SLOVENSKI STANDARD
SIST-TS CEN ISO/TS 25377:2007
01-december-2007

Navodila za doloļ evanje merilne negotovosti v hidrometriji (ISO/TS 25377:2007)

Hydrometric uncertainty guidance (HUG) (ISO/TS 25377:2007)

Leitfaden zu Messunsicherheiten in der Hydrometrie (HUG) (ISO/TS 25377:2007)

Lignes directrices relatives a l'incertitude en hydrométrie (ISO/TS 25377:2007)

Ta slovenski standard je istoveten z: CEN ISO/TS 25377:2007

ICS:

17.120.20 Pretok v odprtih kanalih Flow in open channels

SIST-TS CEN ISO/TS 25377:2007 en

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN ISO/TS 25377

October 2007

ICS 17.120.20

English Version

Hydrometric uncertainty guidance (HUG) (ISO/TS 25377:2007)

Lignes directrices relatives à l'incertitude en hydrométrie (ISO/TS 25377:2007)

Leitfaden zu Messunsicherheiten in der Hydrometrie (HUG) (ISO/TS 25377:2007)

This Technical Specification (CEN/TS) was approved by CEN on 2 August 2007 for provisional application.

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Ref. No. CEN ISO/TS 25377:2007: E

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Foreword

This document (CEN ISO/TS 25377:2007) has been prepared by Technical Committee CEN/TC 318 "Hydrometry", the secretariat of which is held by BSI, in collaboration with Technical Committee ISO/TC 113 "Hydrometric determinations".

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

TECHNICAL SPECIFICATION

ISO/TS 25377

First edition
2007-10-01

Hydrometric uncertainty guidance (HUG)

Lignes directrices relatives à l'incertitude en hydrométrie

Reference number
ISO/TS 25377:2007(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 25377 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 318, *Hydrometry*, in collaboration with Technical Committee ISO/TC 113, *Hydrometry*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Introduction

The management of a natural environment requires knowledge, by measurement, of what is happening. Only then can effective action be taken and the effectiveness of the action assessed. Much depends on the quality of the knowledge itself.

The quality of measurable knowledge is stated in terms of measurement uncertainty. The internationally agreed method for assessing measurement quality is the *Guide to the estimation of uncertainty in measurement* (GUM). Without this uniformity of measurement standards, equitable sharing of the environment is not possible and international obligations to care for the environment would be weakened.

The essential purpose of the GUM is that a statement of the quality of a measurement result will be presented with all measurements described in technical standards. Without this, no two measurements can be compared or standards set. Whereas the GUM is a reference document serving the universal requirements of metrology, the *Hydrometric uncertainty guidance (HUG)* document is specific to hydrometry, i.e. to the measurement of the components of the hydrological cycle. It borrows from the GUM the methods that are the most applicable to hydrometry and applies them to techniques and equipment used in hydrometry.

In the past, error analysis has provided an indication of measurement quality, but such statements cannot properly convey the quality of the result because it presupposes a knowledge of a true, error-free, value against which the measured result can be compared. The true value can never be known. Uncertainty therefore remains. For this reason, the GUM uses the concept of uncertainty and uses it for all stages and components of the measurement process. This ensures consistency.

The GUM defines standard uncertainty of a result as being equivalent to a standard deviation. This can be the standard deviation of a set of measured values or of probable values. This is broadly similar to the approach used in error analysis that preceded the uncertainty technique. However, the GUM provides additional methods of estimating uncertainty based on probability models. The two approaches are equivalent but uncertainty requires only a knowledge or estimate of the dispersion of measurement about its mean value, and not the existence of a true value. It is assumed that a careful evaluation of the components of measurement uncertainty brings the mean value close to a probable true value, at least well within its margin of uncertainty.

In more general terms, uncertainty is a parameter that characterizes the dispersion of measurable values that can be attributed to their mean value.

By treating standard deviations and probability models as if they approximated to Gaussian (or normal) distributions, the GUM provides a formal methodology for combining components of uncertainty in measurement systems where several input variables combine to determine the result.

Within this formal framework, the GUM can be consistently applied to a range of applications and, thereby, be used to make meaningful comparisons of results.

The HUG seeks to promote an understanding of the nature of measurement uncertainty and its significance in estimating the 'quality' of a measurement or a determination in hydrometry.

Hydrometry is principally concerned with the determination of flow in rivers and man-made channels. This includes

— environmental hydrometry, i.e. the determination of the flow of natural waters (largely concerned with hydrometric networks, water supply and flood protection),

— industrial hydrometry, i.e. the determination of flows within industrial plants and discharges into the natural environment (largely concerned with environment protection and also irrigation).

Both are the subject of international treaties and undertakings. For this reason, measured data needs to conform to the GUM to assure that results can be compared.

Hydrometry is also concerned with the determination of rainfall, the movement/diffusion of groundwater and the transport by water flow of sediments and solids. This version of the HUG is concerned with flow determination only.

The results from hydrometry are used by other disciplines to regulate and manage the environment. If knowledge is required of biomass, sedimentary material, toxins, etc., the concentration of these components is determined and their uncertainty estimated. The uncertainty of mass-load can then be determined from the uncertainty of flow determination. The components of this calculation are made compatible through compliance with the GUM.

For practitioners of hydrometry and for engineers, the GUM is not a simple document to refer to. The document has been drafted to provide a legal framework for professional metrologists with a working knowledge of statistical methods and their mathematical representation. A helpful document, NIST Technical Note 1297 [12], is an abbreviated version of the GUM written to be more accessible to engineers and to specialists in fields other than metrology.

The HUG, although simplifying the concepts, in no way conflicts with the principles and methods of the GUM. Accordingly, the HUG interprets the GUM to apply its requirements to hydrometry in a practical way, and, hopefully, in a way accessible to engineers and those responsible for managing the environment.

In addition, the HUG introduces and develops Monte Carlo Simulation, a complementary technique, which has benefits for hydrometry, insomuch as complex measurement systems can be represented realistically.

The HUG summarizes basic hydrometric methods defined in various technical standards. The HUG develops uncertainty estimation formulae from the GUM for these basic methods. The basic hydrometric methods described in the HUG may not be identical to those recited in the published technical standards. In such cases, the methods described in these standards are to be taken as authoritative. However, clauses in technical standards that concern uncertainty should be adapted to be in accordance with the HUG.

NOTE There is no unified definition of space coordinates within the hydrometric standards. The textbook conventional axes are adopted in this document when describing open channel flow: the x axis being horizontal and positive in the mean flow direction, the y axis being orthogonal to the x axis in the horizontal plane and the z axis being vertical positive.

Hydrometric uncertainty guidance (HUG)

1 Scope

This Technical Specification provides an understanding of the nature of measurement uncertainty and its significance in estimating the ‘quality’ of a measurement or a determination in hydrometry.

It is applicable to flow measurements in natural and man-made channels. Rainfall measurements are not covered.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 772, *Hydrometric determinations — Vocabulary and symbols*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772 and the following apply.

NOTE For a complete appreciation of the scope of definitions used in measurement uncertainty, the reader is referred to the GUM [10] or to NIST Technical Note 1297 [12].

3.1
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

3.2
type A evaluation of uncertainty
method of evaluation uncertainty by the statistical analysis of a series of observations

3.3
type B evaluation of uncertainty
method of evaluation uncertainty by means other than the statistical analysis of a series of observations

3.4
combined standard uncertainty
standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

3.5
expanded uncertainty
quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the values that could be attributed to the measurand

3.6
coverage factor
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

4 Symbols and abbreviations

α	coefficient representing the effects of non-uniform energy (velocity) in a channel
$\gamma_{xx}, \gamma_{xy}, \gamma_{xz}$	angles between boat axes and the x axis.
σ	standard deviation
$\Delta' x, \Delta' y$	dispersion of measurement from the mean value of the set of x,y measurements for a symmetric distribution: $\Delta' x = 0{,}5\left(x_{\text{max}} - x_{\text{min}}\right)$, etc.
$\Delta' x^{+}, \Delta' x^{-}$	± dispersion about the mean value, $\bar{x}$, for an asymmetric distribution of measurements where $\Delta' x^{+} = \left(x_{\text{max}} - \bar{x}\right)$ and $\Delta' x^{-} = \left(\bar{x} - x_{\text{min}}\right)$.
Δ	small difference in a measured quantity $\Delta Q, \Delta h, \Delta T$, etc.
$\Delta y, \Delta z$	notional small distances in the y and z directions at a cross-section in the channel
Dc_2	in the dilution method, the downstream mixed change ($c_{\text{m}} - c_{\text{b}}$) of concentration of the tracer
A, $A(z)$, $A(h)$	cross-section area (in the y,z plane) of the flow
B	channel width
b	contracted channel width or flume throat width
c_{b}	dilution method, the background concentration of tracer
c_{T}	dilution method, the feed concentration of tracer
c_{m}	dilution method, the downstream mixed concentration of the tracer
C	discharge coefficient
C_v	velocity coefficient
d_i	deviation of an measurement (the ith measurement of a series) from the mean value of that series
E	datum elevation of a range measuring device
$f(h)$	relationship between head, h, and cross-section area, A
F_x, F_y	multiplying factors to be applied to the summation of velocity-area elements to account for the approximation of a summation process to a true integration of continuously varying parameters.
g	gravitation acceleration
h	head of water relative to a defined datum level in the channel
H	total head relative to a defined datum level in the channel
i,j	indices of a count i = 1 to n, or j = 1 to m of a series
J	false measurement detection factor
K	constant of a flow determination equation for a weir or flume
k_1, k_2	constants for the determination of flow by the dilution method
M	dilution method, the mass of tracer introduced into the stream

n	exponent of a flow determination equation for a weir or flume
n, m	number of measurement in a series
$p(x)$	probability function
Q	flow
Q_p	estimated flow passing close to boundaries or any region where measurement cannot be determined by the primary means
Q_T	dilution method, the flow of tracer into the stream
S	standard deviation of a set of measurements
t_e	factor to be applied to small numbers of samples to enable the standard deviation to be representative of large numbers of samples (see Annex A)
t_1, t_2	in the dilution method, the interval during which a change in concentration is detectable
T	absolute temperature, in Kelvin
T_n	Grubbs' test parameter
$U(x), u(y)$	uncertainty of measured variables x, y, etc.
$u_c(p), u_c(q)$	the combined uncertainty of determined results p, q, etc.
$u^*(x)$	the percentage uncertainty of a measurement of any quantity x
U_{95}	measurement uncertainty expanded to the 95 % level of confidence
$V_{\bar{x}}$	mean velocity through a yx plane intersecting a channel cross-section of the channel
$V_x(y,z)$	velocity in the x direction at point y, z in the channel
$\vec{V}$	water velocity vector relative to channel
$\vec{V}_b$	boat velocity vector relative to the channel
$\vec{V}$	water velocity vector relative to boat
$V_{x'}', V_y', V_z'$	water velocity components relative to boat along boat coordinate axes
$V_{bx'}', V_{by}', V_{bz}'$	components of boat velocity relative the boat axes
$\gamma_{xx}, \gamma_{xy}, \gamma_{xz}$	angles between boat axes and the channel x axis.
x,y,z	channel coordinates
x',y',z'	boat coordinates
x,y	measurable variables

In this document, the term "uncertainty" refers to measurement uncertainty and the following forms of equation are used to signify

— a sum of n values of x $$x_1 + x_2 + x_3 + \ldots\ldots x_i + \ldots\ldots x_n = \sum_{i=1}^{n} x_i,$$

— a difference, $\Delta f(x)$, in the function, $f(x)$, due to a small change, Δx, in the value x $$\Delta f(x) = \frac{\mathrm{d}f}{\mathrm{d}x}\Delta x,$$

— a value of an integral, F, of a function, $f(x)$, between, $x = x_1$, and $x = x_n$ $$F = \int_{x_1}^{x_n} f(x)\,\mathrm{d}x.$$