INTERNATIONAL STANDARD

ISO 14956

First edition
2002-08-15

Air quality — Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty

Qualité de l'air — Évaluation de l'aptitude à l'emploi d'une procédure de mesurage par comparaison avec une incertitude de mesure requise

Reference number
ISO 14956:2002(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 3.

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.

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

ISO 14956 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 4, *General aspects*.

Annex B forms a normative part of this International Standard. Annexes A, C and D are for information only.

Introduction

A measuring task generally includes information on the required quality of the measurement result, which may be quantified by the measurement uncertainty. The required quality may be specified, e.g. by legislation, by authorities or the parties involved.

The quality of a measurement result strongly depends on the performance of the measuring method used. This International Standard specifies the procedures to determine the measurement uncertainty of an individual measurement result, using relevant performance characteristics of the measuring method, and to verify compliance with the requirements of the measuring task.

A procedure for establishing the uncertainty of the time average of a series of single measurements will be given in a separate International Standard [3].

Air quality — Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty

1 Scope

This International Standard specifies, for the field of air quality measurement procedures, the:

— estimation of measurement uncertainty from actual or claimed values of all important performance characteristics of a method under stationary conditions;

— assessment of whether or not specified values for these performance characteristics comply with the required quality of a measured value at a stated measurand value;

— evaluation of the applicability of the measurement method based on laboratory performance and confirmatory field test;

— establishment of requirements on dynamic behaviour of instruments.

This International Standard is applicable to measurement procedures whose output is a defined time average.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 6879:1995, *Air quality — Performance characteristics and related concepts for air quality measuring methods*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 6879 and the following apply.

3.1
dynamic condition
⟨of operation⟩ condition where the measurand value or/and the value of an influence quantity is time-dependent

3.2
performance requirement
requirement of the measurement, in terms of standard uncertainty and dynamic behaviour, against which the suitability of the measurement system is being assessed

3.3
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation.

[GUM:1993, 2.3.1]

3.4
stationary condition
⟨of operation⟩ condition where the measurand value and the values of all influence quantities are constant.

3.5
uncertainty
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand.

[VIM:1993, C.2.11]

4 Symbols and abbreviated terms

b_j	sensitivity coefficient of c for influence quantity x_j at $C = c_{\text{test}}$
$b_{j,\,\text{max}}$	maximum value of b_j
C	measurand
c	measured value of the measurand
c_{test}	value of the measurand at which the required measurement uncertainty is given
$D(y_i)$	drift of measured value on input quantity Y_i at $C = c_{\text{test}}$
$f(y_i)_{\text{cal}}$	analytical function; function of input quantities where the impact of influence quantities is excluded
I_j	ratio of the change in measured value and the corresponding change of the interferent value x_i at $C = c_{\text{test}}$
i	index of input quantities Y
j	index of influence quantities X
k	coverage factor
n	total number of input quantities; last number
m	total number of influence quantities
P	percentage value
p	index of the performance characteristic
p_{max}	maximum number of performance characteristics considered
$s[c(x_j)]$	standard deviation of c caused by x_j at $C = c_{\text{test}}$
$s(x_j)$	standard deviation of x_j at $C = c_{\text{test}}$

$s_{\text{inst}}(y_i)$ standard deviation of y_i due to the random part of instability

$s_r(y_i)$ repeatability standard deviation of input quantity Y_i at y_i

$s_R(y_i)$ reproducibility standard deviation of input quantity Y_i at y_i

$s(\hat{y}_i)$ standard deviation of experimentally determined calibration functions (bias due to calibration) of input quantity Y_i

$t_{0,975}$ 97,5 percentile of the t-distribution

U_{c} combined expanded uncertainty of c at $C = c_{\text{test}}$ expressed as a 95 % confidence interval

U_{req} required expanded uncertainty of c at $C = c_{\text{test}}$ expressed as a 95 % confidence interval

u_{c} combined standard uncertainty of c at $C = c_{\text{test}}$

$u(b_j)$ standard uncertainty of b_j at $C = c_{\text{test}}$

$u[c(x_j)]$ partial standard uncertainty of c due to the value x_j of influence quantity j at $C = c_{\text{test}}$

$u(x_j)$, $u(\Delta x_j)$ standard uncertainty of the difference of x_j between measurement and corresponding calibration

u_p partial standard uncertainty of uncertainty source or group of sources of uncertainty represented by performance characteristic p at $C = c_{\text{test}}$

$u\left[\hat{c}(\hat{y}_i)\right]$ partial standard uncertainty of c due to uncertainty of the experimentally determined calibration functions of input quantity Y_i at y_i corresponding to $C = c_{\text{test}}$

$u_{\text{fit}}[c(y_i)]$ partial standard uncertainty of c due to lack of fit of the calibration function of input quantity Y_i at y_i corresponding to $C = c_{\text{test}}$

$u_{\text{inst}}[c_i(y_i)]$ partial standard uncertainty of c due to the random part of instability of input quantity Y_i at y_i corresponding to $C = c_{\text{test}}$

$u_r[c(y_i)]$ partial standard uncertainty of c due to repeatability of input quantity Y_i at y_i corresponding to $C = c_{\text{test}}$

$u_R[c(y_i)]$ partial standard uncertainty of c due to reproducibility of input quantity Y_i at y_i corresponding to $C = c_{\text{test}}$

u_{req} maximum allowable standard uncertainty of the measured value at $C = c_{\text{test}}$

$u(y_i)$ standard uncertainty of input quantity Y_i

w_i weighting factor of input quantity Y_i; first derivative $\dfrac{\partial f(y_1, \ldots, y_n)}{\partial y_i}$

X influence quantity

X_j — jth influence quantity

x_j — value of X_j

$x_{j,\text{ cal}}$ — value of influence quantity X_j during calibration

$x_{j,\text{ max}}$ — maximum value of influence quantity X_j

$x_{j,\text{ min}}$ — minimum value of influence quantity X_j

Y — input quantity

Y_i — ith input quantity

y_i — value of Y_i

$y_{i,\text{ fit}}$ — lack of fit of input quantity Y_i at y_i corresponding to $C = c_{\text{test}}$

$\Delta c(x_j)$ — systematic deviation of c due to x_j

$\Delta c(x_{j,\text{ p}})$ — change in c caused by the maximum positive change of influence quantity X_j after calibration; take care to include the sign of the value

$\Delta c(x_{j,\text{ n}})$ — change in c caused by the maximum negative change of influence quantity X_j after calibration; take care to include the sign of the value

Δx_j — difference of x_j between measurement and corresponding calibration

$\Delta x_{j,\text{ p}}$ — maximum positive difference of x_j between measurement and corresponding calibration

$\Delta x_{j,\text{ n}}$ — maximum negative difference of x_j between measurement and corresponding calibration

5 Principle

Performance characteristics indicate the deviation from a perfect measurement and therefore contribute to the uncertainty of the measurement result. The combined impact of the performance characteristics on the measurement result quantified by measurement uncertainty is taken as the criterion of suitability of a measurement method rather than each of the performance characteristics.

The procedure for calculating measurement uncertainty as follows is based on the law on propagation of uncertainty laid down in the GUM.

a) Define the measurand and determine the analytical function relating the measured value to the input quantities. Take the quantity representing that part of the measurement system covered by calibration as a single input quantity.

b) Identify all (major) sources of uncertainty (influence quantities) contributing to any of the input quantities or to the measurand directly.

c) Determine the model function and the variance function. Retain major sources of uncertainty.

d) Use available performance characteristics of the measurement system.

e) Assign all (major) sources of uncertainty uniquely to performance characteristics. One performance characteristic may cover several sources of uncertainty (e.g. reproducibility). Each major uncertainty source shall not be assigned to more than one performance characteristic. If major sources of uncertainty are not covered by available performance characteristics, their uncertainty shall be quantified separately.

f) Convert all uncertainty components (performance characteristics) to standard uncertainties of input and influence quantities. Apply the weighting factor w_i derived from the analytical function or the sensitivity coefficient b_j and the difference Δx_j between measurement and corresponding calibration for influence quantity x_j to calculate the corresponding standard uncertainty of the measured value.

g) Calculate the combined standard uncertainty and the expanded uncertainty taking correlation into account.

h) Judge the suitability of the measurement procedure by comparing the expanded uncertainty with the required value.

i) Verify the expanded uncertainty in a field test.

j) Accept or reject fitness for use of the measurement procedure.

A flowchart for assessing fitness for use of the measurement procedure regarding the performance under stationary conditions is given in Figure 1.

The dynamic response may contribute to measurement uncertainty. Performance requirements related to dynamic conditions of operation are excluded from the uncertainty criterion. For the purpose of this International Standard, it shall be demonstrated that the impact of the dynamic response on measurement uncertainty is negligible.

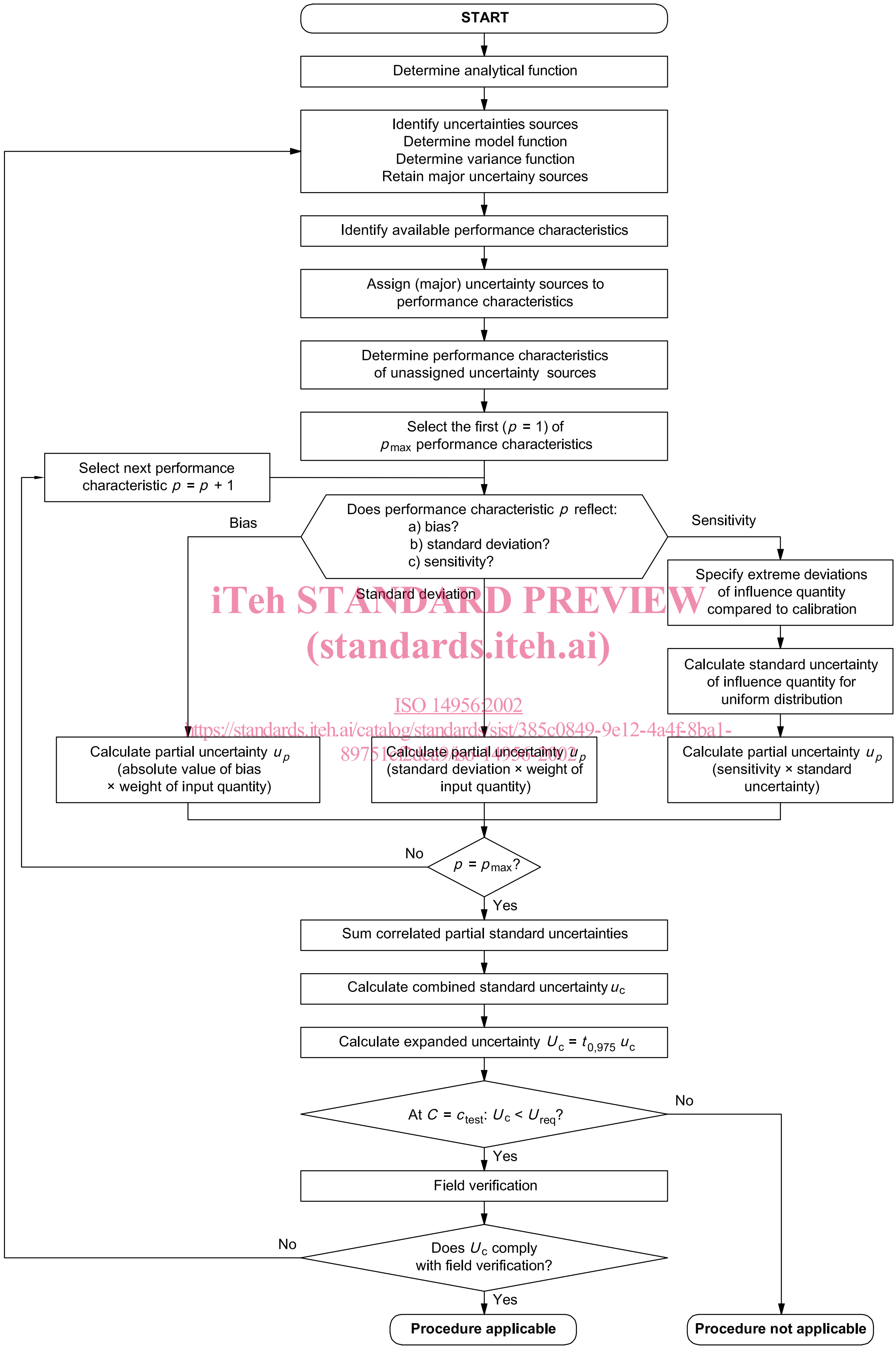

Figure 1 — Flowchart for assessing fitness for use of the measurement procedure