IEC 61207-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Expression of performance of gas analyzers –
Part 1: General**

**Expression des performances des analyseurs de gaz –
Partie 1: Généralités**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPRESSION OF PERFORMANCE OF GAS ANALYZERS –

Part 1: General

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61207-1 has been prepared by subcommittee 65B: Devices and process analysis, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 1994 and constitutes a technical revision.

The significant technical changes with respect to the first edition are the following:

a) All references (normative and informative) have been updated, deleted or added, as appropriate.
b) All the terms and definitions relating to this International Standard have been updated.
c) All references to "errors" have been replaced by "uncertainties" and appropriate updated definitions applied.
d) Where only one value is quoted for a performance specification, such as intrinsic uncertainty, linearity uncertainty or repeatability throughout a measurement range, this

has now been defined as the maximum value, rather than an average or “representative” value. This was previously undefined.

e) Where zero and 100 % span calibration gases are used, there is now a defined requirement that the analyser must be able to respond within its standard performance specifications beyond its normal measurement range, to allow for any under or over response of the instrument to be recorded.

f) A new Annex A has been added giving recommended standard values of influence.

The text of this standard is based on the following documents:

FDIS	Report on voting
65B/741/FDIS	65B/752/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61207 series, under the general title *Expression of performance of gas analyzers*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

EXPRESSION OF PERFORMANCE OF GAS ANALYZERS –

Part 1: General

1 Scope and object

This part of IEC 61207 is applicable to gas analyzers used for the determination of certain constituents in gaseous mixtures.

This part of IEC 61207 specifies the terminology, definitions, requirements for statements by manufacturers and tests that are common to all gas analyzers. Other international standards in this series, for example IEC 61207-2, describe those aspects that are specific to certain types (utilizing high-temperature electrochemical sensors).

This part IEC 61207 is in accordance with the general principles set out in IEC 60359 and IEC 60770.

This standard is applicable to analyzers specified for permanent installation in any location (indoors or outdoors) and to such analyzers utilizing either a sample handling system or an *in situ* measurement technique.

This standard is applicable to the complete analyzer when supplied by one manufacturer as an integral unit, comprised of all mechanical, electrical and electronic portions. It also applies to sensor units alone and electronic units alone when supplied separately or by different manufacturers.

For the purposes of this standard, any regulator for mains-supplied power or any non-mains power supply, provided with the analyzer or specified by the manufacturer, is considered part of the analyzer whether it is integral with the analyzer or housed separately.

Safety requirements are dealt with in IEC 61010-1.

If one or more components in the sample is flammable, and air or another gas mixture containing oxygen or other oxidizing component is present, then the concentration range of the reactive components are limited to levels which are not within flammability limits.

Standard range of analogue d.c. current and pneumatic signals used in process control systems are dealt with in IEC 60381-1 and IEC 60382.

Specifications for values for the testing of influence quantities can be found in IEC 60654.

Requirements for documentation to be supplied with instruments are dealt with in IEC 61187.

Requirements for general principles concerning quantities, units and symbols are dealt with in ISO 1000. See also ISO 31-0.

This part of IEC 61207 does not apply to:

– accessories such as recorders, analogue-to-digital converters or data acquisition systems used in conjunction with the analyzer, except that when two or more such analyzers are combined and sold as a subsystem and a single electronic unit is supplied to provide continuous measurement of several properties, that read-out unit is considered to be part of the analyzer. Similarly, e.m.f-to-current or e.m.f-to-pressure converters which are an integral part of the analyzer are included.

The object of this part of IEC 61207 is:

– to specify the general aspects in the terminology and definitions related to the performance of gas analyzers used for the continuous measurement of gas composition;
– to unify methods used in making and verifying statements on the functional performance of such analyzers;
– to specify which tests should be performed in order to determine the functional performance and how such tests should be carried out;
– to provide basic documents to support the application of standards of quality assurance within ISO 9001.

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.

IEC 60068 (all parts), *Environmental testing*

IEC 60359:2001, *Electrical and electronic measurement equipment – Expression of performance*

IEC 60381-1, *Analogue signals for process control systems – Part 1: Direct current signals*

IEC 60382, *Analogue pneumatic signal for process control systems*

IEC 60654 (all parts), *Industrial-process measurement and control equipment – Operating conditions*

IEC 60654-1, *Industrial-process measurement and control equipment – Operating conditions – Part 1: Climatic conditions*

IEC 60770 (all parts), *Transmitters for use in industrial-process control systems*

IEC 60770-1, *Transmitters for use in industrial-process control systems – Part 1: Methods for performance evaluation*

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*

IEC 61187, *Electrical and electronic measurement equipment – Documentation*

ISO 31-0, *Quantities and units – General principles*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

3 Terms and definitions

3.1 General

For the purposes of this document, the following terms and definitions apply. The definitions in 3.2 (excepting 3.2.17), 3.3 and 3.4 are taken from IEC 60359.

3.2 Basic terms and definitions

3.2.1
measurand
quantity subjected to measurement, evaluated in the state assumed by the measured system during the measurement itself

NOTE 1 The value assumed by a quantity subjected to measurement when it is not interacting with the measuring instrument may be called unperturbed value of the quantity.

NOTE 2 The unperturbed value and its associated uncertainty can only be computed through a model of the measured system and of the measurement interaction with the knowledge of the appropriate metrological characteristics of the instrument that may be called instrumental load.

3.2.2
(result of a) measurement
set of values attributed to a measurand, including a value, the corresponding uncertainty and the unit of measurement

[IEC 60050-311, 311-01-01, modified]

NOTE 1 The mid-value of the interval is called the value (see 3.2.3) of the measurand and its half-width the uncertainty (see 3.2.4).

NOTE 2 The measurement is related to the indication (see 3.2.5) given by the instrument and to the values of correction obtained by calibration.

NOTE 3 The interval can be considered as representing the measurand provided that it is compatible with all other measurements of the same measurand.

NOTE 4 The width of the interval, and hence the uncertainty, can only be given with a stated level of confidence (see 3.2.4, NOTE 1).

3.2.3
(measure-) value
mid element of the set assigned to represent the measurand

NOTE The measure-value is no more representative of the measurand than any other element of the set. It is singled out merely for the convenience of expressing the set in the format $V \pm U$, where V is the mid element and U the half-width of the set, rather than by its extremes. The qualifier "measure-" is used when deemed necessary to avoid confusion with the reading-value or the indicated value.

3.2.4
uncertainty (of measurement)
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

NOTE 1 The parameter can be, for example, a standard deviation (or a given multiple of it), or a half-width of an interval having a stated level of confidence.

NOTE 2 Uncertainty of measurement comprises, in general, many components. Some of these components can be evaluated from the statistical distribution of the results of a series of measurements and can be characterized by experimental standard deviations. The other components, which can also be characterized by standard deviations, are evaluated from the assumed probability distributions based on experience or other information.

[IEC 60050-311, 311-01-02, ISO/IEC Guide 99, 2.26 modified]

NOTE 3 It is understood that the result of the measurement is the best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion.

NOTE 4 The definition and notes 1 and 2 are from GUM, Clause B.2.18. The option used in this standard is to express the uncertainty as the half-width of an interval with the GUM procedures with a coverage factor of 2. This choice corresponds to the practice now adopted by many national standards laboratories. With the normal distribution a coverage factor of 2 corresponds to a level of confidence of 95 %. Otherwise statistical elaborations are necessary to establish the correspondence between the coverage factor and the level of confidence. As the data for such elaborations are not always available, it is deemed preferable to state the coverage factor. This interval can be "reasonably" assigned to describe the measurand, in the sense of the GUM definition, as in most usual cases it ensures compatibility with all other results of measurements of the same measurand assigned in the same way at a sufficiently high confidence level.

NOTE 5 Following CIPM document INC-1 and ISO/IEC Guide 98-3, the components of uncertainty that are evaluated by statistical methods are referred to as components of category A, and those evaluated with the help of other methods as components of category B.

3.2.5
indication or reading-value
output signal of the instrument

[IEC 60050-311, 311-01-01, modified]

NOTE 1 The indicated value can be derived from the indication by means of the calibration curve.

NOTE 2 For a material measure, the indication is its nominal or stated value.

NOTE 3 The indication depends on the output format of the instrument:

- for analogue outputs it is a number tied to the appropriate unit of the display;
- for digital outputs it is the displayed digitized number;
- for code outputs it is the identification of the code pattern.

NOTE 4 For analogue outputs meant to be read by a human observer (as in the index-on-scale instruments) the unit of output is the unit of scale numbering; for analogue outputs meant to be read by another instrument (as in calibrated transducers) the unit of output is the unit of measurement of the quantity supporting the output signal.

3.2.6
calibration
set of operations which establishes the relationship which exists, under specified conditions, between the indication and the result of a measurement

[IEC 60050-311, 311-01-09]

NOTE 1 The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

NOTE 2 The calibration must be performed under well-defined operating conditions for the instrument. The calibration diagram representing its result is not valid if the instrument is operated under conditions outside the range used for the calibration.

NOTE 3 Quite often,e specially for instruments whose metrological characteristics are sufficiently known from past experience, it is convenient to predefine a simplified calibration diagram and perform only a verification of calibration (see 3.3.12) to check whether the response of the instrument stays within its limits. The simplified diagram is, of course, wider than the diagram that would be defined by the full calibration of the instrument, and the uncertainty assigned to the results of measurements is consequently larger.

3.2.7
calibration diagram
portion of the co-ordinate plane, defined by the axis of indication and the axis of results of measurement, which represents the response of the instrument to differing values of the measurand

[IEC 60050-311, 311-01-10]

3.2.8
calibration curve
curve which gives the relationship between the indication and the value of the measurand

NOTE 1 When the calibration curve is a straight line passing through zero, it is convenient to refer to the slope which is known as the instrument constant.

[IEC 60050-311, 311-01-11]

NOTE 2 The calibration curve is the curve bisecting the width of the calibration diagram parallel to the axis of results of measurement, thus joining the points representing the values of the measurand.

3.2.9
indicated value
value given by an indicating instrument on the basis of its calibration curve

[IEC 60050-311, 311-01-08]

NOTE The indicated value is the measure-value of the measurand when the instrument is used in a direct measurement (see 3.3.7) under all the operating conditions for which the calibration diagram is valid.

3.2.10
(measurement) compatibility
property satisfied by all the results of measurement of the same measurand, characterized by an adequate overlap of their intervals

[IEC 60050-311, 311-01-14]

NOTE 1 The compatibility of any result of a measurement with all the other ones that represent the same measurand can be asserted only at some level of confidence, as it depends on statistical inference, a level that should be indicated, at least by implicit convention or through a coverage factor.

NOTE 2 The compatibility of the results of measurements obtained with different instruments and methods is ensured by the traceability (see 3.2.16) to a common primary standard (see 3.3.6) of the standards used for the calibration of the several instruments (and of course by the correctness of the calibration and operation procedures).

NOTE 3 When two results of a measurement are not compatible it must be decided by independent means whether one or both results are wrong (perhaps because the uncertainty is too narrow), or whether the measurand is not the same.

NOTE 4 Measurements carried out with wider uncertainty yield results which are compatible on a wider range, because they discriminate less among different measurands allowing to classify them with simpler models; with narrower uncertainties the compatibility calls for more detailed models of the measured systems.

3.2.11
intrinsic uncertainty of the measurand
minimum uncertainty that can be assigned in the description of a measured quantity

NOTE 1 No quantity can be measured with narrower and narrower uncertainty, in as much as any given quantity is defined or identified at a given level of detail. If one tries to measure a given quantity with uncertainty lower than its own intrinsic uncertainty one is compelled to redefine it with higher detail, so that one is actually measuring another quantity. See also GUM D.1.1.

NOTE 2 The result of a measurement carried out with the intrinsic uncertainty of the measurand may be called the best measurement of the quantity in question.

3.2.12
(absolute) instrumental uncertainty
uncertainty of the result of a direct measurement of a measurand having negligible intrinsic uncertainty

NOTE 1 Unless explicitly stated otherwise, the instrumental uncertainty is expressed as an interval with coverage factor 2.

NOTE 2 In single-reading direct measurements of measurands having intrinsic uncertainty small with respect to the instrumental uncertainty, the uncertainty of the measurement coincides, by definition, with the instrumental uncertainty. Otherwise the instrumental uncertainty is to be treated as a component of category B in evaluating the uncertainty of the measurement on the basis of the model connecting the several direct measurements involved.

NOTE 3 The instrumental uncertainty automatically includes, by definition, the effects due to the quantization of the reading-values (minimum evaluable fraction of the scale interval in analogic outputs, unit of the last stable digit in digital outputs).

NOTE 4 For material measures the instrumental uncertainty is the uncertainty that should be associated to the value of the quantity reproduced by the material measure in order to ensure the compatibility of the results of its measurements.

NOTE 5 When possible and convenient the uncertainty may be expressed in the relative form (see 3.4.3) or in the fiducial form (see 3.4.4). The relative uncertainty is the ratio U/V of the absolute uncertainty U to the measure value V, and the fiducial uncertainty the ratio U/V_f of the absolute uncertainty U to a conventionally chosen value V_f.

3.2.13
conventional value measure
value of a standard used in a calibration operation and known with uncertainty negligible with respect to the uncertainty of the instrument to be calibrated

NOTE This definition is adapted to the object of this standard from the definition of "conventional true value (of a quantity)": value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose (see IEC 60050-311, 311-01-06, ISO/IEC Guide 99, 2.13 modified).

3.2.14
influence quantity
quantity which is not the subject of the measurement and whose change affects the relationship between the indication and the result of the measurement

NOTE 1 Influence quantities can originate from the measured system, the measuring equipment or the environment.

NOTE 2 As the calibration diagram depends on the influence quantities, in order to assign the result of a measurement it is necessary to know whether the relevant influence quantities lie within the specified range.

[IEC 60050-311, 311-06-01]

NOTE 3 An influence quantity is said to lie within a range C' to C'' when the results of its measurement satisfy the relationship: $C' \le V - U < V + U \le C''$.

3.2.15
steady-state conditions
operating conditions of a measuring device in which the variation of the measurand with the time is such that the relation between the input and output signals of the instruments does not suffer a significant change with respect to the relation obtaining when the measurand is constant in time

3.2.16
traceability
property of the result of a measurement or of the value of a standard such that it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties

[IEC 60050-311, 311-01-15, ISO/IEC Guide 99, 2.41 modified]

NOTE 1 The concept is often expressed by the adjective traceable.

NOTE 2 The unbroken chain of comparisons is called a traceability chain.

NOTE 3 The traceability implies that a metrological organization be established with a hierarchy of standards (instruments and material measures) of increasing intrinsic uncertainty. The chain of comparisons from the primary standard to the calibrated device adds indeed new uncertainty at each step.

NOTE 4 Traceability is ensured only within a given uncertainty that should be specified.

3.2.17
mean
summation of the individual values divided by the total number of values for a set of values

3.3 General terms and definitions of devices and operations

3.3.1
(measuring) instrument
device intended to be used to make measurements, alone or in conjunction with supplementary devices

[IEC 60050-311, 311-03-01, ISO/IEC Guide 99, 3.1 modified]

NOTE The term "(measuring) instruments" includes both the indicating instruments and the material measures.

3.3.2
indicating (measuring) instrument
measuring instrument which displays an indication

NOTE 1 The display can be analogue (continuous or discontinuous), digital or coded [IEV].

NOTE 2 Values of more than one quantity can be displayed simultaneously [IEV].

NOTE 3 A displaying measuring instrument can also provide a record [IEV].

NOTE 4 The display can consist of an output signal not directly readable by a human observer, but able to be interpreted by suitable devices [IEV].

[IEC 60050-311, 311-03-02, ISO/IEC Guide 99, 3.3 modified]

NOTE 5 An indicating instrument may consist of a chain of transducers with the possible addition of other process devices, or it may consist of one transducer.

NOTE 6 The interaction between the indicating instrument, the measured system and the environment generates a signal in the first stage of the instrument (called sensor). This signal is elaborated inside the instrument into an output signal which carries the information on the measurand. The description of the output signal in a suitable output format is the indication supplied by the instrument.

NOTE 7 A chain of instruments is treated as a single indicating instrument when a single calibration diagram is available that connects the measurand to the output of the last element of the chain. In this case the influence quantities must be defined for the whole chain.

3.3.3
material measure
device intended to reproduce or supply, in a permanent manner during its use, one or more known values of a given quantity

NOTE 1 The quantity concerned may be called the supplied quantity [IEV].

[IEC 60050-311, 311-03-03, ISO/IEC Guide 99, 3.6 modified]

NOTE 2 The definition covers also the devices, such as signal generators and standard voltage or current generators, often referred to as supply instruments.

NOTE 3 The identification of the value and uncertainty of the supplied quantity is given by a number tied to a unit of measurement or a code term, called nominal value or marked value of the material measure.

3.3.4
electrical measuring instrument
measuring instrument intended to measure an electrical or non-electrical quantity using electrical or electronic means

[IEC 60050-311, 311-03-04]

3.3.5
transducer
technical device which performs a given elaboration on an input signal, transforming it into an output signal

NOTE All indicating instruments contain transducers and they may consist of one transducer. When the signals are elaborated by a chain of transducers, the input and output signals of each transducer are not always directly and univocally accessible.

3.3.6
primary standard
standard that is designated or widely acknowledged as having the highest metrological qualities and whose value is accepted without reference to other standards of the same quantity

NOTE 1 The concept of a primary standard is equally valid for base quantities and derived quantities.

NOTE 2 A primary standard is never used directly for measurement other than for comparison with other primary standards or reference standards.

[IEC 60050-311, 311-04-02, ISO/IEC Guide 99, 5.4 modified]

3.3.7
direct (method of) measurement
method of measurement in which the value of a measurand is obtained directly, without the necessity for supplementary calculations based on a functional relationship between the measurand and other quantities actually measured

NOTE 1 The value of the measurand is considered to be obtained directly even when the scale of a measuring instrument has values which are linked to corresponding values of the measurand by means of a table or a graph [IEV].

NOTE 2 The method of measurement remains direct even if it is necessary to make supplementary measurements to determine the values of influence quantities in order to make corrections [IEV].

[IEC 60050-311, 311-02-01]

NOTE 3 The definitions of the metrological characteristics of the instruments refer implicitly to their use in direct measurements.

3.3.8
indirect (method of) measurement
method of measurement in which the value of a quantity is obtained from measurements made by direct methods of measurement of other quantities linked to the measurand by a known relationship

[IEC 60050-311, 311-02-02]

NOTE 1 In order to apply an indirect method of measurement a model is needed which is able to supply the relationship, and which is fully explicit, between the measurand and the parameters that are measured by direct measurement.

NOTE 2 The computations must be carried out on both values and uncertainties, and therefore require accepted rules for the propagation of the uncertainty as provided by GUM.

3.3.9
(method of) measurement by repeated observations
method of measurement by which the result of the measurement is assigned on the basis of a statistical analysis on the distribution of the data obtained by several observations repeated under nominally equal conditions

NOTE 1 One should resort to a statistical analysis when the instrumental uncertainty is too small to ensure the measurement compatibility. This may happen in two quite different sets of circumstances:

a) when the measurand is a quantity subjected to intrinsic statistical fluctuations (e.g. in measurements involving nuclear decay). In this case the actual measurand is the statistical distribution of the states of the measured quantity, to be described by its statistical parameters (mean and standard deviation). The statistical analysis is carried out on a population of results of measurement, each with its own value and uncertainty, as each observation correctly describes one particular state of the measured quantity. The situation may be considered a particular case of indirect measurement.

b) when the noise associated with the transmission of signals affects the reading-value more than in the operating conditions used for the calibration, contributing to the uncertainty of the measurement to an extent comparable with the instrumental uncertainty or higher (e.g. in the field use of surveyor instruments). In this case, the statistical analysis is carried out on a population of reading-values with the purpose of separating the information on the measurand from the noise. The situation may be considered as a new calibration of the instrument for a set of operating conditions outside their rated range.

NOTE 2 One cannot presume to obtain by means of repeated observation an uncertainty lower than the instrumental uncertainty assigned by the calibration or the class of precision of the instrument. Indeed, if the results of the repeated measurements are compatible with each other within the instrumental uncertainty, the latter is the valid datum for the uncertainty of the measurement and several observations do not bring more information than one. In the other hand, if they are not compatible within the instrumental uncertainty, the final result of the measurement should be expressed with a larger uncertainty in order to make all results compatible as they should be by definition.