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Air quality — Performance characteristics and related concepts for air quality measuring methods

Qualité de l'air — Caractéristiques de fonctionnement et concepts connexes pour les méthodes de mesurage de la qualité de l'air

Reference number
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Foreword

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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.

International Standard ISO 6879 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 4, *General aspects*.

This second edition cancels and replaces the first edition (ISO 6879:1983), which has been technically revised.

Annex A of this International Standard is for information only.

International Organization for Standardization
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Introduction

This International Standard which comprises definitions of terms and performance characteristics used in assessing air quality should be used in conjunction with the specific standard test methods prepared by ISO/TC 146, *Air quality*.

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Air quality — Performance characteristics and related concepts for air quality measuring methods

1 Scope

This International Standard defines terms and performance characteristics related to air quality measuring methods. The values of the performance characteristics, determined in accordance with an associated series of test methods, are intended to be used to confirm whether a method is appropriate when assessing air quality in any given situation. This International Standard does not include specific methods for determining air quality or obtaining representative samples or for selecting the number of measurements necessary for a given task, these being covered in other International Standards.

The performance characteristics listed also apply to respective emission measurement procedures.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO Guide 30:1992, *Terms and definitions used in connection with reference materials.*

ISO 3534-1:1993, *Statistics — Vocabulary and symbols — Part 1: Probability and general statistical terms.*

3 Symbols and abbreviations

C	Air quality characteristic
c	Value of C
$\hat{c}$	Measured value of C
C_i	ith interferent, with i = 1, 2, ..., n
c_i	Value of C_i
c_0	Zero sample value of the air quality characteristic C
c_D	Detection limit
c_Q	Quantification limit
f	Analytical function
g	Calibration function
I	First order measure of the value of selectivity related to the ith interferent
n	Total number of interferents considered
r	Repeatability limit
R	Reproducibility limit
S	Sensitivity
X	Output variable
x	Value of X
$\bar{x}_0$	Mean output signal of a zero sample
x_D	Decision limit
α, β	Significance levels[1] (see ISO 3534-1)

1) 5 % by convention.

4 Rationale

The definitions comprise basic concepts and the three types of performance characteristics (statistical, functional and operational).

In order to define the performance characteristics, it is necessary to describe the three terms basic to the measuring process, i.e. value of air quality characteristic[2], output signal (5.1.10) and measured value (5.1.7).

The value of air quality characteristic c is the true value of the air quality characteristic being investigated. The output signal x is the value of the output variable of a measuring system obtained as a response related to the concentration or value of the air quality characteristic contained in the air sample being considered. The output variable may be an output voltage, a turning angle of an indicator, a scale reading, quantity of standard volumetric solution used for titration, etc. The measured value $\hat{c}$ is the estimated value of the air quality characteristic, derived from output signals, and generally involves calculations related to the calibration process and conversion to required quantities.

The calibration function (5.2.4) is the relation between output variables and quantifiable properties (concentration, particle size, etc.) of reference materials used during the calibration process. The analytical function (5.2.2) is the relation between the measured values and the output variables and is estimated from regression analysis of air quality characteristic values versus output variables. These relations are not deterministic but stochastic, usually unstable (see 5.2.9) and biased (see 5.2.3).

Statistical performance characteristics quantify, for measured values, the possible deviations resulting from the random part of the measuring process; these are, for example, repeatability or instability.

Functional performance characteristics are estimates of the deterministic part of the measuring process, for example, sensitivity, calibration function or response time.

Operational performance characteristics deal with the influence of the physical and chemical environment and maintenance problems, for example, input voltage, temperature, supply of certain substances, set-up time, warm-up time or period of unattended operation.

2) Defined as measurand in [1] in annex A.

The statistical and functional performance characteristics given should be sufficient in most cases. For practical reasons, the list of operational performance characteristics is limited. In special cases, the user is asked to adopt performance characteristics not listed in 5.2, but which are suitable for the special method or instrument under consideration.

5 Basic concepts and performance characteristics

5.1 Basic concepts

5.1.1 air quality characteristic: One of the quantifiable properties relating to an air mass under investigation, for example, concentration of a constituent.

5.1.2 air sample: Amount of air which is assumed to be representative of the air mass under investigation, and which is examined for air quality characteristics.

5.1.3 blank reading: Output signal for a zero sample.

5.1.4 failure of the system: Termination of the ability of a measuring system to perform its required function.

NOTE 1 Any system is a collection of instruments and components that are electrically and mechanically joined to perform a specific function. System failures can therefore be defined as having occurred when the operating characteristics of a component, or a group of components, change to the extent that the system can no longer satisfactorily perform its expected function.

5.1.5 interferent: Component of the air sample, excluding the measured constituent, that effects the output signal.

5.1.6 measured constituent: Component of the air sample for which a quantity is to be determined by measurement.

5.1.7 measured value: Estimated value of the air quality characteristic derived from an output signal; this usually involves calculations related to the calibration process and conversion to required quantities.

5.1.8 memory effect: Temporary dependence of an output signal on one or several previous values of the air quality characteristics.

5.1.9 method: Procedure for sampling and determining one or more air quality characteristics, the accuracy of which is established using either a reference material or reference procedures.

NOTE 2 Two or more methods are considered equivalent if the values for their statistical and functional performance characteristics, for example bias, precision or sensitivity, fall within minimum specified limits and tolerances in the presence of specified interferent(s) and under specified operating conditions.

5.1.10 output signal: Value of output variable of a measuring system obtained as a response related to the value of the air quality characteristic.

5.1.11 reference material (RM): Material or substance one or more of whose property values are sufficiently homogeneous and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials. [ISO Guide 30]

5.1.11.1 reference material (RM): ⟨air quality measuring methods⟩ Substance or mixture of substances, the composition of which is known within specified limits, and one or more of the properties of which are sufficiently well established over a stated period of time to be used for the calibration of an apparatus, the assessment of a measuring method, or for assigning values to materials.

5.1.12 reference procedure: Agreed set of theoretical and practical operations for determining one or more air quality characteristics where it is not practical to produce a reference material; the result obtained is defined as the measure of the air quality characteristic.

5.1.13 zero sample: Substance or mixture of substances resembling, as closely as possible, the matrix of the actual air sample to be measured, but characterized by a value of the air quality characteristic which is not detectable by the method used.

NOTE 3 In practice, the value of the air quality characteristic is considered to be zero.

5.2 Performance characteristics

5.2.1 accuracy: The closeness of agreement between a test result and the accepted reference value. [ISO 3534-1]

5.2.1.1 accuracy: ⟨air quality measuring methods⟩ Closeness of agreement between a single measured value and the value of the air quality characteristic itself, or the accepted reference value.

5.2.2 analytical function: Inverse of the calibration function.

5.2.3 bias: The difference between the expectation of the test results and an accepted reference value. [ISO 3534-1]

5.2.3.1 bias: ⟨air quality measuring methods⟩ Consistent deviation of the measured value from the value of the air quality characteristic itself, or the accepted reference value.

NOTE 4 Bias is often called "systematic error".

5.2.4 calibration function: Output variable X as a function of the air quality characteristic C under investigation represented by reference materials, with all interferents C_i remaining constant:

$$X = g(C, C_1, ..., C_n)|_{C_i = \text{constant},\ i = 1 \ldots n} \quad \ldots (1)$$

If the sensitivity (see 5.2.21) is a constant, the calibration function will be linear and

$$X = S \cdot C + \text{constant}$$

NOTE 5 The calibration function may be estimated by regression analysis.

5.2.5 cut off (for particular matter): Size of particles at which the retention efficiency of an instrument device drops below a specified value under defined conditions.

5.2.6 decision limit: Output signal value above which it can be affirmed, with a probability 1-α of at least 95 %[3], that the measured sample is different from a zero sample (see figure 1).

NOTE 6 A zero sample has 5 %[3] probability of causing an output signal above the decision limit.

5.2.7 detection limit: Value of the air quality characteristic allocated to the decision limit using the calibration function (see figure 1).

NOTES

7 Formerly defined as "lower detection limit".

8 When, in a sample, the value of the air quality characteristic is at the detection limit, 50 % of the measured output signal values will exceed the decision limit, provided that the distribution is symmetrical.

3) By convention.

5.2.8 hysteresis: Dependence of the measured values on previous values of the air quality characteristic. It may be quantified by the difference between the upscale and downscale measurements starting from fixed lower and upper measurement values.

NOTE 9 A measure of the hysteresis is generally not given. The hysteresis effects are usually taken into account by systematically carrying out sequences of upscale and downscale measurements during calibration experiments. The presence of hysteresis is then incorporated in the observed variance of the output variables.

5.2.9 instability: Change in the measured value comprised of drift and dispersion resulting from the change in the calibration function over a stated period of unattended operation, for a given value of the air quality characteristic. Drift and dispersion specify the monotonic and stochastic change with time of the output signal, respectively.

5.2.10 limiting condition of operation: Range of physical and operational parameters in which the method meets given values of performance characteristics with 95 %[4] probability.

5.2.11 mean time between failures (MTBF): Average of operating times between successive failures of a measuring system.

5.2.12 mean time to failure (MTTF): Average lifetime of a non-repairable component, often expressed as expected lifetime.

5.2.13 measurement resolution: Minimum difference of two values of an air quality characteristic that can be distinguished with 95 %[4] probability by measurements.

5.2.14 on-line time: Percentage of time for which valid records are available from a measuring system.

5.2.15 period of unattended operation: Maximum admissible interval of time for which the performance characteristics will remain within a predefined range without external servicing, for example, refill, calibration or adjustment.

5.2.16 precision: The closeness of agreement between independent test results obtained under stipulated conditions. [ISO 3543-1]

5.2.16.1 repeatability: Precision under repeatability conditions. [ISO 3534-1]

5.2.16.1.1 repeatability conditions: Conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time. [ISO 3534-1]

5.2.16.1.2 repeatability standard deviation: The standard deviation of test results obtained under repeatability conditions. [ISO 3534-1]

5.2.16.1.3 repeatability limit: The value less than or equal to which the absolute difference between two test results obtained under repeatability conditions is expected to be with a probability of 95 %. [ISO 3534-1]

NOTE 10 The symbol used is r.

5.2.16.2 reproducibility: Precision under reproducibility conditions. [ISO 3534-1]

5.2.16.2.1 reproducibility conditions: Conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment. [ISO 3534-1]

5.2.16.2.2 reproducibility standard deviation: The standard deviation of test results obtained under reproducibility conditions. [ISO 3534-1]

5.2.16.2.3 reproducibility limit: The value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions is expected to be with a probability of 95 %. [ISO 3534-1]

NOTE 11 The symbol used is R.

5.2.17 quantification limit: Value of the air quality characteristic above which, with a probability 1-β of at least 95 %[4], the measured output signal values will exceed the decision limit (see figure 1).

5.2.18 response time: Time taken for an instrument to respond to an abrupt change in value of the air quality characteristic. It is the sum of the lag time and rise time (rising mode) or lag time and fall time (falling mode).

5.2.18.1 lag time: Time taken for the output signal to reach 10 %[4] of the final change in reading.

5.2.18.2 rise time (fall time): Time taken for the reading to pass from 10 %[4] to 90 %[4] of the final

4) By convention.

change in output signal reading. For instruments where transient oscillations occur in the approach to the final output signal reading, the rise time (fall time) is the time taken for the instrument reading to pass from 10 %[4] of the final change in instrument reading until the oscillations fall to less than 10 %[4] of the final change in instrument reading.

5.2.19 retention efficiency for particulate matter: Ratio of the quantity of particulate matter retained by an instrument to the quantity entering it (it is generally expressed as a percentage).

5.2.20 selectivity: Measure of dependence of the output signal on the quantity of interferent. A first order measure is

$$I_i(C, C_1, C_2, \ldots, C_n) = \frac{\left(\frac{\partial g(C, C_1, C_2, \ldots, C_n)}{\partial C_i} \right)}{\left(\frac{\partial g(C, C_1, C_2, \ldots, C_n)}{\partial C} \right)} \quad \ldots (2)$$

with $i = 1, 2, \ldots, n$.

5.2.21 sensitivity: Ratio of change of output variable to the change of the air quality characteristic

$$S = \frac{\partial g(C, C_1, C_2, \ldots, C_n)}{\partial C} \quad \ldots (3)$$

5.2.22 upper limit of measurement: Highest value of the air quality characteristic which can be measured within specified limits of performance characteristics.

NOTE 12 The range between the quantification limit and upper limit of measurement is the dynamic range of the instrument.

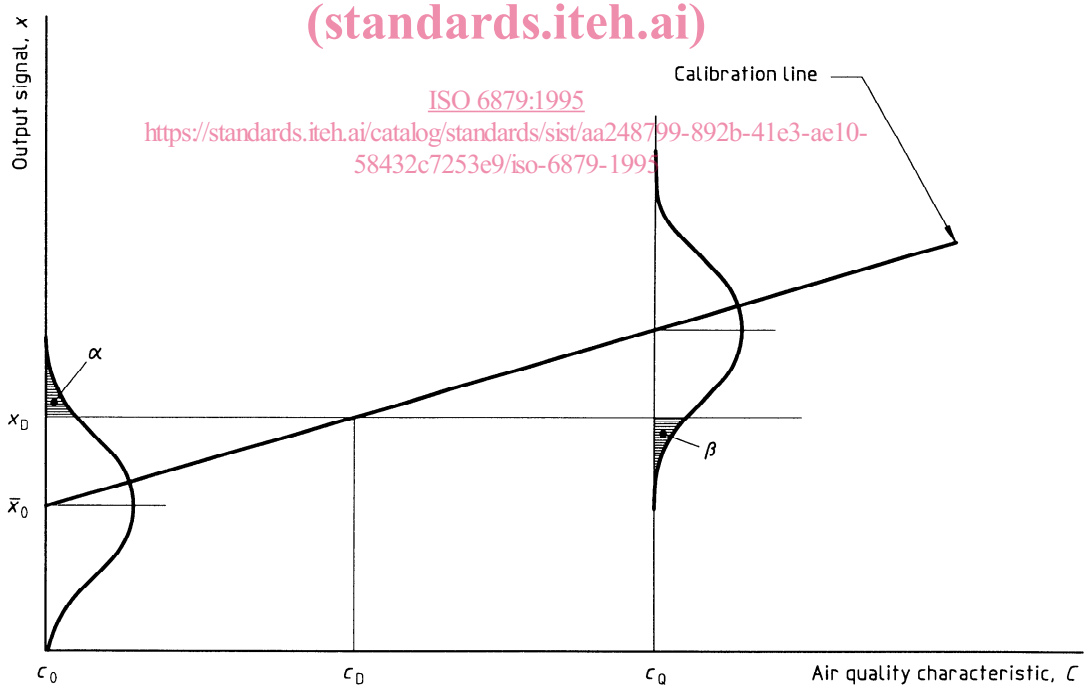

Figure 1 — Illustration of detection limit c_D, quantification limit c_Q and decision limit x_D