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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 mesure de la qualité de l'air

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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 developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been authorized 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.

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 6879 was developed by Technical Committee ISO/TC 146, *Air quality*, and was circulated to the member bodies in December 1981.

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It has been approved by the member bodies of the following countries :

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The member body of the following country expressed disapproval of the document on technical grounds :

United Kingdom

This International Standard has also been approved by the International Union of Pure and Applied Chemistry (IUPAC).

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1 Scope and field of application

This International Standard establishes a glossary of the most important performance characteristics of air quality measuring methods involving gaseous and particulate matter. The values associated with these performance characteristics, when determined, should be used to decide whether the method is suitable for a given air quality measuring task. All problems involved in drafting a specific method, including obtaining a representative sample or the number of measurements necessary for a given task, are excluded from this glossary and will be dealt with in other International Standards. This glossary will be followed by a series of International Standards for evaluating certain of these performance characteristics.

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

2 References

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

ISO 5725, *Precision of test methods — Determination of repeatability and reproducibility by inter-laboratory tests.*

3 Rationale

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 (4.2.1.10), instrument reading (4.2.1.5), and measured value (4.2.1.7).

The value of air quality characteristic, C_a, is the true value of the air quality characteristic being investigated. The instrument reading, X, is the output signal 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 instrument reading 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, $\hat{C}_a$, is the estimated value of the air quality characteristic, derived from instrument readings and generally involves calculations related to the calibration process and conversion to required quantities.

The calibration function (4.2.2.4) is the relation between instrument readings and quantifiable properties (concentration, particle size, etc.) of reference materials used during the calibration process. The analytical function (4.2.2.2) is the relation between the measured values and the instrument readings and is estimated from regression analysis of air quality characteristic values versus instrument readings. These relations are not deterministic but stochastic, usually unstable (see 4.2.2.7) and biased (see 4.2.2.3).

Statistical performance characteristics quantify, for measured values, the possible errors 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 mains voltage, temperature, supply of certain substances, set-up time, warm-up time, period of unattended operation.

The glossary comprises basic concepts and the three types of performance characteristics: operational, functional and statistical. 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 4.2.2, but which are suitable for the special method or instrument under consideration.

4 Glossary of terms

4.1 Symbols and abbreviations used in the glossary

C_a — value of air quality characteristic

$\hat{C}_a$ — measured value

C_i — ith interferent value, with $i = 1, 2, \ldots, n$ where n is the total number of interferents considered

f — analytical function

g — calibration function

I — first order measure of the value of selectivity related to the ith interferent

r — repeatability

R — reproducibility

S — sensitivity

X — instrument reading

4.2 Definitions

4.2.1 Basic concepts

4.2.1.1 air quality characteristic : One of the quantifiable properties relating to an air sample : concentration of a constituent, wind speed, temperature, etc.

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

4.2.1.3 blank reading : Instrument reading for a zero sample.

4.2.1.4 constituent : A component of the air sample for which a specified quantity is to be determined by measurement or analysis.

4.2.1.5 instrument reading : Output signal of a measuring system obtained as a response related to the concentration or the value of the air quality characteristic.

4.2.1.6 interferent : Any component of the air sample, excluding the constituent(s) affecting the instrument reading.

4.2.1.7 measured value : Estimated value of the air quality characteristic derived from instrument readings; this usually involves calculations related to the calibration process and conversion to required quantities.

4.2.1.8 memory effect : Dependence of an instrument reading on one or several previous sample(s).

4.2.1.9 method : Procedure for sampling and analysing one or more air quality characteristics. The accuracy may be established using either a reference material or reference procedures.

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

4.2.1.10 quantity of air quality characteristic : True value of the air quality characteristic being investigated; it is recognized that in practice, this value can only be approximated by existing methods.

4.2.1.11 reference material (RM) : A material or substance, one or more of the properties of which is sufficiently well established to be used for the calibration of an apparatus, the assessment of a measuring method, or for assigning values to materials. (Definition taken from ISO Guide 30.)

For the purpose of this International Standard : Substance or mixture of substances, the composition of which is known within specified limits, and one or more of the properties of which is sufficiently well established to be used for the calibration of an apparatus, the assessment of a measuring method, or for assigning values to materials.

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4.2.1.12 reference procedure : Agreed method 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.

4.2.1.13 span : Difference between the instrument readings for a stated value of air quality characteristic and a zero sample. By convention, this value of air quality characteristic is selected to be 95 % of the upper limit of measurement.

4.2.1.14 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.

4.2.2 Performance characteristics

4.2.2.1 accuracy : The closeness of agreement between the true value and the measured value. (Definition taken from ISO Guide 30.)

For the purpose of this International Standard : Agreement between a single measured value, $\hat{C}_a$, and the value of air quality characteristic, C_a, itself, or the accepted reference value; accuracy denotes the extent to which bias and random errors are absent.

4.2.2.2 analytical function : Function which relates the measured value, $\hat{C}_a$, to the instrument reading, X, with the

values of all interferents, C_i, remaining constant. This function is expressed by the regression

$$\hat{C}_a = f(X)\Big|_{C_i = \text{constant}}$$

of the calibration results.

NOTE — It is assumed that the analytical function is equal to the inverse of the calibration function.

4.2.2.3 bias : Consistent deviation of the results of a measurement process from the true value of the air quality characteristic itself.

NOTE — This deviation cannot be detected under test conditions described in 4.2.2.12.1.

4.2.2.4 calibration function : Instrument reading, X, as a function of measurable properties of the air quality characteristic under investigation represented by the reference material, with all interferents, C_i, remaining constant. This may be quantified by the regression function

$$X = g(C_a)\Big|_{C_i = \text{constant}}$$

of calibration results.

A calibration function designated by $X = C_a S +$ constant, where the sensitivity $S = \dfrac{\partial g(C_a, C_1, C_2, \ldots, C_n)}{\partial C_a}$ is constant, is called a linear function.

If the sensitivity is not a constant, the calibration function is called non-linear. Non-linearity may be expressed by higher order regression coefficients.

4.2.2.5 cut off : Size of particles at which the retention efficiency of an instrument device drops below a specified value under defined conditions.

4.2.2.6 hysteresis : Dependence of the instrument reading on the value and direction of change of previous air quality characteristic values. It may be quantified by the difference between the upscale and downscale measurements starting from fixed lower and upper measurement values (inversion).

4.2.2.7 instability : Change which takes place in instrument reading, X, over a stated period of unattended operation for a given value of the air quality characteristic. It can be characterized by the variation with time of its mean, specifying the drift, and by the dispersion.

4.2.2.7.1 span instability : Change which takes place in instrument span (see 4.2.1.13) over a stated period of unattended operation.

4.2.2.7.2 zero instability : Change in instrument reading in response to a zero sample over a stated period of unattended operation.

4.2.2.8 limiting condition of operation : Range of physical and operational parameters in which the method meets given values of performance characteristics with 95 %[1] probability.

4.2.2.9 lower detection limit : Smallest value of the air quality characteristic which, with 95 %[1] probability, can be distinguished from a zero sample.

NOTE — A zero sample has 5 %[1] probability of causing a reading above the lower detection limit. When the value of air quality characteristic is at the lower detection limit, 50 % of the results will be measured as zero under the assumption that the distribution is symmetric.

4.2.2.10 measurement resolution : Minimum value above which the difference of two values of air quality characteristic can be distinguished with 95 %[1] probability.

4.2.2.11 period of unattended operation : Period for which given values of performance characteristics of an instrument can be guaranteed to remain within 95 %[1] probability without servicing or adjustment.

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4.2.2.12 precision : The closeness of agreement between the results obtained by applying the method several times under prescribed conditions.

NOTE — The smaller the random part of the experimental errors which affect the results, the more precise is the method.

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4.2.2.12.1 repeatability, r : The value below which the absolute difference between two single test results obtained using the same method, on identical test material, under the same conditions (same operator, same apparatus, same laboratory and within a short interval of time) may be expected to lie with a specified probability. (Definition taken from ISO 5725).

For the purpose of this International Standard : The value below which the absolute difference between two measurements on identical material by one operator in one laboratory using the same apparatus within a short interval of time may be expected to lie with 95 %[1] probability.

4.2.2.12.2 reproducibility, R : The value below which the absolute difference between two single test results on identical material obtained using the same method, on identical test material, but under different conditions (different operators, different apparatus, different laboratories and/or different times) may be expected to lie with a specified probability. (Definition taken from ISO 5725).

For the purpose of this International Standard : The value below which the absolute difference between two measurements on identical material by different operators in different laboratories using the same method may be expected to lie with 95 %[1] probability.

1) By convention.

4.2.2.13 response time : Time taken for an instrument to respond to a rapid change in value of the air quality characteristic. It can be divided into two parts.

4.2.2.13.1 lag time : Time taken to reach 10 %[1] of the final change in instrument reading.

4.2.2.13.2 rise time (fall time) : Time taken to pass from 10 %[1] to 90 %[1] of the final change in instrument reading.

For instruments where transient oscillations occur in the approach to the final instrument reading, the latter should be replaced by the time taken for the oscillations to fall to less than 10 %[1] of the final change in instrument reading.

4.2.2.14 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.)

4.2.2.15 selectivity : Degree of independence from interferents. A first order measure is

$$I_i = \frac{\dfrac{\partial g(C_a, C_1, C_2, \ldots, C_n)}{\partial C_a}}{\dfrac{\partial g(C_a, C_1, C_2, \ldots, C_n)}{\partial C_i}}$$

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

I_i may depend on the value of the air quality characteristic.

4.2.2.16 sensitivity : Rate of change of instrument reading with respect to the change of the value of the air quality characteristic (see 4.2.2.4).

4.2.2.17 upper limit of measurement : Highest value of the air quality characteristic which can be measured by an instrument; its variations, caused for example by instability, are expected to lie within specified limits. The difference between the lower detection limit and upper limit of measurement constitutes the dynamic range of the instrument.

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