340	0,585 1	0,931 75
0,341	0,585 1	0,938 62
0,342	0,585 1	0,945 51
0,343	0,585 1	0,952 44
0,344	0,585 1	0,959 40
0,345	0,585 1	0,966 38
0,346	0,585 1	0,973 40
0,347	0,585 1	0,980 45
0,348	0,585 1	0,987 53
0,349	0,585 1	0,994 71
0,350	0,585 2	1,001 92
0,351	0,585 2	1,009 12
0,352	0,585 2	1,016 33
0,353	0,585 2	1,023 56
0,354	0,585 2	1,030 82
0,355	0,585 2	1,038 12
0,356	0,585 2	1,045 45
0,357	0,585 2	1,052 80
0,358	0,585 2	1,060 19
0,359	0,585 2	1,067 67
0,360	0,585 3	1,075 19
0,361	0,585 3	1,082 73
0,362	0,585 3	1,090 24
0,363	0,585 3	1,097 78
0,364	0,585 3	1,105 36
0,365	0,585 3	1,112 97
0,366	0,585 3	1,120 63
0,367	0,585 3	1,128 37
0,368	0,585 4	1,136 15
0,369	0,585 4	1,143 91
0,370	0,585 4	1,151 67
0,371	0,585 4	1,159 47
0,372	0,585 4	1,167 30
0,373	0,585 4	1,175 16
0,374	0,585 4	1,183 10
0,375	0,585 5	1,191 11
0,376	0,585 5	1,199 14
0,377	0,585 5	1,207 12
0,378	0,585 5	1,215 15
0,379	0,585 5	1,223 20
0,380	0,585 5	1,231 28
0,381	0,585 5	1,239 40

TABLE 1 (*concluded*)

b) FEET UNITS

$Q = 4{,}279\ 1\ C_e h^{5/2}$

($g = 32.174$ ft/s^2)

Head h (ft)	Coefficient C_e	Discharge Q (ft^3/s)
0.20	0.602 8	0.046 14
0.21	0.601 5	0.052 02
0.22	0.600 4	0.058 33
0.23	0.599 4	0.065 07
0.24	0.598 3	0.072 24
0.25	0.597 5	0.079 90
0.26	0.596 6	0.088 00
0.27	0.595 7	0.096 56
0.28	0.594 9	0.105 61
0.29	0.594 1	0.115 14
0.30	0.593 4	0.125 17
0.31	0.592 8	0.135 73
0.32	0.592 2	0.146 79
0.33	0.591 5	0.158 35
0.34	0.590 9	0.170 44
0.35	0.590 3	0.183 06
0.36	0.589 8	0.196 27
0.37	0.589 4	0.210 04
0.38	0.589 0	0.224 36
0.39	0.588 7	0.239 26
0.40	0.588 2	0.254 70
0.41	0.588 0	0.270 81
0.42	0.587 7	0.287 51
0.43	0.587 5	0.304 80
0.44	0.587 2	0.322 70
0.45	0.587 0	0.341 21
0.46	0.586 8	0.360 35
0.47	0.586 6	0.380 15
0.48	0.586 4	0.400 53
0.49	0.586 1	0.421 55
0.50	0.586 0	0.443 28
0.51	0.585 9	0.465 68
0.52	0.585 8	0.488 74
0.53	0.585 6	0.512 48
0.54	0.585 5	0.536 88
0.55	0.585 4	0.561 97
0.56	0.585 3	0.587 74
0.57	0.585 2	0.614 21
0.58	0.585 1	0.641 43
0.59	0.585 1	0.669 44
0.60	0.585 0	0.698 05
0.61	0.585 0	0.727 50
0.62	0.585 0	0.757 63
0.63	0.584 9	0.788 52
0.64	0.584 9	0.820 13
0.65	0.584 9	0.852 55
0.66	0.584 9	0.885 68
0.67	0.584 8	0.919 49
0.68	0.584 8	0.954 18
0.69	0.584 8	0.989 65
0.70	0.584 7	1.025 72
0.71	0.584 7	1.062 75
0.72	0.584 7	1.100 57
0.73	0.584 7	1.139 18
0.74	0.584 6	1.178 43
0.75	0.584 6	1.218 61
0.76	0.584 6	1.259 64
0.77	0.584 6	1.301 48
0.78	0.584 6	1.344 15
0.79	0.584 6	1.387 65
0.80	0.584 6	1.431 98
0.81	0.584 6	1.477 15
0.82	0.584 6	1.523 16
0.83	0.584 6	1.570 02
0.84	0.584 6	1.617 74
0.85	0.584 6	1.666 32
0.86	0.584 6	1.715 76
0.87	0.584 6	1.766 08
0.88	0.584 6	1.817 26
0.89	0.584 6	1.869 33
0.90	0.584 6	1.922 28
0.91	0.584 6	1.976 19
0.92	0.584 7	2.031 21
0.93	0.584 7	2.086 86
0.94	0.584 7	2.143 41
0.95	0.584 7	2.200 87
0.96	0.584 7	2.259 32
0.97	0.584 8	2.318 94
0.98	0.584 8	2.379 17
0.99	0.584 8	2.440 33
1.00	0.584 8	2.502 42
1.01	0.584 9	2.565 89
1.02	0.584 9	2.629 87
1.03	0.584 9	2.694 80
1.04	0.584 9	2.760 69
1.05	0.585 0	2.828 01
1.06	0.585 0	2.895 83
1.07	0.585 0	2.964 61
1.08	0.585 0	3.034 36
1.09	0.585 0	3.105 09
1.10	0.585 0	3.176 80
1.11	0.585 1	3.250 05
1.12	0.585 1	3.323 74
1.13	0.585 1	3.398 43
1.14	0.585 1	3.474 12
1.15	0.585 2	3.551 41
1.16	0.585 2	3.629 12
1.17	0.585 2	3.707 84
1.18	0.585 3	3.787 97
1.19	0.585 3	3.869 00
1.20	0.585 3	3.950 79
1.21	0.585 4	4.034 30
1.22	0.585 4	4.118 17
1.23	0.585 5	4.203 51
1.24	0.585 5	4.289 77
1.25	0.585 5	4.376 78

NOTE — The number of significant figures (4 or 5) given in the columns for coefficient and discharge should not be taken to imply a corresponding accuracy in the knowledge of the values given, but only to assist in interpolation and analysis.

TABLE 2 – **Discharge of water over a 1/2 90° V-notch**

a) **METRIC UNITS**

$$Q = 1{,}181\ 25\ C_e\ h^{5/2}$$

$$(g = 9{,}806\ 6\ \text{m/s}^2)$$

Head h (m)	Coefficient C_e	Discharge Q ($m^3/s \times 10$)	Head h (m)	Coefficient C_e	Discharge Q ($m^3/s \times 10$)
0,060	0,611 4	0,006 37	0,120	0,598 9	0,035 29
0,061	0,611 1	0,006 63	0,121	0,598 8	0,036 02
0,062	0,610 8	0,006 91	0,122	0,598 7	0,036 77
0,063	0,610 5	0,007 18	0,123	0,598 5	0,037 51
0,064	0,610 1	0,007 47	0,124	0,598 4	0,038 27
0,065	0,609 8	0,007 76	0,125	0,598 2	0,039 04
0,066	0,609 5	0,008 06	0,126	0,598 1	0,039 82
0,067	0,609 2	0,008 36	0,127	0,598 0	0,040 60
0,068	0,609 0	0,008 67	0,128	0,597 9	0,041 40
0,069	0,608 7	0,008 99	0,129	0,597 8	0,042 20
0,070	0,608 4	0,009 32	0,130	0,597 6	0,043 02
0,071	0,608 1	0,009 65	0,131	0,597 5	0,043 84
0,072	0,607 9	0,009 99	0,132	0,597 3	0,044 67
0,073	0,607 6	0,010 33	0,133	0,597 2	0,045 51
0,074	0,607 3	0,010 69	0,134	0,597 1	0,046 36
0,075	0,607 1	0,011 05	0,135	0,597 0	0,047 22
0,076	0,606 8	0,011 41	0,136	0,596 8	0,048 09
0,077	0,606 6	0,011 79	0,137	0,596 7	0,048 97
0,078	0,606 4	0,012 17	0,138	0,596 6	0,049 86
0,079	0,606 1	0,012 56	0,139	0,596 5	0,050 75
0,080	0,606 0	0,012 96	0,140	0,596 4	0,051 66
0,081	0,605 8	0,013 36	0,141	0,596 2	0,052 58
0,082	0,605 6	0,013 77	0,142	0,596 1	0,053 51
0,083	0,605 4	0,014 19	0,143	0,596 0	0,054 44
0,084	0,605 2	0,014 62	0,144	0,596 0	0,055 39
0,085	0,605 0	0,015 05	0,145	0,595 9	0,056 35
0,086	0,604 8	0,015 49	0,146	0,595 8	0,057 32
0,087	0,604 6	0,015 94	0,147	0,595 7	0,058 30
0,088	0,604 4	0,016 40	0,148	0,595 6	0,059 29
0,089	0,604 2	0,016 86	0,149	0,595 6	0,060 29
0,090	0,604 0	0,017 34	0,150	0,595 5	0,061 30
0,091	0,603 8	0,017 82	0,151	0,595 4	0,062 31
0,092	0,603 6	0,018 30	0,152	0,595 2	0,063 34
0,093	0,603 4	0,018 80	0,153	0,595 2	0,064 37
0,094	0,603 2	0,019 30	0,154	0,595 1	0,065 42
0,095	0,603 0	0,019 81	0,155	0,595 0	0,066 48
0,096	0,602 8	0,020 33	0,156	0,594 9	0,067 55
0,097	0,602 6	0,020 86	0,157	0,594 8	0,068 63
0,098	0,602 4	0,021 39	0,158	0,594 8	0,069 71
0,099	0,602 2	0,021 94	0,159	0,594 7	0,070 81
0,100	0,602 1	0,022 49	0,160	0,594 6	0,071 92
0,101	0,601 9	0,023 05	0,161	0,594 5	0,073 04
0,102	0,601 7	0,023 62	0,162	0,594 4	0,074 17
0,103	0,601 6	0,024 20	0,163	0,594 4	0,075 31
0,104	0,601 4	0,024 78	0,164	0,594 3	0,076 46
0,105	0,601 3	0,025 37	0,165	0,594 2	0,077 62
0,106	0,601 1	0,025 98	0,166	0,594 1	0,078 79
0,107	0,600 9	0,026 59	0,167	0,594 1	0,079 98
0,108	0,600 8	0,027 20	0,168	0,594 0	0,081 17
0,109	0,600 6	0,027 83	0,169	0,593 9	0,082 37
0,110	0,600 5	0,028 47	0,170	0,593 8	0,083 58
0,111	0,600 3	0,029 11	0,171	0,593 7	0,084 81
0,112	0,600 2	0,029 76	0,172	0,593 7	0,086 04
0,113	0,600 0	0,030 42	0,173	0,593 6	0,087 28
0,114	0,599 8	0,031 09	0,174	0,593 5	0,088 54
0,115	0,599 7	0,031 77	0,175	0,593 4	0,089 80
0,116	0,599 5	0,032 46	0,176	0,593 3	0,091 08
0,117	0,599 4	0,033 15	0,177	0,593 3	0,092 37
0,118	0,599 2	0,033 86	0,178	0,593 2	0,093 67
0,119	0,599 1	0,034 57	0,179	0,593 1	0,094 97

TABLE 2 (*continued*)

Head h	Coefficient C_e	Discharge Q	Head h	Coefficient C_e	Discharge Q
m		$m^3/s \times 10$	m		$m^3/s \times 10$
0,180	0,593 0	0,096 29	0,240	0,590 1	0,196 68
0,181	0,592 9	0,097 62	0,241	0,590 0	0,198 72
0,182	0,592 9	0,098 96	0,242	0,590 0	0,200 79
0,183	0,592 8	0,100 32	0,243	0,590 0	0,202 87
0,184	0,592 7	0,101 68	0,244	0,589 9	0,204 96
0,185	0,592 6	0,103 05	0,245	0,589 9	0,207 05
0,186	0,592 6	0,104 44	0,246	0,589 8	0,209 16
0,187	0,592 5	0,105 84	0,247	0,589 8	0,211 27
0,188	0,592 5	0,107 26	0,248	0,589 8	0,213 40
0,189	0,592 4	0,108 67	0,249	0,589 8	0,215 55
0,190	0,592 3	0,110 10	0,250	0,589 8	0,217 72
0,191	0,592 3	0,111 55	0,251	0,589 8	0,219 90
0,192	0,592 2	0,113 00	0,252	0,589 8	0,222 09
0,193	0,592 2	0,114 47	0,253	0,589 7	0,224 29
0,194	0,592 1	0,115 95	0,254	0,589 7	0,226 49
0,195	0,592 0	0,117 43	0,255	0,589 7	0,228 73
0,196	0,592 0	0,118 93	0,256	0,589 7	0,230 98
0,197	0,591 9	0,120 44	0,257	0,589 7	0,233 23
0,198	0,591 9	0,121 97	0,258	0,589 6	0,235 49
0,199	0,591 9	0,123 51	0,259	0,589 6	0,237 77
0,200	0,591 8	0,125 06	0,260	0,589 6	0,240 05
0,201	0,591 8	0,126 62	0,261	0,589 5	0,242 35
0,202	0,591 7	0,128 19	0,262	0,589 5	0,244 66
0,203	0,591 7	0,129 77	0,263	0,589 4	0,246 99
0,204	0,591 6	0,131 36	0,264	0,589 4	0,249 33
0,205	0,591 6	0,132 96	0,265	0,589 4	0,251 68
0,206	0,591 5	0,134 57	0,266	0,589 3	0,254 04
0,207	0,591 5	0,136 20	0,267	0,589 3	0,256 42
0,208	0,591 4	0,137 84	0,268	0,589 2	0,258 81
0,209	0,591 3	0,139 49	0,269	0,589 2	0,261 21
0,210	0,591 3	0,141 15	0,270	0,589 2	0,263 63
0,211	0,591 2	0,142 82	0,271	0,589 1	0,266 06
0,212	0,591 2	0,144 50	0,272	0,589 1	0,268 51
0,213	0,591 1	0,146 20	0,273	0,589 1	0,270 98
0,214	0,591 1	0,147 92	0,274	0,589 1	0,273 47
0,215	0,591 0	0,149 64	0,275	0,589 1	0,275 96
0,216	0,591 0	0,151 38	0,276	0,589 0	0,278 45
0,217	0,591 0	0,153 13	0,277	0,589 0	0,280 97
0,218	0,590 9	0,154 89	0,278	0,589 0	0,283 51
0,219	0,590 9	0,156 66	0,279	0,589 0	0,286 07
0,220	0,590 8	0,158 44	0,280	0,589 0	0,288 63
0,221	0,590 8	0,160 24	0,281	0,588 9	0,291 19
0,222	0,590 8	0,162 04	0,282	0,588 9	0,293 77
0,223	0,590 7	0,163 86	0,283	0,588 9	0,296 38
0,224	0,590 7	0,165 70	0,284	0,588 9	0,299 01
0,225	0,590 6	0,167 54	0,285	0,588 9	0,301 63
0,226	0,590 6	0,169 40	0,286	0,588 8	0,304 27
0,227	0,590 6	0,171 27	0,287	0,588 8	0,306 91
0,228	0,590 5	0,173 15	0,288	0,588 8	0,309 59
0,229	0,590 5	0,175 04	0,289	0,588 8	0,312 29
0,230	0,590 4	0,176 95	0,290	0,588 8	0,314 99
0,231	0,590 4	0,178 86	0,291	0,588 7	0,317 69
0,232	0,590 4	0,180 79	0,292	0,588 7	0,320 40
0,233	0,590 3	0,182 74	0,293	0,588 7	0,323 15
0,234	0,590 3	0,184 69	0,294	0,588 7	0,325 91
0,235	0,590 2	0,186 66	0,295	0,588 7	0,328 69
0,236	0,590 2	0,188 64	0,296	0,588 6	0,331 46
0,237	0,590 2	0,190 63	0,297	0,588 6	0,334 24
0,238	0,590 1	0,192 63	0,298	0,588 6	0,337 04
0,239	0,590 1	0,194 65	0,299	0,588 5	0,339 85

TABLE 2 (*continued*)

Head h	Coefficient C_e	Discharge Q
m		$m^3/s \times 10$
0,300	0,588 5	0,342 68
0,301	0,588 4	0,345 52
0,302	0,588 4	0,348 37
0,303	0,588 4	0,351 24
0,304	0,588 3	0,354 12
0,305	0,588 3	0,357 02
0,306	0,588 3	0,359 95
0,307	0,588 3	0,362 90
0,308	0,588 3	0,365 85
0,309	0,588 2	0,368 80
0,310	0,588 2	0,371 77
0,311	0,588 2	0,374 77
0,312	0,588 2	0,377 79
0,313	0,588 2	0,380 81
0,314	0,588 1	0,383 84
0,315	0,588 1	0,386 87
0,316	0,588 1	0,389 95
0,317	0,588 1	0,393 04
0,318	0,588 1	0,396 15
0,319	0,588 1	0,399 27
0,320	0,588 1	0,402 41
0,321	0,588 1	0,405 53
0,322	0,588 0	0,408 67
0,323	0,588 0	0,411 84
0,324	0,588 0	0,415 03
0,325	0,588 0	0,418 24
0,326	0,588 0	0,421 47
0,327	0,588 0	0,424 71
0,328	0,588 0	0,427 96
0,329	0,588 0	0,431 23
0,330	0,588 0	0,434 51
0,331	0,588 0	0,437 79
0,332	0,587 9	0,441 07
0,333	0,587 9	0,444 38
0,334	0,587 9	0,447 73
0,335	0,587 9	0,451 08
0,336	0,587 9	0,454 46
0,337	0,587 9	0,457 85
0,338	0,587 9	0,461 25
0,339	0,587 9	0,464 67
0,340	0,587 9	0,468 10
0,341	0,587 9	0,471 53
0,342	0,587 8	0,474 97
0,343	0,587 8	0,478 42
0,344	0,587 8	0,481 91
0,345	0,587 8	0,485 42
0,346	0,587 8	0,488 95
0,347	0,587 8	0,492 49
0,348	0,587 8	0,496 04
0,349	0,587 8	0,499 58
0,350	0,587 7	0,503 13
0,351	0,587 7	0,506 72
0,352	0,587 7	0,510 33
0,353	0,587 7	0,513 97
0,354	0,587 7	0,517 58
0,355	0,587 6	0,521 21
0,356	0,587 6	0,524 87
0,357	0,587 6	0,528 56
0,358	0,587 6	0,532 27
0,359	0,587 6	0,535 96
0,360	0,587 5	0,539 67
0,361	0,587 5	0,543 40
0,362	0,587 5	0,547 17
0,363	0,587 5	0,550 96
0,364	0,587 5	0,554 73
0,365	0,587 4	0,558 51
0,366	0,587 4	0,562 31
0,367	0,585 4	0,566 16
0,368	0,587 4	0,570 03
0,369	0,587 4	0,573 91
0,370	0,587 4	0,577 80
0,371	0,587 4	0,581 71
0,372	0,587 4	0,585 60
0,373	0,587 3	0,589 50
0,374	0,587 3	0,593 45
0,375	0,587 3	0,597 42
0,376	0,587 3	0,601 41
0,377	0,587 3	0,605 42
0,378	0,587 3	0,609 44
0,379	0,587 3	0,613 46
0,380	0,587 2	0,617 47
0,381	0,587 2	0,621 50

TABLE 2 (*concluded*)

b) FEET UNITS

$Q = 2{,}139\ 55\ C_e\, h^{5/2}$

$(g = 32.174\ \text{ft/s}^2)$

Head h (ft)	Coefficient C_e	Discharge Q (ft^3/s)
0.20	0.611 1	0.023 39
0.21	0.610 1	0.026 38
0.22	0.609 2	0.029 59
0.23	0.608 4	0.033 02
0.24	0.607 5	0.036 68
0.25	0.606 8	0.040 57
0.26	0.606 1	0.044 70
0.27	0.605 5	0.049 07
0.28	0.604 9	0.053 69
0.29	0.604 3	0.058 56
0.30	0.603 7	0.063 67
0.31	0.603 1	0.069 04
0.32	0.602 5	0.074 67
0.33	0.602 0	0.080 57
0.34	0.601 5	0.086 74
0.35	0.601 0	0.093 19
0.36	0.600 5	0.099 91
0.37	0.600 0	0.106 91
0.38	0.599 6	0.114 19
0.39	0.599 1	0.121 75
0.40	0.598 7	0.129 62
0.41	0.598 2	0.137 77
0.42	0.597 9	0.146 24
0.43	0.597 5	0.154 99
0.44	0.597 1	0.164 05
0.45	0.596 7	0.173 42
0.46	0.596 3	0.183 11
0.47	0.596 0	0.193 12
0.48	0.595 8	0.203 48
0.49	0.595 5	0.214 15
0.50	0.595 2	0.225 12
0.51	0.595 0	0.236 45
0.52	0.594 7	0.248 11
0.53	0.594 5	0.260 11
0.54	0.594 2	0.272 44
0.55	0.594 0	0.285 11
0.56	0.593 8	0.298 13
0.57	0.593 5	0.311 49
0.58	0.593 3	0.325 20
0.59	0.593 0	0.339 26
0.60	0.592 8	0.353 68
0.61	0.592 6	0.368 46
0.62	0.592 4	0.383 65
0.63	0.592 2	0.399 18
0.64	0.592 0	0.415 07
0.65	0.591 9	0.431 37
0.66	0.591 8	0.448 07
0.67	0.591 6	0.465 11
0.68	0.591 4	0.482 51
0.69	0.591 2	0.500 28
0.70	0.591 1	0.518 48
0.71	0.591 0	0.537 08
0.72	0.590 9	0.556 08
0.73	0.590 7	0.575 47
0.74	0.590 6	0.595 26
0.75	0.590 5	0.615 45
0.76	0.590 4	0.636 05
0.77	0.590 3	0.657 04
0.78	0.590 1	0.678 44
0.79	0.590 0	0.700 26
0.80	0.590 0	0.722 60
0.81	0.589 9	0.745 24
0.82	0.589 8	0.768 35
0.83	0.589 7	0.781 91
0.84	0.589 7	0.815 93
0.85	0.589 6	0.840 29
0.86	0.589 5	0.865 04
0.87	0.589 4	0.890 23
0.88	0.589 2	0.915 84
0.89	0.589 1	0.941 89
0.90	0.589 1	0.968 54
0.91	0.589 0	0.995 50
0.92	0.589 0	1.023 01
0.93	0.588 9	1.050 92
0.94	0.588 8	1.079 26
0.95	0.588 8	1.108 15
0.96	0.588 7	1.137 35
0.97	0.588 7	1.167 12
0.98	0.588 5	1.197 19
0.99	0.588 4	1.227 72
1.00	0.588 3	1.258 70
1.01	0.588 3	1.290 36
1.02	0.588 2	1.322 35
1.03	0.588 1	1.354 87
1.04	0.588 1	1.387 90
1.05	0.588 1	1.421 50
1.06	0.588 0	1.455 34
1.07	0.588 0	1.489 91
1.08	0.588 0	1.524 96
1.09	0.587 9	1.560 30
1.10	0.587 9	1.596 27
1.11	0.587 9	1.632 80
1.12	0.587 9	1.669 71
1.13	0.587 8	1.707 06
1.14	0.587 8	1.745 08
1.15	0.587 7	1.783 29
1.16	0.587 7	1.822 25
1.17	0.587 6	1.861 53
1.18	0.587 5	1.901 36
1.19	0.587 5	1.941 77
1.20	0.587 4	1.982 48
1.21	0.587 4	2.024 04
1.22	0.587 4	2.065 98
1.23	0.587 3	2.108 36
1.24	0.587 3	2.151 48
1.25	0.587 2	2.194 74

NOTE – The number of significant figures (4 or 5) given in the columns for coefficient and discharge should not be taken to imply a corresponding accuracy in the knowledge of the values given, but only to assist in interpolation and analysis.

TABLE 3 – **Discharge of water over a 1/4 90° V-notch**

a) **METRIC UNITS**

$$Q = 0{,}590\ 625\ C_e\ h^{5/2}$$

$$(g = 9{,}806\ 6\ m/s^2)$$

Head h	Coefficient C_e	Discharge Q	Head h	Coefficient C_e	Discharge Q
m		$m^3/s \times 10$	m		$m^3/s \times 10$
0,060	0,641 7	0,003 34	0,120	0,616 2	0,018 15
0,061	0,641 0	0,003 48	0,121	0,616 0	0,018 53
0,062	0,640 3	0,003 62	0,122	0,615 8	0,018 91
0,063	0,639 6	0,003 76	0,123	0,615 5	0,019 29
0,064	0,639 0	0,003 91	0,124	0,615 3	0,019 68
0,065	0,638 3	0,004 06	0,125	0,615 1	0,020 07
0,066	0,637 6	0,004 21	0,126	0,614 8	0,020 46
0,067	0,637 0	0,004 37	0,127	0,614 6	0,020 86
0,068	0,636 4	0,004 53	0,128	0,614 4	0,021 27
0,069	0,635 8	0,004 70	0,129	0,614 1	0,021 68
0,070	0,635 2	0,004 86	0,130	0,613 9	0,022 09
0,071	0,634 6	0,005 03	0,131	0,613 7	0,022 51
0,072	0,634 0	0,005 21	0,132	0,613 5	0,022 94
0,073	0,633 5	0,005 39	0,133	0,613 3	0,023 37
0,074	0,632 9	0,005 57	0,134	0,613 1	0,023 80
0,075	0,632 4	0,005 75	0,135	0,612 9	0,024 24
0,076	0,631 8	0,005 94	0,136	0,612 7	0,024 68
0,077	0,631 3	0,006 13	0,137	0,612 5	0,025 13
0,078	0,630 8	0,006 33	0,138	0,612 3	0,025 59
0,079	0,630 3	0,006 53	0,139	0,612 1	0,026 04
0,080	0,629 8	0,006 73	0,140	0,611 9	0,026 51
0,081	0,629 3	0,006 94	0,141	0,611 7	0,026 97
0,082	0,628 9	0,007 15	0,142	0,611 5	0,027 44
0,083	0,628 5	0,007 37	0,143	0,611 3	0,027 92
0,084	0,628 0	0,007 59	0,144	0,611 2	0,028 40
0,085	0,627 6	0,007 81	0,145	0,611 0	0,028 89
0,086	0,627 2	0,008 03	0,146	0,610 8	0,029 38
0,087	0,626 7	0,008 26	0,147	0,610 6	0,029 88
0,088	0,626 4	0,008 50	0,148	0,610 5	0,030 38
0,089	0,626 0	0,008 74	0,149	0,610 3	0,030 89
0,090	0,625 6	0,008 98	0,150	0,610 2	0,031 40
0,091	0,625 2	0,009 22	0,151	0,610 0	0,031 92
0,092	0,624 8	0,009 47	0,152	0,609 9	0,032 45
0,093	0,624 4	0,009 73	0,153	0,609 7	0,032 97
0,094	0,624 0	0,009 98	0,154	0,609 5	0,033 50
0,095	0,623 6	0,010 25	0,155	0,609 3	0,034 04
0,096	0,623 3	0,010 51	0,156	0,609 1	0,034 58
0,097	0,622 9	0,010 78	0,157	0,609 0	0,035 13
0,098	0,622 6	0,011 06	0,158	0,608 8	0,035 68
0,099	0,622 2	0,011 33	0,159	0,608 7	0,036 24
0,100	0,621 9	0,011 61	0,160	0,608 5	0,036 80
0,101	0,621 5	0,011 90	0,161	0,608 3	0,037 37
0,102	0,621 2	0,012 19	0,162	0,608 2	0,037 94
0,103	0,620 9	0,012 49	0,163	0,608 0	0,038 52
0,104	0,620 5	0,012 78	0,164	0,607 9	0,039 11
0,105	0,620 2	0,013 09	0,165	0,607 7	0,039 69
0,106	0,619 9	0,013 39	0,166	0,607 6	0,040 29
0,107	0,619 6	0,013 71	0,167	0,607 4	0,040 89
0,108	0,619 3	0,014 02	0,168	0,607 3	0,041 49
0,109	0,619 0	0,014 34	0,169	0,607 1	0,042 10
0,110	0,618 7	0,014 66	0,170	0,607 0	0,042 72
0,111	0,618 4	0,014 99	0,171	0,606 9	0,043 34
0,112	0,618 1	0,015 33	0,172	0,606 8	0,043 97
0,113	0,617 9	0,015 66	0,173	0,606 7	0,044 60
0,114	0,617 6	0,016 01	0,174	0,606 5	0,045 24
0,115	0,617 3	0,016 35	0,175	0,606 3	0,045 88
0,116	0,617 1	0,016 70	0,176	0,606 2	0,046 53
0,117	0,616 9	0,017 06	0,177	0,606 1	0,047 18
0,118	0,616 6	0,017 42	0,178	0,606 0	0,047 84
0,119	0,616 4	0,017 78	0,179	0,605 9	0,048 51

TABLE 3 (*continued*)

Head h	Coefficient C_e	Discharge Q	Head h	Coefficient C_e	Discharge Q
m		$m^3/s \times 10$	m		$m^3/s \times 10$
0,180	0,605 7	0,049 18	0,240	0,600 8	0,100 13
0,181	0,605 6	0,049 86	0,241	0,600 7	0,101 16
0,182	0,605 5	0,050 54	0,242	0,600 6	0,102 20
0,183	0,605 4	0,051 22	0,243	0,600 6	0,103 25
0,184	0,605 3	0,051 92	0,244	0,600 5	0,104 30
0,185	0,605 1	0,052 61	0,245	0,600 4	0,105 36
0,186	0,605 1	0,053 32	0,246	0,600 3	0,106 42
0,187	0,605 0	0,054 03	0,247	0,600 3	0,107 50
0,188	0,604 9	0,054 75	0,248	0,600 2	0,108 58
0,189	0,604 8	0,055 47	0,249	0,600 2	0,109 67
0,190	0,604 7	0,056 20	0,250	0,600 2	0,110 77
0,191	0,604 5	0,056 93	0,251	0,600 1	0,111 87
0,192	0,604 4	0,057 66	0,252	0,600 1	0,112 99
0,193	0,604 3	0,058 41	0,253	0,600 0	0,114 10
0,194	0,604 2	0,059 16	0,254	0,600 0	0,115 23
0,195	0,604 1	0,059 92	0,255	0,600 0	0,116 35
0,196	0,604 1	0,060 68	0,256	0,599 9	0,117 49
0,197	0,604 0	0,061 45	0,257	0,599 9	0,118 63
0,198	0,603 9	0,062 22	0,258	0,599 8	0,119 78
0,199	0,603 8	0,063 00	0,259	0,599 8	0,120 94
0,200	0,603 8	0,063 79	0,260	0,599 7	0,122 10
0,201	0,603 7	0,064 58	0,261	0,599 6	0,123 26
0,202	0,603 5	0,065 37	0,262	0,599 6	0,124 43
0,203	0,603 4	0,066 17	0,263	0,599 5	0,125 61
0,204	0,603 3	0,066 98	0,264	0,599 5	0,126 80
0,205	0,603 3	0,067 80	0,265	0,599 5	0,127 99
0,206	0,603 2	0,068 62	0,266	0,599 4	0,129 20
0,207	0,603 1	0,069 44	0,267	0,599 4	0,130 41
0,208	0,603 0	0,070 28	0,268	0,599 3	0,131 62
0,209	0,602 9	0,071 11	0,269	0,599 3	0,132 84
0,210	0,602 9	0,071 96	0,270	0,599 2	0,134 07
0,211	0,602 8	0,072 81	0,271	0,599 2	0,135 29
0,212	0,602 7	0,073 66	0,272	0,599 1	0,136 53
0,213	0,602 6	0,074 53	0,273	0,599 1	0,137 78
0,214	0,602 5	0,075 39	0,274	0,599 0	0,139 03
0,215	0,602 5	0,076 27	0,275	0,599 0	0,140 30
0,216	0,602 4	0,077 15	0,276	0,598 9	0,141 57
0,217	0,602 3	0,078 03	0,277	0,598 9	0,142 84
0,218	0,602 2	0,078 93	0,278	0,598 9	0,144 13
0,219	0,602 2	0,079 82	0,279	0,598 8	0,145 42
0,220	0,602 1	0,080 73	0,280	0,598 8	0,146 71
0,221	0,602 0	0,081 64	0,281	0,598 7	0,148 02
0,222	0,601 9	0,082 55	0,282	0,598 7	0,149 33
0,223	0,601 8	0,083 47	0,283	0,598 7	0,150 65
0,224	0,601 8	0,084 41	0,284	0,598 6	0,151 97
0,225	0,601 7	0,085 35	0,285	0,598 6	0,153 30
0,226	0,601 7	0,086 29	0,286	0,598 5	0,154 64
0,227	0,601 6	0,087 24	0,287	0,598 5	0,155 98
0,228	0,601 5	0,088 19	0,288	0,598 5	0,157 34
0,229	0,601 5	0,089 15	0,289	0,598 4	0,158 70
0,230	0,601 4	0,090 11	0,290	0,598 4	0,160 06
0,231	0,601 3	0,091 08	0,291	0,598 3	0,161 43
0,232	0,601 3	0,092 07	0,292	0,598 3	0,162 81
0,233	0,601 2	0,093 06	0,293	0,598 3	0,164 20
0,234	0,601 2	0,094 05	0,294	0,598 2	0,165 59
0,235	0,601 1	0,095 04	0,295	0,598 2	0,166 99
0,236	0,601 0	0,096 05	0,296	0,598 1	0,168 40
0,237	0,601 0	0,097 06	0,297	0,598 1	0,169 82
0,238	0,600 9	0,098 08	0,298	0,598 1	0,171 24
0,239	0,600 9	0,099 10	0,299	0,598 0	0,172 67

TABLE 3 *(continued)*

Head h	Coefficient C_e	Discharge Q
m		$m^3/s \times 10$
0,300	0,598 0	0,174 10
0,301	0,597 9	0,175 55
0,302	0,597 9	0,177 00
0,303	0,597 9	0,178 45
0,304	0,597 8	0,179 92
0,305	0,597 8	0,181 39
0,306	0,597 8	0,182 87
0,307	0,597 7	0,184 35
0,308	0,597 7	0,185 85
0,309	0,597 6	0,187 35
0,310	0,597 6	0,188 85
0,311	0,597 6	0,190 37
0,312	0,597 5	0,191 89
0,313	0,597 5	0,193 42
0,314	0,597 4	0,194 95
0,315	0,597 4	0,196 50
0,316	0,597 4	0,198 05
0,317	0,597 3	0,199 60
0,318	0,597 3	0,201 17
0,319	0,597 2	0,202 74
0,320	0,597 2	0,204 32
0,321	0,597 2	0,205 90
0,322	0,597 1	0,207 50
0,323	0,597 1	0,209 10
0,324	0,597 0	0,210 71
0,325	0,597 0	0,212 32
0,326	0,597 0	0,213 95
0,327	0,596 9	0,215 58
0,328	0,596 9	0,217 21
0,329	0,596 8	0,218 86
0,330	0,596 8	0,220 51
0,331	0,596 8	0,222 17
0,332	0,596 7	0,223 84
0,333	0,596 7	0,225 51
0,334	0,596 7	0,227 19
0,335	0,596 6	0,228 88
0,336	0,596 6	0,230 58
0,337	0,596 5	0,232 28
0,338	0,596 5	0,234 00
0,339	0,596 5	0,235 72
0,340	0,596 4	0,237 44
0,341	0,596 4	0,239 18
0,342	0,596 3	0,240 92
0,343	0,596 3	0,242 67
0,344	0,596 3	0,244 42
0,345	0,596 2	0,246 19
0,346	0,596 2	0,247 96
0,347	0,596 1	0,249 74
0,348	0,596 1	0,251 52
0,349	0,596 1	0,253 32
0,350	0,596 0	0,255 12
0,351	0,596 0	0,256 93
0,352	0,595 9	0,258 75
0,353	0,595 9	0,260 57
0,354	0,595 9	0,262 40
0,355	0,595 8	0,264 24
0,356	0,595 8	0,266 09
0,357	0,595 7	0,267 94
0,358	0,595 7	0,269 81
0,359	0,595 7	0,271 68
0,360	0,595 6	0,273 55
0,361	0,595 6	0,275 44
0,362	0,595 5	0,277 33
0,363	0,595 5	0,279 23
0,364	0,595 5	0,281 14
0,365	0,595 4	0,283 06
0,366	0,595 4	0,284 98
0,367	0,595 4	0,286 91
0,368	0,595 3	0,288 85
0,369	0,595 3	0,290 80
0,370	0,595 2	0,292 75
0,371	0,595 2	0,294 72
0,372	0,595 2	0,296 69
0,373	0,595 1	0,298 67
0,374	0,595 1	0,300 65
0,375	0,595 0	0,302 64
0,376	0,595 0	0,304 65
0,377	0,595 0	0,306 66
0,378	0,594 9	0,308 67
0,379	0,594 9	0,310 70
0,380	0,594 8	0,312 73
0,381	0,594 8	0,314 77

TABLE 3 (*concluded*)

b) FEET UNITS

$Q = 1{,}069\,775\,C_e\,h^{5/2}$

($g = 32.174$ ft/s^2)

Head h (ft)	Coefficient C_e	Discharge Q (ft^3/s)
0.20	0.641 0	0.012 27
0.21	0.639 0	0.013 81
0.22	0.637 0	0.015 47
0.23	0.635 1	0.017 24
0.24	0.633 4	0.019 12
0.25	0.631 7	0.021 12
0.26	0.630 2	0.023 24
0.27	0.628 8	0.025 48
0.28	0.627 4	0.027 85
0.29	0.626 2	0.030 34
0.30	0.625 0	0.032 96
0.31	0.623 8	0.035 71
0.32	0.622 7	0.038 59
0.33	0.621 7	0.041 60
0.34	0.620 7	0.044 76
0.35	0.619 7	0.048 04
0.36	0.618 8	0.051 47
0.37	0.617 9	0.055 05
0.38	0.617 1	0.058 77
0.39	0.616 4	0.062 64
0.40	0.615 8	0.066 66
0.41	0.615 1	0.070 82
0.42	0.614 4	0.075 13
0.43	0.613 7	0.079 60
0.44	0.613 1	0.084 23
0.45	0.612 5	0.089 01
0.46	0.611 9	0.093 94
0.47	0.611 3	0.099 04
0.48	0.610 8	0.104 30
0.49	0.610 3	0.109 73
0.50	0.609 8	0.115 32
0.51	0.609 2	0.121 06
0.52	0.608 7	0.126 98
0.53	0.608 3	0.133 07
0.54	0.607 8	0.139 32
0.55	0.607 3	0.145 75
0.56	0.606 9	0.152 37
0.57	0.606 5	0.159 16
0.58	0.606 1	0.166 12
0.59	0.605 8	0.173 27
0.60	0.605 4	0.180 60
0.61	0.605 1	0.188 11
0.62	0.604 8	0.195 83
0.63	0.604 4	0.203 70
0.64	0.604 1	0.211 78
0.65	0.603 9	0.220 06
0.66	0.603 6	0.228 52
0.67	0.603 3	0.237 15
0.68	0.603 1	0.246 00
0.69	0.602 8	0.255 05
0.70	0.602 8	0.264 28
0.71	0.602 4	0.273 71
0.72	0.602 1	0.283 34
0.73	0.601 9	0.293 16
0.74	0.601 7	0.303 23
0.75	0.601 5	0.313 46
0.76	0.601 3	0.323 89
0.77	0.601 1	0.334 56
0.78	0.600 9	0.345 43
0.79	0.600 7	0.356 49
0.80	0.600 5	0.367 73
0.81	0.600 3	0.379 19
0.82	0.600 2	0.390 93
0.83	0.600 0	0.402 87
0.84	0.599 9	0.415 03
0.85	0.599 8	0.427 41
0.86	0.599 6	0.439 93
0.87	0.599 5	0.452 74
0.88	0.599 3	0.465 77
0.89	0.599 1	0.478 96
0.90	0.599 0	0.492 41
0.91	0.598 9	0.506 10
0.92	0.598 8	0.520 01
0.93	0.598 6	0.534 15
0.94	0.598 5	0.548 52
0.95	0.598 4	0.563 11
0.96	0.598 3	0.577 93
0.97	0.598 2	0.592 98
0.98	0.598 0	0.608 26
0.99	0.597 9	0.623 77
1.00	0.597 8	0.639 51
1.01	0.597 7	0.655 49
1.02	0.597 6	0.671 70
1.03	0.597 4	0.688 14
1.04	0.597 3	0.704 83
1.05	0.597 2	0.721 75
1.06	0.597 1	0.738 91
1.07	0.597 0	0.756 31
1.08	0.596 8	0.773 94
1.09	0.596 7	0.791 83
1.10	0.596 6	0.809 95
1.11	0.596 5	0.828 32
1.12	0.596 4	0.846 93
1.13	0.596 2	0.865 78
1.14	0.596 1	0.884 89
1.15	0.596 0	0.904 24
1.16	0.595 9	0.923 84
1.17	0.595 8	0.943 69
1.18	0.595 6	0.963 79
1.19	0.595 5	0.984 14
1.20	0.595 4	1.004 74
1.21	0.595 3	1.025 60
1.22	0.595 2	1.046 71
1.23	0.595 0	1.068 07
1.24	0.594 9	1.089 70
1.25	0.594 8	1.111 57

NOTE — The number of significant figures (4 or 5) given in the columns for coefficient and discharge should not be taken to imply a corresponding accuracy in the knowledge of the values given, but only to assist in interpolation and analysis.

10 RECTANGULAR THIN-PLATE WEIRS

10.1 Specifications for the standard weir

The rectangular thin-plate weir as defined for this International Standard is a general classification of which the weir with rectangular notch is the basic form and the full-width weir and fully contracted weir are limiting examples. A diagrammatic illustration of the thin-plate weir with rectangular-notch is shown in figure 6.

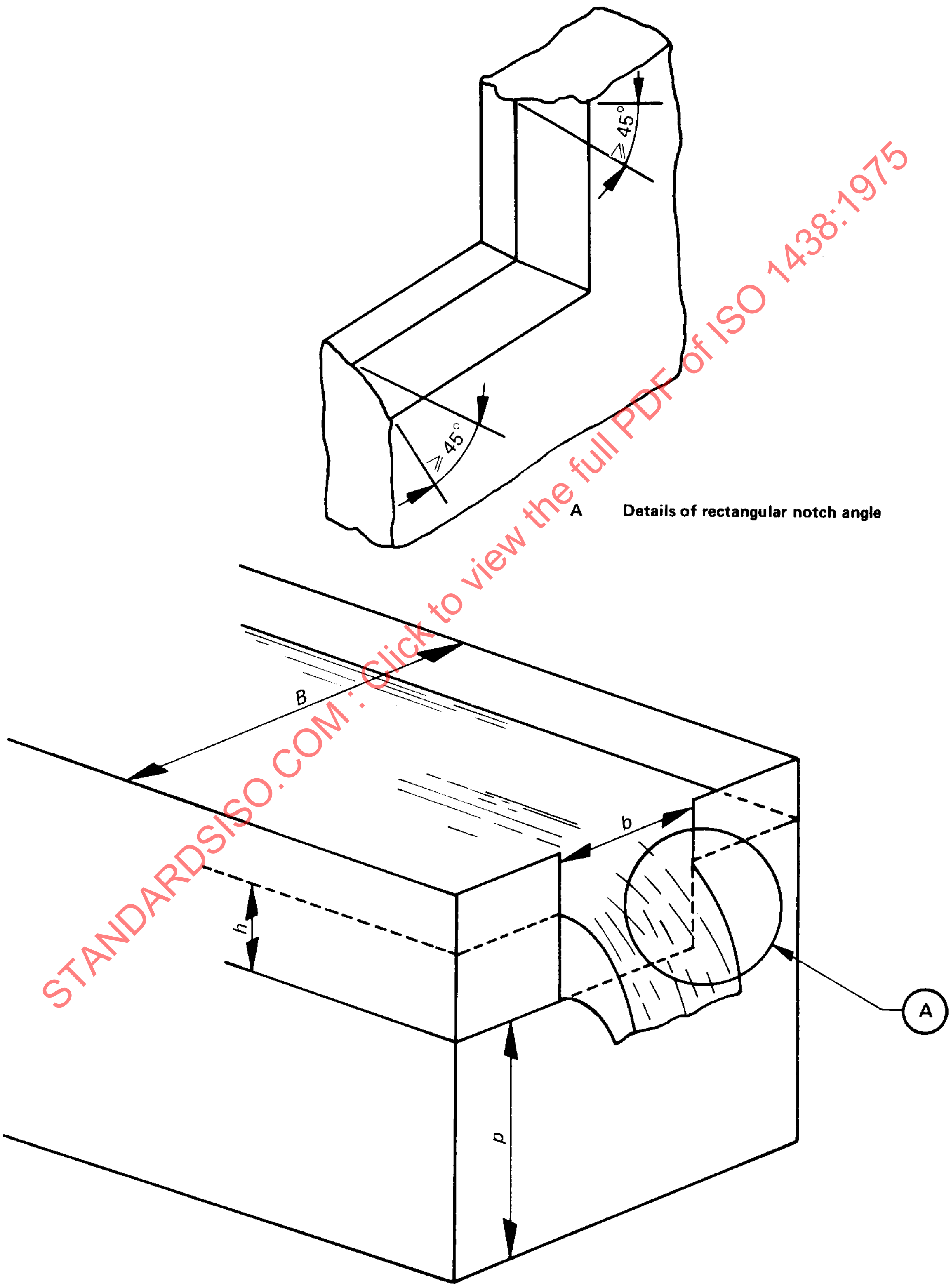


FIGURE 6 – **Rectangular thin-plate weir**

The standard weir shall consist of a rectangular notch symmetrically located in a vertical, thin plate. The whole plate shall be smooth and plane, especially on the upstream side; and it shall be perpendicular to the sides as well as the bottom of the channel.

NOTE — In this International Standard a "smooth" surface shall be equivalent in surface finish to that of rolled sheet metal.

The crest surface of the weir as well as the lateral surfaces of the notch (if they exist) shall be plane surfaces, perpendicular to the upstream faces of the weir plate.

They shall form sharp, right-angled corners at their intersection with the upstream face. Their width measured perpendicular to the upstream face shall be between 1 and 2 mm (0.04 and 0.08 in). The crest surface shall be horizontal and the lateral surfaces of the notch shall form an angle strictly equal to 90°. These surfaces shall be machined (or filed) perpendicular to the upstream face; the edges shall be free from burrs and scratches, and untouched by abrasive cloth or paper. The downstream edges of the weir shall be chamfered if the weir plate is thicker than the allowable crest width. The surface of the chamfer shall make an angle of not less than 45° with the crest surface. The weir plate is usually made of metal, preferably of that kind of metal which can resist erosion and corrosion.

10.2 Specifications for the installation

The conditions given in clause 6 shall generally apply. The weir shall be located in a straight, smooth, horizontal, rectangular channel. As an exception, when the effective opening of the weir is so small in comparison with the upstream channel that the approach velocity is negligible, the shape of the channel is not of significance.

If the length of the crest be equal to the width of the channel (i.e. a full-width weir), it is especially important that the sides of the channel should be vertical, plane, parallel and smooth in the near vicinity of the weir. The sides of the channel above the level of the crest of a full-width weir shall extend at least 0,3 h_{max} downstream of the plane of the weir.

The channel upstream from the weir, described hereinafter as the standard approach channel, shall be of sufficient length to develop the normal (uniform flow) velocity distribution for all discharges; or, it shall be so arranged and equipped with baffles and screens as to simulate the normal velocity distribution and normal turbulence in the approach channel (see 6.2.2).

10.3 Location of head-gauge section

Piezometers or a point-gauge station for the measurement of the head on the weir shall be located a sufficient distance upstream from the weir to avoid the region of surface draw-down. On the other hand, they shall be close enough to the weir for the energy loss between the section of measurement and the weir to be negligible. It is recommended that the head-measurement section be located at a distance equal to three to four times the maximum head ($3\,h_{max}$ to $4\,h_{max}$) upstream from the weir.

10.4 Provisions for ventilated, free flow

Provisions for ventilation of the nappe should ensure that the pressure at all sides is atmospheric. The tailwater level shall be low enough not to interfere with the ventilation or free discharge of the jet.

NOTE — Free (unsubmerged) flow is defined here as flow which is independent of variations in tailwater level.

If necessary, to establish the adequacy of ventilation, a manometer shall be used to verify that the pressure under the nappe is atmospheric.

10.5 Basic discharge equation (Kindsvater-Carter)

The basic equation of discharge for rectangular thin-plate weirs is the Kindsvater-Carter equation :

$$Q = C_e \frac{2}{3} \sqrt{2g}\, b_e\, h_e^{3/2} \qquad \ldots (7)$$

where

Q is the discharge volume rate in cubic metres per second (cubic feet per second);

C_e is the coefficient of discharge (non-dimensional);

g is the acceleration of free fall in metres per second squared (feet per second squared);

b_e is the effective width of the notch in metres (feet);

h_e is the effective piezometric head referred to the level of the crest in metres (feet).

For water at ordinary temperatures, i.e. 5 to 30 °C (or 40° to 85 °F) the coefficient of discharge, C_e, has been determined by experiment as a function of two variables,

$$C_e = f\left(\frac{b}{B}, \frac{h}{p}\right) \qquad \ldots (8)$$

where

b is the measured width of the notch;

h is the measured head;

B is the width of the upstream channel;

p is the apex height in metres (feet).

The effective width and head, b_e and h_e in equation (7), are defined by the equations

$$b_e = b + k_b \qquad \ldots (9)$$

and

$$h_e = h + k_h \qquad \ldots (10)$$

in which k_b and k_h are experimentally determined quantities in metres (feet) which compensate for the influence of surface tension and viscosity.

10.5.1 *Evaluation of C_e, k_b and k_h*

Values of the coefficients required to describe the discharge of water over a full, practical variety of rectangular thin-plate weirs are given in this International Standard.

Figure 7 shows experimentally determined values of C_e as a function of b/B and h/p (equation (8)).

Figure 8 shows the values of k_b which are recommended.

A constant positive value of k_h equal to 1,0 mm (0.003 ft) is recommended for use with all values of b/B and h/p.

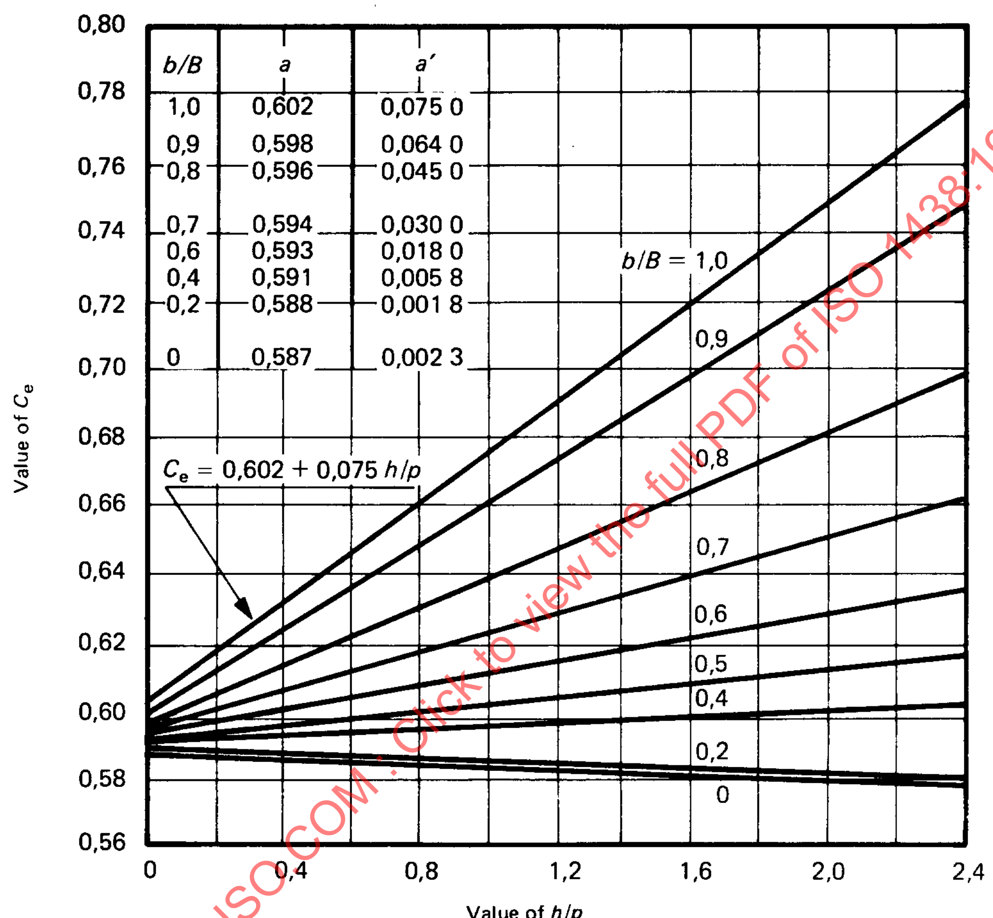


FIGURE 7 — **Coefficient of discharge C_e**

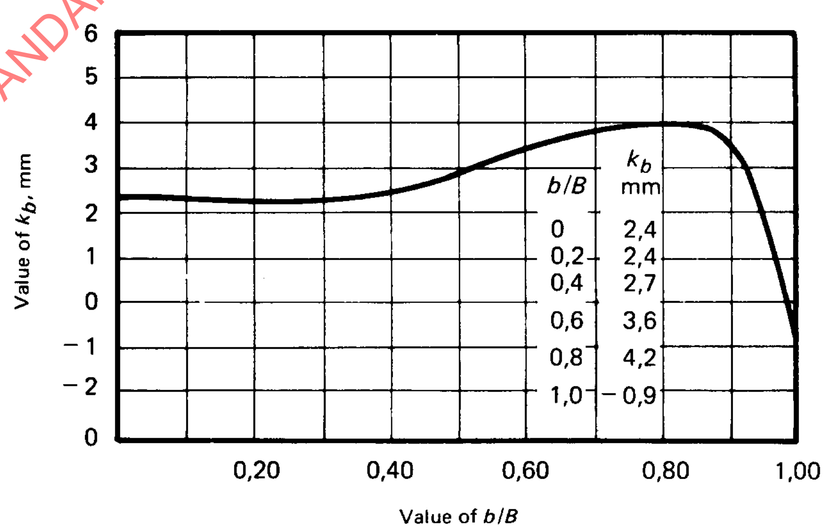


FIGURE 8 — **Value of k_b related to b/B**

10.5.2 *Formulae for C_e for specific values of b/B*

From the curves shown in figure 7 it is apparent that the relationship between C_e and h/p is of the linear form,

$$C_e = a + a' \frac{h}{p} \qquad \ldots (11)$$

Values of a and a' for typical values of b/B are given in figure 7 and in the following equations :

$$(b/B = 1{,}0) : C_e = 0{,}602 + 0{,}075\, h/p \qquad \ldots (12)$$

$$(b/B = 0{,}9) : C_e = 0{,}598 + 0{,}064\, h/p \qquad \ldots (13)$$

$$(b/B = 0{,}8) : C_e = 0{,}596 + 0{,}045\, h/p \qquad \ldots (14)$$

$$(b/B = 0{,}7) : C_e = 0{,}594 + 0{,}030\, h/p \qquad \ldots (15)$$

$$(b/B = 0{,}6) : C_e = 0{,}593 + 0{,}018\, h/p \qquad \ldots (16)$$

$$(b/B = 0{,}4) : C_e = 0{,}591 + 0{,}005\,8\, h/p \qquad \ldots (17)$$

$$(b/B = 0{,}2) : C_e = 0{,}588 - 0{,}001\,8\, h/p \qquad \ldots (18)$$

$$(b/B = 0) : C_e = 0{,}587 - 0{,}002\,3\, h/p \qquad \ldots (19)$$

For intermediate values of b/B, a and a' can be obtained by interpolation from figure 7 or from the preceding equations.

10.5.3 Practical limitations on h/p, h, b and p

Practical limitations on h/p are related to the observation that head-measurement difficulties and errors result from surges and waves which occur in the approach channel at larger values of h/p (in combination with larger values of b/B). The recommended maximum value of h/p is 2,0.

NOTE — Limitations on h/p corresponding to smaller values of b/B have not been established, but it is assumed that the maximum permissible value of h/p increases as b/B decreases. Limitations on h/p shall be determined on the basis of the flow characteristics and related conditions which influence the accuracy of head measurement.

Practical limitations on the magnitude of h are related to the "clinging nappe" phenomenon which characterizes very low heads. To ensure a freely discharging, stable nappe, a minimum value of $h = 0{,}03$ m (0.1 ft) is recommended.

Limitations on the magnitude of b are related to uncertainties regarding the surface tension and viscosity effects represented by the quantity k_b. A minimum value of $b = 0{,}15$ m (0.5 ft) is recommended.

Inaccuracies of measurement are associated with small values of p and $(B - b)$ especially in combination with large values of h/p and b/B respectively. It is recommended that p and $(B - b)/2$ be limited to values greater than 0,10 m (0.3 ft).

10.6 Effect of velocity distribution in the approach channel

The conditions for the standard installation include the requirement that the velocity distribution in the approach channel should be normal such as exists in a smooth, horizontal, rectangular channel. The recommended values of C_e, k_b and k_h, were derived from laboratory tests which satisfy this requirement.

When the velocity distribution in the approach channel differs considerably from the normal, the discharge characteristics are altered. Consequently, flow measurements made with non-standard weir installations are subject to error.

An abnormally uniform velocity distribution ordinarily accounts for an inappreciable error if, in all other respects, the installation meets the specifications for the standard weir. Excessively non-uniform approach velocities on the other hand, influence the discharge characteristics according to the pattern as well as the degree of non-uniformity.

10.7 Accuracy of measurements

The relative accuracy of flow measurements made with a rectangular thin-plate weir depends on the accuracy of the head and width measurements and on the accuracy of the coefficients as they apply to the weir in use.

With reasonable care and skill in the construction and installation of a standard weir, the error in the coefficient of discharge can be expected to be of the order of 1,0 %.

The method by which the error is to be combined with other sources of errors is explained in clause 13. In general, calibration experiments have been carried out on model structures of small dimensions and when transferred to larger structures, there may be small changes in discharge coefficients due to scale effect.

10.8 Alternative equation for rectangular thin-plate weirs (S.I.A.)

Within the given limits of application, the S.I.A., equation may also be used for rectangular thin-plate weirs. The equation is

$$Q = C_e \frac{2}{3} \sqrt{2g}\, b h^{3/2} \qquad \ldots (20)$$

in which C_e is given by the equation,

$$C_e = \left[0{,}578 + 0{,}037 \left(\frac{b}{B}\right)^2 + \frac{0{,}003\,615 - 0{,}003\,0 \left(\frac{b}{B}\right)^2}{h + 0{,}001\,6}\right] \times \left[1 + 0{,}5 \left(\frac{b}{B}\right)^4 \left(\frac{h}{h+p}\right)^2\right] \qquad \ldots (21)$$

for h, b, B and p expressed in metres;

or

$$C_e = \left[0{,}578 + 0{,}037 \left(\frac{b}{B}\right)^2 + \frac{0{,}011\,87 - 0{,}009\,85 \left(\frac{b}{B}\right)^2}{h + 0{,}005}\right] \times \left[1 + 0{,}5 \left(\frac{b}{B}\right)^4 \left(\frac{h}{h+p}\right)^2\right] \qquad \ldots (22)$$

for h, b, B and p expressed in feet.

The general installation conditions shall comply with 10.1 to 10.4. Furthermore, the following conditions for h/p, b/B, h, b and p are to be strictly observed in the application of this S.I.A. equation,

a) h/p shall be less than or equal to 1,0;

b) h shall be greater than $(0{,}025\ B/b)$ but less than 0,8 m [$(0{,}08\ B/b)$ and 2.6 ft];

c) b/B shall be greater than or equal to 0,3;

d) p shall be greater than or equal to 0,30 m (1.0 ft).

For full-width weirs ($b/B = 1{,}0$) the S.I.A. equation is

$$C_e = \left[0{,}615 + \frac{0{,}000\,615}{h + 0{,}001\,6}\right]\left[1 + 0{,}5\left(\frac{h}{h+p}\right)^2\right] \quad \ldots (23)$$

for h and p expressed in metres;

or

$$C_e = \left[0{,}615 + \frac{0{,}002\,02}{h + 0{,}005}\right]\left[1 + 0{,}5\left(\frac{h}{h+p}\right)^2\right] \quad \ldots (24)$$

for h and p expressed in feet.

10.9 Alternative equation for full-width weirs (Rehbock equation)

The full-width weir represents a limiting case of the rectangular weir ($b/B = 1$). As an alternative to the equation given in 10.5.2 for $b/B = 1{,}0$ (equation (12)) and the corresponding graph in figure 7, the Rehbock (1929) equation is also acceptable. The basic equation of Rehbock is

$$Q = C_e \frac{2}{3}\sqrt{2g}\, b h_e^{3/2} \quad \ldots (25)$$

where $C_e = 0{,}602 + 0{,}083\ h/p$ ... (26)

When used in the Rehbock equation, $h_e = h + k_h$

where $k_h = 1{,}2$ mm (0.004 ft).

The general installation conditions shall comply with 10.1 to 10.4. The following practical limitations on h/p, h, b and p are to be strictly observed in the application of this alternative equation :

a) h/p shall be less than or equal to 1,0;

b) h shall be between 0,03 m and 0,75 m (0.1 ft and 2.5 ft);

c) b shall be greater than or equal to 0,30 m (1.0 ft);

d) p shall be greater than or equal to 0,10 m (0.3 ft).

10.10 Alternative equation for weirs with fully developed contractions (Hamilton Smith)

If the bed and walls of the channel upstream from a rectangular notch are remote from its crest and sides, the channel boundaries have no significant influence on the contractions of the nappe, which may then be said to be fully developed. As an alternative to the equations given in 10.5.2, the Hamilton Smith equation is :

$$Q = C_e \frac{2}{3}\sqrt{2g}\, b h^{3/2} \quad \ldots (27)$$

in which $C_e = 0{,}616\ (1 - 0{,}1\ h/b)$ ... (28)

The general installation conditions shall comply with 10.1 to 10.4 and the following practical limitations on h/b, h, b, $B - b$ and p shall be observed in the application of this alternative equation.

a) the walls of the approach channel shall be at a distance greater than or equal to twice the maximum head from the sides of the notch, that is, $(B - b)/2 \geqslant 2h_{max}$;

b) p shall be greater than or equal to twice the maximum head. In addition p shall be greater than or equal to 0,30 m (1.0 ft);

c) h/b shall be less than or equal to 0,5;

d) h shall be between 0,075 and 0,60 m (0.25 and 2.0 ft);

e) b shall be greater than or equal to 0,30 m (1.0 ft);

f) when $B\ (h + p)$ is less than $10\ bh$, the influence of the approach velocity is not negligible, and in this case h in equation (28) will have to be replaced by h'

$$\text{where } h' = h + 1{,}4\frac{v_a^2}{2g} \quad \ldots (29)$$

Provided the approach channel is sufficiently large to render the velocity of approach negligible, and the weir complies also with conditions given in 9.1 to 9.5, the shape of the approach channel is unimportant. The fully contracted form of weir may be used with non-rectangular approach channels under these circumstances.

11 STANDING-WAVE OR FREE-FLOWING VENTURI FLUMES

11.1 General

11.1.1 *Design requirements*

A venturi flume is essentially a streamlined structure built into an open channel to form a throat through which the velocity of water flowing in the channel is increased with a consequent fall in the water level.

A venturi flume is called "free-flowing", if the discharge and the upstream water level are not influenced by the downstream water level. Under such circumstances the velocity in the throat is critical.

The depth of water in the channel downstream is one of the main factors which determine the design of a "free-flowing" venturi flume. In the range of flows to be measured, the level downstream shall be sufficiently low in order to establish the critical depth at the throat. The head losses up to the section where the depth becomes critical shall be also sufficiently low. Normally, the dimensions of the venturi flume shall be such that the depth of water upstream of the throat is at least 1,25 times that at the downstream at all rates of flow. Nevertheless, it may be possible to reduce this difference provided that the occurrence of free discharge is confirmed.

The geometry of the flume shall comply with the following requirements :

a) the dimensions of the flume shall be in accordance with those indicated in figure 9;

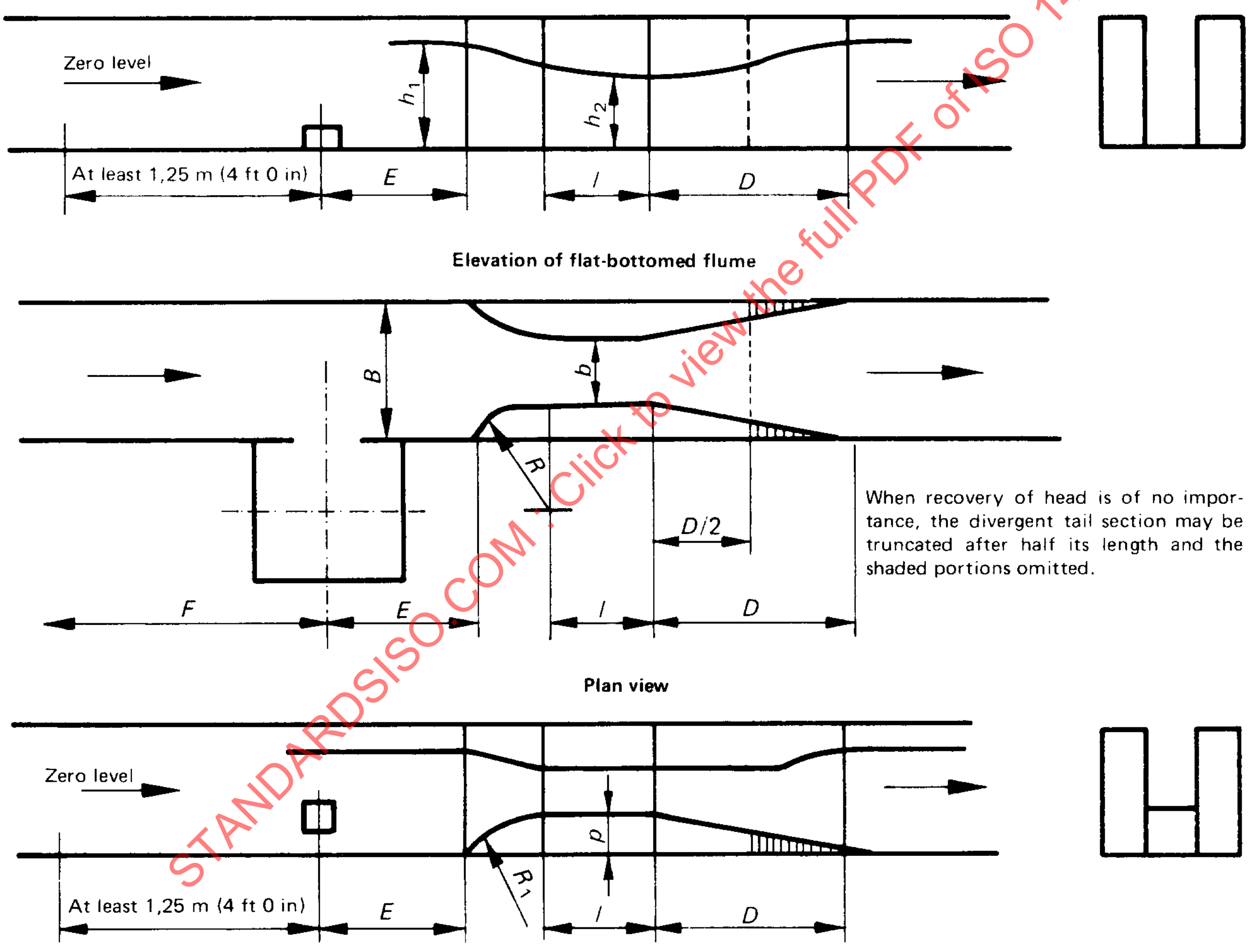
b) the invert of the throat shall be truly level;

c) the sides of the flume throat shall be truly vertical and parallel so that the width is constant at all points of the throat;

d) the centre line of the throat shall be in line with the centre line of the approach channel.

11.1.2 *Downstream conditions*

In artificial channels it is frequently possible to determine the depth downstream at various rates of flow with reasonable accuracy, for example by means of a friction formula if the channel is long enough and of constant slope or by reference to the characteristics of controlling features downstream.



Elevation of flume with raised invert (hump)

b = width of flume throat

B = width of approach channel

h_{max} = maximum head on flume

E = $3h_{max}$ to $4h_{max}$

F = at least $10B$

p = height of hump

l = length of throat $\geqslant 1,5\, h_{max}$

D = $3\,(B - b)$ for maximum recovery of head

R = $2\,(B - b)$

R_1 = $4p$

On flumes with both side and bottom contractions, the contractions must commence at the same point and R and R_1 be adjusted to suit.

FIGURE 9 — **Diagram showing geometrical dimensions of rectangular-throated flume in rectangular channel**

If the flume is to be installed in an existing channel or stream, the velocity at various depths may be determined by the use of one of the methods specified in ISO 748, and from a knowledge of the cross-sectional area, the discharge at these depths may be determined.

The following information shall be obtained at the site :

a) the maximum depth recorded with an estimate of the discharge at that depth;

b) the approximate depths at two or more discharges less than the maximum;

c) the dead water level in the stream, i.e., the level under zero flow conditions.

It shall also be ensured

d) that there are no locks, penstocks or other features downstream which can affect the above conditions in a), b) and c);

e) that at no rate of flow is the velocity greater than the critical velocity.

11.1.3 *Upstream conditions*

The water level upstream of the flume can be determined from the discharge equation given in 11.2.1. The design of the flume shall be such that no flooding of the upstream surrounding shall be caused by the installation.

11.1.4 *Installation requirements*

The following installation conditions shall be observed :

a) if it is required to measure a full range of discharge including low flows, the invert level of the throat shall not be lower than the downstream dead water level in the channel, i.e., the water level downstream at zero-flow;

b) the length of the throat shall be greater than or equal to 1 1/2 times the maximum head to be measured;

c) the surfaces of the throat and curved approach shall be smooth; they may be constructed in concrete with a smooth cement finish, or lined with a smooth non-corrodible material;

d) at the downstream end of the throat each side and/or the invert of the tail section shall have a divergence of not more than 1 in 6 for maximum recovery of head. When recovery of head is of no importance, the divergent tail section may be truncated after half its length;

e) the flow condition in the approach channel of at least 20 times the channel width upstream of the flume shall be sub-critical, i.e.

$$\bar{v} < \sqrt{\frac{gA}{B_s}}$$

where

$\bar{v}$ is the velocity in the channel;

g is the acceleration of free fall;

A is the cross-sectional area;

B_s is the surface width.

11.1.5 *Location of head measurement section*

The head on the flume shall be measured at a section upstream of the flume, such measuring section being located at a distance of about three to four times the maximum head to be measured from the sections where the throat of the flume starts and preferably in a separate gauge-chamber connected to the approach channel by a pipe whose entry is normal to the direction of flow, and flush with the wall.

In order to prevent disturbances in the immediate vicinity of the head measurement section, the floor of the approach channel in the case of flat-bottomed flumes shall be level and flat and at no point higher than the invert of the throat, from the throat to a point at least 1,20 m (4 ft) upstream of the point of measurement.

When the approach channel is uniform in section and its walls and invert are smooth, the connection to the float-wall can be made through a slot in the wall of the channel provided that its invert is at least 0,06 m (0.2 ft) below the invert level of the flume.

On wide rivers and streams where the invert level of the flume is higher than the invert level of the approach channel, the pipe connection to the float-well shall have its entry near mid-stream, normal to the direction of flow, and at such a level that it is always full.

11.2 Flumes with rectangular throats

The rectangular-throated flume consists of a constriction of rectangular cross-section symmetrically disposed with respect to the axis of the approach channel.

This is the most common type of flume and the easiest to construct. It can be adapted to suit most installations except when loss of head is important in non-rectangular channels.

There are three types of rectangular flumes, viz :

a) with side contractions only;

b) with bottom contraction or hump only;

c) with both side and bottom contractions.

The type to be used depends on downstream conditions at various rates of flow, the maximum rate of flow, the permissible head loss and the limitations of the h/b ratio.

11.2.1 *Discharge equation*

The discharge equation for a rectangular throated flume is :

$$Q = (2/3)^{3/2}\, C_v C_e \sqrt{g} b h^{3/2} \qquad \ldots (30)$$

where

Q is the discharge;

C_v is the coefficient of velocity depending on the velocity in the approach channel;

C_e is the coefficient of discharge depending on frictional and turbulent losses;

g is the acceleration of free fall;

b is the width of the throat;

h is the head with respect to the level of the invert in the throat.

11.2.1.1 COEFFICIENT OF DISCHARGE C_e (HORNER)

The coefficient of discharge for a flume with rectangular throat shall be determined from the formula :

$$C_e = \left(\frac{b}{b + 0{,}004\, l}\right)^{3/2} \left(\frac{h - 0{,}003\, l}{h}\right)^{3/2} \qquad \ldots (31)$$

where l is the length of the throat.

Values of C_e for various heads in relation to the width and lengths of the throat are shown in table 4.

11.2.1.2 COEFFICIENT OF VELOCITY C_v (JAMESON)

The velocity coefficient depends on the cross-sectional area of the approach channel in relation to the throat of the flume. If the cross-sectional area of the approach channel is rectangular, the velocity coefficient shall be determined from the following formulae :

Flumes with side contractions only

$$\left(\frac{2}{3\sqrt{3}} \cdot \frac{b}{B}\right)^2 \cdot C_v^2 - C_v^{2/3} + 1 = 0 \qquad \ldots (32)$$

Values of C_v for various ratios b/B are shown in table 5.

TABLE 4 – **Rectangular-throated flume – Values of C_e for various heads in relation to the width and length of the throat**

$$C_e = \left(\frac{b}{b + 0{,}004\, l}\right)^{3/2} \left(\frac{h - 0{,}003\, l}{h}\right)^{3/2}$$

$\frac{l}{b}$	$\frac{h}{l}$													
	0,70	0,65	0,60	0,55	0,50	0,45	0,40	0,35	0,30	0,25	0,20	0,15	0,10	0,05
0,2	0,992 4	0,991 9	0,991 3	0,990 6	0,989 8	0,988 8	0,987 6	0,986 0	0,983 9	0,980 9	0,976 4	0,969 0	0,954 2	0,910 3
0,4	0,991 2	0,990 7	0,990 1	0,989 4	0,988 6	0,987 6	0,986 4	0,984 8	0,982 7	0,979 7	0,975 2	0,967 8	0,953 0	0,909 2
0,6	0,990 0	0,989 5	0,988 9	0,988 3	0,987 5	0,986 5	0,985 2	0,983 6	0,981 5	0,978 5	0,974 1	0,966 7	0,951 9	0,908 1
0,8	0,988 8	0,988 3	0,987 8	0,987 1	0,986 3	0,985 3	0,984 0	0,982 5	0,980 3	0,977 4	0,972 9	0,965 5	0,950 8	0,907 0
1,0	0,987 6	0,987 2	0,986 6	0,985 9	0,985 1	0,984 1	0,982 9	0,981 3	0,979 2	0,976 2	0,971 7	0,964 4	0,949 6	0,905 9
1,2	0,986 5	0,986 0	0,985 4	0,984 7	0,983 9	0,982 9	0,981 7	0,980 1	0,978 0	0,975 0	0,970 6	0,963 2	0,948 5	0,904 8
1,4	0,985 3	0,984 8	0,984 2	0,983 5	0,982 7	0,981 8	0,980 5	0,978 9	0,976 8	0,973 9	0,969 4	0,962 0	0,947 4	0,903 8
1,6	0,984 1	0,983 6	0,983 1	0,982 4	0,981 6	0,980 6	0,979 3	0,977 8	0,975 7	0,972 7	0,968 3	0,960 9	0,946 2	0,902 7
1,8	0,982 9	0,982 4	0,981 9	0,981 2	0,980 4	0,979 4	0,978 2	0,976 6	0,974 5	0,971 5	0,967 1	0,959 8	0,945 1	0,901 6
2,0	0,981 8	0,981 3	0,980 7	0,980 0	0,979 2	0,978 2	0,977 0	0,975 4	0,973 3	0,970 4	0,966 0	0,958 6	0,944 0	0,900 5
2,2	0,980 6	0,980 1	0,979 5	0,978 9	0,978 1	0,977 1	0,975 8	0,974 3	0,972 2	0,969 2	0,964 8	0,957 5	0,942 9	0,899 5
2,4	0,979 4	0,978 7	0,978 4	0,977 7	0,976 9	0,975 9	0,974 7	0,973 1	0,971 0	0,968 1	0,963 7	0,956 3	0,941 7	0,898 4
2,6	0,978 3	0,977 8	0,977 2	0,976 5	0,975 7	0,974 8	0,973 5	0,972 0	0,969 9	0,966 9	0,962 5	0,955 2	0,940 6	0,897 3
2,8	0,977 1	0,976 6	0,976 1	0,975 4	0,974 6	0,973 6	0,972 4	0,970 8	0,968 7	0,965 8	0,961 4	0,954 1	0,939 5	0,896 3
3,0	0,975 9	0,975 5	0,974 9	0,974 2	0,973 4	0,972 4	0,971 2	0,969 6	0,967 6	0,964 6	0,960 2	0,952 9	0,938 4	0,895 2
3,2	0,974 8	0,974 3	0,973 3	0,973 1	0,972 3	0,971 3	0,970 1	0,968 5	0,966 4	0,963 5	0,959 1	0,951 8	0,937 3	0,894 1
3,4	0,973 6	0,973 1	0,972 6	0,971 9	0,971 1	0,970 1	0,968 9	0,967 3	0,965 3	0,962 3	0,958 0	0,950 7	0,936 2	0,893 1
3,6	0,972 5	0,972 0	0,971 4	0,970 8	0,970 0	0,969 0	0,967 8	0,966 2	0,964 1	0,961 2	0,956 8	0,949 5	0,935 0	0,892 0
3,8	0,971 3	0,970 8	0,970 3	0,969 6	0,968 8	0,967 8	0,966 6	0,965 1	0,963 0	0,960 1	0,955 7	0,948 4	0,933 9	0,890 9
4,0	0,970 2	0,969 7	0,969 1	0,968 5	0,967 7	0,966 7	0,965 5	0,963 9	0,961 8	0,958 9	0,954 6	0,947 3	0,932 8	0,889 9
4,2	0,969 0	0,968 5	0,968 0	0,967 3	0,966 5	0,965 6	0,964 3	0,962 8	0,960 7	0,957 8	0,953 4	0,946 2	0,931 7	0,888 8
4,4	0,967 9	0,967 4	0,966 8	0,966 2	0,965 4	0,964 4	0,963 2	0,961 6	0,959 6	0,956 6	0,952 3	0,945 1	0,930 6	0,887 8
4,6	0,966 7	0,966 3	0,965 7	0,965 0	0,964 2	0,963 3	0,962 1	0,960 5	0,958 4	0,955 5	0,951 2	0,943 9	0,929 5	0,886 7
4,8	0,965 6	0,965 1	0,964 6	0,963 9	0,963 1	0,962 1	0,960 9	0,959 4	0,957 3	0,954 4	0,950 0	0,942 8	0,928 4	0,885 7
5,0	0,964 5	0,964 0	0,963 4	0,962 8	0,962 0	0,961 0	0,959 8	0,958 3	0,956 2	0,953 3	0,949 0	0,941 8	0,927 4	0,884 7

NOTE – The number of significant figures (3 or 4) given in the above columns should not be taken to imply a corresponding accuracy in the knowledge of the accuracy given, but only to assist in interpolation and analysis.

TABLE 5 — **Rectangular-throated flume with flat invert in rectangular channel — Values of C_v for various ratios of throat width to width of approach channel, b/B**

$$\left(\frac{2}{3\sqrt{3}} \cdot \frac{b}{B}\right)^2 \cdot C_v^2 - C_v^{2/3} + 1 = 0$$

$\frac{b}{B}$	C_v	$\frac{b}{B}$	C_v
0,10	1,002 2	0,44	1,047 6
0,15	1,005 1	0,46	1,052 6
0,20	1,009 1	0,48	1,057 9
0,22	1,011 0	0,50	1,063 5
0,24	1,013 2	0,52	1,069 5
0,26	1,015 5	0,54	1,076 0
0,28	1,018 1	0,56	1,082 9
0,30	1,020 9	0,58	1,090 1
0,32	1,024 0	0,60	1,098 0
0,34	1,027 2	0,62	1,106 5
0,36	1,030 8	0,64	1,115 4
0,38	1,034 6	0,66	1,125 3
0,40	1,030 6	0,68	1,135 4
0,42	1,043 0	0,70	1,146 9

NOTE — The number of significant figures (3 or 4) given in the above columns should not be taken to imply a corresponding accuracy in the knowledge of the values given, but only to assist in interpolation and analysis.

Flumes with both side and bottom contractions, and flumes with bottom contractions (hump) only,

$$\left(\frac{2}{3\sqrt{3}} \cdot \frac{b}{B}\right)^2 \cdot \left(\frac{h}{h+p}\right)^2 \cdot C_v^2 - C_v^{2/3} + 1 = 0 \quad \ldots (33)$$

where

h is the head with respect to the level of the invert in the throat;

B is the width of the approach channel;

p is the height of the invert level of the throat above the invert level of the approach channel, i.e. the height of the hump.

In cases where the approach channel is not truly rectangular in section where h is measured, B shall be determined from the equation :

$$B = \frac{\text{cross-sectional area corresponding to } h}{h + p} \quad \ldots (34)$$

Values of C_v for various heads in relation to p and to suit various width ratios are shown in table 6.

NOTE — The error involved in the implicit assumption that C_v and C_e are mutually independent factors, is negligible.

TABLE 6 — **Rectangular-throated flume with raised invert (hump) in rectangular channel — Values of C_v in relation to the ratio b/B, the height of the hump p and the measured depth h in the approach channel**

$$C_v^2 \cdot \left(\frac{2}{3\sqrt{3}} \cdot \frac{b}{B}\right)^2 \cdot \left(\frac{h}{h+p}\right)^2 - C_v^{2/3} + 1 = 0$$

$\frac{b}{B}$	$\frac{h}{h+p}$								
	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2
0,10	1,002 2	1,001 8	1,001 4	1,001 1	1,000 8	1,000 6	1,000 4	1,000 2	1,000 1
0,15	1,005 1	1,004 1	1,003 2	1,002 5	1,001 8	1,001 3	1,000 8	1,000 5	1,000 2
0,20	1,009 1	1,007 3	1,005 8	1,004 4	1,003 2	1,002 2	1,001 4	1,000 8	1,000 4
0,25	1,014 3	1,011 5	1,009 1	1,006 9	1,005 1	1,005 5	1,002 2	1,001 3	1,000 6
0,30	1,020 9	1,016 8	1,013 2	1,010 0	1,007 3	1,005 1	1,003 2	1,001 8	1,000 8
0,35	1,029 0	1,032 2	1,018 1	1,013 7	1,010 0	1,006 9	1,004 4	1,002 5	1,001 1
0,40	1,038 6	1,030 8	1,024 0	1,018 1	1,013 2	1,009 1	1,005 8	1,003 2	1,001 4
0,45	1,050 0	1,039 7	1,030 8	1,023 2	1,016 8	1,011 5	1,007 3	1,004 1	1,001 8
0,50	1,063 5	1,050 0	1,038 6	1,029 0	1,020 9	1,014 3	1,009 1	1,005 1	1,002 2
0,55	1,079 3	1,062 0	1,047 6	1,035 7	1,025 5	1,017 5	1,011 0	1,006 1	1,002 7
0,60	1,098 0	1,076 0	1,057 9	1,042 9	1,030 8	1,020 9	1,013 2	1,007 3	1,003 2
0,65	1,120 3	1,092 1	1,069 5	1,050 3	1,036 7	1,024 8	1,015 6	1,008 6	1,003 8
0,70	1,146 9	1,110 8	1,082 9	1,060 6	1,042 9	1,029 0	1,018 1	1,010 0	1,004 4
0,75		1,133 0	1,098 0	1,071 1	1,050 0	1,033 6	1,020 9	1,011 5	1,005 1
0,80			1,115 5	1,082 9	1,057 9	1,038 6	1,024 0	1,013 2	1,005 8
0,85			1,135 8	1,096 0	1,066 4	1,044 1	1,027 2	1,014 9	1,006 5
0,90				1,110 8	1,076 0	1,050 0	1,030 8	1,016 8	1,007 3
0,95				1,127 9	1,086 4	1,056 4	1,034 6	1,018 8	1,008 2
1,00				1,146 9	1,098 0	1,063 5	1,038 6	1,020 9	1,009 1

NOTE — The number of significant figures (3 or 4) given in the above columns should not be taken to imply a corresponding accuracy in the knowledge of the values given, but only to assist in interpolation and analysis.