



# Liquid flow measurement in open channels — Velocity-area methods — Investigation of total error

*Mesure du débit des liquides dans les canaux découverts — Méthode d'exploration du champ des vitesses — Recherche de l'erreur globale*

Technical Report ISO/TR 7178 has been drawn up by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*. It summarizes the results of investigations of the total error in the measurement of flow by velocity-area methods. Although this information is not considered to be a suitable subject for publication as an International Standard, it has been decided, in view of the wide interest which this information occasions, to publish it in the form of a Technical Report.

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**0 Introduction**

All measurements of physical quantities are subject to uncertainties, which may be due to bias errors in the equipment used for calibration and measurement, or to random scatter caused by a lack of sensitivity of the equipment used for the measurements, etc.

During the preparation of ISO 748<sup>[1]</sup>, much discussion was given over to the question of the magnitude of errors in measurements, and it was concluded that recommendations could only be formulated on the basis of an analysis of sufficient data. Moreover, it was recognized that to be able to analyse such data statistically, it was essential that the data be collected and recorded on a standardized basis and in a systematic manner, and this recognition lead to the preparation of ISO 1088<sup>[2]</sup>.

On the basis of the procedures given in these two International Standards, data were subsequently collected and processed from the following rivers (see annex A for the characteristics of the rivers) :

- a) rivers Ganga, Jalangi, Yamuna, and Visvesvaraya Canal, in India;
- b) river IJssel, in the Netherlands;
- c) rivers Derwent, Eden, Lambourn, Ouse, Tyne and Usk, in the United Kingdom;
- d) rivers Columbia and Mississippi, in the USA.

Further data obtained on the rivers Ganga and Krishna, in India, and the Spey, Tay, Tweed, Tyne, Gala Water, Yarrow Water, Ettrick Water and the Clyde, in the United Kingdom, were received later, but could not be included in the processing exercise.

## 1 Scope and field of application

This Technical Report summarizes the results of investigations of the total error in measurements of flow by velocity-area methods. It describes the procedure used and types of errors (section one), and gives recommendation for the collection of data for investigations of errors (section two) with a view to supplementing the information given in ISO 1088.

## 2 Symbols

- $a$  = coefficient of linear regression
- $b$  = coefficient of linear regression
- $b_i$  = unobservable true width of section  $i$
- $d_i$  = unobservable true depth in vertical of section  $i$
- $h_{rel}$  = relative depth, measured from the surface
- $i$  = number of series of measurements (error types II and III)
- $j$  = number of measurements per series (error type II)
- $k$  = time displacement autocorrelation function (of time interval, etc.)
- $m$  = number of verticals or sections per cross-section
- $n$  = number of time intervals of measured velocities (error type I)
- $q$  = unobservable true discharge
- $q_i$  = discharge of section  $i$
- $s_i$  = stochastic sampling error of mean velocity in vertical (error type II)
- $t_i$  = time  $i$
- $t_0$  = initial measuring time
- $v_i$  = velocity at time  $i$  or in section  $i$
- $V_i$  = actual velocity at time  $i$  or in section  $i$
- $V_{corr_i}$  = actual velocity from which trend is removed
- $\mu_s$  = mean sampling error (error type II)
- $\mu_m$  = mean error when measurements are made in  $m$  verticals (error type III)
- $\rho(k)$  = autocorrelation function for time displacement  $k$