BS EN 61207-1:2010

BSI Standards Publication

Expression of performance of gas analyzers

Part 1: General

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 61207-1:2010. It is identical to IEC 61207-1:2010. It supersedes BS EN 61207-1:1994, which will be withdrawn on 1 July 2013.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/2, Elements of systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Expression of performance of gas analyzers - Part 1: General
(IEC 61207-1:2010)

Expression des performances des analyseurs de gaz - Partie 1: Généralités (CEI 61207-1:2010)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 65B/741/FDIS, future edition 2 of IEC 61207-1, prepared by SC 65B, Devices & process analysis, of IEC TC 65, Industrial-process measurement, control and automation, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61207-1 on 2010-07-01.

This European Standard supersedes EN 61207-1:1994.

The significant technical changes with respect to EN 61207-1:1994 are the following:

– All references (normative and informative) have been updated, deleted or added, as appropriate.

– All the terms and definitions relating to this International Standard have been updated.

– All references to “errors” have been replaced by “uncertainties” and appropriate updated definitions applied.

– 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.

– 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.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2011-04-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2013-07-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61207-1:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61207-2	NOTE Harmonized as EN 61207-2.
IEC 61298 series	NOTE Harmonized in EN 61298 series (not modified).
IEC 61326 series	NOTE Harmonized in EN 61326 series (not modified).
ISO 6141	NOTE Harmonized as EN ISO 6141.
ISO 6142	NOTE Harmonized as EN ISO 6142.
ISO 6143	NOTE Harmonized as EN ISO 6143.
ISO 6144	NOTE Harmonized as EN ISO 6144.
ISO 9001	NOTE Harmonized as EN ISO 9001
ISO 16664	NOTE Harmonized as EN ISO 16664.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60068	Series	Environmental testing	EN 60068	Series
IEC 60359	2001	Electrical and electronic measurement equipment - Expression of performance	EN 60359	2002
IEC 60381-1	-	Analogue signals for process control systems - Part 1: Direct current signals	HD 452.1	-
IEC 60382	-	Analogue pneumatic signal for process control systems	EN 60382	-
IEC 60654	Series	Industrial-process measurement and control equipment - Operating conditions -	EN 60654	Series
IEC 60654-1	-	Industrial-process measurement and control equipment - Operating conditions - Part 1: Climatic conditions	EN 60654-1	-
IEC 60770	Series	Transmitters for use in industrial-process control systems	EN 60770	Series
IEC 60770-1	-	Transmitters for use in industrial-process control systems - Part 1: Methods for performance evaluation	EN 60770-1	-
IEC 61010-1	-	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements	EN 61010-1	-
IEC 61187	-	Electrical and electronic measuring equipment - Documentation	EN 61187	-
ISO 31-0	-	Quantities and units - Part 0: General principles	-	-
ISO 1000	-	SI units and recommendations for the use of their multiples and of certain other units	-	-

CONTENTS

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: $C' \leq V - U < V + U \leq C''$.

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.

NOTE 3 For instruments that exhibit non-negligible hysteresis a straightforward statistical analysis of repeated observations is misleading. Appropriate test procedures for such instruments should be expounded in their particular standards.

3.3.10
intrinsic (instrumental) uncertainty
uncertainty of a measuring instrument when used under reference conditions

[IEC 60050-311, 311-03-09, modified]

3.3.11
operating instrumental uncertainty
instrumental uncertainty under the rated operating conditions

NOTE The operating instrumental uncertainty, like the intrinsic one, is not evaluated by the user of the instrument, but is stated by its manufacturer or calibrator. The statement may be expressed by means of an algebraic relation involving the intrinsic instrumental uncertainty and the values of one or several influence quantities, but such a relation is just a convenient means of expressing a set of operating instrumental uncertainties under different operating conditions, not a functional relation to be used for evaluating the propagation of uncertainty inside the instrument.

3.3.12
verification (of calibration)
set of operations which is used to check whether the indications, under specified conditions, correspond with a given set of known measurands within the limits of a predetermined calibration diagram

NOTE 1 The known uncertainty of the measurand used for verification will generally be negligible with respect to the uncertainty assigned to the instrument in the calibration diagram.

[IEC 60050-311, 311-01-13]

NOTE 2 The verification of calibration of a material measure consists in checking whether the result of a measurement of the supplied quantity is compatible with the interval given by the calibration diagram.

3.3.13
adjustment (of a measuring instrument)
set of operations carried out on an measuring instrument in order that it provides given indications corresponding to given values of the measurand

NOTE When the instrument is made to give a null indication corresponding to a null value of the measurand, the set of operations is called zero adjustment.

[IEC 60050-311, 311-03-16]

3.3.14
user adjustment (of a measuring instrument)
adjustment, employing only the means at the disposal of the user, specified by the manufacturer

[IEC 60050-311, 311-03-17]

3.3.15
deviation (for the verification of calibration)
difference between the indication of an instrument undergoing verification of calibration and the indication of the reference measuring instrument, under equivalent operating conditions

[IEC 60050-311, 311-01-21]

NOTE 1 The comparison of the indications may be carried out by simultaneous measurement or by substitution. In principle, the comparison ought to be carried out on the same measurand in the same measuring conditions, but this is impossible because the measurand can never be rigorously the same. Only the metrological expertise of the operator can warranty that the difference in the measurement conditions of the two instruments is negligible for comparison purposes.

NOTE 2 If one of the instruments is a material measure, its nominal value is taken as the assigned measure - value.

NOTE 3 The term is used only in operations of verification of calibration where the uncertainty of the reference instrument is negligible by definition.

3.4 Terms and definitions on manners of expression

3.4.1
metrological characteristics
data concerning the relations between the readings of a measuring instrument and the measurements of the quantities interacting with it

3.4.2
range
domain of values of a quantity included between a lower and an upper limit

NOTE 1 The term "range" is usually used with a modifier. It may apply to a performance characteristic, to an influence quantity, etc.

NOTE 2 When one of the limits of a range is zero or infinity, the other finite limit is called a threshold.

NOTE 3 No uncertainty is associated with the values of range limits or thresholds as they are not themselves results of measurements but a priori statements about conditions to be met by results of measurements. If the result of a measurement have to lie within a rated range, it is understood that the whole interval $V \pm U$ representing it must lie within the values of the range limits or beyond the threshold value, unless otherwise specified by relevant standards or by explicit agreements.

NOTE 4 A range may be expressed by stating the values of its lower and upper limits, or by stating its mid value and its half-width.

3.4.3
relative form of expression
expression of a metrological characteristic, or of other data, by means of its ratio to the measure value of the quantity under consideration

NOTE 1 Expression in relative form is possible when the quantity under consideration allows the ratio relationship and its value is not zero.

NOTE 2 Uncertainties and limits of uncertainty are expressed in relative form by dividing their absolute value by the value of the measurand, ranges of influence quantities by dividing the halved range by the mid value of the domain, etc.

3.4.4
fiducial form of expression
expression of a metrological characteristic, or of other data, by means of its ratio to a conventionally chosen value of the quantity under consideration

NOTE 1 Expression in fiducial form is possible when the quantity under consideration allows the ratio relationship.

NOTE 2 The value to which reference is made in order to define the uncertainity is called fiducial value.

3.4.5
variation (due to an influence quantity)
difference between the indicated values for the same value of the measurand of an indicating instrument, or the values of a material measure, when an influence quantity assumes, successively, two different values

[IEC 60050-311, 311-07-03]

NOTE 1 The uncertainty associated with the different measure values of the influence quantity for which the variation is evaluated should not be wider than the width of the reference range for the same influence quantity. The other performance characteristics and the other influence quantities should stay within the ranges specified for the reference conditions.

NOTE 2 The variation is a meaningful parameter when it is greater than the intrinsic instrumental uncertainty.

3.4.6
limit of uncertainty
limiting value of the instrumental uncertainty for equipment operating under specified conditions

NOTE 1 A limit of uncertainty may be assigned by the manufacturer of the instrument, who states that under the specified conditions the instrumental uncertainty is never higher than this limit, or may be defined by standards, that prescribe that under specified conditions the instrumental uncertainty should not be larger than this limit for the instrument to belong to a given accuracy class.

NOTE 2 A limit of uncertainty may be expressed in absolute terms or in the relative or fiducial forms.

3.4.7
accuracy class
class of measuring instruments, all of which are intended to comply with a set of specifications regarding uncertainty

[IEC 60050-311, 311-06-09]

NOTE 1 An accuracy class always specifies a limit of uncertainty (for a given range of influence quantities), whatever other metrological characteristics it specifies.

NOTE 2 An instrument may be assigned to different accuracy classes for different rated operating conditions.

NOTE 3 Unless otherwise specified, the limit of uncertainty defining an accuracy class is meant as an interval with coverage factor 2.

3.4.8
rated value
quantity value assigned by a manufacturer for a specified operating condition of the equipment or instrument

NOTE A rated value V assigned with an uncertainty U is actually a range $V \pm U$ and should be handled as such (see 3.4.2, Note 4).

3.4.9
(specified) measuring range
range defined by two values of the measurand, or quantity to be supplied, within which the limits of uncertainty of the measuring instrument are specified

NOTE 1 An instrument can have several measuring ranges.

[IEC 60050-311, 311-03-12, modified]

NOTE 2 The upper and lower limits of the specified measuring range are sometimes called the maximum capacity and minimum capacity respectively.

3.4.10
reference conditions
appropriate set of specified values and/or ranges of values of influence quantities under which the smallest permissible uncertainties of a measuring instrument are specified

[IEC 60050-311, 311-06-02, modified]

NOTE The ranges specified for the reference conditions, called reference ranges, are not wider, and are usually narrower, than the ranges specified for the rated operating conditions.

3.4.11
reference value
specified value of one of a set of reference conditions

[IEC 60050-311, 311-07-01, modified]

3.4.12
reference range
specified range of values of one of a set of reference conditions

[IEC 60050-311, 311-07-02, modified]

3.4.13
rated operating conditions
set of conditions that must be fulfilled during the measurement in order that a calibration diagram may be valid

NOTE Beside the specified measuring range and rated operating ranges for the influence quantities, the conditions may include specified ranges for other performance characteristics and other indications that cannot be expressed as ranges of quantities.

3.4.14
nominal range of use or rated operating range (for influence quantities)
specified range of values which an influence quantity can assume without causing a variation exceeding specified limits

[IEC 60050-311, 311-07-05]

NOTE The rated operating range of each influence quantity is a part of the rated operating conditions.

3.4.15
limiting conditions
extreme conditions which an operating measuring instrument can withstand without damage and without degradation of its metrological characteristics when it is subsequently operated under its rated operating conditions

3.4.16
limiting values for operation
extreme values which an influence quantity can assume during operation without damaging the measuring instrument so that it no longer meets its performance requirements when it is subsequently operated under reference conditions

NOTE The limiting values can depend on the duration of their application.

[IEC 60050-311, 311-07-06]

3.4.17
storage and transport conditions
extreme conditions which a non-operating measuring instrument can withstand without damage and without degradation of its metrological characteristics when it is subsequently operated under its rated operating conditions

3.4.18
limiting values for storage
extreme values which an influence quantity can assume during storage without damaging the measuring instrument so that it no longer meets its performance requirements when it is subsequently operated under reference conditions

NOTE The limiting values can depend on the duration of their application.

[IEC 60050-311, 311-07-07]

3.4.19
limiting values for transport
extreme values which an influence quantity can assume during transport without damaging the instrument so that it no longer meets its performance requirements when it is subsequently operated under reference conditions

NOTE The limiting values can depend on the duration of their application.

[IEC 60050-311, 311-07-08]

3.5 Specific terms and definitions for gas analyzers

3.5.1
gas analyzer
analytical instrument that provides an output signal which is a monotonic function of the concentration, partial pressure or condensation temperature of one or more components of a gas mixture

3.5.2
stable test gas mixture
mixture of gases (and/or vapour) where the component to be measured is known and does not react with, and is not adsorbed on to the containment system (such as a gas cylinder). The concentrations of gases and their uncertainty ranges shall be known for the components of the gas mixture, and commensurate with the criteria to be evaluated.

NOTE For preparation of these mixtures, refer to documents in the Bibliography.

3.5.3
calibration gas
stable test gas mixture of known concentration used for periodic calibration of the analyzer and for various performance tests

NOTE 1 For the purpose of this part the parameter to be measured should be expressed in SI units, as in ISO 31-0.

NOTE 2 For example, the partial pressure of a component in Pascals. Alternatively, the ratio of partial pressure to total pressure, this being the same as the volume ratio or the mole ratio for ideal gases. The mass of the component per unit volume has also been used but the component and physical conditions should be stated.

NOTE 3 For the purpose of this part the value of the parameter represents the conventional value, against which the indicated value is compared.

NOTE 4 If the calibration gas mixture is unstable, some components of the mixture can be replaced by substitutes which increase stability and give a known change in analyzer sensitivity, subject to agreement between the manufacturer and the user.

3.5.4
zero gas
calibration gas mixture used to calibrate the lower end of a specified calibration range. This should be of a value which is either at or close to the specified lowest value in the given calibration range when used with a defined analytical procedure.

3.5.5
span gas
calibration gas mixture used to establish the span point (maximum or near maximum value of range) of a calibration curve when used with a given analytical procedure within a defined calibration range.

3.5.6
performance
degree to which the intended functions of an instrument are accomplished

3.5.7
performance characteristic
one of the quantities (described by values, tolerances, range) assigned to an equipment in order to define its performance

NOTE 1 Depending on its application, one and the same quantity may be referred to in this part as a "performance characteristic", as a "measured or supplied quantity", and also may act as an "influence quantity".

NOTE 2 In addition, the term "performance characteristic" includes quotients of quantities, such as voltage per unit of length.

3.5.8
linearity uncertainty
maximum deviation between actual analyzer readings and the readings predicted by a linear function of the measured quantity which includes the indicated values at the upper and lower limits of the effective range

3.5.9
repeatability
spread of the results from measurements taken on successive samples at short intervals of time with identical test material, carried out by the same method, with the same measuring instruments, by the same observer, in the same laboratory, in unchanged environmental conditions

NOTE 1 A time interval equal to about 10 times the 90 % response time of the analyzer may be considered a short interval.

NOTE 2 When practical, the approach to the measured value should be from both upscale and downscale directions.

3.5.10
drift
change of the indications of an analyzer, for a given level of concentration over a stated period of time, under reference conditions which remain constant and without any adjustments being made to the analyzer by external means

NOTE The rate of change of uncertainty with time is derived by linear regression.

3.5.11
output fluctuation
peak-to-peak deviations of the output with constant input and constant influence quantities

3.5.12
minimum detectable change
change in value of the property to be measured equivalent to twice the output fluctuation measured over a 5 min period

3.5.13
delay time
T_{10}
time interval from the instant a step change occurs in the value of the property to be measured to the instant when the change in the indicated value passes (and remains beyond) 10 % of its steady-state amplitude difference

NOTE In cases where the rising delay time and falling delay time differ, the different delay times should be specified.

3.5.14
90 % response time
T_{90}
time interval from the instant a step change occurs in the value of the property to be measured to the instant when the change in the indicated value passes (and remains beyond) 90 % of its steady-state amplitude difference, that is, $T_{90} = T_{10} + T_r$ (or T_f)

NOTE In cases where the rising and falling response times differ, the different response times should be specified.

3.5.15
rise (fall) time
T_r, T_f
difference between the 90 % response time and delay time (see Figure 1)

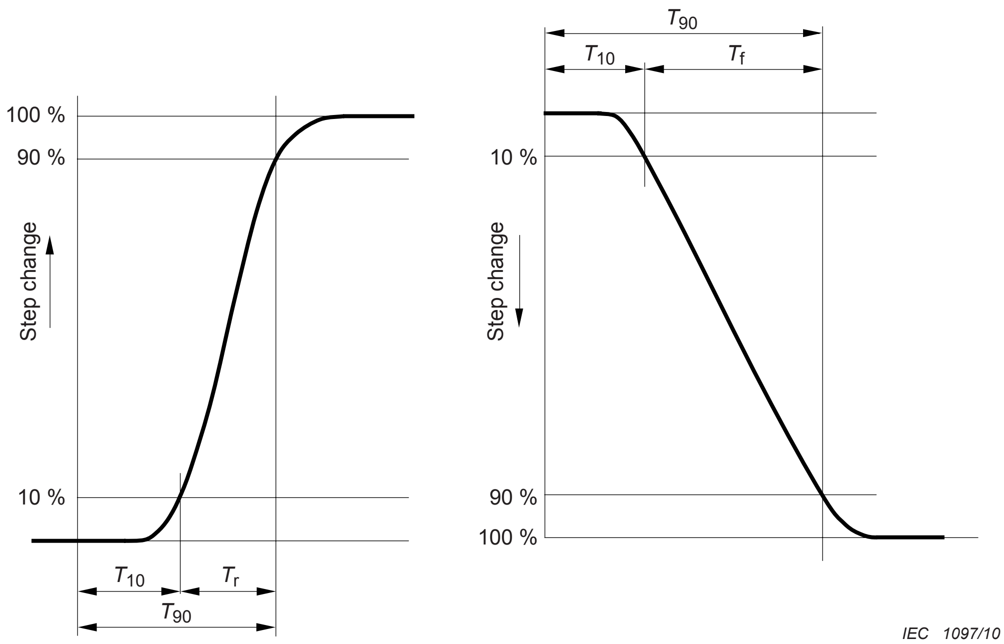

Figure 1 – Rise and fall times

3.5.16
warm-up time
time interval after switching on the power, under reference conditions, necessary for a unit or analyzer to comply with and remain within specific limits of uncertainity

3.5.17
interference uncertainty
special category of influence quantity; it is the uncertainty caused by interfering substances being present in the sample

3.5.18
limits of uncertainty
maximum values of uncertainty assigned by the manufacturer to a measured quantity of an apparatus operating under specified conditions

4 Procedure for specification

4.1 Specification of values and ranges

The manufacturer shall state rated values or specified measuring ranges for all parameters which are considered to be performance characteristics applicable to the particular equipment. The statements on values and ranges shall be accompanied by the appropriate statements on uncertainty. The manufacturer shall state a reference range and/or a rated operating range for each influence quantity which is taken into account. The rated operating range shall include the whole of the reference range.

These statements shall cover the parameters listed below, which will be described in the following subclauses:

– operation and storage requirements;
– specification of ranges of measurement and output signals;
– limits of uncertainties;
– recommended reference values and rated ranges of influence quantities.

4.2 Operation, storage and transport conditions

4.2.1 Statements shall be made on rated operating conditions and limit conditions of operation in such a way that the following requirements are met, unless otherwise specified.

4.2.2 The apparatus, while functioning, shall show no damage or degradation of performance when any number of performance characteristics and/or influence quantities assume any value within the limit conditions of operation during a specified time.

4.2.3 The apparatus shall show no permanent damage or degradation of performance while inoperative when it has been subjected to conditions where any number of influence quantities assume any value within their storage or transport conditions during a specified time.

NOTE Absence of degradation of performance means that, after re-establishing reference conditions or rated operating conditions, the apparatus again satisfies the requirements concerning its performance.

4.2.4 Construction materials in contact with the sample shall be stated and verified to be non-contaminating.

4.2.5 For analyzers consisting of several discrete subunits, the manufacturer shall state if individual units can be replaced by an exact equivalent of the original without re-calibration. If this is not the case, all necessary steps for the replacement of subunits shall be stated.

4.3 Performance characteristics requiring statements of rated values

4.3.1 Minimum and maximum rated values for the property shall be measured (range or ranges).

4.3.2 Minimum and maximum rated values for output signals shall correspond to the rated values as given in 4.3.1.

The output signals, which can be related to the gas concentration, shall be stated in units of voltage, current or pressure. If stated in units of voltage, the minimum allowable load, in ohms, shall also be stated. If stated in units of current, the maximum allowable load, in ohms, shall also be stated.

All multiple outputs for the analyzer shall be stated additionally. If a capacitive or inductive load will influence the output signal, this shall be specified.

If the analyzer output signal is a voltage, see IEC 60382, and if it is an electrical current, see IEC 60381-1. If it is pneumatic, see IEC 60382. If the analyzer output is digital, then the physical interface and protocol shall be specified.

4.3.3 Limiting conditions and rated ranges of use for sample conditions shall be stated, at the analyzer inlet for a sampling analyzer, or at the sensor unit for an *in situ* type analyzer, including flow rate (if appropriate), pressure and temperature, also the rated maximum rate of change for sample temperature.

4.3.4 Limiting conditions and rated ranges for conditions at the sample outlet (where such exists) for pressure, temperature and flow rate shall be stated, and also any special precautions required for the safe venting of the sample.

4.3.5 The reference value (or range) and rated range of use for all influence quantities shall be stated. These should be selected from only one of the usage groups I, II or III in IEC 60359 (see Annex A) or may be from usage groups in IEC 60654-1. Any exceptions to the values given there shall be explicitly and clearly stated by the manufacturer with an indication that they are exceptions.

NOTE The analyzer may correspond to one group of rated ranges of use for environmental conditions, and to another group for mains supply conditions, but this should be clearly stated by the manufacturer.

4.4 Uncertainty limits to be stated for each specified range

4.4.1 General

These shall be in accordance with the limits of intrinsic uncertainty and variations (type A) in IEC 60359.

4.4.2 Limits of intrinsic uncertainty

Limits of intrinsic uncertainty are specified with respect to reference conditions, and limits of variations are specified with respect to rated operating conditions.

4.4.3 Variations

4.4.3.1 Linearity uncertainty

For the analyzer linearity uncertainty may also be stated separately.

Where a non-linear output is produced the manufacturers should accurately specify the relationship between output value and the measured parameter.

NOTE Deviation from linearity is strictly considered as an uncertainty only if a linear output is claimed.

4.4.3.2 Interference uncertainties

Where known, these may also be stated separately in terms of the equivalent level of the property to be measured for at least two concentration levels of the interfering component. The manufacturer should indicate which components are known to have interference effects in the application under consideration, and whether the interference is in a positive or negative direction. The specifications of interfering components, their concentration levels, and test methods shall be made by agreement between the manufacturer and the user except where other publications in this series state specific requirements.

4.4.3.3 Repeatability

This value is to be stated on the basis that no adjustments shall be made by external means during the test.

4.4.3.4 Drift

The drift performance characteristics shall consist of a value for output fluctuation over at least one time interval as chosen from the list in 5.6.6, with the associated value of drift for that time interval. These parameters are to be stated for at least one input value within the span and on the basis that no adjustments shall be made by external means during the stated time intervals. The warm-up time is always excluded from the time interval. The time interval(s) and input value(s) shall be chosen from the list in 5.6.6, and shall be subject to agreement between the user and the manufacturer.

4.5 Other performance characteristics

Although no statements of uncertainty limits are required for the performance characteristics listed below, the manufacturer shall state their values or ranges for each specified operating range.

a) Output fluctuation of electronic unit or the complete analysis system.

b) Minimum detectable change for the electronic unit or the complete analysis system.

c) Delay time (T_{10}). Differences may exist between upscale and downscale delay times.

d) Rise (fall) time (T_r, T_f).

e) 90 % response time (T_{90}). Differences may exist between upscale and downscale 90 % response time.

f) Warm-up time.

g) The quantitative effect on indicated value of the property to be measured produced by variation of ambient temperature.

h) The quantitative effect on indicated value of the property to be measured produced by variation of the sample temperature.

i) The quantitative effect on indicated value of the property to be measured produced by variation in the sample pressure.

j) The quantitative effect on indicated value of the property to be measured produced by any other sample conditions (e.g. flow rate).

5 Procedure for compliance testing

5.1 General

5.1.1 Compliance tests

Compliance tests shall be performed with the apparatus ready for use (including accessories) after warm-up time, and after performing adjustments according to the manufacturer's instructions.

In the case of special applications where these tests are not appropriate, additional test procedures may be agreed upon between manufacturer and user.

Testing shall be based upon the IEC 60359 procedures of limits of intrinsic uncertainty and variations (type A).

5.1.2 Test instruments

In general, measurements for verification shall be carried out with instruments which do not appreciably (or only calculably) affect the value to be measured. In principle, the uncertainties in measurements made with these instruments should be negligible in comparison with the uncertainties to be determined. See also 5.2.

5.1.3 Test instrument uncertainties

When the uncertainty of the test instrument is not negligible, the following rule should apply.

If an apparatus is claimed to have a limit uncertainty of ±*e* % for a given performance characteristic and the manufacturer used for its checking an instrument resulting in an uncertainty of ±*n* %, the uncertainty being checked shall remain between the limits ±(*e* + *n*) %.

Likewise, if a customer checks the same apparatus using another instrument resulting in an uncertainty of measurement of ±*m* %, he is not entitled to reject the apparatus if its apparent uncertainty exceeds the limits ±*e* %, but remains between the limits ±(*e* + *m*) %.

If the apparatus is tested by applying a calibration gas with 95 % confidence limits in composition of ±*m* %, the apparatus should not be rejected or re-calibrated if the apparent uncertainty is within the limits ±(*e* + *m*) %.

5.1.4 Influence quantities

Unless otherwise specified, the influence quantities shall be at reference conditions during the tests concerned, and during the test the apparatus shall be supplied with its rated voltage and frequency. See also 5.6.

5.1.5 Operational conditions

The analyzer shall be in operational condition as specified by this standard and due consideration shall be given to the application of test gas using appropriate conditions for flow, pressure and temperature. These shall be the reference conditions unless otherwise specified by a particular test.

5.2 Calibration gases

Test equipment shall include at least two calibration gas mixtures for initial calibration referred to as zero gas (see 3.5.4) and span gas (see 3.5.5). Span gas shall normally contain the component to be measured at a concentration such that when correctly adjusted, the analyzer indicates between 70 % and 100 % of the range to be tested. Further calibration gases distributed in value through the range can be required where linearity is to be separately adjusted. For preparation or analysis of these calibration mixtures agreed international or national standards or methods shall be utilized (see Bibliography).

5.3 Adjustments made during tests

During tests, adjustments by external means may be repeated at the intervals prescribed by the manufacturer or at any suitable interval, if this adjustment does not interfere with the uncertainty to be checked (e.g. an initial calibration with the gases referred to in 5.2 may be required by the manufacturer).

Adjustments shall also be performed when uncertainty values have expressly been quoted to be valid only after such adjustment. Measurements shall then be made immediately after such adjustment so that any drift will not influence them.

5.4 Reference conditions during measurement of intrinsic uncertainty

When measuring the intrinsic uncertainty of a performance characteristic, the combination of values and/or ranges of influence quantities shall remain within the reference conditions which include relevant tolerances on reference values.

5.5 Reference conditions during measurement of influence quantity

When measuring the influence uncertainty of a performance characteristic due to an influence quantity, all other quantities shall remain within reference conditions. The relevant influence quantity may assume any value within its rated range of use.

5.6 Testing procedures

5.6.1 General

These tests are repeated for each rated input range. Further tests are identified for specific types of analyzer in subsequent parts, as there are variations dependent on type and application of the analyzer. The uncertainties may be expressed as absolute uncertainties, relative uncertainties or percentage uncertainties, but the one selected shall be identified. Where one of the modes of expression is specified, it shall be used.

5.6.2 Intrinsic uncertainty

While operating under reference conditions the analyzer is presented with zero gas, a span gas mixture giving a full-scale (see note 1) or near full scale indication, and at least two intermediate test gas mixtures with concentrations approximately uniformly distributed through the analyzer range. This procedure shall be performed at least six times and the intrinsic uncertainties calculated using the means (see 3.2.17) of the indicated values (see 3.2.9) and conventional values (see 3.2.13) as described below.

The mean value for the intrinsic uncertainty at each gas concentration is the difference between the mean of the indicated values and the conventional values (stable test gas or calibration gas concentrations used for the performance tests). The associated 95% confidence limit is given by twice the standard deviation (see 3.2.4) for a normal distribution of indicated values. The stated intrinsic uncertainty at each concentration in this case will therefore be the summation of the differences between the mean of the indicated values and the conventional values and the associated confidence limits:

Intrinsic uncertainty = (mean indicated value – conventional value) ± twice standard deviation

Where only one value for the intrinsic uncertainty is quoted for these measurements for a specified range, it must be the maximum value.

The intrinsic uncertainty shall be determined at both limits of the reference range where a reference range is specified.

NOTE 1 Where 100 % of range span gas is used, the analyzer must report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

NOTE 2 When the zero gas is used, the analyzer must report any negative (below its minimum stated calibration range) deviation to within its standard performance specifications.

NOTE 3 This test is combined with the repeatability test. The uncertainty limits due to repeatability should be taken into account.

NOTE 4 This definition for intrinsic uncertainty is only used in this standard and is not currently defined in IEC 60359.

NOTE 5 If the indicated values do not fit a normal distribution, then the 95 % confidence limits must be found following the procedures outlined in ISO/IEC Guide 98-3).

5.6.3 Linearity uncertainty

The results obtained in 5.6.2 are used to perform a linear regression using the mean of all the indicated values for each test gas mixture. The maximum deviation between the mean recorded values and this straight line is the linearity uncertainity. It is expressed in terms of the units of the property to be measured.

NOTE 1 Where the output signal is only provided as a non-linear function of the measured parameter, the manufacturer's linear transform function should be applied to the output signal prior to data analysis.

NOTE 2 The line fit from the linear regression values may not necessarily pass through zero.

5.6.4 Repeatability

The results obtained as in 5.6.2 are used to calculate and report the standard deviation for each test gas concentration. This is the repeatability for each gas concentration which should be expressed in the units of the property to be measured.

Where only one repeatability value is quoted for these measurements, it should be the maximum standard deviation.

5.6.5 Output fluctuation

The analyzer is presented with zero gas for a sufficient time that the indicated value is essentially constant. When the zero gas is used, the analyzer shall report any negative (below its minimum stated calibration range) deviation to within its standard performance specifications, otherwise the output should be adjusted so that all indications are positive (on scale, see Note 3). The gas is continuously applied for a further 5 min period and the maximum peak-to-peak value of the random, or regular, deviation from the mean output is determined.

The test is repeated for a total of three times, and the average of the indicated values is reported, in terms of minimum detectable change as a percentage of the span (see Figure 2).

NOTE 1 For the purposes of this standard, spikes caused by the influence of external electromagnetic fields or by supply mains spikes are considered as due to changes in influence quantities, and are therefore ignored in the determination of output fluctuation.

NOTE 2 In the case of the electronic unit or analyzer having variable time constants in the output circuit, the output fluctuation must be stated for the same time constant as used for the statement of delay time, rise time, fall time and response time.

NOTE 3 Where an analyzer cannot be adjusted to give a slight positive reading when presented with zero gas, a stable gas mixture can be used instead of zero gas.

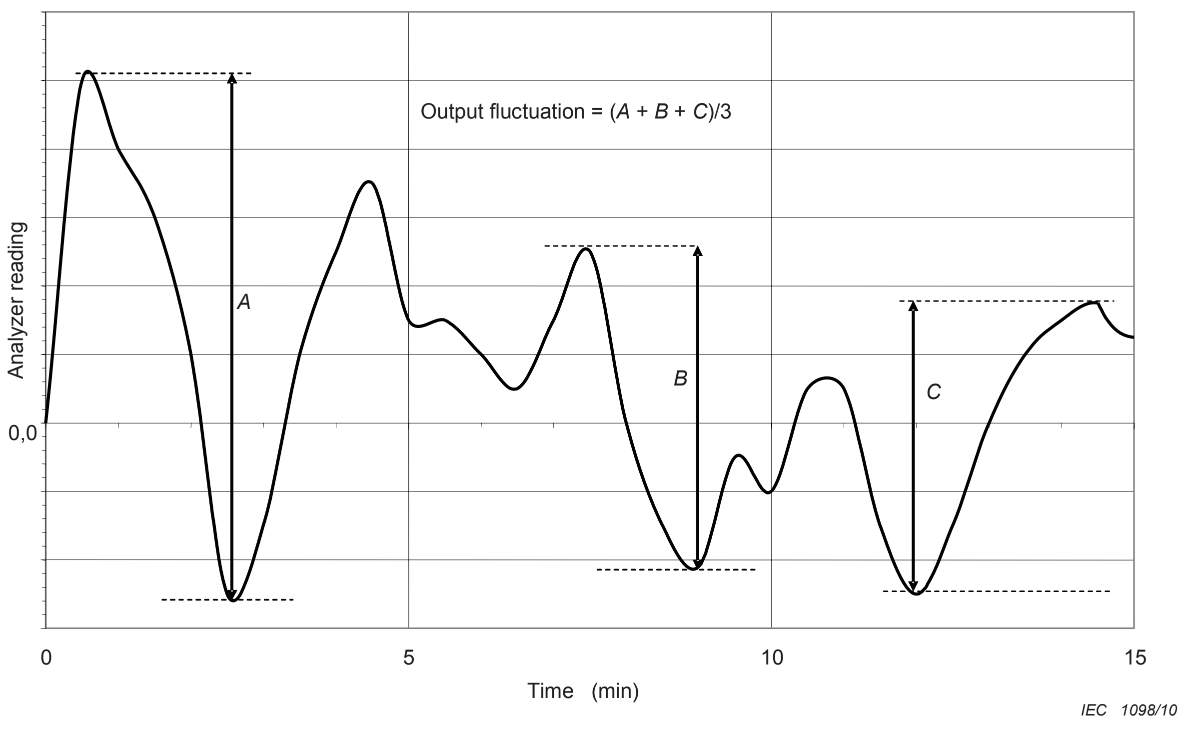

Figure 2 – Output fluctuations

5.6.6 Drift

The test procedure shall be used to determine the output fluctuation and drift performance characteristics under reference conditions, over at least one time interval and for at least one rated input value in the range 50 % to 100 % of span (see Notes 2 and 3). The output fluctuation is the difference between the maximum and minimum indicated values during the the time interval tested.

The time interval for which the stability limits are stated should be chosen appropriately for the specific application from the following values:

15 min	7 days
1 h	30 days
3 h	3 months
7 h	6 months
24 h	1 year

The analyzer should be fully warmed up. It is then calibrated, according to the manufacturer's instructions, immediately before starting the test and operated according to the manufacturer's instructions during the test. At no time after the start of the test may the analysis system be adjusted by external means.

The appropriate stable test gas concentration(s) are applied to the analyzer until a stable indication is given and the indicated value(s) recorded. This procedure is carried out at the beginning and end of the specified time interval, and at a minimum of six, approximately evenly spread, time intervals within the test period. Readings may be corrected for barometric pressure variation.

The results shall be analyzed, to state the output fluctuation over the period, and by linear regression with respect to time. The slope of the linear regression (for each input value) provides an estimate of the drift over that time period (see Annex B).

NOTE 1 Parameters measured over periods up to 24 h are usually referred to as short-term. For on-line analyzer long-term values are also normally required for time periods of 7 days to 3 months.

NOTE 2 Where 100 % of range span gas is used, the analyzer must report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

NOTE 3 Parameters may also be measured for an input value between 0 % and 10 % of span. When the zero gas is used, the analyzer must report any negative (below its minimum stated calibration range) deviation to within its standard performance specifications. If this is the only drift figure quoted then the value of the concentration at which it is measured must also be stated.

NOTE 4 When using zero gas it is advisable to adjust the analyzer to give a slight positive reading initially to allow for the possibility of drift in the downscale direction.

NOTE 5 Where stable test gas mixtures cannot be prepared or stored, the use of a reference analysis technique of known performance characteristics may be acceptable.

5.6.7 Delay time, rise time and fall time

With a time logging data recording device connected to its output terminal, the analyzer is flushed with zero calibration gas at the rated flow rate until a constant indicated value is obtained. Then a calibration gas that gives a reading between 70 % and 100 % of full scale (see note 1) is introduced by the analyzer inlet port at the rated flow rate. The instant this occurs is taken as the start time of the step change. Gas flow is continued until any change in indicated value is less than or equal to the intrinsic uncertainty of the instrument.

Zero calibration gas is then introduced by the analyzer inlet port at the rated flow rate. The instant this occurs is taken as the start time of the step. Gas flow is continued until any change in indicated value is less than or equal to the intrinsic uncertainty of the instrument.

The values for delay time, rise time and fall time as defined in 3.5 are determined from the recorded data, in conjunction with logged time intervals.

NOTE Where 100 % of range span gas is used, the analyzer must report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

5.6.8 Warm-up time

The analyzer is switched off and all of its components are allowed to cool to the reference temperature, for example for a period of at least 12 h.

Calibration gas equivalent to between 70 % and 100 % (see Note 1) of full scale is applied continuously and the analyzer is switched on. Indicated values are recorded until the intrinsic uncertainty reaches and remains within the specified accuracy requirements and for at least 30 min after this is met initially.

NOTE 1 Where 100 % of range span gas is used, the analyzer must report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

NOTE 2 This test may be carried out immediately prior to the drift test to ensure readings are taken over a sufficient time interval.

5.6.9 Interference uncertainty

5.6.9.1 General

Interference uncertainties should be determined for each component of test gas being analyzed which is known to interfere with the component to be measured, and which is expected to affect the sample stream in such a way as to produce an uncertainty equal to, or greater than, the minimum detectable concentration in the desired determination.

Generally, an interfering component should be introduced at the highest expected concentration and at approximately half that level to determine the interference uncertainty.

NOTE 1 Interference uncertainties are generally of lower order. Hence, the required accuracy for interference testing gas concentrations is less than that for calibration gases, but the concentration of the measured component must be known accurately.

NOTE 2 For a given value of the interfering component, the resultant interference uncertainty will normally vary through the measuring range.

5.6.9.2 Procedure for determining interference uncertainty

Interference uncertainties are determined by first presenting the analyzer with test gas and then sequentially with gases which contain the two concentrations of interfering components and which are otherwise identical to the test gas.

Zero gas may be used where the interference uncertainty is not expected to vary significantly through the measuring range. Normally, the test should be repeated with gas mixtures with and without the interfering component but which contain an identical concentration of the measured component equivalent to 70 % to 100 % (see Note) of span.

Each test is repeated three times and the average uncertainties are determined and recorded in terms of the equivalent concentration of the component to be determined.

NOTE Where 100 % of range span gas is used, the analyzer must report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

5.6.9.3 Water vapour interference

Water vapour interference can be determined by the same procedures as stated in 5.6.9.2.

However, the method of preparation of gases with a known concentration of water vapour requires care, particularly where a high moisture content (>2 % v/v) is to be used. Further details of this type of testing are provided in subsequent parts in this series of standards.

All pipework from the point of water vapour or other condensable vapour addition up to and including the optical cell shall be maintained above the dewpoint.

The reference conditions will be with dry test gases.

5.6.10 Variations

5.6.10.1 General

Uncertainties caused by variations in physical parameters can be considered as influence uncertainties. These are determined by presenting the analyzer with at least two test gas concentrations with the reference value of the parameter and then with the same calibration gases and the lower limit of the rated range of use for that parameter. This test should be followed by a return to the reference value for that parameter and the test repeated for the upper limit of the rated range. A final set of readings should be taken at the reference value.

The two test gas concentrations should be chosen to given initial indicated values between 0 % and 100 % (see Notes 1 and 2) of full scale.

Analyzers can incorporate both automatic or manual compensation for physical parameters. Where compensation is only by means of a manual adjustment, the indicated values should be noted both with the analyzer adjusted for the correct value and the reference value for the parameter under test.

NOTE 1 Where 100 % of range span gas is used, the analyzer must report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

NOTE 2 When the zero gas is used, the analyzer must report any negative (below its minimum stated calibration range) deviation to within its standard performance specifications.

5.6.10.2 Primary influence quantities

These influence quantities are normally important and should be tested whenever relevant:

–- ambient temperature
– maximum temperature and pressure
– humidity
– supply voltage
– sample gas pressure
– sample gas flow
– sample gas temperature
– analyzer outlet pressure (where applicable)

The operating ranges for primary influence quantities are listed in Annex B of IEC 60359, except for sample flow, pressure and temperature which are application dependent.

The test sequence for ambient temperature and humidity testing shall be according to procedures in IEC 60068. A convenient summary is given in IEC 60770.

5.6.10.3 Other influence quantities

These are less frequently investigated, but should be tested only where relevant and when specified as necessary by the user or manufacturer. Relevant test procedures can be found in IEC 60770-1 and IEC 60359. The following list is not exhaustive.

- attitude ("tilt")
- a.c. supply frequency
- a.c. supply distortion
- d.c. supply ripple and/or impedance
- vibration
- sound pressure/frequency
- shock (drop-test)
- ventilation
- sand and dust
- liquid water
- salt water
- barometric pressure
- contaminating dust or vapour (environmental)
- ionizing radiation
- electromagnetic compatibility
- electrical grounding requirements
- external influences on sample composition
- effect of particulates

Annex A
(informative)

Recommended standard values of influence – Quantities affecting performance from IEC 60359

A.1 General

The rated ranges of use of the influence quantities below have been divided into the following three usage groups:

I: for indoor use under conditions which are normally found in laboratories and factories and where apparatus will be handled carefully.

II: for use in environments having protection from full extremes of environment and under conditions of handling between those of Groups I and III.

III: for outdoor use and in areas where the analyzer may be subjected to rough handling.

NOTE These influence quantities generally affect the electronic units directly and apply specifically to them. The sensor units, being immersed in the sample are affected primarily by the sample conditions and these influence quantities may not relate to them. For in situ analyzers, where both sensor units and electronic units are immersed in the sample, the sample conditions, rather than these influence quantities, may relate to the electronic unit also. The effects of the external environment on the sensor unit may need to be stated separately.

A.2 Climatic conditions

A.2.1 Ambient temperature

Reference value (to be chosen from): 20 °C, 23 °C, 25 °C or 27 °C.

Tolerance on reference value: ±2 °C.

Rated ranges of use:

Usage group I: +5 °C to +40 °C.

Usage group II : –10 °C to +55 °C.

Usage group III: –25 °C to +70 °C.

Limit range for storage and transport: –40 °C to +70 °C.

NOTE Many sensors need protection from freezing conditions.

A.2.2 Relative humidity of the air

Because extreme values of both temperature and humidity are not likely to occur simultaneously, the manufacturer may specify the time limit over which these may be applied and should specify the limitations of the combination, if any, for continuous operation.

Reference range at 20 °C, 23 °C, 25 °C or 27 °C: 45 % to 75 %.

Rated ranges of use:

Usage group I: 20 % to 80 % excluding condensation.

Usage group II: 10 % to 90 % including condensation.

Usage group III: 5 % to 95 % including condensation.

A.2.3 Barometric pressure

Reference value: existing local barometric pressure.

Rated ranges of use:

Usage group I: 70 kPa to 106 kPa (up to 2 200 m).

Usage groups II and III: 53,3 kPa to 106 kPa (up to 4 300 m)

- Limit range of operation: equal to the rated range of use unless otherwise stated by the manufacturer.
- Limit range for storage and transport: to be stated by the manufacturer.

A.2.4 Heating effect due to solar radiation

Reference value: no direct irradiation.

Rated ranges of use:

Usage groups I and II: no direct irradiation.

Usage group III: the combined effect of solar radiation plus the ambient temperature should never cause the surface temperature to exceed that which is obtained at an ambient temperature of 70 °C alone.

Limit range of operation: equal to the rated range of use, unless otherwise stated by the manufacturer.

Limit range for storage and transport: to be stated by the manufacturer.

A.2.5 Velocity of the ambient air

Reference range: 0 m/s to 0,2 m/s.

Rated ranges of use:

Usage groups I and II: 0 m/s to 0,5 m/s.

Usage group III: 0 m/s to 5 m/s.

Limit range of operation: equal to the rated range of use, unless otherwise stated by manufacturer.

A.2.6 Sand and dust contents of the air – reference value: no measurable contents

Rated ranges of use:

Usage groups I and II: negligible contents (i.e. will have negligible effect on the analyzer).

Usage group III: to be stated by the manufacturer.

Limit range of operation: equal to the rated range of use unless otherwise stated by manufacturer.

Limit range for storage and transport: to be stated by manufacturer.

A.2.7 Salt content of the air

Reference value: no measurable content. Rated ranges of use:

Usage groups I and II: negligible content.

Usage group III: to be stated by the manufacturer.

Limit range of operation: to be stated by the manufacturer.

Limit range of storage and transport: to be stated by the manufacturer.

A.2.8 Contaminating gas or vapour content of the air

Reference value: no measurable content.

Rated ranges of use: usage groups I to III: to be stated by the manufacturer.

Limit range of operation: to be stated by the manufacturer.

Limit range for storage and transport:to be stated by the manufacturer.

A.2.9 Liquid water content of the air

Reference value: no measurable content.

Rated ranges of use:

Usage group I: negligible content.

Usage group II: drip water.

Usage group III: splash water.

Limit range of operation: to be stated by the manufacturer.

Limit range for storage and transport:to be stated by the manufacturer.

A.3 Mechanical conditions

A.3.1 Operating position

Reference value: position as stated by the manufacturer.

Tolerance on reference: ±1°.

Rated ranges of use:

Usage groups I and II: reference position ±30°.

Usage group III: reference position ±90°.

Limit range of operation: to be stated by the manufacturer.

Limit range for storage and transport: to be stated by the manufacturer.

NOTE These rated ranges of use should be understood only for the electronic units without orientation-sensitive indicators. For electronic units with built-in orientation-sensitive indicators, the manufacturer should make suitable statements.

A.3.2 Ventilation

Reference value: ventilation not obstructed.

Rated ranges of use:

Usage groups I and II: negligibly obstructed.

Usage group III: the obstruction of the ventilation plus ambient temperature should never cause the surface temperature to exceed that which is obtained at an ambient temperature of 70 °C alone, with the ventilation not obstructed.

Limit range of operation: to be stated by the manufacturer.

A.3.3 Vibration

Reference value: no measurable value.

Rated ranges of use:

Usage group I: negligible.

Usage groups II and III: to be stated by the manufacturer.

Limit range of operation: to be stated by the manufacturer.

Limit range for storage and transport: to be stated by the manufacturer.

A.4 Mains supply conditions

A.4.1 Mains supply voltage (considering a distorted waveform)

Table A.1 gives mains supply voltages for usage groups I to III.

Table A.1 – Mains supply voltage

	d.c. and a.c. (r.m.s.)	a.c. (peak)
Reference value:	Rated value	Rated value
Tolerance on reference value:	+1 %	±2 %
Rated ranges of use:		
Usage group I :	±10 %	±12 %
Usage group 11:	–12 % to +10 %	–17 % to +15 %
Usage group 111:	–20 % to +15 %	–30 % to +25 %
Limit range of operation: equal to the rated range of use unless otherwise stated by the manufacturer.		

A.4.2 Mains supply frequency

Table A.2 gives mains supply frequencies for usage groups I to III.

Table A.2 – Mains supply frequency

Reference value: rated frequency	
Tolerance on reference value:	1
Rated range of use:	
Usage groups I and II:	±5 %
Usage group III:	±10 %
Limit range of operation: to be stated by the manufacturer.	

A.4.3 Distortion of a.c. mains supply

The distortion is determined by a factor, β, in such a way that the waveform is inside an envelope formed by:

$Y_1 = (1 + \beta) A \sin \omega t$, and

$Y_2 = (1 - \beta) A \sin \omega t$

Reference value: $\beta = 0$ (sine-wave).

Tolerance on reference value: $\beta = 0,05$

Rated ranges of use:

Usage group I: $\beta = 0,05$;

Usage groups II to III: $\beta = 0, 10$.

Limit range of operation: to be stated by the manufacturer.

The values of β are valid when the analyzer is connected to the supply mains.

NOTE 1 The above formulae may be applied over the half cycle or a full cycle depending on whether the zero crossings are equally spaced or not.

NOTE 2 If the a.c. peak voltage exceeds the values stated in A.3.1, the mains supply under consideration cannot be used.

A.4.4 Ripple of d.c. supply

Reference value 0 % of supply voltage, see Table A.3.

Table A.3 – Ripple of d.c. supply

Rated ranges of use	Supply voltage %
Usage group I:	0,5
Usage group II:	1,0
Usage group III:	5,0
Limit range of operation:	5,0
The values given are peak-to-peak values of the ripple voltage expressed as a percentage of the average d.c. supply voltage.	

Annex B
(informative)

Performance characteristics calculable from drift tests

To collect reliable results, the applied test gas concentrations should be stable throughout the test period. (Alternatively, a reference instrument, where used, shall be calibrated prior to each use, against a stable known calibration gas.) Uncertainties in these reference values will affect the limits of acceptability (see 5.1.3). Each indication to be used for calculations (below) should be obtained as a reliable value, i.e. the test gas should be applied for 5 min after stability is achieved and the mean indication utilized. Alternatively, where other tests have indicated a significant discrimination uncertainty can exist, the mean of at least three separate applications of the test gas should be used.

The linear regression is given by the following equation:

$$Y = A + Bt \quad \text{(B.1)}$$

where

Y is the indication (not corrected by the indication obtained with the zero gas) obtained with time t:

n is the number of measurements.

$$A = \frac{\Sigma Y - B\Sigma t}{n} \quad \text{(B.2)}$$

$$B = \frac{n\Sigma tY - (\Sigma t)(\Sigma Y)}{n\Sigma t^2 - (\Sigma t)^2} \quad \text{(B.3)}$$

An example of the calculation of output fluctuation and drift is given below in Table B.1:

Table B.1 – Data: applied concentration 1 000 units

Time (h)	0	100	200	300	400	500	600	700	800	900	1 000
Indicated value	1 010	1 030	995	1 005	980	990	950	970	975	995	965

Y = 1 011,6 – 0,047 7 t

Output fluctuation = 1 030 – 950 = 80

Drift per 1 000 h (one month) = –47,7

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