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Air quality — Definition and determination of performance characteristics of an automatic measuring system

Qualité de l'air — Définition et détermination de caractéristiques de performance d'un système automatique de mesurage

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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.

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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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9169 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 9169:1994), of which it constitutes a technical revision, and ISO 6879:1995.

Introduction

In this International Standard, automatic air quality measuring systems are considered as *black boxes* operated according to specified procedures as described in the terms of reference given by the client to the laboratory performing the tests aiming at determining performance characteristics selected by the client for each automatic measuring system.

This International Standard specifies definitions and methods to determine performance characteristics of automatic air quality measuring systems. This is done for most performance characteristics under steady laboratory conditions so as to have available data on clearly defined characteristics, based on specified conditions that can be adjusted and maintained in laboratory. This is also done under field conditions for a few performance characteristics for which field testing provide relevant additional information.

Air quality — Definition and determination of performance characteristics of an automatic measuring system

1 Scope

This International Standard provides definitions and specifies methods to determine performance characteristics of an identified automatic air quality measuring system. Tests are carried out under stable laboratory conditions or field conditions. The automatic measuring system is considered as a *black box* operated according to specified procedures.

This International Standard applies to measuring systems for which the following information is available:

— a description of the automatic measuring system providing the result of measurement in the physical unit of the measurand;

— operating procedures of the automatic measuring system including, where appropriate, the procedures of routine adjustment, routine verification and calibration;

— terms of reference for the test program specifying the client requirements and test conditions.

This International Standard applies to measuring systems for which it is possible to apply several reference materials with accepted values with known uncertainty for the measurand, within the range of application.

This International Standard does not specify the number of automatic measuring systems to be tested.

NOTE 1 The number of automatic measuring systems is specified by the client in the terms of reference.

NOTE 2 The list of performance characteristics in this document is limited. Additional performance characteristics can be specified by the client in the terms of reference, if appropriate.

2 Terms and definitions

For the purpose of this document, the following terms and definitions apply. Definitions taken from VIM[1] are generally kept identical. Some definitions have been adapted from VIM to take into account the specific wordings of the present International Standard.

2.1 General terms

2.1.1
measuring system
complete set of measuring instruments and other equipment with operating procedures to carry out specified air quality measurements

NOTE 1 Adapted from VIM:1993, 4.5.

NOTE 2 In general, a measuring system encompasses the different steps of the measurement process, such as taking the sample, the analytical quantification, etc.

2.1.2
automatic measuring system
AMS
measuring system interacting with the air under investigation, returning an output signal proportional to the physical unit of the measurand in unattended operation

NOTE The air under investigation includes, e.g. ambient air and emissions.

2.1.3
continuous automatic measuring system
automatic measuring system providing a continuous signal upon continuous interaction with the air mass under investigation

2.1.4
discontinuous automatic measuring system
automatic measuring system providing a series of discrete signals

NOTE Each discrete signal corresponds to the averaging time for field operation specified in the terms of reference.

2.1.5
adjustment
⟨automatic measuring system⟩ operation of bringing an automatic measuring system into a state of performance suitable for its use

NOTE 1 Adapted from VIM:1993, 4.30.

NOTE 2 Adjustment may be automatic, semi-automatic or manual.

2.1.6
primary result of measurement
result of measurement produced by an automatic measuring system measuring the measurand over the shortest period of time for which valid measurements can be obtained and used by the automatic measuring system to calculate the result of measurement over the specified averaging period for routine field operations of the automatic measurement system

NOTE For continuous automatic measurement systems, primary results of measurement are typically obtained for time periods of 1 s to 100 s, while the typical averaging time is 1 h in ambient air measurements and 30 min in emission measurements. For discontinuous automatic measuring systems, one primary measurement result is typically obtained for a cycle of a few minutes.

2.1.7
time interval for the primary measurement result
shortest period of time for which valid measurements can be obtained and used by the automatic measuring system to calculate the measurement result over the specified averaging period during routine functioning of the automatic measurement system

2.1.8
averaging time
minimum time interval equal to a stated multiple of the response time

NOTE See 6.3.1.

2.1.9
averaging time for field operation
time interval used by the automatic measuring system to produce routine results of measurement under normal (or envisaged) field operations

NOTE 1 Examples of averaging time for field operations are half an hour for emission measurements and one hour for ambient air measurements.

NOTE 2 The averaging time for field operation may be too long to be used during laboratory tests. Therefore, an **averaging time for laboratory test** (2.1.10) is defined and specified.

2.1.10
averaging time for laboratory test
time interval used for laboratory test and specified in such a way that

- the duration of the test is limited to minimize the possible drift effect during the test as well as the cost of the test;
- all conditions and influences may be considered as equal under steady laboratory conditions (e.g. insignificant drift effects);
- the number of primary results of measurement collected over the averaging time is equal to the number of primary results of measurement collected over the *intended* averaging time for routine field operations.

NOTE See 6.4.1.

2.1.11
measurand
particular quantity subject to measurement

[VIM:1993, 2.6]

NOTE In the field of air quality, the measurand is, e.g. the mass concentration of particulate matter or SO_2 in air.

2.1.12
interferent
interfering substance
substance present in the air mass under investigation, other than the measurand, that affects the response

2.1.13
influence quantity
quantity that is not the measurand but that affects the result of measurement (VIM:1993, 2.7), either an interferent influence quantity (i.e. the concentration of a substance in the air under investigation that is not the measurand), or an external influence quantity (i.e. a quantity that is not the measurand nor the concentration of a substance in the air mass under investigation)

EXAMPLE Examples include:

- presence of interfering gases in the flue gas matrix (interferent influence quantity);
- temperature of the surrounding air (external influence quantity);
- atmospheric pressure (external influence quantity); and
- pressure of the gas sample (external influence quantity).

2.1.14
reference material
RM
material or substance for which one or more properties are sufficiently homogeneous and well established to be used for the calibration and/or the validation of a measuring system

NOTE 1 Adapted from VIM:1993, 6.13 and ISO 11095:1996, 3.1.

NOTE 2 A reference material can be a pure or mixed gas, liquid or solid.

2.1.15
certified reference material
reference material, accompanied by a certificate, one or more of whose property values are certified by a procedure which establishes traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence

[VIM:1993, 6.14]

2.1.16
basic state
specific state of an automatic measuring system for use as a base for the evaluation of actual states of the automatic measuring system

NOTE 1 Adapted from ISO 11843-1:1997, 2.

NOTE 2 The use of a zero reference gas may establish the basic state. Very often in the air quality field, “zero reference gas” is simply called “zero gas”.

2.1.17
span level
level of concentration in the upper range of testing

NOTE Usually, span level is at 80 % of the intended upper limit of measurement.

2.1.18
calibration
set of operations that establish, under specified conditions, the relationship between the output of the automatic measuring system and the corresponding value given by the applicable reference

NOTE 1 Adapted from VIM:1993, 6.11 and ISO 11095:1996, Clause 4.

NOTE 2 The result of a calibration permits either the assignment of values of measurands to the indications or the determination of corrections with respect to indications.

NOTE 3 A calibration can also provide other metrological properties such as the effect of influence quantities.

NOTE 4 The result of a calibration should be recorded in a document, sometimes called a calibration certificate or a calibration report.

NOTE 5 Calibration as defined here is different from a simple check, i.e. checking without any adjustment that the automatic measuring system is still operating in the specified range. It is also different from a routine adjustment.

NOTE 6 The applicable reference can be a reference material (in the case of automatic ambient air quality measuring systems) or a standard reference method (in the case of automatic emission measuring systems).

2.1.19
expanded uncertainty
quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

[GUM:1995, 2.3.5]

NOTE The fraction may be viewed as the coverage probability or level of confidence of the interval.

2.1.20
linearity
maximum deviation between a linear calibration curve and the true value of the measurand, evaluated in practice as the maximum lack of fit within the measuring range

NOTE See 2.2.9.

2.1.21
memory effect
effect of previous values of the measurand on the current measurement results

2.1.22
parallel measurements
measurements by different measuring systems with sampling the same air over the same time period.

2.2 Performance characteristics

2.2.1
fall time
by convention, time taken for the output signal to pass from 90 % to 10 % of the initial output signal produced by a reference material applied to the automatic measuring system, when the application of this reference material is abruptly terminated to put the automatic measuring system in the basic state

NOTE For instruments where transient oscillations occur in approach to the final output signal, the 10 % of the initial output signal is considered as reached when the oscillations in the vicinity of the final output signal fall to less than 10 % of the initial output signal.

2.2.2
lag time
by convention, time taken for the output signal to reach 10 % of the final change in the output signal when a step function is applied by applying a reference material to the automatic measuring system initially in the basic state

2.2.3
rise time
by convention, time taken for the output signal to pass from 10 % to 90 % of the final change in the output signal when a reference material is abruptly applied to the automatic measuring system initially in the basic state.

NOTE For instruments where transient oscillations occur in approach to the final output signal, 90 % of the final change is considered as reached when the oscillations fall to less than 10 % of the final change in the output signal

2.2.4
response time
time interval between the instant when a stimulus is subjected to a specified abrupt change and the instant when the response reaches and remains within specified limits around its final stable value (VIM:1993, 5.17), determined as the sum of the lag time and the rise time in the rising mode, and the sum of the lag time and the fall time in the falling mode

2.2.5
repeatability
ability of an automatic measuring system to provide closely similar indications for repeated applications of the same measurand under the same conditions of measurement

NOTE 1 Adapted from VIM:1993, 5.27.

NOTE 2 These conditions include:

— same measurement procedure;

— same measuring equipment used under the same conditions;

— same location;

— repetition over a short period of time.

NOTE 3 Repeatability can be expressed quantitatively in terms of the dispersion characteristics of the measurement results of an automatic measuring system.

NOTE 4 The repeatability conditions selected in this International Standard are specified in Clause 6. These specifications are aimed at providing the user with an evaluation of the maximum difference that can be found, with 95 % statistical confidence, between two measurement results obtained:

— from the same automatic measuring system;

— operated according to the same operating procedures;

— at the same measurement location and under the conditions prevailing at this location (either laboratory or field);

— during a period of time short enough not to be sensitive to drift effects;

— at different times during the period of unattended operation.

2.2.6
reproducibility
closeness of the agreement between the results of measurements of the same measurand carried out under changed conditions of measurement

NOTE 1 Adapted from VIM:1993, 3.7.

NOTE 2 The changed conditions may include the measuring system but not the measurement procedure.

NOTE 3 Reproducibility may be expressed quantitatively in terms of the dispersion characteristics of the measurements results of an automatic measuring system.

NOTE 4 The reproducibility conditions selected in this International Standard are specified in Clause 6. These specifications are aimed at providing the user with an evaluation of the maximum difference that may be found, with 95 % statistical confidence, between two measurement results obtained:

— from two automatic measuring systems meeting the same specification;

— operated according to the same specified operating procedures and each system being calibrated with its own reference;

— at the same measurement location and under the conditions prevailing at this location (either laboratory or field);

— by parallel measurements during the same period of time;

— spread over the period of unattended operation.

2.2.7
availability
fraction of the total time that the automatic measuring system is operational and for which valid measuring data are available

2.2.8
drift
change over time of a metrological characteristic (generally an output quantity) of the measuring system

NOTE Adapted from VIM:1993, 5.16.