BS EN 62703:2013

BSI Standards Publication

Expression of performance of fluorometric oxygen analyzers in liquid media

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National foreword

This British Standard is the UK implementation of EN 62703:2013. It is identical to IEC 62703:2013.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/1, System considerations.

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

Published by BSI Standards Limited 2013

ISBN 978 0 580 78815 4

ICS 17.020; 71.040.01; 71.120.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2013.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62703

August 2013

ICS 17.020; 71.040; 71.120

English version

Expression of performance of fluorometric oxygen analyzers in liquid media

(IEC 62703:2013)

Expression des performances des analyseurs d'oxygène fluormétriques en milieu liquide
(CEI 62703:2013)

Angabe zum Betriebsverhalten von fluorometrischen Sauerstoffanalysatoren in flüssigen Medien
(IEC 62703:2013)

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 62703:2013 E

Foreword

The text of document 65B/867/FDIS, future edition 1 of IEC 62703, prepared by IEC/TC 65B "Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62703:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-05-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-08-01

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Endorsement notice

The text of the International Standard IEC 62703:2013 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 60654 (all parts)	NOTE	Harmonised as EN 60654 (all parts).
IEC 60654-1	NOTE	Harmonised as EN 60654-1.
IEC 60770-1	NOTE	Harmonised as EN 60770-1.
IEC 61207-1:2010	NOTE	Harmonised as EN 61207-1:2010.
IEC 61207-2	NOTE	Harmonised as EN 61207-2.
IEC 61298 (all parts)	NOTE	Harmonised as EN 61298 (all parts).
IEC 61326 (all parts)	NOTE	Harmonised as EN 61326 (all parts).
ISO 5814:2012	NOTE	Harmonised as EN ISO 5814:2012.
ISO 7888:1985	NOTE	Harmonised as EN 27888:1993.
ISO 9001	NOTE	Harmonised as EN ISO 9001.
ISO 80000-1:2009	NOTE	Harmonised as EN ISO 80000-1:2013.

Annex ZA
(normative)
Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 61010-1	-	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements	-	-
IEC 61187 (mod)	-	Electrical and electronic measuring equipment - Documentation	EN 61187 + Corr. March	-

CONTENTS

EXPRESSION OF PERFORMANCE OF FLUOROMETRIC OXYGEN ANALYZERS IN LIQUID MEDIA

1 Scope

This International Standard is applicable to fluorometric oxygen analyzers used for the continuous determination of dissolved oxygen partial pressure or concentration. It applies to fluorometric oxygen analyzers suitable for use in water containing liquids, ultrapure waters, fresh or potable water, sea water or other aqueous solutions, industrial or municipal waste water from water bodies (e.g. lakes, rivers, estuaries) as well as for industrial process streams and process liquids. Whilst in principle fluorometric oxygen-analyzers are applicable in gaseous phases, the expression of performance in the gas-phase will not be subject of this standard.

The sensor unit of a fluorometric oxygen analyzer being in contact with the media to be measured contains a luminophore in a polymer-membrane permeable for oxygen or within other oxygen permeable materials (or substrates).

This standard specifies the terminology, definitions, requirements for statements by manufacturers and tests for fluorometric oxygen analyzers.

This standard is in accordance with the general principles set out in IEC 60359 and IEC 60770 series.

This standard is applicable to analyzers specified for permanent installation installation in any location (indoors or outdoors) utilizing an on-line measurement technique.

Safety requirements are dealt with in IEC 61010-1.

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

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

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 80000-1:2009.

The object of IEC 62703 is:

- to specify the general aspects in the terminology and definitions related to the performance of fluorometric oxygen analyzers used for the continuous determination of dissolved oxygen partial pressure or concentration in liquid media;
- 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 61010-1, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*

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

3 Terms, definitions, quantities and units

For the purposes of this document, the following terms, definitions, quantities and units apply.

NOTE Terms and definitions are taken partially from IEC 60359:2001and IEC 61207-1:2010.

3.1 Basic terms and definitions

3.1.1
measurand
quantity subjected to measurement, evaluated in the state assumed by the measured system during the measurement itself

Note 1 to entry: 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 to entry: 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.

3.1.2
result of a measurement
set of values attributed to a measurand, including a value, the corresponding uncertainty and the unit of measurement

Note 1 to entry: The mid-value of the interval is called the value (see 3.1.3) of the measurand and its half-width the uncertainty (see 3.1.4).

Note 2 to entry: The measurement is related to the indication (see 3.1.5) given by the instrument and to the values of correction obtained by calibration.

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

Note 4 to entry: The width of the interval, and hence the uncertainty, can only be given with a stated level of confidence (see 3.1.4, NOTE 1).

[SOURCE: IEC 60050-300:2001, 311-01-01, modified – revision of the definition and the notes]

3.1.3
measure-value
mid element of the set assigned to represent the measurand

Note 1 to entry: 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 ± 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.

3.1.4

uncertainty
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 to entry: 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 to entry: 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.

Note 3 to entry: 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 to entry: The definition and notes 1 and 2 are from JCGM 100:2008 Clause 2.2.3 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.

[SOURCE: IEC 60050-300:2001, 311-01-02, modified – deletion of the existing Note 1 and addition of two new notes]

3.1.5

indication
reading-value
output signal of the instrument

Note 1 to entry: The indicated value can be derived from the indication by means of the calibration curve.

Note 2 to entry: For a material measure, the indication is its nominal or stated value.

Note 3 to entry: 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 to entry: 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.

[SOURCE: IEC 60050-300:2001, 311-01-01, modified – modification of the definition and addition of new notes]

3.1.6

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

Note 1 to entry: Calibrations are 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 2 to entry: The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

[SOURCE: IEC 60050-300:2001, 311-01-09, modified – modification of Note 1]

3.1.7

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

[SOURCE: IEC 60050-300:2001, 311-01-10, modified – deletion of the note]

3.1.8

calibration curve

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

Note 1 to entry: 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.

Note 2 to entry: 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.

[SOURCE: IEC 60050-300:2001, 311-01-11, modified – deletion of Note 1]

3.1.9

indicated value

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

Note 1 to entry: The indicated value is the measure-value of the measurand when the instrument is used in a direct measurement under all the operating conditions for which the calibration diagram is valid.

[SOURCE: IEC 60050-300:2001, 311-01-08, modified – update of the definition and the note]

3.1.10

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 1 to entry: 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 60050-300:2001 311-01-06).

3.1.11

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 to entry: Influence quantities can originate from the measured system, the measuring equipment or the environment.

Note 2 to entry: 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.

Note 3 to entry: An influence quantity is said to lie within a range C' to C" when the results of its measurement satisfy the relationship: $C' \leq V - U < V + U \leq C''$. (see 3.1.3)

[SOURCE: IEC 60050-300:2001, 311-06-01, modified – deletion of Note 1 and addition of a new Note 3]

3.1.12
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

3.1.13
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

Note 1 to entry: The concept is often expressed by the adjective traceable.

Note 2 to entry: The unbroken chain of comparisons is called a traceability chain.

Note 3 to entry: 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 to entry: Traceability is ensured only within a given uncertainty that should be specified.

[SOURCE: IEC 60050-300:2001, 311-01-15, modified – deletion of Note 3 and addition of new Notes 3 and 4]

3.1.14
mean

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

3.2 General terms and definitions of devices and operations

3.2.1
electrical measuring instrument

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

[SOURCE: IEC 60050-300:2001, 311-03-04]

3.2.2
transducer

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

Note 1 to entry: Measuring 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.

3.2.3
intrinsic uncertainty
intrinsic instrumental uncertainty

uncertainty of a measuring instrument when used under reference conditions

[SOURCE: IEC 60050-300:2001, 311-03-09, modified – update of the term]

3.2.4
operating instrumental uncertainty

instrumental uncertainty under the rated operating conditions

Note 1 to entry: 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.

3.2.5
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 to entry: 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.

Note 2 to entry: 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.

[SOURCE: IEC 60050-300:2001, 311-01-13, modified – deletion of Note 1 and addition of the new Notes 2]

3.2.6
adjustment of a measuring instrument
set of operations carried out on a measuring instrument in order that it provides given indications corresponding to given values of the measurand

Note 1 to entry: 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.

[SOURCE: IEC 60050-300:2001, 311-03-16]

3.2.7
user adjustment of a measuring instrument
adjustment, employing only the means at the disposal of the user, specified by the manufacturer

[SOURCE: IEC 60050-300:2001, 311-03-17]

3.3 Terms and definitions for manners of expression

3.3.1
range
domain of values of a quantity included between a lower and an upper limit

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

Note 2 to entry: When one of the limits of a range is zero or infinity, the other finite limit is called a threshold.

Note 3 to entry: 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 shall 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 to entry: 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.

3.3.2
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

Note 1 to entry: 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 to entry: The variation is a meaningful parameter when it is greater than the intrinsic instrumental uncertainty.

[SOURCE: IEC 60050-300:2001, 311-07-03, modified – addition of two new notes]

3.3.3
limit of uncertainty

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

Note 1 to entry: 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 to entry: A limit of uncertainty may be expressed in absolute terms or in the relative or fiducial forms.

3.3.4
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 to entry: An instrument can have several measuring ranges.

Note 2 to entry: The upper and lower limits of the specified measuring range are sometimes called the maximum capacity and minimum capacity respectively.

[SOURCE: IEC 60050-300:2001, 311-03-12, modified – addition of a new Note 2]

3.3.5
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

Note 1 to entry: 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.

[SOURCE: IEC 60050-300:2001, 311-06-02, modified – update of the definition and addition of a new note]

3.3.6
reference value

specified value of one of a set of reference conditions

[SOURCE: IEC 60050-300:2001, 311-07-01, modified – update of the definition]

3.3.7
reference range

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

[SOURCE: IEC 60050-300:2001, 311-07-02, modified – update of the definition]

3.3.8
rated operating conditions

set of conditions that shall be fulfilled during the measurement in order that a calibration diagram may be valid

Note 1 to entry: 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.

3.3.9
nominal range of use
rated operating range for influence quantities
specified range of values which an influence quantity can assume without causing a variation exceeding specified limits

Note 1 to entry: The rated operating range of each influence quantity is a part of the rated operating conditions.

[SOURCE: IEC 60050-300:2001, 311-07-05, modified – addition of a new Note 1]

3.3.10
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

3.3.11
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 1 to entry: The limiting values can depend on the duration of their application.

[SOURCE: IEC 60050-300:2001, 311-07-06]

3.3.12
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

3.3.13
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 1 to entry: The limiting values can depend on the duration of their application.

[SOURCE: IEC 60050-300:2001, 311-07-07]

3.3.14
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 1 to entry: The limiting values can depend on the duration of their application.

[SOURCE: IEC 60050-300:2001, 311-07-08]

3.4 Specific terms and definitions for fluorometry

3.4.1
luminescence
spontaneous emission of radiation from an electronically excited molecular entity (or atom or group of atoms) emitted with a particular intensity (luminescence-intensity)

Note 1 to entry: A luminophore (lumiphore) is a fluorescent or phophorescent molecular entity (or atom or group of atoms) in which electronic excitation associated with a given emission band is approximately localized. (see Bibliography, PAC, 1996, 68, 2223)

Note 2 to entry: The fluorescence is the luminescent radiation that occurs after excitation of a fluorophore from its originated excited state without electron spin conversion. (see Bibliography, PAC, 1994, 66, 2513)

A fluorophore (fluoriphore) is the molecular entity (often organic or inorganic transition metal complexes) that emits fluorescence. (see Bibliography, PAC, 2007, 79, 293)

A fluorometer (fluorimeter) is an instrument used to measure the intensity and the wavelength distribution of the radiation emitted as fluorescence from a molecule excited at a specific wavelength or wavelengths within the absorption band of a particular compound. (see Bibliography, PAC, 1990, 62, 2167)

Note 3 to entry: The phosphorescence the term designates luminescence involving change in spin multiplicity, typically from triplet to singlet. (see Bibliography, PAC, 1996, 68, 2223)

Note 4 to entry: Luminescence quenching occurs, if instead of fluorescent or phosphorescent luminescence, the excitation energy is radiationless redistributed via interaction (electronic energy or charge transfer) between an emitting species and a quenching species.The radiationless deactivation may occur from an singulet state or from an triplet state of the exited species. (see Bibliography, PAC, 1984, 56, 231)

3.4.2
luminescence quenching by oxygen

phenomenon that occurs occurs mainly by quenching of the exited state of the luminophore with triplet dioxygen (the groundstate of common molecular dioxygen, O2)

3.4.3
lifetime of luminescence

time required for the luminescence intensity to decay from some initial value to 1/e of that value (e = 2,718 28)

Note 1 to entry: Lifetimes can be measured by decay time measurements, flash fluorometry or single-photon timing techniques, by frequency-domain fluorometry (phase fluorometry) where the phase shift between the sinusoidally modulated exciting light and the emitted light is measured.

Note 2 to entry: Applying flash (pulse) fluorometry for the measurement of lifetimes of luminescence using a pulsed source of radiation, it is often necessary to separate the signal due to the light flash from the luminescence emission signal by a deconvolution technique in order to obtain the correct decay curve for the emission. Decay times corrected for this effect are termed corrected decay times of fluorescence or phosphorescence. (see Bibliography, PAC, 1984, 56, 231)

3.4.4
frequency-domain fluorometry
phase-domain fluorometry

technique that permits recovery of the parameters characterizing fluorescence decay or phosphorescence decay (lifetime of luminescence)

Note 1 to entry: The sample is excited by (sinusoidally) modulated radiation at a specific frequency. The fluoresence will be modulated at the same frequency, but delayed in phase, as a measure of the lifetime of luminescence.

Note 2 to entry: The modulation ratio is defined as the ratio is defined as the ratio of the modulation depth of the fluorescence and the modulation depth of the excitation. The phase shift and the modulation ratio characterize the harmonic response of the system. These parameters are measured as a function of the modulation frequency.

3.4.5
temperature effect of luminescence

change of the luminescence parameters caused by changes in temperature

3.4.6
bleaching of the luminophore

loss of luminescence intensity due to degradation of the luminophore

3.5 Specific terms and definitions for fluorometric oxygen analyzers

3.5.1
fluorometric oxygen analyzer
analytical instrument that provides an output signal which is a monotonic function of the dissolved oxygen partial pressure or the concentration

3.5.2
sensor unit
fluorometric oxygen sensor consisting of an oxygen permeable substrate containing a luminophore and an optoelectronic unit for illumination and detection purposes

Note 1 to entry: The luminescence-effect of the luminophore are detected by means of the optoelectronic unit. The measurement of the ambient temperature at the site of the active sensor using a temperature-sensor is recommended.

Note 2 to entry: Applying direct intensity measurements require the impact of external interfering light sources on the sensor unit will be excluded. Furthermore the amount of absorbed light will be dependant from the residual concentration of the used luminophore-system and its stability especially under long-term considerations.To overcome those various impacts, lifetime measurements of the luminophore represent the state of the art. Lifetimes of luminescence (see 3.4.3) will be measured by decay-time measurements applying flash fluorometry techniques or by frequency-domain fluorometry (phase fluorometry),(see 3.4.4) where the phase shift between the sinusoidally modulated exciting light and the emitted light is measured.

Note 3 to entry: The luminophore containing transparent substrate will be directly illuminated by means of a transfer optic or will be coupled to the opto-electronic unit using a fibre-optical device. The center wavelength or the wavelength range of a Laserdiode, Light Emitting Diode, LED, of other light sources, flash lamps etc. is optimized to match the absorbtion range of the luminophore-system to be exited.

Note 4 to entry: The oxygen sensitive luminophore exhibiting a quenching effect in the presence of oxygen will be embedded in an oxygen permeable polymer-matrix, or in a comparable substrate. In general the luminophore will be (identical) with the light absorbing species embedded within an identical molecular entity. In peculiar cases energy transfer systems comprising a particular absorbing site and a different luminescent site are applicable. Specific additives to reduce degradation, or bleaching-effects of the luminophore, acting as additional functional components to enhance the longterm stability will be used as appropriate.

3.5.3
electronic unit
device used to control the opto-electronic unit and for evaluation puposes of the intensity or the lifetime of the detected luminescence-signals in order to estimate the luminescence quenching by oxygen (3.4.2)

Note 1 to entry: The electronic unit has a microprocessor device with an implemented software routine which correlates the measured luminescence-intensity ratios or the estimated differential lifetimes with the oxygen content.

Note 2 to entry: To quantify the measured values of oxygen, software based algorithmic routines or data sets comprising solubility tables of oxygen in water (with consideration of temperature, pressure and salinity); (see Annex C) and a vapour pressure table of water shall be used.

3.5.4
oxygen solubility
maximal possible dissolved oxygen concentration of the water sample in contact and equilibrium with air (air-saturated solution) at the actual conditions of pressure, temperature and salinity

Note 1 to entry: The oxygen solubility in water is dependent on other dissolved organic and inorganic compounds, dissolved electrolytes, salt-content in seawater (salinity).(see Annex C).

3.5.5
sensor test-medium
stable mixture of gases (nitrogen, nitrogen + oxygen), saturated with water vapour or humidifed reference air showing a known concentration or a known partial pressure of oxygen used for performance tests

Note 1 to entry: The concentration or partial pressure or volume fraction (see 3.7.1) of dissolved oxygen and its uncertainty range shall be known.

3.5.6
sensor calibration-medium

stable mixture of humidified (saturated with water vapour) gases (nitrogen, oxygen) or humidifed reference air exhibiting a known stable concentration or partial pressure or volume fraction (see 3.7.1) of oxygen (with tracable uncertainties) used for calibration of the analyzer

Note 1 to entry: Solution with dissolved gas (pure nitrogen) or dissolved molecular or ionogenic compounds (substitutes) used to eliminate the content of free oxygen or a gaseous phase (pure nitrogen) saturated with water vapour.

Note 2 to entry: Specific solutions (substitutes), in particular hydrogensulfite dissolved in water, generally used to provide an oxygen free solution, yield sulfurdioxyd at pH-dependant rates acting as luminescence-quencher beside oxygen. If solutions with dissolved substitutes will be used as test solutions exhibiting a zero deviation that exeeds the uncertainties applying inert humidified gases (nitrogen) the deviations and the uncertainties have to be stated.

[SOURCE: adapted from 7.3 of ISO 5814:2012]

3.5.7
repeatability

spread of the results from measurements of the fluorometric oxygen analyzer 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 unchanged environmental conditions

3.5.8
drift

change of the indications of the fluorometric oxygen analyzer, for a given level of concentration or partial pressure of oxygen 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 1 to entry: In most cases, the lower value of the rated range is zero; then the drift is the shift in reading of the upper value of the rated range expressed in percent of full-scale range per hour or per day, at constant composition, pressure, temperature and dissolved oxygen concentration or oxygen partial pressure of the sample.

3.5.9
stabilization time

time necessary for obtaining a stable measurement after installation of a new sensor or after reconditioning

Note 1 to entry: Reconditioning procedures for fluorometric oxygen sensors comprising a membrane or a luminophore containing substrate require a replacement of the membrane.

3.5.10
output fluctuation

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

3.5.11
minimum detectable change

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

3.5.12
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 1 to entry: In cases where the rising delay time and falling delay time differ, the different delay times should be specified.

3.5.13
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, $T_{90} = T_{10} + T_{\mathrm{r}}$ (or T_{f})

Note 1 to entry: In cases where the rising and falling response times differ, the different response times should be specified.

3.5.14
rise time

T_{r}

difference between the 10 % time, T_{10}, and the 90 % time, T_{90}

3.5.15
fall time

T_{f}

difference between the 90 % time, T_{90}, and the 10 % time, T_{10}

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 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

3.6 Influence quantities for fluorometric oxygen analyzers

3.6.1
temperature

in addition to the temperature dependant solubility-effect of oxygen (see C.3), the temperature has an impact on the thermal deactivation of the excited state and the temperature dependant quenching rate of the exited luminophore with molecular oxygen

Note 1 to entry: These dependences have to be evaluated for the applied luminophore-system.(see 3.6.2).

3.6.2
temperature compensation

fluorometric oxygen sensor-unit comprising a temperature sensor located at the active site of the luminophore containing substrate being in thermal contact with the sample to be measured

Note 1 to entry: A microprocessor device will be used to evaluate the temperature-depedency for the expression of the oxygen content (see 3.5.1).

3.6.3
pressure

external force affecting the pressure of the sample to be measured

Note 1 to entry: An alteration of pressure affects the dissolved oxygen saturation value, or respectively the maximal oxygen concentration or the oxygen partial pressure. The air-pressure of the ambient media (calibration with water-vapour saturated air) or respectively the sample pressure has to be determined applying an appropriate pressure sensor, or has to be manually entered at the electronic unit (see. 3.5.3).

3.6.4
dissolved substances

dissolved inorganic substances (salts, acids, alkalies), as well as organic substances having an impact on the oxygen solubility in water

Note 1 to entry: In seawater the salinity (salt content by weight) has to be considered in addition to the measured temperature employing combined salinity-temperature tables in order to determine the correct oxygen solubility (see Annex C).

3.6.5
flow

external streaming affecting the agitation of the sample to be measured

Note 1 to entry: In principle fluorometric oxygen sensors do not show an intrinsic oxygen-consumption, that requires an adjusted flow-rate. Flow-rates affect only the transport of the media to be measured.

3.7 Quantities and units

No.	Quantity	Unit	Remarks
3.7.1	oxygen partial pressure (p_{02})	millibar (mbar) or kilopascal (kPa) In the case of special applications, the units mm Hg (Torr) and inch Hg are used The conversion ratios of said units are given in Table C.6	In the case of applications in the gaseous phase the unit, volume fraction (v/v) is used. The volume fraction is the quotient of the volume of a specified component and the sum of the volumes of all components of a gas mixture before mixing, all volumes referring to the pressure and the temperature of the gas mixture. The volume fraction will be expressed in %. The volume fraction and volume concentration take the same value if, at the same state conditions, the sum of the component volumes before mixing and the volume of the mixture are equal. However, because the mixing of two or more non ideal gases at the same state conditions is usually accompanied by a slight contraction (or, less frequently, a slight expansion), this is not generally the case. [SOURCE: EN 50104:2010, 3.1.5]
3.7.2	dissolved oxygen concentration	parts per million (ppm)= milligram · kg^{-1} parts per billion (ppb) = microgram · kg^{-1}	The mass of the test medium means in this case the mass of the sample water, including salts or other substances dissolved or suspended in it. Although ppm units are used in this standard, it is sometimes convenient to use the units of milligrams per liter ($\mathrm{mg \cdot dm^{-3}}$) or of micrograms per liter ($\mathrm{\mu g \cdot dm^{-3}}$).
3.7.3	oxygen saturation index	percent	Expression of the dissolved oxygen. It is used to express the relative saturation of the actual oxygen concentration (ppm), (see 3.7.2) as a fraction of the theoretical oxygen concentration (ppm) of the air-saturated solution at the actual conditions of pressure, temperature and salinity (see 3.5.4)

4 Procedure for specification

4.1 Specification of values and ranges for fluorometric oxygen analyzers

The manufacturer shall state 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 Rated operating conditions

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 Performance under rated operating conditions

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 Performance under rated operating conditions while inoperative

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

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

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 measurand, shall be stated in units of voltage or current. 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.

If the analyzer output signal is a voltage, see IEC 60382-2, and if it is an electrical current, see IEC 60381-1. 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 including flow rate (if appropriate), pressure and temperature, also the rated maximum rate of change for sample temperature.

4.3.4 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. If an analyzer corresponds to one group of rated ranges of use for environmental conditions, and to another group for mains supply conditions, this should be clearly stated by the manufacturer.

4.4 Uncertainty limits

4.4.1 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.

4.4.2 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 Repeatability

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

4.4.4 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 5.6.5, 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 5.6.4, and shall be subject to agreement between the user and the manufacturer.

5 Test methods

5.1 Test procedures

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.

NOTE For testing purposes of the opto-electronic-unit and electronic unit an opto-electronic simulator-device of kown performance characteristics is applicable.

5.2 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 5.6).

5.3 Operational conditions

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

5.4 Calibration

Calibration equipment shall include suitable containments comprising at least a zero oxygen solution or an oxygen-free humidified gas (nitrogen), (zero oxygen media) (see 3.5.7) and humidified calibration gas mixture (nitrogen, oxygen) (see 3.5.6). In addition calibration gas mixtures with varying oxygen volume fractions will be required. For preparation or analysis of these calibration mixtures agreed international standards, national standards, or regulatory authority guidance regarding the calibration mixtures or methods used shall be applied.

5.5 Reference conditions

5.5.1 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.

5.5.2 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 Intrinsic uncertainty

While operating under reference conditions the sensor unit is immersed in zero oxygen solution (medium), medium for sensor test giving a full-scale (see note) or near full scale indication, and at least two intermediate test media with concentrations approximately uniformly distributed through analyser range. This procedure shall be performed at least six times and the intrinsic uncertainties calculated using the means (see 3.1.14) of the indicated values (see 3.1.9) and conventional values (see 3.3.8) as described below.

The mean value for the intrinsic uncertainty at each oxygen-concentration is the difference between the mean of the indicated values and the conventional values (medium for sensor test or medium for sensor calibration). The associated 95 % confidence limit is given by twice the standard deviation (see 3.1.4) 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 shall be the maximum value.

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

Where a medium for sensor test giving a full-scale used, the analyzer shall report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

When the zero oxygen solution (medium) is used, the analyzer shall report any negative (below its minimum stated calibration range) deviation to within its standard performance specifications.

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

5.6.2 Repeatability

The results obtained as in 5.6.1 are used to calculate and report the standard deviation for each test concentration. This is the repeatability for each test 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.

5.6.3 Output fluctuation

The sensor-unit is immersed in the zero oxygen solution (medium) for a sufficient time that the indicated value is essentially constant. When the zero oxygen solution (medium) 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. The zero oxygen solution (medium) 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 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.

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

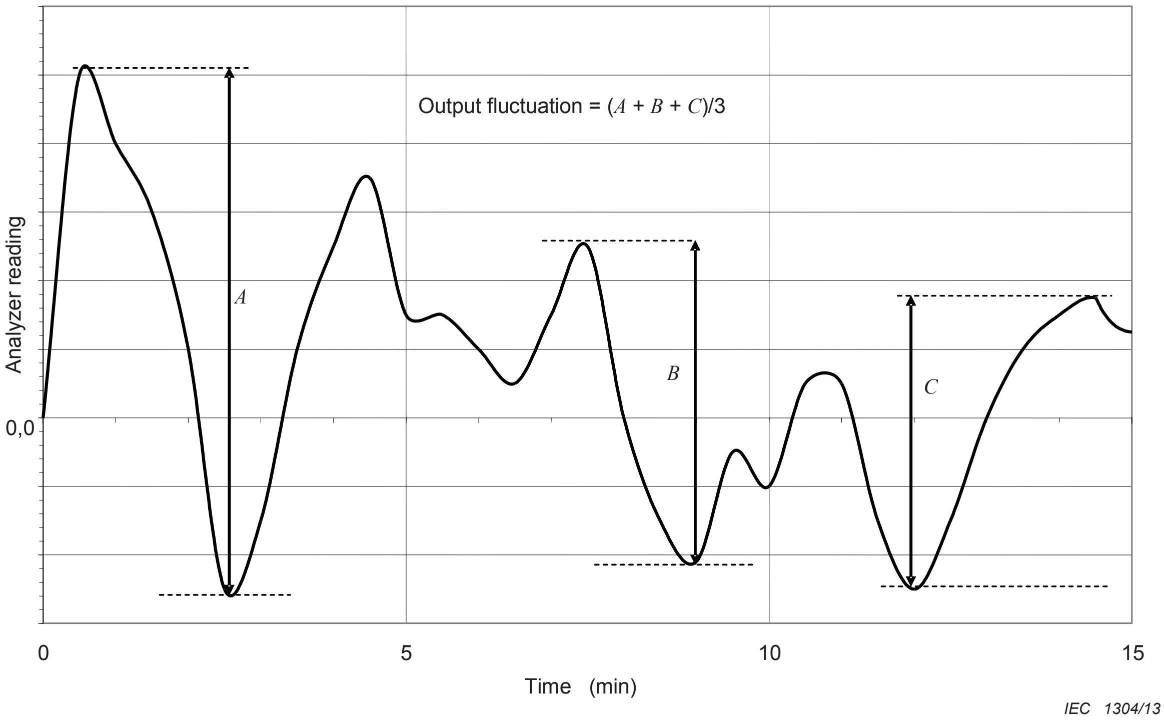

Figure 1 – Output fluctuations

5.6.4 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 0 % and 100 % of span. 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 values listed in Table 1 below.

Table 1 – Time intervals for statement of stability limits

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 sensor-unit is immersed in a medium for sensor test 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). Where 100 % of range stable test medium is used, the analyzer shall report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

When the zero medium is used, the fluorometric oxygen analyzer shall report any negative (below its minimum stated calibration range) deviation to within its standard performance specifications.

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

5.6.5 Delay time, rise time and fall time

With a time logging data recording device connected to its output terminal, the zero oxygen medium is applied tom the sensor-unit until a constant indicated value is obtained. Then a test medium that gives a reading between 70 % and 100 % of full scale is applied to the sensor-unit until any change in indicated value is less than or equal to the intrinsic uncertainty of the instrument.

Zero oxygen medium is then introduced and constantly applied until any change in indicated value is less than or equal to the intrinsic uncertainty of the instrument.

Sensor-units assembled in flow-cells will be directly supplied with the test medium.

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

Where stable test medium that gives a reading of 100 % is used, the analyzer shall report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

5.6.6 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.

Stable test medium that gives a reading between 70 % and 100 % 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. Where a test medium that gives a reading of 100 % is used, the analyzer shall report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications. This test may be carried out immediately prior to the drift test to ensure readings are taken over a sufficient time interval.

5.6.7 Procedure for determining interference uncertainty

Interference uncertainties are determined by immersing the sensor-unit in the test medium and then sequentially with medium which contain the two concentrations of interfering components and which are otherwise identical to the test medium.

Zero oxygen medium may be used where the interference uncertainty is not expected to vary significantly through the measuring range. Normally, the test should be repeated with test medium with and without the interfering component but which contain an identical concentration or partial pressure of dissolved oxygen equivalent to 50 % to 100 %.

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. Where stable test medium that gives a reading between 70 % and 100 % is used, the analyzer shall report any positive deviation (above the maximum stated calibration range) to within its standard performance specifications.

5.6.8 Variations

5.6.8.1 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 pressure
- sample temperature

The operating ranges for primary influence quantities are listed in Annex B of IEC 60359:2001, except for sample pressure, temperature and flow (application dependent).

The test sequence for ambient temperature and humidity testing shall be according to procedures in IEC 60068 series. A convenient summary is given in IEC 60770-1.

5.6.8.2 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 60359:2001. 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. These influence quantities generally affect the electronic units directly and apply specifically to them. For fluorometric oxygen, where the sensor unit with the opto-electronic-unit is immersed in the sample, the sample conditions have an ambient influence. The effects of the external impact on the sensor unit shall 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.

Some 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: no measurable content.

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.

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 II	–12 % to +10 %	–17 % to +15 %
Usage group III	–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.

The above formulae are applicable over the half cycle or a full cycle depending on whether the zero crossings are equally spaced or not.

If the a.c. peak voltage exceeds the values stated in A.4.1, 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 medium 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 medium.) Uncertainties in these reference values will affect the limits of acceptability. Each indication to be used for calculations (below) should be obtained as a reliable value, i.e. the test medium 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 medium should be used.

The linear regression is given by the following equation:

$$Y = A + Bt \tag{B.1}$$

where

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

n is the number of measurements.

$$A = \frac{\Sigma Y - B\Sigma t}{n} \tag{B.2}$$

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

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

Annex C
(informative)

Physico-chemical data of oxygen in water

C.1 Salinity and conductivity

Use the values in Table C.1 if the conductivity meter in use does not measure salinity. Use a conductivity meter to determine conductivity at reference temperature (20 °C), then use Table C.1 to estimate the salinity to the nearest whole number.

If the conductivity meter is only able to display the conductivity at another reference temperature, the conductivity at 20 °C has to be calculated by a correction factor (see ISO 7888).

Table C.1 was calculated up to the conductivity of 5,4 S/m from the International Oceanographic Tables.[1]

Table C.1 – Correlation conductivity-salinity

Conductivity	Salinity value[a]	Conductivity	Salinity value[a]	Conductivity	Salinity value[a]
S/m[b]		S/m[b]		S/m[b]	
0,5	3	2,0	13	3,5	25
0,6	4	2,1	14	3,6	25
0,7	4	2,2	15	3,7	26
0,8	5	2,3	15	3,8	27
0,9	6	2,4	16	3,9	28
1,0	6	2,5	17	4,0	29
1,1	7	2,6	18	4,2	30
1,2	8	2,7	18	4,4	32
1,3	8	2,8	19	4,6	33
1,4	9	2,9	20	4,8	35
1,5	10	3,0	21	5,0	37
1,6	10	3,1	22	5,2	38
1,7	11	3,2	22	5,4	40
1,8	12	3,3	23	—	—
1,9	13	3,4	24	—	—

[a] Salinity determined from conductivity at 20 °C.

[b] 1 S/m = 10 mmhos/cm.

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[1] International Oceanographic Tables, Vol. I, National Institute of Oceanography of Great Britain, Womley, Godaming, Surrey, England and Uncesco, Paris 1971

C.2 Barometric pressure and elevation

Table C.2 is used to estimate the true barometric pressure at certain elevations. The correspondence is based on the assumption that at sea level the barometric pressure is 1 013 hPa. After taking the barometric pressure depending on the elevation from Table C.2 or more precisely from a local weather service, enter this value into the instrument.

NOTE 1 The values given in Table C.2 are an approximation according to the theoretical Schmassmann equation and can differ in respect of other data based on different but also possible equations.

NOTE 2 Corrections of the barometric pressure only have to be made, if the instrument does not do this automatically.

Table C.2 – Elevation barometric pressure (example)

Elevation m	**Barometric pressure** hPa	**Elevation** m	**Barometric pressure** hPa
0	1 013	1 800	815
150	995	1 950	800
300	978	2 100	785
450	960	2 250	771
600	943	2 400	756
750	926	2 550	742
900	910	2 700	728
1 050	893	2 850	715
1 200	877	3 000	701
1 350	861	3 150	688
1 500	846	3 300	675
1 650	830	-	-

C.3 Solubility of oxygen in water

Table C.3 is used to estimate the solubility of oxygen in water with different salt content exposed to water-saturated air at atmospheric pressure.

Table C.3 – Solubility of oxygen in water exposed to water-saturated air at atmospheric pressure (1 013 hPa) (Salinity see Table C.1)

Temperature	**Oxygen solubility** mg/l				
°C	**Salinity**				
	0	**9**	**18**	**27**	**36**
0	14,62	13,73	12,89	12,11	11,37
1,0	14,22	13,36	12,55	11,79	11,08
2,0	13,83	13,00	12,22	11,49	10,80
3,0	13,46	12,66	11,91	11,20	10,54
4,0	13,11	12,34	11,61	10,93	10,28
5,0	12,77	12,03	11,33	10,66	10,04
6,0	12,45	11,73	11,05	10,41	9,81
7,0	12,14	11,44	10,79	10,17	9,58
8,0	11,84	11,17	10,54	9,94	9,37
9,0	11,56	10,91	10,29	9,71	9,16
10,0	11,29	10,66	10,06	9,50	8,97
11,0	11,03	10,42	9,84	9,29	8,78
12,0	10,78	10,19	9,63	9,09	8,59
13,0	10,54	9,96	9,42	8,90	8,42
14,0	10,31	9,75	9,22	8,72	8,25
15,0	10,08	9,54	9,03	8,55	8,09
16,0	9,87	9,35	8,85	8,38	7,93
17,0	9,67	9,15	8,67	8,21	7,78
18,0	9,47	8,97	8,50	8,05	7,63
19,0	9,28	8,78	8,34	7,90	7,49
20,0	9,09	8,62	8,18	7,75	7,35
21,0	8,92	8,46	8,02	7,61	7,22
22,0	8,74	8,30	7,88	7,47	7,09
23,0	8,58	8,14	7,73	7,34	6,97
24,0	8,42	8,00	7,59	7,21	6,85
25,0	8,26	7,85	7,46	7,09	6,73
26,0	8,11	7,71	7,33	6,97	6,62
27,0	7,97	7,58	7,20	6,85	6,51
28,0	7,83	7,45	7,08	6,73	6,40
29,0	7,69	7,32	6,96	6,62	6,30
30,0	7,56	7,20	6,85	6,52	6,20
31,0	7,43	7,07	6,74	6,41	6,10
32,0	7,31	6,96	6,63	6,31	6,01
33,0	7,18	6,86	6,52	6,21	5,92

Temperature	**Oxygen solubility** mg/l				
°C	**Salinity**				
	0	**9**	**18**	**27**	**36**
34,0	7,07	6,73	6,42	6,11	5,83
35,0	6,95	6,63	6,32	6,02	5,74
36,0	6,84	6,52	6,22	5,93	5,65
37,0	6,73	6,42	6,12	5,84	5,57
38,0	6,62	6,32	6,03	5,75	5,48
39,0	6,52	6,22	5,93	5,66	6,40
40,0	6,41	6,12	5,84	5,58	5,32
41,0	6,31	6,03	5,75	5,50	5,25
42,0	6,21	5,94	5,67	5,41	5,17
43,0	6,12	5,84	5,58	5,33	5,09
44,0	6,02	5,75	5,50	5,25	5,02
45,0	5,93	5,67	5,42	5,18	4,95

EXAMPLE

Temperature at measurement	20 °C
Measured conductivity	0,87 S/m (20 °C)
Salinity (Table C.1)	6
Oxygen solubility (20 °C), salinity: 0 (Table C.3)	9,09 mg/l
Oxygen solubility (20 °C), salinity: 9 (Table C.3)	8,62
Increment	(9,09 mg/l-8,62 mg/l)/9 = 0,052 2 mg/l
Real oxygen solubility at given salinity	9,09 mg/l − (0,052 2 mg/l × 6) = 8,78 mg/l

Table C.4 is used to estimate the solubility of oxygen in water at different temperature and at different barometric pressure in the lower range of pressure.

Table C.4 – Solubility of oxygen in water vs. temperature and barometric pressure (lower range)

	Pressure hPa						
	733	**767**	**800**	**833**	**867**	**900**	**933**
Temperature °C	**Oxygen solubility** mg/l						
0	10,56	11,04	11,53	12,01	12,49	12,98	13,46
1	10,27	10,74	11,21	11,68	12,15	12,62	13,09
2	9,98	10,44	10,90	11,36	11,82	12,27	12,73
3	9,72	10,16	10,61	11,05	11,50	11,94	12,39
4	9,46	9,89	10,33	10,76	11,20	11,63	12,06
5	9,21	9,64	10,06	10,48	10,91	11,33	11,75
6	8,98	9,39	9,80	10,22	10,63	11,04	11,46
7	8,75	9,16	9,56	9,96	10,37	10,77	11,17
8	8,54	8,93	9,33	9,72	10,11	10,51	10,90
9	8,33	8,72	9,10	9,48	9,87	10,25	10,64
10	8,13	8,51	8,88	9,26	9,64	10,01	10,39
11	7,94	8,31	8,68	9,04	9,41	9,78	10,15
12	7,76	8,12	8,48	8,84	9,20	9,56	9,92
13	7,58	7,94	8,29	8,64	8,99	9,34	9,69
14	7,41	7,76	8,10	8,45	8,79	9,14	9,48
15	7,25	7,59	7,93	8,26	8,60	8,94	9,28
16	7,10	7,43	7,76	8,09	8,42	8,75	9,08
17	6,94	7,27	7,59	7,92	8,24	8,56	8,89
18	6,80	7,12	7,43	7,75	8,07	8,39	8,70
19	6,66	6,97	7,28	7,59	7,91	8,22	8,53
20	6,52	6,83	7,13	7,44	7,75	8,05	8,36
21	6,39	6,69	6,99	7,29	7,59	7,89	8,19
22	6,26	6,56	6,85	7,15	7,45	7,74	8,04
23	6,14	6,43	6,72	7,01	7,30	7,59	7,88
24	6,02	6,31	6,59	6,88	7,16	7,45	7,73
25	5,91	6,19	6,47	6,75	7,03	7,31	7,59
26	5,80	6,07	6,35	6,62	6,90	7,18	7,45
27	5,69	5,96	6,23	6,50	6,77	7,05	7,32
28	5,58	5,85	6,12	6,38	6,65	6,92	7,19
29	5,48	5,74	6,01	6,27	6,53	6,80	7,06
30	5,38	5,64	5,90	6,16	6,42	6,68	6,94
31	5,28	5,54	5,80	6,05	6,31	6,56	6,82
32	5,19	5,44	5,69	5,95	6,20	6,45	6,70
33	5,10	5,35	5,59	5,84	6,09	6,34	6,59
34	5,01	5,25	5,50	5,74	5,99	6,23	6,48

	Pressure hPa						
	733	**767**	**800**	**833**	**867**	**900**	**933**
Temperature °C	**Oxygen solubility** mg/l						
35	4,92	5,16	5,40	5,64	5,89	6,13	6,37
36	4,83	5,07	5,31	5,55	5,79	6,03	6,26
37	4,75	4,98	5,22	5,46	5,69	5,93	6,16
38	4,67	4,90	5,13	5,36	5,60	5,83	6,06
39	4,58	4,81	5,04	5,27	5,50	5,73	5,96
40	4,50	4,73	4,96	5,19	5,41	5,64	5,87
41	4,43	4,65	4,88	5,10	5,32	5,55	5,77
42	4,35	4,57	4,79	5,01	5,24	5,46	5,68
43	4,27	4,49	4,71	4,93	5,15	5,37	5,59
44	4,20	4,41	4,63	4,85	5,07	5,28	5,50
45	4,12	4,34	4,55	4,77	4,98	5,20	5,41

Table C.5 is used to estimate the solubility of oxygen in water at different temperature and at different barometric pressure in the upper range of pressure.

Table C.5 – Solubility of oxygen in water vs. temperature and barometric pressure (upper range)

	Pressure hPa						
	967	**1 000**	**1 013**	**1 033**	**1 066**	**1 100**	**1 133**
Temperature °C	**Oxygen solubility** mg/l						
0	13,94	14,43	14,62	14,91	15,39	15,88	16,36
1	13,56	14,03	14,22	14,50	14,97	15,44	15,91
2	13,19	13,65	13,83	14,10	14,56	15,02	15,48
3	12,84	13,28	13,46	13,73	14,17	14,62	15,06
4	12,50	12,93	13,11	13,37	13,80	14,24	14,67
5	12,18	12,60	12,77	13,02	13,45	13,87	14,29
6	11,87	12,28	12,45	12,69	13,11	13,52	13,93
7	11,57	11,98	12,14	12,38	12,78	13,19	13,59
8	11,29	11,69	11,84	12,08	12,47	12,87	13,26
9	11,02	11,41	11,56	11,79	12,17	12,56	12,94
10	10,76	11,14	11,29	11,51	11,89	12,26	12,64
11	10,51	10,88	11,03	11,25	11,61	11,98	12,35
12	10,27	10,63	10,78	10,99	11,35	11,71	12,07
13	10,04	10,40	10,54	10,75	11,10	11,45	11,80
14	9,82	10,17	10,31	10,51	10,86	11,20	11,54
15	9,61	9,95	10,08	10,29	10,62	10,96	11,30
16	9,41	9,74	9,87	10,07	10,40	10,73	11,06
17	9,21	9,54	9,67	9,86	10,18	10,51	10,83

	Pressure hPa						
	967	**1 000**	**1 013**	**1 033**	**1 066**	**1 100**	**1 133**
Temperature °C	**Oxygen solubility** mg/l						
18	9,02	9,34	9,47	9,66	9,98	10,29	10,61
19	8,84	9,15	9,28	9,46	9,77	10,09	10,40
20	8,66	8,97	9,09	9,28	9,58	9,89	10,19
21	8,49	8,79	8,92	9,10	9,40	9,70	10,00
22	8,33	8,63	8,74	8,92	9,21	9,51	9,80
23	8,17	8,46	8,58	8,75	9,04	9,33	9,62
24	8,02	8,30	8,42	8,59	8,87	9,16	9,44
25	7,87	8,15	8,26	8,43	8,71	8,99	9,27
26	7,73	8,00	8,11	8,28	8,55	8,83	9,11
27	7,59	7,86	7,97	8,13	8,40	8,67	8,94
28	7,45	7,72	7,83	7,99	8,25	8,52	8,79
29	7,32	7,59	7,69	7,85	8,11	8,37	8,64
30	7,20	7,46	7,56	7,71	7,97	8,23	8,49
31	7,07	7,33	7,43	7,58	7,84	8,09	8,35
32	6,95	7,20	7,31	7,46	7,71	7,96	8,21
33	6,84	7,08	7,18	7,33	7,58	7,83	8,08
34	6,72	6,97	7,07	7,21	7,46	7,70	7,95
35	6,61	6,85	6,95	7,09	7,34	7,58	7,82
36	6,50	6,74	6,84	6,98	7,22	7,46	7,70
37	6,40	6,63	6,73	6,87	7,10	7,34	7,57
38	6,29	6,53	6,62	6,76	6,99	7,22	7,46
39	6,19	6,42	6,52	6,65	6,88	7,11	7,34
40	6,09	6,32	6,41	6,55	6,78	7,00	7,23
41	6,00	6,22	6,31	6,45	6,67	6,90	7,12
42	5,90	6,12	6,21	6,35	6,57	6,79	7,01
43	5,81	6,03	6,12	6,25	6,47	6,69	6,91

C.4 Pressure conversions

Refer to Table C.6 for pressure conversions by the given conversion factors.

Table C.6 – Pressure conversions

Unit	mbar	mm Hg	Inches Hg
1 hPa	1	0,750 06	0,029 53
1 mbar	1	0,750 06	0,029 53
1 mm Hg	1,333 2	1	0,039 370
1 inch Hg	33,864	25,400	1

EXAMPLE

To convert 1 013,25 mbar into inches Hg, multiply 1 013,25 by 0,029 53. The result is 29,92 inches Hg.

To convert 1 013,25 mbar into mm Hg, multiply 1 013,25 by 0,750 06. The result is 760 mm Hg.

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